APPENDIX 9-1

FLOOD RISK ASSESSMENT

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REPOWERING OF KILGARVAN WIND FARM, CO. KERRY

FLOOD RISK ASSESSMENT

FINAL REPORT

Prepared for:

ORSTED

Prepared by:

HYDRO-ENVIRONMENTAL SERVICES

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1. INTRODUCTION

1.1 BACKGROUND

Hydro-Environmental Services (HES) were requested by MKO Ireland (MKO) to undertake a Flood Risk Assessment (FRA) for the proposed repowering of the Kilgarvan wind farm on the hydrological and hydrogeological environment.

The Kilgarvan wind farm currently comprises 2 no. operational wind farms, Kilgarvan I and Kilgarvan II. Currently there are 28 no. operational turbines at the Kilgarvan wind farm site. 15 no. turbines were erected as part of the Kilgarvan I wind farm development with an additional 13 no. turbines erected as part of the Kilgarvan II (Lettercannon and Inchincoosh) wind farm development.

The proposed repowering of the Kilgarvan wind farm comprises the decommissioning and dismantling of the existing 28 no. operational turbines and the erection of 11 no. larger turbines. The Proposed Development also includes upgrades to the existing site access road network, new site access roads, the expansion of an existing onsite borrow pit, temporary construction compounds and underground cabling between the proposed turbines and the existing onsite substation at Coomagearlahy. The Proposed Development utilises as much of the existing infrastructure as possible. The existing overhead grid connection will not be altered and will be utilised for the Proposed Development.

Please note that for the purposes of this FRA, where:

- the 'Proposed Development' is referred to, this relates to all the project components described in Chapter 4; and,
- 'the Proposed Development site' is referred to, this relates to the primary study area for the EIAR, as delineated by the EIAR Site Boundary.

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009).

1.2 STATEMENT OF QUALIFICATIONS

Hydro-Environmental Services ("HES") are a specialist geological, hydrological, hydrogeological and environmental practice that delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core area of expertise and experience in hydrology and hydrogeology, including flooding assessment and surface water modelling. We routinely work on surface water monitoring and modelling and prepare flood risk assessment reports.

Michael Gill PGeo (BA, BAI, MSc, MIEI) is an Environmental Engineer and Hydrogeologist with 22' years of environmental consultancy experience in Ireland. Michael has completed numerous hydrological and hydrogeological assessments for various developments across Ireland. Michael has significant experience in surface water drainage issues, SUDs design, and flood risk assessment.

Conor McGettigan (BSc, MSc) is an Environmental Scientist with 3 years' experience in the environmental sector in Ireland. Conor holds an M.Sc. in Applied Environmental Science and a B.Sc. in Geology from University College Dublin. Conor routinely completes hydrological and hydrogeological impact assessment reports, WFD compliance assessment report and flood risk assessments for a wind range of developments including wind farms on peatlands.

1.3 REPORT LAYOUT

This FRA report has the following format:

- Section 2 describes the setting and details of the Proposed Development;
- Section 3 outlines the hydrological and geological characteristics of the Proposed Development site and downstream surface water catchments;
- Section 4 presents a site-specific flood risk assessment (FRA) undertaken for the Proposed Development which was carried out in accordance with the above-mentioned guidelines;
- Section 5 assesses the development in terms of local planning policies and assesses the potential for the Proposed Development to impact flooding further downstream; and,
- Section 6 presents the FRA report conclusions.

2. BACKGROUND INFORMATION

2.1 INTRODUCTION

This section provides details on the topographical setting of the site along with a description of the Proposed Development site.

2.2 SITE LOCATION AND TOPOGRAPHY

The Proposed Development site is located approximately 5.5km northeast of the village of Kilgarvan, Co. Kerry and approximately 6km west of Coolea, Co. Cork. The Proposed Development Site has a total area of 775hectares (ha).

The Proposed Development site is located in an upland setting on the western slopes of the Derrynasaggart Mountain Range, Co. Kerry. The Proposed Development site is characterised by mountainous terrain with moderate to steep slopes in places. The land is characterised by abundant protruding ridges of bedrock outcrop with peat deposits between the ridges. Ground elevation contours within the Proposed Development site range from approximately 190 to 500mOD (metres above Ordnance Datum). Within the existing wind farm site, the local topography generally slopes to the south and southwest towards the Roughty River. The Proposed Development site is characterised by areas of coniferous forestry, transitional woodlands scrub and upland blanket bog. The Proposed Development site is drained by several mountain streams which flow to the southwest. These watercourses include the Glanlee River in the east, the Thureehouma stream to the west and several other unnamed tributaries of the Roughty River.

The topography along the main access road, which runs from the N22 to the existing wind farm site entrance, generally slopes to the north. Ground elevations in this area of the Proposed Development site range from approximately 140mOD in the vicinity of the N22 to approximately 465mOD at the entrance to the existing wind farm site. This area predominantly drains towards the Flesk River via the Coomagearlahy and the Owgarriv rivers. A small area of main access road slopes to the southwest towards the Sullane River. This area of the Proposed Development site is characterised by upland blanket bog, coniferous forestry and abundant rock outcrops.

The Proposed Development site is the location of the existing Kilgarvan Phase I and Phase II wind farm developments. These existing wind farm developments comprise a total of 28 no. operational wind turbines. The existing turbines are supported by a network of access roads, underground cabling, a meteorological mast and the on-site 110kV Coomagearlahy substation.

Access to the Proposed Development site is via the N22 using the pre-existing site access roads. The main access road is ~4km in length and runs from the N22 to the existing Kilgarvan I wind farm entrance and forms the north of the Proposed Development site.

A site location map is shown below in **Figure A**.

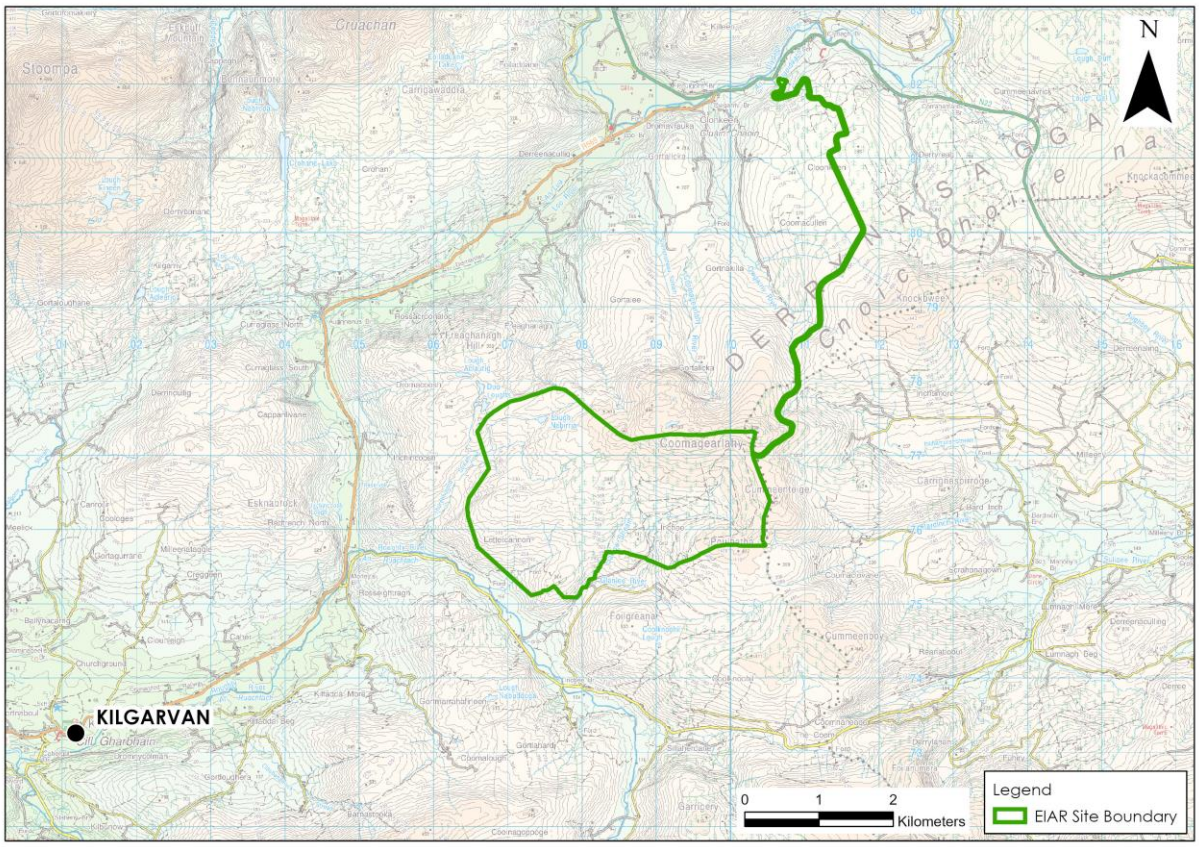

Figure A: Site Location Map

2.3 PROPOSED DEVELOPMENT DETAILS

The Proposed Development includes the dismantling of the existing 28 no. turbine wind farm (Kilgarvan Phase I and Kilgarvan Phase II wind farm developments), the upgrade of the existing site access road network, the erection of 11 no. new turbines, underground grid cabling between the proposed turbines and the existing on-site substation, upgrade of the existing substation, extension of the onsite borrow pit, 2 no. temporary construction compounds, forestry felling and all associated site development works including drainage infrastructure and landscaping.

3. EXISTING ENVIRONMENT AND CATCHMENT CHARACTERISTICS

3.1 INTRODUCTION

This section gives an overview of the hydrological and geological characteristics of the region and the Proposed Development site.

3.2 HYDROLOGY

On a regional scale, the Proposed Development site is located in 3 no. surface water catchments. The vast majority of the Proposed Development site is located within the Dunmanus-Bantry-Kenmare surface water catchment within Hydrometric Area 21. A small area in the northwest of the Proposed Development site and the majority of the main access road, is located in the Laune-Maine-Dingle Bay catchment within Hydrometric Area 22. Meanwhile, a small section of the main access road in the east is located within Lee, Cork Harbour and Youghal Bay surface water catchment within Hydrometric Area 19. All 3 no. surface water catchments are situated within the South Western River Basin District.

The Dunmanus-Bantry-Kenmare catchment includes the area drained by all streams entering the tidal water in Dunmanus, Bantry and Kenmare Bays, between Mizen Head and Glanearagh Head, Co. Kerry. The catchment drains a total area of 1,898km^2. The catchment is characterised by a series of east-west trending sandstone ridges and limestone valleys, with the limestone valleys nearly completely submerged by the sea.

On a more local scale within the Dunmanus-Bantry-Kenmare surface water catchment, the Proposed Development site is located within the Roughty River sub-catchment (Roughty_SC_010) and the Roughty_030 river WFD sub-basin. Here the Proposed Development site is drained by several tributaries of the Roughty River which flow to the southwest before discharging into the north-westerly flowing Roughty River. The main tributaries include the Garrow stream in the southeast which discharges into the Glanlee River to the south. The Glanlee River confluences with the Roughty River ~600m south of the Proposed Development Site. Further north, the Thureehouma stream flows to the southwest ~100m west of the Proposed Development site, and drains several lake waterbodies (Lough Nabirria and Doo Loughs) before its confluence with the Roughty River ~720m to the southwest of the Proposed Development site. OSI and EPA mapping also records the presence of several additional unnamed mountain streams which flow from the Proposed Development site to the southwest before discharging into the Roughty River and its tributaries. The Roughty River flows to the northwest to the south of Proposed Development Site before veering to the southwest near the R569. The Roughty River then flows to the south of Kilgarvan town before it discharges into the Roughty River Estuary.

The Laune-Maine-Dingle Bay catchment includes the area drained by the Rivers Laune and Maine and all streams entering the tidal water between Glanearagh Head and Clogher Head, Co. Kerry. The catchment drains a total area of 2,036km^2.

On a more local scale within the Laune-Maine-Dingle Bay surface water catchment, the Proposed Development site is located within the Flesk River sub-catchment (Flesk[Kerry]_SC_010) and 3 no. WFD river sub-basins. The northwest of the Proposed Development site is located in the Loo_010 river WFD sub-basin. An unnamed tributary of the Loo River rises immediately to the northwest of the Proposed Development site and flows to the north before discharging into the Loo River. The Loo River continues to the northeast and confluences with the Flesk River ~3.6km north of the Proposed Development site. However, no Proposed Development infrastructure is located within the catchment of the Loo River. Meanwhile, much of the main access road from the N22 to the existing wind farm site is located within the Flesk[Kerry]_040 and Flesk[Kerry]_030 river sub-basins. This area of the Proposed Development site is drained by the Coomagearlahy and the Owgarriv rives which merge before discharging into the Flesk River west of Clonkeen substation. The Flesk River

continues to flow to the northwest before discharging into Lough Leane to the south of Killarney town.

The Lee, Cork Harbour and Youghal Bay surface water catchment includes all areas drained by the River Lee and all streams entering the tidal water in Cork Harbour and Youghal Bay. This catchment drains a total area of 2,153km^2.

On a more local scale within the Lee, Cork Harbour and Youghal Bay surface water catchment, a small section of the Proposed Development site (main access road) is located within the Sullane River sub-catchment (Sullane_SC_010) and the Sullane_010 river WFD sub-basin. This area of the Proposed Development site is drained by the Inchamore stream which flows to the southeast before discharging into the Bardinch River. The Bardinch River confluences with the Sullane River ~4.5km southeast of the Proposed Development site.

A regional hydrology map is shown as **Figure B** below.

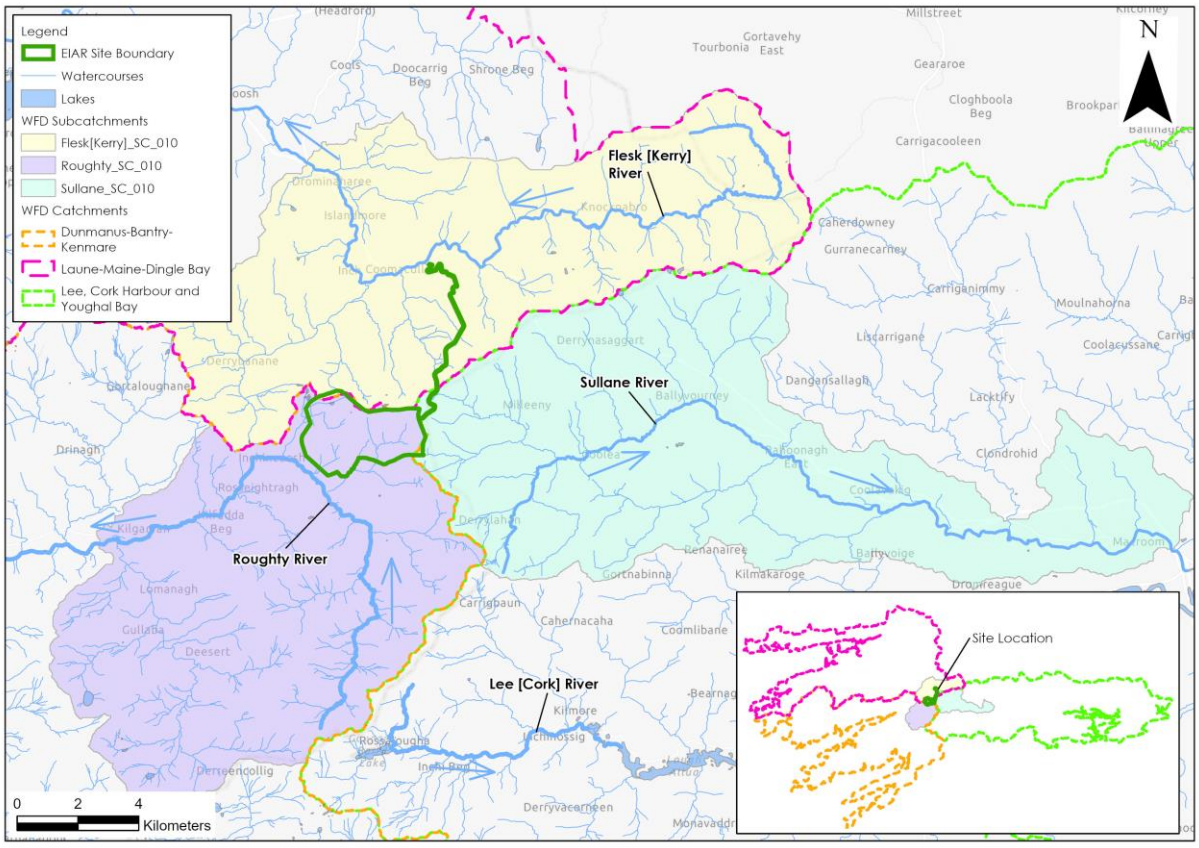

Figure B: Regional Hydrology Map

3.3 RAINFALL AND EVAPORATION

The SAAR (Standard Average Annual Rainfall) recorded at M. Ballyvourney (~6.5km northeast of the Proposed Development site), the closest rainfall station to the Proposed Development Site with long term SAAR data, is 2,024mm (www.met.ie).

Met Éireann also provide a grid of average annual rainfall for the entire country for the period of 1991 to 2020. Based on this more site-specific modelled rainfall values, the average annual rainfall at the Proposed Development site ranges from 2,129 to 2,343mm/year. The average annual rainfall is 2,236mm/yr (this is considered to be the most accurate estimate of average annual rainfall from the available sources).

The average potential evapotranspiration (PE) at Valentia Observatory, approximately 60km west of the Proposed Development site is taken to be 528.6mm (www.met.ie). The actual evapotranspiration (AE) is calculated to be 502.1mm (95% PE). Using the above values, the effective rainfall (ER)[1] for the area is calculated to be (ER = SAAR – AE) ~1,734mm/yr.

Groundwater recharge coefficient estimates are available from the GSI (www.gsi.ie) and range from 22.5% recharge in areas of blanket peat to 85% in areas where rock is close to or at the ground surface. An estimate of 4338mm/year average annual recharge is given for this area (based on a recharge coefficient of ~25%). A recharge coefficient at the lower end of the GSI scale (22.5-85% recharge) was chosen due to the coverage of blanket peat, the sloping nature of the local area and the low permeability of the underlying bedrock aquifer. This means that the hydrology of the Proposed Development site is characterised by very high surface water runoff rates and very low groundwater recharge rates where peat is present at the surface. conservative annual recharge and runoff rates for areas of the Proposed Development site which are covered in peat are estimated to be 433mm/yr and 1,301mm/yr respectively.

Table A below presents return period rainfall depths for the Proposed Development site. These data are taken from https://www.met.ie/climate/services/rainfall-return-periods and they provide rainfall depths for various storm durations and sample return periods (1-year, 5-year, 30-year, 100-year). These extreme rainfall depths will be the basis of the proposed wind farm drainage hydraulic design as described further below.

Table A. Rainfall Return Period Depths (mm)

	Return Period (Years)			
Duration	**1**	**5**	**30**	**100**
5 mins	4.0	5.7	8.3	10.5
15 mins	6.5	9.4	13.6	17.2
30 mins	9.2	13.0	18.6	23.2
1 hours	12.8	18.0	25.3	31.4
6 hours	30.6	41.4	56.4	68.3
12 hours	42.9	57.2	76.8	92.3
24 hours	60.0	79.0	104.7	124.6
2 days	78.1	100.5	130.2	152.8

**Estimated using growth factors as data not available from (www.met.ie)*

3.4 GEOLOGY

The published soils map (www.epa.ie) for the local area shows that the Proposed Development site is overlain by acid shallow, lithosolic or podzolic type soils potentially with a peaty topsoil (AminSRPT) and blanket peat (BktPt). Meanwhile, soils in the north of the main access road, in the vicinity of Clonkeen substation, are mapped by the EPA as acid deep poorly drained mineral soils (AminPD) and acid deep well drained mineral soils (AminDW). Soils in the surrounding lands are predominantly AminSRPT soils with localised pockets of blanket peat, acid shallow well drained mineral soils (AminSW) and acid poorly drains mineral soils with a peaty topsoil (AminPDPT). Mineral alluvium (AlluvMin) is mapped along the Glanlee and Roughty rivers to the south of the Proposed Development site and the Flesk River to the north.

The published subsoils map (www.gsi.ie) for the area shows that that the Proposed Development site is underlain by bedrock outcrop or subcrop (Rck) and blanket peat (BktPt). Subsoils in the existing wind farm site are dominated by bedrock outcrop with localised pockets of blanket peat. Meanwhile, subsoils along the main site access road are mapped predominantly as blanket peat with some Till derived from Devonian sandstones in the north near the existing Clonkeen substation and bedrock outcrop in the vicinity of the existing wind farm site. Subsoils in the surrounding lands comprise largely of bedrock outcrop and blanket

[1] ER – Effective Rainfall is the excess rainfall after evaporation which produces overland flow and recharge to groundwater.

peat with some areas of Till derived from Devonian sandstones (TDSs) to the south and northeast of the Proposed Development Site. Meanwhile, alluvium is mapped along the Roughty River to the southwest.

The site investigation data on soil and subsoil types within the Proposed Development site is consistent across multiple instances of trial pitting and peat probing between 2006 and 2022. A total of 106 no. trial pits have been excavated within the Proposed Development site. In addition, a total of 557 no. peat probes have been completed. Site investigation data has revealed that across much of the Proposed Development site, the peat deposits are found to be overlying bedrock. Where present subsoils underlying the peat comprise of SILTS, SANDS, GRAVELS and BOULDERS.

The GSI map the bedrock underlying the Proposed Development site to comprise of Devonian Old Red Sandstones (DORS). The Gun Point Formation underlies the south of the Proposed Development site. The Gun Point Formation is noted to comprise of green-grey sandstone and purple siltstone. The GSI state that "*in the Derrynasagart Mountains the formation comprises purple and green medium-coarse grained sandstones (locally pebbly) with thin interbedded purple siltstones*" (www.gsi.ie). Meanwhile, the north of the Proposed Development Site, including the northern section of the main access road, is underlain by the Glenfesk Chloritic Sandstone Formation. The GSI state that the main lithologies of the Glenfesk Chloritic Sandstone Formation consist of "*green coloured, mostly medium grained sandstone, conglomerate and pebbly sandstone, together with green and purple siltstone*" (www.gsi.ie).

Bedrock was encountered during the historic and recent trial pit investigations completed as part of the Kilgarvan Phase I and Phase II wind farm developments. The bedrock encountered during these excavations was described as largely red medium grained sandstone with some blue/green medium grained sandstone. The bedrock encountered during the recent walkover surveys was recorded as red and green sandstones.

3.5 DESIGNATED SITES & HABITATS

Designated sites include Natural Heritage Areas (NHAs), Proposed Natural Heritage Areas (pNHAs) Special Areas of Conservation (SACs), candidate Special Areas of Conservation (cSAC) and Special Protection Areas (SPAs). Proposed Development site is not located within any designated conservation site.

Within the Dunmanus-Bantry-Kenmare surface water catchment, the only designated sites with potential to be impacted by the Proposed Development will occur downstream along the Roughty River.

The closest designated site is the Roughty River pNHA (Site Code: 001376). This pNHA is located ~400m southwest of the Proposed Development site along the Roughty River.

The Sillahertane Bog NHA (Site Code:001882) exists ~3.1km southeast of the Proposed Development site. This designated site is located upstream of the Proposed Development site, in the Roughty_020 WFD river sub-basin.

The Kilgarvan Ice House pNHA/SAC (Site Code: 000364) exists ~3.8km southwest of the Proposed Development site, in the townland of Caher and ~7.8km to the southwest in the townland of Lounaghan.

The Roughty River Estuary becomes a pNHA (Site Code: 002092) ~12.7km southwest of the Proposed Development site. Further downstream in the vicinity of Kenmare town, the Kenmare River Estuary is designated as an SAC (Site Code: 002158). Kenmare Bay also contains a number of islands which are designated as the Kenmare River Islands pNHA (Site Code: 000363).

Within the Laune-Maine-Dingle Bay Catchment, the closest designated site to the Proposed Development site is the Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC/pNHA (Site Code: 000365). This designated site exists ~1.4km northwest of the Proposed Development site, along the Loo River and ~70m north of the existing Clonkeen substation along the Flesk River.

Further downstream, Lough Leane forms part of the Killarney National Park SPA (Site Code: 004038) and supports a wide variety of wintering waterfowl. This designated site is hydrologically connected with the Proposed Development site via the Flesk River and its associated tributaries.

Within the Lee, Cork Harbour and Youghal Bay Catchment, the only designated sites with potential to be impacted by the Proposed Development will occur downstream along the Sullane River. The closest downstream designated site is St. Gobnet's Wood SAC/pNHA (Site Code: 000106) which is located ~8.7km east of the Proposed Development site.

4. SITE-SPECIFIC FLOOD RISK ASSESSMENT

4.1 INTRODUCTION

The following assessment is carried out in accordance with '*The Planning System and Flood Risk Management Guidelines for Planning Authorities*' (DoEHLG, 2009). The basic objectives of these guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere, including that which may arise from surface water run-off;
- Ensure effective management of residual risks for development permitted in floodplains;
- Avoid unnecessary restriction of national, regional or local economic and social growth;
- Improve the understanding of flood risk among relevant stakeholders; and,
- Ensure that the requirements of EU and national law in relation to the natural environment and nature conservation are complied with at all stages of flood risk management.

4.2 FLOOD RISK ASSESSMENT PROCEDURE

This section of the report details the site-specific flood risk assessment carried out for the site and surrounding area. The primary aim of the assessment is to consider all types of flood risks and the potential impact on the development. As per the relevant guidance (DOEHLG, 2009), the stages of a flood risk assessment are:

- *Flood risk identification* – identify whether there are surface water flooding issues at a site;
- *Initial flood risk assessment* - confirm sources of flooding that may affect a proposed development; and,
- *Detailed flood risk assessment* – quantitative appraisal of the potential risk to a proposed development.

As per the Guidelines, there are essentially two major causes of flooding:

Coastal flooding, which is caused by higher sea levels than normal, largely as a result of storm surges, resulting in the sea overflowing onto the land. Coastal flooding is influenced by the following three factors, which often work in combination:

- High tide level;
- Storm surges caused by low barometric pressure exacerbated by high winds (the highest surges can develop from hurricanes); and,
- Wave action, which is dependent on wind speed and direction, local topography and exposure.

Coastal Flooding is not applicable to the Proposed Development Site.

Inland flooding which is caused by prolonged and/or intense rainfall. Inland flooding can include a number of different types:

- Overland flow occurs when the amount of rainfall exceeds the infiltration capacity of the ground to absorb it. This excess water flows overland, ponding in natural hollows and low-lying areas or behind obstructions. This occurs as a rapid response to intense rainfall and eventually enters a piped or natural drainage system.

- River flooding occurs when the capacity of a watercourse is exceeded or the channel is blocked or restricted, and excess water spills out from the channel onto adjacent low-lying areas (the floodplain). This can occur rapidly in short steep rivers or after some time and some distance from where the rain fell in rivers with a gentler gradient.

- Flooding from artificial drainage systems results when flow entering a system, such as an urban stormwater drainage system, exceeds its discharge capacity and the system becomes blocked, and/or cannot discharge due to a high-water level in the receiving watercourse. This mostly occurs as a rapid response to intense rainfall. Together with overland flow, it is often known as pluvial flooding. Flooding arising from a lack of capacity in the urban drainage network has become an important source of flood risk, as evidenced during recent summers.

- Groundwater flooding 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 tends to be very local and results from interactions of site-specific factors such as tidal variations. While water levels may rise slowly, they may be in place for extended periods. Hence, such flooding may often result in significant damage to property rather than be a potential risk to life.

- Estuarial flooding may occur due to a combination of tidal and fluvial flows, i.e., the interaction between rivers and the sea, with tidal levels being dominant in most cases. A combination of high flow in rivers and a high tide will prevent water flowing out to sea, tending to increase water levels inland, which may flood over riverbanks.

The Flood Risk Management Guidelines (DoEHLG, 2009) provide direction on flood risk and development. The guidelines recommend a precautionary approach when considering flood risk management and the core principle of the guidelines is to adopt a risk-based sequential approach to managing flood risk and to avoid development in areas that are at risk. The sequential approach is based on the identification of flood zones for inland and coastal flooding.

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

There are three types or levels of flood zones defined within the guidelines:

Flood Zone A – where the probability of flooding from rivers and the sea is highest (greater than 1% (AEP)[2] or 1 in 100 for river flooding or 0.5% (AEP) or 1 in 200 for coastal flooding);

Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% (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 from rivers and the sea is low (less than 0.1% (AEP) or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

Once a flood zone has been identified for a site, the guidelines set out the different types of development appropriate to each identified zone (pg. 25, Table 3.1 of the Guidelines). Exceptions to the restriction of development due to potential flood risks are provided for

2 AEP – Annual Exceedance Probability

through the application of a Justification Test (JT), where the planning need and the sustainable management of flood risk to an acceptable level must be demonstrated by the applicant.

The Justification Test (JT) has been designed to rigorously assess the appropriateness, or otherwise, of particular developments that, for the reasons outlined above, are being considered in areas of moderate or high flood risk. The test is comprised of two processes.

- The first is the **Plan-making Justification Test** described in chapter 4 of the Guidelines and used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding. Plan making Justification Tests are made at Plan/Policy development stage such as County Development Plans, or Local Area Plans.

- The second is the **Development Management Justification Test** described in chapter 5 of the Guidelines and 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. For example, application of Development Management Justification Test would be required at a site-specific level, such as for this FRA assessment, if a Justification Test is required.

4.3 FLOOD RISK IDENTIFICATION

4.3.1 Soils Maps - Fluvial Maps

A review of the soil types in the vicinity of the Proposed Development site was undertaken as soils can be a good indicator of past flooding in an area. Due to past flooding of rivers deposits of transported silts/clays referred to as alluvium build up within the floodplain and hence the presence of these soils is a good indicator of potentially flood-prone areas.

Based on the EPA/GSI soil map (www.epa.ie and www.gsi.ie) for the local area mineral alluvium is mapped along the Roughty River to the southwest. Some small areas of alluvium are also recorded along the Glanlee River ~750m south of T11. No mineral alluvium is mapped along the Garrow stream, the Thureehouma stream or any of the other small mountainous streams which drain the existing wind farm site. Therefore, there is not any significant alluvium deposition within this area of the Proposed Development site that would be associated with a flood plain or a large geographical area prone to flooding.

In terms of the main site access road, no areas of alluvium are mapped along the Coomagearlahy or Owgarriv rivers. Mineral alluvium is mapped along the Flesk River, ~100m north of the Proposed Development site. Meanwhile, within the Lee, Cork Harbour and Youghal Bay catchment, mineral alluvium is recorded on the Inchamore stream, ~3km southeast of the Proposed Development site.

4.3.2 Historical Mapping

To identify those areas as being at risk of flooding, historical mapping was consulted and reviewed. There is no text on local available historical 6" or 25" mapping that identify areas that are "*prone to flooding*" within the Proposed Development site.

4.3.3 OPW National Flood Hazard Mapping

To identify those areas as being at risk of flooding, OPW's River Flood Extents Mapping, National Indicative Fluvial Mapping, Past Flood Event mapping (https://www.floodinfo.ie/map/floodmaps/) were consulted.

The OPW National Flood Hazard Maps have no records any recurring or historic flood incidences within the Proposed Development site (www.floodinfo.ie).

Within the Dunmanus-Bantry-Kenmare catchment the closest mapped recurring flood event (Flood ID: 4707) is located at Insheese, ~2.35km southeast and upstream of the Proposed Development site. Here a section of the roadway was washed away by floods in 1991 (www.floodinfo.ie). There are no recurring or historic fluvial flood events recorded downstream of the Proposed Development site on the Roughty River. The closest mapped downstream flood events are situated near Kenmare town and are associated with coastal and estuarine flooding.

Meanwhile, within the Laune-Maine-Dingle Bay catchment a historic flood event is mapped ~800m downstream of the Proposed Development site along the Flesk River (Flood ID: 4677). This flood event is associated with fluvial flooding along the Flesk River and is mapped ~800m downstream of the Proposed Development site. This flood event dates from 1986 where ~400m of the R569 was washed away. Following the flooding, the river was cleaned and deepened and flooding has not recurred at this location (www.floodinfo.ie). Further downstream a recurring flood event is also recorded on the Flesk River at Loo Bridge (Flood ID: 4727) where heavy rainfall is reported to result in the Flesk River overflowing its banks. Recurring flood events are also noted on the Flesk River at Garries (flood ID: 3481) and at Glenflesk (Flood ID: 4676). A report from the local area engineer in 1995 stated that "*the River Flesk is a fast flowing river from a catchment containing high mountains. During floods the water cannot be contained within the riverbanks and there is extensive overland flow*" (www.floodinfo.ie).

Within the Lee, Cork Harbour and Youghal Bay surface water catchment, the closest mapped historic flood event (Flood ID: 13963) is located in the townland of Coolea on the Sullane River, ~5km southeast of the Proposed Development site.

Furthermore, according to the OPW (www.floodmaps.ie), no areas of the Proposed Development site are classified as "*Benefiting Lands*". Benefiting lands are defined as a dataset prepared by the Office of Public Works identifying land that might benefit from the implementation of Arterial (Major) Drainage Schemes (under the Arterial Drainage Act 1945) and indicating areas of land subject to flooding or poor drainage.

A map of local recurring and historic flood events is shown below as **Figure C**.

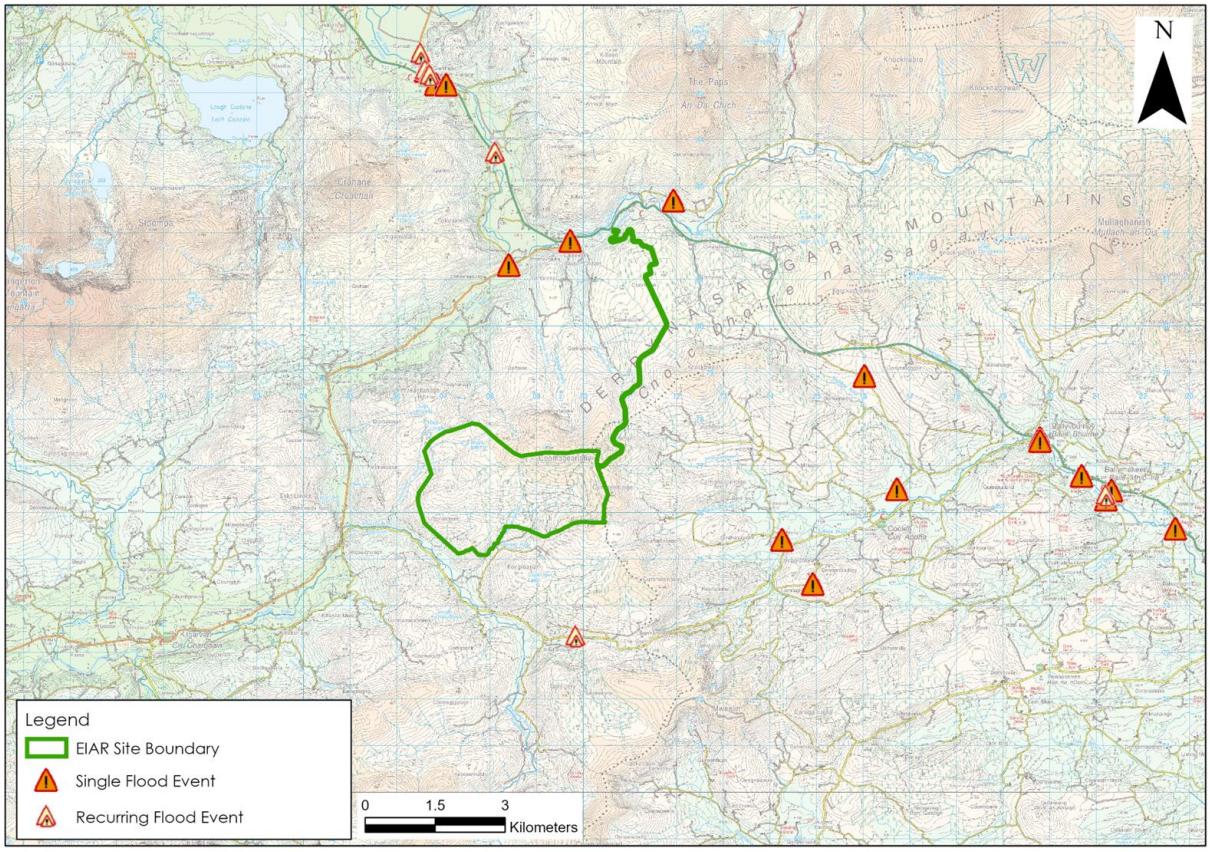

Figure C: OPW Indicative Flood Map (www.floods.ie)

4.3.4 GSI Surface Water Flood Mapping

The GSI Winter (2015/2016) Surface Water Flooding map[3] shows areas of fluvial and pluvial flood extents during the Winter 2015/2016 flood event, which was the largest recorded flood event in many areas. This surface water flood map is available to view at www.floodinfo.ie.

The GSI Winter 2015/2016 Surface Water Flood Map does not record any flood zones long the streams and watercourses which drain the Proposed Development site. However, an area of surface water flooding occurs in the northwest of the Proposed Development site and coincides with the location of Lough Nabirria. This flood zone is situated ~170m southwest of T6.

To the north and downstream of the Proposed Development site, flooding was recorded along the Flesk River near Garries and Glenflesk.

Several other small areas of flooding are mapped to the north and northwest of the Proposed Development site and correspond to the locations of Lough Greana, Doo Loughs and Lough Aclawrig.

No areas of surface water flooding were recorded along the Roughty River, the Garrow River or any of the watercourses draining the Proposed Development site. Meanwhile, surface water flooding was recorded along the Flesk River with the nearest flood zones situated ~3km northwest of the Proposed Development site. No surface water flooding was recorded along the Inchamore stream or the Bardinch River to the east of the Proposed Development site.

The GSI Historic Surface Water Flood map is included as **Figure D**.

3 GSI Historical flood mapping principally developed using Sentinel-1 Satellite Imagery from the European Space Agency Copernicus Programme as well as any available historic records (from winter 2015/2016 or otherwise).

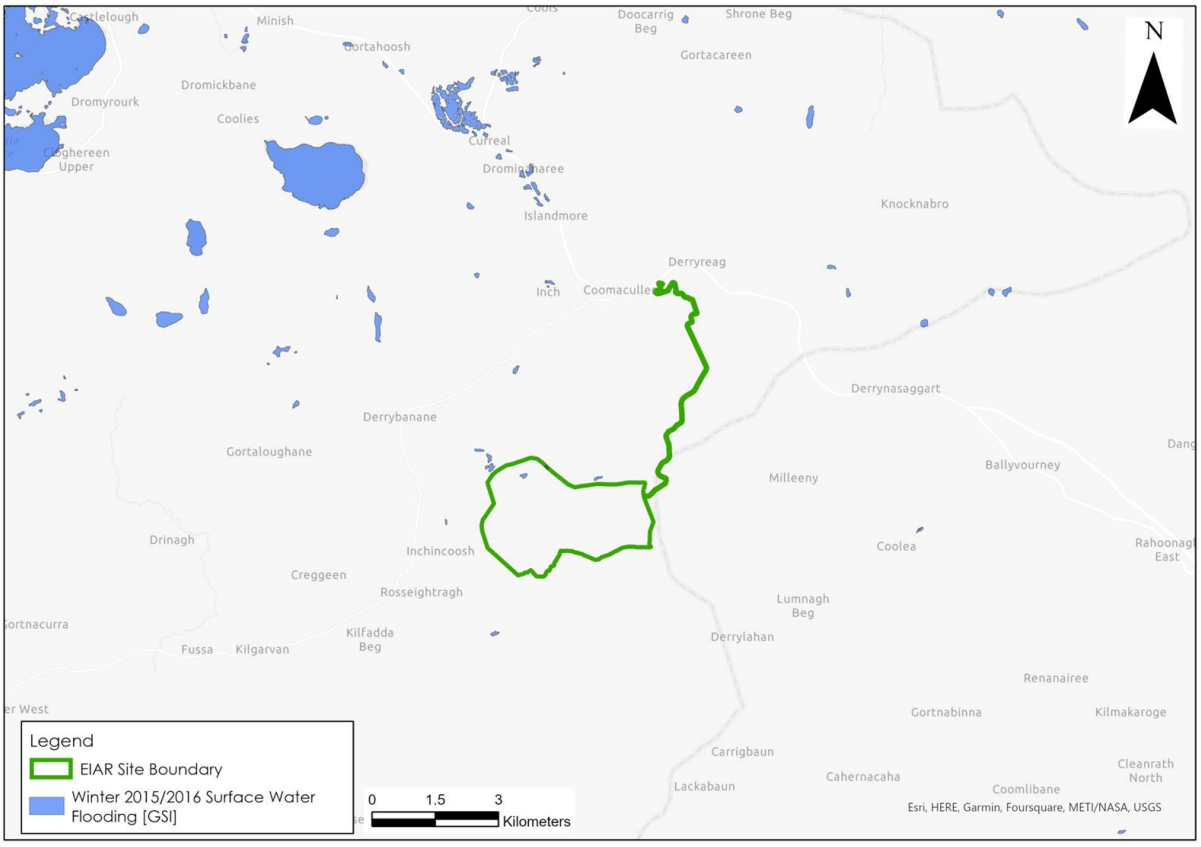

Figure D: GSI Historical Surface Water Flood Map (www.opw.ie)

4.3.5 CFRAM Fluvial Flood Mapping

Catchment Flood Risk Assessment and Management (CFRAM)[4] OPW Flood Risk Assessment Maps are now the primary reference for flood risk planning in Ireland and supersede the previous PFRA[5] maps. CFRAM mapping of river flood extents are available at www.floodinfo.ie.

However, no CFRAM mapping has been completed in the vicinity of the Proposed Development site. The closest CFRAM mapping downstream of the Proposed Development site, within the Dunmanus-Bantry-Kenmare catchment, is located at Kenmare where fluvial and coastal flood zones have been modelled.

Meanwhile, within the Laune-Maine-Dingle Bay Catchment, CFRAM mapping has been completed along the Flesk River. The closest fluvial flood zones are located ~850m west of the Proposed Development site.

Within the Lee, Cork Harbour, Youghal Bay Catchment, CFRAM mapping has been completed along the Sullane River. However, the closest fluvial flood zones are located ~8km east of the Proposed Development site.

4.3.6 OPW National Indicative Fluvial Flood Mapping

The National Indicative Fluvial Flood Mapping (www.floodinfo.ie) shows probabilistic fluvial flood zones for catchments greater than 5km^2 for which flood maps were not produced under the River Flood Extents Mapping.

4 CFRAM is Catchment Flood Risk Assessment and Management. The national CFRAM programme commenced in Ireland in 2011 and is managed by the OPW. The CFRAM Programme is central to the medium to long-term strategy for the reduction and management of flood risk in Ireland.

5 Preliminary Flood Risk Assessment mapping.

The Present Day Scenario has been generated using methodologies based on historic flood data and does not consider the potential changes due to climate change. The potential effects of climate change on flooding have been separately modelled (see **Section 4.3.9** below).

For the Present Day Scenario, medium (1 in 100-year) and low probability (1 in 1,000-year) fluvial flood zones have been mapped along the Roughty and the Glanlee Rivers to the south of the Proposed Development site. These modelled fluvial flood zones do not encroach upon the Proposed Development site.

Meanwhile, within the Laune-Maine-Dingle Bay Catchment, fluvial flood zones have been mapped along the Loo River ~2km northwest of the Proposed Development site. Flood zones are also recorded along the Owgarriv River downstream of the main site access road. At its closest point the low probability flood zone is mapped ~1.5km from the Proposed Development site. Flood zones are also mapped along the Flesk River, ~70m north of Clonkeen substation.

Within the Lee, Cork Harbour, Youghal Bay Catchment, medium and low probability flood zones are mapped along the Bardinch River and Inchamore stream to the southeast of the Proposed Development site. These fluvial flood zones are situated ~2.5km from the Proposed Development site boundaries.

Therefore, according to the National Flood Indicative Flood Mapping the Proposed Development site is located in Flood Zone C, where the probability of fluvial flood mapping is low. NIFM for the local area is shown as **Figure E**.

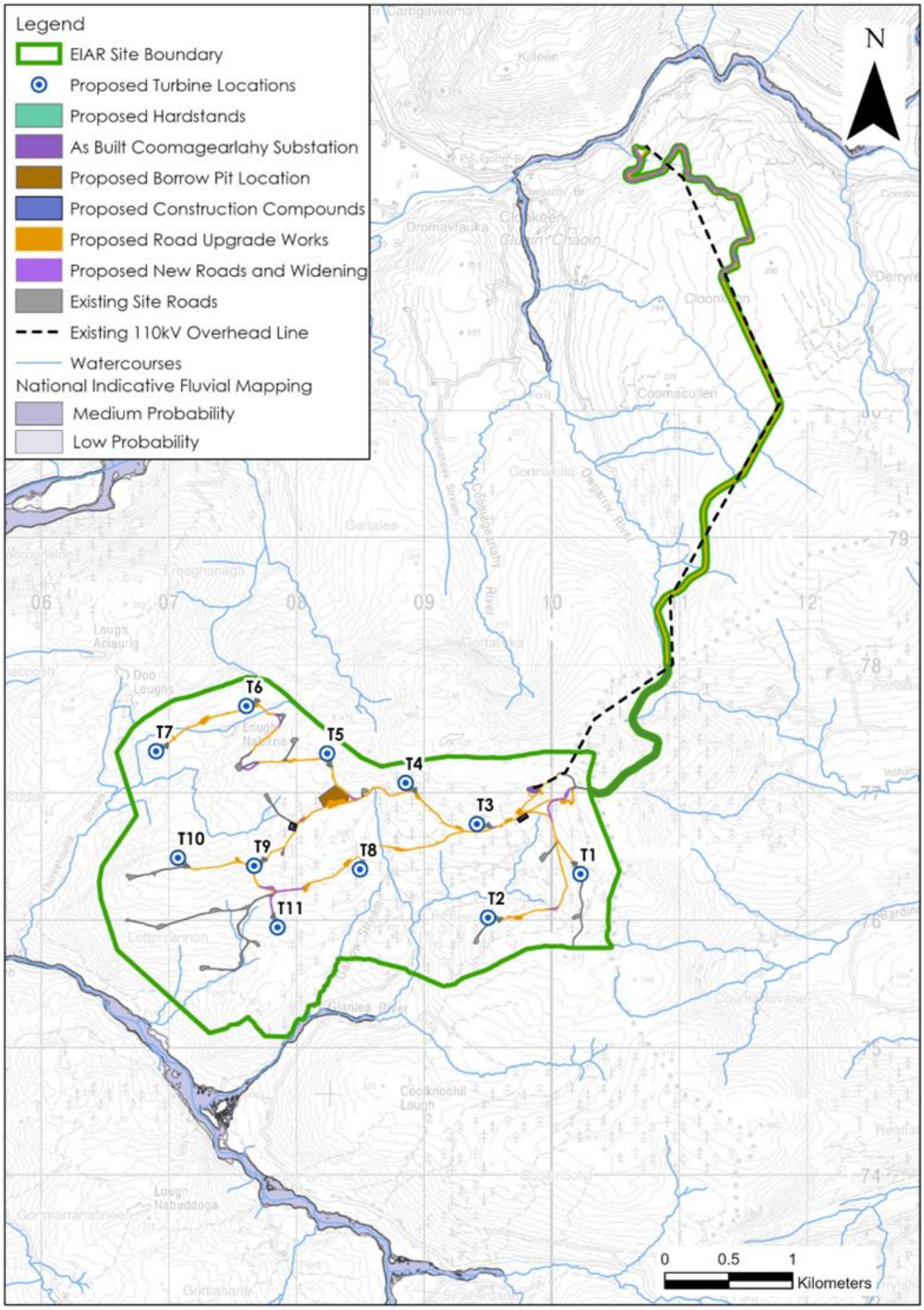

Figure E: OPW National Indicative Fluvial Flood Zone Mapping (www.floodinfo.ie)

4.3.7 Groundwater Flooding

The GSI Historical Groundwater flood map and the modelled groundwater flood extents maps (www.floodinfo.ie) do not show the occurrence of any groundwater flooding within the Proposed Development site or in the surrounding lands.

4.3.8 Coastal Flooding

The closest mapped coastal (tidal) flood zones to the Proposed Development site are located in the Inner Kenmare Estuary ~13km to the southwest.

The Proposed Development site is located inland and at a significant elevation (190-500mOD) and is therefore not at risk of coastal/tidal flooding.

4.3.9 Climate Change

It is likely that climate change will have significant impacts on flooding and flood risk in Ireland due to rising sea levels, increased winter rainfall and more intense rainfall. The CFRAM Programme has modelled flooding associated with potential future climate change scenarios. However as stated above no CFRAM modelling has been completed in the vicinity of the Proposed Development Site.

National Indicative Fluvial Mapping has been completed for catchments greater than 5km^2 for which flood maps were not produced under the CFRAM Programme. These flood zones have also been modelled for 2 no. potential future climate change scenarios, with the Mid-Range and High-End Future Scenario flood extents generated using an increase in rainfall of 20% and 30% respectively.

Both of these modelled flood extents show similar flood zones to the Present Day Scenario discussed above in **Section 4.3.6**. Therefore, flood zones at the Proposed Development site are unlikely to be significantly impacted by future climate change.

4.3.10 Summary – Flood Risk Identification

Based on the information gained through the flood identification process, no parts of the Proposed Development site are mapped within any fluvial flood zones (Flood Zones A - B). The Proposed Development site is located above the mapped 1,000-year flood level and therefore is in Flood Zone C (Low Risk).

The main potential flood risk associated within the Proposed Development site is pluvial flooding/surface water ponding. However, due to the sloping topography of the Proposed Development site, the risk is likely to be low.

4.4 INITIAL FLOOD RISK ASSESSMENT

4.4.1 Site Walkover Survey

Detailed walkover surveys of the Proposed Development site and the surrounding areas was undertaken by HES on 7th July 2022 and 25th January 2023.

During these surveys the Proposed Development site was noted to be mountainous with topography falling steeply in places. The existing wind farm site slopes to the south and towards the Roughty River valley while the majority of the main site access road slopes steeply to the north towards the Flesk River valley.

Bedrock outcrop is abundant towards the north of the existing wind farm site. The site was noted to be drained by several 1st or 2nd order streams which flow rapidly downslope, discharging into the Roughty River to the south.

The Garrow Stream is mapped to originate in the north of the Proposed Development site, ~250m southwest of T4. This stream drains the east of the Proposed Development site, flowing southwards before discharging into the Glanlee River ~750m southeast of T11. The Glanlee River discharges into the Roughty River 800m to the southwest of the Proposed Development

site. The west of the Proposed Development site also drains towards the Roughty River via several 1st and 2nd order streams, many of which are unnamed. The Thureehouma stream drains Lough Nabirra, a surface water lake located ~180m southwest of T6. This stream also receives drainage from Doo Loughs, 2 no. surface water lakes located to the northwest of the Proposed Development site. The Thureehouma stream discharges into the Roughty River to the southwest of the Proposed Development site.

During the walkover survey, there was little evidence of previous out-of-bank flow from within the various stream channels.

Two rounds of surface water flow monitoring were carried out at the main streams draining the Proposed Development site and the results are shown in **Table B** below, with the locations shows in **Figure B** below also. With the exception of SW4 which is located on the Roughty River to the south of the Proposed Development site, the measured flows are typical of seasonal flows for first/second order streams.

Table B: Surface Water Flow Monitoring

Location/Date	07/07/2022	24/01/2023
	Flow (l/sec)	Flow (l/sec)
SW1	5	5
SW2	3	3
SW3	12	10
SW4	1,000	5,000
SW5	3	5
SW6	5	5

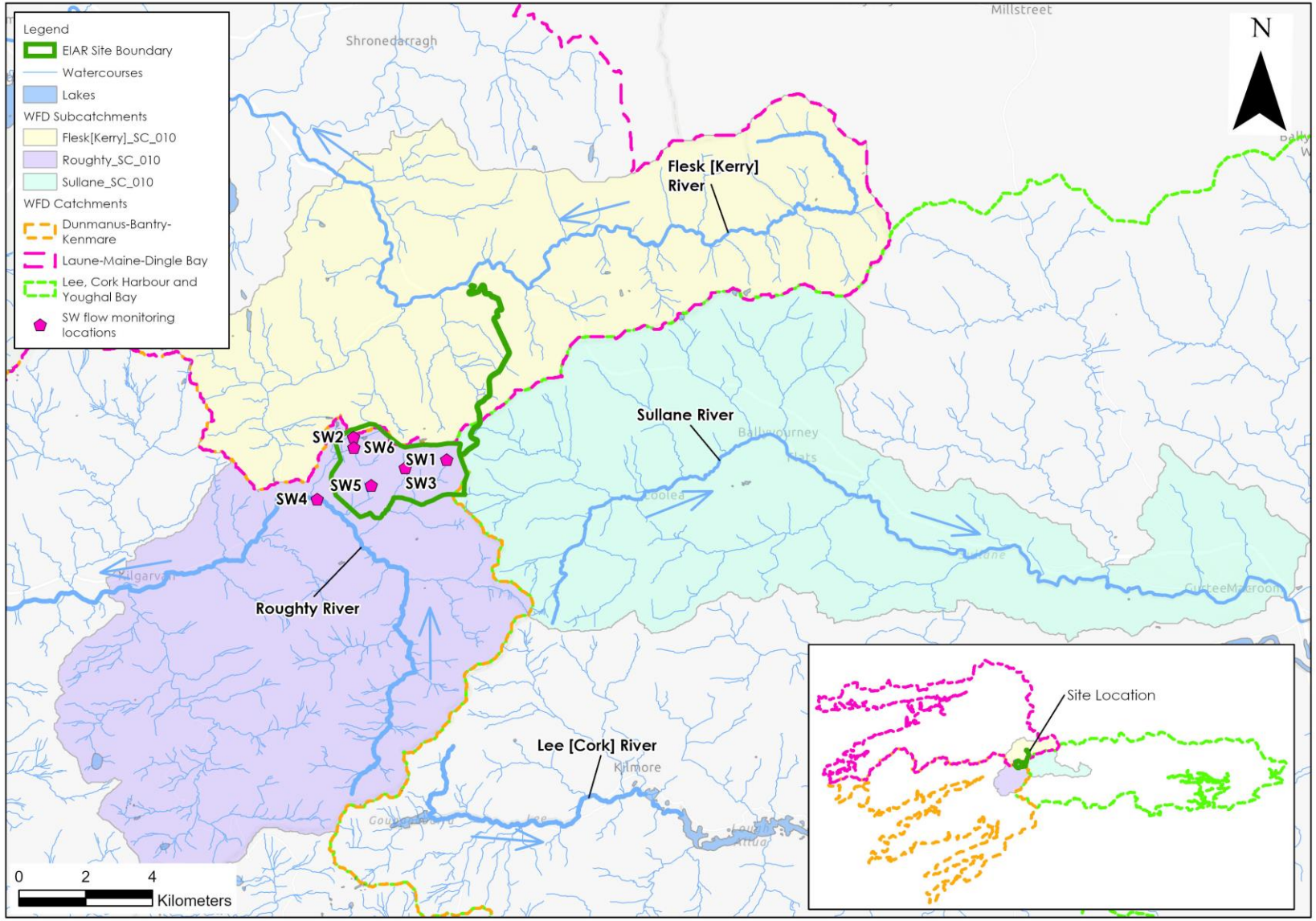

Figure F: Surface Water Flow Monitoring Locations

4.4.2 Hydrological Flood Conceptual Model

Potential flooding in the vicinity of the Proposed Development site can be described using the Source – Pathway – Receptor Model (S-P-R). The primary potential source of flooding in this area, and the one with the most consequence for the Proposed Development site, is fluvial flooding. The primary potential pathways, in the most likely order of significance, would be overbank flooding of the first and second order streams which drain the Proposed Development site. The potential receptors in the area are infrastructure and land as outlined below.

4.4.3 Summary – Initial Flood Risk Assessment

Based on the information gained through the flood identification process and Initial Flood Risk Assessment process the sources of flood risk for the site are outlined and assessed in **Table C.**

Table C. S-P-R Assessment of Flood Sources for the Proposed Development Site.

Source	Pathway	Receptor	Comment
Fluvial	Overbank flooding of the 1st and 2nd order streams within the Proposed Development site including the Garrow and Thureehouma streams	Land and infrastructure	Within the Proposed Development site all proposed turbine location and key infrastructures are located outside the 50m hydrological buffer zone. All streams are small (i.e., first and second order streams) with small flow volumes. All watercourses flow downslope, flowing the topography and discharge to the Roughty River. No fluvial flood zones are mapped within the Proposed Development site. There is a low risk of fluvial flooding within the Proposed Development site due to the small nature of these streams and the sloping ground.
Pluvial	Ponding of rainwater on-site	Land and infrastructure.	There is very little risk of pluvial flooding within the Proposed Development site as drainage moves relatively freely off sloping ground. Some areas of flatter ground may be susceptible to surface water ponding following periods of intense or prolonged rainfall.
Surface water	Surface ponding/ Overflow	Land and infrastructure.	Same as above (pluvial)
Groundwater	Rising groundwater levels	Land and infrastructure.	Based on the local hydrogeological regime and GSI groundwater flood mapping, there is no apparent risk from groundwater flooding.
Coastal/tidal	Not applicable	Land and infrastructure	The Proposed Development site is >13km from the coast, and at an elevation of ~190 to 500m OD and there is no risk of coastal flooding.

4.5 REQUIREMENT FOR A JUSTIFICATION TEST

A matrix of vulnerability versus flood zone is shown in **Table D**. This table is used to illustrate appropriate development types or indicate when a Justification Test[6] is required.

It may be considered that the Proposed Development can be categorised as "Highly Vulnerable Development". However, as stated above, all Proposed Development infrastructure is located in Flood Zone C (Low Risk) and therefore the Proposed Development is appropriate from a flood risk perspective.

Table D: Matrix of Vulnerability versus Flood Zone

	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

Note: *Taken from Table 3.2 (DoEHLG, 2009)*
Bold: *Applies to this project.*

[6] *A 'Justification Test' is an assessment process designed to rigorously assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk, (DoEHLG, 2009).*

5. FLOOD IMPACT PREVENTION AND DRAINAGE MANAGEMENT

5.1 RELEVANT LOCAL AUTHORITY SUDS GUIDANCE

Guidance in relation to surface water management and sustainable urban drainage is provided in the Draft Kerry County Development Plan (CDP) 2022-2028.

Section 11.5 of the CDP details the objectives of the Council in relation to 'Land Use and Flood Risk Management".

Council objective 11-66 states that:

> *"It is an objective of the Council to have regard to and implement the recommendation and provisions of the Planning System and Flood Risk Management guidelines (DoEHLG, 2009)*."

Furthermore, and of particular relevance for the Proposed Development, council objective 11-68 states that:

> *"It is an objective of the Council to ensure that development in upland areas provide sufficient storm water attenuation to avoid the occurrence of river erosion or flooding downstream subject to hydrological and ground/peat stability assessments".*

5.2 PROPOSED DRAINAGE

The Proposed Development drainage system was designed integrally with the wind farm layout as a measure to ensure that the Proposed Development will not change the existing flow regime across the Proposed Development site, will not deteriorate water quality and will safeguard existing water quality status of the catchments from wind farm related sediment runoff.

Given the presence of several surface streams in the vicinity of the Proposed Development site and the sloping / mountainous nature of the land, overland flow rates are likely to be significant. Therefore, the drainage system must be designed and managed properly if it is to work effectively. A fundamental principle in the drainage design is that clean water continues to flow downstream in existing streams. The primary threat is due to potential contaminated by silt from the works. The dirty water from the works areas shall be collected in a separate drainage system and treated by removing the suspended solids before discharging into the existing watercourses.

Drains will be constructed on the uphill side of the works and piped to the downhill side, bypassing the works areas. However, this will cause the normally dispersed flow to be concentrated at specific discharge points downstream of the works. In order to disperse this flow each clean water drain will be terminated in a discharge channel running parallel to the ground contours that will function as a weir to disperse the flow over a wider area of vegetation. This will prevent erosion of the ground surface and will attenuate the flow rate to the downstream receiving waters.

The resultant diversion of clean water runoff will ensure that the treatment system will only need to deal with construction related runoff. The treatment system consists of a series of settlement ponds that are located at each works site and at intervals along the access roads. The outflow from the settlement ponds will be allowed to disperse across vegetation and will become diluted through contact with the clean water runoff in the buffer areas before entering the downstream watercourses.

5.3 PROPOSED ON-SITE RUNOFF ATTENUATION

The creation of impermeable areas within the Proposed Development site has the effect of increasing rates of runoff into the downstream drainage system and this may increase flood risk and flood severity downstream. This applies particularly to urban areas that drain to closed pipe systems which do not have the capacity to cater for increased hydraulic loads. However, the Proposed Development site is located within a large rural catchment with an open drainage system. The footprint of the impermeable areas and the associated increase in runoff rate is very small in the context of the catchment size and therefore represents a negligible increase in downstream flood risk. Notwithstanding the low increase in flood risk due to the development, the drainage system has been designed to prevent any increase in discharge rates above that which already exist at the site.

The volume of water requiring attenuation relates to direct precipitation on the roads and hard-standing footprint only. The aim of the storm water attenuation measures is to limit the flow rate from the developed area to that which prevails at the site. This is achieved by limiting the flow rate to the downstream receiving waters and temporarily storing the excess water that accumulates as a result. The developed surfaces have some permeability and this reduces the attenuation requirement. Conventional attenuation systems use proprietary flow control units but these can become blocked with debris and vegetation and require regular maintenance. They are therefore not appropriate for use within a forestry environment or where routine maintenance would not be practical.

It is proposed to provide the temporary storage within the drainage channels by creating stone dams within them at regular intervals. The spacing of the dams is typically 100m but depends on the channel slope, with steeper channels requiring shorter intervals. The dams, which are constructed with small sized aggregate, also reduce the flow rate through the drainage system and are an effective means of providing flow control. Silt fence also provide storage and flow control.

All runoff from the developed areas will be routed through settlement ponds downstream. The outflow from the settlement ponds will be released in a controlled and diffuse manner. Therefore, the proposal will not increase the magnitude of the hydrograph peak. The control measures are passive as opposed to mechanical and do not require maintenance to ensure their ongoing effectiveness.

5.4 FLOOD IMPACT SCREENING FOR DESIGNATED SITES

Table E provides a flood impact screening for local designated sites.

Table E: Flood Impact Screening for Local Designated Sites

Name	Site Code	Flood Risk Screening
Roughty River pNHA	001376	No increased flood risk, small development footprint and attenuation proposals outlined above.
Kilgarvan Ice House pNHA/SAC	000364	No increased flood risk, small development footprint and attenuation proposals outlined above.
Kilgarvan Wood pNHA	001787	No increased flood risk, small development footprint and attenuation proposals outlined above.
Roughty River Estuary pNHA	002092	No increased flood risk, small development footprint and attenuation proposals outlined above.

6. REPORT CONCLUSIONS

- A flood risk identification study was undertaken to identify existing potential flood risks associated with the proposed repowering of Kilgarvan wind farm, Co. Kerry. From this study:
    - No instances of historical flooding were identified in historic OS maps within the Proposed Development site;
    - No instances of recurring flooding were identified on OPW maps within the Proposed Development site;
    - The GSI Historical 2015/2016 flood map records some areas of flooding within the Proposed Development site and in the surrounding lands. These historic surface water flood zones correspond to the location of several mapped lake waterbodies;
    - The Proposed Development site was not identified as being within CFRAM Flood Zones;
    - No National Indicative Fluvial Flood Zones are located within the Proposed Development site. The closest mapped fluvial flood zones are located on the Glanlee and Roughty rivers to the south and the Owgarriv River to the north;
    - The GSI Groundwater flood mapping does not record any historic or modelled flood zones within the Proposed Development site; and,
    - There is no evidence that the existing wind farm at Kilgarvan has contributed to downstream flooding.
- The main risk of flooding across the Proposed Development site is via pluvial flooding in the flatter areas;
- Site walkover surveys indicate that the site contains a high density of small mountainous streams which flow rapidly downslope. However, following periods of intense or prolonged rainfall some surface water ponding may occur in certain flat areas of the Proposed Development site. Elsewhere where the topography is sloping , surface water will runoff into nearby watercourses;
- The Proposed Development site is not susceptible to coastal, fluvial or pluvial flooding.
- It can be considered that the Proposed Development can be categorised as a "Highly Vulnerable Development". This flood risk assessment concludes that the Proposed Development Site is located within a low-risk areas (Flood Zone C), and as such is appropriate from a flood risk perspective;
- Flood risks associated with potential fluvial flooding downstream of the Proposed Development site can be managed by way of standard road drainage measures, scour protection measures and the implementation of attenuation systems; and,
- The overall risk of flooding within the Proposed Development site is estimated to be low due to the elevation of the site and the sloping and mountainous nature of the local area.

* *

7. REFERENCES

AGMET	1996	Agroclimatic Atlas of Ireland.
DOEHLG	2009	The Planning System and Flood Risk Management.
Met Eireann	1996	Monthly and Annual Averages of Rainfall for Ireland 1961-1990.
Kerry County Council	2021	Kerry County Development Plan 2022-2028
CIRA	2003	Development and Flood Risk – Guidance for the Construction Industry.