Templar Place
Quay St,
Balbriggan,
Co. Dublin

Flood Risk Assessment

Final Report

August 21

2021s0326

Rhonellen Developments Limited,

63 Fitzwilliam Square,

DUBLIN 2,

Co Dublin,

D02 N938

JBA Project Manager

David Casey
Unit 8, Block 660
Greenogue Business Plaza
Greenogue Business Park
Rathcoole,
Dublin
Co Dublin
IRELAND
D24 CY64

Revision History

Revision Ref / Date Issued	Amendments	Issued to
S3-P01 - 18/06/2021	Draft Report	Rhonellen Developments Ltd
A3-C01 - 23/07/2021	Final Report	Rhonellen Developments Ltd

Contract

This report describes work commissioned by Tom Burke on behalf of Rhonellen Developments Limited. The representative for the contract was John Brennan of ORS Consulting. David Casey and Daniel Iordache of JBA Consulting carried out this work.

Prepared by ..... Daniel Iordache BEng MEng
Engineer

David Casey BSc MSC MCIWEM
Senior Engineer

Reviewed by ..... Ross Bryant BSc MSc CEnv MCIWEM C.WEM
Principal Analyst

Purpose

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Abbreviations

1D ..... One Dimensional (modelling)
2D ..... Two Dimensional (modelling)
AEP ..... Annual Exceedance Probability
CFRAM ..... Catchment Flood Risk Assessment and Management
DoEHLG ..... Department of the Environment, Heritage and Local Government
FARL ..... FEH index of flood attenuation due to reservoirs and lakes
FB ..... Freeboard
FFL ..... Finish Floor Levels
FRA ..... Flood Risk Assessment
FSR ..... Flood Studies Report
FSU ..... Flood Studies Update
GSI ..... Geological Survey of Ireland
LHB ..... Left Hand Bank
OPW ..... Office of Public Works
PFRA ..... Preliminary Flood Risk Assessment
RFI ..... Request for Further Information
RHB ..... Right Hand Bank
RR ..... Rainfall-Runoff
SAAR ..... Standard Average Annual Rainfall (mm)
SFRA ..... Strategic Flood Risk Assessment
URBEXT ..... FEH index of fractional urban extent
WL ..... Water Level

1 Introduction

Under The Planning System and Flood Risk Management Guidelines for Planning Authorities (DoEHLG & OPW, 2009) the proposed development must undergo a Flood Risk Assessment to ensure sustainability and effective management of flood risk.

1.1 Terms of reference

JBA Consulting was appointed by Rhonellen Developments Limited to prepare a Flood Risk Assessment (FRA) for a site in Balbriggan, Co. Dublin.

1.2 Flood Risk Assessment; Aims and Objectives

This study is being completed to inform the future development of the site as it relates to flood risk. It aims to identify, quantify and communicate to the client the risk of flooding to land, property and people and the measures that would be recommended to manage the risk in order to facilitate the development of the site.

The objectives of the FRA are to:

- Identify potential sources of flood risk;
- Confirm the level of flood risk and identify key hydraulic features;
- Assess the impact that the proposed development has on flood risk;
- Develop appropriate flood risk mitigation and management measures which will allow for the long-term development of the site.

Recommendations for development have been provided in the context of the OPW/DECLG planning guidance, "The Planning System and Flood Risk Management". A review of the likely effects of climate change, and the long-term impacts this may have on developments has also been undertaken.

For general information on flooding, the definition of flood risk, flood zones and other terms see 'Understanding Flood Risk' in Appendix A.

1.3 Development Proposal

The proposed development is residential comprising three blocks (Block A, Block B and Block C), with shared amenity, retail, utilities, ESB switchroom and car park at the ground floor. The predominant Finish Floor Level's (FFL's) for the shared amenity, car park and utilities area is 4.7mOD. The retail units have been set at 4mOD and 4.55mOD. The minimum residential FFL onsite is 8.225mOD.

Figure 1-1 (Ground Floor) and Figure 1-2 (1st Floor) show the proposed design layout for the residential development at this site. T

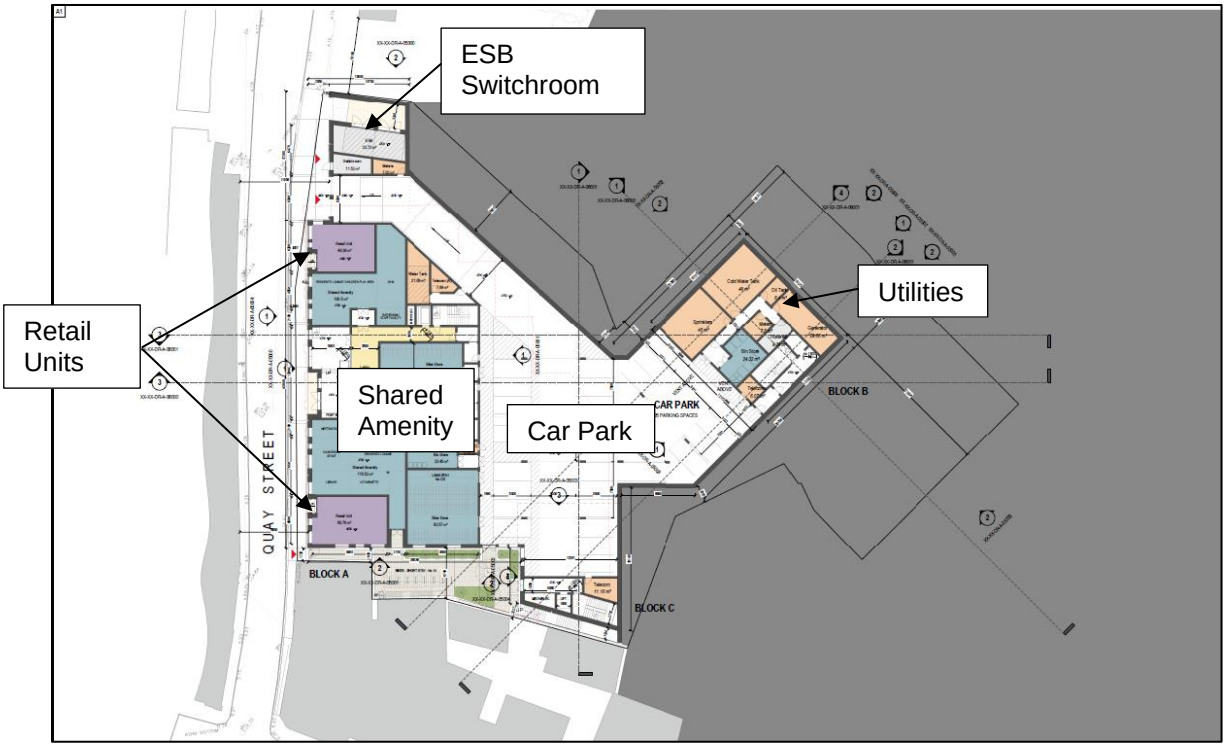


Figure 1-1: Site Layout - Ground Floor

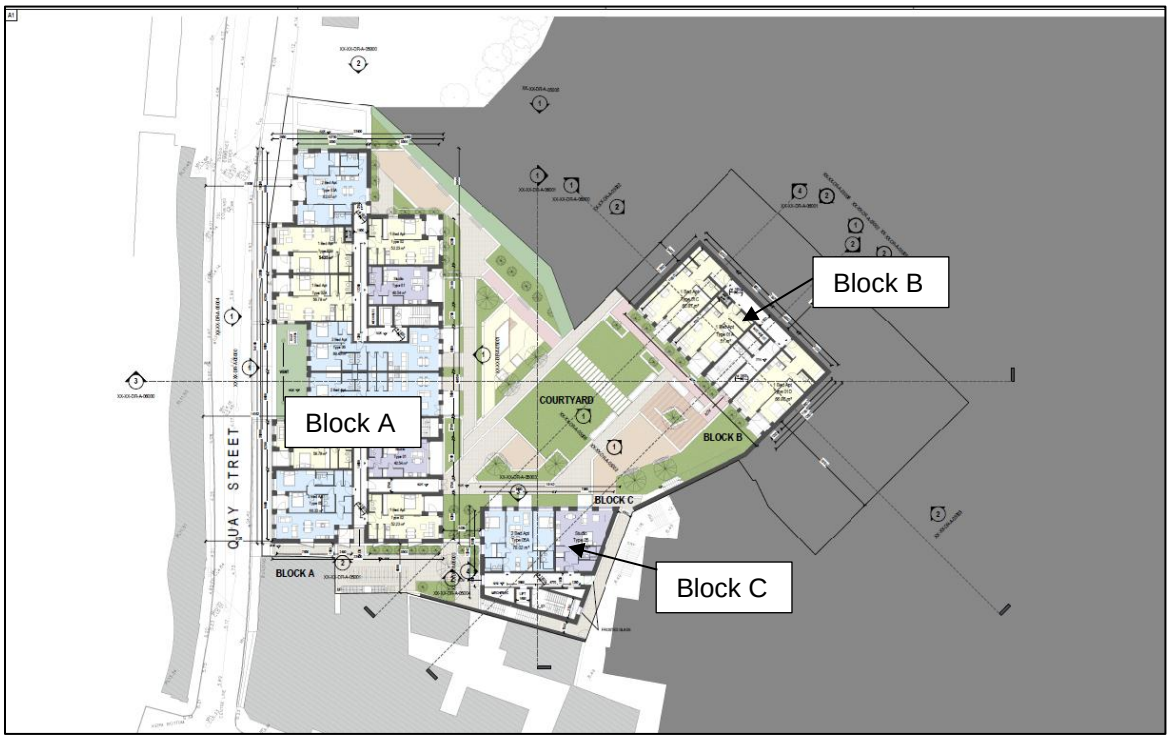


Figure 1-2: Site Layout - First Floor

2 Site Background

2.1 Location

The proposed development is located on Quay Street, Balbriggan, Co Dublin, which is situated in the town centre. The site is currently a car park and lies within a heavily urbanised area of the town, approximatively 450m south-east of the Balbriggan Harbour and Irish Sea. The Braken Stream flows 15m north-west of the site.

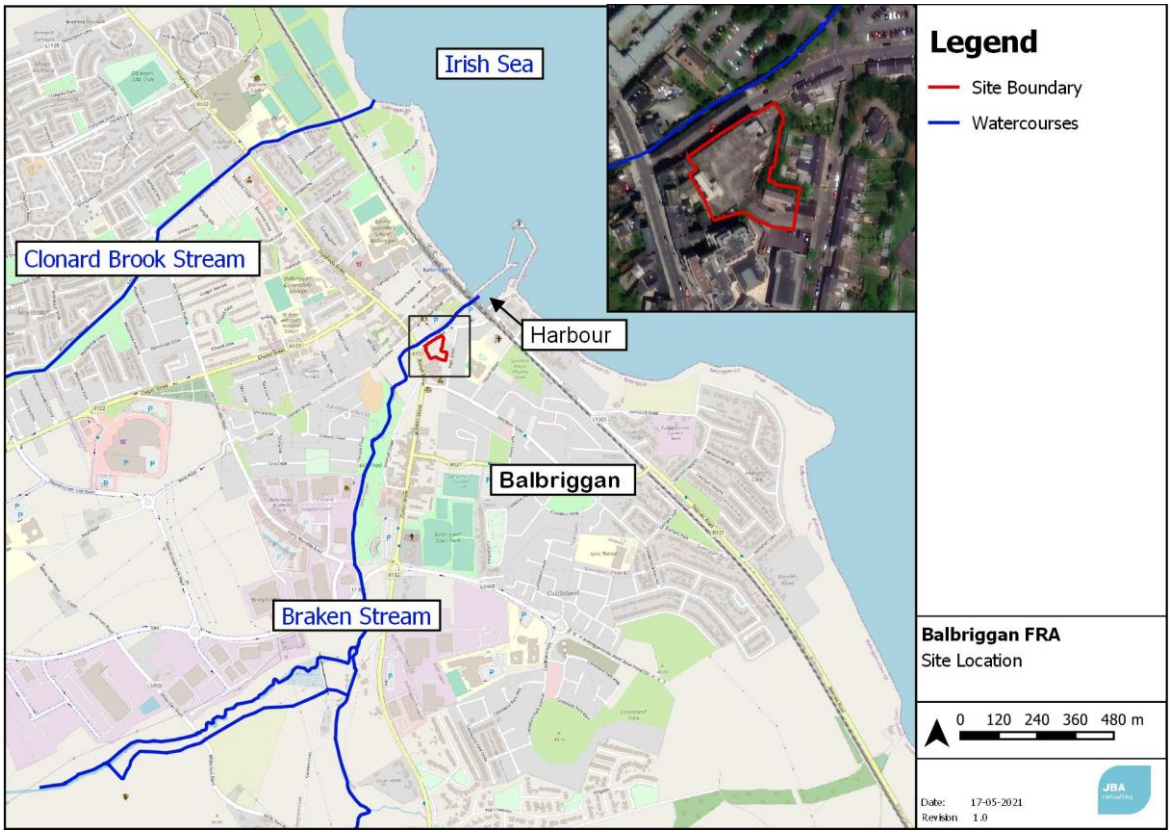


Figure 2-1: Site Location & Hydrological Environment

2.2 Watercourses

As shown in Figure 2-1, Braken and Clonard Brook are the two main local watercourses in the area.

The Braken Stream flows from the south, passing along the Quay Street where the proposed development is located. It then flows into the Irish Sea through the Balbriggan Harbour approximately 0.45km downstream of the site.

The Clonard Brook Stream flows easterly, through farmland before continuing through town approximatively 1km north of the site location and eventually flowing into the Irish Sea. There is no hydraulic connection from the Clonard Brook Stream to the site.

2.3 Site Topography

The eastern part of the site is located on higher ground, between 13-14mOD while the rest of the site is relatively flat, with elevations ranging between 4-5mOD. The site topography is presented in Appendix B.

2.4 Site Geology

The Geological Survey of Ireland (GSI) groundwater and geological maps indicate that the subsoil within the site is largely made of Irish Sea Till derived from sandstones and shales (IrSTLPSsS), and, to a lower extent, Alluvium (A). No Alluvium type soils are identified within the site boundary that would indicate the possible occurrence of historic flooding in the absence of other records. It is noted that the alluvium deposits runs across the site north-western boundary.

The underlying bedrock is classified as Belcamp Formation which consists of andesite, pillow breccia and mudstone.

The groundwater vulnerability is classified from "high" to "moderate". The groundwater vulnerability classifications reflect the potential risk of groundwater infiltrations through the bedrock and risk of groundwater contamination from the site. There is no evidence of karst features at the site or in the surrounding area, which would commonly be linked to groundwater flooding.

Figure 2-2: Quaternary Sediments

3 Flood Risk Identification

An assessment of the potential and scale of flood risk at the site was conducted using historical and predictive information. This identifies any sources of potential flood risk to the site and reviews historic flood information. The findings from the flood risk identification stage of the assessment are provided in the following sections.

3.1 Flood History

A number of sources of flood information were reviewed to establish any recorded flood history at, or near the site. This includes the OPW's website, www.floodmaps.ie and general internet searches.

3.1.1 Floodmaps.ie

The OPW host a National Flood hazard mapping website, www.floodmaps.ie, which highlights areas at risk of flooding through the collection of recorded data and observed flood events. See Figure 3-1 for historic flood events in the area, which are listed below.

Review of this mapping shows three instances of historical flooding within the area, as follows:

- Re-occurring flooding from coastal sources occurring at Bremore Court Balbriggan, located to the north-west of the site (1)
- 14th November 2002 - Flooding at Bath Road from coastal sources located to the north-west of the site (2)
- 14th November 2002 - Flooding at Covetown Balbriggan from coastal sources. Flooding was located approximately 550m north-west of the development site (3).

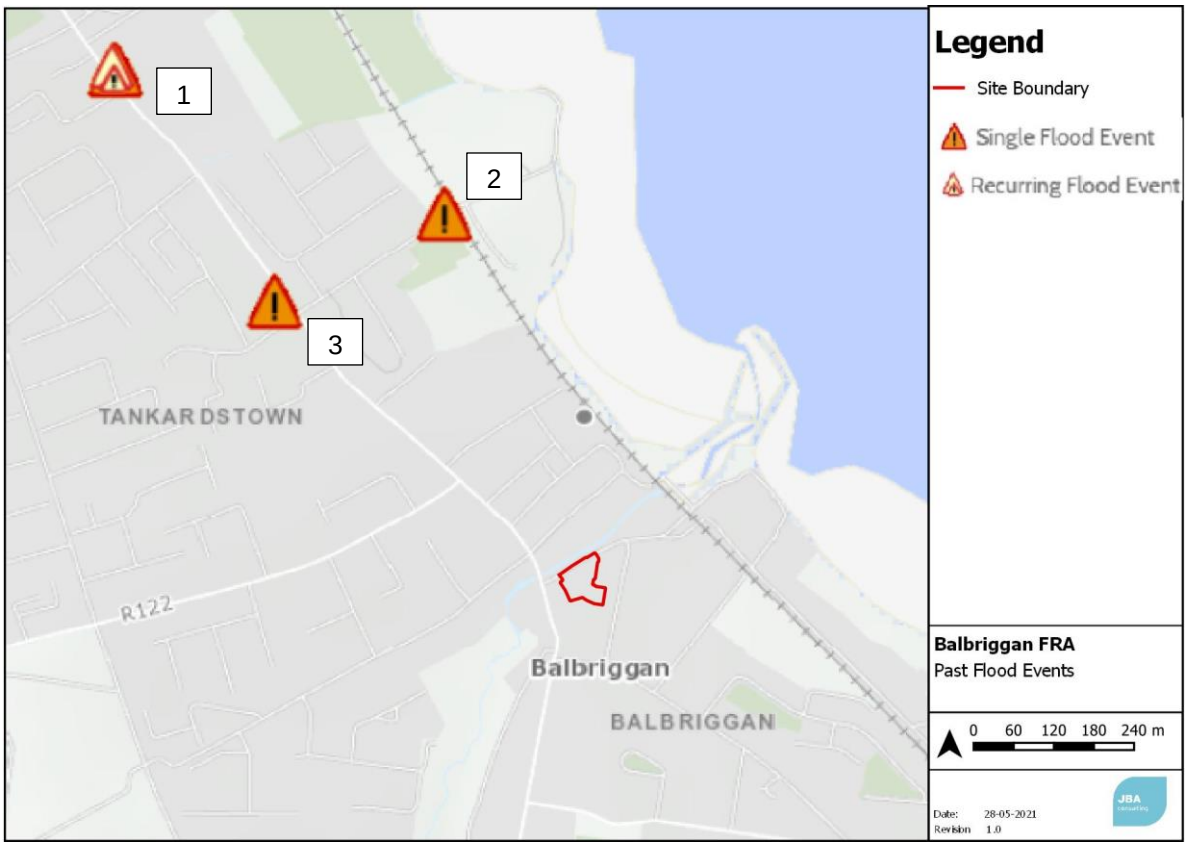


Figure 3-1: Historical Flooding (source: floodmaps.ie)

3.1.2 Internet Searches

An internet search was conducted to gather information about whether or not the site was affected by flooding previously. While there were no results for flooding affecting the site itself, there were reports confirming of flooding in the areas mentioned above.

3.2 Predictive Flooding`

The study area has been subject to two predictive flood mapping and modelling studies.

- Irish Coastal Protection Strategy Study Phase 3 - North East Coast - 2010;
- Fingal East Meath Flood Risk Assessment and Management Study (FEM FRAM) - 2014.

The level of detail presented in each method varies according to the quality of the information used and the approaches involved, with FEM FRAM study being the most detailed assessment.

3.2.1 Fingal East Meath Flood Risk Assessment and Management Study (FEM FRAM)

The FEM FRAM study is the most detailed mapping undertaken in the Balbriggan region. The study involves detailed hydraulic modelling of rivers, while also considering the tidal impacts. The Clonard Brook and the Braken watercourses were modelled within the FEM FRAM study, which resulted in flood mapping for the 10%, 1% and 0.1% AEP fluvial and tidal events.

The fluvial flood extents presented in Figure 3-1 show spilling occurs along the northern boundary of the site with Quay Street, during the 1% and 0.1% AEP events.

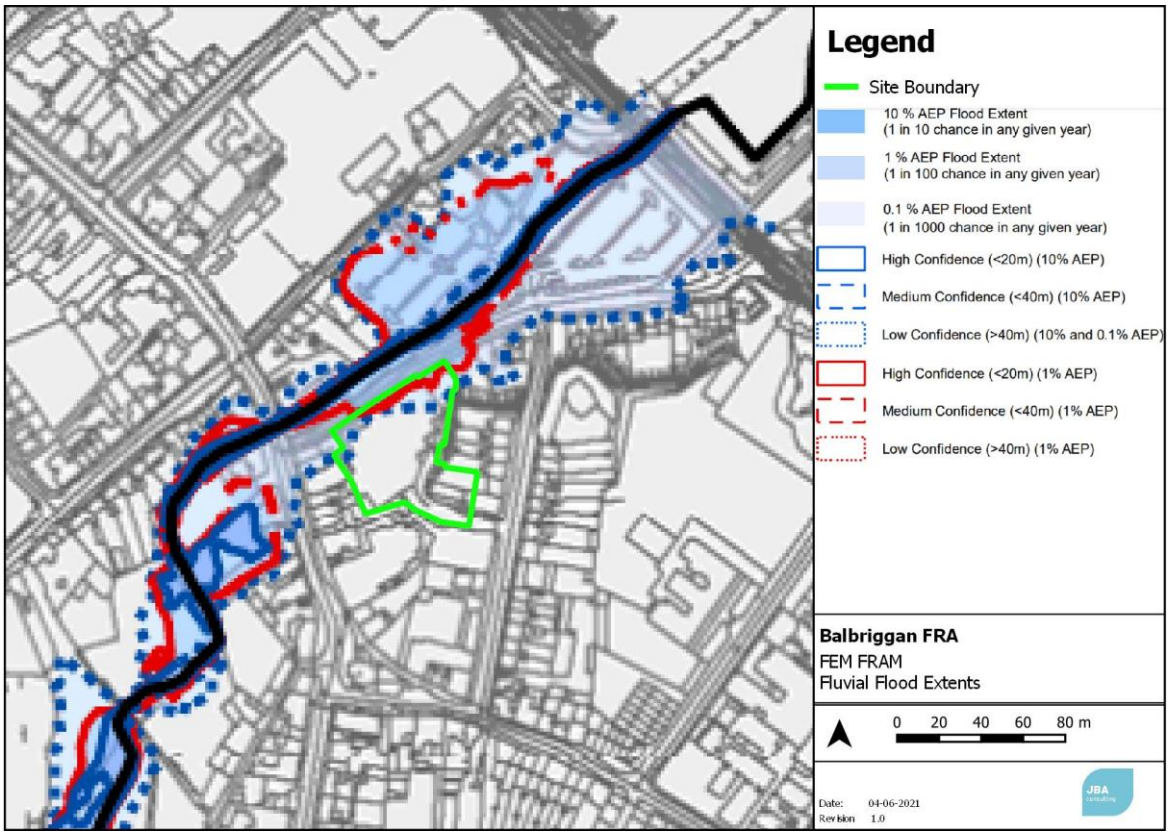


Figure 3-2: FEM FRAM - Fluvial Flood Extents

The tidal flood extents are presented Figure 3-3. Review of Figure 3-3 confirms only minor spill occurs within the northern corner of the site during the 0.1% AEP tidal event.

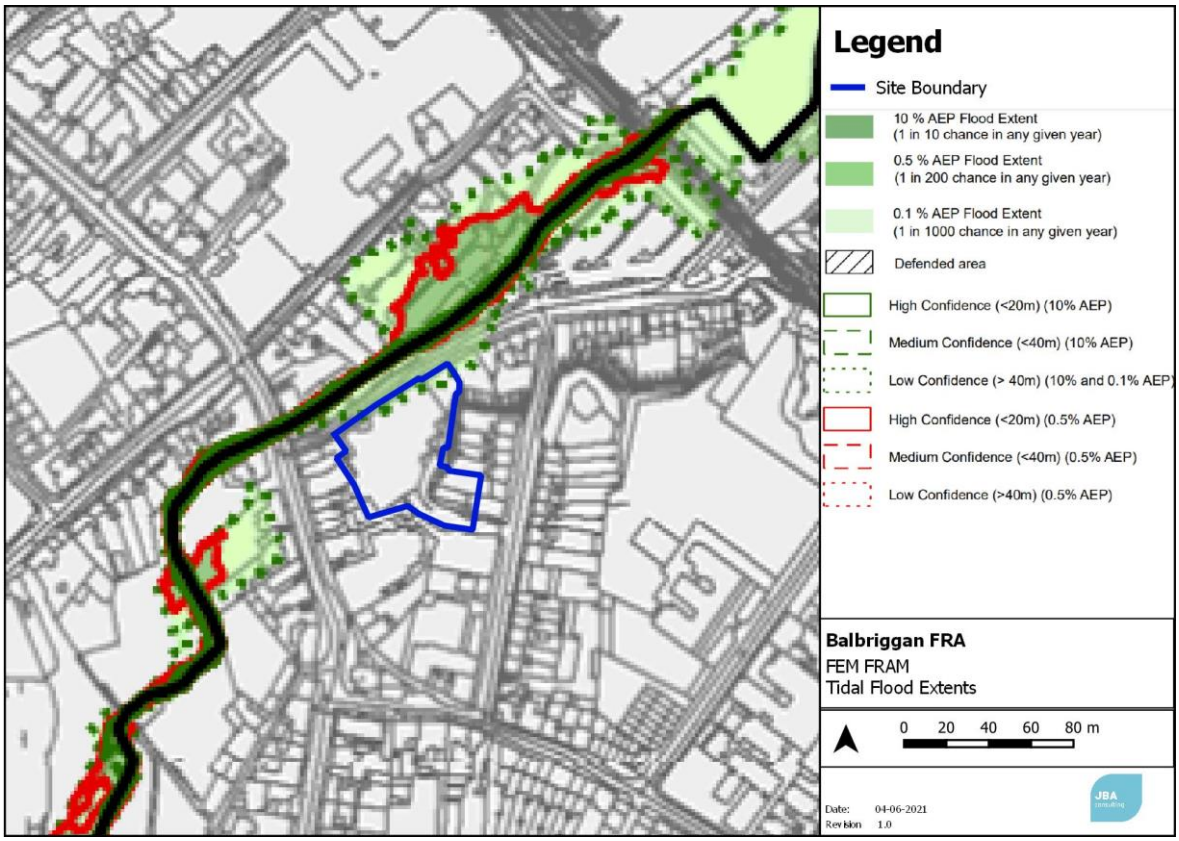


Figure 3-3: FEM FRAM - Coastal Flood Extents

3.3 Flood Sources

The initial stage of a Flood Risk Assessment requires the identification and consideration of probable sources of flooding. These sources are described below.

3.3.1 Fluvial

The Braken Stream is considered to be the main source of flood risk to the site. Review of the FEM FRAM mapping identifies the northern and western corners of the site being at flood risk from the Braken Stream during the 1% and 0.1% AEP events, therefore placing the majority of the site (approximatively 80%) within Flood Zone C and at low risk of flooding, with the remaining (20%) within Flood Zone A/B.

The fluvial flood risk for the proposed development will be further assessed in Section 4 using a site-specific hydraulic model. This will aid in the development of mitigation measures for the proposed development.

3.3.2 Tidal

Review of the FEM FRAM mapping confirms only the northern boundary of the site is subject to flooding during the 0.1% AEP tidal event.

Same as the fluvial flood risk, the tidal flood risk for the site will be assesses in more detail in Section 4 using the site-specific hydraulic model.

3.3.3 Pluvial/ Surface Water

Pluvial or surface water flooding is the result of rainfall-generated flows that arise before run-off can enter a watercourse or sewer. In any development, the poor design of a surface water system can influence the specific surface water flood risk to a site. To manage the potential generation of surface water runoff by a proposed development on the site, careful consideration should be given to the overall site design.

A review of the survey data for the site confirms there are no isolated depressions that would be at risk of surface water ponding. The pluvial mitigation is discussed in Section 5.

3.3.4 Groundwater

There are no karst features in the area which would indicate areas at risk of groundwater flooding. The overall vulnerability at the proposed development to groundwater is deemed low. As such, groundwater is not a likely source of flood risk to the site and has been screened out of this assessment.

4 Flood Model Assessment

4.1 Hydrology

To assist in the estimation of potential flood risk to the proposed development from the local watercourses, this section provides flow estimates for the 1% and 0.1% AEP flood event flows expected along the watercourse that flows through the northern section of the site. A summary of the hydrology estimation process is provided in this section. Refer to Appendix F for a detailed overview of the hydrology process.

4.1.1 Catchment Characteristics

The physical characteristics of the catchment influence the hydrology, this includes catchment size, soil type, steepness and the average annual rainfall. Table 4-1 outlines the parameters calculated for the river catchments and Figure 4-1 presents the catchment and the river network.

Figure 4-1: Catchment Delineation

Table 4-1: Catchment Characteristics (source: OPW FSU)

Descriptor	HEP 1 (site location)	Pivotal Gauge (Naul)
Centroid X	263680	313183
Centroid Y	260750	261157
Area	27.747	33.4276
SAAR	738.64	791.12
FARL	0.977	1
BFI Soil	0.525	0.524
URBEXT	0.0387	0.0054
MSL	9.667	10.646
S1085	4.05596	0.0663
Stream Frequency	38	19
DrainD	1.138	0.787
ArtDrain2	0.3929	0
Soil (number)	2	2
M5-2day	0.5	0.5
r	0.3	0.3

4.1.2 Flow Estimation

Two flood estimation methods were compared under the hydrological analysis: FSU and IH 124.

The FSU method was found to be more suitable given the catchment size and characteristics, the expected catchment behaviour, while being in line with a reasonably conservative approach, namely the FSU calculations returned higher flow values.

Two inflow points were chosen for the hydraulic model. The points are located upstream of Balbriggan town (refer to Figure 4-1), with lateral flows applied to the model between these points down to the site location.

Table 4-2: Final Design Flows (m^3/s)

AEP%	HEP 1	Inflow 1 (US)	Inflow 2 (US)	DS (Lateral)
10% (10yr)	10.2	6.98	2.39	0.82
1% (100yr)	14.56	9.97	3.41	1.08
0.1%(1000yr)	18.57	12.72	4.35	1.50

4.1.3 Tidal

The downstream tidal levels have been sourced from the FEM FRAM Study for the T10, T200 and T1000 tidal flood events. The tidal hydrography was sourced from the Marine Institute (marine.ie.) for Dublin Port.

The final tidal peak flood levels used in the hydraulic model are presented in Table 4-3.

Table 4-3: Peak Tidal Flood Levels

AEP%	Tidal Levels [mOD]
10% (10yr)	3.01
2% (50yr)	3.15
0.5% (200yr)	3.43
0.1% (100yr)	3.66

4.1.4 Climate Change

Current OPW guidance requires that the effects of climate change be considered when assessing flood risk. The expected increase in 100 year peak flows, rainfall and tidal level is provided in the draft OPW guidance which provides allowances for two different climate change scenarios. These are the Mid-Range Future Scenario (MRFS) and the High-End Forecast Scenario (HEFS). The recommended allowances for climate change are given in Table 4-4 below. The potential implications for the development from climate change are discussed further in Section 5.

For the purpose of this model, the HEFS event will be applied to the fluvial flows and to the tidal boundary in the design assessment.

Table 4-4 OPW Climate Change Guidance

Events	MRFS	HEFS
Extreme Rainfall Depths	+20%	+30%
Flood Flows	+20%	+30%
Mean Sea Level Rise	+500mm	+1000m

4.1.5 Design Flood Events

The main design flood events on which the proposed development will be assessed are the 1% AEP fluvial/ 0.5% AEP tidal and the 0.1% AEP fluvial/tidal scenarios. These provide the Flood Zone A and B extents respectively. The resulting flood levels from these flood events will guide the appropriate FFL with freeboard.

To ensure that the necessary fluvial and tidal boundaries have been applied, a realistic combination of the upstream fluvial and downstream tidal models was determined. The following scenarios have been selected as the design events in the hydraulic model as part of the FRA to test both the fluvial and tidally dominated events:

1. Fluvial
    a. 1% AEP Fluvial + 10% AEP Tidal (Flood Zone A)
    b. 0.1% AEP Fluvial + 2% AEP Tidal (Flood Zone B)
2. Tidal
    a. 0.5% AEP Tidal + 10% AEP Fluvial (Flood Zone A)
    b. 0.1% AEP Tidal + 2% AEP Fluvial (Flood Zone B)

As previously stated, in addition to the above main design flood event, sensitivity scenarios will be undertaken to appraise the proposed design against the potential impact of climate change and the residual risk of blockage of critical culverts along the watercourse in the vicinity of the site. Climate change will be assessed in accordance to the HEFS event will be applied to the fluvial flows in the design assessment.

4.2 Hydraulic Model

4.2.1 Model Set-up

To provide a detailed assessment of flood risk at the site a 1D-2D ESTRY-TUFLOW hydraulic model was constructed. It allows for the modelling of river channels, streams, floodplains and hydraulic structures to predict water levels for a range of scenarios (see Figure 4-1 for hydraulic model structure). The hydraulic model was developed in the following stages:

- A 1D-2D ESTRY-TUFLOW model of the Sluice River created using a DTM and available surveyed data,
- The existing structures were inserted into the model based on survey and a baseline condition was established,
- Hydraulic simulations were run to derive the existing flood extent to determine Flood Zones A, B and C at the site (the 1% and 0.1% AEP flood events),
- Hydraulic simulations were run under the post-development analysis to appraise the impact of the proposed works,
- The post-development analysis defines the building levels onsite,
- The post-development design has been assessed against a range of climate change scenarios (MRFS & HEFS),
- A number of residual risks were also assessed for the site, including partial blockage of the R132 bridge (upstream) and a pedestrian bridge (downstream).

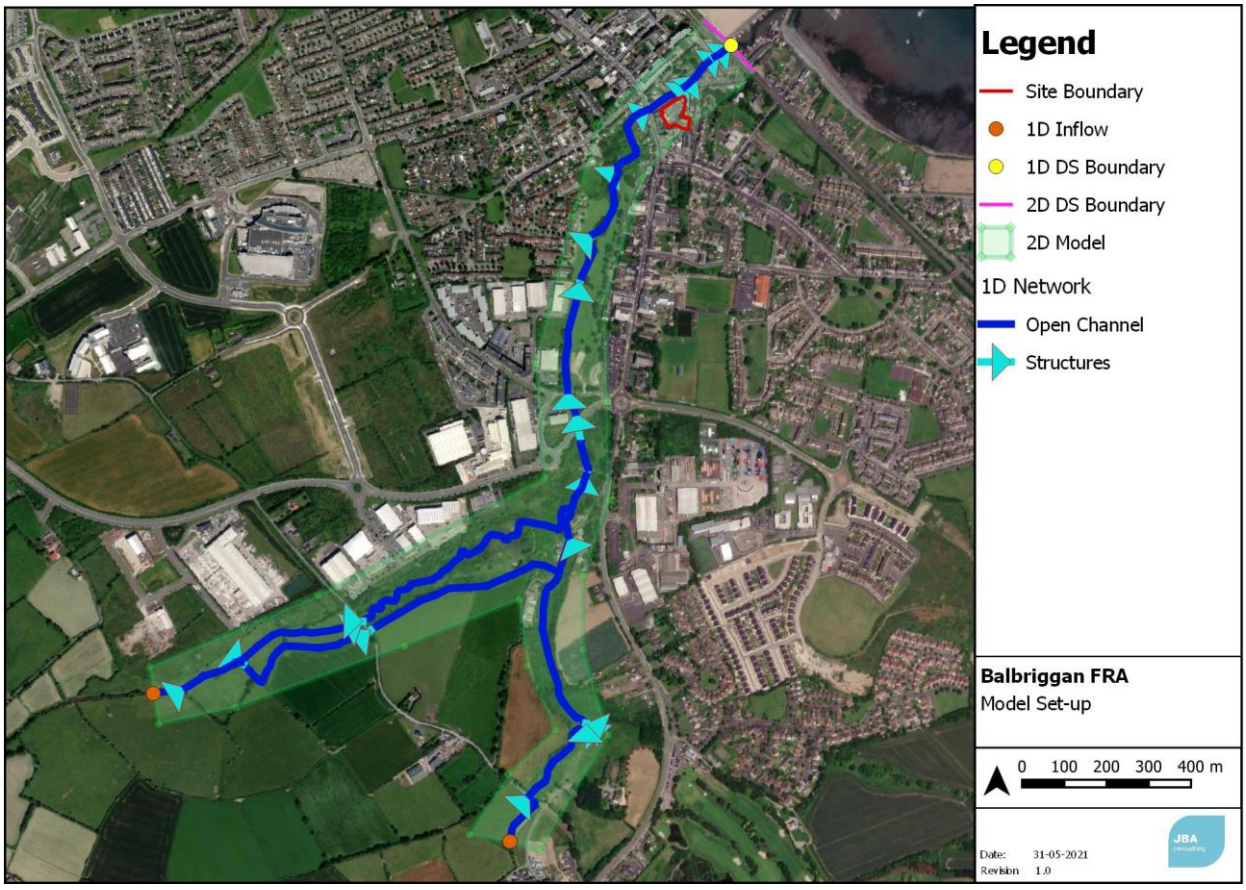


Figure 4-2: Model Schematisation

4.2.2 Model Results

The modelled flood extents representing the Flood Zone A/B are presented in Figure 4-3. Review of Figure 4-3 confirms the site is not at flood risk during the 1% AEP fluvial event and 0.5% AEP tidal event.

Only a small portion of the northern corner of the site is affected by flooding during the 0.1% AEP fluvial event.

The results differ from that presented within FEM FRAM study. It is likely that the cause is the application of the building structures in the model area. The existing buildings between Quay Street and the River Bracken retain flood waters in bank.

Figure 4-3: Pre-Development Flood Extents

4.2.3 Post-Development Flood Extents

As outlined in Section 1.3, the proposed development involves the construction of residential buildings, with shared amenities and car park at the ground floor and apartments at the higher floors. The ground floor was included in the model based on the finished floor level.

The model was then run to assess the flood risk for the proposed development and the resulting flood extents are presented in Figure 4-4, showing the proposed development is not at flood risk for events up to and including 0.1% AEP fluvial and tidal.

Figure 4-4 also provides the monitoring location points used to provide water levels for pre-development and post-development results and for further discussion in the following sections of the report.

The pre-development and post-development water levels are presented in Table 4-5, showing the proposed development does not increase the flood risk elsewhere.

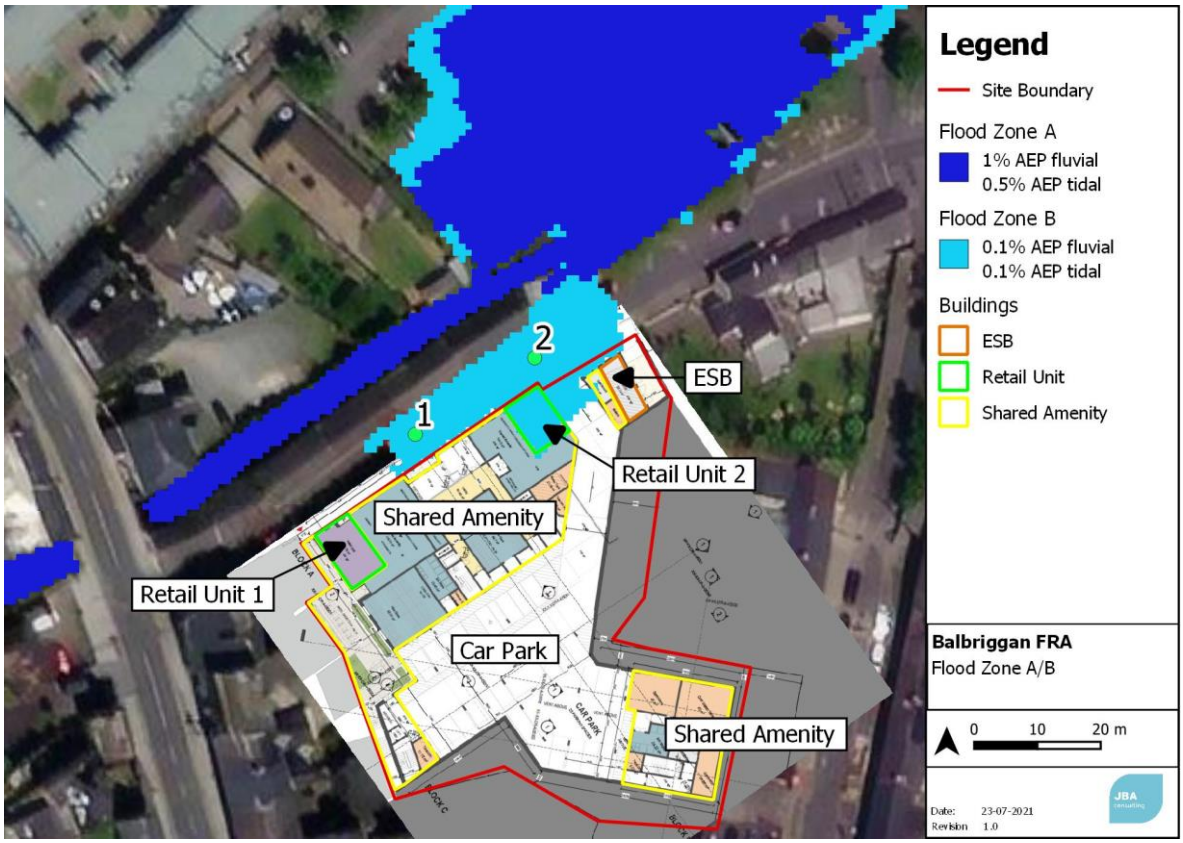


Figure 4-4: Post-Development Flood Extents

Table 4-5: Impact Table - 0.1% AEP Water Levels

Monitoring Point	Pre-development 0.1% AEP [mOD]	Post-development 0.1% AEP [mOD]
1	4.10	4.10
2	4.10	4.10

5 Flood Risk Assessment and Mitigation

5.1 Flood Risk/Mitigation Measures

From reviewing the available sources of flooding outlined in Section 3, only the northern boundary of the site is at flood risk from the 1% and 0.1% AEP fluvial events and from the 0.1% AEP tidal events. This is based on the FEM FRAM flood mapping.

The JBA site specific hydraulic model confirms that in the pre-development condition, the majority of the site is located in Flood Zone C, and at a low risk of inundation. The residential apartments are located at higher floors and therefore at very low risk of flooding. The shared amenities, the ESB building, one retail unit and the car park are located in Flood Zone C, while the other retail unit is located in Flood Zone B. According to …, retail units can be developed in Flood Zone B.

Specific mitigation measures have been outlined in the following sections to minimise flood risk to the development.

5.1.1 Building Finished Floor Levels

The appropriate setting of the Finish Floor Level's (FFL) has been based on the governing development plan and associated SFRA. The specific freeboard required is outlined as follows:

- Highly Vulnerable Developments - 0.1% AEP plus 500mm freeboard,
- Less Vulnerable Developments - 1% AEP (0.5% AEP tidal) plus 500mm freeboard.

Based on the modelled flood levels along Quay Street (refer to Monitoring Points 1 & 2 provided in Figure 4-4), the minimum required FFL is 4.6mOD for the ESB and 4.49mOD for the shared amenities, retail units and car park.

The provided FFLs (refer to Table 5-1:) within the development is provided below which surpasses the minimum requirements outlined above. The exception is for the two retail units fronting onto Quay Street. It is necessary to comply with Part M building standard requirements therefore the FFL of the retails units needs to tie into the existing levels along Quay Street. A unit is located in Flood Zone C while the other is located in Flood Zone B. This complies with the FRA guidelines.

Table 5-1: Proposed FFLs (mOD)

	FFL [mOD}	Water Level [mOD]	Freeboard [m]
ESB	4.70	4.10 (0.1% AEP - FZ B)	0.60
Shared Amenities	4.70	3.99	0.71
Retail Unit 1	4.55	3.99	0.56
Retail Unit 2	4.00	3.99	0.01
Car Park	4.70	3.99	0.71

5.1.2 Access/Egress

The access route provided to the proposed development is through Quay Street and High Street. Figure 4-4 confirms that both access routes are at low risk of inundation from the 1% AEP flood event. In summary, access to the development can be maintained for events up to and including the 1% AEP flood event.

5.1.3 Stormwater design/Pluvial Flood Risk

The proposed development will increase the hardstanding area onsite and therefore could potentially increase the surface water runoff from the site if not mitigated against. Surface water flow from hardstanding areas will be managed by the proposed stormwater system. The stormwaters need to comply with the overarching Fingal County development policy and the GDSDS guidance document.

There is no identified pluvial flooding onsite and any surface water onsite will be managed post-development by the stormwater system.

To minimise the risk of pluvial flooding, a threshold of 150mm is required from the FFL to the external ground levels. No further mitigation measures are required to manage the pluvial flood risks.

5.2 Climate Change

The site has been assessed for the HEFS climate change scenario for both the fluvial and tidal events (1% and 0.1% AEP). The resulting flood levels and proposed FFLs are provided in Table 5-2. Review of Table 5-3 confirms that the proposed development will not be impacted by the predicted HEFS flood event.

Table 5-2: Climate Change Levels (mOD)

	FFL [mOD}	Water Level [mOD]	Freeboard [m]
ESB	4.70	4.67 (0.1% AEP HEFS)	0.03
Shared Amenities	4.70	4.44 (0.5% AEP HEFS)	0.26
Retail Unit 1	4.55	4.44 (0.5% AEP HEFS)	0.10
Retail Unit 2	4.00	4.44 (0.5% AEP HEFS)	-0.44
Car Park	4.70	4.44 (0.5% AEP HEFS)	0.26

5.3 Residual Risk/Additional Assessment

Residual risks are defined as risks that remain after all risk avoidance, substitution and mitigation measures have been taken. The flood risk assessment identifies the following as the main sources of residual risk to the proposed development. The main residual risk to the development has been identified as the potential blockage of the upstream bridge and is covered in the following section.

5.3.1 Culvert Blockage

As part of the residual risk assessment process the upstream bridge has modelled with a blockage of 66%. This is done to ensure that any residential properties will not be impacted by a potential blockage event. The results from this scenario from the 1% AEP fluvial event is presented Table 5-3, confirming that the development will not be impacted during this scenario.

The retails are at flood risk during this event, however as outlined previously it is necessary to tie into the existing Quay Street elevation to comply with the Part M building standards.

Table 5-3: Culvert Blockage Water Levels (mOD)

	FFL [mOD}	Water Level [mOD]	Freeboard [m]
ESB	4.70	4.39	0.31
Shared Amenities	4.70	4.47	0.23
Retail Unit 1	4.55	4.60	-0.05
Retail Unit 2	4.00	4.41	-0.41
Car Park	4.70	4.40	0.30
Block A West	4.70	4.67	0.03
Block A Central	4.70	4.46	0.24

6 Conclusion

JBA Consulting has undertaken a detailed Flood Risk Assessment for a proposed residential development in Balbriggan, Co Dublin. The nearest watercourse to the site is identified as the Bracken Stream which runs across the northern boundary of the site.

The site is located in the urban core of Balbriggan and the existing buildings onsite will be demolished as part of the proposed works. The proposed development mainly comprises residential apartment units and creche, car park etc.

A review of the available historic information confirms that the site has not experienced historic flooding. However, the Balbriggan has been subject to predictive flood modelling under the FEM FRAM study. The resulting flood maps confirms that the northern boundary of the site with Quay Street during the 1% AEP (Flood Zone A) and the 0.1% AEP (Flood Zone B) events.

Based on the historic and predicted flood risk, a site-specific hydraulic model has been developed to investigate the flood risk to the site and includes the assessment of climate change and residual risks.

The resulting flood maps from the modelling study confirm that all the proposed residential dwellings are at a low risk of inundation and not at risk from the 0.1% AEP flood event. Due to the site location, the site has been assessed for both fluvial and tidal flood sources.

A minimum FFLs of 8.225mOD has been provided for the residential properties for the apartment blocks. Review of the flood levels ensures that a minimum freeboard of approx. 4m has been provided over all modelled flood events.

Residual risk and climate change (HEFS scenario) have also been assessed for the site. The residual risk has included the potential blockage of the proposed culvert. Under the climate change (HEFS), the tidal event provided the highest flood levels onsite. Review of the model results confirms that the shared amenity areas on the ground floor will not be impacted from climate change or the identified residual risks (bridge blockage).

Pluvial flood risk has also been reviewed for the site. A detailed stormwater system has been designed for the site to minimise increased pluvial flood risk generated by the increase in hardstanding are, refer to the supporting stormwater engineering report.

In summary the key areas of the proposed residential dwellings and shared amenity areas will not be impacted any of the modelled flood events therefore, are suitable for the development of residential and commercial buildings.

This Flood Risk Assessment was undertaken in accordance with 'The Planning System and Flood Risk Management Guidelines' and is in agreement with the core principles contained within. The Sequential Approach and specifically the Justification Test has been undertaken and passed as part of the Flood Risk Assessment process.

Appendices

A Appendix - Understanding Flood Risk

Flood Risk is generally accepted to be a combination of the likelihood (or probability) of flooding and the potential consequences arising. Flood Risk can be expressed in terms of the following relationship:

Flood Risk = Probability of Flooding x Consequences of Flooding

A.1 Probability of Flooding

The likelihood or probability of a flood event (whether tidal or fluvial) is classified by its Annual Exceedance Probability (AEP) or return period years, a 1% AEP flood 1 in 100 chance of occurring in any given year. In this report, flood frequency will primarily be expressed in terms of AEP, which is the inverse of the return period, as shown in the table below and explained above. This can helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval and is the terminology which will be used throughout this report.

Table: Conversion between return periods and annual exceedance probabilities

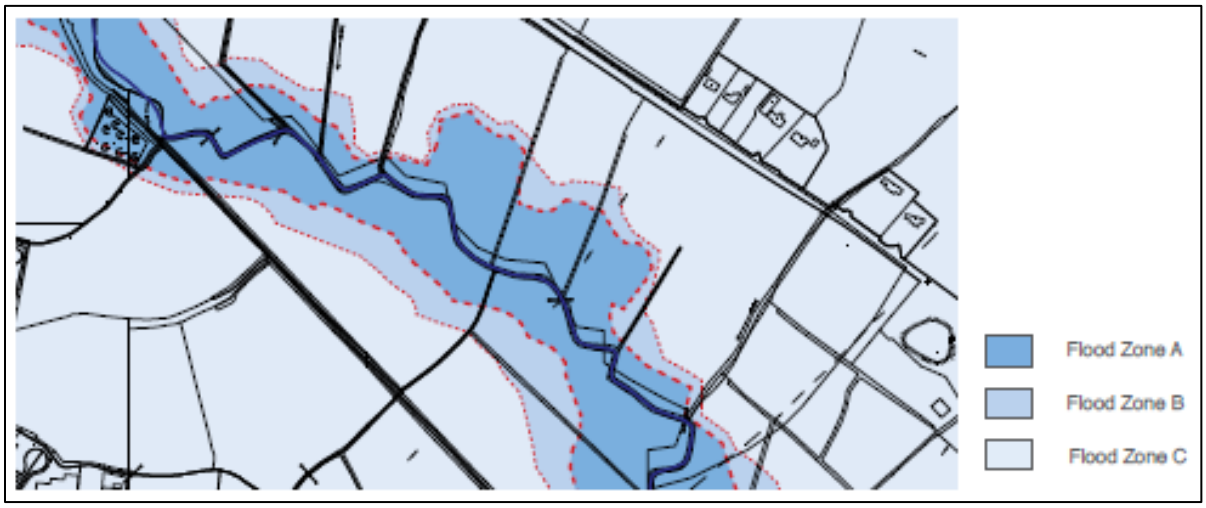
• Return period (years)	• Annual exceedance probability (%)
2	50
10	10
50	2
100	1
200	0.5
1000	0.1

A.2 Flood Zones

Flood Zones are geographical areas illustrating the probability of flooding. For the purpose of the Planning Guidelines, there are 3 types of levels of flood zones, A, B and C.

Zone	Description
Flood Zone A	Where the probability of flooding is highest, greater than 1% (1 in 100) from river flooding or 0.5% (1 in 200) for coastal/ tidal Flooding
Flood Zone B	Moderate probability of flooding, between 1% and 0.1% from rivers and between 0.5% and 0.1% from coastal/ tidal.
Flood Zone C	Lowest probability of flooding, less than 0.1% from both rivers and coastal/ tidal.

It is important to note that the definition of the flood zones is based on an undefended scenario and does not take into account the presence of flood protection structures such as flood walls or embankments. This is to allow for the fact that there is a residual risk of flooding behind the defences will be maintained in perpetuity.



A.3 Consequences of Flooding

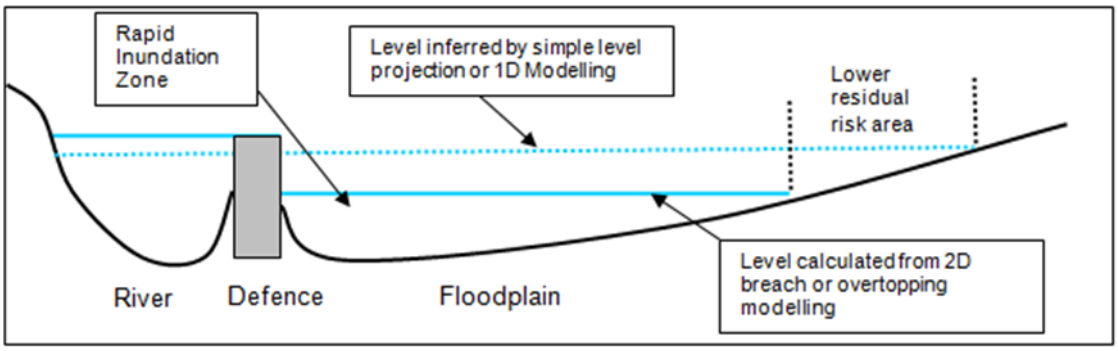
Consequences of flooding depend on the Hazards caused by flooding (depth of water, speed of flow. Rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure of the population, presence and reliability of mitigation measures etc.)

The 'Planning System and Flood Risk Management' provides three vulnerability categories, based on type of development, nature, which are detailed in Table X of the Guidelines, and are summarised as:

- **Highly vulnerable**, including residential properties, essential infrastructure and emergency service facilities
- **Less vulnerable**, such as retail and commercial and local transport infrastructure, such as changing rooms.
- **Water compatible**, including open space, outdoor recreation and associated essential infrastructure, such as changing rooms.

A.4 Residual Risk

The presence of flood defences, by their very nature, hinder the movement of flood water across the floodplain and prevent flooding unless river levels rise above the defence crest level or a breach occurs. This known as residual risk:



Offices at
Dublin
Limerick

Registered Office
24 Grove Island
Corbally
Limerick
Ireland

t: +353 (0) 61 345463
e:info@jbaconsulting.ie

JBA Consulting Engineers and Scientists Limited
Registration number 444752

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