Prepared for:

Jennings O'Donovan

Firlough Wind Farm, Bunnyconnellan (Mayo)

Site Flood Risk Assessment (SFRA)

Project no. 603676-Hydro-R02--(00) DRAFT Firlough Wind Farm FRA

RSK GENERAL NOTES

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1 INTRODUCTION

RSK Ireland was commissioned to carry out a Flood Risk Assessment by Jennings O' Donovan (JOD, the Client). The assessment is in support of the planning application for the Windfarm project in Carrowleagh Co. Mayo.

This Flood Risk Assessment has been carried out in accordance with the Department of Housing and Local Government (DEHLG) and the Office of Public Works (OPW) document *"The Planning Process and Flood Risk Management Guidelines for Planning Authorities"* published in November 2009. This Assessment identifies and sets out possible mitigation measures against potential risks of flooding from various sources. Sources of possible flooding include coastal, fluvial, pluvial (direct heavy rain), groundwater and human/mechanical error. This report provides an assessment of the subject site for flood risk purposes only.

RSK (Ireland) Ltd. (RSK), part of RSK Group, is a consultancy providing environmental services in the hydrological, hydrogeological and other environmental disciplines. The company and group provide consultancy to clients in both the public & private sectors. More information can be found at www.rskgroup.com. The principal members of the RSK EIA team involved in this assessment include the following persons;

- Project Manager & Lead Author: Sven Klinkenbergh – B.Sc. (Environmental Science), P.G. Dip. (Environmental Protection). Current Role: Principal Environmental Consultant. Experience c. 8 years
- Project Scientist: Mairéad Duffy - B.Sc. (Environmental Science), M.Sc. (Climate Change). Current Role: Graduate Project Scientist
- Project Scientist: Jayne Stephens - B.Sc. (Environmental Science), PhD (Environmental and Infection Microbiology). Current Role: Environmental Consultant. Experience c.5 years

2 SOURCES OF INFORMATION

2.1 Introduction

Reliance has been placed on factual and anecdotal data obtained from the sources identified. RSK cannot be held responsible any omissions, misrepresentations, errors or inaccuracies with the supplied information. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report in whole or in part.

All opinions expressed are based upon current design standards and policies in force at the date of this report. These standards may be subject to change with the passage of time.

The opinions expressed herein are intended to provide general guidance as to how a problem related to a particular development might be resolved. Given the paucity of the original information, and the often-indirect nature of information received, they should not be relied upon as absolute or definitive guidance as to any particular solution. Such conclusions can only sensibly be arrived at upon detailed design.

As a consequence of the above, RSK Ltd. will not be held liable for any consequential losses, howsoever caused, as a consequence of inaccurate missing, incomplete, or erroneous data contained in this report, nor any data capable of being subject to variable interpretation by means of its generalised nature.

2.2 Desk Study

During the desktop study the following maps were viewed.

2.2.1 Environmental Protection Agency Maps

The Environmental Protection Agency (EPA) Map Viewer Application was consulted to identify the local hydrology around the vicinity of the Site along with specific Water Framework Directive (WFD) statuses and risks.

2.2.2 Catchment Flood Risk Assessment Flood Maps

Flood Hazard Maps, produced by the Office of Public Works under Eastern Catchment Flood Risk Assessment (CFRAM) (CFRAM) were investigated to determine present-day risks to flooding in relation to the proposed Development. The Office of Public Works (OPW) mapping study for Ireland is available on their website[1].

[1] OPW Flood Maps and Catchment Flood Risk Assessment and Management (CFRAM) Programme

2.2.3 Google Earth Pro

National Grid Reference and topography mapping of the study site setting was drawn from Google Earth Pro (2022) *TerraMetrics; version 7.3.4.8573 (64-bit).*

2.2.4 Geological Survey Ireland Maps

Geological Survey Ireland (GSI) Spatial Resources from the Department of the Environment, Climate and Communications, were utilised to determine the Site's hydrogeology, site-specific aquifer and vulnerability, borehole/well information, soil and subsoils data as well as Corine 2018 land use classification.[2].

2.2.5 Ordnance Survey Ireland Maps

Records from the National mapping agency of Ireland, the Ordnance Survey, were studied, on the websites interactive GeoHive Map Viewer (i.e., Historic 25-inch map) to determine the Site's flood history [3].

[2] Geological Survey Ireland Spatial Resources

[3] Government of Ireland and Ordnance Survey Ireland 2022

3 SITE DESCRIPTION

3.1 Introduction

The proposed Firlough / Kilbride Windfarm site is situated in the townland of Carrowleagh, northeast of the village of Bunnyconnellan, Co. Mayo, Irish Grid Reference (ITM): 536617, 821819. The proposed development is 'significant' relative to the historic use of the Site which is characterised as being rural peatland. However, there are a number of established wind farms in the region including, for example; Carrowleagh Wind Farm directly to the east and the Bunnyconnellan Wind Farm c. 3.5 km southwest of the proposed Development site **Chapter 8Chapter 8 Figure 8.1 a Site Location &** Wind farm**.** The Site area is covered in extensive cutover blanket bog with some forestry to the west and southwest of the boundary and is characterised by relatively flat topography with associated elevations ranging between c. 110 to 160 metres above datum (maOD).

3.2 Historical Maps & Land Use

Historical 6" maps (GeoHive, 2022) indicate that the proposed windfarm Site is situated with peatland areas liable to flooding, that have not previously been developed **(Plate 1).**

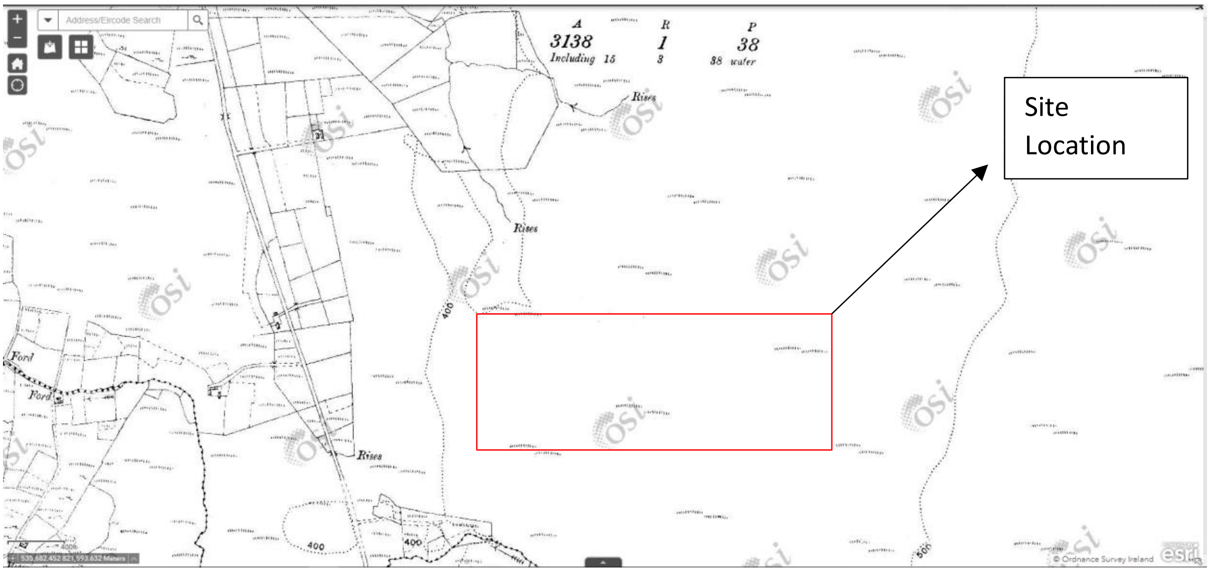

Plate 1: Historical Maps (Geo Hive, 2022)

Land use practices on the Site, in consultation with Corine 2018 (GSI, 2022) data indicates the proposed Site is situated over 'Peat bogs' with surrounding 'Coniferous forest' and 'Traditional woodland scrub', 'Land principally occupied by agriculture with significant areas of natural vegetation'.

3.3 Site Hydrology

The proposed Firlough Wind Farm Development is situated within both the Moy Catchment, (Catchment ID: 34_01), which has an area of 2,110.72 km2, and the Easky-Dunneil-Coastal Catchmane (Catchment ID: 35_03), with an area of 359.52 km2. Surface water runoff associated with the Site drain into two sub catchments and/or three river sub basins, or four no. rivers;

- Sub Catchment: Glenree_SC_010; River Sub Basins: Brusna (North Mayo)_020; Brusna (North Mayo)_010; and Glenree_020
- Sub Catchment: Easky_SC_010; River Sub Basin; Gowlan (Sligo)_010

Surface waters draining to the west of the Site eventually combine in Moy River, from which waters eventually flow to Killala Bay and into the North Atlantic Ocean. Surface waters draining the east of the Site join the Easky River which flows directly to the North Atlantic Ocean.

3.4 Site Soil, Subsoil and Geology

Consultation with available data indicates that soil types across the Site are primarily comprised of Peat Bogs (Blanket Peat). The location of the proposed Firlough Wind Farm Substation is otherwise comprised of Forest and semi-natural areas (Coniferous forests). Although much of the site is mapped as Peat Bogs, these areas are significantly impacted by peat cutting activities and extensive manmade drainage networks.

Consultation with published soil maps compiled by GSI, GIS/SIS and the EPA specify that soil type of the Site is described as “Dark fine-grained limestone and shale”.

According to the GSI, the underlying geology of the site corresponds to the Ballina Limestone Formation described as ‘dark grey fine-grained limestones with subordinate interbedded calcareous shale’.

3.5 Groundwater Vulnerability & Recharge

The bedrock underlying aquifer been assigned the GSI aquifer classification of a “Locally Important Aquifer” and is moderately productive only in local zones **Chapter 9 Figure 9.7a Bedrock Aquifer Windfarm**. According to the National Well Database compiled by the GSI (2022), no boreholes have been identified near the Site. Groundwater vulnerability at the windfarm Site ranges from ‘Low’ to ‘Moderate’ Vulnerability. The eastern half of the Site is classified as Moderate Vulnerability while the remaining western portion of the Site is classified as ‘Low’ Vulnerability **Chapter 9 Figure 9.8a Groundwater Vulnerability Windfarm.**

According to Groundwater data from GSI (2022) the area of windfarm site has an average effective rainfall of 922.50 mm/year and a recharge coefficient of 4% According to GSI information about Subsoil Permeability, the site is characterised by low recharge rates. This implies that, particularly during seasonally wet or extreme meteorological conditions, the majority of water (rain) introduced to the Site will drain off the site as surface water runoff, and the rejected recharge water volumes will likely discharge to surface waters relatively rapidly and locally. As such, the surface water network associated with the Site is characterised as having a rapid hydrological response to rainfall.

3.5.1 Rainfall and Evapotranspiration

Rainfall data for the region associated with the Development site has been assessed in terms of the following parameters;

- Historical average and max monthly rainfall and effective rainfall. Effective rainfall is calculated as being rainfall minus evapotranspiration equals effective rainfall, or the amount of rainfall which will contribute to surface water runoff discharge volumes and/or groundwater recharge.
- Potential significant storm events including events with a 1 in 100 year return period over 1 hour duration and 25 day duration.
- The above storm events plus allowance (+20%) accounting for climate change.

Data from the meteorological stations listed in Met Eireann are used in this assessment[4]. Using data presented in **Plate 2,** storm event of 25 days duration with a 1 in 100 year return period is inferred to be 361.2 mm. For the purpose of this environmental impact assessment, predicted extreme or worst-case values are used, as presented in **Table 2: EIA Specific Assessment Data**.

Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 136774, Northing: 321397,

	Interval		Years													
DURATION	6months	1year	2	3	4	5	10	20	30	50	75	100	150	200	250	500
5 mins	2.7	4.0	4.7	5.8	6.5	7.1	9.1	11.4	13.0	15.2	17.2	18.8	21.3	23.2	24.8	N/A
10 mins	3.8	5.6	6.6	8.1	9.1	10.0	12.7	15.9	18.1	21.2	24.0	26.2	29.6	32.3	34.6	N/A
15 mins	4.4	6.5	7.7	9.5	10.7	11.7	14.9	18.7	21.3	24.9	28.2	30.8	34.8	38.0	40.7	N/A
30 mins	5.9	8.5	10.0	12.2	13.8	15.0	18.9	23.6	26.6	31.0	35.0	38.1	42.9	46.7	49.8	N/A
1 hours	7.8	11.1	13.0	15.7	17.6	19.1	24.0	29.6	33.4	38.6	43.4	47.1	52.8	57.3	61.0	N/A
2 hours	10.2	14.5	16.8	20.3	22.6	24.5	30.4	37.3	41.8	48.1	53.8	58.2	65.0	70.3	74.7	N/A
3 hours	12.1	16.9	19.6	23.5	26.2	28.2	35.0	42.6	47.6	54.7	61.0	65.9	73.4	79.2	84.1	N/A
4 hours	13.5	18.9	21.8	26.1	29.0	31.3	38.6	46.9	52.3	59.9	66.7	72.0	80.0	86.3	91.5	N/A
6 hours	15.9	22.1	25.4	30.3	33.5	36.1	44.3	53.6	59.7	68.2	75.7	81.5	90.4	97.3	103.0	N/A
9 hours	18.8	25.8	29.5	35.1	38.8	41.7	50.9	61.3	68.0	77.5	85.8	92.2	102.1	109.7	115.9	N/A
12 hours	21.1	28.8	32.9	39.0	43.0	46.1	56.2	67.4	74.7	84.9	93.8	100.7	111.3	119.4	126.1	N/A
18 hours	24.8	33.7	38.3	45.2	49.7	53.3	64.6	77.1	85.2	96.5	106.4	114.0	125.7	134.6	141.9	N/A
24 hours	27.9	37.6	42.7	50.2	55.1	59.0	71.2	84.8	93.6	105.7	116.4	124.5	137.0	146.5	154.4	181.5
2 days	35.8	46.9	52.5	60.8	66.1	70.3	83.3	97.4	106.4	118.8	129.5	137.7	150.0	159.4	167.0	193.3
3 days	42.8	55.1	61.3	70.2	76.0	80.4	94.3	109.2	118.6	131.4	142.5	150.9	163.5	173.0	180.8	207.1
4 days	49.3	62.7	69.4	79.0	85.2	89.9	104.5	120.1	130.0	143.3	154.7	163.4	176.3	186.1	194.0	220.8
6 days	61.5	76.8	84.4	95.1	102.0	107.2	123.3	140.3	151.0	165.3	177.5	186.6	200.2	210.5	218.8	246.7
8 days	73.0	90.1	98.4	110.2	117.7	123.4	140.8	159.0	170.4	185.6	198.4	208.1	222.4	233.2	241.8	270.8
10 days	84.1	102.7	111.8	124.5	132.6	138.7	157.3	176.7	188.7	204.7	218.3	228.4	243.3	254.5	263.6	293.6
12 days	94.9	115.0	124.8	138.4	147.0	153.4	173.2	193.6	206.2	223.0	237.2	247.7	263.3	274.9	284.3	315.4
16 days	116.0	138.8	149.8	165.0	174.6	181.8	203.6	225.9	239.7	257.9	273.2	284.5	301.2	313.6	323.6	356.5
20 days	136.7	162.0	174.1	190.8	201.3	209.1	232.7	256.8	271.6	291.1	307.4	319.4	337.1	350.3	360.8	395.5
25 days	162.2	190.5	203.8	222.2	233.7	242.2	268.0	294.1	310.0	330.9	348.4	361.2	380.1	394.1	405.2	441.9

NOTES:
N/A Data not available
These values are derived from a Depth Duration Frequency (DDF) Model
For details refer to:
'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

Plate 2: Rainfall Return Periods (Met Eireann, 2022)

[4] Met Eireann, Historical Data, Available at; www.met.ie, Accessed: 04th January 2023

Table 1: Meteorological Stations

Category	Meteorological Station/s & Data Set	Approx. Distance from the Site (km)
Rainfall (Historical Monthly)	Belmullet	78.6
Rainfall (2020/21 Monthly/Daily)	Belmullet	78.6

Table 2: EIA Specific Assessment Data

Category	Value (mm Rain)
Average Annual Effective Rainfall (Long term) (mm/year)	1,206.0
Average Annual Effective Rainfall (Long term) (mm/year) +20% Accounting for Climate Change	1,447.2
1 in 100 Year Rainfall Event (25 day duration) (mm/month)	361.2
1 in 100 Year Rainfall Event (25 day duration) (mm/month) +20% Accounting for Climate Change	433.4
1 in 100 Year Rainfall Event (1 hour duration) (mm/hour)	47.1
1 in 100 Year Rainfall Event (1 hour duration) (mm/hour) +20% Accounting for Climate Change	56.5

3.6 Proposed Development

The proposed wind farm, is comprised of 13 turbines. The main components making up windfarm infrastructure to consider as part of the Development are:

- 13 No. 5.6 - 6.6 MW wind turbines with an overall ground to blade tip height ranging from 179m to 185m inclusive. The wind turbines will have a rotor diameter ranging from 149m to 155m inclusive and a hub height ranging from 102.5m to 110.5m inclusive
- Construction of permanent Turbine Hardstands and Turbine Foundations.
- Construction of one temporary construction compound with associated temporary site offices, parking areas and security fencing.
- Installation of one (35-year life cycle) meteorological mast with a height of 110m and a 4m lightning pole on top.
- Development of two permanent on-site borrow pits.

- Construction of new permanent internal Site Access Roads and upgrade of existing Site Access Roads, to include passing bays and all associated drainage infrastructure.
- Development of a site drainage network.
- Construction of one permanent 110 kV substation.
- All associated underground electrical and communications cabling connecting the wind turbines to the wind farm substation.
- All works associated with the permanent connection of the wind farm to the national electricity grid comprising 6.8km of 110 kV underground cable from the proposed, permanent, on-site substation to the existing Carrowleagh - Kilbride 110kV Overhead Line.

4 FLOOD RISK

4.1 Introduction

4.1.1 Guidelines for FRAs

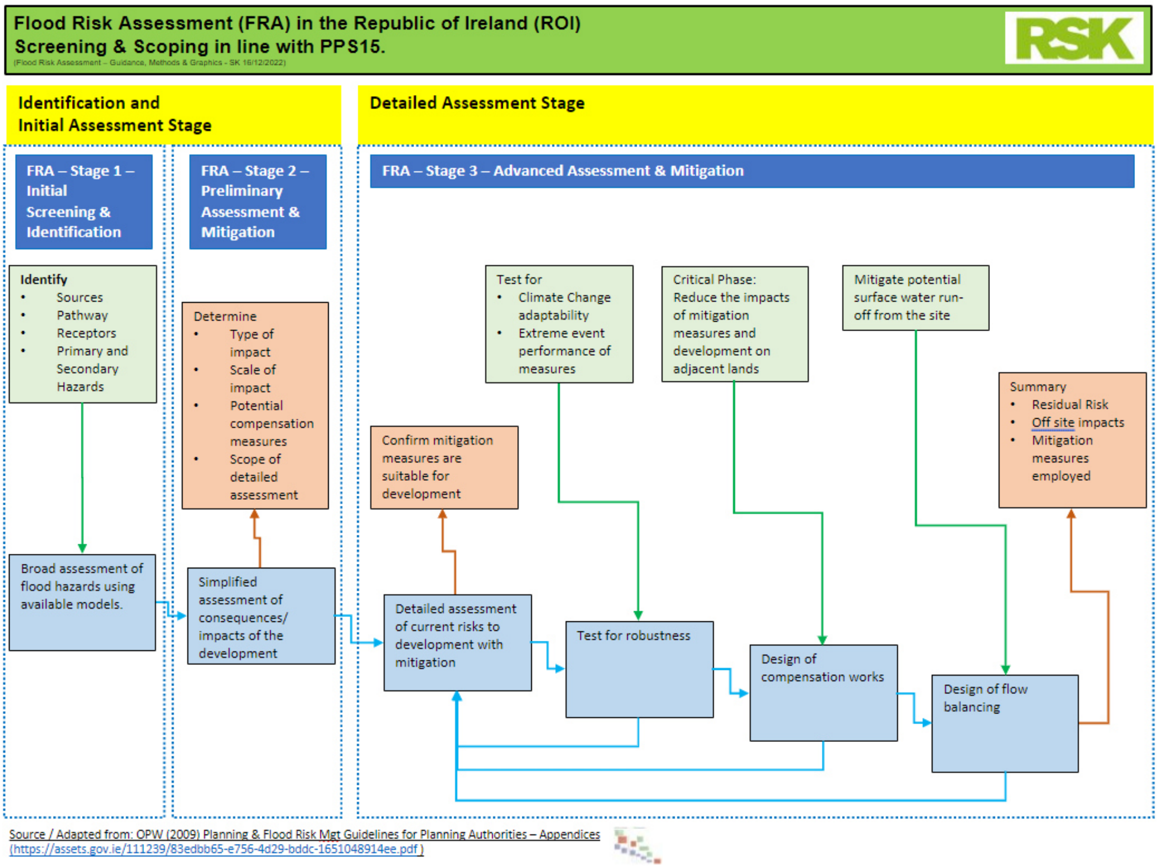

Plate 3: Screening and Scoping for an FRA in the Republic of Ireland

The Stage 1 Flood Risk Assessment Report

Stage 1 RSK Ireland will prepare for Jennings O' Donovan follows the guidelines set out in the DEHLG/OPW *Guidelines on the Planning Process and Flood Risk Management* published in November 2009. This assessment will address where surface water and groundwater within or around the site boundary comes from (i.e., the source), how and where it flows (i.e., the pathways) and the people and assets affected by it (i.e., the receptors). This stage aims to quantify the risk posed to any site and/or development and to the surrounding environment by this site/development using available models **(Plate 3)**. As per Flood Risk Management (FRM) Guidelines the purpose of Stage 1 is to identify whether there may be any flooding or surface water management issues related to either the area of regional planning guidelines, development plans and local area plans (LAP's) or a proposed development site that may warrant further investigation at the appropriate lower-level plan or planning application levels.

Flood Risk Assessment Stage 2

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 scope the extent of the risk of flooding which may involve preparing indicative flood zone maps. Where hydraulic models exist the potential impact of a development on flooding elsewhere and of the scope of possible mitigation measures can be assessed. In addition, the simplified assessment of the current consequences and impacts to the development **(Plate 3).**

Flood Risk Assessment Stage 3

Stage 3 Detailed flood risk assessment – to assess flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to a proposed or existing development or land to be zoned, of its potential impact on flood risk elsewhere and of the effectiveness of any proposed mitigation measures **(Plate 3).**

4.1.2 Sources of Flooding

The components to be considered in the identification and assessment of flood risk are:

- Tidal – flooding from high sea levels. Occurs when sea levels along the coast or in estuaries exceed neighbouring land levels, or overcome coastal defences where these exist, or when waves overtop the coastline or coastal defences.
- Fluvial – flooding from water courses. Occurs when rivers and streams break their banks and water flows out onto the adjacent low-lying areas (the natural floodplains). This can arise where the runoff from heavy rain exceeds the natural capacity of the river channel, and can be exacerbated where a channel is blocked or constrained or, in estuarine areas, where high tide levels impede the flow of the river out into the sea. While there is a lot of uncertainty on the impacts of climate change on rainfall patterns, there is a clear potential that fluvial flood risk could increase into the future.
- Pluvial – flooding from rainfall / surface water. occurs when the amount of rainfall exceeds the capacity of urban storm water drainage systems or the infiltration capacity of the ground to absorb it. This excess water flows overland, ponding in natural or man-made hollows and low-lying areas or behind obstructions. This occurs as a rapid response to intense rainfall before the flood waters eventually enter a piped or natural drainage system. This type of flooding is driven in particular by short, intense rain storms.
- Ground Water – flooding from springs / raised ground water. occurs when the level of water stored in the ground rises as a result of prolonged rainfall, to meet the ground surface and flows out over it, i.e. when the capacity of this underground reservoir is exceeded. Groundwater flooding results from the interaction of site-specific factors such as local geology, rainfall infiltration routes and tidal variations. While the water level may rise slowly, it may cause flooding for extended periods of time. Hence, such flooding may often result in

significant damage to property or disruption to transport. In Ireland, groundwater flooding is most commonly related to turloughs in the karstic limestone areas prevalent in particular in the west of Ireland.

- Human/mechanical error – flooding due to human or mechanical error. can also be caused by the failure or exceedance of capacity of built or man-made infrastructure, such as bridge collapses, from blocked piped sewerage networks, or the failure or over-topping of reservoirs or other water-retaining embankments (such as raised canals).

4.1.3 Assessing Flood Risk

The two components of flood risk, as outlined in the FRM Guidelines, are the likelihood of flooding and the potential consequences arising from planned works; expressed as:

Flood Risk = Probability of flooding x Consequences of flooding

- *Likelihood of flooding is normally defined as the percentage probability of a flood of a given magnitude or severity occurring or being exceeded in any given year. For example, a 1% probability indicates the severity of a flood that is expected to be exceeded on average once in 100 years, i.e., it has a 1 in 100 (1%) chance of occurring in any one year.*
- *Consequences of flooding depend on the hazards associated with the flooding (e.g., depth of water, speed of flow, rate of onset, duration, wave- action effects, water quality), and the vulnerability of people, property and the environment potentially affected by a flood (e.g., the age profile of the population, the type of development, presence and reliability of mitigation measures etc).*

4.1.4 Assessing Likelihood of Flood Risk

In the FRM Guidelines, the likelihood of a flood occurring in an area is identified and separated into Flood Zones **(Appendix A-1)** which indicate a high, moderate or low risk of flooding from fluvial or tidal sources, defined as follows:

- Flood Zone A - Where the probability of flooding is highest (greater than 1% Annual Exceedance Probability (AEP) or 1 in 100 for river flooding and 0.5% AEP or 1 in 200 for coastal flooding) and where a wide range of receptors would be located and therefore vulnerable;
- Flood Zone B - Where the probability of flooding is moderate (between 0.1% AEP or 1 in 1000 and 1% AEP or 1 in 100 for river flooding and between 0.1% AEP or 1 in 1000 year and 0.5% AEP or 1 in 200 for coastal flooding); and
- Flood Zone C - Where the probability of flooding is low (less than 0.1% AEP or 1 in 1000 for both river and coastal flooding).

As outlined in the FRM Guidelines, future developments must avoid where possible areas at risk of flooding. The FRM Guidelines categorises all types of development as either; 1. Highly Vulnerable, 2. Less Vulnerable and 3. Water Compatible e.g. flood infrastructure, docks, amenity open space. As the development at Firlough is essential infrastructure it is considered a Highly vulnerable development **Appendix A-2.**

Presented in **Appendix A-2** from the OPW (2009), a Justification Test is a guiding document that aims to determine the appropriateness of a particular development in areas that may be at risk of flooding. As a proportion of the site is in Zone B, the site is subject to a justification test. A Justification Test is required to assess such proposals in the light of proper planning and sustainable development objectives **Appendix A-4.**

5 STAGE 1 – FLOOD RISK IDENTIFICATION

The flood risk identification stage was carried out in order to establish whether a flood risk exists within the boundaries of the Site or the surrounding vicinity.

5.1 Existing Flood Records

Consultation with the Flood Map database operated by the OPW (2022) indicates that there are no past flood events within the proposed redline boundary of the Site. There is however, the existence of one (1 no.) recurring flooding event (Easky River Bellafarney Gleneasky area Recurring) c. 10.56 km downstream of the Gowlan (Sligo)_010 which drains the eastern extent of the Site and within the same river sub-basin as the proposed location of T13. The second recorded flood event noted being hydrologically linked to the proposed Development was an 'Undated Flood Event' (River Moy Quignamanger) c. 18.11 km downstream, to the west of the Site along the Moy Estuary. The Brusna (North Mayo)_020, draining a majority of the Development merges with the Glenree_030. The Glenree River discharges to the Moy Estuary c. 1.78 km down gradient of where the River Moy Quignamanger Flood Event occurred.

5.2 Probable Flood Extent - CFRAM

Consultation with the Catchment Flood Risk Assessment and Management (CFRAM) maps for the area, offers a high level overview of process and data review to produce models covering a range of river and coastal flooded extents. Present Day CFRAM river flood extents do not indicate a low, medium or high probability or risk of flooding within or near the vicinity of the Site. Furthermore, Mid-Range and High-End Future Scenarios, which take into account modelled extents of land that may be flooded during extreme flood events, have not indicated a risk to flooding by the CFRAM maps either. All areas outside the 0.1% AEP flood extent (the proposed Development), are classified as residing in Flood Zone C. Therefore, CFRAM flood-maps confirm that the proposed Development Site resides in Flood Zone C and is a suitable development for this area.

5.3 Coastal or Tidal Flooding

Tidal flooding is caused by elevated sea levels or overtopping by wave action. The proposed Firlough Wind Farm is inland, located approximately 10 km east of Moy Estuary. As stated above, there have been no Coastal Flood Extents Present or Future Scenarios mapped as part of the CFRAM project. Therefore the residual risk to coastal and/or tidal flooding is considered low.

5.4 Fluvial Flooding

Fluvial flooding is caused by rivers, watercourses or ditches overflowing. Historic floods maps do not indicate the Site or surrounding the areas are liable to flooding. Review of the National Indicative Fluvial Mapping (NIFM) River Flood Extents for the Present day, do not indicate a flood zone on Site. However, the Brusna (North

Mayo)_020 has been mapped under the NIFM for both a 0.1% AEP as well as a 1% AEP. The area, modelled as liable to flood during a theoretical design flood event is located c. 1.5 km downstream of the Site and within the catchment that drains the eastern portion of the Site encompassing the proposed locations of T3, T4, T5, T7, T9, T10, T11 and T12.

Mid-Range and High-End Future Scenarios have also been mapped at the above location as part of the NIFM project which takes into consideration the potential effects of climate change using an increase in rainfall of 20%.

5.5 Pluvial Flooding

Pluvial flooding is usually caused by intense rainfall that may only last a few hours, often referred to as flooding from surface water. Surface water flooding can also occur as a result of overland flow or ponding during periods of extreme prolonged rainfall. During pluvial flooding events, water follows natural valley lines, creating flow paths along roads, through and around Developments and ponding in low spots, which often coincide with fluvial floodplains in low lying areas. It is generally noted, areas at risk from fluvial flooding will almost certainly be at risk from pluvial flooding.

Consultation with the OPW's Present Day CFRAM Rainfall Flood Extents (Current Scenario) and Pluvial maps have not indicated any risk to land within the redline boundary of the Site or within the immediate vicinity which would be directly flooded by rainfall in an extremely severe rainfall event. Therefore, the residual risk from pluvial flooding is considered low.

5.6 Groundwater Flooding

Groundwater flooding can occur on some sites in connection with high water tables and increased recharge following long periods of wet weather. Groundwater flooding typically occurs in areas underlain by limestone and where underlying geology is highly permeable with high capacity to receive and store rainfall. According to the Geological Survey Ireland (2022), the Groundwater Flood Maps developed 2016-2019, indicate no evidence of a Low, Medium or High Probability groundwater flooding event within the Site. Therefore, the residual risk from groundwater flooding is considered low.

5.7 Proposed Development

The proposed Development will include land take and the implementation of impermeable concrete foundations for the wind turbines and a meteorological mast. Additionally, greenfield land take will be required to facilitate with foundations for an on-site substation and the Material Storage Area. This presents the potential for a net decrease in recharge potential (rain percolating through soils to groundwater) and increase in the hydrological response to rainfall (quantity and rate of surface water runoff) at the Site, which will potentially adversely impact on flood risk areas downstream of the Site.

5.8 Human/Mechanical Error

Consultation with the Past Flood Event database from the OPW indicates a potential for mechanical or human errors through past flood mitigation works. For instance, as part of the Arterial Drainage Scheme (ADS) channels along watercourses were established under the Arterial Drainage Act (1945) to improve land for agriculture and to mitigate flooding. As part of this Scheme, according to the OPW, rivers, lakes weirs and bridges were modified to enhance conveyance and control the movement of flood water. These channels have been mapped as feeding directly (hydrologically linked) to the Brusna (North Mayo)_020), **Plate 4**, which as discussed in **Section 5.4** has a 0.1% and 1% AEP under Present Day and Future scenarios.

Benefitted Lands, mapped by the OPW, identifies land that was drained as part of the ADS, which in earlier years facilitated peat extraction for fuel and horticulture. Benefitted Land, similar to ADS channels, overlay with the NIFM ‘low probability’ and ‘medium probability’ flood extents.

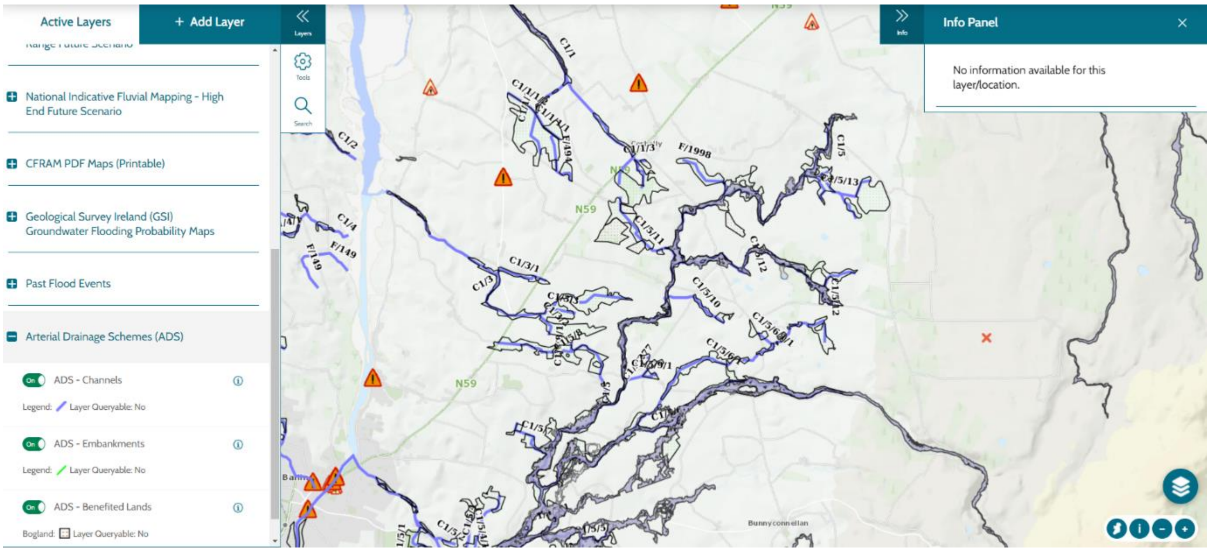

Plate 4: Location of Proposed Firlough Wind Farm Development (denoted by red ‘x’, upstream of National Indicative Fluvial Map (NIFM) flood extents and Arterial Drainage Scheme (ADS) measures (Source: FloodMaps, 2022).

Summary of Stage 1 Flood Risk Assessment

This Stage 1 Flood Risk Assessment was compiled and based on data presented in public records, in accordance with the guidelines set out in the DEHLG/OPW *Guidelines on the Planning Process and Flood Risk Management* published in November 2009. From reviewing the available records there was no evidence of historic flooding at the Site. Furthermore, comprehensive flood maps produced by the OPW under the Coastal Maps, Drainage Maps and the National Fluvial Flood Maps confirm that the proposed Development resides in a Flood Zone C, **Appendix A-1.**

5.9 Stage 1 Conclusion

The nature of the Development is industrial as opposed to residential or leisure, and as such, this type of development is categorized as a ‘Less Vulnerable Development’, according to FRM Guidelines. Therefore, the Development is considered an ‘appropriate’ development for Flood Zone C, **Appendix A-2, Appendix A-3.** In keeping with the Stage 1 Flood Risk Assessment, the review of available information has identified no flood hazards for the proposed Development.

The proposed Development has the potential to lead to a net decrease in recharge potential and net increase in the hydrological response to rainfall at the Site, potentially leading to adverse impacts on flood risk areas downstream of the site. The extent of the risk of flooding and potential impact of a development on flooding elsewhere (downstream) requires FRA Stage 2. The sequential approach, as outlined in the FRM Guidelines, was applied as part of this assessment.

6 STAGE 2 – INITIAL FLOOD RISK ASSESSMENT

6.1 Assessing Potential Impacts of Development

While the Catchment Flood Risk Management Plan (CFRAM) programme did not indicate any flood extents within the proposed Site boundaries, downgradient of the Site, there are probable flood areas as noted by NIFM in **Section 5.4**. The closest mapped probable flood areas are associated with;

- The Brusna (North Mayo)_020 river approximately 1.5 kilometres to the west (downstream) of the proposed Site.

To highlight, there have not been any recorded localised flood events between the Site and the CFRAM mapped probable flood areas.

6.2 Assessing Potential Effects of Development – Increased Hydraulic Loading

6.2.1 Preliminary Water Balance Assessment

For the purposes of assessing changes in runoff the following information has been considered:

- Main Turbine Hardstands and Foundations = c.3,600m^2 x 13 no. = 46,800m^2 + c. 510 m^2 x 13 no. = 6,640 m^2 = 53,440 m^2
- Existing access track = c. 14,475m^2
- New Access track = c.1145m^2 x 4.5m^2 = 5,153m^2
- Wind Farm Internal Cabling = c. 5,850m^2
- Substation Hardstand = c. 13,892m^2
- Contractors Compound = c. 1,800 m^2
- Materials Storage Area = c. 19,953 m^2
- 1 in 100 year rainfall event = c. 47.1mm of rainfall in 1 hour.
- Recharge capacity = 10.0% of Effective Rainfall (As mapped by GSI, 2022).

This assessment is considered a simple preliminary water balance assessment for the purposes of qualifying and adding quantitative context to potential impacts of the development in terms of hydrological response to rainfall and flooding. It considers and uses site specific data as well as associated downstream attribute data. (Note: This is not considered advanced modelling for flood risk assessment (i.e. FRA Stage 3).

Table 3 summarises a preliminary water balance analysis and potential net increase in runoff for the Site during a 1 in 100 year storm event relative to baseline conditions.

The table presents the two scenarios,

a) Baseline conditions – Site is characterised in terms of ground sealing and vegetated areas with a view to estimating baseline runoff and recharge during particular meteorological conditions.

b) Development conditions – Site is characterised similar to above, but with updated values in terms of ground cover i.e. net change in area sealed, reduction in recharge and potential net increase in runoff from the site.

Data used and presented in the preliminary water balance assessment (**Table 3**) includes the following;

- Land/ Category: This discusses whether the area is Developed and sealed or vegetated with potential infiltration and recharge capacity.
- Estimated Portion: This is the estimated percentage of Site area for the category of land on the site
- 1 in 100 year Storm Event: Amount of rain predicted in 1 in 100 year event per m^2
- 1 in 100 year Storm Event + 20%: Amount of rain predicted in 1 in 100 year event per m^2 including for increased risk posed by climate change.
- Evapotranspiration: Is the amount of water on the Site that is lost to plants or the environment.
- Effective Rainfall: 1 in 100 year event + Climate Change (20%) – Evapotranspiration
- Recharge: Estimated amount of water runoff which will infiltrate and contribute to groundwater systems.

Table 3: Baseline and Development Scenario Volumes (1 in 100 Year Storm + 20% Climate Change)

Net Increase in Runoff as a function of the Development per Micro-catchment Areas and Baseline Runoff Volumes (1 in 100 Year Hour Storm Event)																	
Micro Catchment	Category	Unit	Approx. Area Per Unit	Approx. Quantity	Approximate Area (m2)	1 in 100 Year Rainfall Event (m/hour Rain)	Capped Recharge Capacity. Percentage of Effective Rainfall (Conservative Value for Water Balanace Calc's)	Rejected Recharge / Runoff (m/hour Rain)	Runoff Discharge Rate (m3/hour)	Net Increase Runoff Discharge Rate (m3/sec)	Runoff Discharge Rate (m3/sec)	Recharge Capacity. Percentage of Effective Rainfall (Hardstand Areas assumed impermeable)	Rejected Recharge / Runoff (m/hour Rain)	Runoff Discharge Rate (m3/hour)	Net Increase Runoff Discharge Rate (m3/sec)	Runoff Discharge Rate (m3/sec)	Net Increase (m3/sec)
SW1	Turbines Hardstand	No.	3600	2	7,200.00	0.0471	10.00%	0.04239	305.21	0.08		0.00%	0.0471	339.12	0.09		
SW1	New Access Track / hardstand	m	5	680	3,400.00	0.0471	10.00%	0.04239	144.13	0.04		0.00%	0.0471	160.14	0.04		
SW1	**Subtotal**										0.12					0.14	**0.014**
SW2	Turbines Hardstand	No.	3600	1	3,600.00	0.0471	10.00%	0.04239	152.60	0.04		0.00%	0.0471	169.56	0.05		
SW2	New Access Track / hardstand	m	5	8053.042	40,265.21	0.0471	10.00%	0.04239	1,706.84	0.47		0.00%	0.0471	1,896.49	0.53		
SW2	Contractors Compund	No.	1800	1	1,800.00	0.0471	10.00%	0.04239	76.30	0.02		0.00%	0.0471	84.78	0.02		
SW2	On-Site Substation	No.	13892	1	13,892.00	0.0471	10.00%	0.04239	588.88	0.16		0.00%	0.0471	654.31	0.18		
SW2	Material Stroage Area	No.	19953	1	19,953.00	0.0471	10.00%	0.04239	845.81	0.23		0.00%	0.0471	939.79	0.26		
SW2	**Subtotal**										0.52					0.57	**0.057**
SW3	Turbines Hardstand	No.	3600	2.25	8,100.00	0.0471	10.00%	0.04239	343.36	0.10		0.00%	0.0471	381.51	0.11		
SW3	New Access Track / hardstand	m	5	560	2,800.00	0.0471	10.00%	0.04239	118.69	0.03		0.00%	0.0471	131.88	0.04		
SW3	**Subtotal**										0.13					0.14	**0.014**
SW4	Turbines Hardstand	No.	3600	7.75	27,900.00	0.0471	10.00%	0.04239	1,182.68	0.33		0.00%	0.0471	1,314.09	0.37		
SW4	New Access Track / hardstand	m	5	320.451	1,602.26	0.0471	10.00%	0.04239	67.92	0.02		0.00%	0.0471	75.47	0.02		
SW4	**Subtotal**										0.35					0.39	**0.039**
													Total	**6147.137102**	**1.71**	**1.24**	**0.124**

Water balance calculations allow for the addition of area for the Development required (land take) during the construction and operational phases of the Development. This equates to approximately 114,563m^2. A 1 in 100 year storm event scenario results in a net increase of surface water runoff associated with the Development, calculated to be +6,147m^3/hour, or 0.124m^3/sec (+124 l/sec). This net increase relative to the scale of the Site or the scale of the associated catchment is considered an **adverse but slight to moderate** impact of the development. With suitable mitigation measures i.e. SuDS, the impact to the surface water bodies downgradient can be reduced to a neutral impact through the design process.

7 MITIGATION MEASURES ASSOCIATED WITH THE DEVELOPMENT

Under the OPW CFRAM study, Ballina Town and its low-lying surroundings were identified as an Area for Further Assessment (AFA) in 2012. A number of potential flood relief/protection measures were identified and assessed to be viable and effective to reduce flooding in the area. In consultation with the Ballina Flood Relief Scheme, the OPW along with Mayo County Council have appointed engineers to further assess the CFRAM Study, to identify options and prepare a detailed scheme for Ballina which is economically viable, socially acceptable and environmentally sustainable. According to the OPW (2020), Stage I is currently ongoing (having commenced in March 2020).

Furthermore, under the 2013-2015 Work Programme of the Common Implementation Strategy (CIS) for the Water Framework Directive (WFD), and in response to the 2012 Blueprint to Safeguard Europe's Water Resources proposals, the Working Group Programme of Measures has developed guidance for supporting the implementation of Natural Water Retention Measures (NWRM) in Europe. (European, 2015).

The OPW and EPA Catchments Unit in conjunction with Local Authorities are actively adopting and promoting NWRM as part of a broader suite of mitigation measures that could contribute to the achievement of environmental objectives (WFD) set out in the second River Basin Management Plan (RBMP) (Catchments, 2020).

Mitigation measures are important for reducing the runoff at the site which can be seen in **Appendix A-5: Example of the Hydrograph (CIRCA, 2015)**. The green line indicates run off at the site before the commencement of the development. The blue line indicates a very sharp rise in run off post development excluding mitigation measures and the red line indicates run off post development which includes the necessary SuDS mitigation measures.

Flood Relief Scheme and Flood Risk Management Objectives such as Land Use Management and Natural Flood Risk Management are relevant to the proposed Development, whereby; the assessment and design of proposed Development will qualify and mitigate any potential adverse impact in terms of hydrological response to rainfall and flood risk within or downstream of the Site. The objective of mitigation in this respect will be to achieve, at a minimum, a neutral impact, and to identify and promote beneficial impacts (net decrease in hydrological response to rainfall) at the Site, particularly in terms of Natural Water Retention Measures (NWRM) as part of baseline conditions, namely; restoration of peatlands.

To mitigate any net change in hydraulic loading to surface waters during the construction and operational phase of the Development, the following examples will be utilised where appropriate;

- Check dams, dams, other flow restricting infrastructure
- Collector drains
- Inlet/Outlet/Sumps

- Wastewater Infiltration pit
- Constructed Wetland
- Swale
- Buffered outfalls to vegetated areas
- Restricting pumped water discharge directly to drainage or surface water networks.
- Riverbank restoration
- Land and soil management practices – cover crops, cross contour hedgerows.

The Development has the potential to result in increased volumes of runoff during the operational phases of the Development relative to baseline conditions. However, with the appropriate environmental engineering controls and mitigation measures, previously outlined, these potential impacts will be reduced. The combined attenuation capacity of the proposed drainage infrastructure will be designed to attenuate net increase in water runoff, including during extreme storm events relative to greenfield or baseline runoff rates. These mitigation measures required during the construction and operational phases will buffer the discharge rate and reduce the hydrological response to rainfall at the site, maintain (or improve) the hydrological regime at the site, in turn reducing loading on the receiving surface water drainage network. This will mitigate against the potential for rapid runoff and rapid hydrological responses to rainfall, lessening the likelihood to flooding of the drainage network or downstream of the Development.

Mitigation measures will be considered and designed in line with engineering and construction best practices and methodologies, including the following guidance documents (non-exhaustive);

- Scottish Environment Protection Agency (SEPA) (2009) Flood Risk Management (Scotland) Act 2009 – Surface Water management Planning Guidance
- Scottish Environment Protection Agency (SEPA) (2015) Natural Flood Management Handbook
- CIRIA (2006) Control of Water Pollution from Linear Construction Projects – Technical Guidance
- CIRIA (2015) The SuDS Manual (C753)

The following observations and recommendations are made with a view to ensuring mitigation measures are designed and deployed effectively;

- The magnitude of potential net increase in runoff as a function for the Development at the Site is considered adverse; quantifiable with significant impact relative to the appropriate scale (flood risk areas downstream of the site and associated with a much larger catchment compared to the site boundary). Therefore, FRA Stage 3 including advanced flood modelling with a view to ensuring significant risks to flood risk areas are managed and minimised, is not deemed required as part of FRA. However, in terms of detailed engineered design of the proposed Development and with a view to applying mitigation measures adequately, it is recommended that drainage, attenuation and associated infrastructure is designed and specified by a competent water infrastructure engineer, which might include modelling of runoff in site drainage, to ensure that all aspects are sufficiently specified. Drainage modelling, including assessment of inundation rates, lag times and discharge rates, will be particularly useful where particularly sensitive environmental attributes exist downstream, or example; ecological attributes where surface water runoff and surface water quality are linked (**EIAR Chapter 9).**

- Detailed design and specification of drainage, attenuation and associated infrastructure will be included in a detailed Surface Water Management Plan (SWMP) prior to the commencement of the construction phase which will include detailed development drainage layout and details regarding construction, maintenance, monitoring and emergency response. It is recommended that this is done in conjunction with relevant stakeholders including relevant authorities and other stakeholders such as landholders etc. in line with River Basin Management practices i.e. engagement at local level.

7.1 Site Specific Measures

The mitigation measures for the proposed site include a attenuation in surface water runoff, using attenuation features such silt beds, check dams, inlet and outlet sumps utilising diffuse discharge rates of surface water collected.

The proposal also incorporates regeneration areas for peatland using soil berms as barriers, creating deposition areas for the peat arisings to go surrounding the hardstand (see Appendix 9.7. This peat will then be ‘protected’ from cutting etc. These measures ensure, that the development will not only have a neutral effect on surface water levels, but it will also enhance the peat habitat on site in the form of net increase in peat cover, and further attenuate runoff.

8 FRA CONCLUSIONS & RECOMMENDATIONS

A 1 in 100 year storm event scenario results in a net increase of surface water runoff associated with the Development, calculated to be +6,147m^3/hour, or + 0.124 m^3/sec. This net increase relative to the scale of the Site or the scale of the associated catchment is considered an adverse but imperceptible impact of the Development.

The proposed Development will use the latest best practice guidance to ensure that flood risk within or downstream of the Site is not increased as a function of the Development, i.e. a neutral impact at a minimum.

Considering the development does not acutely or significantly impact on a probable flood risk area, FRA Stage 3 including advanced flood modelling is not required. However, it is recommended to include drainage modelling during the detailed design phase of the Development.

A detailed Surface Water Management Plan (SWMP) will be prepared prior to the construction phase commencing, with a view to ensuring that the surface water runoff at the Site is managed effectively and does not exacerbate flood risk to the surrounding areas downstream. It is recommended that this is done in consultation with relevant stakeholders.

As the associated drainage - some of which is permeant for the lifetime of the development, will be attenuated for greenfield run-off, the proposed development will not increase the risk of flooding elsewhere in the catchment. Based on this information, the proposed development complies with the appropriate policy guidelines for the area and is at no risk of flooding.

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APPENDIX A

Site Name: Firlough Windfarm FRA, Co. Mayo	**Project No.**	603676	**Drawn By:**	Mairéad Duffy Graduate Project Scientist	RSK
	Client:	Jennings O'Donovan			
Figure Name: **Appendix A- 1**: Indicative flood zone map from (Department of Housing, Local Government and Heritage 2009)	**Date:**	27/10/2022	**Reviewed By:**	Sven Klinkenbergh Principal Environmental Consultant	
	Revision:	00			

Conceptual Graphics & Design for consideration at detailed design phase and engineered specification of required infrastructure. Not to scale.

Vulnerability class	Land uses and types of development which include*:
Highly vulnerable development (including essential infrastructure)	Garda, ambulance and fire stations and command centres required to be operational during flooding; Hospitals; Emergency access and egress points; Schools; Dwelling houses, student halls of residence and hostels; Residential institutions such as residential care homes, children's homes and social services homes; Caravans and mobile home parks; Dwelling houses designed, constructed or adapted for the elderly or, other people with impaired mobility; and Essential infrastructure, such as primary transport and utilities distribution, including electricity generating power stations and sub-stations, water and sewage treatment, and potential significant sources of pollution (SEVESO sites, IPPC sites, etc.) in the event of flooding.
Less vulnerable development	Buildings used for: retail, leisure, warehousing, commercial, industrial and non-residential institutions; Land and buildings used for holiday or short-let caravans and camping, subject to specific warning and evacuation plans; Land and buildings used for agriculture and forestry; Waste treatment (except landfill and hazardous waste); Mineral working and processing; and Local transport infrastructure.
Water-compatible development	Flood control infrastructure; Docks, marinas and wharves; Navigation facilities; Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location; Water-based recreation and tourism (excluding sleeping accommodation); Lifeguard and coastguard stations; Amenity open space, outdoor sports and recreation and essential facilities such as changing rooms; and Essential ancillary sleeping or residential accommodation for staff required by uses in this category (subject to a specific warning and evacuation plan).

*Uses not listed here should be considered on their own merits

Site Name: Firlough Windfarm FRA, Co. Mayo	**Project No.**	603676	**Drawn By:**	Mairéad Duffy Graduate Project Scientist	RSK
	Client:	Jennings O'Donovan			
Figure Name: **Appendix A- 2**: Classification of vulnerability of different types of development (OPW,2009)	**Date:**	27/10/2022	**Reviewed By:**	Sven Klinkenbergh Principal Environmental Consultant	
	Revision:	00			

Conceptual Graphics & Design for consideration at detailed design phase and engineered specification of required infrastructure. Not to scale.

	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

Site Name: Firlough Windfarm FRA, Co. Mayo	**Project No.**	603676	**Drawn By:**	Mairéad Duffy Graduate Project Scientist	RSK
	Client:	Jennings O'Donovan			
Figure Name: **Appendix A- 3**: Matrix of vulnerability versus flood zone to illustrate appropriate development and that are required to meet the Justification Test (OPW, 2009)	**Date:**	27/10/2022	**Reviewed By:**	Sven Klinkenbergh Principal Environmental Consultant	
	Revision:	00			

Conceptual Graphics & Design for consideration at detailed design phase and engineered specification of required infrastructure. Not to scale.

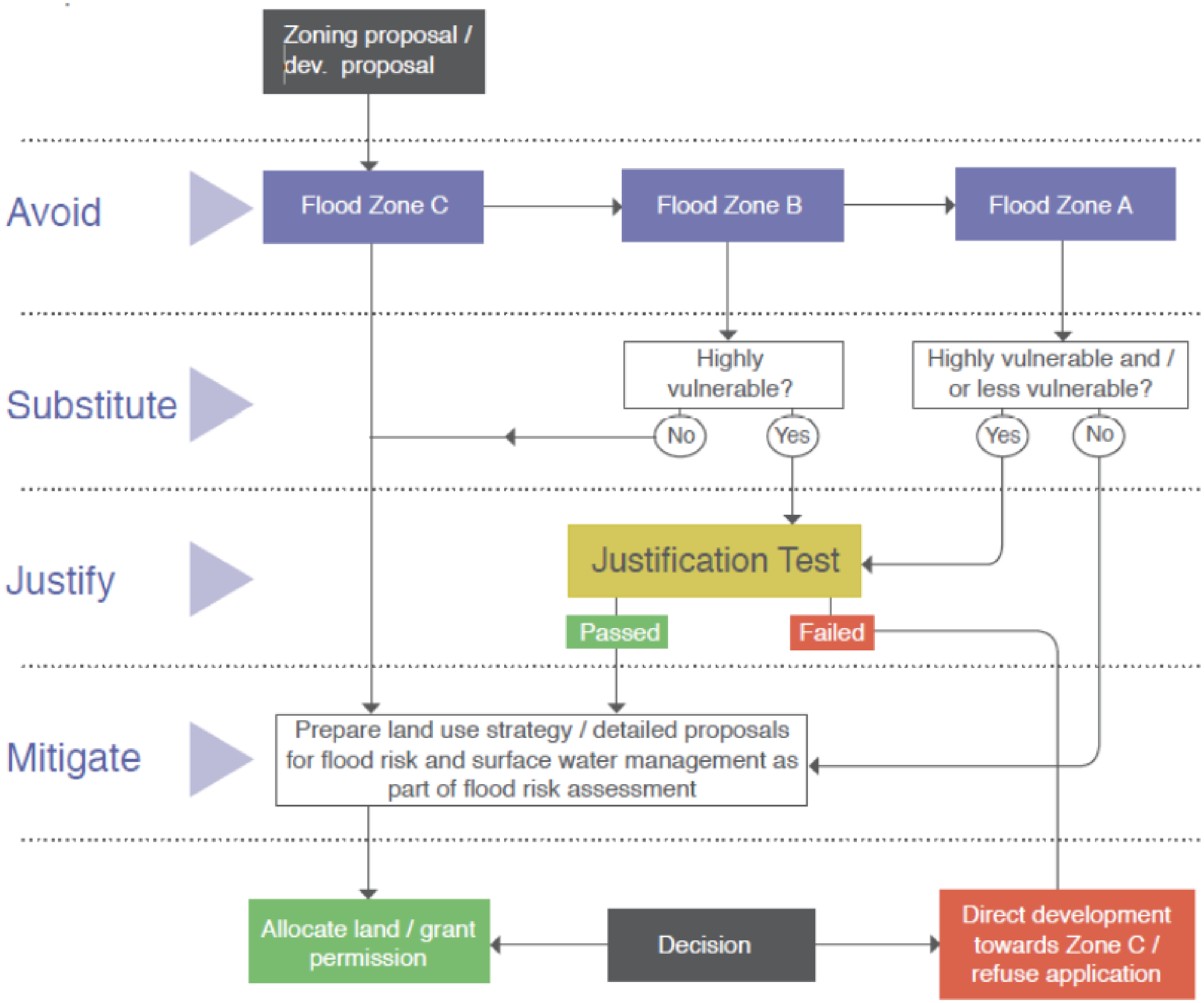
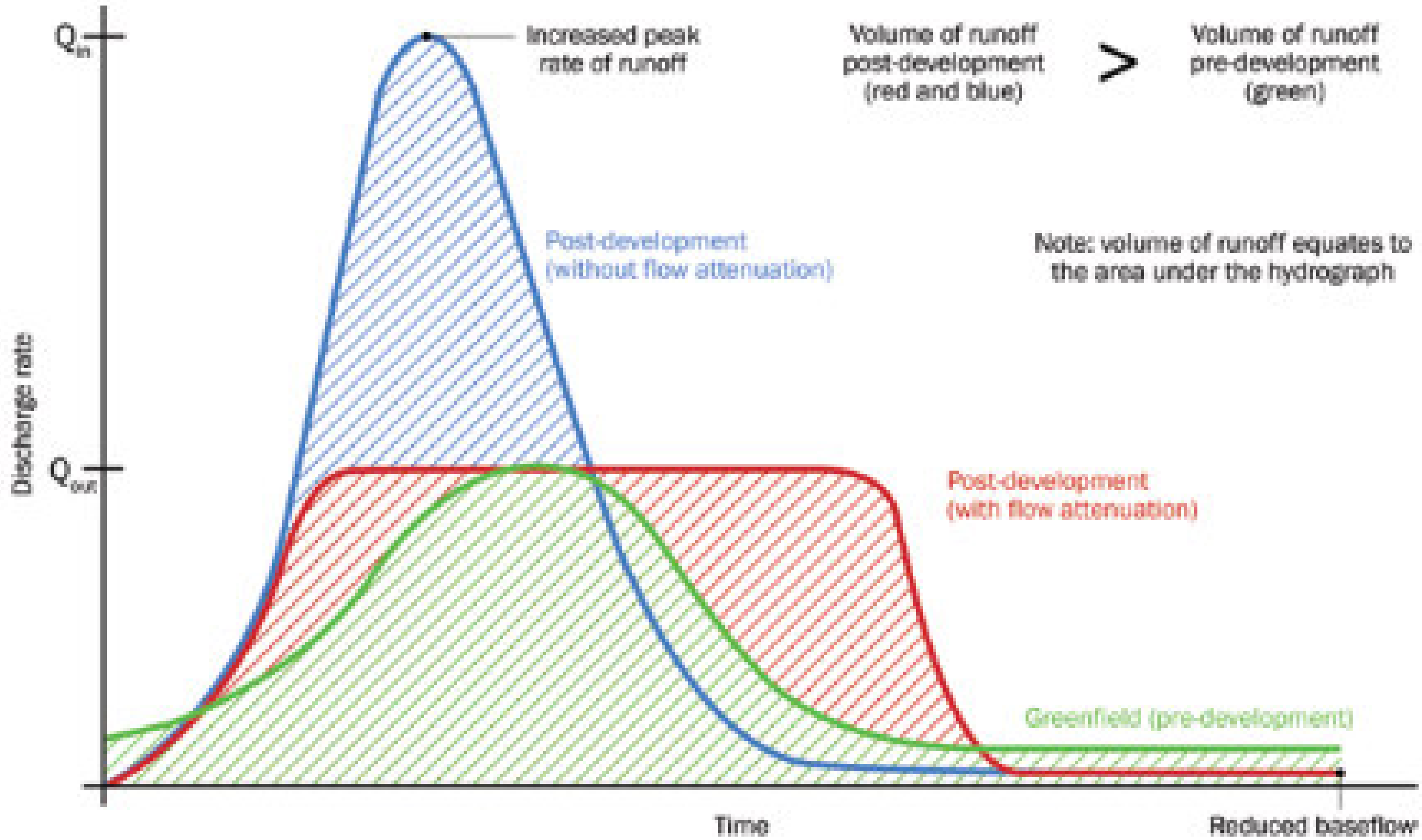


Fig 2 Sequential approach mechanism in the planning process

Site Name: Firlough Windfarm FRA, Co. Mayo	**Project No.**	603676	**Drawn By:**	Mairéad Duffy Graduate Project Scientist
	Client:	Jennings O'Donovan		
Figure Name: **Appendix A- 4:** Sequential approach mechanism in planning process (OPW,2022)	**Date:**	27/10/2022	**Reviewed By:**	Sven Klinkenbergh Principal Environmental Consultant
	Revision:	00		

Conceptual Graphics & Design for consideration at detailed design phase and engineered specification of required infrastructure. Not to scale.



Site Name: Firlough Windfarm FRA, Co. Mayo	**Project No.**	603676	**Drawn By:**	Mairéad Duffy Graduate Project Scientist	RSK
	Client:	Jennings O'Donovan			
Figure Name: **Appendix A- 5**: Example of a hydrograph (CIRCA,2015)	**Date:**	28/10/2022	**Reviewed By:**	Sven Klinkenbergh Principal Environmental Consultant	
	Revision:	00			

Conceptual Graphics & Design for consideration at detailed design phase and engineered specification of required infrastructure. Not to scale.