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EIAR Volume 6: Onshore Infrastructure Technical Appendices Appendix 6.5.4-3: Flood Risk Assessment for the Dublin Array, Operation and Maintenance Base

Kish Offshore Wind Ltd

RWE SLR GoBe APEM Group

www.dublinarray-marineplanning.ie




Flood Risk Assessment

Dublin Array, Operation and Maintenance Base, Dún Laoghaire Harbour.

August 2024

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Comments

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1. Introduction

This report has been prepared by Waterman Moylan, on behalf of the Applicant, Kish Offshore Wind Limited, as part of the development consent submission for a proposed Operation and Maintenance (O&M) Base, located at St Michael's Pier, Dún Laoghaire Harbour, for the proposed Dublin Array Offshore Wind Farm. This O&M development is located in the Dún Laoghaire Rathdown County Council (DLRCC) administrative area, Dublin.

The Dublin Array Offshore Wind Farm is referred to as 'Dublin Array' within this report.

This Flood Risk Assessment has been carried out in accordance with the DEHLG/OPW Guidelines on the Planning Process and Flood Risk Management published in November 2009. This assessment identifies and assesses the potential risk of flooding of the proposed development from various sources and, where necessary, sets out possible mitigation measures against the identified risk. Sources of possible flooding include coastal/tidal, fluvial, pluvial, groundwater, and human error.

This report provides an assessment of the subject site for flood risk purposes only.

2. Subject Site

2.1 Existing Site Location

The site is located at Dún Laoghaire Harbour, Dún Laoghaire, Co. Dublin and is also referred to as 'St. Michaels Pier' which is located north of Harbour Road. Refer to Figure 2-1 for the location of the subject site. The site is located on and adjacent to tidal waters.

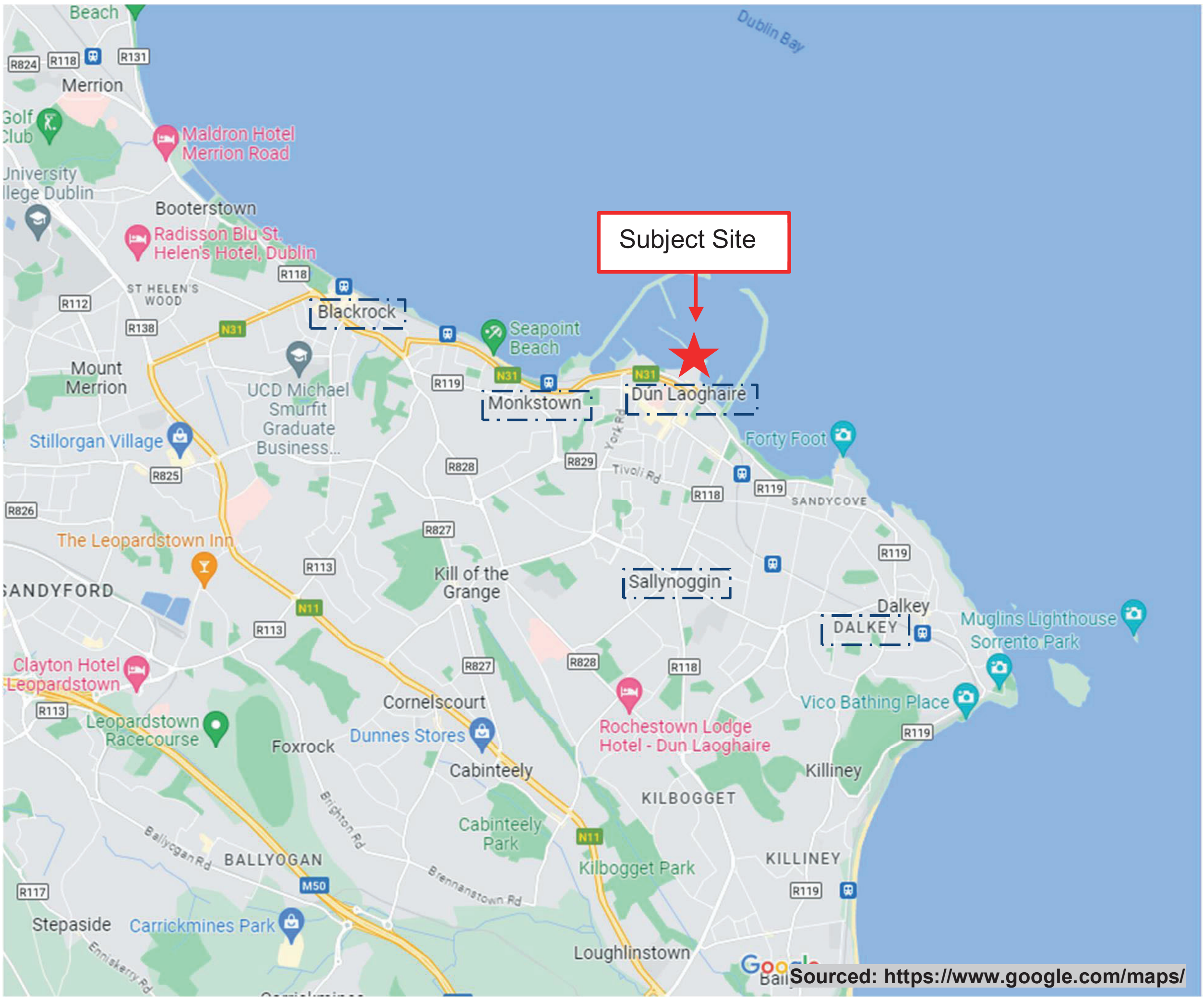


Figure 2-1: Subject Site Location Map (Google Maps)

2.2 Existing Site Description

The existing site is currently used as a maintenance depot and service yard for maintenance associated with harbour operations by Dún Laoghaire Rathdown County Council (DLRCC). The overall site area is approximately 25,898 m^2 (2.5898ha).

The current infrastructure within the site includes a parking area, an office and maintenance workshop building, dock storage containers and the northern end of the St. Michael's Pier. The site also includes the landside ramp structure that served the HSS Stena Ferry service. This ramp structure is now redundant. Other infrastructure includes the now redundant main fender piles and fender panel for the HSS Stena ferry, which are located in the sea adjacent to the northern end of St Michael's Pier and which are propped from the pier via 4 large diameter tubular steel struts.

The existing services on site include a foul drainage network, water supply network, surface water drainage network, gas, public lighting, and electrical ducting. All existing services will remain in-situ. Refer to Waterman Moylan Drawing No. DUN-WMC-ZZ-XX-DR-C-P0400 included as part of this application for the layout of the existing civil services within the subject site.

Access to the site is from Harbour Road. Refer to Figure 2-2 for an aerial image of the existing St. Michaels Pier.

Figure 2-2: Proposed Operation and Maintenance Base Site

2.3 Site Topography

St. Michael's Pier is generally flat at an elevation of c. +4.10 m OD Malin, and the existing ferry ramp from northeast to southwest with elevations ranging from a high of +7.14 m OD Malin at the top and a low of +4.40 m OD Malin at the bottom of the ramp. Levels in the marshalling yard and paved areas west of St Michael's Pier vary between +4.1m and +4.4m OD Malin in the vicinity of the site. Refer to Figure 2-3 for an extract of the existing site levels. Seabed levels around St Michael's Pier are variable, with depths between 5m and 8m below Chart Datum (-7.5m OD Malin to -10.5m OD Malin).

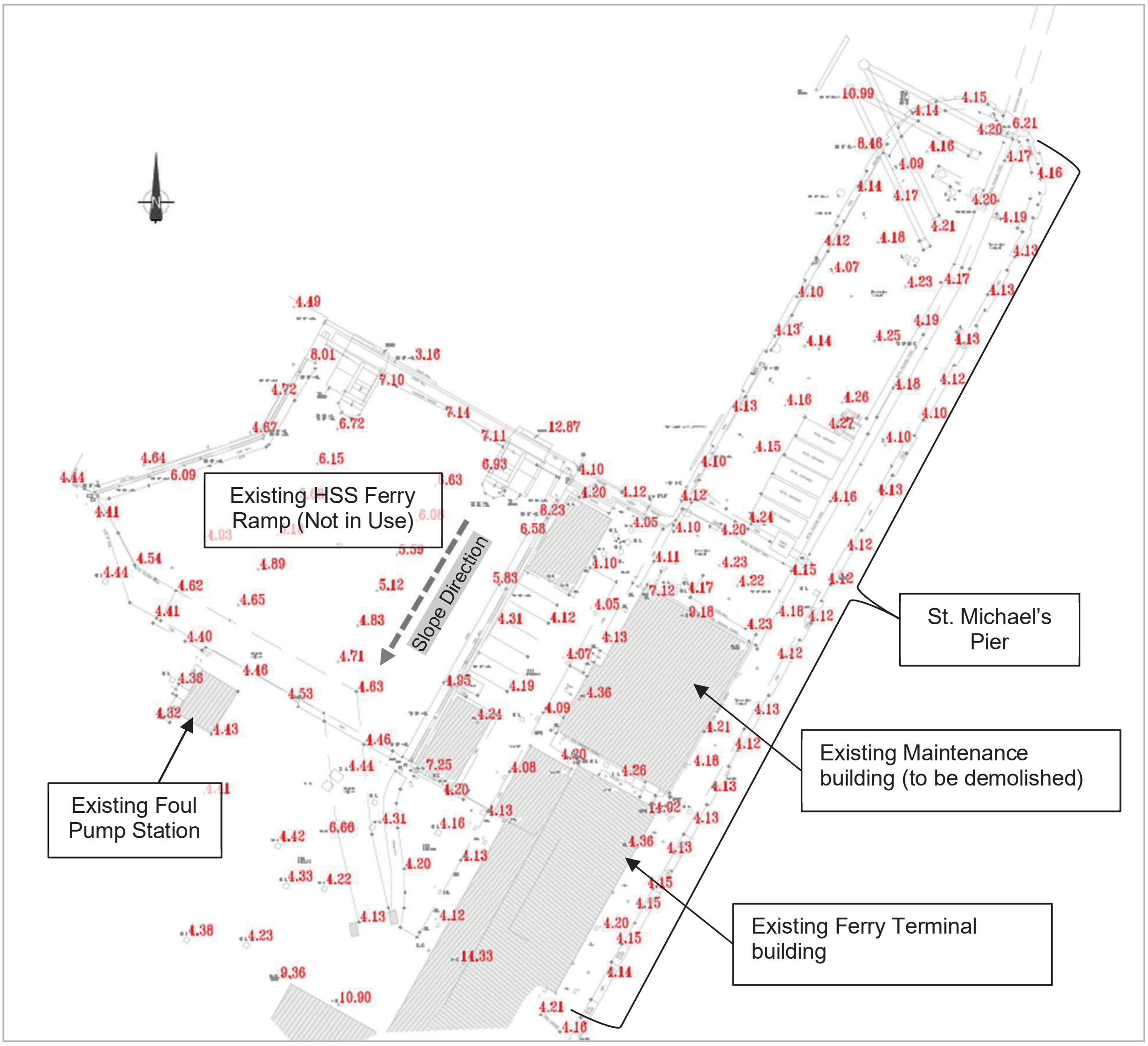


Figure 2-3: Existing Site Levels (OD Malin)

2.4 Existing Watercourses

The subject site is located adjacent to and on Dublin Bay (Irish Sea) as shown in Figure 2-4.

Figure 2-4: Subject Site Location relative to Irish Sea

Several rivers exist in the vicinity of the subject site and can be seen in Figure 2-5. The Priory Stream exists west of the subject site in Blackrock, as does the Brewery Stream, both discharge into the Irish Sea. The closest river to the subject site is the Stradbrook Stream (also refered to as the Monkstown Stream) that begins at Honey Park in Monkstown, located southwest of the site.

Figure 2-5: Existing River Watercourses near the Subject Site

2.5 Proposed Development

The proposed development includes the demolition of the existing harbour maintenance building on St Michael's Pier, the demolition of the existing ramp and concrete towers located at Berth 5 and the partial demolition of elements of the existing fender structures off St Michael's Pier.

A new O&M building will be constructed and will include office space, meeting rooms, toilet and changing facilities and an operations control centre which will be the main base for the Dublin Array support team. It will also include a warehouse which will store small spare parts for the wind farm and a workshop. The building will be arranged over three floors. A new substation will be built adjacent to the existing Motorist Lounge building which will facilitate ESB connection to the local network.

A new floating pontoon up to 60m long and up to 6m wide will be installed adjacent to the existing Berth 5 which will facilitate the berthing of crew transfer vessels (CTVs). The proposed pontoon will be anchored to the quay wall by means of steel guide beams.

External works include fencing off a portion of the Dún Laoghaire Harbour vehicle compound, which is the area that was formerly the HSS Stena ferry marshalling yard, to provide a secure parking and delivery area for staff working at the O&M building for staff, skip waste bays and all associated civil infrastructure including water, foul and surface water drainage and ESB and comms for the development.

Surface water will pass through an existing petrol interceptor located on the existing surface water outfall to the sea.

The existing ferry ramp structure will be demolished, regraded and reprofiled to accommodate the proposed car parking, delivery area and vehicle turning area for the O&M building.

The final finished floor levels (FFLs) of the proposed building will be set at +4.40 m OD Malin which is equivalent to the FFL of the existing maintenance building on the pier.

External pavement levels within the subject site, at the proposed O&M building, will be designed to ensure surface water runoff away from the building. In particular, external surfaces on the pier will be graded to fall from the centre of the pier/O&M building facades towards the pier edge (matching the existing pier surface grading) so that there is positive drainage from the pier surface to the pier edges (which vary between +4.10 and +4.15m OD Malin) and into the sea.

It is proposed that the site will be accessed from the existing site access to the Dún Laoghaire Harbour vehicle compound from Harbour Rd, which has a controlled access arrangement and high security fence to protect the vehicle compound from unauthorised access. A new access gate and fence will be constructed around the segregated parking/storage area for the O&M building.

Two surface water catchments currently exist within the site boundaries. It is proposed to retain these catchment areas. Catchment No.1 collects and conveys runoff from the existing carparking areas and the ferry ramp. Catchment No.2 collects and conveys runoff from the pier and existing maintenance building, which is to be demolished and replaced by a new O&M building. The existing catchment areas will remain unchanged. Refer to Figure 2-6 for an illustration of the surface water catchment areas for the proposed development.

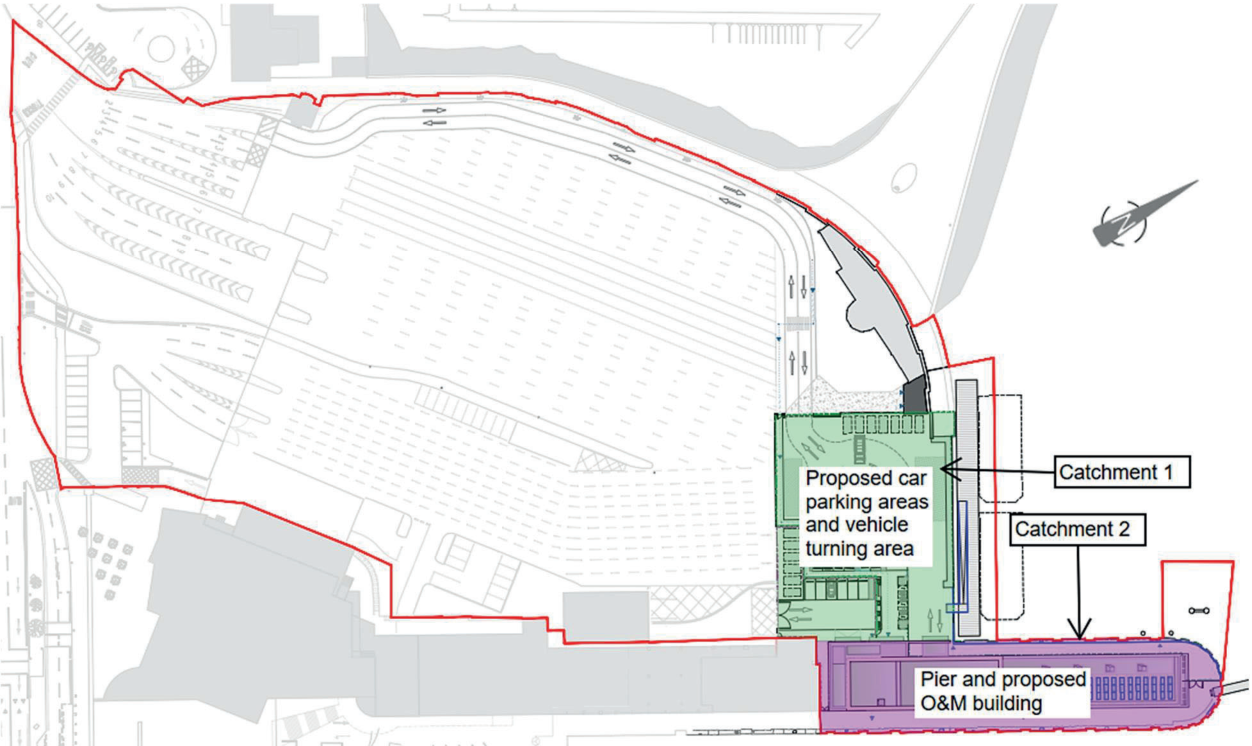


Figure 2-6: Surface Water Catchment Areas

The existing surface water network, consisting of a single 225 mm diameter pipe, is located directly northwest of the proposed O&M building. This network solely serves surface water Catchment No. 1 and collects runoff from parking areas via gullies before discharging water to the Irish Sea via a petrol interceptor.

Surface water runoff from Catchment No. 2 is currently discharged either through the pier directly into the Irish Sea, via gullies over cores through the concrete deck slab of the pier, or over the edge of the pier into the Irish Sea.

3. Flood Risk

3.1 Introduction

The flood risk assessment of a development should be carried out in accordance with the Planning System and Flood Risk Management Guidelines for Planning Authorities (2009), published by the Department of Environment, Heritage and Local Government in conjunction with the Office of Public Works (EHLG/OPW). This document will be referred to as the 'Guidelines (EHLG/OPW)' in this report.

The types of possible flooding to be considered in the identification and assessment of flood risk are described in Chapter 2 of the Guidelines (EHLG/OPW) and are summarised below:

- Coastal – flooding from higher sea levels than normal
- Fluvial – flooding from watercourses
- Pluvial – flooding from heavy rainfall/surface water
- Ground Water – flooding from springs / raised groundwater
- Human/mechanical error – flooding due to human or mechanical error

Each type will be investigated from a Source, Pathway and Receptor perspective, followed by an assessment of the likelihood of a flood occurring, and the possible consequences. An illustration of this model can be seen in Figure 3-1, taken directly from the Guidelines (EHLF/OPW).

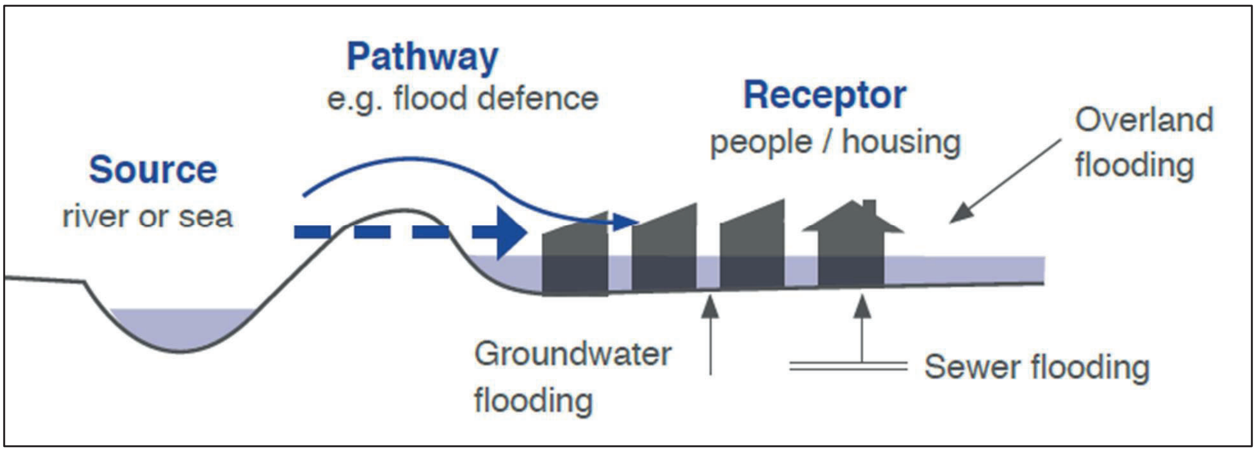


Figure 3-1: Source-Pathway-Receptor S-P-R Model

A flood risk assessment combines these above components and maps or describes the risks on a spatial scale so that the consequences can then be analysed.

The likelihood and the consequences of flooding (overall risk) fall into three categories; low, moderate and high, as described in the Guidelines (EHLF/OPW) and set out in Table 3-2.

The ultimate aim of a flood risk assessment is to establish the risk of flooding for a subject site, this can be assessed using two components, summarised below:

Flood Risk = Likelihood of flooding X Consequences of flooding

3.1.1 Assessing Likelihood

The likelihood of flooding falls into the categories of low, moderate and high, which are described in the Guidelines (EHLF/OPW) as follows:

Table 3-1: Guidelines for Assessing Likelihood

LIKELIHOOD	LOW	MODERATE	HIGH
Coastal	Probability < 0.1%	0.5% > probability > 0.1%	Probability > 0.5%
Fluvial	Probability < 0.1%	1.0% > probability > 0.1%	Probability > 1.0%
Pluvial	Probability < 0.1%	1.0% > probability > 0.1%	Probability > 1.0%

Note: Probability denotes the likelihood of occurrence in a given year.

For groundwater flooding and flooding from human/mechanical error, the limits of probability are not defined and therefore professional judgement is used. However, the likelihood of flooding is still categorised as low, moderate and high for these components.

3.1.2 Assessing Consequence

There is no defined method used to quantify a value for the consequences of a flooding event. Therefore, in order to determine a value for the consequences of a flooding event, the elements likely to be adversely affected by such flooding will be assessed, with the likely damage being stated, and professional judgement will be used to determine a value for consequences. Consequences will also be categorized as low, moderate, and high.

3.1.3 Assessing Risk

Based on the determined 'likelihood' and 'consequences' values of a flood event and the above equation of Flood Risk = Likelihood of flooding X Consequences of flooding, the 3x3 Risk Matrix in Table 3-2 below will then be used to determine the overall risk of a flood event.

Table 3-2: 3x3 Risk Matrix

		CONSEQUENCES		
		LOW	MODERATE	HIGH
LIKELIHOOD	LOW	Extremely Low Risk	Low Risk	Moderate Risk
	MODERATE	Low Risk	Moderate Risk	High Risk
	HIGH	Moderate Risk	High Risk	Extremely High Risk

3.2 Flood Zones

Flood zones are used to identify the likelihood, and therefore vulnerability, of flooding in a particular area. The zones are geographical areas with associated ranges of the likelihood of flooding and are essential in the creation of flood risk management plans. According to the Guidelines (DEHLG/OPW) flood zones can be categorised into 3 types or levels of flood zones, namely:

Table 3-3: Flood Zone Types according to the Guidelines (DEHLF/OPW)

Type	Description	Probability of flooding
Zone A	Where the probability of flooding from rivers and the sea is highest	Greater than 1% (1:100 year) for fluvial flooding, or greater than 0.5% (1:200 year) for coastal flooding
Zone B	Where the probability of flooding from rivers and the sea is moderate	Between 0.1% (1:1000 year) & 1% (1:100 year) for fluvial flooding, and 0.1% (1:1000 year) & 0.5% (1:200 year) for coastal flooding
Zone C	Where the probability of flooding from rivers and the sea is low	Less than 0.1% (1:1000 year) for both fluvial and coastal flooding

Flood zone maps are used to establish the level of flooding for a site, an example of this can be seen in the indicative map shown in Figure 3-2.

Figure 3-2: Indicative flood zone map extract from the Guidelines (DEHLF/OPW)

3.3 Flood Mapping

3.3.1 CFRAM Maps

CFRAM (Catchment Flood Risk Assessment and Management) maps are predictive flood maps that show areas predicted to be inundated during a theoretical or 'design' flood event with an estimated probability of occurrence. These probabilities may also be expressed as odds (e.g., 100 to 1) of the event occurring in any given year. They are also commonly referred to in terms of a return period (e.g., the 100-year flood).

The CFRAM Programme is managed and funded by the Office of Public Works (OPW) in consultation with Local Authorities and supported by external engineering consultants. The OPW has a statutory duty to maintain these maps.

The relevance of CFRAM maps in reviewing flood risk is significant. They provide detailed studies of the flood risk for communities, including coastal areas. These maps indicate the estimated extents, peak water levels, and flows associated with flooding from only those river reaches, estuaries, and coastlines that have been modelled. They are essential in understanding and managing flood risks, helping to identify feasible structural and non-structural measures to effectively manage the assessed risk in each of the Areas for Further Assessment (AFAs). They also show the indicative number of people potentially affected by floods, providing an indication of risks to human health and communities.

3.4 Sequential Approach and Justification Test

3.4.1 Sequential Approach

A sequential approach to planning is a vital tool in ensuring that development, particularly new development, is first and foremost directed towards the land that is at low risk of flooding. Sequential approaches are already established and working effectively in other areas in the plan-making and development management processes. The sequential approach principles are described in Figure 3-3, taken from the Guidelines (DEHLF/OPW). The sequential approach should be applied to all stages of the planning and development management process, particularly the planning stage. The mechanism for use of the sequential approach can be seen in Figure 3-4.

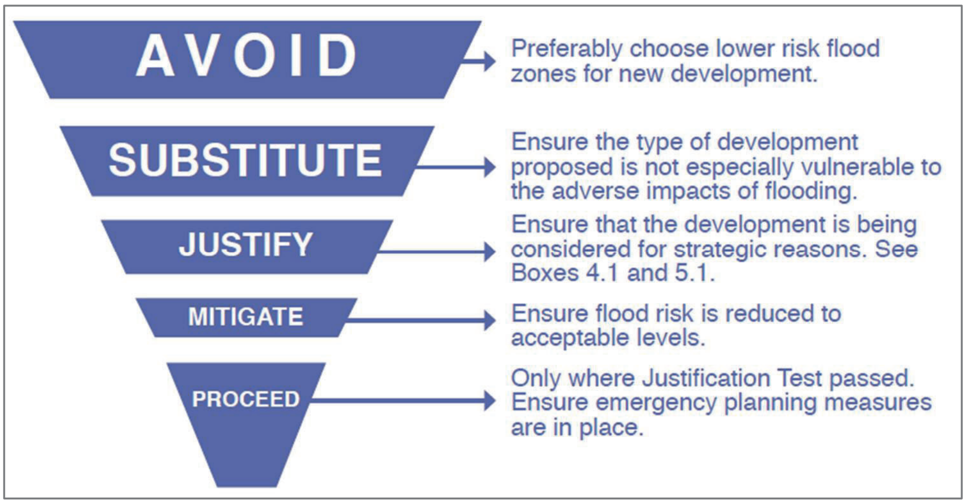


Figure 3-3: Sequential Approach Principles in Flood Risk Management

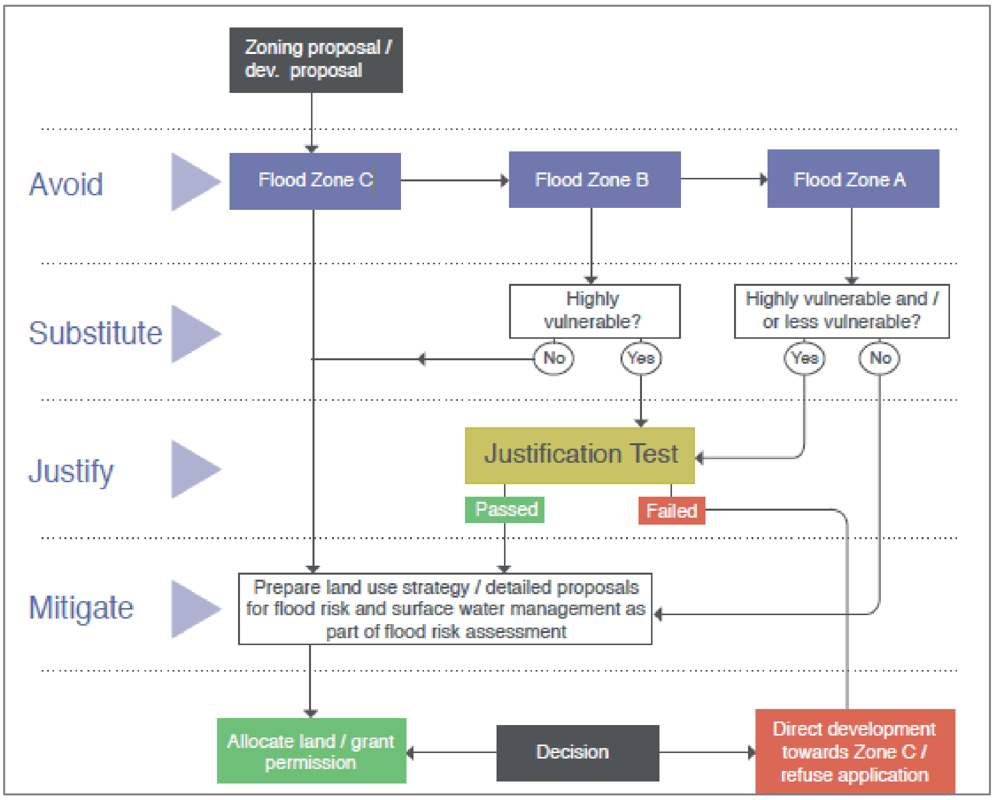


Figure 3-4: Sequential Approach Mechanisms

If the subject site does not fall within the 'Avoid' or 'Substitute' tiers of the sequential approach principle, a Justification test is required.

3.4.2 Justification Test

A matrix of vulnerability versus flood zone clearly outlines which types of development require a Justification Test.

The vulnerability of a site is categorized into 3 levels, highly vulnerable, less vulnerable, and water compatible. Figure 3-5 taken from the Guidelines (DEHLG/OPW) illustrates these categories.

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	

Figure 3-5: Vulnerability Classes

The resulting matrix of vulnerability vs. flood zone, taken from the Guidelines (DEHLG/OPW) and reproduced as Table 3-4 below, illustrates which type of developments require a Justification Test.

As this subject site falls within the 'Less vunerable development' category (Buildings used for retail, leisure, warehousing, commercial,industrial and non-residential institutions) according to Figure 3-5, when assessing the matrix vs. vulnerability of the development, a Justification Test is only required where the development is being considered in Flood Zone A. This type of development in Flood Zone B or C is considered to be "Appropriate" development that does not require a Justification Test. Refer to Table 3-4 for the matrix of vulnerability vs. flood zone relevant to the subject site.

Table 3-4: Matrix of vulnerability vs. flood zone - Justification Test

Type	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water compatible development	Appropriate	Appropriate	Appropriate

The DLRCC County Development Plan 2022-2028, Appendix 16: Strategic Flood Risk Assessment, Section 5.1.2 includes a Justification Test for Dún Laoghaire Harbour Waterfront. Dún Laoghaire Harbour Waterfront includes St Michael's Pier and the former HSS Stena ferry marshalling yard. This area has been recognised in the Development Plan as a strategic large-scale regeneration site and the development plan concludes that the Justification Test for development of these lands is passed. In its conclusion, the Justification Test states:

> *Lands within the Waterfront zoning are within Flood Zone B and C. Although occupying a water frontage position, much of the subject land is elevated by several meters from the mean sea level. There are a number of pockets of land which are within the 0.1% AEP coastal flood extents, and risk associated with climate change and sea level rise are likely to be high. SSFRA is required for all development within the Harbour area and should particularly assess the risks associated with sea level risk and wave overtopping. Provided the risks can be managed, for example through setting finished floor levels and ensuring an appropriate emergency response, development within Flood Zone B is considered to pass the Justification Test.*

Thus, as the proposed O&M building site is in Flood Zone B and is "Less vulnerable development", it is considered an appropriate development and **does not require a Justification Test** or further flood mitigation measures other than what is described in this report.

4. Coastal Flooding – Irish Sea

4.1 Source

Coastal flooding occurs due to elevated sea levels, mainly driven by storm surges. This results in the overflowing of the sea or tidally influenced rivers onto the land. This type of flooding is primarily influenced by high tides and storm surges, which are caused by factors like low atmospheric pressure and strong winds, along with wave action.

4.2 Pathway

The Irish Sea is immediately adjacent to the proposed development, refer to Figure 2-4. The pathway from the Irish Sea is the overtopping of St Michael's Pier surface and/or the seawall or rock embankment on the waterside perimeter of the Dún Laoghaire Harbour vehicle compound.

4.3 Receptor

The possible receptor of any flooding in the proposed site would be the pier surface, open spaces, yard and parking areas, the ground floor of the O&M building and the ESB substation.

4.4 Likelihood

There are currently no printable PDF Catchment Flood Risk Assessment Management (CFRAM) Coastal Flooding Maps available for the subject site area on floodinfo.ie, however an extract of the National Coastal Flood Hazard Map for the 1 in 200 year flood event (0.5% AEP) representing the High-End Future Scenario (from floodinfo.ie) has been retrieved for the subject site and can be seen in Figure 4-1.

The AEP refers to the Annual Exceedance Probability which is defined as the probability of a flood occurring or being exceeded in any given year. MRFS refers to Mid-Range Future Scenario and HEFS refers to High-End Future Scenario, these represent future estimated flood levels for sites in Ireland. The current recommendation in the Guidelines (DEHLG/OPW) for climate change allowance in designs is the use of the 'likely' future scenario, the MRFS.

The MRFS is the present day flood level plus 500 mm, and the HEFS is the present day flood level plus 1.0 m. As mentioned above, the flood data retrieved includes the more severe flood scenario (HEFS), offering a substantially more conservative benchmark for flood risk assessment.

The nearest national coastal extreme water level estimation point, node SE2, can also be seen in Figure 4-1. The flood levels at this node point (SE2) are shown in Table 4-1 in m OD (Malin).

Table 4-1: Extreme Flood Water Level (m OD Malin) at Node SE2

	Scenario				
AEP	**Present Day** (PD)	**MRFS*1** (PD +0.5m)	**HEFS*2** (PD +1.0m)	**H+EFS*3**	**H++EFS*4**
2% (1in 50 yrs)	+3.08	+3.58	+4.08	+4.58	+5.08
1% (1in 100 yrs)	+3.17	+3.67	+4.17	+4.67	+5.17
0.5%	+3.27	**+3.77**	**+4.27**	+4.77	+5.27

AEP	Scenario				
	Present Day (PD)	**MRFS**[*1] (PD +0.5m)	**HEFS**[*2] (PD +1.0m)	**H+EFS**[*3]	**H++EFS**[*4]
(1in 200 yrs)					
0.1% (1in 1000 yrs)	+3.48	+3.98	+4.48	+4.98	+5.48

*1 MRFS: Mid-Range Future Scenario. This scenario represents a projected future scenario for flood risk, considering potential impacts of climate change.

*2 HEFS: High-End Future Scenario. This scenario represents a more severe projected future scenario for flood risk, considering more extreme potential impacts of climate change.

*3 H+EFS: refers to a High-End Future Scenario with additional factors considered. These could be factors such as increased sea levels or other environmental changes.

*4 H++EFS: High++ End Future Scenario. This scenario represents a worst-case projected future scenario for the end of the century (circa 2100). It includes allowances for projected future changes in sea levels and glacial isostatic adjustment (GIA). The maps include an increase of 2000mm in sea levels above the current scenario estimations.

Table 4-1 indicates a MFRS flood level of +3.77m and a HEFS flood level of +4.27 m for the 0.5% AEP (1 in 200-year) flood event. The surface level of St Michael's Pier is +4.10m to +4.25m while the proposed FFL for the O&M Base will be +4.40m. Thus, and as can be seen from Figure 4-1, the subject site not at risk of flooding in the 0.5% MRFS but is at risk of flooding in the 0.5% HEFS.

Figure 4-1: Excerpt from National Coastal Flood Hazard Map 1 in 200-Year Flood Event (HEFS) on the Subject Site

An excerpt of the 1 in 200-year flood coastal map for the HEFS showing the estimated flood depth can also be seen in Figure 4-2. From this map it can be seen that the subject site may experience flooding in excess of 2m deep on the extreme northern end of St Michael's Pier. However, this result appears to be anomalous and should be treated with some caution, as the predicted HEFS flood level is only 0.15m above the existing pier deck level. This depth of flooding is only predicted at the very northern end of the pier whereas significantly lower depths of flooding are predicted elsewhere on the pier even though the pier is at the same level throughout. It is also noted that the adjacent Carlisle Pier, which is only 200mm higher than St Michael's Pier, is not shown as flooding at all in the HEFS.

There are no records of either St Michael's Pier or Carlisle Pier having been previously submerged or inundated as a result of high sea levels.

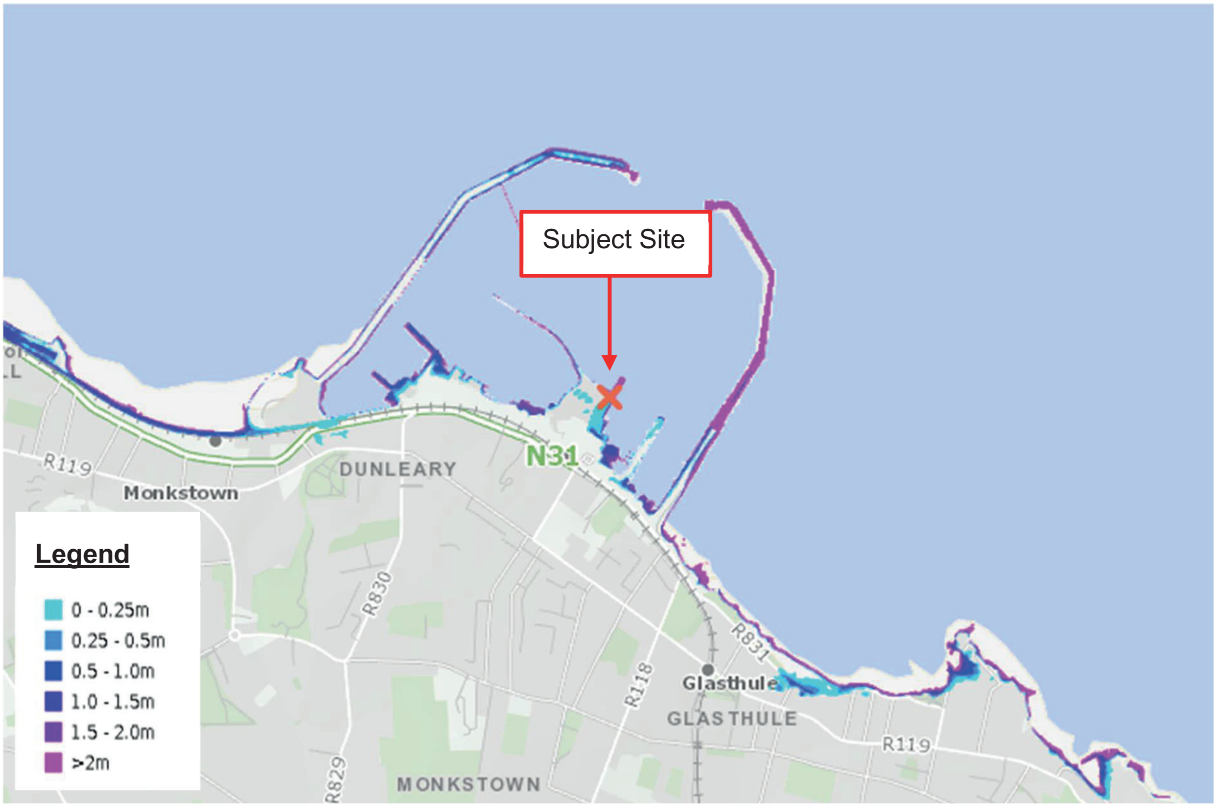


Figure 4-2: National Coastal Flood Hazard 0.5% AEP (HEFS) Flood Depths

Table 4-2 contains a summary of the discussed flood levels and the proposed FFLs on the subject site. As can be seen in the table, the proposed FFL for the O&M building is above the more severe, HEFS, flood level. The FFL is more than 1m above the present day flooding scenario for the site and 0.63m above the MRFS flood level and thus considered an adequate level of protection for flood risk purposes.

Table 4-2: Comparison of Flood Levels & FFLs on the Subject Site

	Scenario (AOD Malin)			**Subject Site** (AOD Malin)	
AEP	**Present Day** (PD)	**MRFS** (PD +0.5m)	**HEFS** (PD +1.0m)	**FFL**	**Difference** (FFL – HEFS)
0.5% (1 in 200 yr)	3.27	**3.77**	4.27	4.40 m	0.13 m

The likelihood of flooding of the proposed O&M building under the HEFS is between 0.5% and 0.1% (refer to Tables 3-1 and 4-1. Therefore the likelihood of flooding is considered moderate.

The existing ground level in the vicinity of the proposed ESB substation is +4.5m OD (Malin) and the ESB substation FFL will be +4.6m. Thus the FFL will be 0.33m above the 0.5% HEFS flood level and +0.12m above the 0.1% HEFS flood level (refer to Table 4-1). The likelihood of flooding is therefore less than 0.1%. The liklihood of flooding is considered low.

4.5 Wave Overtopping

Wave action must be considered in addition to the flood levels identified in the National Coastal Flood Hazard Map. The waters within Dún Laoghaire Harbour are sheltered by the East and West Piers from waves from most directions, with the most significant waves within the harbour occurring when the winds and offshore waves are from the North to East directions (moving clockwise). Dublin Bay and the harbour are sheltered from significant wave action when winds are blowing from the South through the West to North directions.

An extract from the Coastal Areas Potentially Vunerable to Wave Overtopping Map is included at Figure 4-3 for the south Dublin Bay coastline (from floodinfo.ie). This map summarises the result of studies into combined wave climate and water level conditions for a range of AEPs (50% to 0.1%) for the MRFS and HEFS.

Figure 4-3 indicates that the coastline from Sandymount to Seapoint is vunerable to wave overtopping events in combination with high sea levels, but the coastline south of this is not identified as having vunerability.

Numerical modelling studies have been carried out to support previous proposed developments within Dún Laoghaire harbour. These predict significant wave heights of 0.3m to 0.6m in the sea adjacent to St Michael's Pier for winds from the worst direction (ENE), with a return period of 50 years. The significant wave height (Hs) is defined as the mean wave height of the highest third of the waves. As a rule of thumb the maximum wave height that will be encountered in a weather event will be about twice the significant wave height.

Wave action will result in overtopping and seawater splash impact above the flood level. Wave action sees the sea level rising and falling above and below the mean flood level. On St Michael's Pier, wave overtopping will result in water splashing onto the pier surface and then draining over the sides of the pier back into the sea. It will not result in a build-up of water levels on the pier to any higher level than the mean flood level of the sea.

If the significant wave height during the HEFS flood event is taken as 0.6m, and assuming that these waves occur coincidently with the 0.5% AEP (1 in 200 year) flood level, then it could be expected that waves could overtop the pier to a level of +4.87m OD, which is 0.47m above the proposed FFL of the O&M building. While some waves would be higher than this, these would be infrequent. Waves washing over the top of the pier will either pass over the pier and back to the sea on the other side, or will strike the façade of the O&M building and reflect back to the sea on the same side of the pier.

The proposed FFL for the ESB substation is +4.60m OD. However, the proposed location for the substation is between the bankseat for the HSS ferry ramp structure and the Motorists Lounge building and landward of a solid concrete security wall. These structures will effectively protect the ESB substation from the effects of wave overtopping as they will present a vertical face to the sea, the lowest level of which is approximately +6.2m OD (being the top of the security wall). The external pavement area to the landward (southern) side of the ESB substation and the motorists lounge falls away from these buildings to low points of +4.2m OD to +4.4m OD, so that any potential flooding from wave overtopping to the east of the bankseat wall will not have a pathway to the ESB substation.

Figure 4-3: Coastal Areas Potentially Vunerable to Wave Overtopping (Map – Dublin Bay)

4.6 Consequence

The consequence of coastal flooding would include flood damage to the O&M building ground floor and the ESB substation. O&M building ground floor uses will include storage areas, workshops, reception, locker and shower facilities, electrical rooms, plant room, lift, stairs and corridors.

The potential consequences of wave overtopping in conjunction with coastal flooding will be potential damage to the building façade and water leakage into the ground floor of the building at door, window or other openings that are not sealed. Wave overtopping will not result in a build-up of water levels in the subject site, as water is free to flow directly back to the sea as the wave passes over the pier.

The potential consequences to the ESB substation would be forced power outages to all facilities served by the substation, which would have a negative impact on the operation of the O&M building.

The external car parking and deliveries area will be less prone to the effects of wave overtopping as the seaward edge of this area is protected by the retained portion of the concrete bankseat structure, the top of which is at +7.14m OD. Water may flow from the pier into the external area adjoining the pier, but the pavement levels are such that this water will naturally drain back to the sea as the wave passes.

The consequence of flood damage is considered moderate to high.

4.7 Risk

As the likelihood of flooding for the O&M building is moderate (low for the ESB substation) and the consequence of flooding is moderate to high, referring to Table 3-2: 3x3 Risk Matrix, the resulting risk is considered moderate to high for the O&M building and low to moderate for the ESB substation.

4.8 Flood Risk Mitigation Measures

The O&M building will be set above the HEFS flood level (ie FFL to be set at +4.40m OD v HEFS flood level at +4.27m OD) to mitigate against any risk of flooding from coastal waters. It is noted that the proposed +4.40m FFL is +0.63m above the +3.77m MRFS, against which “Less vunerable development” would normally be assessed in accordance with the Guidelines (DEHLG/OPW) for climate change allowance in designs. The DLRCC County Development Plan 2022-2028, Appendix 16: Strategic Flood Risk Assessment, Section 4.9.3, indicates a freeboard of at least +0.3m above the 0.5% AEP MRFS for “Less vunerable development”. The freeboard provided will be +0.63m above the 0.5%AEP MRFS.

To mitigate against the risk of waters entering the O&M building ground floor as a result of wave overtopping and splash, the building façade will be designed to be flood resistant. The external paving on the pier will slope from the building face towards the pier edge, facilitating the flow of wave splash back to the pier edge and into the Irish Sea. All door and other opes at low level will either be designed to be flood resistant when closed or measures such as guide rails for portable flood barriers will be incorporated in the building frame so that the barriers can be installed in advance of any expected weather events which bring the risk of high water levels combined with high wave conditions. In addition, Aco drains will be installed in front of all opes at ground level and will facilitate the capture of water and its direction through the drainage system to gulley points through the pier deck and back into the Irish Sea.

In addition, it is recommended that critical systems including plant and electrical systems, power sockets etc, be designed so that they are at a level that would not be affected by any potential flooding event. The ESB substation propsed FFL is +4.60m OD, which is +0.33m above the HEFS flood level and +0.83m above the MRFS level. No further mitigation measures are proposed for the substation.

4.9 Residual Risk

Upon setting the FFL’s of the proposed buildings above the HEFS Flood Level and taking measures to ensure the O&M building design is flood resistant and keeps critical plant and electrical systems sufficiently above floor level so that the building ground floor can tolerate some water ingress, there is a low residual risk anticipated for the proposed development from coastal flooding.

5. Fluvial Flooding

5.1 Source

Fluvial flooding is caused by rivers, watercourses or ditches exceeding their capacity and excess water spilling out onto the adjacent floodplain.

5.2 Pathway

The potential pathway for fluvial flooding from these rivers would be overland flooding and flooding via the roads network in Dún Laoghaire.

5.3 Likelihood

According to the extract from the online CFRAM River Flood Extents – present day flood maps containing the medium and high probability flood extents (1% and 10% AEP), combined with the national indicative fluvial mapping (present day) medium probability (1% AEP) flood extents, the river flooding in the vicinity of the subject site is as seen in Figure 5-1. This map has been sourced from floodinfo.ie.

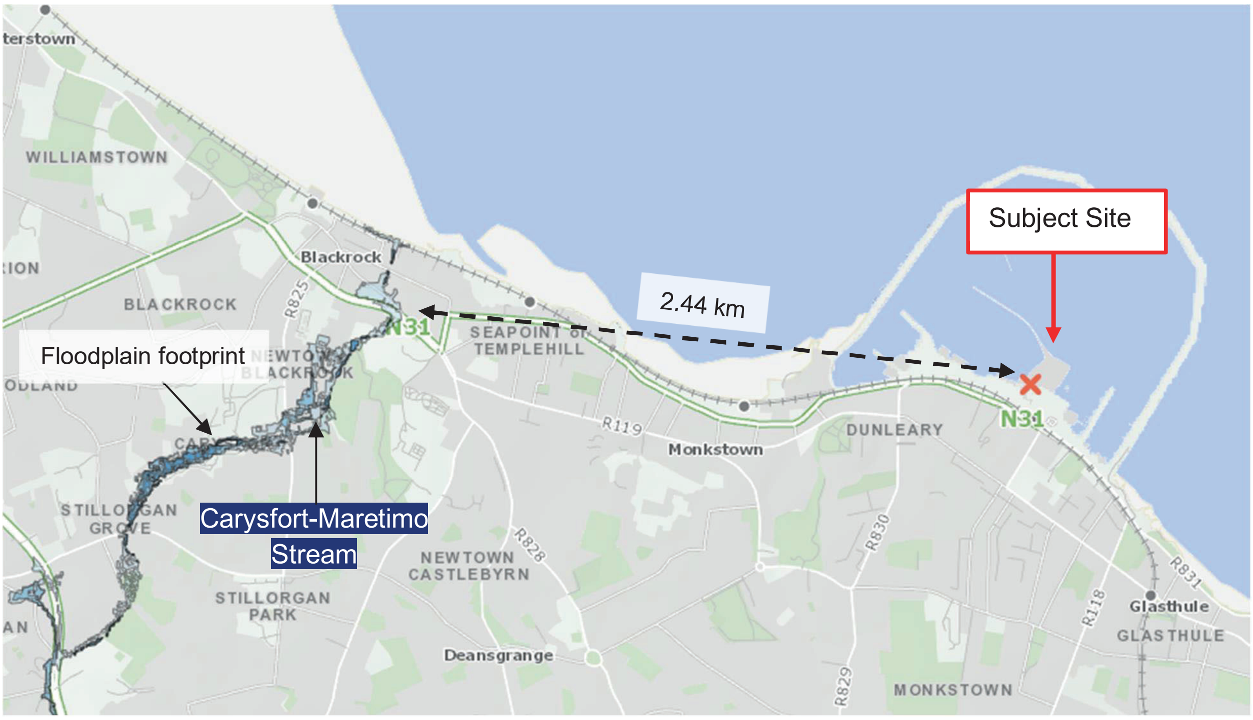


Figure 5-1: Extract of online CFRAM River Flood Extents Maps (1% & 10% AEP)

Possible fluvial flooding in the area originates from the Carysfort-Maretimo Stream to the west of the subject site, c. 2.44 km away. Considering the size of the floodplain footprint shown in Figure 5-1 and the substantial distance of the floodplain from the subject site, the likelihood of flooding from fluvial sources is considered to be low.

5.4 Consequence

The consequence of fluvial flooding would include flooding of the pier and open spaces on the Harbour. The consequence is thus considered to be low.

5.5 Risk

Given a low likelihood and low consequence, referring to Table 3-2: 3x3 Risk Matrix, the resulting risk is considered extremely low.

5.6 Flood Risk Mitigation Measures

As the risk is considered extremely low, there are no mitigation measures required.

5.7 Residual Risk

There is a low residual risk anticipated for the proposed development from fluvial flooding.

6. Pluvial

6.1 Source

The source of pluvial flooding is heavy rainfall.

6.2 Pathways & Receptors

During periods of extreme prolonged rainfall, pluvial flooding may occur through the following pathways:

Table 6-1: Pluvial Pathway and Receptor Summary

	Pathway	Receptor
1	Surcharging of the proposed internal drainage systems during heavy rain events leading to internal flooding.	Proposed development – pier surface, parking and external yard areas
2	Surcharging from the existing surrounding drainage system leads to flooding within the subject site by surcharging surface water pipes	Proposed development – pier surface, parking and external yard areas
3	Surface water discharging from the subject site to the existing drainage network leads to downstream flooding	Irish Sea
4	Overland flooding from surrounding areas flowing onto the subject site	Proposed development – pier surface, parking and external yard areas
5	Overland flooding from the subject site flowing onto surrounding areas	Downstream properties and roads

6.3 Likelihood

6.3.1 Surcharging of the proposed internal drainage systems

The proposed on-site surface water drainage network has been designed to accommodate flows from a 1 in 100-year return event in line with the Greater Dublin Strategic Drainage Study (GDSDS). Therefore, the likelihood of surcharging on the on-site drainage system is considered low.

6.3.2 Surcharging from the existing surrounding drainage system

The subject site is surrounded by Dún Laoghaire Harbour. The subject site is proposed to connect into the existing surface water network which serves the eastern part of the Dún Laoghaire Harbour vehicle compound area and also roof drainage from several small inspection sheds adjacent to the existing ferry terminal building. The drainage network consists a single 225 mm pipe into which a number of gullies are connected, falling via oil interceptor and outfalling through the Berth 5 seawall to the Irish Sea. The exisitng area catered for by this drain is 100% hard standing. There have been no reported flood incidents on the site. As the proposed drainage system does not modify the existing scenario, even when the proposed green roof on the O&M building is saturated (and therefore not providing any attenuation benefit), the likelihood of surcharging from the existing surrounding drainage system is thus considered low.

6.3.3 Surface water discharge from the subject site

The site is currently 100% hardstanding with no SUDS or surface water flooding mitigation measures. The proposed site will introduce c. 538 m^2 of green roofs, capturing, reducing, slowing and treating the surface water runoff intercepted by these roofs.

The surface water from the proposed development will flow directly into the Irish Sea.

Considering the proposed development can only improve the current surface water discharge from the site, that the surface water network will be designed to accommodate the required flood flows and that the surface water will flow into the Irish Sea, there is a low likelihood of the subject site causing flooding from surface water discharge.

6.3.4 Overland flooding from surrounding areas

The OPW records for predictive and historic flood maps have been consulted for recorded flood events in the vicinity of the subject site. There are a number of historic flood events in the vicinity of the subject site (within a 2.5 km radius). Refer to Figure 6-1 for an illustration of the recorded flood locations in relation to the subject site.

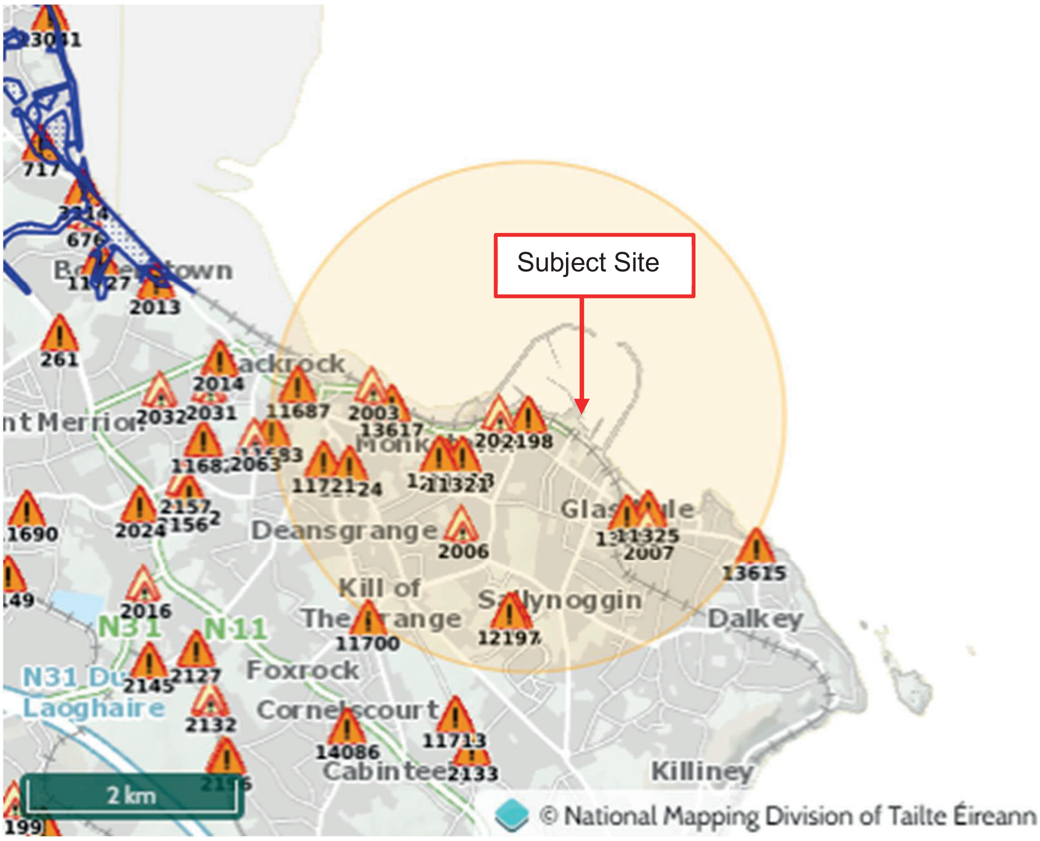


Figure 6-1: OPW Past Flood Event Summary

The nearest flood event with a flood ID of 2198, was recorded on Crofton Road in October of 2002, c. 21 years ago. A DLRCC memo cites the flooding occuring as a result of "all rivers and streams flowing at full capacity” at that time “which only left inches to spare before flooding in all areas which meant the screens had to be attended to urgently at all times over the period of heavy rain, to avoid major flooding occuring" Flooding through manholes on Crofton Road was recorded, no floods in this location have been recorded since.

The second nearest flood event with a flood ID of 2004, contains 5 flood report entries occuring between the years 2002-2005. All reports refer to road flooding in the Dún Laoghaire area. No flood event has been reported at this location since 2005.

The likelihood of flooding from surrounding areas, overland, is considered low for this subject site.

6.3.5 Overland flooding from the subject site

The onsite drainage network has been designed to adequately capture and convey the 1 in 100-year storm return period to the existing outfall to the Irish Sea. Should there be any surface runoff from the proposed site beyond that which the proposed surface water network is designed to cater for, an overland flood route exists which will adequately convey surface runoff straight into the Irish Sea.

The likelihood of flooding at the subject site from overland flooding is considered to be low.

6.4 Consequence

The consequence of surface water flooding arising from the 5 pathway types mentioned above is **low**. The development incorporates appropriate mitigating measures including ensuring buildings are constructed at appropriate finished floor levels and the application of an appropriate and sizeable SUDS feature (green roof).

6.5 Risk

Referencing Table 3-2: 3x3 Risk Matrix, the following risks are noted for the 5 pathway types:

6.5.1 Surcharging of the proposed on-site drainage systems

With a low likelihood and low consequence of flooding the site from surcharging the on-site drainage system, the resultant risk is low. Mitigation measures are not required.

6.5.2 Surcharging from the existing surrounding drainage system

With a low likelihood and low consequence of flooding the site from the existing surface water network, the resultant risk is extremely low.

6.5.3 Surface water discharging from the subject site

With a low likelihood and low consequence of flooding downstream of the site due to excess discharge surface water from the site, the resultant risk is extremely low.

6.5.4 Overland flooding from surrounding areas

With a low likelihood and low consequence of overland flooding from surrounding areas, the resultant risk is extremely low.

6.5.5 Overland flooding from the subject site

With a low likelihood and low consequence of overland flooding from the subject site, the resultant risk is extremely low.

6.6 Flood Risk Mitigation Measures

The following are flood risk management strategies proposed to minimise the risk of pluvial flooding for each risk:

6.6.1 Surcharging of the proposed on-site drainage systems

The risk of flooding the proposed buildings is minimised with adequate sizing of the on-site surface water network, the addition of the green roof, and the setting of appropriate finished floor levels for the building.

6.6.2 Surcharging from the existing surrounding drainage systems

None required.

6.6.3 Surface water discharging from the subject site

None required.

6.6.4 Overland flooding from surrounding areas

None required.

6.6.5 Overland flooding from the subject site

None required.

6.7 Residual Risk

As a result of the design measures detailed above in Section 6.6, there is a low residual risk of flooding from each of the pluvial pathways mentioned above.

7. Groundwater

7.1 Source

The proposed O&M building is located on a pier that is supported on piles over the sea at Dún Laoghaire Harbour. Therefore, there is no groundwater under the building so groundwater is not relevant when considering the building.

The ground under the proposed ESB substation and external parking and yard area is reclaimed ground that was filled to form the HSS Stena ferry terminal marshalling area (now the Dún Laoghaire Harbour vehicle compound). This fill material is granular in nature. Groundwater recharge would occur from rainwater falling on the pavement areas. The existing drainage system captures surface water and conveys it to the Irish Sea via the surface water drainage system. Some water may percolate to ground through the joints between the pavement block paviours. However, as the area is surrounded by the sea and relatively free-draining, a build up of groundwater above the level of the sea will not occur. Groundwater levels will be tidally influenced and will fluctuate with the tide, with or without an element of tidal lag.

7.2 Pathway

Rising groundwater levels could result in groundwater seeping into the ground surface of the external parking and yard areas of the Dún Laoghaire Harbour vehicle compound. However, as the groundwater is tidally influenced and can drain freely to the sea, the only pathway that could result in surface flooding from groundwater would be coincident with high flood levels from the sea (at or above the level of the parking and yard areas).

7.3 Receptor

According to the Environmental Protection Agency Ground Waterbodies online map, the subject site is located in an area with possible waterbodies. Refer to Figure 7-1 for an illustration of this, the ground waterbody area is represented by purple shading. This indicates that the Pier itself is an area of potential Ground Waterbody. This is not correct, as the Pier is a hard concrete surface supported on piles and with no ground under it. The map does not highlight the marshalling yard area as a Ground Waterbody.

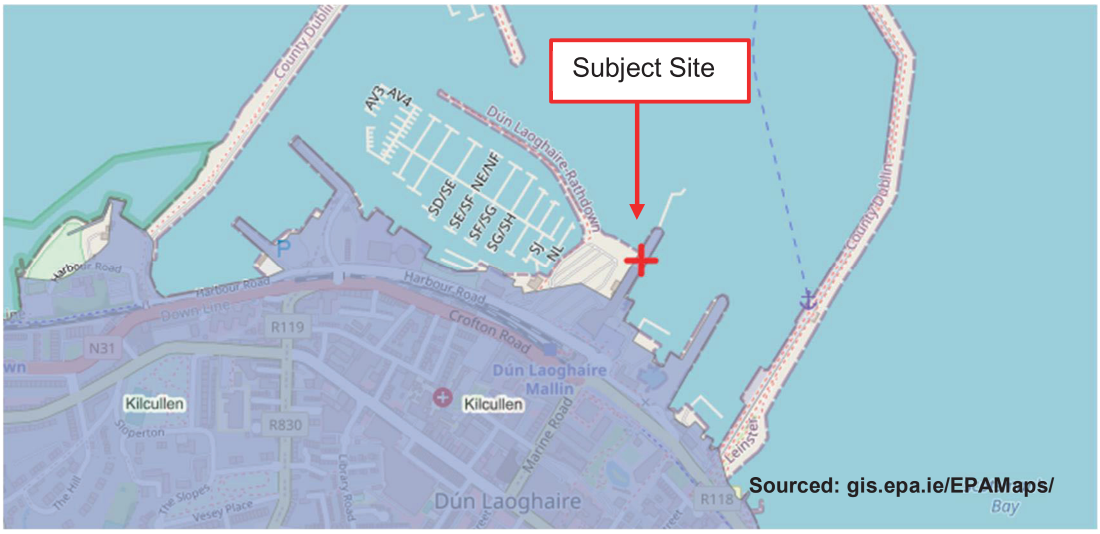


Figure 7-1: Excerpt of EPA Ground Waterbodies Online Map

7.4 Likelihood

The likelihood of flooding from groundwater is considered to be low. The groundwater level will be tidally influenced and the granular nature of the filled ground under the block paving surface of the Dún Laoghaire Harbour vehicle compound area allows for relatively free drainage of groundwater. Any potential build up of groundwater will dissipate by draining to the north and the west, where it can drain directly to the sea.

7.5 Consequence

There is a low consequence from groundwater flooding, as if it occurs, it will only affect the external car parking and yard areas.

7.6 Risk

There is an extremely low risk of groundwater flooding to the site as any potential groundwater build up above sea level will drain directly to the sea through the fill material forming the marshalling yard area.

8. Human / Mechanical Errors

8.1 Source

This surface water network within the subject site is the source of possible flooding from the system if it was to become blocked.

8.2 Pathway

The pathway is via surface water manholes and gullies within the Harbour and potentially via the green roof.

8.3 Receptor

If the proposed private drainage system blocks this could lead to possible flooding within the O&M building, the ESB substation, the yard area, the car parking area and the pier.

8.4 Likelihood

There is a high possibility of flooding on the subject site if the surface water network was to block.

8.5 Consequence

The surface water network would surcharge and overflow through gullies and manhole lids, and discharge over the pier edge into the sea. It is therefore considered that the consequences of such flooding are low.

8.6 Risk

Referencing Table 3-2: 3x3 Risk Matrix, with a high likelihood and low consequence, there is a moderate risk of surface water overflowing onto the surrounding external yard and parking areas, should the surface water network block.

8.7 Flood Risk Mitigation Measures

Levels on-site have been designed such that in the event of the surface water system surcharging, surface water can still escape from the site and flow away from building structures, into the Irish Sea, by overland flood routing without damaging properties. The surface water network would need to be unblocked and maintained should a blockage occur. Normal maintenance of the drainage system to include inspection and jetting when necessary will reduce the risk of blockages to the drainage system occurring.

8.8 Residual Risk

As a result of the flood risk management outlined above, there is a low residual risk of overland flooding from human/mechanical error.

9. Conclusions and Recommendations

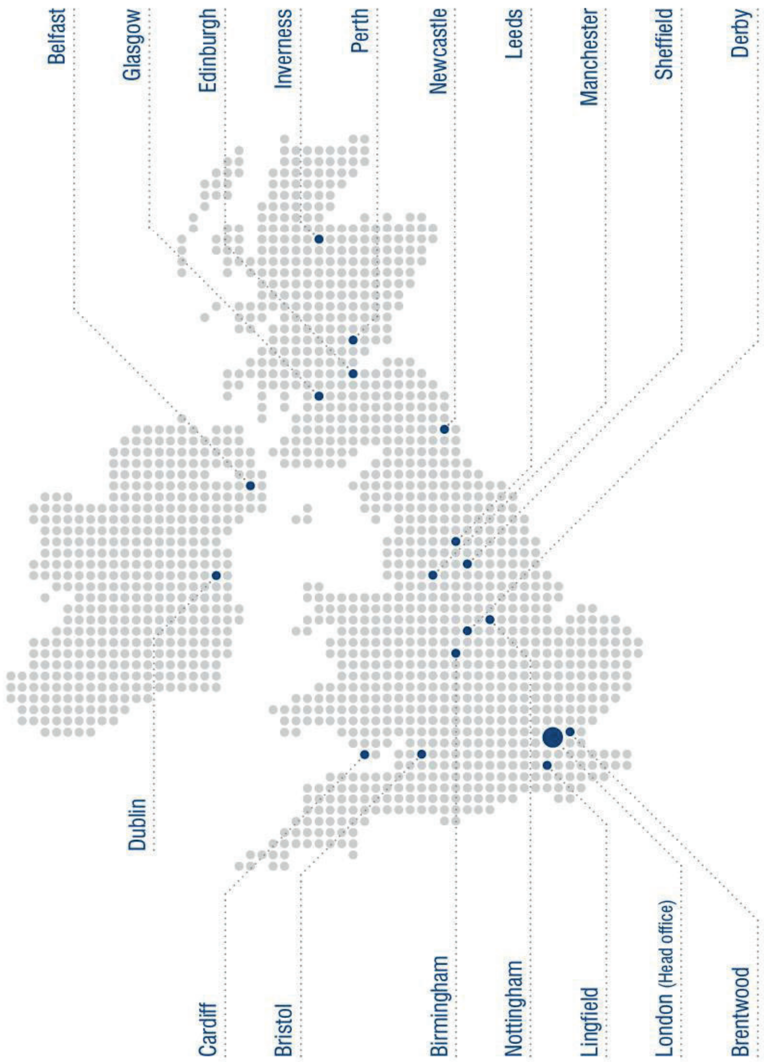
The site which is the subject of the proposed development consent application has been analysed for risks from flooding from the Irish Sea via Dún Laoghaire Harbour, fluvial flooding, pluvial flooding, groundwater, and failures of mechanical systems. Through careful design and appropriate mitigation measures, the risks and consequences of flooding have been mitigated across the development.

Refer to Table 9-1 for the summary of risks and mitigation measures for each of the potential flooding sources/types.

Table 9-1: Summary of Flood Risks for the Site

Source	Pathway	Receptor	Likelihood	Consequence	Risk	Mitigation Measure	Residual Risk
Coastal	Overflowing Harbour/Pier	Proposed Development	Moderate	High	High	Appropriate setting of building level and design	**Low**
Fluvial	Overland from the west	Proposed Development	Low	Low	Extremely Low	None needed	**Extremely Low**
Pluvial	Private and Public Drainage Systems	Proposed Development	Low	Low	Extremely Low	None needed	**Extremely Low**
Ground Water	Ground	Proposed Development	Low	Low	Extremely Low	None needed	**Extremely Low**
Human / Mechanical Error	Drainage network	Proposed Development	High	Low	Moderate	Appropriate drainage design, maintenance, & overland flood routing	**Low**

UK and Ireland Office Locations



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