GREENPARK MASTERPLAN, LIMERICK

FLOOD RISK ASSESSMENT

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1 INTRODUCTION

RPS were commissioned by Voyage Property Ltd to carry out a Flood Risk Assessment (FRA) in support of Masterplan for previously undeveloped land at a site at the former Greenpark racecourse, with existing access from the Dock Road in Limerick. Greenpark was the home to Limerick Racecourse until it was relocated to Patrickswell, making way for the potential redevelopment of these lands and mix of use as prescribed in the City Development Plan e.g. office campus, housing, neighbourhood and leisure.

The purpose of this FRA is to define the flood risk to proposed development lands and demonstrate that with appropriate mitigation they can be developed in accordance with the requirements of 'The Planning System and Flood Risk Management' Guidelines' (DEHLG 2009).

The site is located west of Limerick city centre, between the N69 and the N18, adjacent to the Limerick Greyhound Stadium. The general location of the site is shown in Figure 1.1.

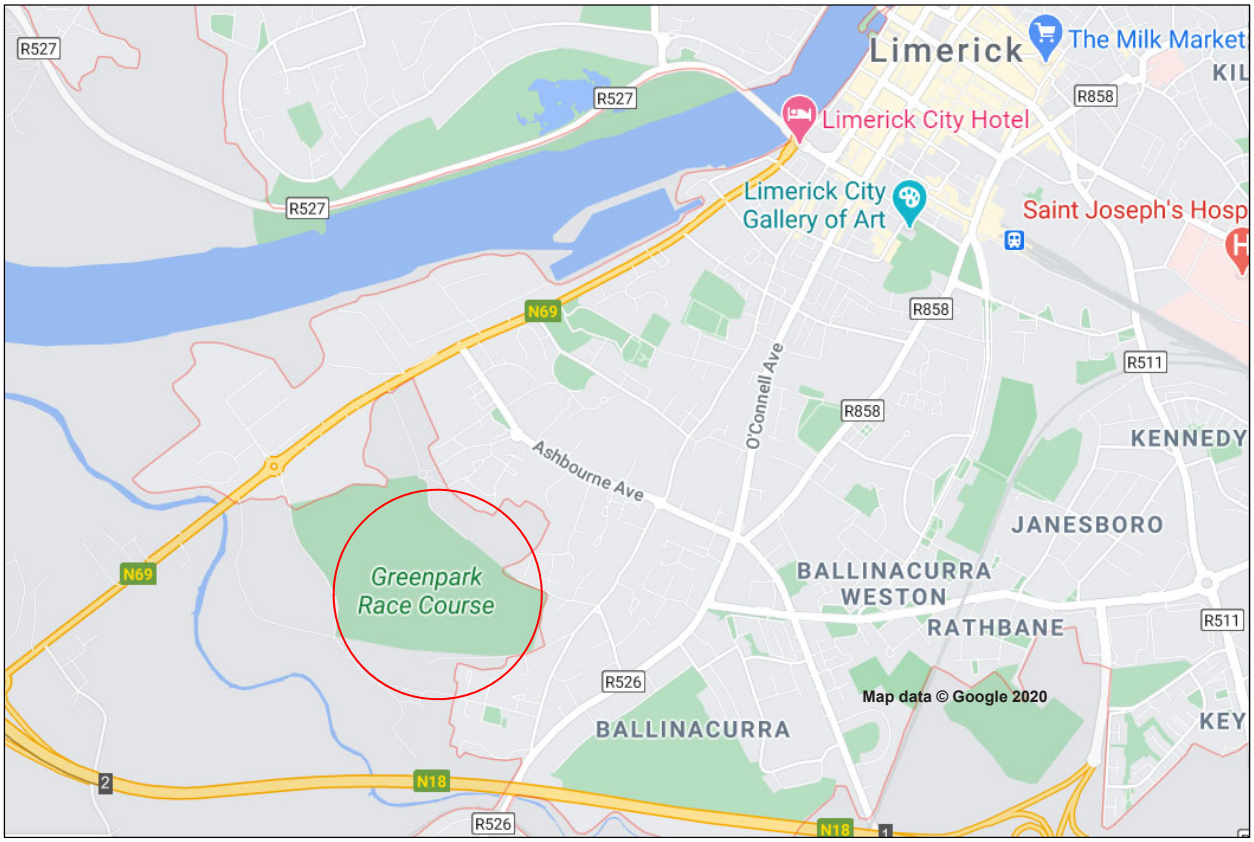


Figure 1.1 Location map

2 SITE DESCRIPTION

The existing site is part of the former Limerick Race Course. It is relatively low lying with respect to the Shannon Estuary and Ballynaclough River. The majority of the site is flat with levels in the vicinity of 2.4m OD rising to above 7m OD adjacent to the existing Log Na gCapall development to the south east.

Limerick Greyhound Stadium is located adjacent to the site along with a large hardstanding area of car park and existing pond/lagoon located adjacent to the Ballynaclough River. Figure 2.1 shows an aerial photo of the development site with the Masterplan area highlighted in red.

Figure 2.1 Aerial photograph indicating the extent of the masterplan area

The River Shannon flows at a distance of approximately 500m to the north and, a tributary, the Ballynaclough River, flows along the western boundary of the masterplan area. There is a the line of existing flood defences along both the Ballynaclough River and the River Shannon which offer a good standard of protection to this area of Limerick. More detail on these is provided in Section 3.

3 EXISTING FLOOD RISK

The National Catchment-based Flood Risk Assessment and Management (CFRAM) Programme was developed by the Office of Public Works (OPW) to meet national policy needs and the requirements of the EU Floods Directive. As part of the Shannon Catchment-based Flood Risk Assessment and Management (CFRAM) Study, Limerick was identified as an Area for Further Assessment (AFA). This meant that the watercourses in the area were modelled and flood maps produced. The maps are available to download from the OPW Flood Info website and provide the best available information to characterise the existing flood risk.

3.1 Existing Flood Defences

The defences along the Ballynaclough River and the Shannon Estuary were built by the OPW under the Arterial Drainage Act, 1945. Arterial Drainage Schemes were carried out to improve land for agriculture and to mitigate flooding. The intention of building the embankments was initially to provide protection against the 3 year flood but in many locations the embankments have been raised further over time and a much higher standard of protection is provided. That can be said of the embankments at this location which have been constructed along the estuary to a height of approximately 5.2m OD and along the Ballynaclough River to a height in excess of 6m OD. Figure 3.1 has been extracted from the floodinfo.ie website which provides records of the various drainage districts and the embankments located within them. At this location there are three embankments which offer protection to the masterplan area denoted on Figure 3.1 as E1A, E1 and E2. The defences also continue further into Limerick towards Ted Russell Dock but these are in private ownership and are therefore not shown on this mapping.

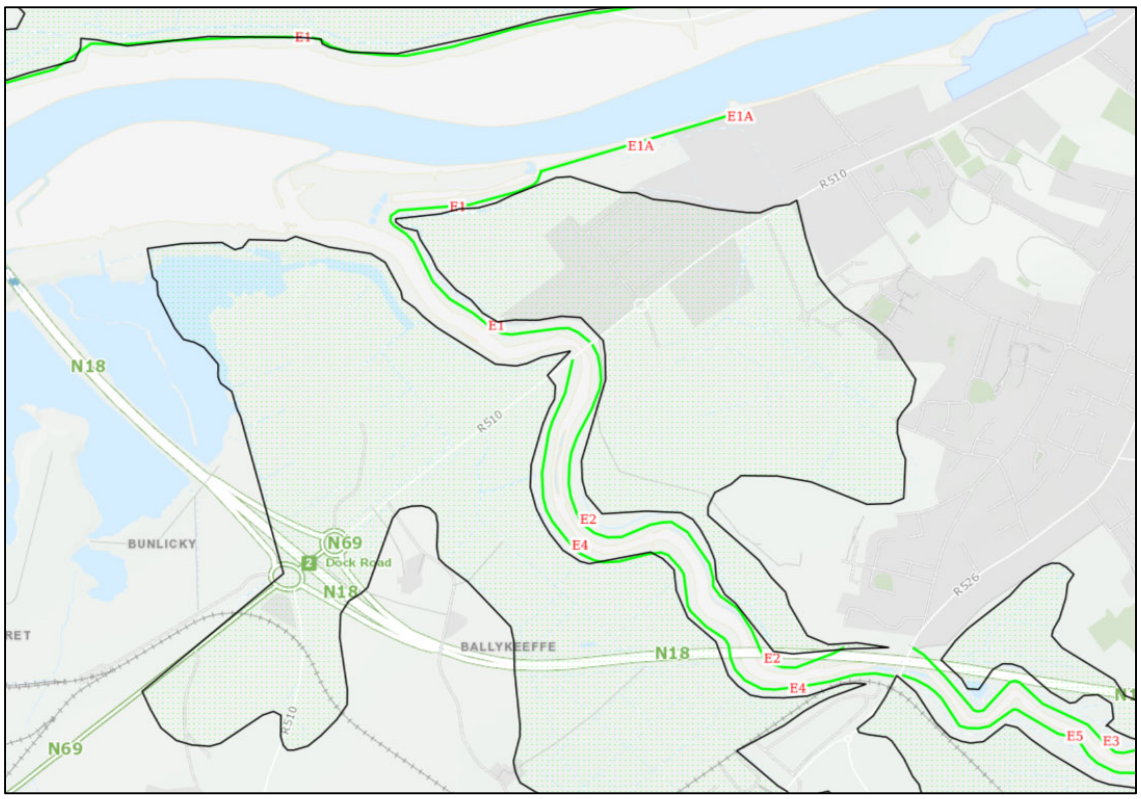


Figure 3.1 Extract of Arterial Drainage Districts mapping showing defences and benefitting areas

The embankments are constructed of unknown material and indeed it can be assumed that they are constructed of varying grades and types of strata including estuarine mud which is known to have been used at various points along the estuary. These defences extend for miles down the estuary on both banks. At this particular location the embankments provide a good standard of protection to all properties along the Dock Road which would otherwise be frequently inundated to a significant depth. Despite there being no historical risk of breach at this location, it remains a possibility and therefore will be addressed in the mitigation measures required to ensure the safety of the masterplan area. RPS have not carried out any visual or intrusive testing of the embankments and instead will set out mitigation measures for the masterplan area to deal with the event of a breach.

3.2 Fluvial Flood Risk

The CFRAMS maps show that the site is not at risk of fluvial flooding. An extract from the CFRAM Study Fluvial Flood Extents Map is shown in Figure 3.2, and the full map is shown in Appendix A. Fluvial flooding is not therefore conisdered further in this report.

Figure 3.2 Extract from CFRAMS fluvial flood extents map

3.3 Coastal Flood Risk

The CFRAMS maps show that the site has areas which are defended from coastal flooding by flood embankments along the Ballynaclough River which have a standard of protection of 0.5% AEP. There are some areas of the site which are at risk of coastal flooding in a 0.5% AEP event from the River Shannon to the north, as the defences in this area only have a standard of protection of 2% AEP. There are also some areas within the site that are not at risk of coastal flooding. Extracts from the CFRAM Study Tidal Flood Extents Maps are shown in Figures 3.3 and 3.4 and the full maps are shown in Appendix A.

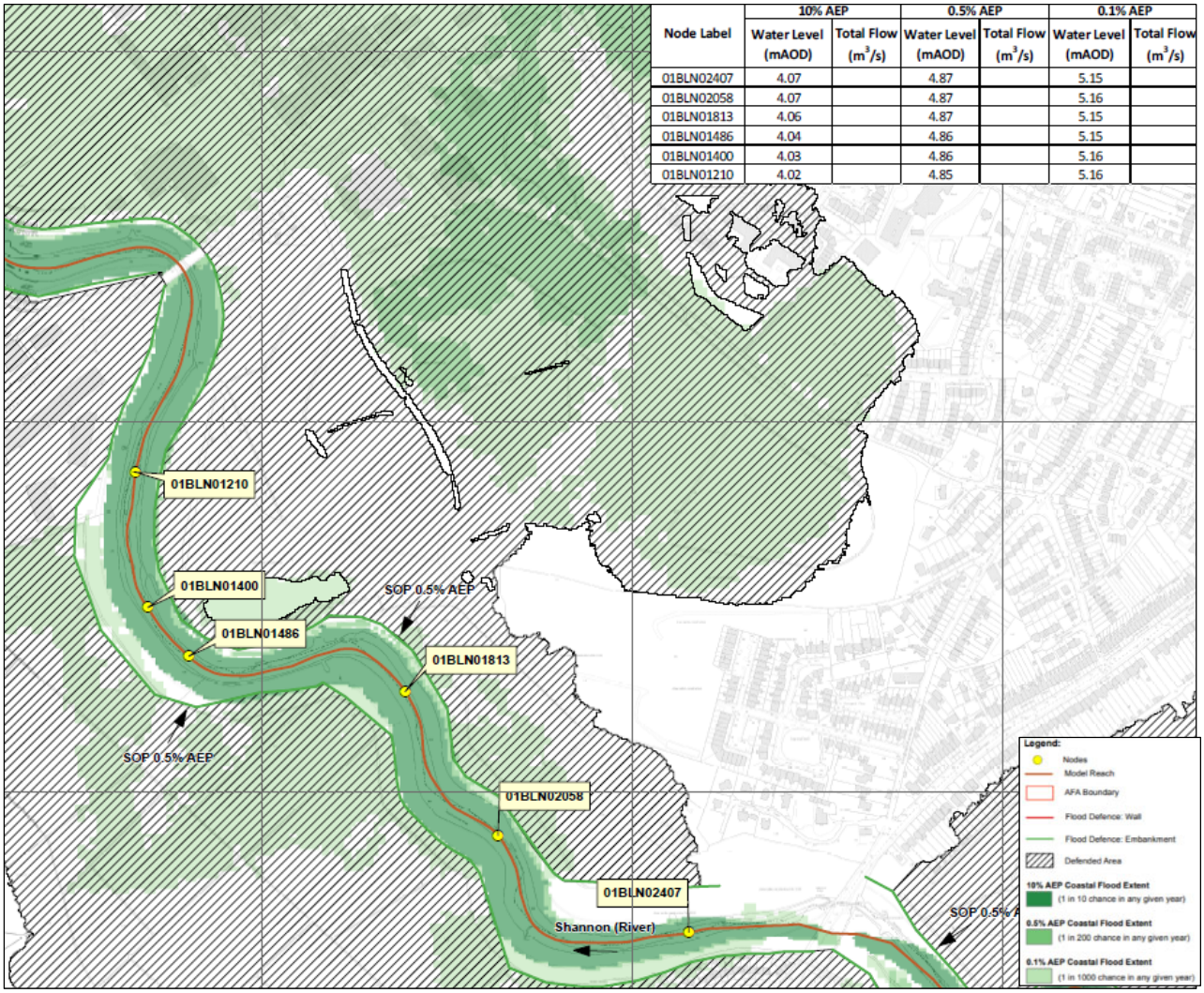
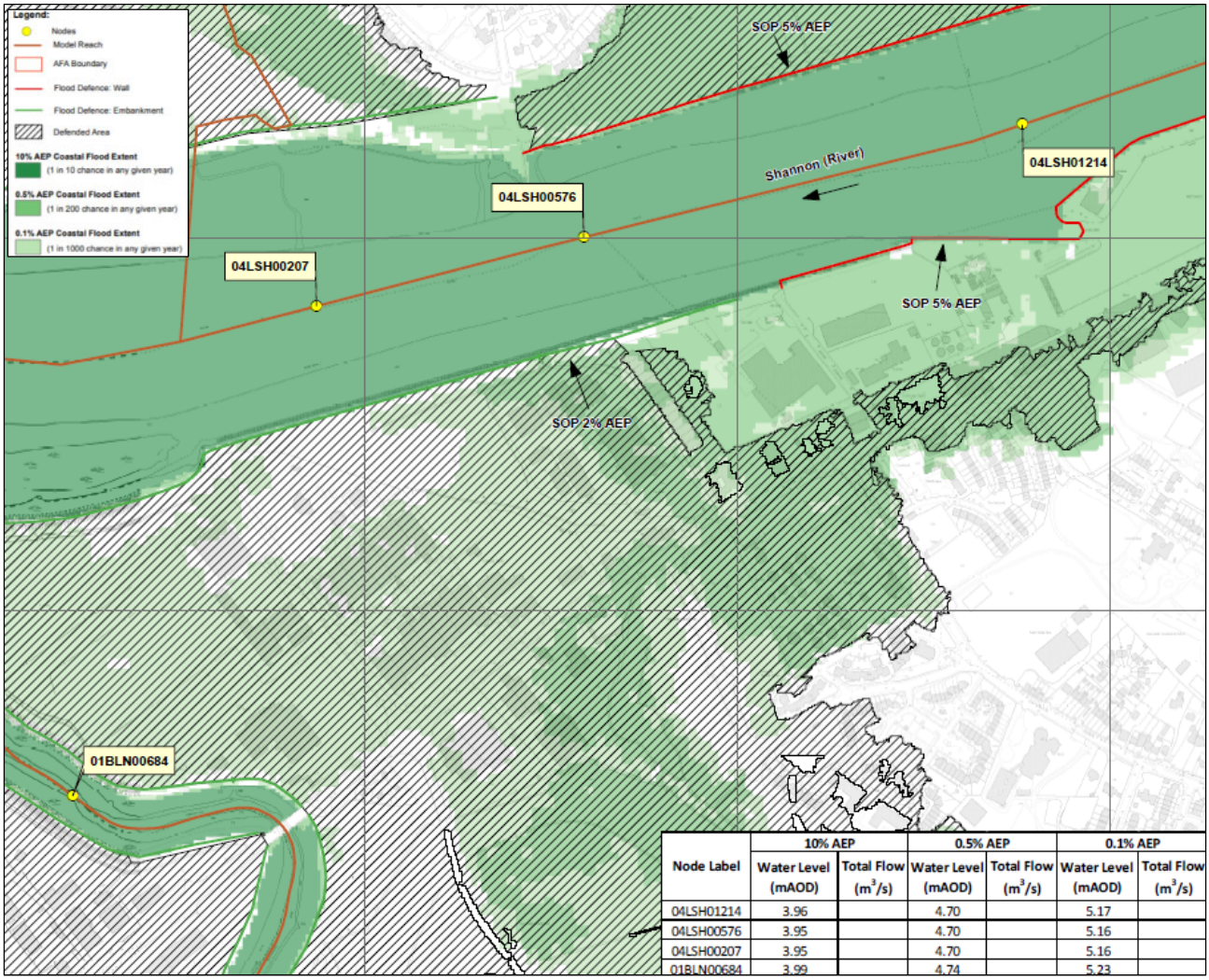


Figure 3.3 Extract from CFRAMS tidal flood extents map (Ballynaclough River)



Node Label	10% AEP		0.5% AEP		0.1% AEP	
	Water Level (mAOD)	Total Flow (m^3/s)	Water Level (mAOD)	Total Flow (m^3/s)	Water Level (mAOD)	Total Flow (m^3/s)
04LSH01214	3.96		4.70		5.17	
04LSH00576	3.95		4.70		5.16	
04LSH00207	3.95		4.70		5.16	
01BLN00684	3.99		4.74		5.23	

Figure 3.4 Extract from CFRAMS tidal flood extents map (River Shannon)

3.4 Flood Zones

Under the requirement of 'The Planning System and Flood Risk Management' Guidelines (2009) when considering existing flood risk it is necessary to assign flood zoning to the proposed development site. Flood zoning is defined as:

- **Flood Zone A**: areas where the probability of flooding from rivers and the sea is highest (greater than 1% for river flooding or 0.5% for coastal flooding).
- **Flood Zone B:** areas where the probability of flooding from rivers and the sea is moderate (between 0.1% and 1% for river flooding, and between 0.1% and 0.5% for coastal flooding).

- **Flood Zone C**: Areas where the probability of flooding from rivers and the sea is low (less than 0.1% for both river and coastal flooding).

An important consideration for this particular location is the presence of the existing defences, which although, offering a good standard of protection even during extreme flood events must be ignored for the purpose of flood zoning. This is stated in Clause 2.25 of the Guidelines and is required because areas protected by flood defences still carry a residual risk of flooding from overtopping or breach of defences and the fact that there may be no guarantee that the defences will be maintained in perpetuity. In this respect, Figure 3.2 shows that part of the site is in Flood Zone C (white areas), however a significant portion of the site can be considered to be in Flood Zone A (dark blue) with a very small section of the land being contained within Flood Zone B. Figure 3.5 shows the flood zoning.

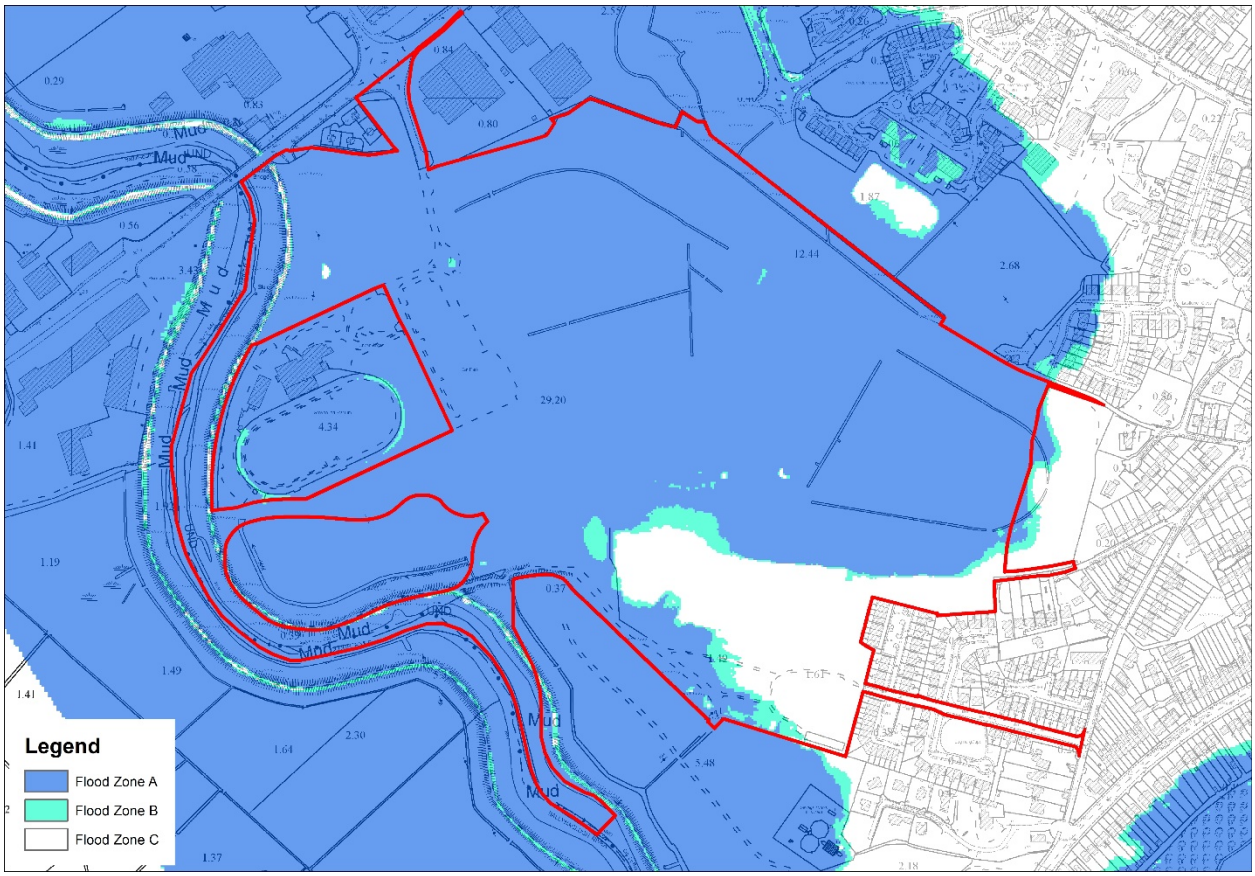


Figure 3.5 Flood Zone identification

Given the flood zoning identified in Figure 3.4, the Planning System and FRM Guidelines provide direction on the type of development appropriate to each flood zone. This is shown in Table 3.2 in guidelines which is reproduced in this report as Figure 3.6.

	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

Table 3.2: Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test.

Figure 3.6 Flood zones and appropriate development

It follows from Table 3.2 that for residential (vulnerable) and commercial (less vulnerable) development in Flood Zone A the Justification Test will need to be applied and fully satisfied before development can be permitted. For land designated as being within Flood Zone C it is considered appropriate for all types of development. With respect to the masterplan area this includes an area adjacent to the existing Log Na gCapall development.

4 PROPOSED DEVELOPMENT

4.1 Description of the Proposed Development

The Greenpark Masterplan encompasses multi-phasing residential development and office campus, neighbourhood centre and public open spaces adjacent to Bord na gCon greyhound stadium along Ballynaclough River. The office floor plates will be designed with greater flexibility and adaptability to local and multinational demands. Neighbourhood centre strategically located to serve the need of the local community and residents.

The residential component of the Masterplan, consists of 831 dwelling units, age appropriate housing, apartments, creche and residential amenity spaces. The development will be carried out in several phases. The first phase of the development includes strategic housing development application for 289 dwelling units with a residential density of 40.37 units/ha, creche and other associated ancillary uses in line with the masterplan.

The open space and riverwalk amenity are an essential and vital part of the masterplan to provide a greater biodiversity and sustainable amenity spaces for the new and existing community in Greenpark.

The overall Masterplan is shown in Figure 4.1.

Figure 4.1 Overall Masterplan

There are three significant parts of the masterplan- the Office Campus Development, the Neighbourhood Centre, and the Residential Development. For the purposes of this assessment the Neighbourhood Centre has been included with the Residential Development. The remainder of the masterplan area will remain at existing levels and as per the existing land use. These areas will be the primary focus of this flood risk assessment.

The purpose of the flood risk assessment is therefore to demonstrate how, given the flood risk identified in Section 3, the office campus and residential development (including the neighbourhood centre) areas can be developed in a manner that is fully compliant with the Planning System and Flood Risk Management Guidelines. In that respect there are a number of key principles which must be addressed in order to pass the Justification Test, these are:

- Firstly, demonstrating that during a 200 year (0.5% AEP) event and during a 200 year (0.5% AEP) Climate Change event there is no risk to the proposed development or increase in flood risk elsewhere.
- Secondly, Clause 5.16 on page 49 states that a precautionary approach should be applied for developments located behind existing defences. It suggests that an appropriate mitigation measure would be to set floor levels above the 0.5% AEP flood level (for a site affected by coastal flooding) and to include for the effects of climate change. When determining this 0.5% AEP level the effect of defences should be ignored.

Addressing these key issues is best practice in demonstrating compliance with the Justification Test as set out in Box 5.1 of the Planning system and Flood Risk Management Guidelines. Section 5 of this report describes the mitigation measures that address these criteria and the numerical modelling undertaken to demonstrate their effectiveness. Section 6 describes compliance with the Justification Test.

5 PROPOSED MITIGATION MEASURES

Given the scale of the masterplan area it is recognised that any mitigation measures proposed must be robust, sustainable with respect to climate change and not place any burden on the city of Limerick whereby there would be a requirement in the future to provide additional flood defences and capital expenditure to protect this development. It is also acknowledged that under the CFRAM process, where Limerick was an Area for Further Assessment (AFA), a significant capital scheme was proposed. This scheme is currently being tendered to engineering consultants under the OPW Capital Works Framework and should be developed over the next 10-15 years. While there is no doubt a scheme of this nature would further benefit the masterplan lands, RPS also recognise there is no guarantee a scheme will be developed as it will be subject to a cost-benefit analysis and availability of government funding. Conversely there is also a need to ensure mitigation measures proposed as part of this masterplan in no way compromise the development of a suitable flood alleviation scheme for Limerick.

5.1 Model Construction

In order to be able to assess the impact of any proposed mitigation measures RPS have developed a site specific model incorporating the masterplan area. As the masterplan lands are located behind existing defences it is obvious there is no impact either upstream or downstream in the Ballynaclough River or the Shannon Estuary. Instead the model has been developed specifically to understand the impact of the defences overtopping and also breaching, ensuring that the masterplan area is resilient to these flooding mechanisms and doesn't significantly adversely affect adjacent property and land.

Therefore RPS have constructed a InfoWorks ICM 2D model of this area of Limerick based on a Digital Terrain Model (DTM) constructed from LIDAR data which covers this area of Limerick. This has been supplemented by more detailed topographical survey of the existing flood defences to capture any low points or defects. The LiDAR provides a high resolution survey that is sufficient for establishing the effects of overtopping and breaching of the existing flood defences. RPS have utilised the 0.5% Annual Exceedance Probability (AEP) flood levels for the Shannon estuary and that for the Ballynaclough River developed in the CFRAM study. These provide the best available estimation of the predicted water level during extreme coastal events for this return period.

In addition RPS have improved upon the CFRAM inundation modelling by incorporating all of the existing buildings within Dock Road area within the model and blocked these out to prevent flow through them. This is a significant addition to the modelling undertaken during the CFRAM process as it can identify new flow paths as the water passes between buildings.

5.2 Modelling of Existing Situation

5.2.1 0.5% AEP Simulation with Existing Ground Levels

As a baseline model run RPS took the peak tidal levels from the CFRAM study in the estuary and Ballynaclough River and ran a 0.5 % AEP flood inundation simulation. This model was run over 72 hours covering tidal cycles leading up to and after the 0.5% AEP event with an appropriate tidal curve reflecting the rising and falling level of the flood and ebb tide during an extreme storm surge event. As stated previously the majority of the defences surrounding the Dock Road area are sufficiently high enough to prevent inundation and overtopping however there is a lower section near to the Ted Russel Dock where a limited amount of flooding can occur. The flood mapping output from this model simulation is shown in Figure 5.1.

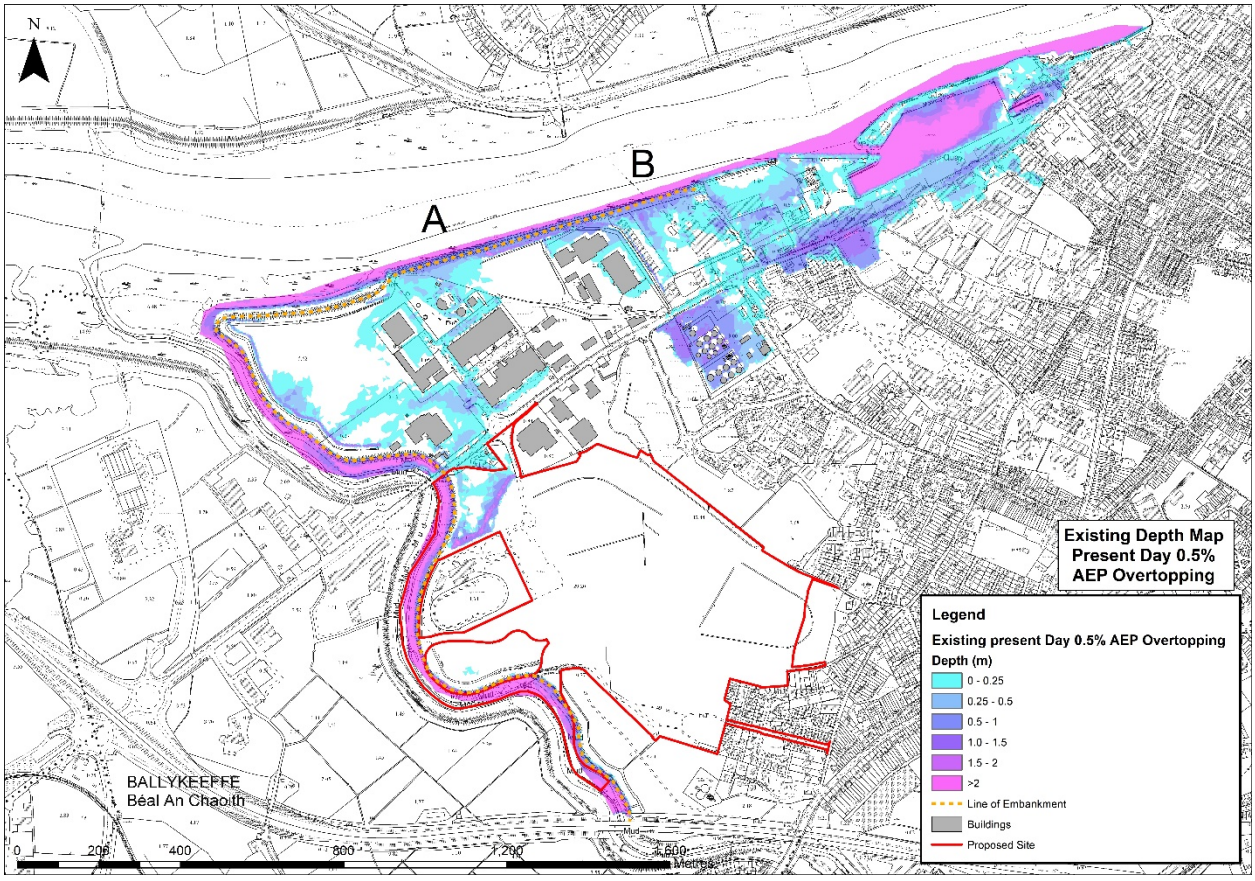


Figure 5.1 Flood depth map showing impact of 0.5% AEP flood inundation simulation

The model simulation indicates overtopping at two locations (Points A and B on Figure 5.1) where the defences are insufficiently high to prevent inundation. The extent of this inundation shows that the only

part of the masterplan area affected is open space to the north of the greyhound stadium. There is no proposed alterations to existing ground levels in this area as part of the masterplan so from this model run we can conclude:

- There is no risk to the area of the masterplan lands proposed for commercial or residential development during a 0.5% flood event providing defences are only overtopped and not breached.
- During inundation from an event of this magnitude where overtopping occurs, the water level behind the defences reaches a water level of approximately 2.3m OD. All existing levels within the masterplan area proposed for commercial or residential development are in excess of this level.
- As the 0.5% AEP water level does not inundate the proposed development area in the existing scenario there can be no increase in water level as a result of constructing the proposed development and therefore no further assessment is required in this regard.

5.3 Development and Modelling of Mitigation Measures

As stated previously in this FRA when quoting Clause 5.16 of the Planning System and Flood Risk Management Guidelines, there is a need to ensure a precautionary approach when developing behind existing defences. It suggests that the mitigation measures for dealing with that risk would be to set finished floor levels at the 0.5% flood level (for coastal flooding) ignoring the moderation effects of flood defences. Following this logic to address the impact of the inundation from the 0.5% AEP Climate Change MRFS event during a breach scenario, it is proposed to raise the level of the office campus and residential development to minimise the residual risk. By raising levels on the site it will provide sufficient protection to the proposed development, but it raises the question if it could also increase the risk of flooding to surrounding land and existing development. RPS have therefore carried out a comprehensive modelling exercise focussing on the breach scenario to ensure there in no increase risk to adjacent developments should this occur during a 0.5% AEP and 0.5% AEP Mid-range Future Scenario events.

5.4 Breach Analysis of the Flood Defences

5.4.1 Modelling of the Existing Defences

Given the scale of the proposed development and the high number of both residential and commercial properties a robust assessment of residual risk is required. The original purpose of the existing defences and the unknown make-up of their construction means it is necessary to undertake a breach analysis at certain locations along both the Ballynaclough River and the Shannon estuary to assess the impact of such an event on the proposed and existing developments. Breach analysis was undertaken using the UK

Environment Agencies guidance on breach modelling which was also adopted for use during the CFRAM process. It was undertaken at three locations:

Breach 1 – along the Estuary at the rear of McMahon Building Providers

Breach 2 – along the lower reaches of Ballynaclough River

Breach 3 – on the Ballynaclough River upstream of the Greyhound Stadium.

All breaches were run over 72 hour tidal cycle with the breach set to occur 1 hr before the peak of flood. At this time in the simulation a 50m section of the embankment is removed with the spill level being reduced to existing ground levels on either side of the defence. A separate map was produced for each location i.e. it is assumed only one breach occurred at a time. All 3 breach locations produced approximately the same flood extent and Figure 5.2 shows the 0.5% AEP Breach extent for the existing lands.

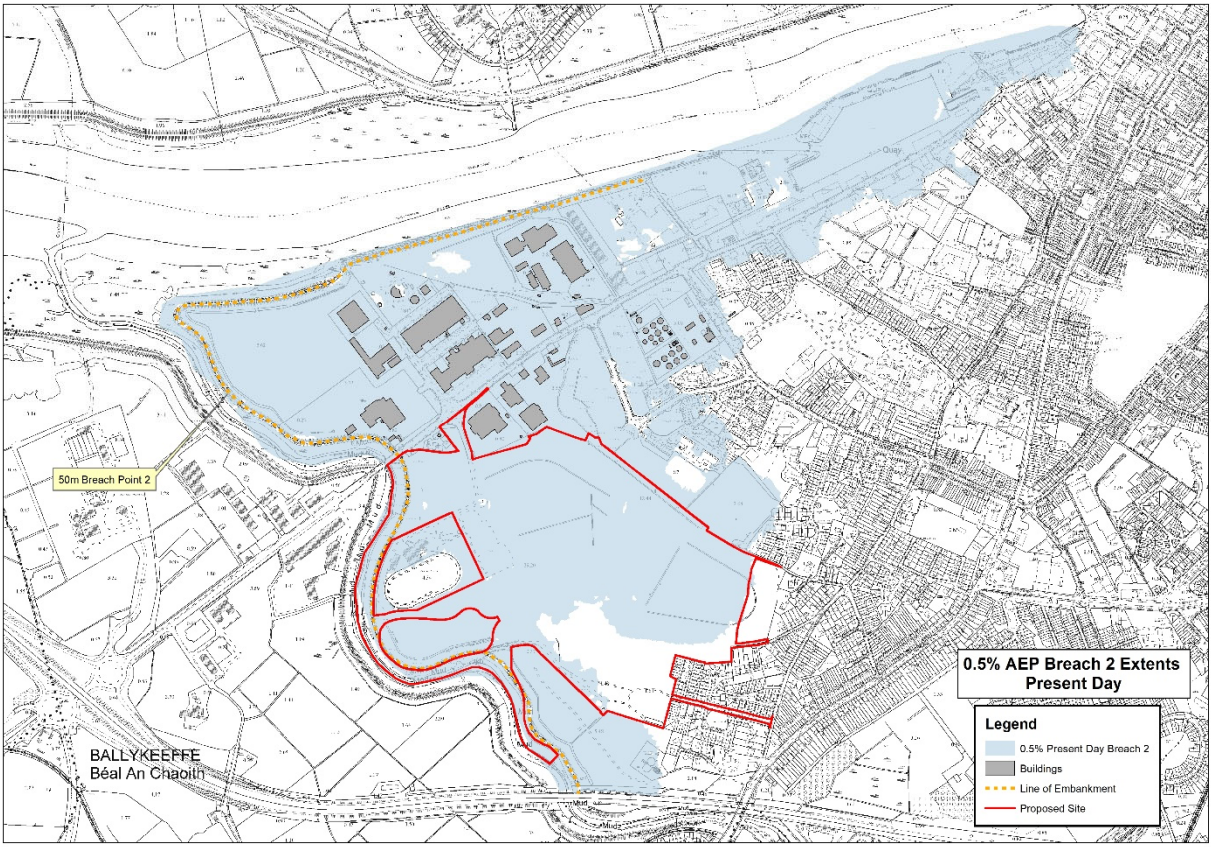


Figure 5.2 Breach Location 2 with 0.5% AEP event with Existing Ground Levels.

5.5 Mitigation Measures for Breach Scenario

RPS wanted to use the maximum breach water level to define suitable development levels for both the Office and Residential Campuses. From the three breach simulations described above the maximum derived water level reached within the masterplan area was 4.3m OD and was subsequently used as a design water level. Note this is less than the 4.87m OD level derived for the 0.5% AEP flood level in the Ballynaclough River during the Shannon CFRAM Process, but the spreading out of the water across the Dock Road area during a breach means that the maximum water level reached along the boundary of the masterplan area is 4.3m OD.

In order to address the risk from the potential flood depths during a breach, the preferred mitigation measure, as advised in the Planning system and Flood Risk Management Guidelines, is to raise the levels of the proposed development. In Clause 5.16 this is suggested as being above the 0.5% AEP flood level even when behind existing defences. The guidelines also state, on page 73, that although filling to this level is effective and beneficial it also has to balanced against the risk of displacing water elsewhere during an overtopping or breach scenario. RPS have therefore proposed the following mitigation measures to manage the identified risk.

Table 5.1 Description of proposed mitigation measures during the breach scenario

Objective of Mitigation Measures	Proposed Mitigation Measures
To raise the proposed development area as far as is reasonably possible with the focus on protecting people and buildings	Based on the maximum breach level of 4.3m OD all buildings in Office Campus and Residential Campus should be protected to minimum level of 4.6m OD, which provides 300mm freeboard above the predicted breach level. Car parking and open space can be kept at a lower level. This lower level should be above the 0.5% AEP overtopping level, but there is an acceptance that it can flood during an unlikely breach scenario.
Recognise less vulnerable and vulnerable type of development	For Residential Development, which is classed as 'vulnerable' under the guidelines, additional freeboard should be added to allow for climate change and provide a full 500mm freeboard. This freeboard is incorporated into the majority of OPW flood schemes. This results in a proposed FFL of

	5.3m OD, which is made up of 4.3m OD maximum breach level + 500mm freeboard + 500mm climate change allowance.
Provide egress and access during extreme event to provide access for emergency services and also those wishing to evacuate the area	Designated internal roads should be raised to 4.6m OD. This provides access and egress to all vehicles and pedestrians even during a breach scenario.
Balance the beneficial effect of infilling verses the risk of increasing flood risk elsewhere for existing development	The raising of buildings and roads to the stated levels is a priority, but rather than infill the entire site an attempt has been made to balance the impact of infilling and not increase flood risk elsewhere. Hence areas of open space and car parking have been permitted to flood in a controlled manner.

5.5.1 Residential Campus mitigation measures

The residential campus and neighbourhood centre will be filled to minimum platform level of 4.6m OD. From this level the roads will be built up to approximately 5.0m OD and then all FFLs constructed to a minimum of 5.3m OD. This provides over 1m freeboard to all properties and provides a very high standard of protection to what is considered “vulnerable” development under the guidelines.

5.5.2 Office Campus mitigation measures

The office campus is considered “less vulnerable” development and therefore a balance can be struck on protecting buildings and people from the breach scenario as well as allowing open spaces to flood.

The proposed way of achieving this is shown in Figure 5.3 which indicates indicative development levels for the office campus. It depicts a ring of office development and plaza levels around the circumference which will prevent water inundation into buildings, internal roads and central car parking area during a breach scenario. Initially it was proposed to keep external car parking and open spaces at a lower level of approximately 2.6m OD which will not flood during a 0.5% AEP overtopping scenario but will be allowed to be inundated during a breach scenario. These proposed development levels achieve the balance of protecting new development to the required standard i.e. the 0.5% AEP plus climate change event but also minimising the risk of flooding to neighbouring properties. Figure 5.4 provides further illustration of the proposed development levels in cross section.

Figure 5.3 Proposed Mitigation Measures

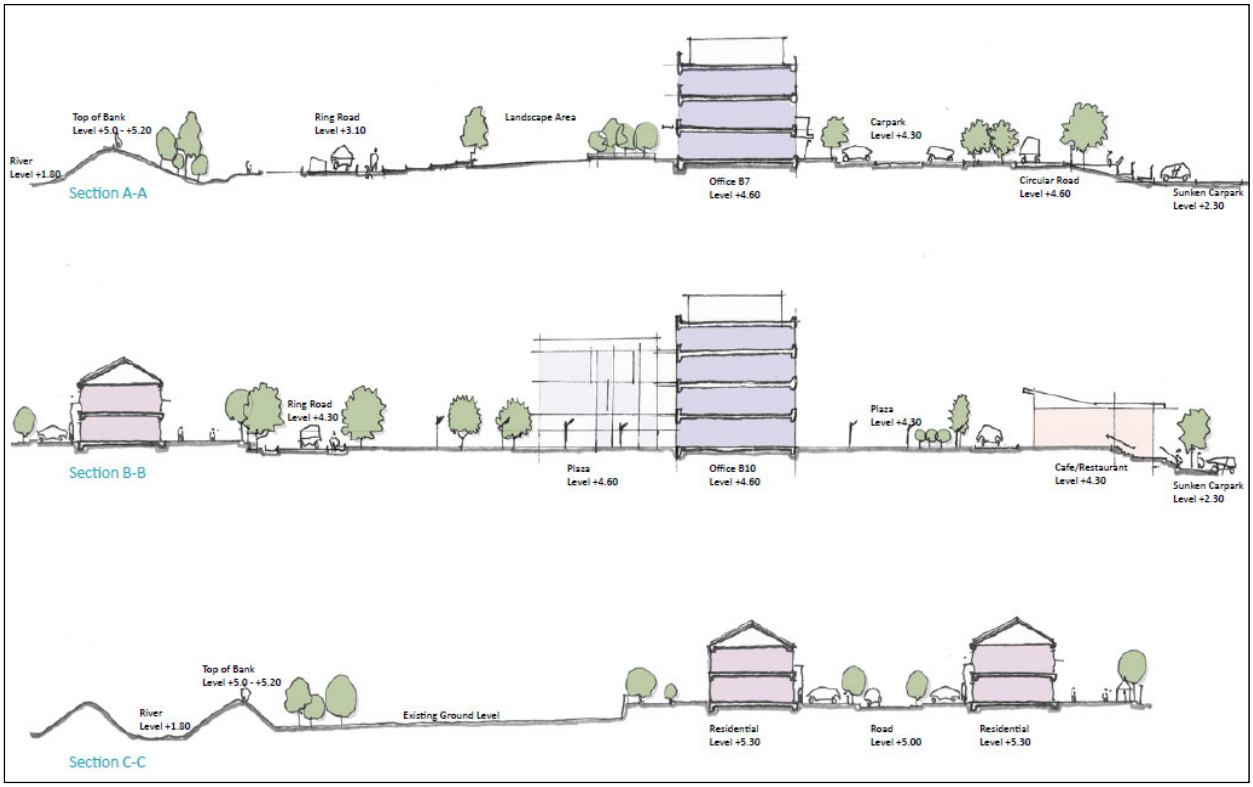


Figure 5.4 Cross sections through the proposed Office Campus

5.5.3 Impact Modelling of Breach Mitigation Measures

Based on the proposed development levels for the Office and Residential Campuses breach modelling has been undertaken for each of the three breach locations. Using the same boundary conditions as described for the existing scenario in Section 5.4 of this report.

To provide an easy comparison for the existing and proposed development scenarios a series of combined extent maps have been produced which clearly indicate the impact of infilling in the breach scenario.

These comparative maps show three different colours at each breach location:

1. Anywhere shown as green floods only in the existing scenario but not in the proposed scenario, which is reflective of the areas that have been infilled.
2. Anywhere shown as pink floods in both the existing scenario and in the proposed scenario. This means there is no flooding impact in this area as a result of the proposed development.
3. Anywhere shown as yellow floods only in the proposed scenario and not in the existing scenario.

Based on the proposed mitigation measures described in section 5.1 the impact of the raising all of the lands is shown in Figure 5.5.

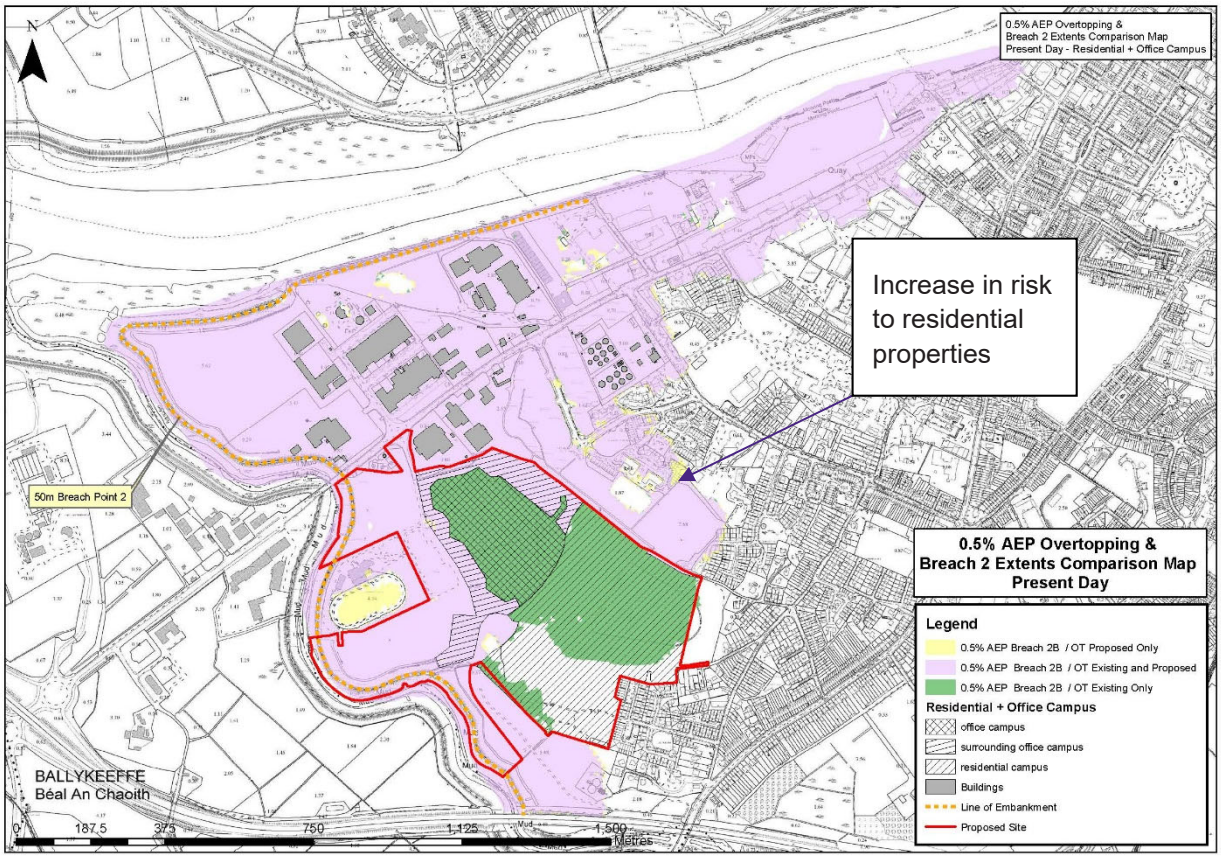


Figure 5.5 Impact of Raising Proposed Development Lands.

It can be seen from Figure 5.5 that raising of the lands highlighted in green is causing an impact to the Greyhound Stadium track and also residential properties to the north west of the masterplan area. While this increase in risk is very small, around 60mm in terms of an actual increase in water level, there are additional properties affected and therefore the proposal to raise all of the lands is unacceptable in the context of the guidelines and further mitigation measures will be required.

5.5.4 Additional Mitigation Measures for Office Campus

In order to offset the increase in risk identified in Figure 5.5, RPS considered allowing the inner car park of the Office Campus to store flood water during the breach scenario. This will be achieved by allowing roads into the proposed development to be lowered to convey water into this central area during the breach scenario thus providing additional storage. This will not affect the proposed development levels or finished floor levels in either the residential campus or office campus which will remain at the 4.6m and 5.3m OD respectively. Potential conveyance routes are shown in Figure 5.6.

Figure 5.6 Potential Lowered Conveyance Routes into the Central Car Parking Area

Based on this revised approach the breach models were re-run to show the benefit of the additional storage area now provided. Figure 5.7, 5.8, 5.9 show comparative maps for each of the 3 breach locations based on this proposed mitigation measure.

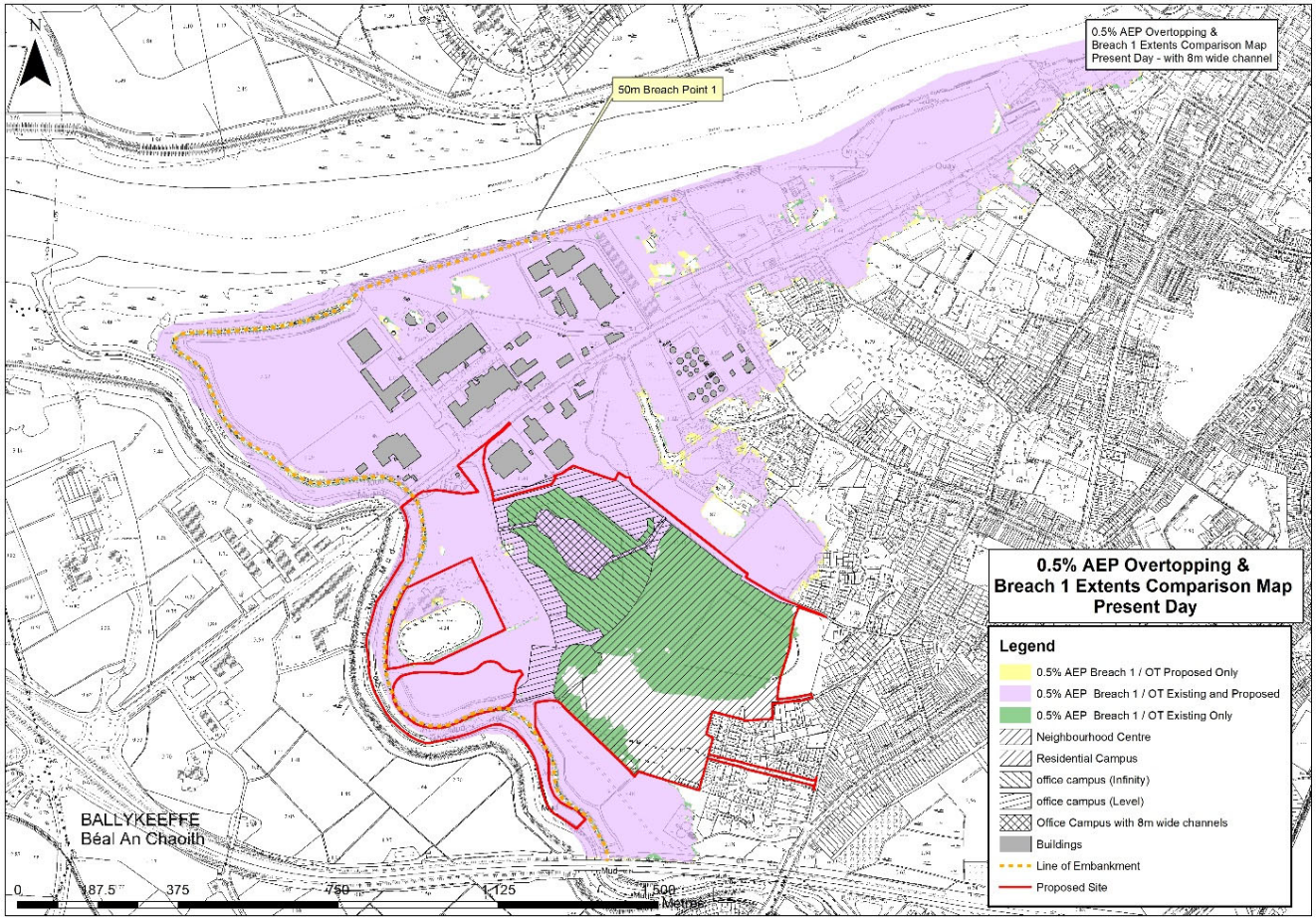


Figure 5.7 Extents comparison map- Breach 1 location

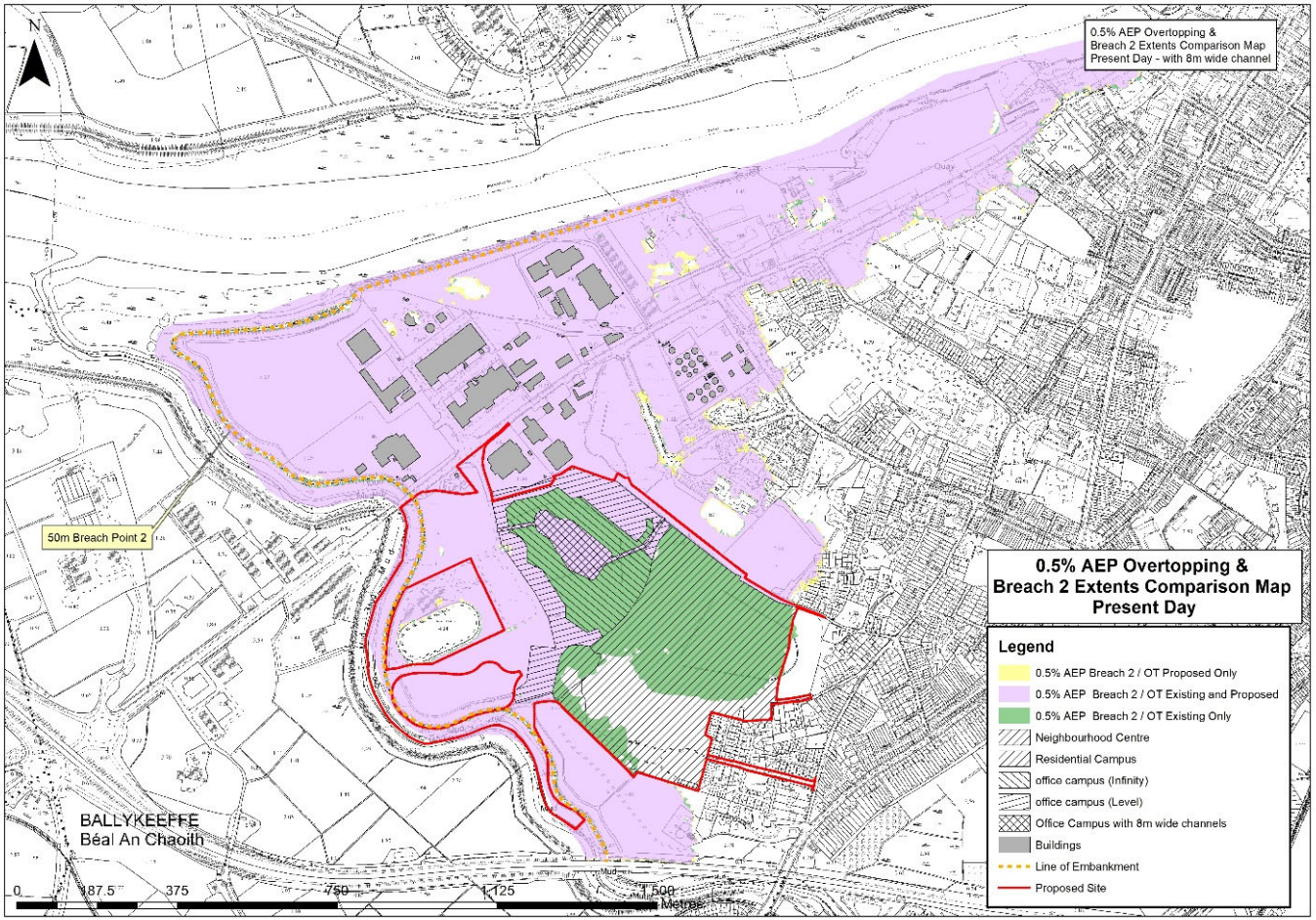


Figure 5.8 Extents comparison map – Breach 2 location

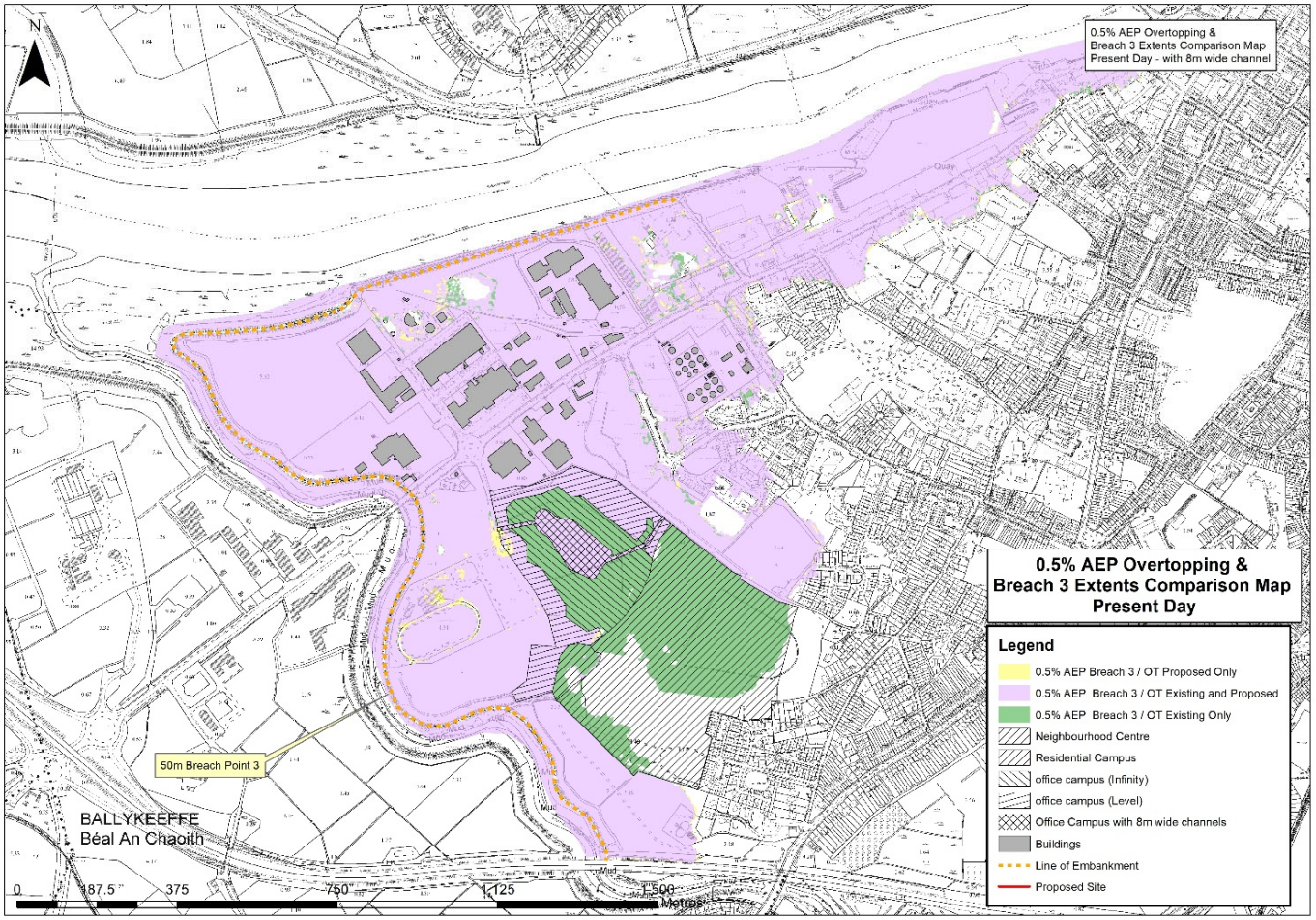


Figure 5.9 Extents comparison map – Breach 3 location

5.5.5 Conclusions on Breach Modelling

Based on the analysis the overwhelming conclusion is that the breach modelling indicates the proposed development does not create an increase in flood risk to existing development. These mitigation measures have also been tested for the 0.5% AEP MRFS event with no impact identified these maps are contained in Appendix B of this report.

As a point of note in relation to figures 5.7-5.9, it can be seen that along the edges of the flood extent small amounts of yellow and blue are visible. This is not an indication of the either an increase or a decrease in flood risk extent instead it occurs as a result of mesh in the 2D domain of the model changing as a result of the new mitigation measures introduced.

5.6 Surface Water Drainage Strategy

Given the scale of the proposed development and the change from a largely greenfield site to a residential and office campus there is the potential for a significant increase in the rate of run off and the need to attenuate flows to the receiving watercourse/s.

In order to mitigate this impact the proposed surface water design has been based on the requirement to ensure that the development does not result in increased runoff rates. The discharge rates from the identified contributing areas are to be limited for all events up to and including the 1 in 100 year extreme rainfall event. All flows will be attenuated within the development itself and by use of the existing Lagoon adjacent to the Ballynaclough River.

The existing storage lagoon top surface area is lined with puddle clay providing an impermeable layer. It has a current capacity of approximately 24,000m^3 based on recent topographical survey (November 2017) and an allowance for 500mm freeboard.

There is an open channel from the last manhole on the existing drainage network to the lagoon inlet structure which is also lined with puddle clay. This channel directs the flows by gravity to the open lagoon. There are three storm water control structures associated with the lagoon;

1. Inlet structure to the lagoon - this headwall structure is located at manhole S.1 and is constructed of reinforced concrete. A baffle wall allows the stormwater to discharge directly to the lagoon via the open channel.
2. Penstock structure - the penstock structure controls the flow of the water from the lagoon to the outfall structure in the Ballynaclough River.
3. Outfall structure - the outfall structure is constructed of reinforced concrete and contains a 1050mm diameter Tideflex valve with thimble plate that allows discharge of water to the river at low tide but prevents backflow into the lagoon in times of high tide.

Given the proposed development levels for the office and residential campuses this will ensure free discharge to the Lagoon under gravity. The elevated development levels will also ensure that there will be no backing up from the storm drainage network resulting from elevated tidal levels even during a 0.5% AEP event.

5.6.1 Access and Egress from the Proposed Masterplan Area

Given the identified mitigation measures which propose to raise all development and finished floor levels above the 0.5% AEP breach level with suitable allowance for climate change and freeboard. There will be no requirement to evacuate either the office campus or residential campus even during a 0.5% AEP MRFS climate change event even when a breach occurs. This is an exceptionally high standard of protection given the severity and probability of the event being considered.

Access and egress therefore only needs to be considered in relation to emergency services, e.g. ambulance or fire services, requiring access when a breach of the defences occurs and thus cutting off the main access road leading onto the Dock Road. In this scenario there is still emergency access available in and out of the masterplan area from Greenpark Avenue. This is indicated on Figure 5.10.

Figure 5.10 Emergency Access and Egress Routes

5.6.2 Office Campus car parking areas

The central car parking area and those to North West of the office campus are being constructed to the lower level of 2.6m OD to maximise the amount of storage during a breach scenario. That also means that these areas are susceptible to flooding during a breach and given the nature of this event there no time for office users to move their cars once it has occurred. To mitigate this risk to property and also to anyone entering these areas during a breach, an emergency plan will be required to prevent cars being there in the first instance.

This can achieved by the management company looking after the office campus reacting to coastal flood warnings which are readily given from Met Eireann and can facilitate closing of the car parks on those particular locations in advance. This will minimise the risk of damage to vehicles should a breach occur. A detailed flood warning and evacuation plan would need to be developed as part of a detailed planning application for the office campus.

6 PLANNING SYSTEM AND FLOOD RISK MANAGEMENT GUIDELINES

6.1 Classification

The 'Planning System and Flood Risk Management' Guidelines classify different types of development in terms of their vulnerability class (Table 3.1 of the Guidelines). This table has been reproduced as Table 6.1.

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	

Table 3.1 Classification of vulnerability of different types of development

Figure 6.1 Extract from Planning Guidelines- Classification of vulnerability of development

Table 3.2 of the Guidelines identifies the type of development that would be appropriate to each flood zone and those that would need the Justification Test. This table has been reproduced as Figure 6.2.

	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

Table 3.2: Matrix of vulnerability versus flood zone to illustrate appropriate development and that required to meet the Justification Test.

Figure 6.2 Extract from Planning Guidelines- Vulnerability versus flood zones

The proposed site will incorporate an office campus and residential housing. The office campus would be classified as 'less vulnerable development', while the residential area will be 'highly vulnerable development'. Both of these types of development requires a Justification Test in Flood Zone A (see Figure 6.2).

6.2 Development Management Justification Test

Where a planning authority is considering proposals for new development in areas at a high or moderate risk of flooding that includes types of development that are vulnerable to flooding and that would generally be inappropriate as set out in Table 3.2 of the Guidelines, the planning authority must be satisfied that the development satisfies all of the criteria of the Development Management Justification Test outlined in Box 5.1 of the guidelines and reproduced as Figure 6.3.

It is deemed not necessary to complete the Development Plan Justification Test as it is evident the Limerick City Development Plan 2010-2016 has already taken account of The Guidelines when considering the zoning for the masterplan area. Therefore the Development Management Justification Test need only be applied.

Box 5.1 Justification Test for development management (to be submitted by the applicant)

When considering proposals for development, which may be vulnerable to flooding, and that would generally be inappropriate as set out in Table 3.2, the following criteria must be satisfied:

1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:
   - (i) The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;
   - (ii) The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;
   - (iii) The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access; and
   - (iv) The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The acceptability or otherwise of levels of residual risk should be made with consideration of the type and foreseen use of the development and the local development context.

Note: See section 5.27 in relation to major development on zoned lands where sequential approach has not been applied in the operative development plan.

Refer to section 5.28 in relation to minor and infill developments.

Figure 6.3 Extract from Planning Guidelines- Justification Test for Development Management

Table 6.1 sets out the response to the criteria in Box 5.1 that must be satisfied. Each of the criteria have been shown to be satisfied and therefore it is concluded that the proposed development complies with the requirements of the Development Plan Justification Test.

Table 6.1 Response to Justification Test for Development Management for proposed development

	Criteria	Response
1.	The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which takes account of these Guidelines	The lands are zoned for mixed use and residential in the Limerick City Development Plan 2010-2016 (as extended). The Development Plan clearly states that the plan was produced taking full account of the Guidelines and was still zoned on that basis. It can be considered that Point 1 of the Development Management Justification Test has therefore been met.
2.	The proposal has been subject to an appropriate flood risk assessment that demonstrates:	
(i)	The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk	During a present day 0.5% AEP flood event and a 0.5% AEP climate change event there is no risk to the proposed development and no subsequent increase in flood risk elsewhere. This is described in detail in section 5.1 to 5.3 of this report. Additional modelling has been undertaken to consider the impact of the infilling of the site on the displacement of water in a breach of the existing defences. This was found to not have an increased risk on any existing properties. This is described in detail in Section 5.4 and Section 5.5 of this report. It is therefore considered that Point 2 (i) of the Justification Test has been met.
(ii)	The development proposal includes mitigation measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible	The proposed development will not flood during a 0.5% AEP flood event or in the case of the 0.5% AEP flood event plus climate change event. This provides an exceptionally high standard of protection and therefore, the risk of flooding to people, property and the environment is very low. This level of protection will ensure that there will be no impact on the economy, i.e. there will not be an unacceptable level of flood risk which might subsequently require government capital expenditure to alleviate the problem to either the proposed development or existing development As a further robustness check full consideration of a flood defence breach during a 0.5% AEP and 0.5% AEP MRFS CC flood event has been assessed. As a result of this analysis the proposed development has been elevated to provide protection against a catastrophic event of this nature. Breach analysis has confirmed that this does not increase the flood risk to the existing developments. It is therefore considered that Point 2 (ii) of the Justification Test has been met
(iii)	The development proposed includes measures to ensure that residual risks to the area and/or	The residual risk to the proposed development is low, as the development is protected up to a future 0.5% AEP plus climate change tidal event with additional freeboard. This gives added assurance that

	development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access	the proposed mitigation measures are more than adequate to deal with any future flood risk. Designated internal roads will be elevated to ensure free access and egress even during an extreme event. No specific residual risks have been identified that would necessitate a flood evacuation plan for the site. It is therefore considered that Point 2 (ii) of the Justification Test has been met
(iv)	The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes	The flood mitigation measures proposed do not materially impact upon the desired layout, orientation or approach to the proposed development. It is considered that the proposed development is compatible with the wider planning objectives in relation to development of good design and planning for the area, and is complaint with the Limerick City Development Plan 2010-2016 (as extended).

7 SUMMARY AND CONCLUSION

RPS were commissioned to carry out a Flood Risk Assessment (FRA) in support of a masterplan for Greenpark, Limerick which will be a mix of office developments, residential units and a neighbourhood centre. The purpose of this assessment is to ensure that the development takes cognisance of the existing flood risk and does not result in increased flood risk elsewhere. This report has been prepared in accordance with the requirements of 'The Planning System and Flood Risk Management' Guidelines (DEHLG 2009).

The River Shannon flows at a distance to the north of the site and a small tributary, the Ballynaclough River, flows to the west of the site. Both of these rivers can be considered to be tidal at this location. There are flood embankments along both the River Shannon and the Ballynaclough River.

As part of the Shannon Catchment Flood Risk Assessment and Management (CFRAM) Study, Limerick was identified as an Area for Further Assessment (AFA). The CFRAM mapping and the levels derived from this study provide the best available information to assess the flood risk to proposed development site. These maps indicate that the 0.5% AEP flood event does not reach the application site. This is because of the protection afforded by the existing flood defences constructed under the 1945 Arterial Drainage Act. Under the requirements of 'The Planning System and Flood Risk Management Guidelines' the effects of any existing defences must be ignored and therefore the vast majority of the masterplan area is considered to be Flood Zone A, a small section is Flood Zone B and parts are Flood Zone C.

Applying the sequential approach set out in 'The Planning System and Flood Risk Management Guidelines' requires a Justification Test to be carried for development of residential and office use within flood zone A and B.

In accordance with Clause 5.16 of the guidelines a precautionary approach to development behind existing defences is to raise the finished levels to at least the 1% or 0.5% coastal flood level. This approach has been adopted for both the office and residential areas of the masterplan area.

Modelling of the impact of raising existing development was then undertaken considering both the 0.5% AEP and 0.5% AEP Climate Change (mid-range future scenario) flood level. There was no identified increase in risk to existing development as a result of this analysis. This is described in detail in Section 5.3 of this report.

As a further robustness check full consideration of a flood defence breach during a 0.5% AEP flood event has been assessed. As a result of this analysis the proposed development has been elevated to provide protection against a catastrophic event of this nature. Breach analysis has confirmed that there no increase in flood risk to existing developments. This is described in detail in Section 5.4 and 5.5 of this report.

Proposed development levels have been applied to the Office and Residential Campuses based on this breach analysis. Designated internal roads and office levels will be elevated to approximately 4.6m OD. Residential floor levels will be raised to 5.3m OD. This provides between 0.3m and 1m freeboard to predicted water levels during a breach scenario, which is considered a very high standard of protection.

Storm water from the proposed development will be fully attenuated for a 1 in 100yr rainfall event and the proposed drainage network and existing Lagoon beside the Ballynaclough River will provide the necessary attenuation. The elevated development levels will ensure drainage under gravity even during extreme tidal events in the Ballynaclough River and the Shannon Estuary.

Based on the proposed mitigation measures, consideration of the designated zoning and the proposed urban design, each of criteria in the Development Management Justification Test was shown to be satisfied. Therefore it was concluded that the proposed development complies with the requirements of the Development Management Justification Test and hence is compliant with 'The Planning System and Flood Risk Management Guidelines'.

7.1 Key Aspects of the Flood Mitigation Measures

The following are the key aspects of the mitigation measures proposed within this Flood Risk Assessment and demonstrate a robust and sustainable approach to developing the Greenpark lands.

1. There is no reliance on the existing flood defences to provide any level of protection to the masterplan area.
2. The proposed masterplan is sustainable and will place no burden on Limerick City and County Council to provide additional flood defence infrastructure in the future.
3. The entire masterplan area will remain free from flooding during a 0.5% AEP Mid-Range Future Scenario event where overtopping of the existing defences occurs.
4. All buildings and key internal roads will be protected during a 0.5% AEP Mid-range Future Scenario event even when a breach of the existing defences has also occurred.
5. It has been robustly demonstrated that there is no increase in flood risk, even during a breach event, to surrounding developments.
6. A clear access and egress route for emergency vehicles can be provided to the office and residential campus and neighbourhood centre even during a breach event.
7. All storm drainage will be attenuated to existing run off rates and therefore will not cause capacity issues on the existing network or raise the increase of flooding elsewhere.

8 REFERENCES

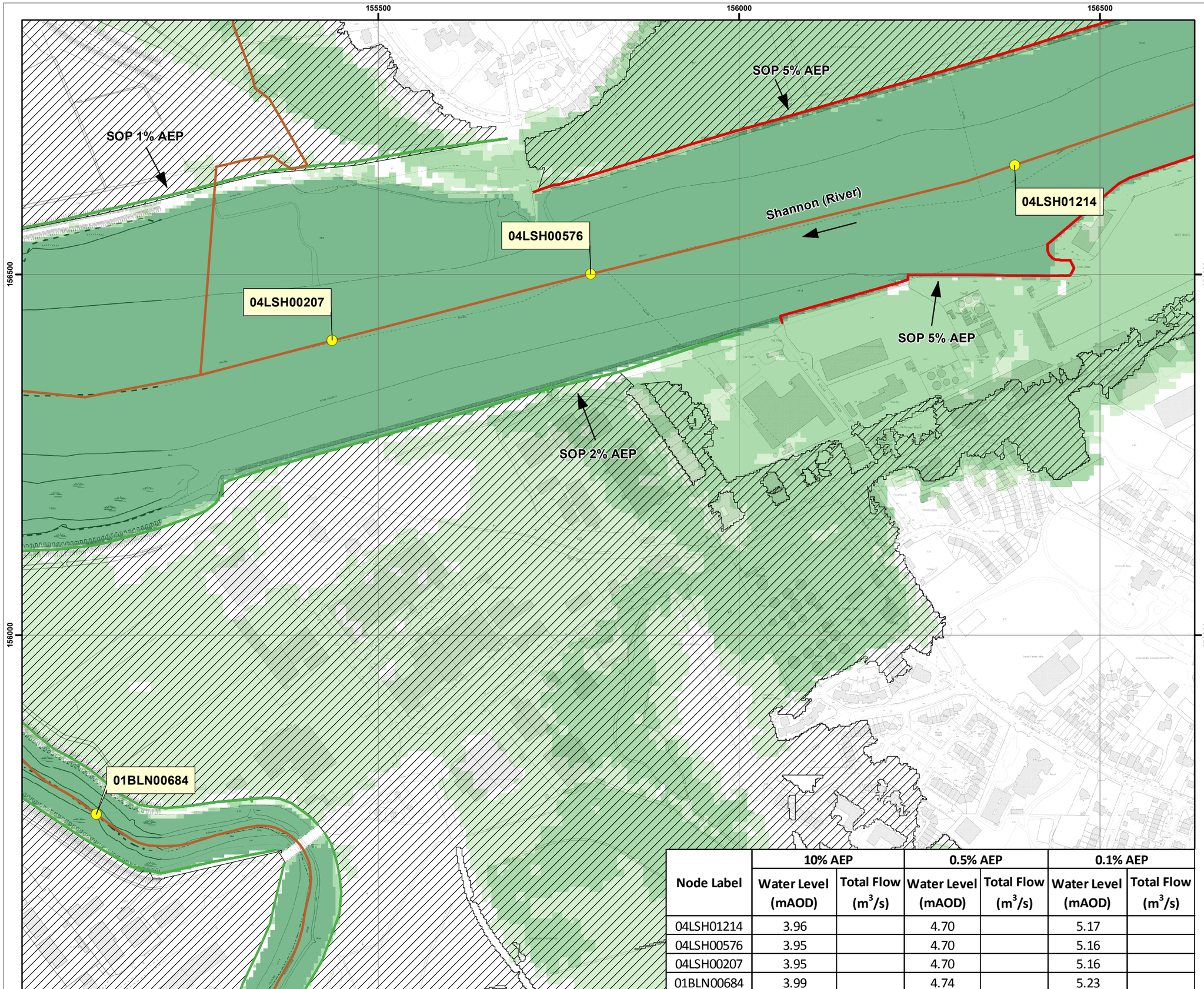
1 The Planning System and Flood Risk Management Guidelines, DEHLG (2009)

2 OPW Flood Maps available at http://www.floodinfo.ie/map/floodmaps/

3 Limerick City Development Plan 2010-2016 (as extended).

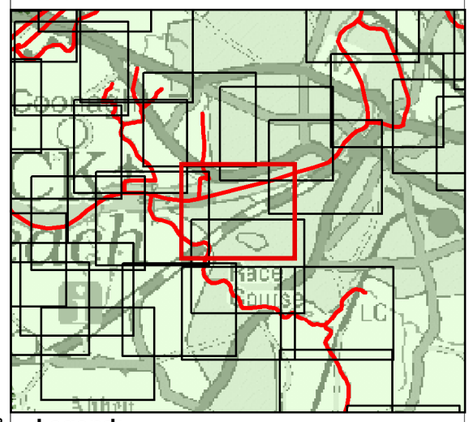
Appendix A

Flood Maps from Shannon CFRAM Study



Node Label	10% AEP		0.5% AEP		0.1% AEP	
	Water Level (mAOD)	Total Flow (m^3/s)	Water Level (mAOD)	Total Flow (m^3/s)	Water Level (mAOD)	Total Flow (m^3/s)
04LSH01214	3.96		4.70		5.17	
04LSH00576	3.95		4.70		5.16	
04LSH00207	3.95		4.70		5.16	
01BLN00684	3.99		4.74		5.23	

Location Plan:



Legend:

- Nodes
- Model Reach
- AFA Boundary
- Flood Defence: Wall
- Flood Defence: Embankment
- Defended Area

10% AEP Coastal Flood Extent
(1 in 10 chance in any given year)

0.5% AEP Coastal Flood Extent
(1 in 200 chance in any given year)

0.1% AEP Coastal Flood Extent
(1 in 1000 chance in any given year)

IMPORTANT USER NOTE:
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The Office of Public Works
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Trim
Co. Meath
C15 NX36

Merrion House
Merrion Road
Dublin 4
D04 R2C5

Project:	SHANNON CFRAM STUDY
Map Type:	EXTENT
Source:	COASTAL - TIDAL
Area:	LIMERICK
Scenario:	EXISTING
Drawn by: EH	Date: June 2016
Checked by: KM	Date: June 2016
Reviewed by: MC	Date: June 2016
Approved by: PS	Date: June 2016
Map No.:	S2526LIK_EXCCD_F1_26
Sheet: 26 of 65	Revision: 0
Map Scale: 1: 5000	Plot Scale: 1:1 @ A3

Node Label	10% AEP		0.5% AEP		0.1% AEP	
	Water Level (mAOD)	Total Flow (m^3/s)	Water Level (mAOD)	Total Flow (m^3/s)	Water Level (mAOD)	Total Flow (m^3/s)
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01BLN02058	4.07		4.87		5.16	
01BLN01813	4.06		4.87		5.15	
01BLN01486	4.04		4.86		5.15	
01BLN01400	4.03		4.86		5.16	
01BLN01210	4.02		4.85		5.16	

155500 156000 156500

156000 155500 155000

01BLN01210

01BLN01400

01BLN01486

01BLN01813

01BLN02058

01BLN02407

SOP 0.5% AEP

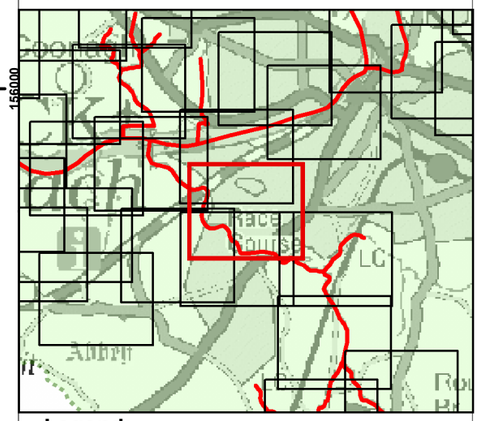
SOP 0.5% AEP

SOP 0.5% AEP

Shannon (River)

0 50 100 200 300 400 500 Meters

Location Plan:



Legend:

- Nodes
- Model Reach
- AFA Boundary
- Flood Defence: Wall
- Flood Defence: Embankment
- Defended Area

10% AEP Coastal Flood Extent
(1 in 10 chance in any given year)

0.5% AEP Coastal Flood Extent
(1 in 200 chance in any given year)

0.1% AEP Coastal Flood Extent
(1 in 1000 chance in any given year)

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JACOBS

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Project:		SHANNON CFRAM STUDY
Map Type:		EXTENT
Source:		COASTAL - TIDAL
Area:		LIMERICK
Scenario:		EXISTING
Drawn by:	EH	Date: June 2016
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Approved by:	PS	Date: June 2016
Map No.:		S2526LIK_EXCCD_F1_65
Sheet: 65 of 65		Revision: 0
Map Scale: 1: 5000		Plot Scale: 1:1 @ A3

Appendix B

Climate Change Comparative Breach Maps

0.5% AEP Overtopping &
Breach 2 Extents Comparison Map
with Climate Change - Residential + Office Campus

N

50m Breach Point 2

BALLYKEEFFE
Béal An Chaoith

0 187.5 375 750 1,125 1,500
Metres

0.5% AEP Overtopping & Breach 2 Extents Comparison Map with Climate Change

Legend

- 0.5% AEP Breach 2B / OT Proposed Only
- 0.5% AEP Breach 2B / OT Existing and Proposed
- 0.5% AEP Breach 2B / OT Existing Only

Residential + Office Campus

- office campus
- surrounding office campus
- residential campus
- Buildings
- Line of Embankment
- Proposed Site