Appendix 7-3 Site-Specific Flood Risk Assessment

EIAR – Volume 3

Knockanarragh Wind Farm

SLR Project No.: 501.V00727.00008

25 January 2024

Making Sustainability Happen

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1 Draft	12 December 2022	KD	PG	AOB
2 Final	18 January 2024	KD	PG/DB	AOB
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Acronyms and Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
AEP	Annual Exceedance Probability
CFRAM Study	Catchment Flood Risk and Management Study
DEM	Digital Elevation Model
DTM	Digital Terrain Model
DS	Downstream
FRA	Flood Risk Assessment
FSU	Flood Study Update
GIS	Geographical Information System
GSI	Geological Survey of Ireland
HEFS	High-End Future Scenario
LA	Local Authority
LiDAR	Light detection and ranging
mOD	Meters above Ordnance Datum (Malin)
MRFS	Mid- range future scenario
NIFM	National Indicative Fluvial Mapping
OPW	Office of Public Works
OSi	Ordnance Survey Ireland
PFRA	Preliminary Flood Risk Assessment
SFRA	Strategic Flood Risk Assessment
SSFRA	Site Specific Flood Risk Assessment
SuDS	Sustainable Drainage Systems
US	Upstream

1.0 Introduction

SLR Consulting (Ireland) (SLR) has been commissioned by Statkraft (the Client) to complete a Site-Specific Flood Risk Assessment (SSFRA) in support of a planning application for the proposed Knockanarragh Wind Farm development in Co. Meath / Co. Westmeath.

1.1 Proposed Development

The proposed project will primarily consist of a wind farm of 8 number of wind turbine generators (WTGs), one substation compound along with ancillary civil and electrical infrastructure.

The associated grid connection route will consist entirely of underground cable and will connect the off-site substation at 110 kV substation at Clonmellon.

The proposed development layout is shown on Figure 1-1 below.

1.1 Aim of the Flood Risk Assessment

The aim of this SSFRA is to assess the determine flood risks and to demonstrate that the flood risk to the site has been considered for the planning application for the proposed development.

This SSFRA has been undertaken in accordance with the Guidelines for Planning Authorities for Developments and Flood Risk Management (2009).

1.2 Site Visit

Staff from SLR has visited the site on a number of occasions since 2021 and a Hydrologist from SLR has walked the site to inspect the watercourses and drainage features.

The key objectives of the site visits were to assess the existing hydrological and hydrogeological environment and to understand the existing surface water drainage at the site for the SSFRA.

1.3 Limitations of this Flood Risk Assessment

This assessment is based on available desktop information, DTM survey data for the site area, information from the site walkover survey and professional experience in undertaking similar SSFRA's.

This SSFRA includes hydraulic modelling to determine the flood levels within the site. Hydraulic models, such as this one, use DTM survey data to represent the underlying terrain in the model. The DTM data has been provided to us by Bluesky Ltd. which according to the data provider, the vertical accuracy of the DTM data used has standard deviation of 1.5m.

Figure 1-1The proposed wind farm layout

1.4 Nominated Hydrologists

This SSFRA report has been prepared by:

- *Kristian Divjak MSc (Water Resources)– Senior Flood Risk Engineer; and*
- *EurGeol Dr. Peter Glanville PGeo. PhD (Geomorphology) MSc (GIS) – Technical Director Hydrology.*

Kristian is a hydrologist with SLR with over 7 years' experience in the sector, specialising in hydraulic modelling, drainage design and hydrology environmental assessments for planning applications. He has undertaken and prepared flood risk assessment repots for a wide range of projects across Ireland, UK and Croatia.

Peter is a Technical Director (Hydrology) with SLR and has over 20 years' experience in the area of Hydrology and Flood Risk Assessments. Peter has undertaken and prepared flood risk assessments for a wide range of projects and has also prepared Section 4 Discharge Licences for a variety of developments. He has also been involved as a hydrologist in a range of environmental monitoring projects for Environmental Baseline Studies, exploration operations, quarry site operations and infrastructure projects – this work has typically included hydrology monitoring (flow) and water quality sampling and testing.

2.0 FLOOD PLANNING GUIDELINES AND METHODOLOGY

Government (DoEHLG) issued guidelines for planning authorities addressing the management of flood risk in the planning system (hereinafter referred to as the 'Flood Planning Guidelines').

The flood planning guidelines introduced comprehensive mechanisms for the incorporation of flood risk identification, assessment and management into the planning process. Implementation of the guidelines will be achieved through actions at national, regional, local authority and site-specific levels, depending on the plan or development project being considered.

2.1 Planning Objectives in Relation to Flooding

The Flood Planning Guidelines require the planning system at national, regional and local level to:

- Avoid development in areas at risk of flooding by not permitting development in flood risk areas, particularly floodplains, unless where it can be fully justified, there are wider sustainability grounds for appropriate development and unless the flood risk can be managed to an acceptable level, without increasing flood risk elsewhere and, where possible, reducing flood risk overall;
- Adopt a sequential approach to flood risk management based on avoidance, reduction and then mitigation of flood risk as the overall framework for assessing the location of new development in the development planning processes; and
- Incorporate flood risk assessment into the process of making decisions on planning applications and planning appeals.

A sequential approach is adopted in the Flood Planning Guidelines in order to guide development away from areas at risk of flooding, this entails the following actions:

- Avoid Locate new development in lower risk flood zones;
- Substitute Ensure that the type of development is not particularly vulnerable to the adverse impacts of flooding;
- Justify Ensure that the development is considered for strategic reasons;
- Mitigate Ensure that flood risk is reduced to acceptable levels; and
- Proceed Development to proceed only where Justification Test passed and emergency planning measures are in place.

The sequential approach identifies and defines three different flood zones (designated Zones A, B and C) in order to guide development at a particular site. The flood zones are:

Zone A High probability of flooding. This zone defines areas with the highest risk of flooding from rivers (i.e. more than 1% probability or more than 1 in 100) and the coast (i.e. more than 0.5% probability or more than 1 in 200).

Zone B Moderate probability of flooding. This zone defines areas with a moderate risk of flooding from rivers (i.e. 0.1% to 1% probability or between 1 in 100 and 1 in 1000) and the coast (i.e. 0.1% to 0.5% probability or between 1 in 200 and 1 in 1000).

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 1000).

2.2 Flood Risk Management

Technical Appendix B of the Flood Planning Guidelines addresses the incorporation of flood risk management in the design of developments, and sets out practical measures, with the aid of design examples, which can be incorporated into the development design in order to reduce the risk of flooding in areas where a potential flood risk has been identified. The design examples match flood risk with appropriate land uses, while also protecting flood conveyance routes and preserving floodplain storage.

A number of core principles are outlined in the Flood Planning Guidelines regarding design for, and management of, flood risk. These follow a sequential approach to flood risk management, and involve:

- Locating development away from areas at risk of flooding, where possible;
- Substitution of less vulnerable land uses for the more vulnerable ones that are to be replaced, where the principle of development within flood risk areas has been established; and
- Identifying and protecting land required for current and future flood risk management, such as conveyance routes, flood storage areas and flood protection schemes etc. where the principle of development within flood risk areas has been established.

In the Flood Planning Guidelines, Section 3.4 of Appendix B outlines practical landscape and drainage measures which can be closely integrated to play a key role in effective flood-reduction measures if incorporated into the design of developments. Key elements which can be incorporated include:

- Creating a permeable network and hierarchy of green space providing for direct access to areas of lower flood risk;
- Planting and shaping the land surrounding individual buildings and groups of buildings to encourage drainage away from a property;
- The use of “higher-risk” low-lying ground in waterside areas for recreation, amenity and environmental purposes;
- Modest land-raising of a part of the area at high risk of flooding accompanied by compensatory provision of flood storage in areas of existing lower risk of flooding having considered other natural and built heritage issues;
- Recontouring of edge of floodplain;
- Use of earth bunds to provide local flood defense;
- The use of surface runoff attenuation measures / sustainable drainage systems (SuDS) to manage run-off from rain falling on a development can be an effective means of reducing its impact reflecting natural drainage processes and removing pollutants from urban run-off at source; and
- Avoiding structures in the floodplain.

2.3 Development Vulnerability and Justification Test

The Flood Planning Guidelines classify potential development in terms of its vulnerability to flooding and assigns each land-use to an appropriate Flood Risk Zone. There are three categories, Highly vulnerable development, such as housing, emergency services and strategic infrastructure, Less vulnerable development, such as retail, commercial and industrial uses, and Water compatible development, such flood control infrastructure, docks and marines.

Full list of types of development and related vulnerability class is provided in Table 3.1 of the Flood Planning Guidelines. Uses which are not listed in the table should be considered on their own merits.

Table 3.2 of the Flood Planning Guidelines illustrate those types of development that would be appropriate to each flood zone and those that would be required to meet the Justification Test.

The Justification Test has been prepared to rigorously assess the appropriateness of developments that are being considered in areas of moderate or high flood risk. The test comprises the following two processes:

- The first is the Plan-making Justification Test and is used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate to high risk of flooding
- The second is the Development Management Justification Test and is used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land.

2.4 Flood Risk Assessment - Methodology

A methodology for the identification and assessment of flood risk is outlined in Technical Appendix A of the Flood Planning Guidelines. The aim of the SSFRA is to identify and quantify the risk of flooding to land, property and people and also to provide sufficient information to assess whether the site is appropriate at a specific site.

The SSFRA is undertaken over a number of stages which each progressing to a more detailed assessment, dependant on the outcome of each stage, until the level of detail in the SSFRA is appropriate to support the planning application or it has been demonstrated that flooding is not a relevant issue for the site. The stages in the assessment are typically;

- Stage 1: Flood Risk Identification;
- Stage 2: Initial Flood Risk Assessment; and
- Stage 3: Detailed Flood Risk Assessment (including quantitative model).

At the end of Stages 1 and 2, a decision is taken as to whether it is necessary to proceed to the next stage in the assessment process, in relation to flood risk at a site.

2.5 Flood Risk Assessment Conceptual Model

To assess the flood risk for a particular site, it is essential to understand what the risk is. This is undertaken using a conceptual Source-Pathway-Receptor (SPR) model, which is widely used in understanding and managing environmental risks.

In order to develop a conceptual SPR model for the purpose of risk assessment, it is necessary to understand the origin and magnitude of potential flooding (the Source), the mechanism or route of flooding (the Pathway) and the nature / scale of the site (the Receptor).

2.6 Data Sources

In order to assess the flood risk at a site, it is necessary to understand both the flood Source and Pathway for flooding at a site. This is completed using available desktop data for Stages 1 and 2 of the SSFRA. Desktop data sources for Stages 1 and 2 include:

- **The Office of Public Works** (Flood Risk Assessment Maps, flood study reports and flood hazard mapping);
- **Environmental Protection Agency** (hydrology flow / levels, catchment boundaries);
- **Ordnance Survey of Ireland** (historical mapping);
- **Geological Survey of Ireland** (groundwater flooding, soils, subsoil, karst);
- **Site Walkover and Topographic Surveys** (site water management and topographic survey).

This report follows the methodology for a Stage 1 flood risk identification, Stage 2 initial flood risk assessment and Stage 3 detailed flood risk assessment at the site-specific level as outlined in the Flood Planning Guidelines.

3.0 Baseline Scenario

This section details the information obtained from the desk top study relating to the site of the proposed development. The desktop study obtained information relating to:

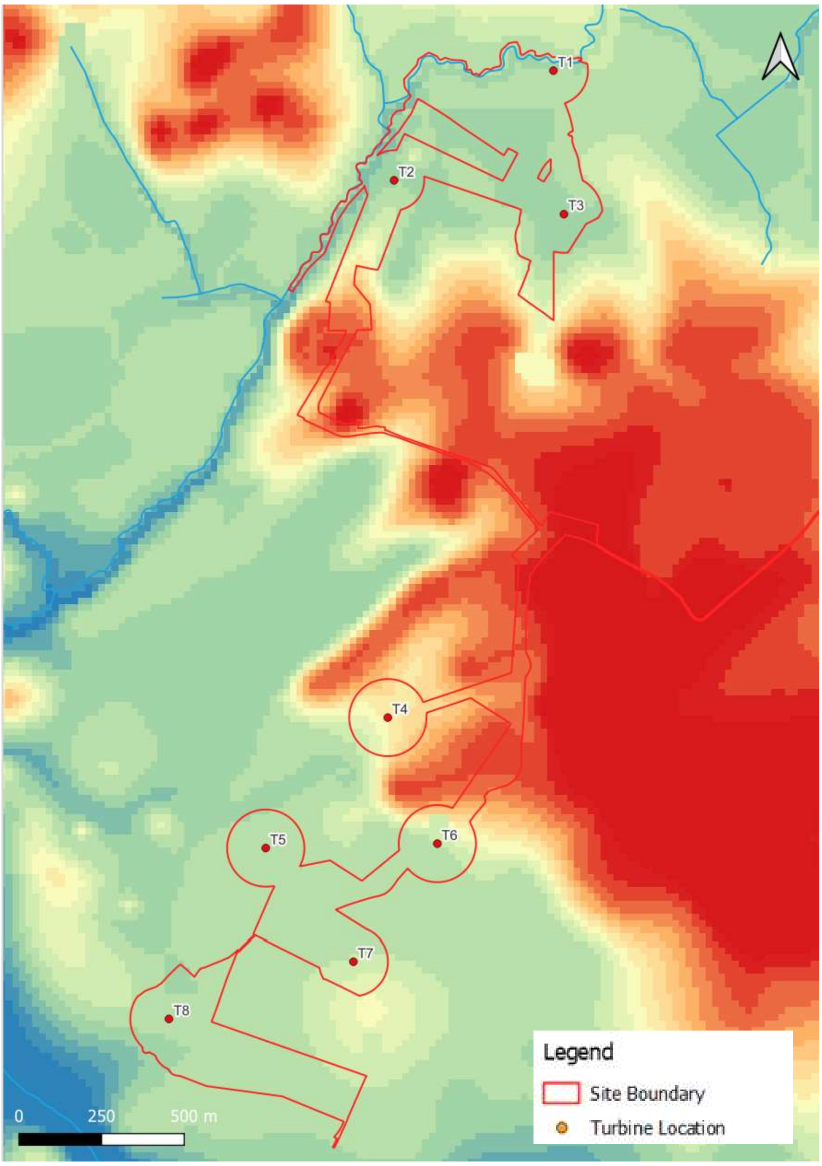
- Topography;
- Hydrology (surface water features); and
- Soils, Geology and Hydrogeology (groundwater).

The baseline environment within c. 500 m of the planning area Red Line boundary was assessed here.

3.1 Topography

The north-western part of the site has a gentle slope in the north direction towards the Killacroy Stream and to the west towards the Darcy Crossroads Stream. The central and southern part of the site drain into the River Stonyford. Surface runoff follows local topography, draining towards the watercourses. Ground levels within the site varies between 80 mOD and 110 mOD.

Figure 3-1 Local Topography



3.2 Hydrology

The site is located within the catchment of the Boyne (ID 07). There are no streams and rivers within the site on the EPA catchment mapping. However, the Darcy Crossroads Stream runs along the north-western boundary of the site. The Killacroy Stream runs along the northern boundary in the east-west direction where it ultimately joins the Darcy Crossroad Stream. Approximately 1.8 8 km south-west of the confluence, the Darcy Crossroad Stream flows into the River Stonyford.

The River Stonyford flows in the south-east direction for approximately 19 km where it joins the River Boyne.

3.3 Soils, Geology and Hydrogeology

Soils

The soil underlaying the site is predominantly a typical Luvisol, classified as Elton (1000ET) within National Soil Series. The Sub Soil parent material is identified as limestone drift material. Luvisols with a good internal drainage and are potentially suitable for a wide range uses because of their moderate stage of weathering and high base saturation.

The west and northern portions of the site have more variable soil type with a combination of primarily low permeability soils and area of till overlain by poorly drained gley with minor isolated areas of peat and areas of exposed bedrock.

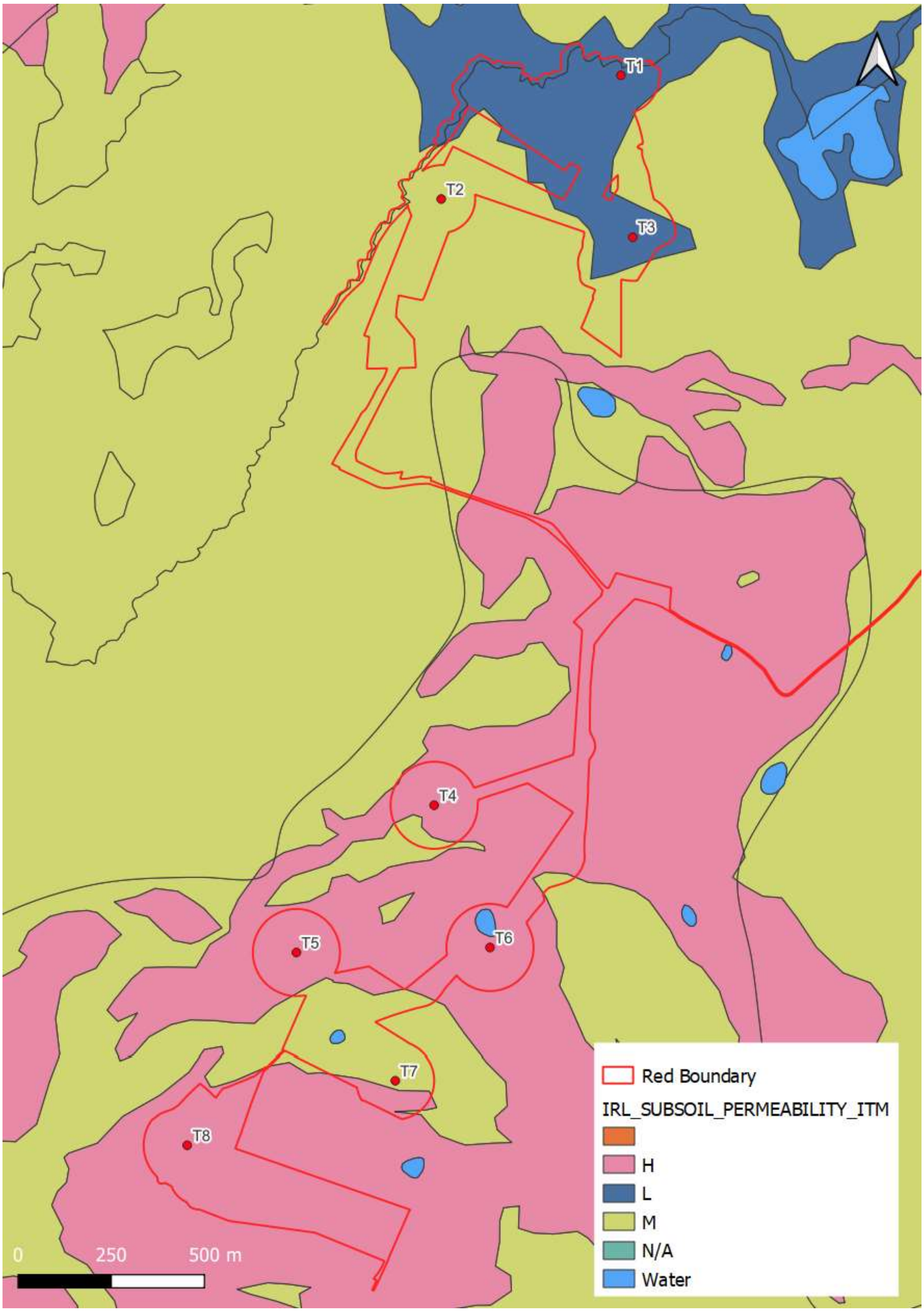
Subsoils / drift

According to the GSI database[1] the majority of the soils underlying the site are defined as 'high permeability' subsoil, as shown on Figure 3-2, with have particularly low groundwater recharge rates (c. 44 mm/year) across the northern part of the site.

According to the GSI database[1] the bedrock at the site is classified as a Locally Important Aquifer (Li) - Bedrock which is Moderately Productive only in Local Zones. Groundwater flow is considered to be entirely through interconnected networks of fractures, with flow from high elevations to low elevations. The site lies within the Athboy Ground Water Body (GWB).

[1] Groundwater Data Viewer
https://dcenr.maps.arcgis.com/apps/webappviewer/index.html?id=7e8a202301594687ab14629a10b748ef

Figure 3-2 Subsoil Permeability Features



4.0 STAGE 1: FLOOD RISK IDENTIFICATION

Flood risk identification uses existing and recorded information to identify whether there may be any flooding or surface water management issues related to the site. The potential sources of flooding to any site are varied and can include one or more of the following:

- Flooding from rivers (fluvial);
- Flooding from the sea or tidal (coastal);
- Flooding from land (pluvial);
- Flooding from groundwater and karst;
- Flooding from sewers; and
- Flooding from manmade impoundments (reservoirs, canals, and other artificial sources).

4.1 Desktop review of potential flooding sources

4.1.1 Historical Flooding

The Office of Public Works (OPW) is the Government agency with statutory responsibility for flooding. The OPW website (www.floodinfo.ie) indicates that there are no recorded recurring flood events at the site and within 500m of the site.

The Internet research did not provide any information indicating the site was flooded in the past.

4.1.2 Fluvial Flooding

OPW CFRAM Maps

The Catchment Flood Risk Assessment and Management (CFRAM) Programme has been implemented for seven areas across Ireland termed River Basin Districts (RBDs) which cover the whole country. Each RBD is divided into a number of River Basins (Units of Management, or 'UoMs'), where one Plan has been prepared for each River Basin.

The subject site is within Flood Risk Management Plan the Boyne River Basin (UOM07).

The subject site was outside of any detailed OPW CFRAM flood modelled area.

OPW National Indicative Flood Mapping

The OPW National Indicative Fluvial Mapping (NIFM) dataset has been produced nationally for catchments greater than 5 km^2 in areas for which flood maps were not produced under the National CFRAM Programme and should be read in this context. The NIFM dataset are ‘predictive’ flood maps showing indicative areas predicted to be inundated during a theoretical fluvial flood event with an estimated probability of occurrence.

The NIFM are not the best achievable representation of projected flood extents, such as those that could be generated through detailed hydraulic modelling for a particular watercourse; they are only indicative of the predicted flood extent of any given probability at any particular location.

The NIFM dataset shows the modelled extent of land that might be flooded by rivers (fluvial flooding) during a theoretical or ‘design’ flood event with an estimated probability of occurrence, rather than information for actual floods that have occurred in the past. In this respect, the NIFM data only provide an indication of areas that may be prone to flooding.

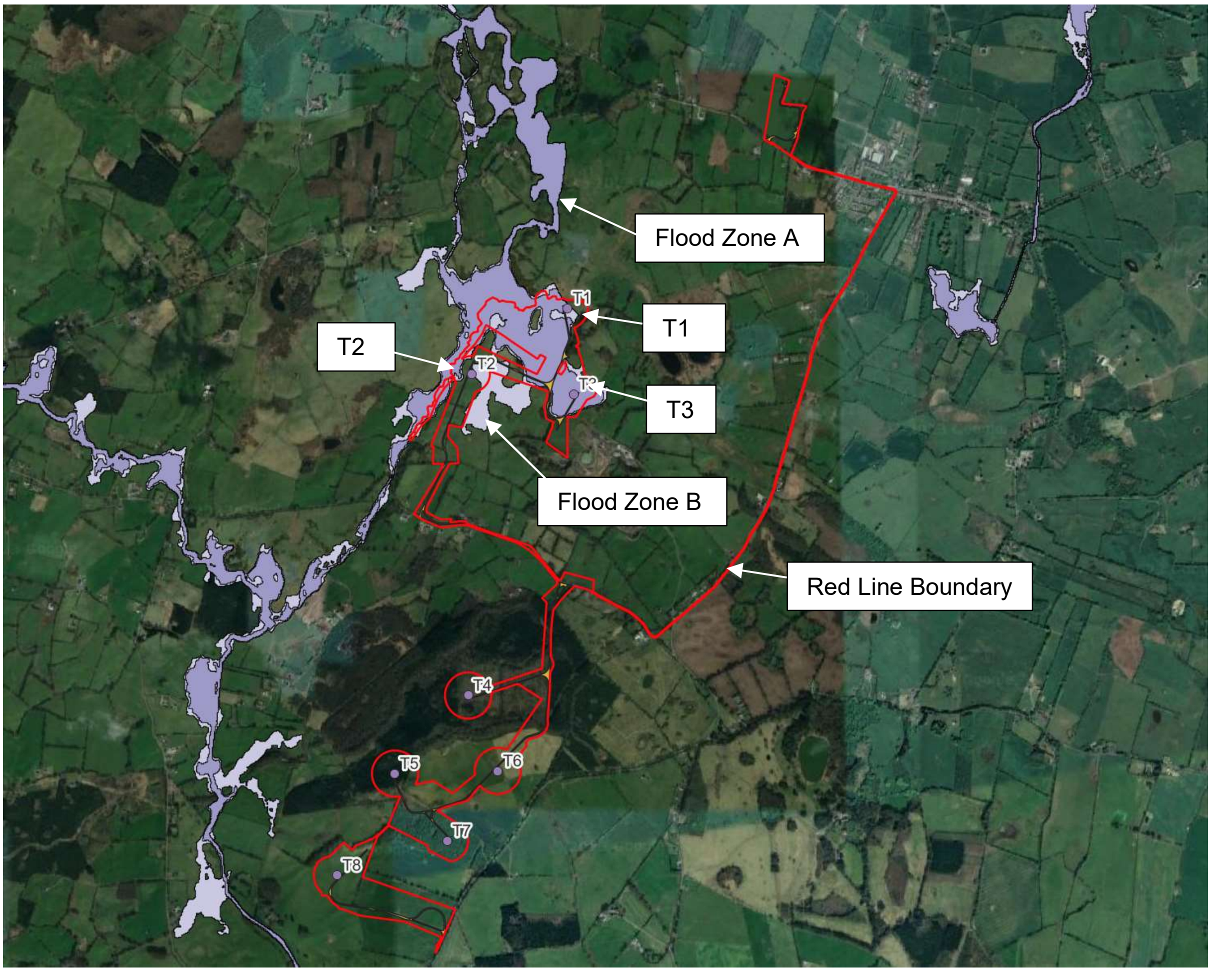
The OPW states that the NIFM data may be used in the preparation of a Stage 1 Flood Risk Assessment to identify areas where further assessment would be required for a development. The NIFM data may be used to identify whether flood risk might be a relevant issue when considering a planning application, or when discussing a potential application at pre-planning stage.

According to the NIFM data, the northern part of the site is within Flood Zone A and Flood Zone B as shown on Figure 4-1 below. The proposed turbines T1 and T3 are within Flood Zone A, the proposed turbine T2 is just outside of Flood Zone B. Note that a figure showing the area at the northern part of the site in more detail is shown in Section 5.

The remaining turbines and substation are in Flood Zone C.

Flood Zone C is everything that is not Flood Zone A or Flood Zone B.

Figure 4-1 NIFM Maps – Flood Zone A and B



4.1.3 Coastal Flooding

A review of the OPW national coastal / tidal flood mapping indicates that the site is not at risk from coastal or tidal flooding due to its location and elevation.

4.1.4 Pluvial Flooding

Pluvial flooding occurs when the amount of rainfall exceeds the capacity of urban storm water drainage systems or the ground to absorb it. This excess water flows overland, ponding in natural or man-made hollows and low-lying areas or behind obstructions. During the site walker, a numerous ponds were identified.

4.1.5 Groundwater Flooding

Groundwater flooding is caused when the water table rises up above ground level, causing flooding to occur at the surface. Such groundwater flooding tends to be seasonal occurring after seasonally higher rainfall. Seasonal rainfall infiltrates into the ground causing the groundwater level to rise and where it rises above the ground surface then groundwater flood occurs.

Groundwater flooding is unlike river or coastal flooding where a flood event may be relatively short lived; groundwater flooding can last up to several months where the groundwater table is still above ground level. An example of groundwater flooding in Ireland is Turloughs in karst limestone environment which can be flooded for several months at a time.

According to the Geological Survey of Ireland (GSI) groundwater flooding probability maps, the site is at a low risk of groundwater flooding.

The GSI Groundwater Flood database does not show any historical groundwater flooding in the area.

4.1.6 OPW Arterial Drainage Benefiting Lands

The site is within the OPW Arterial Drainage designated ‘benefiting lands’. The River Stonyford and Darcys Crossroad and Killacroy Stream, are within benefitting lands.

Benefitting lands are lands benefiting from works undertaken as part of the Arterial Drainage Scheme; the OPW have a statutory duty to maintain Arterial Drainage Schemes.

4.2 Classification of the Proposed Development

The wind farm developments are not classified within Table 3.1 of the Flood Planning Guidelines which covers development types and flooding compatibility; therefore it must be considered on their own merits in terms of compatibility with flooding.

Recent ABP judgements have indicated that turbines and access roads are considered to be water compatible development, making them suitable for locating within Flood Zone A or Flood Zone B.

While it may be possible to place a wind turbine within a flood zone, the base of the turbine would need to be elevated above the 1% AEP medium-range future scenario (MRFS) which accounts for predicted climate change out to 2100, and also to allow at least 300 mm to freeboard.

When it comes to the layout of wind farms the appropriate approach would be to locate any water sensitive infrastructure, such as substation(s), in Flood Zone C at the site.

4.3 Flood Screening - Summary

With reference to identified potential sources of flooding at the site identified in Section 4.1 above, the flood risk from each source is screened in Table 4-1 Flood Risk Screening below.

Table 4-1 Flood Risk Screening

Source of Flooding	Potential to Flood at the Site	Flood Screening - Potential Impact from Flooding
Flooding from rivers (fluvial)	The available NIFM mapping show the north-western part of the site is within Flood Zone A and B.	At Risk
Flooding from the sea (coastal / tidal)	The OPW tidal / coastal flood mapping indicates that the site is not at risk from coastal or tidal flooding.	Not Significant
Flooding from land (rainfall - pluvial)	There are local depressions within the site which could flood as a result of overland flow from pluvial flooding.	At Risk
Flooding from groundwater	There are numerous ponds within the site which could cause flooding as a result of rising groundwater level.	At Risk
Flooding from sewers	The site is located within a forestry and grazing area. No sewers were identified in the vicinity of the site during the walkover surveys.	Not Significant
Flooding from Impoundments - reservoirs and artificial sources	There are no artificial sources of water in the vicinity of the site.	Not Significant

4.4 Requirement for a Stage 2 Flood Risk Assessment

The Flood Planning Guidelines state that if a flood risk is identified at this Stage 1, it is necessary to progress and undertake a Stage 2 Initial Flood Risk Assessment for the site. Each of the potential flooding sources have been assessed here based on the findings of a desktop study. The desktop survey has been verified by a site visit.

The screening exercise demonstrated the site is at the risk of fluvial, pluvial and groundwater flooding. Therefore, it is proposed to proceed to Stage 2 to assess the initial flood risk.

5.0 STAGE 2: INITIAL FLOOD RISK ASSESSMENT

This initial flood risk assessment for the site is based on available desktop information and site information. The following steps have been undertaken in this section

- Delineation of flood zones at the site;
- Conceptual Site Model: Source - Pathway - Receptor;
- Assessment of flood risk to the site;
- Stage 2 findings and assessment of the requirement to proceed to a Stage 3 - Detailed SSFRA.

5.1 Fluvial Flooding

The NIF maps show the north-western part of the site being within Flood Zone A (high flood risk, 1% AEP) and Flood Zone B (medium flood risk, 0.1% AEP). The flood mapping indicates that the northern part of the site is liable to flood from the Killacroy and Darcy Crossroads Stream as shown on Figure 5-1.

Figure 5-1 NIFM Flood Maps

The main flood path occurs approximately 1.4 km north of the site, where water overtops both banks of the Darcy Crossroads Stream. The flood water continues towards the east where it eventually enters the Killacroy Stream as shown on Figure 5-2. The overland flow runs over the agricultural fields in the south direction, towards the proposed wind farm development.

The catchment area of the Killacroy Stream at the confluence with the Darcys Crossroad Stream is less than 5 km^2, which means the Killacroy Stream was not modelled within the NIFM Study.

Just north of the site it can be noticed that the modelling results have two sharp edges. This indicates that the model boundary did not include the area to the east of these location, or that the results have been trimmed. In this respect, the NIFM maps at this particular area provides uncertainty around the extent of the modelled flooding, and therefore a detailed site specific assessment is required to determine the flood risk within the site.

Figure 5-2 Flood Zones North of the Site

5.2 Pluvial Flooding and Groundwater Flooding

During a site walkover, a numerous ponds were identified within the site. These ponds were small and isolated as shown on Figure 7-2 of the Environmental Impact Assessment Report. It is considered that they would be filled up with water following a prolonged rainfall event.

Locating the infrastructure outside of the these ponds, with an additional buffer, and placing the sensitive electrical equipment at least 300 mm above the ground levels is sufficient measure to mitigate the pluvial and groundwater flood risk within the site.

5.3 Source-Pathway-Receptor Model and Flood Risk Assessment

A review of the published desktop information relating to the site is applied in the formulation of a Source-Pathway-Receptor (SPR) conceptual flood model. Using the available data in relation to fluvial, pluvial and groundwater flooding, the subject site and infrastructure, an initial flood risk assessment is summarised in this section.

Table 5-1 Initial Flood Risk Assessment

Conceptual Site Model			Likelihood and Consequence of Site Flooding	Recommended Measures	Residual Risk
Source	Pathway	Receptor			
Fluvial flooding: Darcy Crossroads and Killacroy Stream.	Overflow of the watercourses in times of flood.	Subject site and site infrastructure.	High (Flood Zone A) likelihood of flooding based on NIF maps.	The existing flood source data is not detailed to provide adequate flood mitigation measures.	**High** for those parts of the development site which are considered vulnerable.
Pluvial flooding: intense rainfall event Groundwater flooding: high ground water levels	Overflow towards the local low points. Local low points expected to be flooded due to increase in the groundwater levels.	Subject site and site infrastructure	Low likelihood of flooding based on GSI database.	Locate the proposed infrastructure at least 25 m from the identified ponds.	**Low** for those parts of the development site which are considered vulnerable.

5.4 Requirement for a Stage 3 Flood Risk Assessment

The initial SSFRA has assessed existing baseline information in relation to fluvial, pluvial and groundwater flooding at the site and determined that the subject site is at the high risk of fluvial flooding and low risk of pluvial and groundwater flooding.

Based on the above, it is suggested to proceed to Stage 3: Detailed flood risk assessment and to develop a hydraulic model to determine the flood levels within the site

6.0 STAGE 3: DETAILED FLOOD RISK ASSESSMENT

The Stage 3 Detailed SSFRA undertaken in relation to the site has involved the following elements:

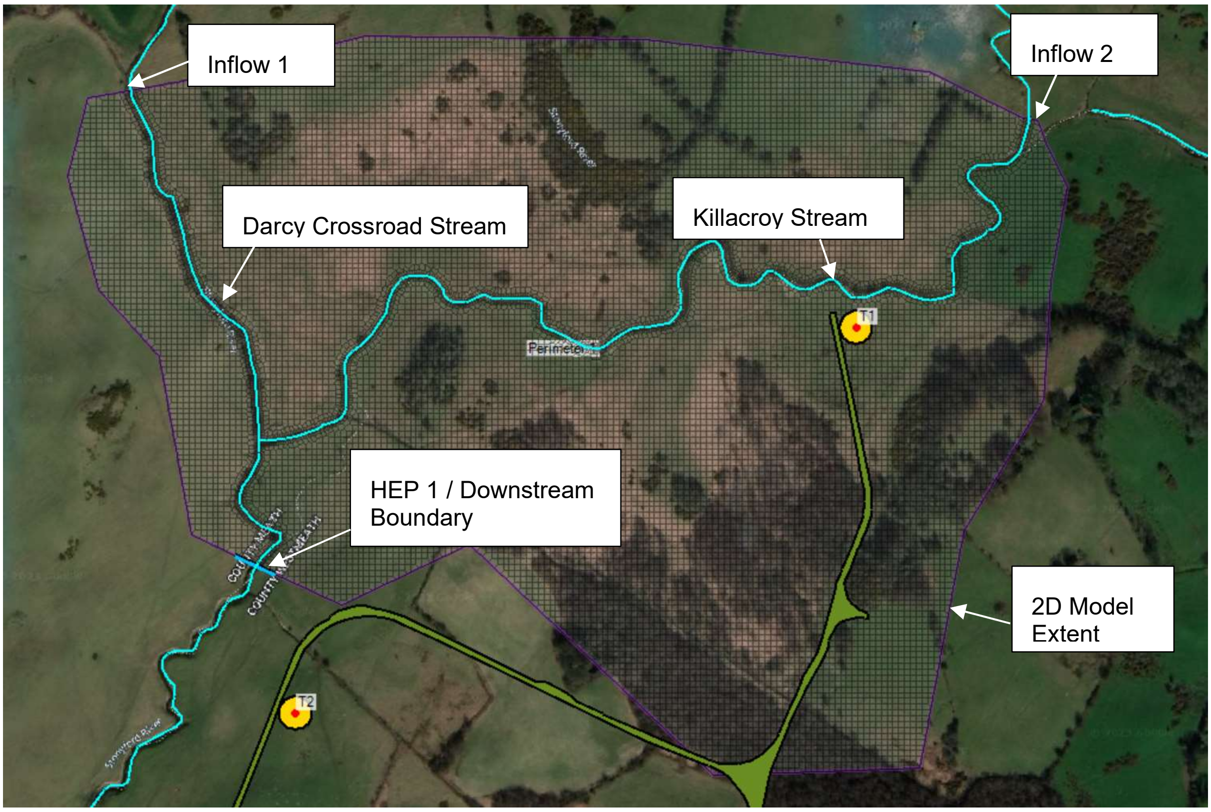
- Modelling Methodology;
- Hydrological Analysis
- Modelling Approach;
- Critical Scenario;
- Flood Modelling Results; and
- Design Flood Levels and Freeboard.

6.1 Modelling Methodology

As discussed in Section 5.1 the overtopping of the Darcy Crossroad Stream occurs some1.5 km north of the site as shown on Figure 5-2. Due to the location of the overtopping, access to the numerous private lands, necessity for surveying streams located outside of the site boundary, the SLR hydraulic model did not cover the full flood extent in the catchment.

The modelling extent for this SSFRA exercise is presented on Figure 6-1 below. This extent covers the area that was recognised as being vulnerable to fluvial flooding in Stage 2 of this report.

Figure 6-1 Model 2D Extent



The hydraulic modelling exercise undertaken encompassed five scenarios; these are listed in Table 6-1 below. The total flow has been determined through the OPW FSU Web Portal for the location HEP 1, shown on Figure 6-1 above, and then it was split between the streams as defined in Table 6-1 below for the purpose of modelling flood flows. For this exercise, HEP 1 has been defined just downstream of the confluence of the Darcy Cross road Stream and Killacroy Stream. This location also matches with the location of the downstream model boundary. For the downstream model boundary a normal depth has been used. This is further discussed in Section 6-3.

For example, in Scenario 1 it is assumed that there is no flow at Killacroy Stream (Inflow 2), in Scenario 2 that 25% of the total stream flow is running through the Killcaroy Stream, and in Scenario 3 the total flow has been equally divided between the streams.

Defining flows this way preserves the amount of water that enters the system between the scenarios and allows assessing the impact of water overtopping the bank of the Darcy Crossroad Stream, and then entering the Killacroy Stream.

The analysis is carried out for the 0.1% AEP event, present day since this flow is higher than 1% AEP MRFS flow to include for Climate Change.

The flood risk at the site has been analysed in detail for the scenario which resulted in the maximum flood extent.

Table 6-1 Modelled Peak Flow Scenarios

Modelled Scenario ID	Darcy Crossroad Stream (Inflow 1)	Killacroy Stream (Inflow 2)
1	100%	0%
2	75%	25%
3	50%	50%
4	25%	75%
5	0%	100%

6.2 Hydrological Analysis

In order to undertake the flood flow estimation, it is necessary to establish a number of Hydrological Estimation Points (HEPs) at appropriate locations along the watercourse. HEPs are typically located at confluences, and at the upstream and downstream end of modelled watercourses. Hydrological analysis is then carried out on the catchments contributing to each HEP in order to calculate the design flows at the HEP.

The estimation of design flows and hydrographs has followed the OPW Flood Studies Update (FSU) methods and processes as set out in the FSU Web Portal (https://opw.hydronet.com/). As part of Work Package 5.3 of Flood Studies Update, catchment descriptors were generated at 500 m intervals or less, on watercourses across the country. Hydrological estimation points (HEPs, also known as FSU Nodes) are points at these intervals along a watercourse at which flow estimates are derived, based on catchment descriptors.

The principal flood estimation method set out in the FSU is a statistical method, using donor (pivotal) gauged sites and pooling groups of hydrologically similar catchments in order to estimate the peak flowrates of probabilistic events.

6.2.1 Growth Factors

The growth factors have been determined through the FSU Web Portal using the pooling group method. The growth factors are listed in Table 6-2.

Table 6-2 Growth Factors

Return Period	Growth Factors
2	1.00
10	1.47
100	1.98
1000	2.40

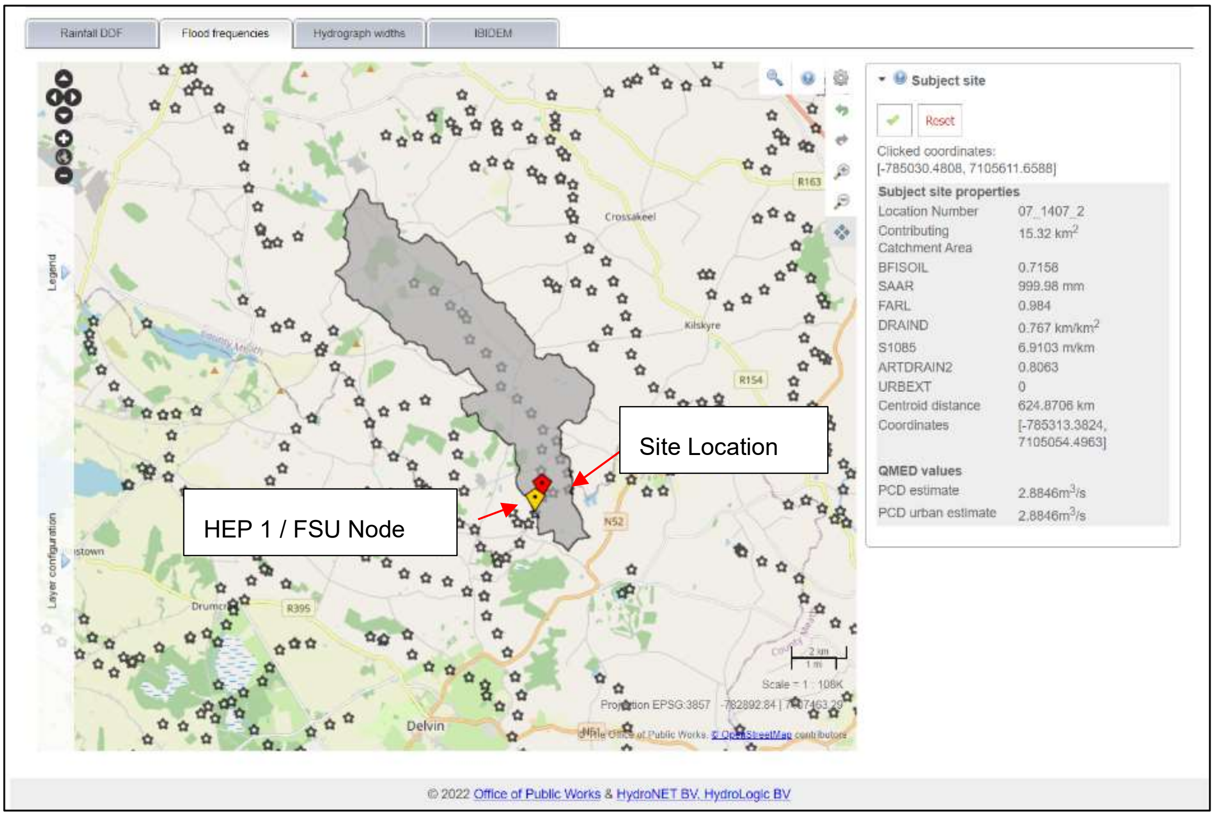
6.2.2 Estimated Peak Runoff

Figure 6-2, below, shows an extract from the OPW FSU Web portal which presents the catchment area and catchment characteristics at the FSU node approximately 200 m downstream of the confluence of the Darcy Crossroads Stream and Killacroy Stream (node 07_1407_2). The catchment area to this node is 15.32 km^2.

The location the principal gauging site used in flood flow estimation is 07006 Trim, located approximately 32 km downstream of HEP 1.

The key details of the FSU donor adjustment method are provided in Appendix A.

Figure 6-2 HEP 1 – Catchment Area



The outcomes of the flow analysis for HEP 1, in terms of peak flowrate for the Q_{med}, 1% AEP and 0.1% AEP events, are shown below in Table 6-3.

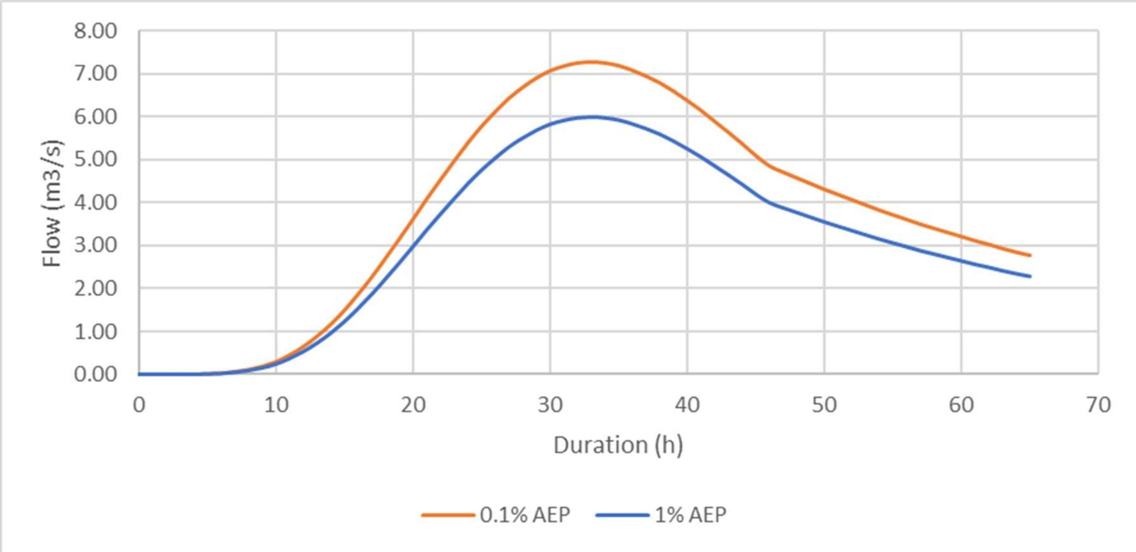
Table 6-3 Peak Flow at HEP 1

Location	QMED Estimation Method	Flow Event	Peak Flowrate (m^3/s)
HEP 1	FSU Web Portal - Donor Adjustment	Q_{MED}	**3.04**
		1% AEP	**6.01**
		0.1% AEP	**7.29**

6.2.3 Design Flow Hydrographs

Design hydrographs for 1% AEP and 0.1% AEP have been developed for HEP 1 using the FSU Web portal, refer to Figure 6-3 below.

Figure 6-3 HEP 1 Hydrographs

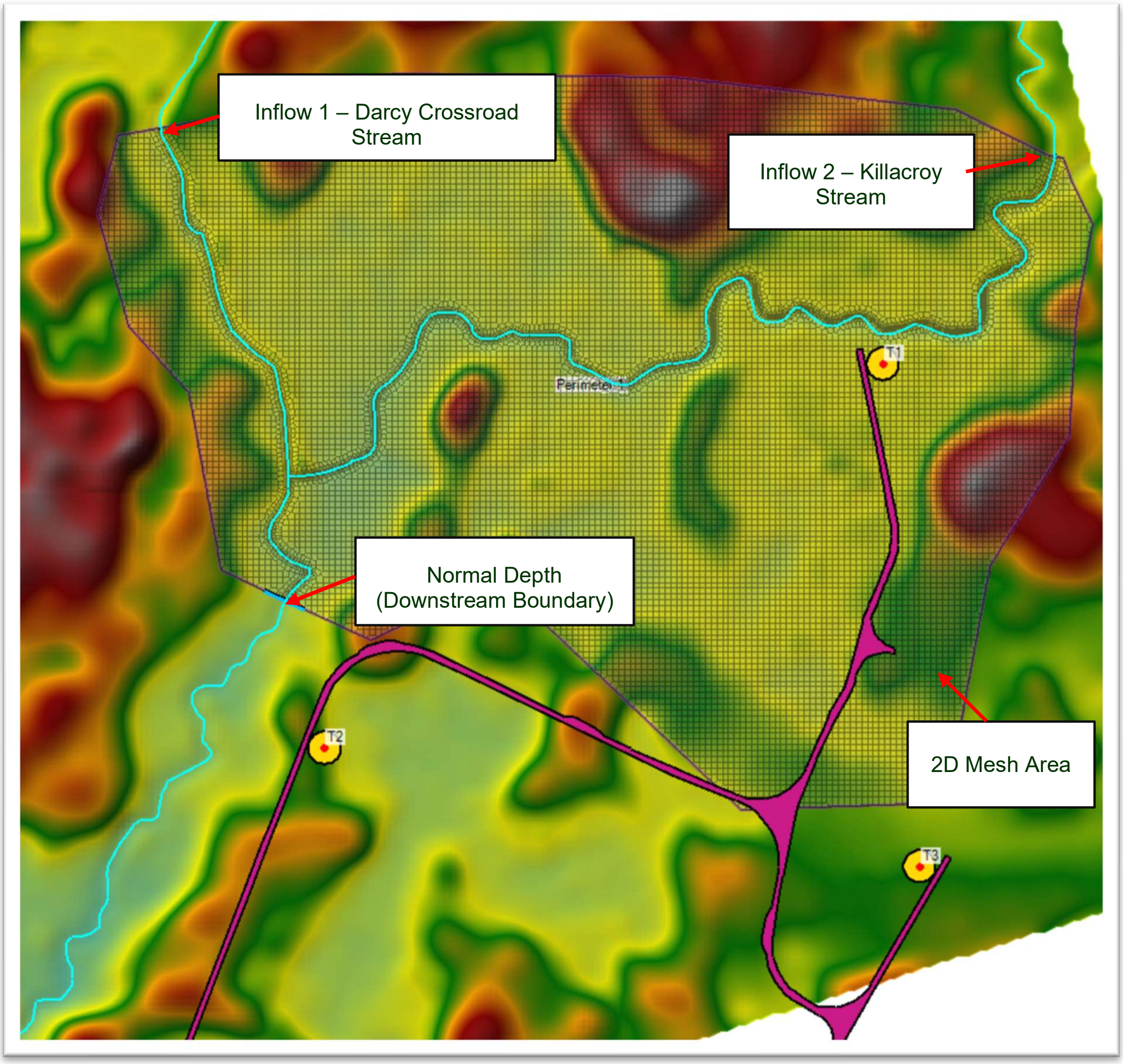


6.3 Modelling Approach

The hydraulic modelling has been undertaken here using HEC-RAS v6.2 as a full 2D model. The key hydraulic features incorporated into the hydraulic models are presented on Figure 6-4 and they include:

- The Darcy Crossroad Stream; and
- The Killacroy Stream.

Figure 6-4 Hydraulic Model Schematic



The key modelling parameters adopted in the modelling were as follows:

- 2D mesh: 5.0 m nominally square mesh across the whole area;
- Refinement Region: 1.0 m along the streams;
- Tailwater characteristics: a Normal Depth relationship was adopted for the downstream boundary, reflecting the generally uniform flow conditions, based on the DTM data, slope of 0.005 (i.e. 5 in 1000) has been applied. Normal depth is the depth of flow in a channel when the slope of the water surface and channel bottom is the same and the water depth remains constant;
- Surface roughness values:

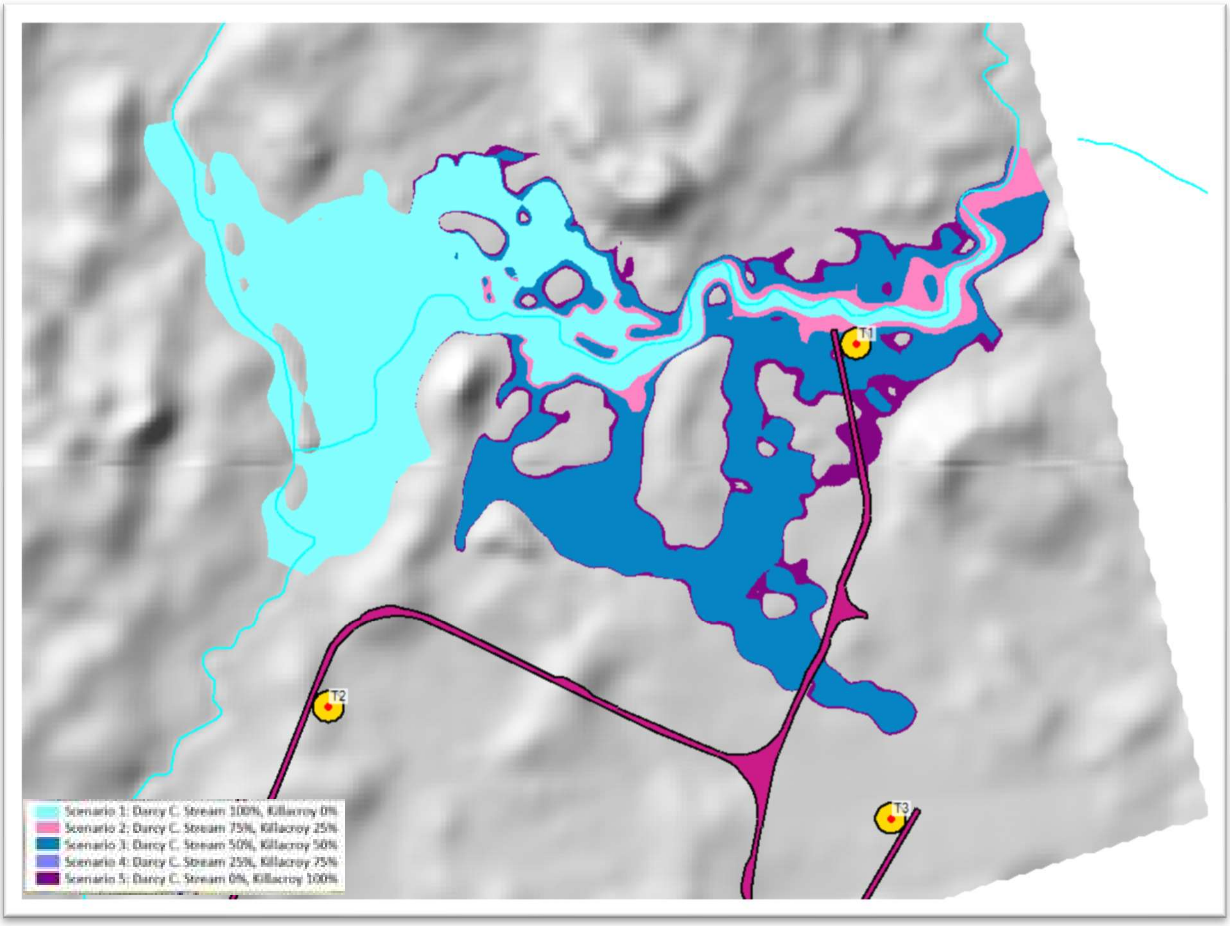
  A mannings coefficient of 0.045 for channel roughness was adopted as a uniform value across the 2D area. The coefficient is principally reflective of the overgrown nature of the watercourses and provided a conservative position in respect of any flows across overbank areas. With higher surface roughness, higher flood levels are expected;
- Timestep: Adaptive Timestep Adopted.

6.4 Critical Scenario

Figure 6-5 shows the flood extend for each modelled flood scenario for the 0.1% AEP event. The following can be observed:

- For Scenario 2 there is a minor overtopping at the Killacroy Stream;
- For Scenarios 3, 4 and 5 the flooding significantly enters the site;
- There is a slight difference in the flood extent between Scenario 4 and Scenario 5;
- Scenario 5 shows the widest flood extent. However, this scenario is not realistic since it is very unlikely there would be no flows in the Darcy Crossroad Stream; and
- There is a significant difference in the flood extent between Scenario 3 and Scenario 4.

Figure 6-5 Flood Extent 0.1% AEP – Modelled Flood Scenarios 1 to 5



Scenario 4 has been determined to be the 'critical scenario' because this scenario would cause the widest flood extent and flood levels for the 0.1% AEP event. In this scenario it is assumed that 25% of the total flow runs through the Darcy Crossroad Stream, while the remaining 75% flows through the Killacroy Stream.

Flood Zone A and Flood Zone B have been delineated based on the Scenario 4 in Section 6.5 below and are used in this SSFRA.

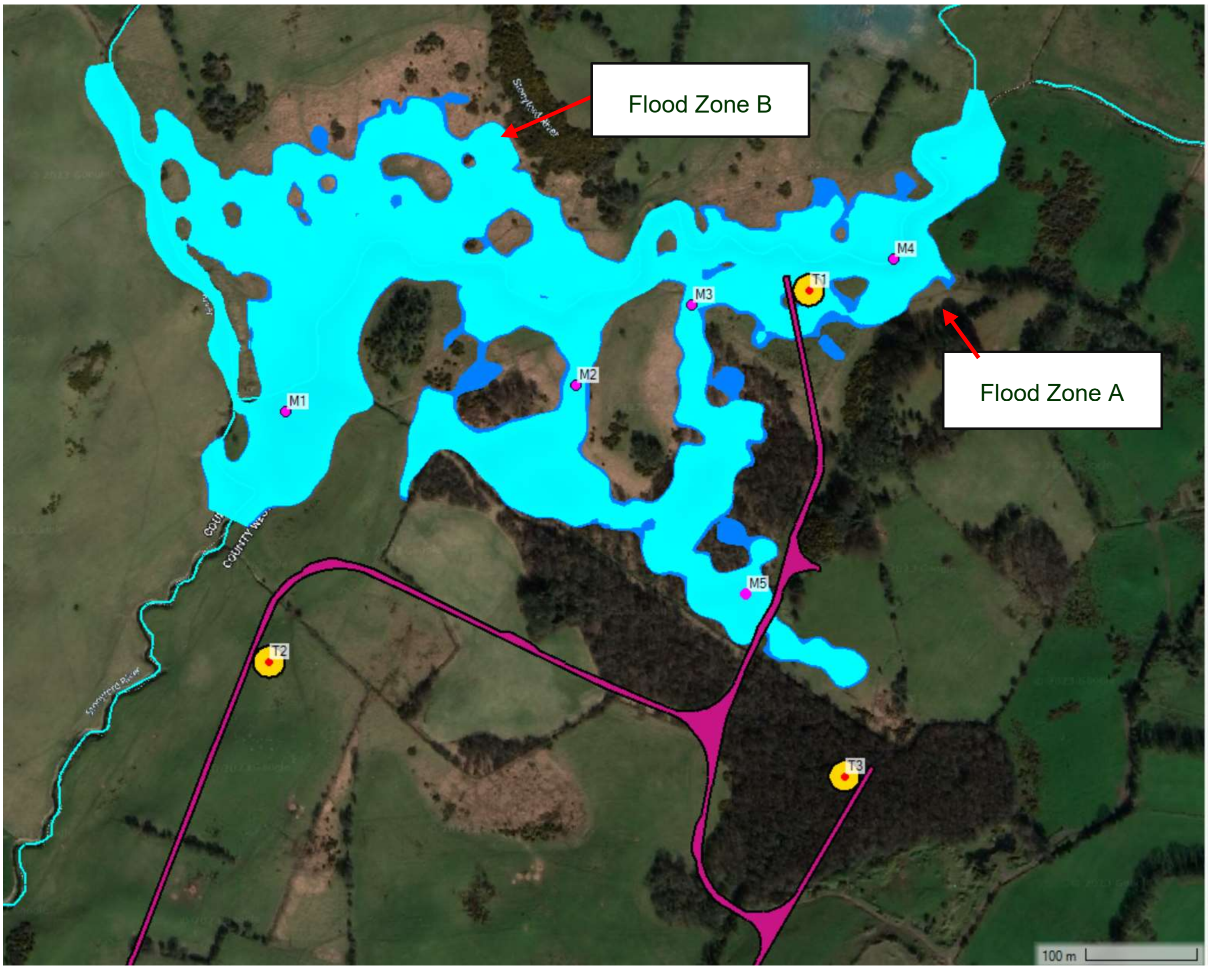
6.5 Detailed Flood Modelling Results – Scenario 4 'Critical Scenario'

The modelled extents of flooding that could occur during the 1% AEP and 0.1% AEP flood events for flow Scenario 4, the 'critical scenario' are shown in the Figure 6-6.

The flood levels at the site for both flood events are discussed in Section 6.6.

Modelled flood details including water level, water depth and maximum velocity at various points (M1-M5) across the site, see Figure 6-6, are shown in Table 6-5 below.

Figure 6-6 Flood Zone A and B Extents - 1% AEP and 0.1% AEP Events



The above flood extents map shows there is a slight difference in the flood extent between Flood Zone A and Flood Zone B. Water leaves the Killacroy Stream, which runs along the northern boundary and starts flowing towards the low lying area following site topography, this is marked with yellow arrows on the figure above.

The list of modelled events including sensitivity analysis are shown in Table 6-4. We are not aware of any useful historical flood event data at the site, such as surveyed flood marks, which would allow the model to be calibrated or verified. On that basis, a number of model runs were carried out at the 0.1% AEP level to test the sensitivity of the modelled flood levels in relation to the key parameters adopted in the model.

The key parameters are detailed below, and the outcomes of the sensitivity runs, are noted below in Table 6-5.

Table 6-4 Modelled Events

Model ID	Modelled Hydraulic Events
1-1	1 in 100 years flood event (1% AEP)
1-2	1 in 1000 years flood event (0.1% AEP)
1-3	1 in 100 years flood event with climate change allowance 20% (1% AEP + CC)
1-4	1 in 1000 years flood event with climate change allowance 20% (0.1% AEP + CC)
Model ID	**Sensitivity**
1-5	1 in 1000 years flood event, Tailwater reduced by 20%
1-6	1 in 1000 years flood event, Roughness increased by 20%
1-7	1 in 1000 years flood event, Calculation method Shallow Water Equation
1-8	1 in 1000 years flood event, Flow increased by 20%

The detailed results, in terms of flood levels, depths and velocities, are given at a range of locations across the study area. Table 6-5 provides flood levels for the critical scenario for modelled events listed in Table 6-4. The particular points referenced in the table are shown on Figure 6-6 above.

The following events have been analysed to test the sensitivity of model parameters and to assess the residual risk at the site:

- Normal depth defined at the downstream boundary condition has been reduced from 0.005 to 0.004. Lower slope of normal depth causes higher flood levels in the model;
- Manning's coefficient has been increased by 20%. Increased roughness causes higher water levels in the model; and
- Using the full momentum equations for calculating water levels, rather than the diffusion wave equations. The former set can be more accurate but increase run times. It is reasonably standard to use the diffusion equation set, but a check was made as to the difference it might make in resulting water levels in the model.

Table 6-5 Modelling Outcomes

Point		M1	M2	M3	M4	M5
Ground Level (mOD)		86.83	87.74	88.02	87.75	87.60
BASE MODEL RUNS						
1% AEP	Water Level (mOD)	87.56	87.79	88.07	88.16	88.02
	Water Depth (m)	0.73	0.05	0.05	0.41	0.42
	Maximum Velocity (m/s)	0.14	0.07	0.17	0.26	0.01
0.1% AEP	Water Level (mOD)	87.61	87.84	88.11	88.20	88.05
	Water Depth (m)	0.78	0.10	0.09	0.45	0.45
	Increment over 1:100 (m)	0.05	0.05	0.04	0.04	0.03
	Maximum Velocity (m/s)	0.16	0.13	0.21	0.28	0.01
1% AEP + 20% CC	Water Level (mOD)	87.61	87.84	88.10	88.20	88.05
	Water Depth (m)	0.78	0.10	0.08	0.45	0.45
	Increment over 1:100 (m)	0.05	0.05	0.03	0.04	0.03
0.1% AEP + 20% CC	Water Level (mOD)	87.65	87.87	88.13	88.24	88.07
	Water Depth (m)	0.82	0.13	0.11	0.49	0.47
	Increment over 1:1000 (m)	0.04	0.03	0.02	0.04	0.02
	Increment over 1:100 +CC (m)	0.04	0.03	0.03	0.04	0.02
SENSITIVITY RUNS						
0.1% AEP Flatter Tailwate	Water Level (mOD)	87.62	87.84	88.11	88.20	88.05
	Water Depth (m)	0.79	0.10	0.09	0.45	0.45
	Increment over 1:1000 (m)	0.01	0.00	0.00	0.00	0.00
0.1% AEP High Roughness	Water Level (mOD)	87.65	87.87	88.13	88.24	88.07
	Water Depth (m)	0.82	0.13	0.11	0.49	0.47
	Increment over 1:1000 (m)	0.04	0.03	0.02	0.04	0.02
0.1% AEP Calculation Met	Water Level (mOD)	87.63	87.86	88.12	88.22	88.07
	Water Depth (m)	0.80	0.12	0.10	0.47	0.47
	Increment over 1:1000 (m)	0.02	0.02	0.01	0.02	0.02
0.1% AEP Inflow +20%	Water Level (mOD)	87.65	87.87	88.13	88.24	88.07
	Water Depth (m)	0.82	0.13	0.11	0.49	0.47

The key points noted from these results are as follows:

- The 0.1% AEP event results in flood levels within the site some 50 mm higher than the 1% AEP event; and
- Higher roughness coefficient increased the flood levels across the site up to 40 mm.

Table 6-6 Critical Scenario – Sensitivity Analysis Outcomes

Parameter	Details	Outcomes
Flatter Tailwater	Normal depth at culvert C2 reduced by 20%.	Increased flood levels around Location 1 for 10 mm. No impact on the remaining area.
Surface roughness of 2D mesh area	Global increase of 20%	Increased flood levels between 20 mm and 40 mm within the site.
Calculation method	Use of full momentum equation set	Some 20 mm difference in flood levels with the site.

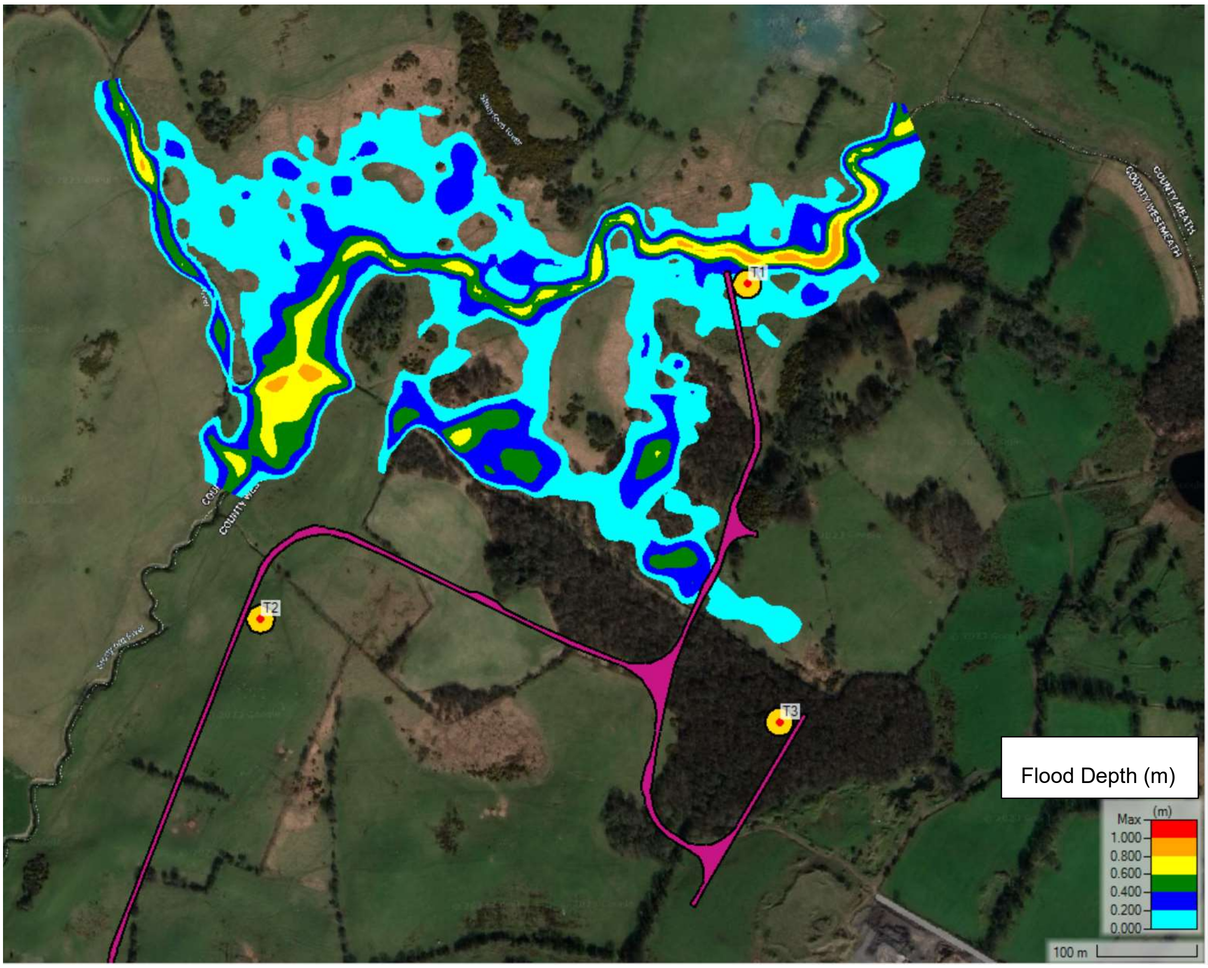
The sensitivity analysis shows that the flood levels are not in a high correlation with model's parameters. Changing the value of the adopted parameters did not have a significant impact on the results.

6.6 Design Flood Level and Freeboard

The flood depth map shows water depth within the site being mostly up to 0.20 m for 0.1% AEP MRFS event. There is one localised low point where flood depth is up to 0.75 m (orange colour).

Flood depth is 0.14 m at the location of proposed turbine T1 for the 0.1% AEP MRFS event, see point 'T1' on Figure 6-7 below.

Figure 6-7 Flood Depth within the Site - 0.1% AEP MRFS Event



7.0 Conclusion

This SSFRA has been prepared to identify, quantify and communicate to decision makers and other stakeholders the risk of flooding associated with the proposed development.

This report has been prepared in the accordance with The Planning System and Flood Risk Management Guidelines.

The following conclusions are made from this SSFRA study:

- **i.** The only source of fluvial flooding maps come from the NIFM maps which show the northern part of the site being within Flood Zone A and Flood Zone B. The NIFM maps are not detailed enough to assist in assessing the flood risk.
- **ii.** A hydraulic model has been developed as part of this assessment to adequately determine the flood zones and flood depths within the site. The results show that only turbine T1 and the access road leading to it is within Flood Zone A.
- **iii.** Flood depth is 0.14 m at the location of proposed turbine T1 for the 1% AEP MRFS. The flood level for the 1% AEP MRFS at the location of T1 is 88.24 mOD.
- **iv.** The modelled extents of flooding that could occur are concentrated around the area of turbine T1.
- **v.** The maximum flood depth along the access road leading to turbine T1 is 0.18 m. This means that the turbine T1 can be accessed even during the flood event.
- **vi.** The remaining site infrastructure, which included the on-site substation, is within Flood Zone C.
- **vii.** The risk of the pluvial and groundwater flooding is considered to be low.

A recent An Bord Pleanála judgement (case: PL09.306500) has indicated that turbines and access roads are considered to be water compatible development, making them suitable for locating within Flood Zone A or Flood Zone B.

While it may be possible to place a wind turbine within a flood zone, the base of the turbine will be elevated above the 1% AEP MRFS which accounts for predicted climate change out to 2100 and also to allow at least 300 mm freeboard from the highest modelled flood level.

8.0 Closure

This report has been prepared by SLR Environmental Consulting (Ireland) Ltd. with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

Appendix A FSU Web Portal Output

Knockanarragh Wind Farm

SLR Project No.: 501.V00727.00008

25 January 2024

Flood Estimation Report #13920 (Knockannaragh WF)

Generated 20-09-2022 14:38

Subject site

Attributes

Name	Unit	Value
Coordinate [X]		-785313.382377106
Coordinate [Y]		7105054.49633723
Distance	km	624.870636407973
Station Number		07_1407_2
Location		
Water Body		
Catchment		
Hydrometric Area		
Organisation		
FSU Rating Classification		
Drainage works	year	
Contributing Catchment Area	km^2	15.32
Center Northing	m	270790
Center Easting	m	260910
Northing	m	267625
Easting	m	262558
A-Max series gap in years	year	
A-Max series number of years	year	
A-Max series number of usable years	year	
A-Max series end year	year	
A-Max series start year	year	
FARL		0.984
ALLUV		0.0176
PEAT		0
FOREST		0.0092
PASTURE		1
S1085	m/km	6.91025
MSL	km	8.191
DRAIND	km/km^2	0.767
ALTBAR		122.7
NETLEN	km	11.745
T4		
T3		

SAAPE	mm	494.83
T2		
ARTDRAIN2		0.8063
ARTDRAIN		0.1243
TAYSLO		1.753735
STMFRQ		7
BFISOIL		0.715806162
SAAR	mm	999.98
RWSEG_CD		07_1407
TOP_RWSEG		
Bankfull		
HGF	m^3/s	
MAF	m^3/s	
FAI		0.1135
FLATWET		0.63
URBEXT		0
HGF/QMED		
centroidx3857		-787638.016506133
centroidy3857		7111075.67506121
x3857		-785313.382377106
y3857		7105054.49633723

Pivotal site

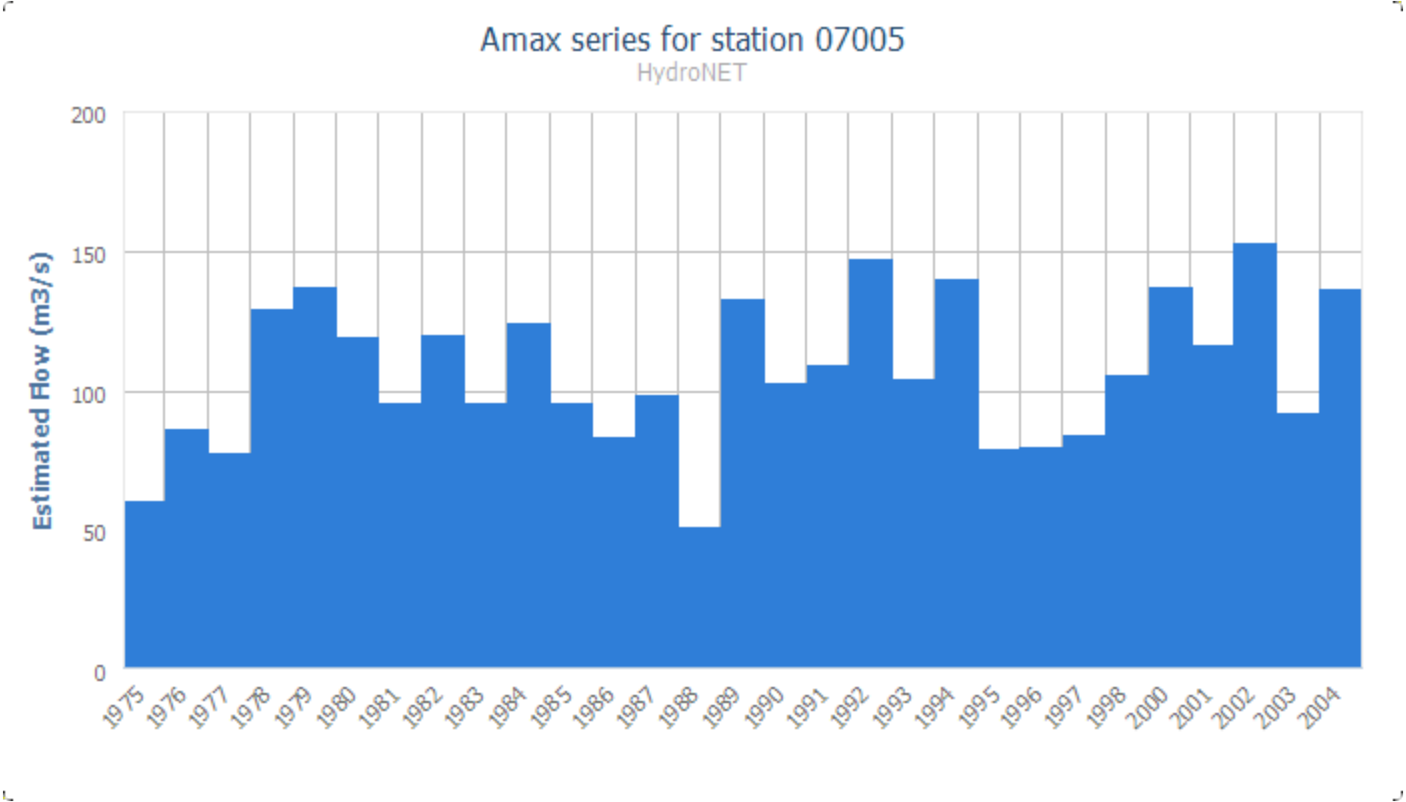
Attributes

Name	Unit	Value
Coordinate [X]		-756064.134938129
Coordinate [Y]		7086588.55154521
Station Number		07005
Location		TRIM
Water Body		BOYNE
Catchment		Boyne
Hydrometric Area		7
Organisation		OPW
FSU Rating Classification		A1
Drainage works	year	1971-74
Contributing Catchment Area	km^2	1332.1663
Center Northing	m	253853
Center Easting	m	263021
Northing	m	256934
Easting	m	280116
A-Max series gap in years	year	0
A-Max series number of years	year	30
A-Max series number of usable years	year	29
A-Max series end year	year	2004
A-Max series start year	year	1975
FARL		0.983
ALLUV		0.0353
PEAT		0.0872
FOREST		0.0491
PASTURE		0
S1085	m/km	0.48133
MSL	km	62.536
DRAIND	km/km^2	0.819
ALTBAR		0
NETLEN	km	1090.402
T4		0.057685729178871
T3		-0.00774648570109
SAAPE	mm	503.47
T2		0.14269351730061
ARTDRAIN2		0.7615
ARTDRAIN		0.2987
TAYSLO		0.164232
STMFRQ		908
BFISOIL		0.7206
SAAR	mm	879.71
RWSEG_CD		07_1887
TOP_RWSEG		07_1856
Bankfull		N/A
HGF	m^3/s	128
MAF	m^3/s	92
FAI		0.22
FLATWET		0.61
URBEXT		0.0069
HGF/QMED		1.2258188086573
x3857		-756064.134938129
y3857		7086588.55154521

centroidx3857		-784986.590379431
centroidy3857		7075863.1357105
Distance	km	35.312221510844

Map

Amax Series Chart



QMED Estimates

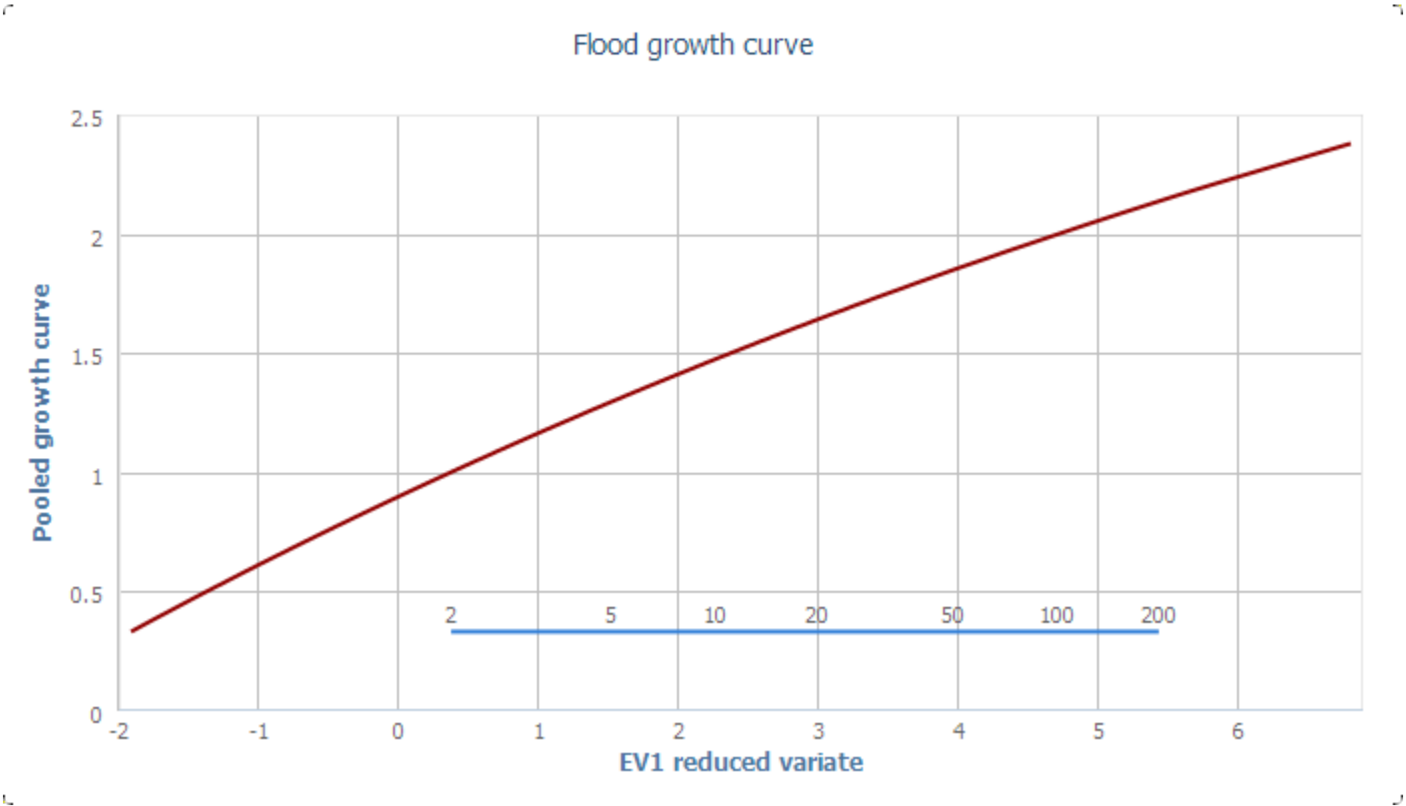
Subject rural QMED	2.88
Subject urban QMED	2.88
Pivotal gauged QMED	104.42
Pivotal adjustment factor QMED	1.05
Subject adjusted QMED	**3.04**

Pooling Group

Station	**Amax years**
25034 ROCHFORT	26
25040 ROSCREA	19
16051 CLOBANNA	13
30020 BALLYHAUNIS	16
26058 BALLINRINK BR.	24
13002 FOULKS MILL	19
22009 WHITE BRIDGE	24
10022 CARRICKMINES	17
06031 CURRALHIR	18
10021 COMMONS ROAD	24

09035 KILLEEN ROAD	9
19046 STATION ROAD	9
26022 KILMORE	33
24022 HOSPITAL	20
19020 BALLYEDMOND	28
14009 CUSHINA	25
26018 BELLAVAHAN	48
16006 BALLINACLOGH	33
25027 GOURDEEN BRIDGE	42
25023 MILLTOWN	33
08002 NAUL	21

Selected Flood Growth Curve



Pooled growth curve	EV1 reduced variate
0.33	-1.92
0.38	-1.75
0.41	-1.66
0.43	-1.6
0.45	-1.55
0.46	-1.5
0.47	-1.47
0.48	-1.43
0.49	-1.4
0.5	-1.38
0.51	-1.35
0.52	-1.33
0.52	-1.3
0.53	-1.28
0.53	-1.26
0.54	-1.24
0.55	-1.23
0.55	-1.21
0.56	-1.19
0.56	-1.18
0.57	-1.16
0.57	-1.15
0.57	-1.13
0.58	-1.12
0.58	-1.1
0.59	-1.09
0.59	-1.08
0.59	-1.06
0.6	-1.05

0.6	-1.04
0.61	-1.03
0.61	-1.02
0.61	-1.01
0.62	-0.99
0.62	-0.98
0.62	-0.97
0.63	-0.96
0.63	-0.95
0.63	-0.94
0.63	-0.93
0.64	-0.92
0.64	-0.91
0.64	-0.9
0.65	-0.89
0.65	-0.88
0.65	-0.87
0.65	-0.87
0.66	-0.86
0.66	-0.85
0.66	-0.84
0.66	-0.83
0.67	-0.82
0.67	-0.81
0.67	-0.8
0.67	-0.8
0.68	-0.79
0.68	-0.78
0.68	-0.77
0.68	-0.76
0.69	-0.76
0.69	-0.75
0.69	-0.74
0.69	-0.73
0.69	-0.73
0.7	-0.72
0.7	-0.71
0.7	-0.7
0.7	-0.7
0.71	-0.69
0.71	-0.68
0.71	-0.67
0.71	-0.67
0.71	-0.66
0.72	-0.65
0.72	-0.64
0.72	-0.64
0.72	-0.63
0.72	-0.62
0.73	-0.62
0.73	-0.61
0.73	-0.6
0.73	-0.6
0.73	-0.59
0.74	-0.58
0.74	-0.58
0.74	-0.57

0.74	-0.56
0.74	-0.56
0.75	-0.55
0.75	-0.54
0.75	-0.54
0.75	-0.53
0.75	-0.52
0.75	-0.52
0.76	-0.51
0.76	-0.51
0.76	-0.5
0.76	-0.49
0.76	-0.49
0.77	-0.48
0.77	-0.47
0.77	-0.47
0.77	-0.46
0.77	-0.46
0.77	-0.45
0.78	-0.44
0.78	-0.44
0.78	-0.43
0.78	-0.42
0.78	-0.42
0.78	-0.41
0.79	-0.41
0.79	-0.4
0.79	-0.4
0.79	-0.39
0.79	-0.38
0.79	-0.38
0.8	-0.37
0.8	-0.37
0.8	-0.36
0.8	-0.35
0.8	-0.35
0.8	-0.34
0.81	-0.34
0.81	-0.33
0.81	-0.33
0.81	-0.32
0.81	-0.31
0.81	-0.31
0.82	-0.3
0.82	-0.3
0.82	-0.29
0.82	-0.29
0.82	-0.28
0.82	-0.27
0.83	-0.27
0.83	-0.26
0.83	-0.26
0.83	-0.25
0.83	-0.25
0.83	-0.24
0.83	-0.23
0.84	-0.23

0.84	-0.22
0.84	-0.22
0.84	-0.21
0.84	-0.21
0.84	-0.2
0.85	-0.2
0.85	-0.19
0.85	-0.18
0.85	-0.18
0.85	-0.17
0.85	-0.17
0.86	-0.16
0.86	-0.16
0.86	-0.15
0.86	-0.15
0.86	-0.14
0.86	-0.13
0.86	-0.13
0.87	-0.12
0.87	-0.12
0.87	-0.11
0.87	-0.11
0.87	-0.1
0.87	-0.1
0.87	-0.09
0.88	-0.09
0.88	-0.08
0.88	-0.07
0.88	-0.07
0.88	-0.06
0.88	-0.06
0.89	-0.05
0.89	-0.05
0.89	-0.04
0.89	-0.04
0.89	-0.03
0.89	-0.03
0.89	-0.02
0.9	-0.02
0.9	-0.01
0.9	0
0.9	0
0.9	0.01
0.9	0.01
0.9	0.02
0.91	0.02
0.91	0.03
0.91	0.03
0.91	0.04
0.91	0.04
0.91	0.05
0.92	0.06
0.92	0.06
0.92	0.07
0.92	0.07
0.92	0.08
0.92	0.08

0.92	0.09
0.93	0.09
0.93	0.1
0.93	0.1
0.93	0.11
0.93	0.12
0.93	0.12
0.93	0.13
0.94	0.13
0.94	0.14
0.94	0.14
0.94	0.15
0.94	0.15
0.94	0.16
0.95	0.16
0.95	0.17
0.95	0.18
0.95	0.18
0.95	0.19
0.95	0.19
0.95	0.2
0.96	0.2
0.96	0.21
0.96	0.21
0.96	0.22
0.96	0.23
0.96	0.23
0.96	0.24
0.97	0.24
0.97	0.25
0.97	0.25
0.97	0.26
0.97	0.26
0.97	0.27
0.98	0.28
0.98	0.28
0.98	0.29
0.98	0.29
0.98	0.3
0.98	0.3
0.98	0.31
0.99	0.32
0.99	0.32
0.99	0.33
0.99	0.33
0.99	0.34
0.99	0.34
1	0.35
1	0.36
1	0.36
1	0.37
1	0.37
1	0.38
1	0.38
1.01	0.39
1.01	0.4
1.01	0.4

1.01	0.41
1.01	0.41
1.01	0.42
1.02	0.42
1.02	0.43
1.02	0.44
1.02	0.44
1.02	0.45
1.02	0.45
1.03	0.46
1.03	0.47
1.03	0.47
1.03	0.48
1.03	0.48
1.03	0.49
1.03	0.5
1.04	0.5
1.04	0.51
1.04	0.51
1.04	0.52
1.04	0.53
1.04	0.53
1.05	0.54
1.05	0.54
1.05	0.55
1.05	0.56
1.05	0.56
1.05	0.57
1.06	0.58
1.06	0.58
1.06	0.59
1.06	0.59
1.06	0.6
1.06	0.61
1.07	0.61
1.07	0.62
1.07	0.63
1.07	0.63
1.07	0.64
1.07	0.65
1.08	0.65
1.08	0.66
1.08	0.66
1.08	0.67
1.08	0.68
1.08	0.68
1.09	0.69
1.09	0.7
1.09	0.7
1.09	0.71
1.09	0.72
1.09	0.72
1.1	0.73
1.1	0.74
1.1	0.74
1.1	0.75
1.1	0.76

1.11	0.76
1.11	0.77
1.11	0.78
1.11	0.78
1.11	0.79
1.11	0.8
1.12	0.81
1.12	0.81
1.12	0.82
1.12	0.83
1.12	0.83
1.13	0.84
1.13	0.85
1.13	0.86
1.13	0.86
1.13	0.87
1.13	0.88
1.14	0.88
1.14	0.89
1.14	0.9
1.14	0.91
1.14	0.91
1.15	0.92
1.15	0.93
1.15	0.94
1.15	0.94
1.15	0.95
1.16	0.96
1.16	0.97
1.16	0.97
1.16	0.98
1.16	0.99
1.17	1
1.17	1.01
1.17	1.01
1.17	1.02
1.17	1.03
1.18	1.04
1.18	1.05
1.18	1.05
1.18	1.06
1.18	1.07
1.19	1.08
1.19	1.09
1.19	1.09
1.19	1.1
1.19	1.11
1.2	1.12
1.2	1.13
1.2	1.14
1.2	1.15
1.21	1.15
1.21	1.16
1.21	1.17
1.21	1.18
1.21	1.19
1.22	1.2

1.22	1.21
1.22	1.22
1.22	1.22
1.23	1.23
1.23	1.24
1.23	1.25
1.23	1.26
1.24	1.27
1.24	1.28
1.24	1.29
1.24	1.3
1.24	1.31
1.25	1.32
1.25	1.33
1.25	1.34
1.25	1.35
1.26	1.36
1.26	1.37
1.26	1.38
1.26	1.39
1.27	1.4
1.27	1.41
1.27	1.42
1.28	1.43
1.28	1.44
1.28	1.45
1.28	1.46
1.29	1.47
1.29	1.49
1.29	1.5
1.29	1.51
1.3	1.52
1.3	1.53
1.3	1.54
1.31	1.55
1.31	1.56
1.31	1.58
1.31	1.59
1.32	1.6
1.32	1.61
1.32	1.63
1.33	1.64
1.33	1.65
1.33	1.66
1.34	1.68
1.34	1.69
1.34	1.7
1.34	1.71
1.35	1.73
1.35	1.74
1.35	1.76
1.36	1.77
1.36	1.78
1.36	1.8
1.37	1.81
1.37	1.83
1.38	1.84

1.38	1.86
1.38	1.87
1.39	1.89
1.39	1.9
1.39	1.92
1.4	1.93
1.4	1.95
1.41	1.96
1.41	1.98
1.41	2
1.42	2.01
1.42	2.03
1.43	2.05
1.43	2.07
1.43	2.09
1.44	2.1
1.44	2.12
1.45	2.14
1.45	2.16
1.46	2.18
1.46	2.2
1.47	2.22
1.47	2.24
1.48	2.26
1.48	2.28
1.49	2.31
1.49	2.33
1.5	2.35
1.5	2.37
1.51	2.4
1.51	2.42
1.52	2.45
1.52	2.47
1.53	2.5
1.54	2.52
1.54	2.55
1.55	2.58
1.56	2.61
1.56	2.64
1.57	2.67
1.58	2.7
1.58	2.73
1.59	2.77
1.6	2.8
1.61	2.84
1.62	2.87
1.62	2.91
1.63	2.95
1.64	2.99
1.65	3.03
1.66	3.08
1.67	3.12
1.68	3.17
1.69	3.22
1.7	3.28
1.72	3.33
1.73	3.39

1.74	3.46
1.76	3.52
1.77	3.6
1.79	3.67
1.81	3.76
1.83	3.85
1.85	3.95
1.87	4.06
1.9	4.19
1.92	4.33
1.96	4.5
2	4.69
2.05	4.94
2.11	5.27
2.2	5.77
2.38	6.8

Adopted Growth Factors

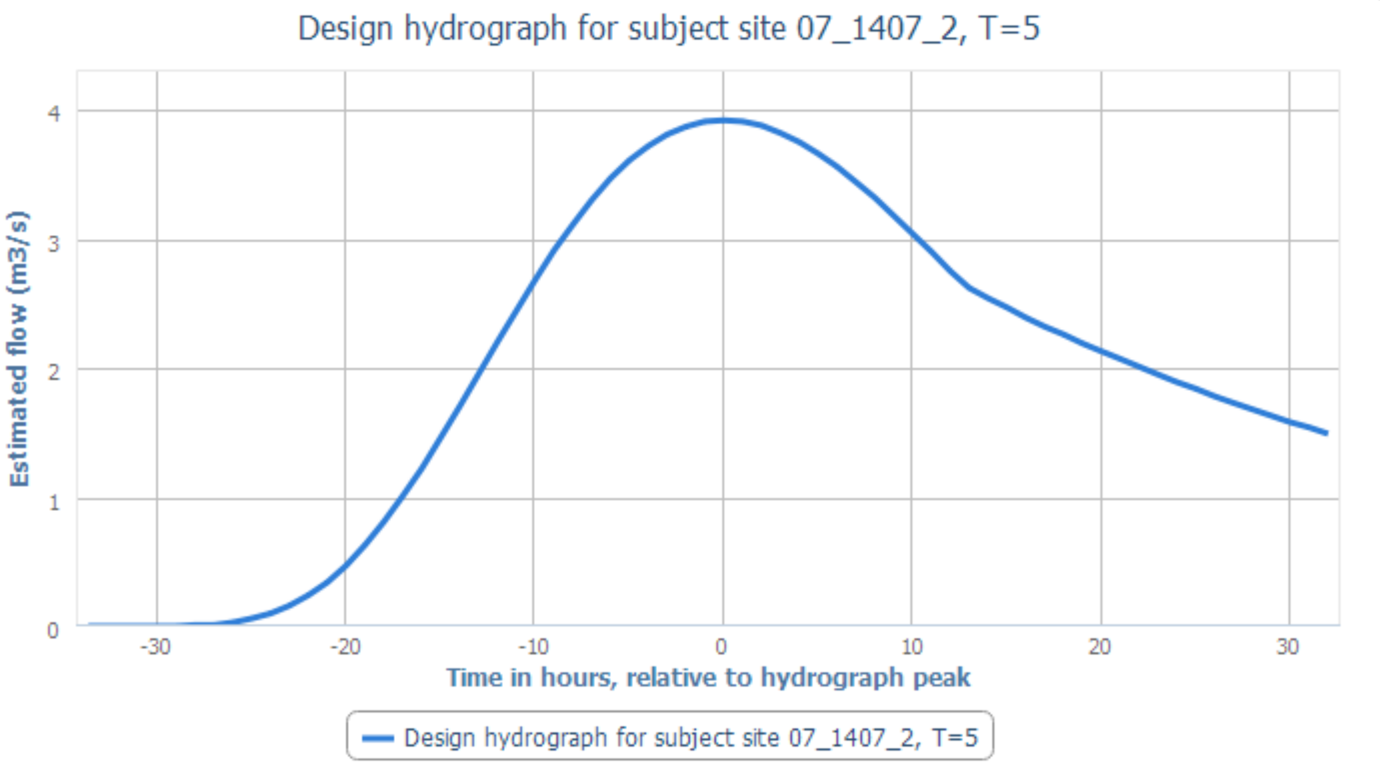
Return Period	Growth Factor	Design Peak Flow (m^3/s)
1.3	0.79	2.4
2	1	3.04
5	1.29	3.92
10	1.47	4.46
20	1.64	4.98
30	1.73	5.25
50	1.84	5.59
100	1.98	6.01
200	2.11	6.41
500	2.28	6.92
1000	2.4	7.29

Hydrograph Width Estimation Summary

Name	Value
Pivotal site	25022 "SYNGEFIELD"
Adjustment type	The user adopted the original PCD hydrograph
Transfer type	The user adjusted the subject site estimate with the pivotal site deformation factor
Deformation factor	1
Custom deformation factor	1
Accepted n	7.86250772651184
Accepted Tr	33.6490993999536
Accepted C	33.8791705060316

Hydrograph Plots

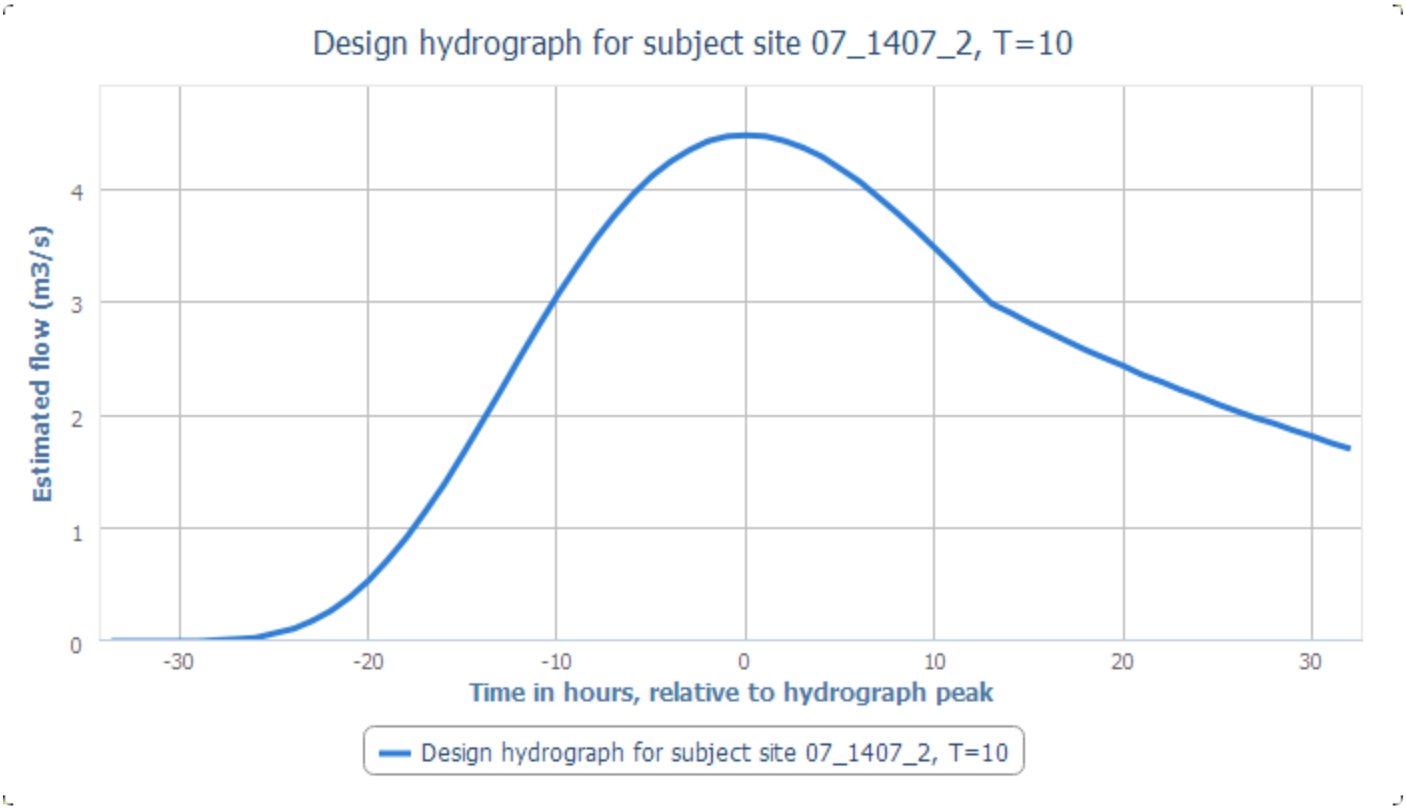
Return Period: 5



Hours relative to hydrograph peak	Estimated flow (m3/s)
-33.65	0
-33	0
-32	0
-31	0
-30	0
-29	0
-28	0.01
-27	0.01
-26	0.03
-25	0.06
-24	0.1
-23	0.16
-22	0.24
-21	0.34
-20	0.47
-19	0.63
-18	0.81
-17	1.01
-16	1.22
-15	1.46
-14	1.7
-13	1.95
-12	2.2
-11	2.44
-10	2.68
-9	2.91
-8	3.11
-7	3.3
-6	3.47

-5	3.61
-4	3.72
-3	3.81
-2	3.87
-1	3.91
0	3.92
1	3.91
2	3.88
3	3.82
4	3.75
5	3.66
6	3.56
7	3.44
8	3.32
9	3.18
10	3.04
11	2.9
12	2.75
13	2.62
14	2.54
15	2.47
16	2.39
17	2.32
18	2.26
19	2.19
20	2.13
21	2.07
22	2.01
23	1.95
24	1.89
25	1.84
26	1.78
27	1.73
28	1.68
29	1.63
30	1.58
31	1.54
32	1.49

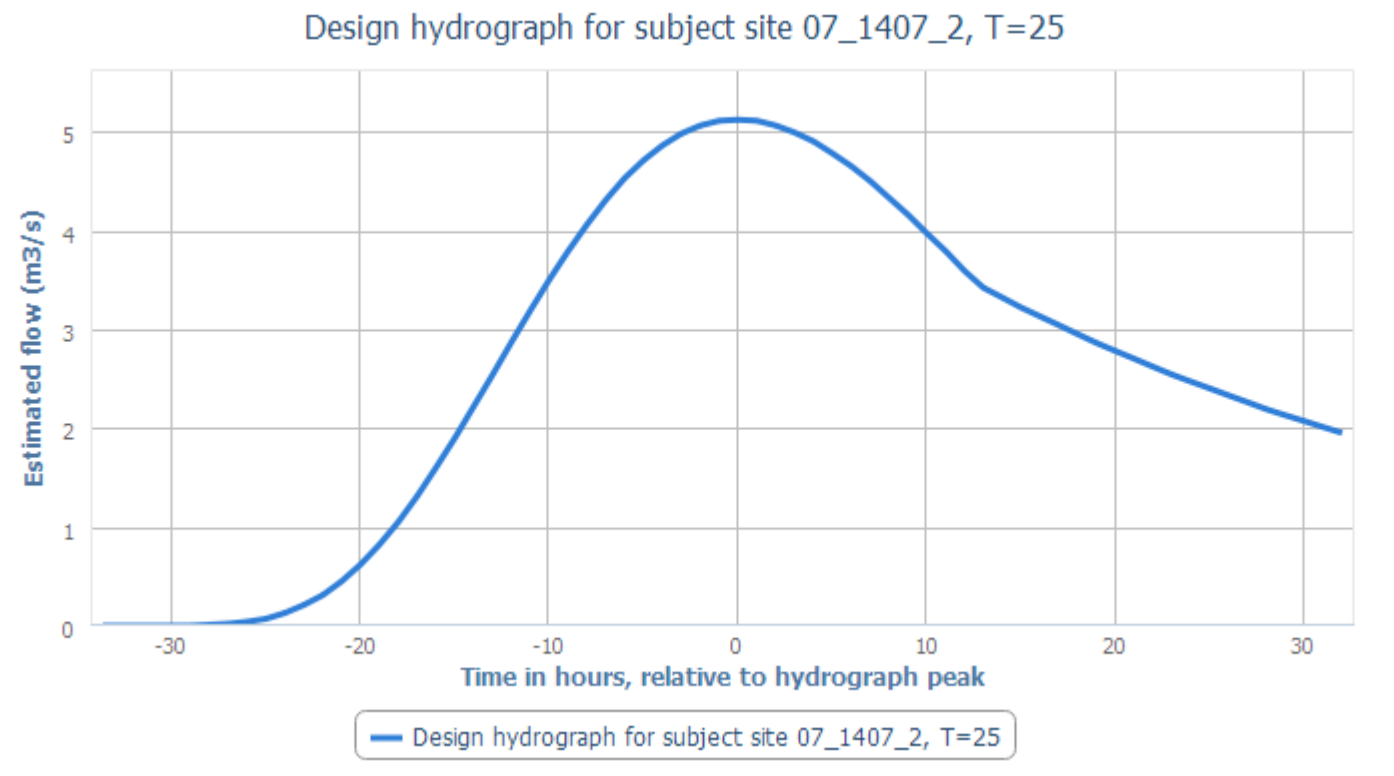
Return Period: 10



Hours relative to hydrograph peak	Estimated flow (m3/s)
-33.65	0
-33	0
-32	0
-31	0
-30	0
-29	0
-28	0.01
-27	0.02
-26	0.03
-25	0.07
-24	0.11
-23	0.18
-22	0.27
-21	0.39
-20	0.54
-19	0.72
-18	0.92
-17	1.15
-16	1.39
-15	1.66
-14	1.94
-13	2.22
-12	2.51
-11	2.79
-10	3.06
-9	3.31
-8	3.55
-7	3.76
-6	3.95
-5	4.11
-4	4.24

-3	4.34
-2	4.42
-1	4.46
0	4.47
1	4.46
2	4.42
3	4.36
4	4.28
5	4.17
6	4.06
7	3.92
8	3.78
9	3.63
10	3.47
11	3.31
12	3.14
13	2.98
14	2.9
15	2.81
16	2.73
17	2.65
18	2.57
19	2.5
20	2.43
21	2.35
22	2.29
23	2.22
24	2.16
25	2.09
26	2.03
27	1.97
28	1.92
29	1.86
30	1.81
31	1.75
32	1.7

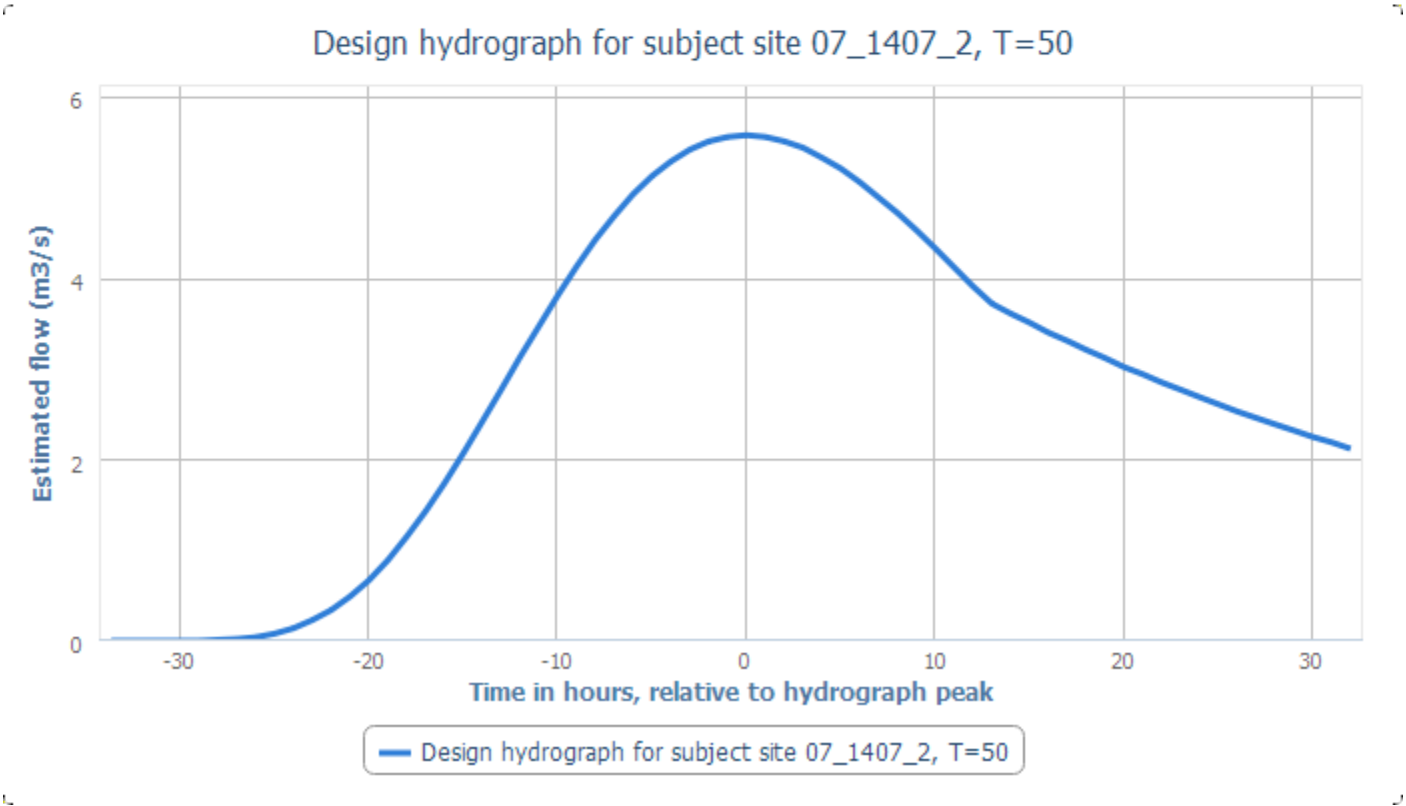
Return Period: 25



Hours relative to hydrograph peak	Estimated flow (m3/s)
-33.65	0
-33	0
-32	0
-31	0
-30	0
-29	0
-28	0.01
-27	0.02
-26	0.04
-25	0.07
-24	0.13
-23	0.21
-22	0.31
-21	0.45
-20	0.62
-19	0.82
-18	1.05
-17	1.31
-16	1.6
-15	1.9
-14	2.22
-13	2.54
-12	2.87
-11	3.19
-10	3.5
-9	3.79
-8	4.06
-7	4.31
-6	4.53
-5	4.71
-4	4.86

-3	4.98
-2	5.06
-1	5.11
0	5.12
1	5.11
2	5.06
3	4.99
4	4.9
5	4.78
6	4.65
7	4.5
8	4.33
9	4.16
10	3.97
11	3.79
12	3.59
13	3.42
14	3.32
15	3.22
16	3.13
17	3.04
18	2.95
19	2.86
20	2.78
21	2.7
22	2.62
23	2.54
24	2.47
25	2.4
26	2.33
27	2.26
28	2.19
29	2.13
30	2.07
31	2.01
32	1.95

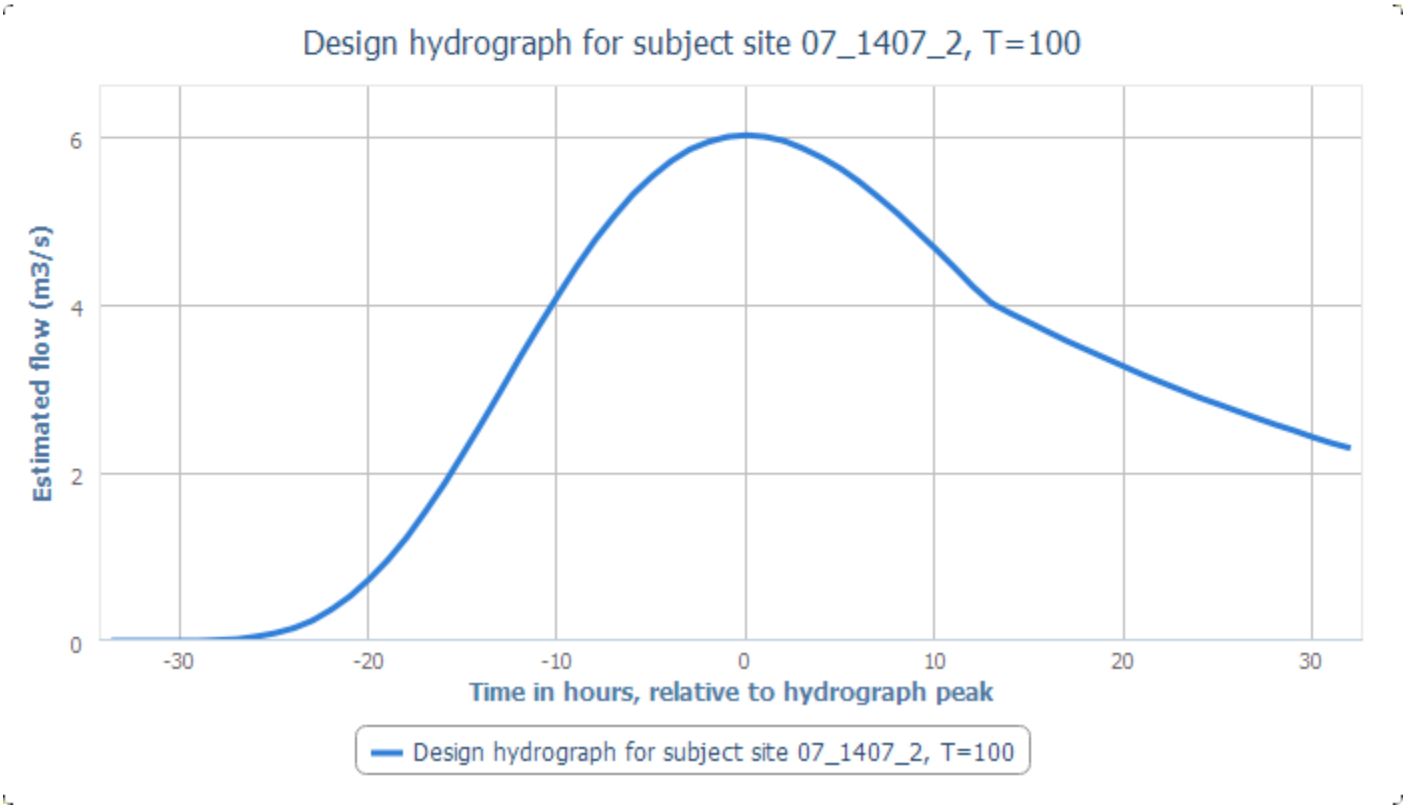
Return Period: 50



Hours relative to hydrograph peak	Estimated flow (m3/s)
-33.65	0
-33	0
-32	0
-31	0
-30	0
-29	0
-28	0.01
-27	0.02
-26	0.04
-25	0.08
-24	0.14
-23	0.23
-22	0.34
-21	0.49
-20	0.67
-19	0.89
-18	1.15
-17	1.43
-16	1.74
-15	2.07
-14	2.42
-13	2.77
-12	3.13
-11	3.47
-10	3.81
-9	4.13
-8	4.43
-7	4.69
-6	4.93
-5	5.13
-4	5.29

-3	5.42
-2	5.51
-1	5.56
0	5.58
1	5.56
2	5.51
3	5.44
4	5.33
5	5.21
6	5.06
7	4.89
8	4.72
9	4.53
10	4.33
11	4.12
12	3.91
13	3.72
14	3.61
15	3.51
16	3.4
17	3.31
18	3.21
19	3.12
20	3.02
21	2.94
22	2.85
23	2.77
24	2.69
25	2.61
26	2.53
27	2.46
28	2.39
29	2.32
30	2.25
31	2.19
32	2.12

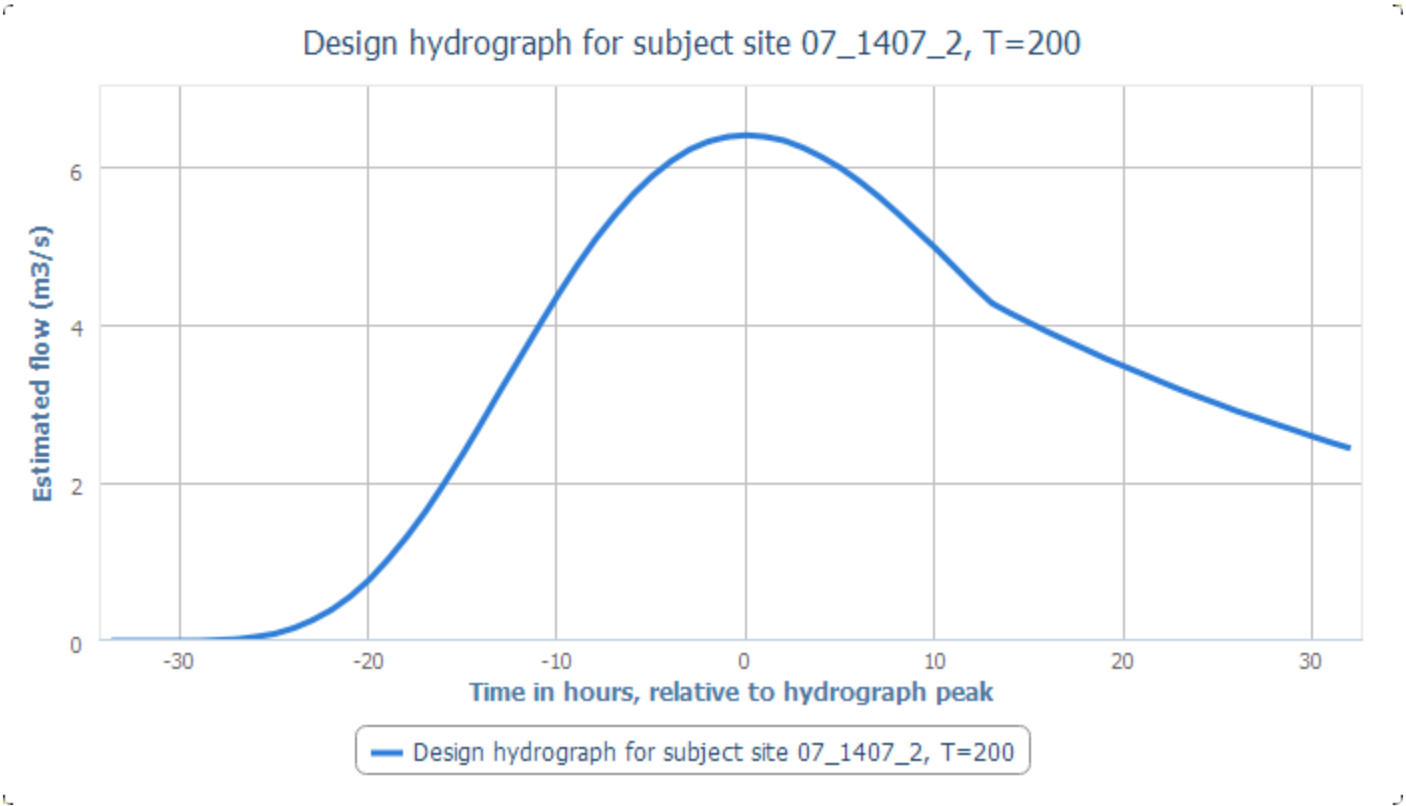
Return Period: 100



Hours relative to hydrograph peak	Estimated flow (m3/s)
-33.65	0
-33	0
-32	0
-31	0
-30	0
-29	0
-28	0.01
-27	0.02
-26	0.05
-25	0.09
-24	0.15
-23	0.24
-22	0.37
-21	0.53
-20	0.73
-19	0.96
-18	1.23
-17	1.54
-16	1.87
-15	2.23
-14	2.6
-13	2.98
-12	3.37
-11	3.74
-10	4.1
-9	4.45
-8	4.77
-7	5.05
-6	5.31
-5	5.52
-4	5.7

-3	5.84
-2	5.93
-1	5.99
0	6.01
1	5.99
2	5.94
3	5.85
4	5.74
5	5.61
6	5.45
7	5.27
8	5.08
9	4.87
10	4.66
11	4.44
12	4.21
13	4.01
14	3.89
15	3.78
16	3.67
17	3.56
18	3.46
19	3.36
20	3.26
21	3.16
22	3.07
23	2.98
24	2.89
25	2.81
26	2.73
27	2.65
28	2.57
29	2.5
30	2.42
31	2.35
32	2.29

Return Period: 200



Hours relative to hydrograph peak	Estimated flow (m3/s)
-33.65	0
-33	0
-32	0
-31	0
-30	0
-29	0
-28	0.01
-27	0.02
-26	0.05
-25	0.09
-24	0.16
-23	0.26
-22	0.39
-21	0.56
-20	0.77
-19	1.03
-18	1.32
-17	1.64
-16	2
-15	2.38
-14	2.78
-13	3.19
-12	3.59
-11	3.99
-10	4.38
-9	4.75
-8	5.09
-7	5.39
-6	5.66
-5	5.89
-4	6.08

-3	6.23
-2	6.33
-1	6.39
0	6.41
1	6.39
2	6.34
3	6.25
4	6.13
5	5.99
6	5.82
7	5.63
8	5.42
9	5.2
10	4.98
11	4.74
12	4.5
13	4.28
14	4.15
15	4.03
16	3.91
17	3.8
18	3.69
19	3.58
20	3.48
21	3.38
22	3.28
23	3.18
24	3.09
25	3
26	2.91
27	2.83
28	2.75
29	2.67
30	2.59
31	2.51
32	2.44

IBIDEM Plots and Tables

No IBIDEM plots were saved by the user.

Audit Trail Report #13920 (Knockannaragh WF)

User ID:	kristian.divjak@ftco.ie
Name:	Divjak, Kristian
Company:	
Address:	
Report date & time:	20-09-2022 14:39
Start of Calculation:	09-08-2022 17:30

Decisions made by the user:

Decision	User comment	System information	Date
2.1 Subject site accepted	N/A	Location 07_1701_6	19-09-2022 14:30
2.2 Subject site with area < 25km2 accepted	N/A		19-09-2022 14:30
2.4 Pivotal site accepted	Reason for accepting: Good match with SAAR, DRAIND, FARL, BFISOIL Reason for ignoring warnings:	Station: 07005 TRIM The user has been notified that 167 candidates where either hydrologically or geographically closer to the subject site than the chosen pivotal site. The user has accepted to reject these sites in preference of the chosen pivotal site.	19-09-2022 14:31
2.1 Subject site accepted	N/A	Location 07_1407_2	19-09-2022 14:32
2.2 Subject site with area < 25km2 accepted	N/A		19-09-2022 14:32

2.4 Pivotal site accepted	Reason for accepting: Pilot site DS Reason for ignoring warnings:	Station: 07005 TRIM The user has been notified that 163 candidates where either hydrologically or geographically closer to the subject site than the chosen pivotal site. The user has accepted to reject these sites in preference of the chosen pivotal site.	19-09-2022 14:32
2.8 QMED data transfer performed	N/A		19-09-2022 14:33
2.11 Pooling group accepted	N/A	Pooled group accepted with the following stations: [25034, 25040, 16051, 30020, 26058, 13002, 22009, 10022, 06031, 10021, 09035, 19046, 26022, 24022, 19020, 14009, 26018, 16006, 25027, 25023, 08002] and distribution: GEV	19-09-2022 14:34
2.13 Module 2 finalized	N/A	Finished pooled analysis with the following distribution selected: GEV.	19-09-2022 14:36
3.1 Hydrograph pivotal site rejected	Relatively good match at the peak flow.	Station: 14009 CUSHINA	19-09-2022 14:45
3.3 Proceeded from hydrograph display	N/A		19-09-2022 14:45
3.3 Proceeded from hydrograph display	N/A		19-09-2022 14:45
3.4 Hydrograph inspected and adjusted	N/A	The user adopted the original PCD hydrograph	19-09-2022 14:46
3.5 Hydrograph transferred to subject site	N/A	The user kept the unadjusted subject site estimate	19-09-2022 14:46
2.1 Subject site accepted	N/A	Location 07_1407_2	20-09-2022 16:30
2.2 Subject site with area < 25km2 accepted	N/A		20-09-2022 16:30
2.4 Pivotal site accepted	Reason for accepting: Pivotal site downstream Reason for ignoring warnings:	Station: 07005 TRIM The user has been notified that 163 candidates where either hydrologically or geographically closer to the subject site than the chosen pivotal site. The user has accepted to reject these sites in preference of the chosen pivotal site.	20-09-2022 16:30
2.8 QMED data transfer performed	N/A		20-09-2022 16:31

2.11 Pooling group accepted	N/A	Pooled group accepted with the following stations: [25034, 25040, 16051, 30020, 26058, 13002, 22009, 10022, 06031, 10021, 09035, 19046, 26022, 24022, 19020, 14009, 26018, 16006, 25027, 25023, 08002] and distribution: EV1	20-09-2022 16:32
2.11 Pooling group accepted	N/A	Pooled group accepted with the following stations: [25034, 25040, 16051, 30020, 26058, 13002, 22009, 10022, 06031, 10021, 09035, 19046, 26022, 24022, 19020, 14009, 26018, 16006, 25027, 25023, 08002] and distribution: GEV	20-09-2022 16:33
2.13 Module 2 finalized	N/A	Finished pooled analysis with the following distribution selected: GEV.	20-09-2022 16:33
3.1 Hydrograph pivotal site rejected	Relatively good match.	Station: 25022 SYNGEFIELD	20-09-2022 16:34
3.3 Proceeded from hydrograph display	N/A		20-09-2022 16:35
3.3 Proceeded from hydrograph display	N/A		20-09-2022 16:35
3.4 Hydrograph inspected and adjusted	N/A	The user adopted the original PCD hydrograph	20-09-2022 16:35
3.5 Hydrograph transferred to subject site	N/A	The user adjusted the subject site estimate with n = 7.86250772651184, Tr = 33.6490993999536, C = 33.8791705060316	20-09-2022 16:36

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