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Comhairle Contae County Council

COUNTY DEVELOPMENT PLAN 2016-2022

Appendix 13 Strategic Flood Risk Assessment

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IMPORTANT DISCLAIMER

Dún Laoghaire-Rathdown Strategic Flood Risk Assessment

Please read below the disclaimer, and limitations associated with this assessment to avoid incorrect interpretation of the information and data provided.

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UNCERTAINTY

Although great care and modern, widely-accepted methods have been used in the preparation of this assessment there is inevitably a range of inherent uncertainties and assumptions made during the estimation of design flows and the construction of flood models.

BEST AVAILABLE INFORMATION

There has been a wide range of datasets utilised in the production of this plan which are constantly changing and subsequently the analysis of these datasets is only correct at the time of assessment. The assessment is based on the maps available in June 2015 (which includes Draft Eastern CFRAM maps). It is acknowledged that new methodologies and/or recently recorded data could have a minor impact on the analysis undertaken herein.

The SFRA is not a statutory planning document. It is a consultation document that should be used to inform a development plan or local area plan, enabling the implementation of the 'Sequential Approach'' and the testing of development zoning against flood risk criteria. It can also be used to assist other planning decisions, such as Development Management, and emergency planning. In any instance, a site-specific flood risk assessment may be required when deciding on the grant of planning permission. (Department of Environment, Heritage and Local Government and OPW, The Planning System and Flood Risk Management; (2009).

This SFRA covers the entire County excluding Cherrywood Planning Scheme

1 Background

1.1 Introduction

Flood Risk is defined as:

"Flood risk is the damage that may be expected to occur at a given location arising from flooding. It is a combination of the likelihood, or probability, of flood occurrence, the degree of flooding and the impacts or damage that the flooding would cause" (OPW, 2014).

One of the key messages of the then Department of Environment, Heritage and Local Government Guidelines "The Planning System and Flood Risk Management, Guidelines for Planning Authorities", published in 2009, was that *"Flood risk management should be integrated into spatial planning at all levels to enhance certainty and clarity in the overall planning process".* The purpose of this Strategic Flood Risk Assessment (SFRA) is to provide sufficient information to allow proper planning decisions to be made on sites at risk of flooding over the lifetime of the next County Development Plan 2016 – 2022 and also to ensure that Elected Members have the necessary information with regard to flooding, the 'Sequential Approach' and the 'Justification Test' (see below and Glossary for definitions) in coming to decisions on the Draft Plan.

1.2 SFRA Structure

A two stage assessment of flood risk was undertaken, as recommended in 'The Planning System and Flood Risk Management' guidelines, for the area that lies within the County Development Plan area. The first stage was to identify flood risk and develop Flood Zone maps which confirmed that a proportion of zoned lands are at flood risk. The second stage and the main purpose of this SFRA report is to highlight development areas that require more detailed assessment on a site specific level. The SFRA also provides guidelines for development within areas at potential risk of flooding, and specifically looks at flood risk and the potential for development across the County.

Section 2 of this SFRA gives an overview of the Planning System and Flood Risk Management. Section 3 provides a background to flood risk in Dún Laoghaire-Rathdown, including a review of available flood risk information and a summary of sources of flooding. In Section 4 an overview of flood management policy has been provided. This includes details of development which may be considered appropriate in certain areas and the expected content of site specific FRAs. Having established the planning and development controls, the Justification Test has been applied across Dún Laoghaire-Rathdown and the outcome of this assessment is provided in Section 5. This section also provides specific requirements for FRA at key sites. Finally, in Section 6 a summary of the triggers for monitoring and review of the SFRA is provided.

2 The Planning System and Flood Risk Management

2.1 Introduction

Prior to discussing the management of flood risk, it is helpful to understand what is meant by the term. It is also important to define the components of flood risk in order to apply the principles of the Planning System and Flood Risk Management in a consistent manner.

The Planning System and Flood Risk Management: Guidelines for Planning Authorities, published in November 2009, describe flooding as a process that can occur at any time and in a wide variety of locations. Flooding can often be beneficial, and many habitats rely on periodic inundation. However, when flooding interacts with human development, it can threaten people, their property and the environment.

The following paragraphs will outline the definitions of flood risk and the Flood Zones used as a planning tool; a discussion of the principles of the Planning Guidelines and the management of flood risk in the planning system follows.

2.2 Definition of 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

The assessment of flood risk requires an understanding of the sources, the flow path of floodwater and the people and property that can be affected.

Principal sources of flooding are rainfall or higher than normal sea levels while the most common pathways are rivers, drains, sewers, overland flow and river and coastal floodplains and their defence assets. Receptors can include people, their property and the environment. All three elements must be present for flood risk to arise. Mitigation measures, such as defences or flood resilient construction, have little or no effect on sources of flooding but they can block or impede pathways or remove receptors.

The planning process is primarily concerned with the location of receptors, taking appropriate account of potential sources and pathways that might put those receptors at risk.

2.2.1 Likelihood of Flooding

Likelihood or probability of flooding or a particular flood event is classified by its annual exceedance probability (AEP) or return period (in years). A 1% AEP flood indicates the flood event that will occur or be exceeded on average once every 100 years and has a 1 in 100 chance of occurring in any given year.

Return period is often misunderstood to be the period between large flood events rather than an average recurrence interval. Annual exceedance probability is the inverse of return period as shown in Table 2-1.

Table 2-1 Probability of Flooding

Return Period (Years)	Annual Exceedance Probability (%)
2	50
100	1
200	0.5
1000	0.1

Considered over the lifetime of development, an apparently low-frequency or rare flood has a significant probability of occurring. For example, a flood with a 1% AEP (1 in 100 year) has a 22% (1 in 5) chance of occurring at least once in a 25-year period, which is the period of a typical residential mortgage, and a 53% (1 in 2) chance of occurring in a 75-year period, which is a typical human lifetime.

2.2.2 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 the type of development, which are detailed in Table 3.1 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;
- **Water compatible**, including open space, outdoor recreation and associated essential infrastructure, such as changing rooms.

2.3 Definition of Flood Zones

In the 'Planning System and Flood Risk Management', Flood Zones are used to indicate the likelihood of a flood occurring. These Zones indicate a high, moderate or low risk of flooding from fluvial or tidal sources and are defined below in Table 2-2.

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 due to overtopping or breach and that there may be no guarantee that the defences will be maintained in perpetuity.

It is also important to note that the Flood Zones indicate flooding from fluvial and tidal sources and do not take other sources, such as groundwater or pluvial, into account, so an assessment of risk arising from such sources should also be made.

Table 2-2 Definition of Flood Zones

Zone	Description
Zone A High probability of flooding.	This zone defines areas with the highest risk of flooding from rivers (i.e. more than 1% probability or more than 1 in 100) and the coast (i.e. more than 0.5% probability or more than 1 in 200).
Zone B Moderate probability of flooding.	This zone defines areas with a moderate risk of flooding from rivers (i.e. 0.1% to 1% probability or between 1 in 100 and 1 in 1000) and the coast (i.e. 0.1% to 0.5% probability or between 1 in 200 and 1 in 1000).
Zone C Low probability of flooding.	This zone defines areas with a low risk of flooding from rivers and the coast (i.e. less than 0.1% probability or less than 1 in 1000).

2.4 Objectives and Principles of the Planning Guidelines

The 'Planning System and Flood Risk Management' describes good flood risk practice in planning and development management. Planning authorities are directed to have regard to the guidelines in the preparation of Development Plans and Local Area Plans, and for development control purposes.

The objective of the 'Planning System and Flood Risk Management' is to integrate flood risk management into the planning process, thereby assisting in the delivery of sustainable development. For this to be achieved, flood risk must be assessed as early as possible in the planning process. Paragraph 1.6 of the Guidelines states that the core objectives are to:

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

The guidelines aim to facilitate '*the transparent consideration of flood risk at all levels of the planning process, ensuring a consistency of approach throughout the country.*' SFRAs therefore become a key evidence base in meeting these objectives.

The 'Planning System and Flood Risk Management' works on a number of key principles, including:

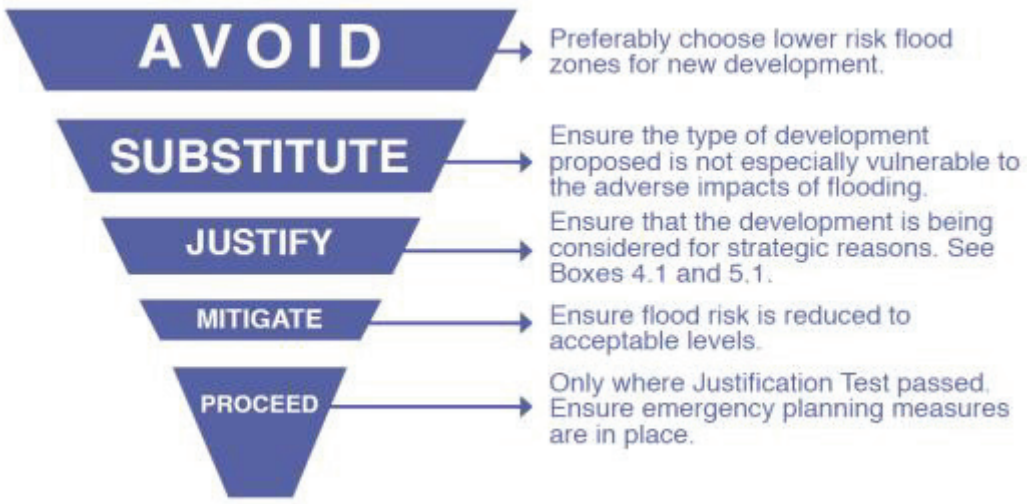
- Adopting a staged and hierarchical approach to the assessment of flood risk;
- Adopting a sequential approach to the management of flood risk, based on the frequency of flooding (identified through Flood Zones) and the vulnerability of the proposed land use.

2.5 The Sequential Approach and Justification Test

Each stage of the FRA process aims to adopt a sequential approach to management of flood risk in the planning process.

Where possible, development in areas identified as being at flood risk should be avoided; this may necessitate de-zoning lands within the plan boundary. If de-zoning is not considered appropriate, then it must be ensured that permitted uses are water compatible or less vulnerable, such as open space, and that vulnerable uses such as residential are not permitted in the flood risk area.

Figure 2-1 Sequential Approach Principles in Flood Risk Management



Source: The Planning System and Flood Risk Management (Figure 3.1)

Where rezoning is not considered appropriate, exceptions to the development restrictions are provided for through the Justification Test. Many towns and cities have central areas that are

affected by flood risk and have been targeted for growth. To allow the sustainable and compact development of these urban centres, development in areas of flood risk may be considered necessary. For development in such areas to be allowed, the Justification Test must be passed.

The Justification Test has been designed to rigorously asses the appropriateness, or otherwise, of such developments. The test is comprised of two processes; the Plan-making Justification Test, which is undertaken in Section 5 of this SFRA, and the Development Management Justification Test. The latter is used at the planning application stage where it is intended to develop land that is at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be considered inappropriate for that land.

Table 2-3 shows which types of development, based on vulnerability to flood risk, are appropriate land uses for each of the Flood Zones. The aim of the SFRA is to guide development zonings to those which are 'appropriate' and thereby avoid the need to apply the Justification Test.

A planning circular (PL2/2014[1]) has also been issued which provides greater clarity on the need to apply the Justification Test to existing development and areas which are proposed for redevelopment, included as Section 4.27a. Further, this amendment requires the SFRA to specify the nature and design of structural or non-structural flood risk management measures required prior to development in such areas. As part of the Application of the Justification Test, detailed in Section 5, consideration has been given to both developed and currently undeveloped land.

Table 2-3 Matrix of Vulnerability versus Flood Zone

	Flood Zone A	Flood Zone B	Flood Zone C
Highly vulnerable development (Including essential infrastructure)	Justification Test	Justification Test	Appropriate
Less vulnerable development	Justification Test	Appropriate	Appropriate
Water-compatible development	Appropriate	Appropriate	Appropriate

Source: Table 3.2 of The Planning System and Flood Risk Management

2.6 Scales and Stages of Flood Risk Assessment

Within the hierarchy of regional, strategic and site-specific flood-risk assessments, a tiered approach ensures that the level of information is appropriate to the scale and nature of the flood-risk issues and the location and type of development proposed, avoiding expensive flood modelling and development of mitigation measures where it is not necessary. The stages and scales of flood risk assessment comprise:

- **Regional Flood Risk Appraisal (RFRA)** – a broad overview of flood risk issues across a region to influence spatial allocations for growth in housing and employment as well as to identify where flood risk management measures may be required at a regional level to support the proposed growth. This should be based on readily derivable information and undertaken to inform the Regional Planning Guidelines.
- **Strategic Flood Risk Assessment (SFRA)** – an assessment of all types of flood risk informing land use planning decisions. This will enable the Planning Authority to allocate appropriate sites for development, whilst identifying opportunities for reducing flood risk. This SFRA will revisit and develop the flood risk identification undertaken in the RFRA, and give consideration to a range of potential sources of flooding. An initial flood risk assessment, based on the identification of Flood Zones, will also be carried out for those areas which will be zoned for development. Where the initial flood risk assessment highlights the potential for a significant level of flood risk, or there is conflict with the proposed vulnerability of development, then a detailed stage 3 FRA will be required to

[1] Department of Environment, Community and Local Government, Planning Circular PL2/2014 (13/08/2015)

ensure zoning objectives are compatible with flood risk at the site, and more importantly that mitigation measures which reduce flood risk to the site and neighbouring lands can be implemented. The SFRA will highlight where a site specific FRA is required as part of the planning application process.

In Dún Laoghaire-Rathdown, a range of flood data sources have been reviewed and used to compile a composite Flood Zone map. In most locations this map, coupled with engineering knowledge has been sufficient to provide recommendations for flood risk assessment and development management. However, in Dún Laoghaire-Rathdown a Stage 3 FRA has been carried out for the area within the Dundrum Major Town Centre lands. The aim of the FRA was to indicate it, in principle, development of the lands could be carried out without increasing risk to neighbouring sites. The details of the Detailed FRA are provided in Annex A.

- **Site Specific Flood Risk Assessment (FRA)** – site or project specific flood risk assessment to consider all types of flood risk associated with the site and propose appropriate site management and mitigation measures to reduce flood risk to and from the site to an acceptable level. If the previous tiers of study have been undertaken to appropriate levels of detail, it is highly likely that the site specific FRA will require detailed channel and site survey, and hydraulic modelling. It should consider residual risks, such as culvert blockage or defence overtopping and access and evacuation plans are likely form important element of the assessment.

3 Strategic Flood Risk Assessment of Dún Laoghaire Rathdown

3.1 Description of Study Area

Dún Laoghaire-Rathdown covers an area of 125 km^2 to the south of Dublin City. Along the east of the County runs 17 kilometres of coastline which includes beaches cliffs and marshes. It is along the coast that the County town of Dún Laoghaire is located. In terms of settlement approximately two thirds of the County is made up of the built-up area which forms part of suburban Dublin. This suburban area is made up of a network of smaller towns and villages which have been subsumed into the urban form. To the south and west the built-up area gives way to agricultural lands and then rises into the upland scenic area of the Dublin Mountains.

3.2 Identification of Flood Risk (Stage 1)

One of the first tasks within the SFRA is to undertake a data collection exercise which will allow Flood Zone maps to be developed. The Flood Zones relate to risk arising from fluvial (river) and coastal flooding. Other sources of flooding should also be taken into account through the SFRA process, but are not part of the initial assessment process.

It is important to note that the Flood Zones do not take into account the benefits of flood defences. The sequential approach and Justification Test should be applied using the undefended outlines, but the benefits of the defences can be used to inform the requirements for detailed flood risk assessment and development design, if the Justification Test has been passed.

Due to the number of flood investigation and management studies that have focused on Dún Laoghaire-Rathdown, there are a number of datasets which record either historical or predicated flood extents. The aim of this phase of work is to identify flood risk based on the data available, including historical records, considering all sources of flooding, and to appraise the quality and usefulness of the data. Table 3-1 below summarises the data available and its quality, includes an assessment of confidence in its accuracy (when attempting to incorporate it into the flood zone map) and gives an indication of how it was used in the SFRA study.

The Office of Public Works (OPW) are the lead Authority on flooding in the Country and in 2011 they commenced a National Catchment Flood Risk Assessment and Management (CFRAM) programme. CFRAM is currently being carried out for the Eastern Region - which includes Dún Laoghaire-Rathdown - and these studies have been used as the basis of this Strategic Flood Risk Assessment. The Eastern CFRAMs are still being finalised, but draft flood extent maps are available in the public domain. The Dodder River, which forms part of the Eastern Region CFRAM, was the subject of an earlier pilot project and the maps in relation to the Dodder CFRAM have been finalised and are consequently in the public domain. The plan area of Dún Laoghaire-Rathdown has also been subject to a number of other flood assessments at both the County and local scales. These have looked at risks arising from sources such as coastal inundation and wave overtopping, surface water and manhole surcharge, culvert blockage and direct fluvial flooding. There have also been a number of recorded flood events. This information has been compiled to form the Flood Zone maps that are the basis for this SFRA.

The Flood Zone maps have been developed using the most appropriate data available to Dún Laoghaire-Rathdown at the time of preparing the Development Plan. The Flood Zone maps have been created specifically to inform the application of the Justification Test and to guide development policy within the County and have been through several iterations of review, and are now considered to be fit for purpose. However, it should be borne in mind that the input data was developed at a point in time and there may be changes within the catchment that mean a future study, or more localised assessment of risk may result in a change in either flood extent or depth. This means a site specific flood risk assessment may result in locally appropriate information which could show a greater or less level of risk than is included in the Flood Zone maps. This is to be expected and it will require discussion between the developer and the Dún Laoghaire-Rathdown Planning and Engineering teams to ensure the assessment is appropriate and relevant to the site in question.

The Flood Zone maps show Flood Zones A, B and C and also show historical and predicted flooding hotspots in the County. Flood Zone A refers to areas where the probability of flooding from rivers is greater than 1% or 1 in 100 year for river flooding, or 0.5% or 1 in 200 for coastal flooding. Flood Zone B refers to areas where the probability of flooding from rivers and seas is up to 0.1% or 1 in 1000. The rest of the map shows Flood Zone C, where there is less than a 0.1% or 1 in 1000 chance of flooding. Historical surface water hotspots are those where Dún Laoghaire-Rathdown County Council has a record of a flood occurring, although in some cases work has been carried out to remediate the issue. The predicted hotspots are based on modelling and indicate where surface water has the potential to pond to depths of greater than 0.3m. Guidance on applying this information is provided in Section 4.4.

Table 3-1: Flood Risk Datasets

Data	Description / Coverage	Quality	Data used in developing Flood Zones
Dodder CFRAM Flood Extents	Flood extents covering the Dodder River and its tributaries, the Dundrum Slang and the Little Dargle	Moderate to high, but gives extents (defended) not flood zones (undefended)	Where no defences are present, extents have been used directly. Where there are defences, the benefit of those defences has been estimated and the extents reconfigured to give Flood Zones
Draft Eastern CFRAM extents and defence layers	Flood extents covering the Crinken Stream, Shanhanagh River, Loughlinstown River, Deansgrange Stream, Carrickmines River and Carysfort Maritimo, as well as the coastline of the County.	High in most locations. Maps are draft, but have been subject to several iterations of review through the CFRAM development process	Flood extents, defence lines and defended area polygons have been used to develop Flood Zones
Irish Coastal Protection Strategy Study	Tidal extents for 200 year and 1000 year events	High	Used to define the tidal risk within Flood Zone A and B.
JFLOW® (JBA's multi-scale two dimensional hydraulic fluvial flood modelling software)	Covers full study area, including all watercourses with catchment greater than 3km^2.	Moderate	Some minor watercourses, and the upstream reach of some CFRAM watercourses.
OPW Preliminary Flood Risk Assessment (PFRA) flood maps	The PFRA was a national screening exercise that was undertaken by OPW to identify areas at potential risk of flooding.	Moderate	Some minor watercourses, and the upstream reach of some CFRAM watercourses.
LiDAR	Digital terrain model covering the whole County	High, but not direct representation of flood zones.	Not used directly, but has helped define the undefended floodplain.

Data	Description / Coverage	Quality	Data used in developing Flood Zones
Dundrum flood extents	Flood maps produced as part of this SFRA, providing detailed FRA for Dundrum town centre	High	Replaces part of the Dodder flood extent through Dundrum.
Historical event outlines and point observations and reports	Various: 2011 event outlines received. OPW flood maps.ie also to be consulted. Surface water risk locations mapped	Various – based on anecdotal evidence and post flood survey	Indirectly used to validate flood zones and identify non-fluvial and tidal flooding
Deansgrange and Kilbogget Park flood extents	Localised studies as part of flood relief scheme appraisal	High	Indicates defended areas and guides requirements for site specific FRAs.
Wave overtopping from DART Drainage Impact Study	Merrion Gate to Monkstown. Indicates risks associated with wave overtopping	Moderate to high	Not used to create Flood Zones, but mapped to indicate 'other' risk areas.
Culvert blockage	The impact of blockage was tested at 21 culverts across the County	Moderate to high (but based on an assumption of 100% blockage)	Not used to create Flood Zones, but reviewed to indicate residual risk areas.
Direct rainfall modelling	Shows surface water routes, but does not take into account contributions from surcharging sewer networks. Whole County covered.	Moderate	Used to highlight areas at high risk of surface water flooding. Also indicates potential Flood Zones at the upstream end of some small watercourses.

3.3 Summary of flood sources

Using the information detailed above, along with the knowledge of engineering staff, the following potential sources of flooding have been identified with the development plan area.

3.3.1 Fluvial Flooding

Flooding of watercourses is associated with the exceedance of channel capacity during higher flows. The process of flooding on watercourses depends on a number of characteristics associated with the catchment including; geographical location and variation in rainfall, steepness of the channel and surrounding floodplain and infiltration and rate of runoff associated with urban and rural catchments. Generally there are two main types of catchments; large and relatively flat or small and steep, both giving two very different responses during large rainfall events.

In a large, relatively flat catchment, flood levels will rise relatively slowly and natural floodplains may remain flooded for several days, acting as the natural regulator of the flow. This is typical of the River Dodder. In small, steep catchments, such as some of the tributaries, local intense

rainfall can result in the rapid onset of deep and fast-flowing flooding with little warning. Such "flash" flooding, which may only last a few hours, can cause considerable damage and possible threat to life.

The form of the floodplain, either natural or urbanised, can influence flooding along watercourses. The location of buildings and roads can significantly influence flood depths and velocities by altering flow directions and reducing the volume of storage within the floodplain. Critical structures such as bridge and culverts can also significantly reduce capacity creating pinch points within the floodplain. These structures are also vulnerable to blockage by natural debris within the channel or by fly tipping and waste.

In Dún Laoghaire-Rathdown, flood risk arises from a number of different watercourses, each of which has its own specific characteristics. These have been taken into account when flood risk to specific potential development sites was reviewed. Where zoning for development is proposed within Flood Zones A or B, the Justification Test must be applied, and passed.

3.3.2 Tidal Flooding

Dún Laoghaire-Rathdown is located on the east coast of Ireland, and much of the County boundary is subject to flood risk from the Irish Sea. As well as direct inundation associated with high tides and storm surge, wave overtopping has also been investigated as part of the Dart Drainage Impact study, for the length of coast from Merrion Gate to Monkstown. The extents of the overtopping outline are the very similar to the Flood Zones, so this does not need specific consideration in the SFRA, but should be a factor in site specific flood risk assessments near the coastal zone.

The tide can also impact on flood risk from rivers, particularly at the downstream end of those which discharge directly into the sea. On such watercourses, if high river flows coincide with high tides, the rivers can't discharge and may cause flooding locally.

Peak tide levels were calculated as part of ICPSS and the Eastern CFRAM study and should be referred to in any site specific FRA.

3.3.3 Residual Risks arising from Flood Defence Overtopping or Breach

Residual risk is the risk that remains after measures to control flood risk have been carried out. Residual risk can arise from overtopping of flood defences and / or from the breach from structural failure of the defences.

The concept of residual risk is explained in the Planning System and Flood Risk Management guidelines as follows:

"Although flood defences may reduce the risk of flooding, they cannot eliminate it. A flood defence may be overtopped by a flood that is higher than that for which it was designed, or be breached and allow flood water to rapidly inundate the area behind the defence. In addition, no guarantee can be given that flood defence will be maintained in perpetuity. As well as the actual risk, which may be reduced as a result of the flood defence, there will remain a residual risk that must be considered in determining the appropriateness of particular land uses and development. For these reasons, flooding will still remain a consideration behind flood defences and the flood zones deliberately ignore the presence of flood defences."

Owing to an extensive and frequent history of flooding in some parts of the County, there are a number of flood relief schemes in Dún Laoghaire-Rathdown. These include large scale OPW managed schemes on the River Dodder, and some smaller works which have been constructed, or are due for construction on smaller watercourses. It should be noted that whilst existing development clearly benefits from the construction of defences, it is against sustainability objectives, and the general approach of the OPW, to construct defences with the intention of releasing land for development. It is also not appropriate to consider the benefits of schemes which have not been constructed, and which may only be at pre-feasibility or design stage. Overtopping of flood defences will occur during flood events greater than the design level of the defences. Overtopping is likely to cause more limited inundation of the floodplain than if defences had not been built, but the impact will depend on the duration, severity and volume of

floodwater. However, and more critically, overtopping can destabilise a flood defence, cause erosion and make it more susceptible to breach or fail.

Overtopping may become more likely in future years due to the impacts of climate change and it is important that any assessment of defences includes an appraisal of climate change risks.

Breach or structural failure of flood defences is hard to predict and is largely related to the structural condition and type of flood defence. 'Hard' flood defences such as solid concrete walls are less likely to breach than 'soft' defence such as earth embankments.

Breach will usually result in sudden flooding with little or no warning and presents a significant hazard and danger to life. There is likely to be deeper flooding in the event of a breach than due to overtopping.

Defence locations in Dún Laoghaire-Rathdown have been identified through the Eastern CFRAM, which has included an assessment of the defences' ability to provide an effective function, and to what standard of protection. Individual defence locations have been highlighted in the consideration of specific risks. Where walls and embankments are not discussed it is highly likely that they are informal or ineffective structures which should not be relied upon in a flood event. For the purposes of a site specific flood risk assessment it should be assumed that the site is undefended.

3.3.4 Pluvial Flooding

Flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours. The resulting water follows natural valley lines, creating flow paths along roads and through and around developments and ponding in low spots, which often coincide with fluvial floodplains. Any areas at risk from fluvial flooding will almost certainly be at risk from surface water flooding.

Although having potentially severe consequences, pluvial flooding can generally be managed through site design, layout and drainage. However, SFRAs require a strategic assessment of the likelihood of surface water flooding, which includes consideration of the following:

- Are there zoned lands which may need to accommodate and retain surface water flow routes?
- Are there zoned lands which might discharge upstream of an area vulnerable to surface water flooding?

A preliminary screening of surface water hot-spots has been carried out for this SFRA, drawing on historical flood records and the OPW's PFRA mapping amongst other sources. For development within or near these areas, particular attention to surface water risk is required. Drainage Impact Assessments are required for all development proposals, and are further detailed in Section 4.4

3.3.5 Flooding from Drainage Systems

Flooding from artificial drainage systems occurs when flow entering a system, such as an urban storm water drainage system, exceeds its discharge capacity, it becomes blocked or it cannot discharge due to a high water level in the receiving watercourse.

Flooding in urban areas can also be attributed to sewers. Sewers have a finite capacity which, during certain load conditions, will be exceeded. In addition, design standards vary and changes within the catchment areas draining to the system, in particular planned growth and urban creep, will reduce the level of service provided by the asset. Sewer flooding problems will often be associated with regularly occurring storm events during which sewers and associated infrastructure can become blocked or fail. This problem is exacerbated in areas with under-capacity systems. In the larger events that are less frequent but have a higher consequence, surface water will exceed the sewer system and flow across the surface of the land, often following the same flow paths and ponding in the same areas as overland flow.

Foul sewers and surface water drainage systems are spread extensively across the urban areas with various interconnected systems discharging to treatment works and into local watercourses.

3.3.6 Groundwater Flooding

Groundwater flooding is caused by the emergence of water originating from underground, and is particularly common in karst landscapes. This can emerge from either point or diffuse locations. The occurrence of groundwater flooding is usually very local and unlike flooding from rivers and the sea, does not generally pose a significant risk to life due to the slow rate at which the water level rises. However, groundwater flooding can cause significant damage to property, especially in urban areas and pose further risks to the environment and ground stability. There are many underground streams within Dún Laoghaire-Rathdown, particularly in the Dalkey, Killiney, Dun Laoghaire, Glenageary and Glasthule areas. Some of these streams continue to give issues in private properties, and care should be taken to ensure high-water tables do not impact on basements, foundations, percolation areas or other sub-ground construction works. This should be assessed on a site by site basis through percolation testing and bore holes.

3.3.7 Climate Change

Climate change should be considered when assessing flood risk and in particular residual flood risk. Areas of residual risk are highly sensitive to climate change impacts as an increase in flood levels will increase the likelihood of defence failure.

The 'Planning System and Flood Risk Management' recommends that a precautionary approach to climate change is adopted due to the level of uncertainty involved in the potential effects. Specific advice on the expected impacts of climate change and the allowances to be provided for future flood risk management in Ireland is given in the OPW draft guidance[2]. Two climate change scenarios are considered. These are the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). The MRFS is intended to represent a "likely" future scenario based on the wide range of future predictions available. The HEFS represents a more "extreme" future scenario at the upper boundaries of future projections. Based on these two scenarios the OPW recommended allowances for climate change are given in Table 3-2. These climate change allowances are particularly important at the development management stage of planning, and will ensure that proposed development is designed and constructed to take into account current Government advice. Guidance on when the MRFS or HEFS should be used is provided in Section 4.9. Further work on the impacts of climate change on flood levels is being undertaken as part of the Eastern CFRAM for a number of watercourses in Dún Laoghaire-Rathdown. When complete, this study will include both current and potential future water levels across the river system, and these levels can be used to inform design criteria for developments within the CFRAM study area.

It is acknowledged that climate change research is advancing rapidly, and the allowances provided in the OPW guidance may be an underestimate of future impacts. At this, the development planning stage, a detailed knowledge of the impact of climate change on flood levels is not required to inform the strategic allocation of land. Instead, and in the absence of detailed projections of climate change impacts, fluvial flood extents can be assessed by using the Flood Zone B outline as a surrogate for 'Flood Zone A with allowance for the possible impacts of climate change', as suggested in the 'Planning System and Flood Risk Management'. For tidal flood risk, an increase of 0.5m or 1m should be assessed using LiDAR or other available ground level data.

Table 3-2: Allowances for Future Scenarios (100 Year Time Horizon)

Criteria	MRFS	HEFS
Extreme Rainfall Depths	+20%	+30%
Flood Flows	+20%	+30%
Mean Sea Level Rise	+500mm	+1000mm
Land Movement	-0.5mm / year*	-0.5mm / year*
Urbanisation	No General Allowance - Review on Case by Case Basis	No General Allowance - Review on Case by Case Basis
Forestation	-1/6 Tp**	-1/3 Tp** +10% SPR***

[2] OPW Assessment of Potential Future Scenarios, Flood Risk Management Draft Guidance, 2009

Notes:
* Applicable to the southern part of the country only (Dublin - Galway and south of this)
** Reduce the time to peak (Tp) by a third; this allows for potential accelerated runoff that may arise as a result of drainage of afforested land
*** Add 10% to the Standard Percentage Runoff (SPR) rate; this allows for increased runoff rates that may arise following felling of forestry

4 Policy Response

4.1 The Strategic Approach

A strategic approach to the management of flood risk is particularly important in Dún Laoghaire-Rathdown due to the density of existing development and the strategic importance of the County in relation to future growth and expansion. This makes it impractical to consider flood management on a site by site basis. This is particularly true where higher levels of flood risk have been identified and a more detailed flood risk assessment and options appraisal study, such as is being carried out through the CFRAM, may be required prior to permitting further development. In some cases, such a study may demonstrate a manageable level of risk and in others, a whole, or partial-catchment scheme may be recommended and should be constructed prior to further development taking place.

Following the Planning Guidelines, development should always be located in areas of lowest flood risk first, and only when it has been established that there are no suitable alternative options should development (of the lowest vulnerability) proceed. Consideration may then be given to factors which moderate risks, such as defences, and finally consideration of suitable flood risk mitigation and site management measures is necessary.

It is important to note that whilst it may be technically feasible to mitigate or manage flood risk at site level, strategically it may not be a sustainable approach.

A summary of flood risks associated with each of the zoning objectives has been provided in Table 4-1, below. It should be noted that this table is intended as a guide only and should be read in conjunction with the detailed assessment of risks in Section 5. However, when applications are being considered it is important to remember that not all uses will be appropriate on flood risk grounds, hence the need to work through the Justification Test for Development Management on a site by site basis and with reference to Section 5. For example, zoning objective MTC (mixed use town centre) could include a highly vulnerable crèche, less vulnerable shops and water compatible car parking but they would not be equally permissible on the ground floor within Flood Zone A or B.

Table 4-1: Zoning objective vulnerability

Zoning Objective		Indicative Primary Vulnerability	Flood Risk Commentary
A	To protect and-or improve residential amenity.	Highly vulnerable	Generally not appropriate in areas at risk of flooding.
A1	To provide for new residential communities in accordance with approved local area plans.	Highly vulnerable	Generally not appropriate in areas at risk of flooding.
A2	To provide for the creation of sustainable residential neighbourhoods and preserve and protect residential amenity.	Highly vulnerable	Generally not appropriate in areas at risk of flooding.
B	To protect and improve rural amenity and to provide for the development of agriculture.	Water compatible	In general rural amenity will include water compatible uses, but individual and groups of residential and other developments may arise. Applying the Justification Test would require such developments to avoid areas with Flood Zone A / B.
DC	To protect, provide for and-or improve mixed-use district centre facilities.	Less / highly vulnerable	A mix of uses within this zoning objective is possible. Flood risk should be assessed and managed in accordance with this SFRA, and applying the

Zoning Objective		Indicative Primary Vulnerability	Flood Risk Commentary
			sequential approach.
E	To provide for economic development and employment.	Less vulnerable	Generally appropriate in Flood Zone B and extensions of existing development in Flood Zone A are justified, subject to site specific FRA.
F	To preserve and provide for open space with ancillary active recreational amenities.	Water compatible	Appropriate for all Flood Zones. Ancillary developments to be assessed in accordance with the sequential approach.
G	To protect and improve high amenity areas.	Water compatible	Appropriate for all Flood Zones. Objective is to avoid new development in these areas, and what development is allowed should be located within Flood Zone C.
GB	To protect and enhance the open nature of lands between urban areas.	Water compatible	Appropriate for all Flood Zones. Any ancillary developments to be assessed in accordance with the sequential approach.
LIW	To improve and provide for low density warehousing/light industrial warehousing uses	Less vulnerable	Generally appropriate in Flood Zone B and extensions of existing development in Flood Zone A are justified, subject to site specific FRA.
MH	To improve, encourage and facilitate the provision and expansion of medical/hospital uses and services.	Highly vulnerable	Appropriate in Flood Zone C. Sequential approach may be applied within a site to locate water compatible elements (car parks) within Flood Zone A/B, provided emergency plan is in place.
MIC	To consolidate and complete the development of the mixed use inner core to enhance and reinforce sustainable development.	Less / highly vulnerable	A mix of uses within this zoning objective is possible. Flood risk should be assessed and managed in accordance with this SFRA, and applying the sequential approach.
MOC	To provide for a mix of uses which complements the inner core, but with less retail and residential and more emphasis on employment and services.	Less / highly vulnerable	A mix of uses within this zoning objective is possible. Flood risk should be assessed and managed in accordance with this SFRA, and applying the sequential approach.
MTC	To protect, provide for and-or improve major town centre facilities.	Highly / less vulnerable	A mix of uses within this zoning objective is possible. Flood risk should be assessed and managed in accordance with this SFRA, and applying the sequential approach.
NC	To protect, provide for and-or improve mixed-use neighbourhood centre facilities.	Highly / less vulnerable	A mix of uses within this zoning objective is possible. Flood risk should be assessed and managed in accordance with this SFRA, and applying the sequential approach.
OE	To provide for office and enterprise development.	Less vulnerable	Generally appropriate in Flood Zone B and extensions of existing development in Flood Zone A are justified, subject to site specific FRA.
TLI	To facilitate, support and enhance the	Highly vulnerable	Appropriate in Flood Zone C. Sequential approach may be applied within a site to

Zoning Objective		Indicative Primary Vulnerability	Flood Risk Commentary
	development of third level education institutions.		locate water compatible elements (car parks and playing fields) within Flood Zone A/B, provided emergency plan is in place.
W	To provide for waterfront development and harbour related uses.	Water compatible	Appropriate for all Flood Zones. Ancillary developments to be assessed in accordance with the sequential approach.

4.2 Development Management and Flood Risk

In order to guide both applicants and planning officials through the process of planning for, and mitigating flood risk, the key features of a range of development scenarios have been identified (relating the flood zone, development vulnerability and presence or absence of defences). For each scenario, a number of considerations relating to the suitability of the development are summarised below.

It should be noted that this section of the SFRA begins from the point that all land zoned for development has passed the Justification Test for Development Plans, and therefore Part 1 of the Justification Test for Development Management. In addition to the general recommendations in the following sections, Section 5 should be reviewed for specific recommendations for the watercourses within Dún Laoghaire-Rathdown, including details of the application of the Justification Test.

In order to determine the appropriate design standards for a development it may be necessary to undertake a site specific flood risk assessment. This may be a qualitative appraisal of risks, including drainage design. Alternatively, the findings of the CFRAM, or other detailed study, may be drawn upon to inform finished floor levels. In other circumstances a detailed modelling study and flood risk assessment may need to be undertaken. Further details of each of these scenarios, including considerations for the flood risk assessment are provided in the following sections.

4.3 Requirements for a Flood Risk Assessment

An appropriately detailed flood risk assessment will be required in support of any planning application. The level of detail will vary depending on the risks identified and the proposed land use. As a minimum, all proposed development, including that in Flood Zone C, must consider the impact of surface water flood risks on drainage design. In addition, flood risk from sources other than fluvial and tidal should be reviewed.

For sites within Flood Zone A or B, a site specific "Stage 2 - Initial FRA" will be required, and may need to be developed into a "Stage 3 - Detailed FRA". The extents of Flood Zone A and B are delineated through this SFRA. However, future studies may refine the extents (either to reduce or enlarge them) so a comprehensive review of available data should be undertaken once a FRA has been triggered.

Within the FRA the impacts of climate change and residual risk (including culvert/structure blockage) should be considered and remodelled where necessary, using an appropriate level of detail, in the design of FFL. Further information on the required content of the FRA is provided in the Planning System and Flood Risk Management Guidelines.

Any proposal that is considered acceptable in principle shall demonstrate the use of the sequential approach in terms of the site layout and design and, in satisfying the Justification Test (where required), the proposal will demonstrate that appropriate mitigation and management measures are put in place.

4.4 Drainage impact assessment

All proposed development, including that in Flood Zone C, must consider the impact of surface water flood risks on drainage design. In this regard, all the other development scenarios must pass through this stage before completing the planning and development process, and should be

accompanied by an appropriately detailed flood risk assessment, or drainage impact assessment.

There are extensive networks of surface water runoff routes across the County, with areas vulnerable to ponding indicated on the Flood Zone Map. Particular attention should be given to development in low-lying areas which may act as natural ponds for collection of runoff.

The drainage design should ensure no increase in flood risk to the site, or the downstream catchment. Considerable detail on the process and design of SUDS is provided in the Greater Dublin Strategic Drainage Study, and more details and guidance are available on the 'Irish SuDS: Guidance and Tools' website[3].

Master planning of development sites should ensure that existing flow routes are maintained, through the use of green infrastructure. Where possible, and particularly in areas of new development, floor levels should at a minimum be 300mm above adjacent roads and hard standing areas to reduce the consequences of any localised flooding. Where this is not possible, an alternative design appropriate to the location may be prepared. The surface water flood locations are indicated as both historical and predicated 'surface water hotspots' on the Flood Zone map. A more rigorous design approach will be required in locations indicated to be at, or near (approximately 50m radius) these locations. Further discussion with the Water Services Section of Dún Laoghaire-Rathdown County Council is recommended in this situation.

4.5 Development proposals in Flood Zone C

Where a site is within Flood Zone C, but adjoining or in close proximity to Flood Zone A or B there could be a risk of flooding associated with factors such as future scenarios (climate change) or in the event of failure of a defence, blocking of a bridge or culvert. Risk from sources other than fluvial and coastal must also be addressed for all development in Flood Zone C. As a minimum in such a scenario, a flood risk assessment should be undertaken which will screen out possible indirect sources of flood risk and where they cannot be screened out it should present mitigation measures. The most likely mitigation measure will involve setting finished floor levels to a height that is above the 1 in 100 year fluvial or 1 in 200 year tidal flood level, with an allowance for climate change and freeboard, or to ensure a step up from road level to prevent surface water ingress. Design elements such as channel maintenance or trash screens may also be required. Evacuation routes in the event of inundation of surrounding land should also be detailed.

The impacts of climate change should be considered for all proposed developments. This is particularly important for development near areas at risk of tidal flooding. A development which is currently in Flood Zone C may be shown to be at risk when 0.5m is added to the extreme (1 in 200 year) tide. Details of the approach to incorporating climate change impacts into the assessment and design are provided in Section 4.8.

4.6 Applications for Minor Developments in Areas at Risk of Flooding

In an extension to Section 5.28 of the Planning Guidelines on Flood Risk Management, two classes of 'Minor developments' have been defined through this SFRA. These are:

- Class 1 - Works directly associated with existing developments, such as extensions, renovations and rebuilding within the footprint of the existing development, and changes of use.
- Class 2 - Works in relation to infill development, which may include development of previously unused (greenfield) land, or building within the curtilage of an existing development, but outside the footprint of the building.

In the case of class 1, the 'Sequential Approach'' and 'Justification Test' will not apply as they relate to existing buildings. However, an assessment of the risks of flooding should accompany such applications to demonstrate that they would not have adverse impacts or impede access to a watercourse, floodplain or flood protection and management facilities. Where possible, the design of built elements in these applications should demonstrate principles of flood resilient

design (See Section 4 - Designing for Residual Flood Risk of the Technical Appendices to the DoECLG Flooding Guidelines). Emergency access must be considered as in many cases flood resilience will not be easily achieved in the existing built environment.

For Class 2 development, construction of new buildings on what would otherwise be greenfield, or undeveloped land, has generally been found to generate an un-justifiable level of risk, either through introducing additional people into the floodplain, blocking surface water and overland flow paths or requiring works which are likely to have a negative impact on flood risk elsewhere. For this reason, new, standalone development is not permitted within Flood Zone A or B for highly vulnerable uses or in Flood Zone A for less vulnerable uses.

Checklist of what is required for Minor Applications in Areas at Risk of Flooding.

- Consideration of minor works classification.
- Assessment of flood risk carried out by an appropriately qualified Engineer with relevant FRA experience (as deemed acceptable by the Planning Authority).
- Flood resilient design
- Access, egress and emergency plans must be in place which are appropriate to the vulnerability of the development and its occupiers, the intensity of use and the level of flood risk.

4.7 Applications for Larger Development in Areas at Risk of Flooding

4.7.1 Highly vulnerable development in Flood Zone A or B

Development which is highly vulnerable to flooding, as defined in The Planning System and Flood Risk Management, includes (but is not limited to) dwelling houses, hospitals, emergency services and caravan parks.

4.7.1.1 New development

It is not appropriate for new, highly vulnerable development to be located on greenfield land in Flood Zones A or B, particularly outside the core of a settlement and where there are no flood defences. Such proposals do not pass the Justification Test. Instead, a less vulnerable use should be considered.

4.7.1.2 Existing developed areas

The Planning Circular (PL02/2014) states that "*notwithstanding the need for future development to avoid areas at risk of flooding, it is recognised that the existing urban structure of the country contains many well established cities and urban centres which will continue to be at risk of flooding. In addition, development plans have identified various strategically important urban centres … whose continued consolidation, growth, development or generation, including for residential use, is being encouraged to bring about compact and sustainable growth*.

Within this SFRA, small scale infill housing, extensions or changes of use have been considered and, subject to site specific flood risk assessment, can generally be considered appropriate provided they constitute a continuation of the existing level of development. There are a number of areas within Dún Laoghaire-Rathdown that prove to be exceptions to this approach, such as Seafield, Bayview and downstream of Dundrum town centre, so the detail contained in Section 5 should be consulted for more site specific information.

In cases where development has been justified, the outline requirements for a flood risk assessment and flood management measures have been detailed in this SFRA in both the following sections and the site specific assessments in Section 5, which also details where such development has been justified. Of prime importance are the requirement to manage risk to the development site and not to increase flood risk elsewhere. This should give due consideration to safe evacuation routes and access for emergency services during a flood event.

4.7.2 Less vulnerable development in Flood Zone A or B

Less vulnerable development includes retail, leisure and warehousing and buildings used for agriculture and forestry. This category includes less vulnerable development in all forms, including refurbishment or infill development, and new development both in defended and undefended situations.

The design and assessment of less vulnerable development should begin with 1% AEP fluvial or 0.5% tidal events as standard, with climate change and a suitable freeboard included in the setting of finished floor levels.

The presence or absence of flood defences informs the level of flood mitigation recommended for less vulnerable developments in areas at risk of flooding. In contrast with highly vulnerable development, there is greater scope for the developer of less vulnerable uses to accept flood risks and build to a lower standard of protection, which is still high enough to manage risks for the development in question. However, any deviation from the design standard of 1%/0.5% AEP, plus climate change, plus freeboard, needs to be fully justified within the FRA.

Major developments may also be located in areas with a higher likelihood of flooding, provided the risks are understood, and accepted, and operability and emergency response is clearly defined; this may allow construction to a finished floor level which is lower than the 'ideal' starting point.

4.8 Key points for FRAs for all types of development

- Finished floor levels to be set above the 1% AEP fluvial (0.5% AEP tide) level, with an allowance for climate change plus a freeboard of at least 300mm. The freeboard allowance should be assessed and the choice justified.
- Flow paths through the site and areas of surface water storage should be managed to maintain their function and without causing increased flood risk elsewhere
- Compensatory storage is to be provided to balance floodplain loss as a result of raising ground levels within Flood Zone A. The storage should be provided within the flood cell and on a level for level basis up to the 1% level.
- Within currently developed areas, the impact of loss of storage should also be investigated for the 0.1% AEP event, and further compensatory storage provided if the development is shown to have a negative impact on flood risk elsewhere[4].
- In a defended site, compensatory storage is not required, but the impact of removing the net reduction in floodplain storage should be assessed, and any impacts to existing development mitigated for the 0.1% event or a breach of these defences.
- A site is considered to be defended if the standard of protection is 1% AEP, within which a freeboard of at least 300mm is included. The FFL of the proposed development needs to take into include for the impacts of climate change and other residual risks, including the 0.1% event, unless this has also been incorporated into the defence design. This may be assessed through breach analysis, overtopping analysis or projection of levels from the channel inland.
- For less vulnerable development, it may be that a finished floor level as low as the 1% AEP level could be adopted, provided the risks of climate change are included in the development through adaptable designs or resilience measures. This approach should reflect emergency planning and business continuity to be provided within the development. It may reflect the design life of the development, the proposed use, the vulnerability of items to be kept in the premises, the occupants and users, emergency plan and inclusion of flood resilience and recovery measures.

Checklist for Applications for Larger Development in Areas at Risk of Flooding.

- Development Management 'Justification Test' has been passed.

[4] A negative impact would result in additional numbers of properties being at flood risk, or an increase in flood depth to properties currently at flood risk.

- FRA in accordance the Dún Laoghaire-Rathdown SFRA and the Planning System and Flood Risk Management Guidelines, to be carried out by an appropriately qualified Engineer with relevant FRA experience (as deemed acceptable by the Planning Authority).
- Flood resilience statement to be submitted.
- Compliance with GDSDS and inclusion of SuDS.
- Assessment of the potential impacts of Climate Change and the adaptive capacity of the development
- Access, egress and emergency plans must be in place which are appropriate to the vulnerability of the development and its occupiers, the intensity of use and the level of flood risk.

4.9 Incorporating Climate Change into Development Design

As detailed throughout this SFRA, consideration and incorporation of the potential impacts of climate change into development layout and design is essential. The following summary provides an indication of allowances that should be considered when assessing the impacts of climate change. It should be noted that this information is intended as a guide only and there may be instances where it is appropriate for a greater or lesser allowance to be provided, particularly as climate change projections are further refined. The guidance does not necessarily relate directly to the vulnerability of the development used within the Planning Guidelines, but should be assessed on a case by case basis. For watercourses that fall within the Eastern CFRAM study area, water levels for future scenarios are being developed. For other watercourses a conservative approach would be to take the 0.1% AEP event levels as representing the 1% AEP event plus climate change. Where access to the hydraulic river model is readily available a run with climate change could be carried out, or hand calculations undertaken to determine the likely impact of additional flows on river levels.

For most development, including residential, nursing homes, shops and offices, the medium-range future scenario (20% increase in flows and / or 0.5m increase in sea level) is an appropriate consideration.

Where the risk associated with inundation of a development is low and the design life of the development is short (typically less than 30 years) the allowance provided for climate change may be less than the 20% / 0.5m level. However, the reasoning and impacts of such an approach should be provided in the site specific FRA.

Conversely, there may be development which requires a higher level response to climate change. This could include major facilities which are extremely difficult to relocate, such as hospitals, Seveso sites or power stations, and those which represent a high-economic and long term investment within the scale of development across the city. In such situations it would be reasonable to expect the high-end future scenario (30% increase in flow or 1m in sea level) to be used as the design standard. In the case of coastal locations, and as climate projections are further developed, it may be prudent to demonstrate adaptability to even higher sea levels.

4.10 Flood Mitigation Measures at Site Design

For any development proposal in an area at moderate or high risk of flooding that is considered acceptable in principle, it must be demonstrated that appropriate mitigation measures can be put in place and that residual risks can be managed to acceptable levels. Guidance on what might be considered 'acceptable' has been given in a number of sections in this document.

To ensure that adequate measures are put in place to deal with residual risks, proposals should demonstrate the use of flood-resistant construction measures that are aimed at preventing water from entering a building and that mitigate the damage floodwater causes to buildings. Alternatively, designs for flood resilient construction may be adopted where it can be demonstrated that entry of floodwater into buildings is preferable to limit damage caused by floodwater and allow relatively quick recovery.

Various mitigation measures are outlined below and further detail on flood resilience and flood resistance are included in the Technical Appendices of the Planning Guidelines, The Planning System and Flood Risk Management[5].

It should be emphasised that measures such as those highlighted below should only be considered once it has been deemed 'appropriate' to allow development in a given location. The Planning Guidelines do not advocate an approach of engineering solutions in order to justify the development which would otherwise be inappropriate.

4.10.1 Site Layout and Design

To address flood risk in the design of new development, a risk based approach should be adopted to locate more vulnerable land use to higher ground while water compatible development i.e. car parking, recreational space can be located in higher flood risk areas. Highly vulnerable land uses (i.e. residential housing) should be substituted with less vulnerable development (i.e. retail unit).

The site layout should identify and protect land required for current and future flood risk management. Waterside areas or areas along known flow routes can be used for recreation, amenity and environmental purposes to allow preservation of flow routes and flood storage, while at the same time providing valuable social and environmental benefits. Reference should be made to the DLR Green Infrastructure Strategy.

4.10.2 Ground levels, floor levels and building use

Modifying ground levels to raise land above the design flood level is a very effective way of reducing flood risk to the particular site in question. However, in most areas of fluvial flood risk, conveyance or flood storage would be reduced locally and could have an adverse effect on flood risk off site. There are a number of criteria which must all be met before this is considered a valid approach:

- Development at the site must have been justified through this SFRA based on the existing (unmodified) ground levels.
- The FRA should establish the function provided by the floodplain. Where conveyance is a prime function then a hydraulic model will be required to show the impact of its alteration.
- Compensatory storage should be provided on a level for level basis to balance the total area that will be lost through infilling where the floodplain provides static storage.
- The provision of the compensatory storage should be in close proximity to the area that storage is being lost from (i.e. within the same flood cell).
- The land proposed to provide the compensatory storage area must be within the ownership / control of the developer.
- The land being given over to storage must be land which does not flood in the 1% AEP event (i.e. Flood Zone B or C).
- The compensatory storage area should be constructed before land is raised to facilitate development.

In some sites it is possible that ground levels can be re-landscaped to provide a sufficiently large development footprint. However, it is likely that in other potential development locations there is insufficient land available to fully compensate for the loss of floodplain. In such cases it will be necessary to reconsider the layout or reduce the scale of development, or propose an alternative and less vulnerable type of development. In other cases, it is possible that the lack of availability of suitable areas of compensatory storage mean the target site cannot be developed and should remain open space.

Raising finished floor levels within a development is an effective way of avoiding damage to the interior of buildings (i.e. furniture and fittings) in times of flood.

[5] The Planning System and Flood Risk Management Guidelines for Planning Authorities, Technical Appendices, November 2009

Alternatively, assigning a water compatible use (i.e. garage / car parking) or less vulnerable use to the ground floor level, along with suitable flood resilient construction, is an effective way of raising vulnerable living space above design flood levels. It can however have an impact on the streetscape. Safe access and egress is a critical consideration in allocating ground floor uses.

Depending on the scale of residual risk, resilient and resistance measures may be an appropriate response but this will mostly apply to less vulnerable development.

4.10.3 Raised Defences

Construction of raised defences (i.e. flood walls and embankments) traditionally has been the response to flood risk. However, this is not a preferred option on an ad-hoc basis where the defences to protect the development are not part of a strategically led flood relief scheme. Where a defence scheme is proposed as the means of providing flood defence, the impact of the scheme on flood risk up and downstream must be assessed and appropriate compensatory storage must be provided.

4.11 'Green Corridor'

It is recommended that, where possible, and particularly where there is greenfield land adjacent to the river, a 'green corridor', is retained on all rivers and streams. This will have a number of benefits, including:

- Retention of all, or some, of the natural floodplain;
- Potential opportunities for amenity, including riverside walks and public open spaces;
- Maintenance of the connectivity between the river and its floodplain, encouraging the development of a full range of habitats;
- Natural attenuation of flows will help ensure no increase in flood risk downstream;
- Allows access to the river for maintenance works;
- Retention of clearly demarcated areas where development is not appropriate on flood risk grounds, and in accordance with the Planning System and Flood Risk Management.

The width of this corridor should be determined by the available land, and topographically constraints, such as raised land and flood defences, but would ideally span the fully width of the floodplain (i.e. all of Flood Zone A). The DLR Green Infrastructure Strategy has identified core green corridors which have been mostly formed along watercourses.

5 Application of the Justification Test

Having reviewed the level of flood risk within the County, and determined appropriate measures for assessing and managing risks to high and low vulnerability development in Flood Zones A, B and C, a more detailed assessment of sites and areas was carried out. The aim of this assessment was to apply the Plan Making Justification Test, taking into account circular PL02/2014 in relation to existing development.

5.1 Undeveloped land

With the exception of zoned Major Town Centres, District Centres and Sandyford Business District, new development within Flood Zones A or B does not pass the Justification Test and will not be permitted. This applies to undeveloped areas which are zoned for development but are currently undeveloped and to areas of existing low intensity development. Whilst lands may have retained a zoning objective which would include development, applying the guidance in Section 4 means such development is restricted to Flood Zone C, with water compatible uses located within Zone A and B.

5.2 Existing, developed, zoned areas at risk of flooding

5.2.1 Highly vulnerable uses

Circular PL02/2014 states that "*In some instances, particularly in older parts of cities and towns, an existing land use may be categorised as a "highly vulnerable development" such as housing, be zoned for residential purposes and also be located in flood zone A/B. Additional development such as small scale infill housing, extension or changes of use that could increase the risk or number of people in the flood-prone are can be expected in such a zone into the future. In these instances, where the residential/vulnerable use zoning has been considered as part of development plan preparation, including uses of the Justification Test as appropriate, and it is considered that the existing use zoning is still appropriate, the development plan must specify the nature and design of structural or non-structural flood risk management measures prior to future development in such areas in order to ensure that flood hazard and risk to the area and to other adjoining locations will not be increased or, if practicable, will be reduced".*

There are a number of such areas in the County identified on the Flood Zone maps, including existing housing areas at Seafield and Bayview, Shankill, Carysfort, Ludford and in and around Dundrum Town Centre. It is considered that it would be unrealistic to down zone these lands as they are fully developed. Parts 1 and 2 of the Justification Test in relation to these area of existing housing in the County is outlined below in Table 5.1.

In applying the Justification Test Part 3, consideration has been given to structural and non-structural measures which may be required prior to further development taking place. In most locations, future opportunities for development are likely to be limited to small extensions, infill houses or small commercial units and changes of use. As such, in most areas flood risk can be addressed through non-structural responses, such as requiring a site specific flood risk assessment which will identify appropriate mitigation measures such as retaining flow paths, flood resilient construction and emergency planning.

There are a number of locations where flood risk is greater and non-structural responses are not appropriate to the scale of risks. In these locations, structural measures, generally in the form of flood defences, will be required prior to future development occurring. Further detail on the specifics of the flood management measures in these locations will be available in the ECFRAM.

Section 5.3 provides more detail on the various flood risk areas within the County, and gives a details of the outcome of Part 3 of the Justification Test.

Table 5-1: Justification Test (Part 1 and 2) only for zoning objective A, A1, A2, NC, DC, MTC, E,TLI, MH, MIC, MOC, OE, W areas in the County that are already developed (excluding area with very low intensity development) and include existing vulnerable uses and are in flood zone A and/or B.

	Criteria	Response
1	The urban settlement is targeted for growth under the National Spatial Strategy, regional planning guidelines, statutory plans or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act 2000, as amended.	The National Spatial Strategy 2002-2022 is a twenty year plan for the Country and consolidating the Greater Dublin Area, a Gateway, is a primary policy of this Strategy. The Regional Planning Guidelines for the Greater Dublin Area 2010 – 2016 show the entire built up area of the County of Dun Laoghaire Rathdown as falling within the Metropolitan Area as illustrated in Figure 12 (p89 of Development Plan).
2	The zoning or designation of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in particular:	
2(i)	Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement:	All of these areas are developed areas that include suburban housing and are essential in order to support the continued viability of the urban centres in the County.
2(ii)	Comprises significant previously developed and/or under-utilised lands:	All the lands is question contain existing development and are therefore previously developed lands.
2(iii)	Is within or adjoining the core of an established or designated urban settlement:	The lands in question fall within the Metropolitan Area of the GDA.
2(iv)	Will be essential in achieving compact and sustainable urban growth; and,	As the lands in question contain existing development in the County they are already essential in achieving compact and sustainable urban growth.
2(v)	There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.	There are no suitable alternative lands identified within the County.

5.3 Justification Test: Part 3

In the following sections a simplified version of the land zoning objectives have been mapped alongside the Flood Zones. Essentially, yellow (and yellow hatching) indicates residential, brown/orange is rural amenity, pink/purple is commercial or mixed use (generally less vulnerable), light blue is high amenity and green is open space.

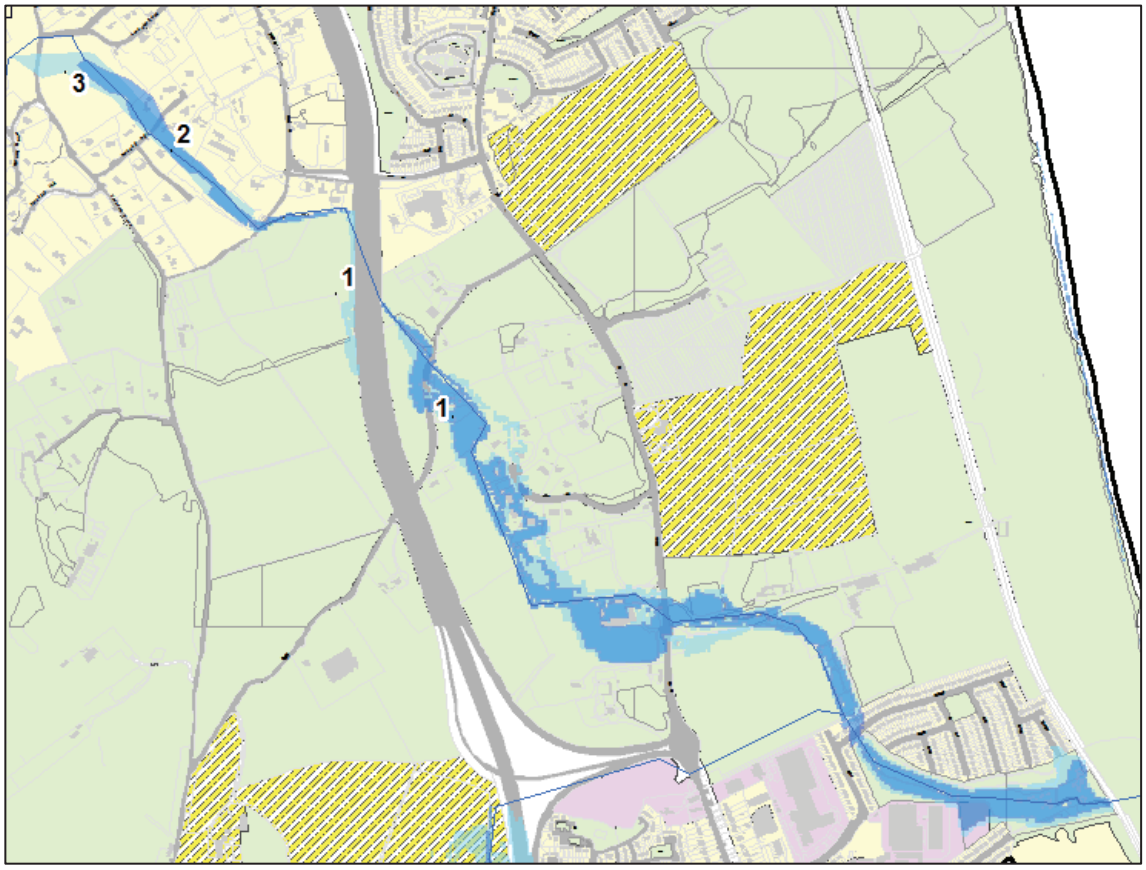
5.3.1 Crinken Stream

Flooding shown to west of M50 south of Crinken Lane and east of M50 either side of Allies River Road, see Figure 5-1 (1). Flood risk arising from the Crinken Stream in this area primarily within land zoned as greenbelt (GB and F), which is water compatible and therefore appropriate within Flood Zone A and B and should be retained. Flooding is also shown at St Brendans School, Wilford and lands to north at Woodbrook Downs and Woodbrook Golf course and open space area associated with Woodbrook Glen residential development. This land is also zoned as greenbelt.

There is also limited flood risk shown within the existing development at the upstream end of the northern reach of the Stream (2). It is likely that opportunities for further development will be limited to small scale infill / extensions. At the upstream end of the Crinken Stream there is a plot which is currently undeveloped (3) and shown through the PFRA mapping to be at flood risk.

Ground conditions also indicate high water table / poor infiltration of surface water at this site. Risks to these lands can be further defined through site specific risk assessment, following the guidance within this SFRA, with development in Flood Zone A and B to be avoided.

Figure 5-1: Crinken Stream



5.3.2 Old Conna LAP

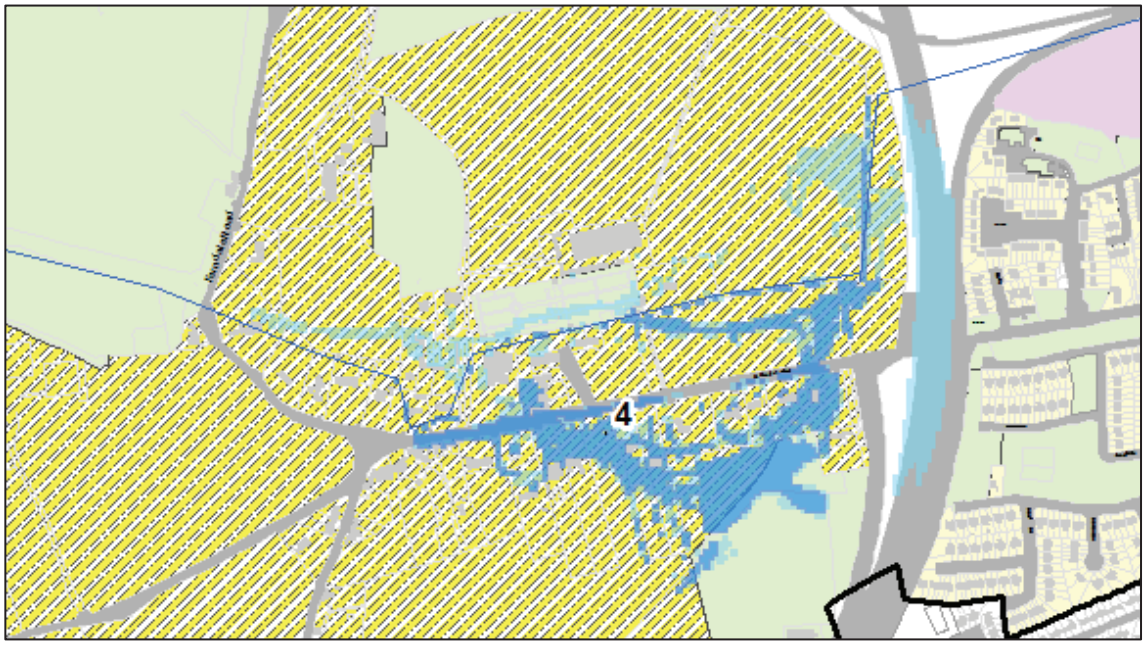
Lands zoned zoning Objective A1 - 'to provide for new residential communities in accordance with approved local area plans' - have been shown to be at risk of flooding, Figure 5-2 (4). The lands fall into both Flood Zone A and B. To determine the appropriateness of such development in Old Conna, the sequential approach has been applied, which has culminated in application of the Justification Test.

As outlined in the Core Strategy and in accordance with housing targets set by the Regional Planning Guidelines Dún Laoghaire-Rathdown are obliged to provide a certain number of residential units over the life time of the next County Development Plan. To achieve these targets various areas in the County are zoned for future development in accordance with approved Local Area Plans. Old Conna is one such area.

In a County such as Dún Laoghaire-Rathdown which consists of a significant built-up area and an upland area which is of high landscape value land suitable for future residential communities is scarce. As such it is not considered that there is an alternative site available for significant development such as that envisaged at Old Conna; Dún Laoghaire-Rathdown is by far the smallest County in the State. In addition, as the specific need is for residential accommodation, substitution for a less vulnerable land use will not be possible.

The Guidelines state that where an Authority is considering the future development of areas in an urban settlement that are at moderate or high risk of flooding, for uses or development vulnerable to flooding that would generally be inappropriate, it must be satisfied that it can clearly demonstrate on a solid evidence base that the zoning or designation for development will satisfy the 'Justification Test'.

Figure 5-2: Old Conna LAP



Section 4.23 of the Flooding Guidelines relate to the 'Justification Test' and outline the three criteria that must be satisfied. The criteria and the local authority's response detailed in Table 5-2.

Table 5-2: Justification test for Old Conna

	Criteria	Response
1	The urban settlement is targeted for growth under the National Spatial Strategy, regional planning guidelines, statutory plans or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act 2000, as amended.	The National Spatial Strategy 2002-2022 is a twenty year plan for the Country and consolidating the Greater Dublin Area, a Gateway, is a primary policy of this Strategy. The Regional Planning Guidelines for the Greater Dublin Area 2010 – 2016 show the Old Conna area as falling within the Metropolitan Area as illustrated in Figure 12 (p89). The focus of the RPGs is on new housing within the built-up footprint of Dublin City and suburbs within the Metropolitan Area. Under the existing plan the Old Conna area was to be serviced by an extension to the Luas line. The NTA Draft Transport Strategy 2011 – 2030 states that a southward extension of the Luas to Bray is still proposed but will be subject to the timing of new development. Bray and Environs - including the surrounding areas of Old Conna and Fassaroe - is identified as a Metropolitan Consolidation Town in the GDA Regional Planning Guidelines 2010 – 2022 (RPGs p91). Metropolitan Consolidation Towns are defined as towns close to Dublin which will function as part of the Gateway. The Regional Planning Guidelines state that these towns should continue to be developed at a large scale, with key public transport corridors connecting these towns to the City (RPGs, p93).
2	The zoning or designation of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in	

	Criteria	Response
	particular:	
2(i)	Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement:	It is considered that the lands at Old Conna are essential to allow for growth and expansion of Dún Laoghaire-Rathdown (and Bray Town) in order to meet the targets as set out in the RPGs.
2(ii)	Comprises significant previously developed and/or under-utilised lands:	The subject lands consist of significant under-utilised zoned land suitable for a higher density mixed-use type development, proximate to the N11 which will have quality bus corridor.
2(iii)	Is within or adjoining the core of an established or designated urban settlement:	The lands at Old Conna fall within the Metropolitan Area of the GDA.
2(iv)	Will be essential in achieving compact and sustainable urban growth; and,	The future development of these lands will be in accordance with an approved LAP prepared in accordance with up-to-date guidance on sustainable settlement and compact urban growth.
2(v)	There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement.	There are no suitable alternative lands identified within the County and in order to meet the requirements of the RPGs and the Core Strategy this land is required to be zoned for future development.
3	A flood risk assessment to an appropriate level of detail has been carried out as part of the Strategic Environmental Assessment as part of the development plan preparation process, which demonstrates that flood risk to the development can be adequately managed and the use or development of the lands will not cause unacceptable adverse impacts elsewhere.	Flood Zone A and B cover some land within the LAP boundary, and some to the south of the LAP. The lands within Flood Zone A have largely been developed, particularly along Old Conna Avenue, but the surrounding area is also zoned for new residential development. It is noted that a surface water pipe has been installed to mitigate flood risk in the village environs. Whilst providing benefits to existing development, it is important that residual risks, such as through culvert blockage, should be addressed through LAP / site specific flood risk assessment. Although residential uses have been identified for the area, the LAP should take care to allocate land uses sequentially within the plan boundary, focusing the residential housing in Flood Zone C and retaining open space, roads and gardens in Flood Zones A and B.

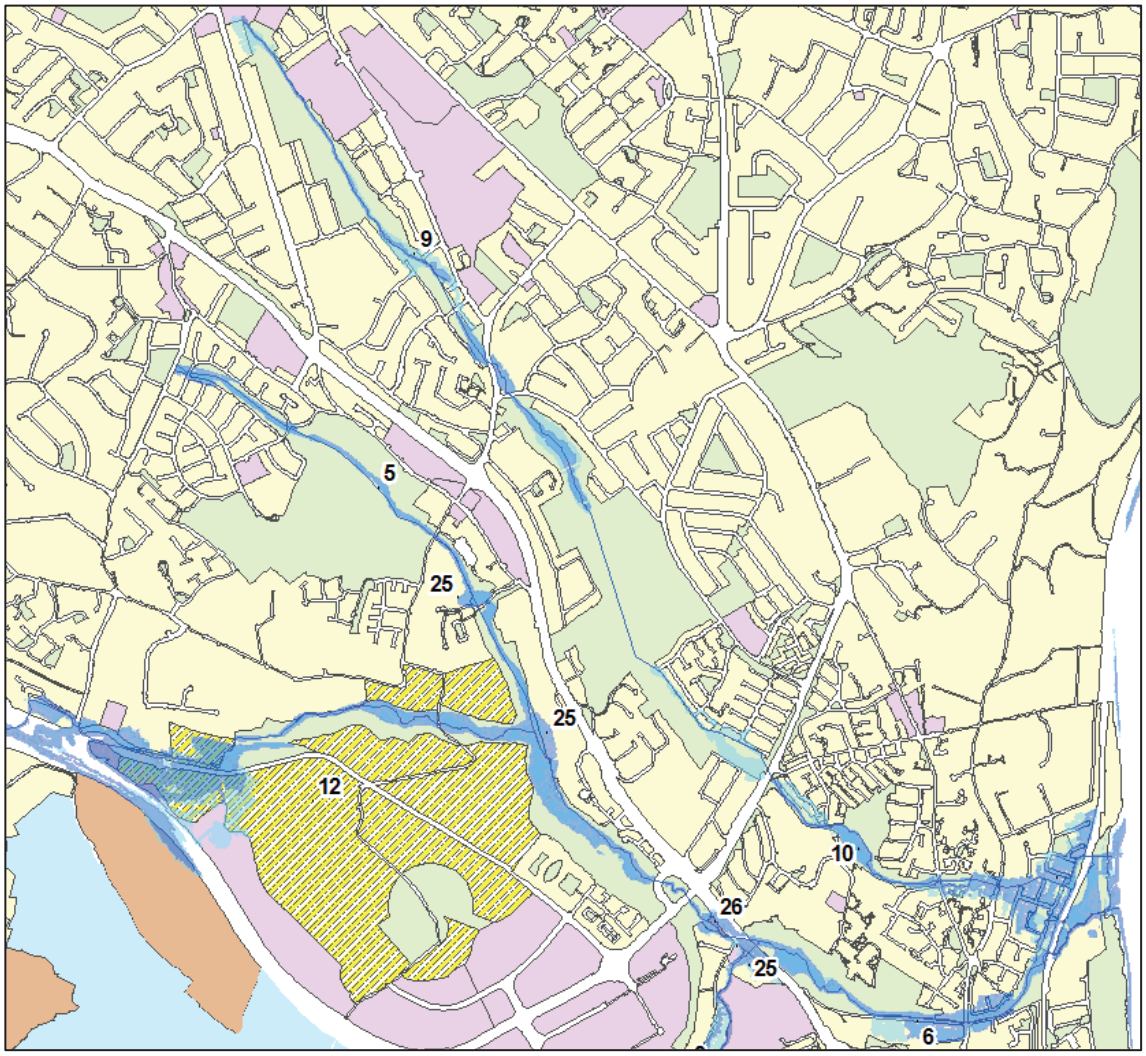
5.3.3 Shanganagh River

Upstream of the crossing point between the Shanganagh River and the N11, and at the confluence of the Shanganagh and Loughlinstown Rivers , lands within Flood Zone A and B are mainly zoned for water compatible uses, which should be retained (5), see Figure 5-3. There are some areas of existing residential development (25), including parts of , Beech Park, Sunnyhill Park and Cherrywood Park and an area zoned neighbourhood centre at the junction of Cherrywood Road and the M11 (26), that are located in Flood Zone A and B. In areas of existing development, flood risks are generally moderate and risks to minor development, such as extensions and changes of use, can be managed through site specific risk assessments in accordance with the specification guidance in this SFRA. New development within Flood Zone A and B cannot be justified and floodplain land should be retained as open space.

Downstream of M11 and upstream of the DART line Flood Zone A extends into areas of existing residential development (6) along the Commons Road, with some additional flood risk indicated by Flood Zone B. The area along Mill Lane has flooded in the past, both before and after construction of the defences. The defences consist of a combination of reinforced concrete walls and embankment. The walls were designed to provide a 1 in 50 year standard of protection, which is below the required standard of protection for Flood Zone A so it must be assumed that the lands are undefended and development should only proceed in accordance with the general

FRA recommendations. Development should be limited to Class 1 Minor Developments (see Section 4.6 for more details) until such as time as the defences are brought up to the 1 in 100 year standard.

Figure 5-3: Shanganagh and Deansgrange Rivers



5.3.4 Loughlinstowns River

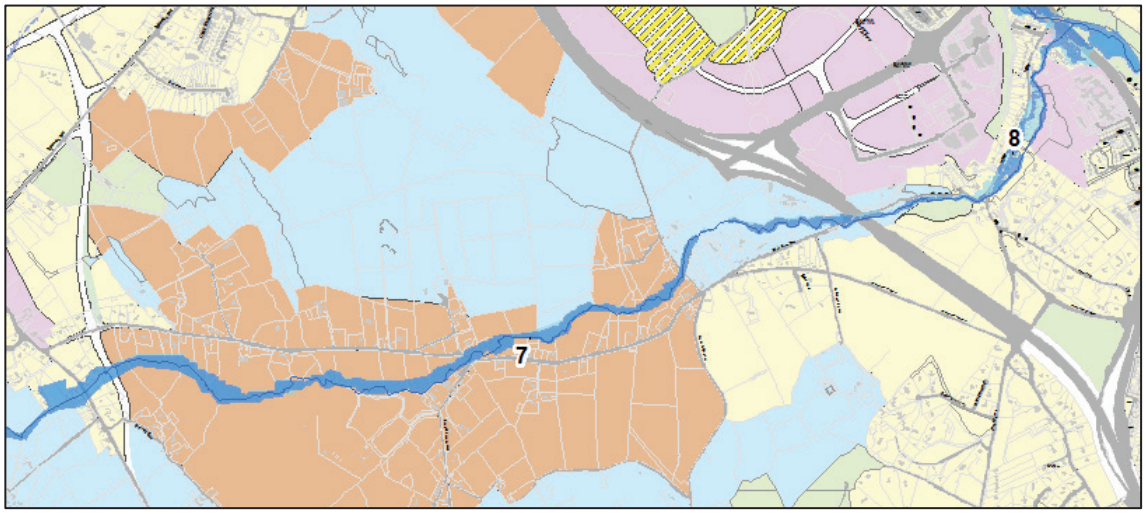
The Loughlinstown River, shown in Figure 5-4, passes through areas zoned for various vulnerabilities, including high amenity, rural amenity and agricultural development and existing residential development.

Within currently undeveloped areas (7) there is no justification for development within Flood Zones A and B.

In areas of existing residential development (8), flood risks are generally moderate and minor development, such as extensions and changes of use, can be managed through site specific risk assessments in accordance with the specification guidance in this SFRA.

Infill development should be restricted to Flood Zone C and new largescale development within Flood Zone A or B does not pass the justification test. This would include one-off housing in existing plots, or large scale new development.

Figure 5-4: Loughlinstown River



5.3.5 Deansgrange Stream

The majority of the Flood Zones associated with the Deansgrange River (Figure 5-3) cover land zoned for water compatible open space uses (9). Areas at risk include residential areas of Little Meadow and Cabinteely Court, the rear of properties along Pottery Road near its junction with Johnstown Road, the rear of houses in Coolevin estate, the Glenavon Park residential estate, Clonkeen Park, particularly to rear of Kill of Grange School and Kilbogget Park.

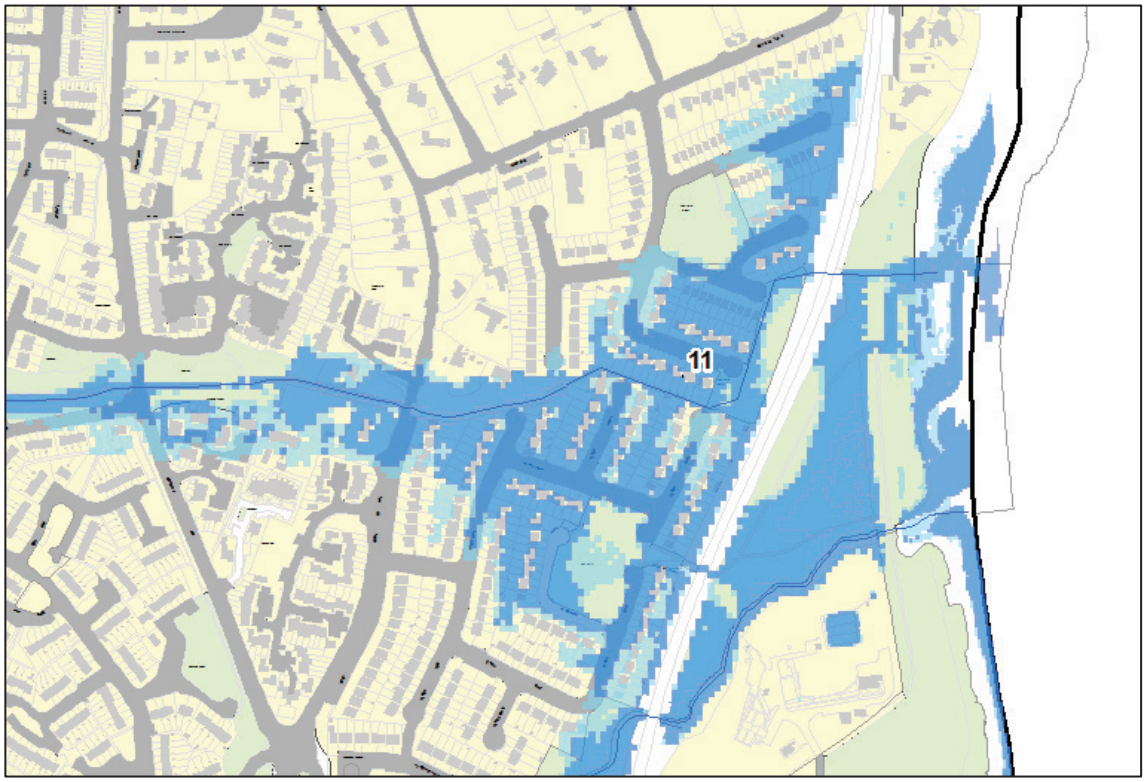
It is noted that no flooding is shown in Deansgrange Village despite recent significant flooding events. These events have been attributed to pluvial flooding and not fluvial and are therefore not included in the Flood Zones, but has been identified as a surface water hotspot.

A feasibility study has been carried out and reviewed the potential for increasing flood storage on Kilbogget Park with a view to limiting downstream flows and manage flooding to residential development between the park and the areas downstream (10). However, the study has not progressed to detailed design. Until such time as this study has been completed and the scheme put in place, extensive development within this area would be considered premature. Minor extensions (such as garages and conservatories) are unlikely to increase flood risk and may be considered, but uses which introduce additional people into the floodplain (such as an extension to a nursing home or change of use from less to highly vulnerable) should be avoided.

At the downstream end of the Deansgrange Steam there is a high level of flood risk arising from a combination of low capacity watercourses and culverts below the DART line (Figure 5-5). The result is extensive flood risk to the Seafield, Bayview and neighbouring residential areas (11). This risk could be exacerbated during periods of high tide which could further restrict outflows into the sea. This area is within the Eastern CFRAM and should be subject to detailed flood management options assessment through the FRMP.

Whilst Parts 1 and 2 of the Justification Test have been passed, the draft CFRAM outputs indicate possible flood depths of up to 1m. Development in Flood Zones A and B, whether infill or extensions that increase the footprint of a building, should be considered premature without consideration of the CFRAM findings and its recommendations for flood management measures (Class 1 domestic extensions which do not increase the footprint of a building, including garage and attic conversions and/or building over an existing ground floor will be considered). If the CFRAM proposes a flood relief scheme, this should be implemented prior to larger development taking place and care should be taken to ensure minor developments will not have a negative impact on the CFRAM's recommended scheme and will not bring additional people into the floodplain (such as an extension to a nursing home or change of use from less to highly vulnerable).

Figure 5-5: Seafield and Bayview



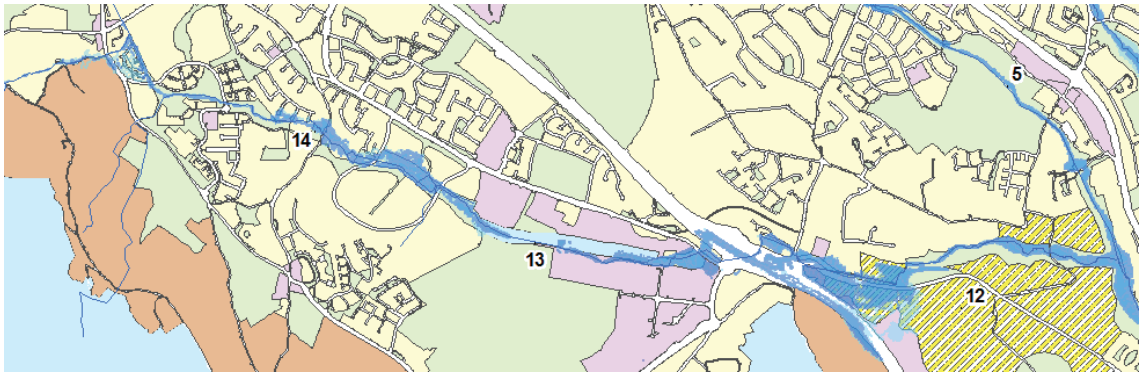
5.3.6 Carrickmines River

(Note: The 'Carrickmines/Shanganagh' river catchment comprises several tributaries including the Carrickmines River, Loughlinstown River, Shanganagh River, Glenamuck Stream, Brides Glen River, Foxrock Stream and Cabinteely Stream. The boundaries of these sub-catchments are not definitive and may indeed overlap and thus are to be considered indicative only.)

The Carrickmines River is shown in Figure 5-6. As part of the Cherrywood SDZ (12) process a stage 3 FRA was carried out, and included assessment of risks at the M50 and Carrickmines Luas Station (Priosland)[6]. As a result, the SDZ has not been re-reviewed under this SFRA.

Much of the river margins upstream of the Cherrywood SDZ, and therefore Flood Zone A and B, are within land zoned for open spaces uses, and this should be retained as water compatible uses (13). New development within Flood Zone A and B cannot be justified.

Figure 5-6: Carrickmines River



[6] "Flood Risk Assessment and management Study at Priorsland, Carrickmines".

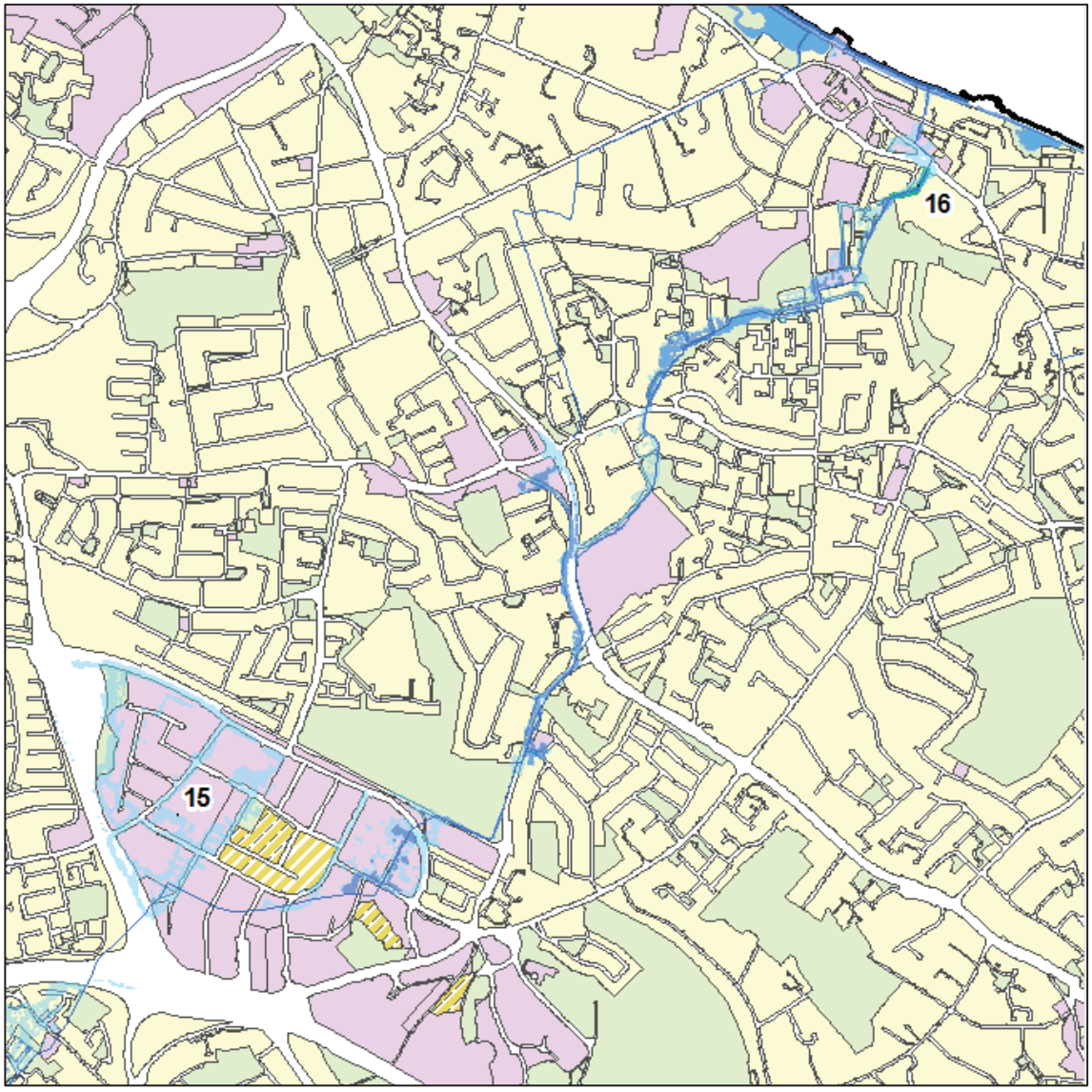
Towards the upstream end of the Carrickmines River is an area of existing, low density residential housing (14). Flood risk in this area is indicated to be high, with many properties in Flood Zone A. Future development in this area should be limited to extensions to existing dwellings and should not include infill or larger scale new development. Minor extensions (such as garages and conservatories) are unlikely to increase flood risk and may be considered but uses which introduce additional people into the floodplain (such as an extension to a nursing home or change of use from less to highly vulnerable) should be avoided. The CFRAM extends along the Carrickmines River and may include flood management measures which, when implemented, will allow development to occur.

5.3.7 Carysfort Maretimo

The CFRAM shows flood risk along the majority of the Carysfort Maretimo River, being a combination of Flood Zone A and B and covering a range of land existing land uses, including open space, residential and office and enterprise (Figure 5-7).

In particular, flooding is indicated at Blackrock Bypass, Brookfield, Carysfort Avenue, Avondale Lawn, Carysfort Hall, Avoca Park, Grove Paddock, Stillorgan Grove, Stillorgan Road and Brewery Road, Blackthorn Avenue and Blackthorn Road, Corrig Road, Blackthorn Drive, Lakelands, Moreen Estate, along M50 at Sandyford Interchange, Sandyford Park, Coolkill, Sandyford Downs and Sandyford Village (15).

Figure 5-7: Carysfort Maretimo Rivers



Where there is existing residential housing, and supporting infrastructure, Part 1 and 2 of the Justification Test have been applied and passed and flood risk can be managed through non-structural responses. Future development within Flood Zone A and B should be limited to extensions, changes of use and small scale infill and flood risks can be managed through a site specific FRA, which should include consideration of culvert blockage (where appropriate) and the impact this could have on flood risk at lower return periods.

The majority of flood risk highlighted in the Sandyford Business District and surrounding area is shown to be Flood Zone B, with small pockets indicated to be Flood Zone A. Where less vulnerable development is proposed within or near Flood Zone A or B a site specific flood risk assessment should be undertaken with the aim of a) refining the delineation of flood risk based on local topography and surface water systems; b) demonstrating that the proposed development will not increase flood risk to neighbouring lands; and c) developing flood management measures appropriate to the development proposed.

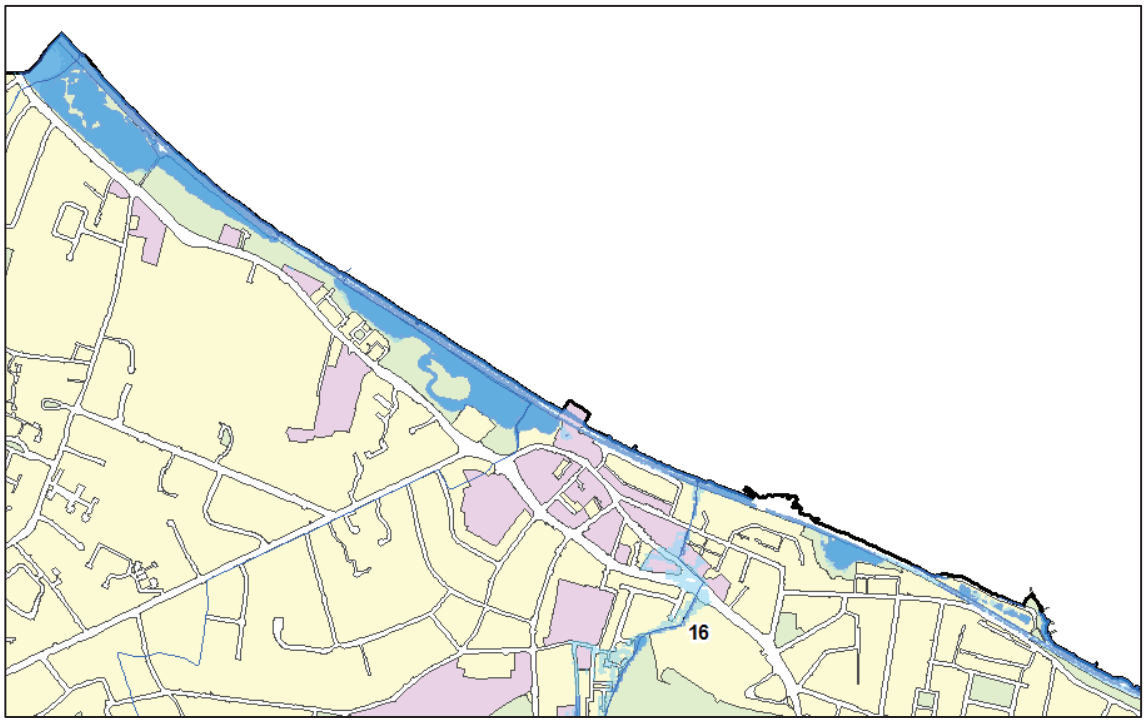
There is a length of defence along this watercourse which runs parallel to Rockfield Park (16). These defences are of robust construction, although consideration of the impacts of overtopping, either through higher return period events or with the impact of climate change on river flows, should be taken into account in any site specific flood risk assessment. Breach assessment is unlikely to be required.

5.3.8 Coastal flooding

Coastal inundation between West Pier and the County boundary to the north results in some existing shoreline development being with Flood Zone A (Figure 5-8). Area shown at flood risk includes backlands and the train line. There are also some harbour buildings that are within Flood Zone A. Climate change projected to result in sea levels to increase, with latest OPW recommendations indicating rises of between 0.5 and 1m should be planned for.

Development opportunities along the seafront are limited, but any flood risk assessment for infill or small new development should take into account the potential impact of climate change on sea levels. Depending on the nature and design life of the development, this may include additional allowances in finished floor levels, emergency planning and business continuity and recovery. The CFRAM study may propose flood management measures for this length of shoreline.

Figure 5-8: Merrion Strand to Blackrock

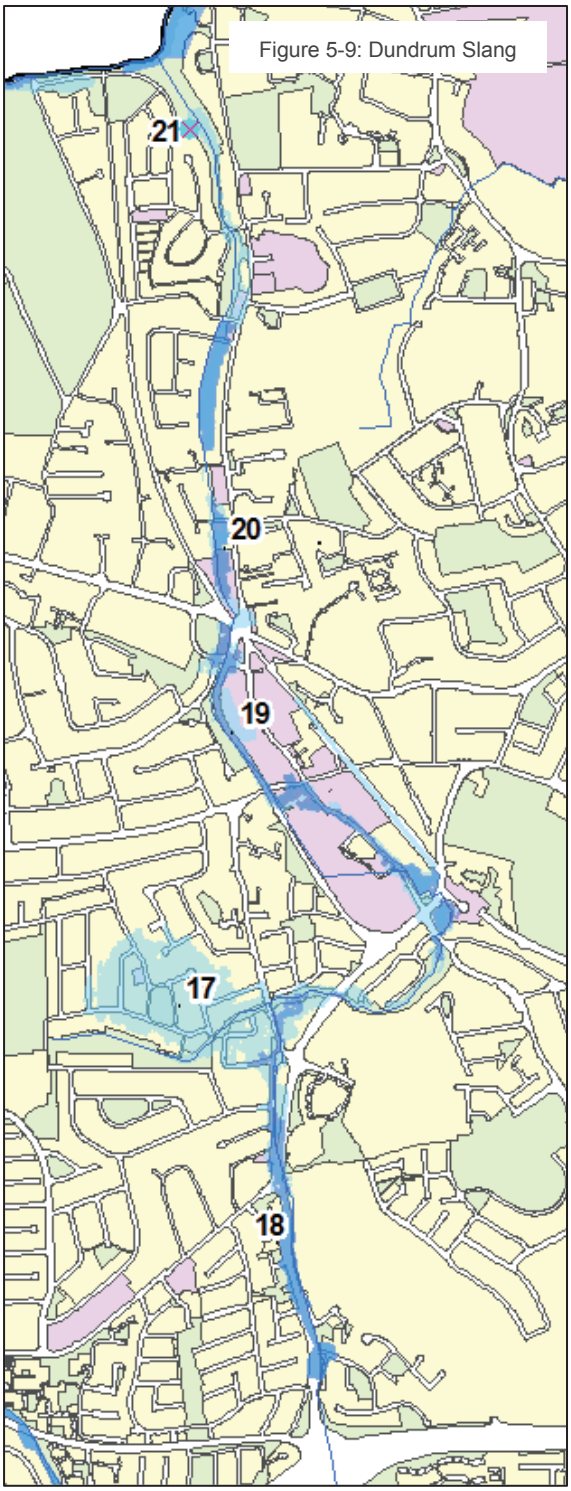


5.3.9 The Dundrum Slang

This area was included in the Dodder CFRAM, which identified a number of flood management measures, and some follow on works have taken place. The watercourse can be seen in Figure 5-9.

Upstream of Dundrum Town Centre the Slang and its tributaries pass through areas of residential housing, including Hillview Estate, Ashlawn and Willow Gate (17). These areas are shown to be within Flood Zone B, and rainfall modelling indicates these housing estates also act as a collection pond for surface water. The extents of Flood Zone B indicate that the area may be particularly vulnerable to channel blockage, and sensitive to reductions in channel capacity. In addition, climate change impacts are likely to be significant here. Part 1 and 2 of the Justification Test have been passed and will allow continued residential zoning in this area. Extensions to existing development within Flood Zone B are unlikely to present a significant flood risk, provided overland flow routes are maintained between and around buildings. Flood risks to development on vacant plots, or reconstruction of buildings and infill development within Flood Zone B can be managed, with the Flood Risk Assessment considering appropriate finished floor levels. Where minor development is proposed within Flood Zone A extreme caution should be exercised both to ensure no increase in risk to the development and its occupants and to protect flow paths and storage areas that may impact surrounding development.

Figure 5-9: Dundrum Slang



Should there be proposals to develop / redevelop larger areas of the housing estates a more detailed assessment of the risks will be needed. The Dodder CFRAM demonstrated that site-scale management measures would not be sufficient so future development in this area will be considered premature until such a time as further assessment is undertaken and follow on works, if found to be sustainable, are implemented. Further details are provided in Annex A.

Further to the north, flooding is indicated in the rear gardens of properties along Dundrum Road and to a neighbourhood centre between Highfield Park and St Columbanus Road. Development in this area should be limited to Flood Zone C.

Flooding is shown at Dundrum Shopping Centre Phase Two lands (site of old shopping centre) in Dundrum Village. Flood risk arising from culvert blockage and channel constrictions has been identified at Dundrum Shopping Centre and at the library.

The Dundrum Shopping Centre and adjoining library and gym sites (zoned MTC) have been subject to Detailed FRA under this SFRA, and the findings are detailed in an Annex A of this report, along with detailed responses to the Justification Test. Modelling carried out as part of this SFRA shows the flow path crosses the shopping centre site and ponds near the river prior to discharging back into the Slang.

The modelling also showed that the modelled water levels are very sensitive to model parameters and any ingress to Flood Zone B could increase flood risk to neighbouring properties. It is therefore important that the flow path and the capacity for storage on site is respected in any development proposal.

The detailed modelling assessment also highlighted the vulnerability of the library site (also zoned MTC) to flood risk and its importance in providing a flow path back into the river.

It is clear from the consideration of the suite of risks that the potential impact of development within the MTC lands poses significant impact to others. Structural flood management methods would involve catchment scale measures including storage and attenuation to reduce flow volumes.

There is currently no formal specification of the nature and design of catchment management measures and the MTC lands remain at potential risk of flooding. In this case a policy of avoidance of highly or less vulnerable land uses within Flood Zone A & B has been adopted. Further, where water compatible uses are proposed, such as surface level car parking, all existing conveyance routes and floodplain storage volumes must be retained. This policy will also safeguard areas for mitigation.

Downstream of Dundrum town centre there are areas of MTC and residential zoned land to the north of Churchtown Road Upper, and around the junction of Churchtown Road Upper, Taney Road, Dundrum Road, Main Street which are within Flood Zone A and B. These lands are currently developed. It is recommended that until such time as the flood risk issues for the Dundrum town centre are resolved, development in this area is limited to changes of use and redevelopment within the original development footprint. As overland flow is known to be a problem, even small extensions could have a negative impact on flood risk elsewhere.

Further downstream (north of St. Columbanus Road) Flood Zone A and B are generally within areas of open space, which should be retained.

5.3.10 River Dodder

The Dodder forms a County boundary between Dún Laoghaire-Rathdown and the jurisdictions of Dublin City and South Dublin (Figure 5-10). Development which occurs in Dublin City or South Dublin County Council could have implications on flooding in Dún Laoghaire-Rathdown.

Flood risk arising from the River Dodder has long since been identified as a problem in Dún Laoghaire-Rathdown and Dublin City. Specific locations shown to be at flood risk include Orwell Park and Orwell Gardens, Milltown Golf Course, some of Patrick Doyle Road and apartments at Milltown Grove and Dodderbank.

The Dodder Catchment Flood Risk Management Plan identifies a number of flood risk management measures including flood embankments and walls starting at the Dundrum Slang confluence and finishing at the Clonskeagh Road. The Plan also includes for the maintenance of existing defences and design and construction of new defences at Orwell Gardens (22) and along the Little Dargle (23).

The Dodder CFRAM Plan does not provide solutions to all the flooding problems that exist in the catchment as this would simply not be economically viable. It does however, identify viable structural and non-structural options for managing flood risk.

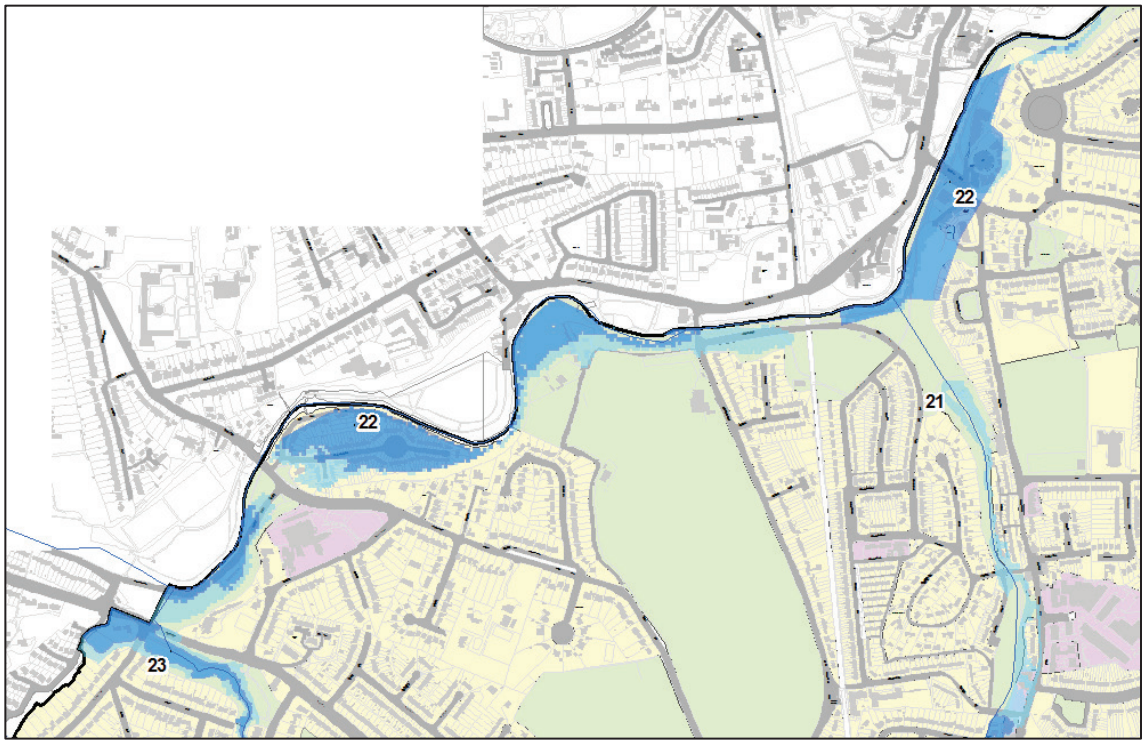
Flood defence works largely completed include raising flood defence walls along the tidal stretches of the Dodder to Ballsbridge. Works have commenced in the fluvial section upstream of Ballsbridge and are programmed to be completed by the end of 2015. Further works are under construction in Herbert Park. It is programmed to have all works completed to the Smurfit weirs by the end of 2016 bring the existing standard of protection up to the estimated 100 year fluvial flood level. The defences are generally providing protection (or will defend) existing residential areas. There are also parks and other areas of open space along the river which should be retained.

Opportunities for development in areas that are defended will generally be limited to infill and other minor works. Given the standard of protection provided by the defences, a relatively simple flood risk assessment should be completed, which should acknowledge risks associated

with overtopping and climate change, but will not need to consider breach analysis. Infill development should be in-keeping with the surrounding residences, although opportunities to further reduce flood risk, particularly associated with surface water should be sought. This will primarily be in the form of finished floor levels and consideration of flood resilience and emergency access. New development, or regeneration of brownfield sites can be carried out behind defences and opportunities to further reduce flood risks should be sought and incorporated into the development.

Outside these defended areas, new development would be considered premature until the flood relief scheme has been completed.

Figure 5-10: River Dodder



5.3.11 Little Dargle

The Little Dargle is a tributary of the Dodder, and included in the Dodder CFRAM. As detailed above, flood defence works for some length of the Little Dargle is proposed. Flood risk is shown to rear of Crannagh Hall, Landscape Road, and in open space area to the north of Riverside Drive. Risk is also indicated to Dodder Park open space area. There is an ESB substation in this open space. As most risks arising from the Little Dargle are generally moderate and occurs in open space, the Justification Test is not required.

There is an area of Flood Zone B near the upstream end of the Little Dargle (Figure 5-11) shown to extend across Llewellyn Park and Llewellyn Court (24). This appears to arise as a result of a localised overflow point from the Little Dargle. It could be indicative of an area which is also vulnerable to surface water ponding. Development should be limited to Class 1 minor

Figure 5-11: Little Dargle

developments (see section 4.6 for more details), in which case consideration of finished floor levels and maintenance of overland flow paths is important.

6 SFRA review and monitoring

An update to the SFRA will be triggered by the six year review cycle that applies to Local Authority development plans. In addition, there are a number of other potential triggers for an SFRA review and these are listed in the table below.

There are a number of key outputs from possible future studies and datasets, which should be incorporated into any update of the SFRA as availability allows. Not all future sources of information should trigger an immediate full update of the SFRA; however, new information should be collected and kept alongside the SFRA until it is updated.

Much of Dún Laoghaire-Rathdown is currently subject to a detailed flood risk mapping and management study under the Eastern CFRAM. It will be necessary to review the results and recommendations of the CFRAM with respect to Dún Laoghaire-Rathdown when the results become available. This will include taking into account the findings of the flood risk management plan, and recommendations for flood protection works. As recommended works are completed areas of the County can be released for more extensive development.

Table 6-1: SFRA Review Triggers

Trigger	Source	Possible Timescale
Catchment Flood Risk Assessment and Management (CFRAM) Flood Hazard Mapping	OPW under the Floods Directive	2015
Eastern River Basin Flood Risk Assessment and Management (EFRAM) Plan	OPW	2016, and 6 yearly reviews
Flood maps of other sources, such as drainage networks	Various	Unknown
Significant flood events	Various	Unknown
Changes to Planning and / or Flood Management Policy	DoEHLG / OPW	Unknown
Construction / completion of flood relief schemes	OPW / DLRCC	Unknown

7 Glossary

Annual Exceedence Probability (AEP) - Likelihood or probability of flooding or a particular flood event is classified by its annual exceedance probability (AEP) or return period (in years). A 1% AEP flood indicates the flood event that will occur or be exceeded on average once every 100 years and has a 1 in 100 chance of occurring in any given year.

Catchment - The area that is drained by a river or artificial drainage system.

Catchment Flood Risk Assessment and Management Studies (CFRAMS) - A catchment-based study involving an assessment of the risk of flooding in a catchment and the development of a strategy for managing that risk in order to reduce adverse effects on people, property and the environment. CFRAMS precede the preparation of Flood Risk Management Plans.

Flood Risk - An expression of the combination of the flood probability or likelihood and the magnitude of the potential consequences of the flood event. Flood Risk Assessment (FRA) can be undertaken at any scale from the National down to the individual site and comprises three stages: flood risk identification, initial flood risk assessment and detailed flood risk assessment.

Flood Risk Assessment - An examination of the risks from all sources of flooding of the risks to and potentially arising from development on a specific site, including an examination of the effectiveness and impacts of any control or mitigation measures to be incorporated in that development.

Flood Zones - A geographic area for which the probability of flooding from rivers, estuaries or the sea is within a particular range as defined within these Guidelines.

Fluvial Flooding - Flooding from a river or other watercourse.

Freeboard - Freeboard is a factor of safety expressed in a height (usually mm) above a flood level for purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood, such as wave action, bridge openings, and hydrological uncertainty.

Initial Flood Risk Assessment - A qualitative or semi-quantitative study to confirm sources of flooding that may affect a Plan area or proposed development site, to appraise the adequacy of existing information, to provide a qualitative appraisal of the risk of flooding to development, including the scope of possible mitigation measures, and the potential impact of development on flooding elsewhere, and to determine the need for further detailed assessment.

'Justification Test' - An assessment of whether a development proposal within an area at risk of flooding meets specific criteria for proper planning and sustainable development and demonstrates that it will not be subject to unacceptable risk nor increase flood risk elsewhere. The 'Justification Test' should be applied only where development is within flood risk areas that would be defined as inappropriate under the screening test of the sequential risk based approach adopted by this guidance.

Mitigation Measures - Elements of a development design which may be used to manage flood risk to a development, either by reducing the incidence of flooding both to the development and as a result of it and/or by making the development more resistant and/or resilient to the effects of flooding.

Precautionary Approach - The approach to be used in the assessment of flood risk which requires that lack of full scientific certainty, shall not be used to assume flood hazard or risk does not exist, or as a reason for postponing cost-effective measures to avoid or manage flood risk. River Basin Management Plan (RBMP) are required by the EU Water Framework Directive (2000/60/EC). These plans will establish a strategic plan for the long-term management of the River Basin District, set out objectives for water bodies and in broad terms, identify what measures are planned to meet these objectives, and act as the main reporting mechanism to the European Commission.

Pluvial Flooding - Usually associated with convective summer thunderstorms or high intensity rainfall cells within longer duration events, pluvial flooding is a result of rainfall-generated

overland flows which arise before run-off enters any watercourse or sewer. The intensity of rainfall can be such that the run-off totally overwhelms surface water and underground drainage systems.

Return Period - The return period is means of expressing the likelihood or probability of flooding or a particular flood event occurring and is comparable to the AEP of the event. A 1% AEP flood indicates the flood event that will occur or be exceeded on average once every 100 years and has a 1 in 100 chance of occurring in any given year.

'Sequential Approach'' - The 'Sequential Approach'' is a risk-based method to guide development away from areas that have been identified through a flood risk assessment as being at risk from flooding.

Strategic Flood Risk Assessment (SFRA) - The assessment of flood risk on a wide geographical area against which to assess development proposed in an area (Region, County, Town).

Sustainable Drainage Systems (SuDS) - A form of drainage that aims to control run-off as close to its source as possible using a sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques.

Annexes

A Dundrum Shopping Centre

A.1 Justification Test Part 1 and 2

	Criteria	Response
1	The urban settlement is targeted for growth under the National Spatial Strategy, Regional Planning Guidelines, and statutory plans or under the Planning Guidelines or Planning Directives provisions of the Planning and Development Act 2000, as amended.	The National Spatial Strategy 2002-2022 is a twenty-year plan for the Country. Consolidating the Greater Dublin Area, which is identified in the Strategy as a 'Gateway', is a primary policy of the Strategy. Enhancing the competiveness of the Greater Dublin Area (GDA) through physically consolidating growth of the Metropolitan Area is also identified as being of importance. The Metropolitan area is identified as Dublin City and suburbs, which would include Dundrum. The Regional Planning Guidelines for the Greater Dublin Area 2010 – 2022 identify Dundrum as a Metropolitan Consolidation Town within the settlement hierarchy outlined. Such Towns are defined as strong active urban places within the Metropolitan area with strong transport links. The RPGs state that; "As key destination (and interchange) points on public transport corridors and important locations for services, retail and economic activity, these towns are important foci within the metropolitan area. They present opportunities for intensive development and activity….." (p93) The RPGs recommendation for the DLR Development Plan and Core Strategy is "As mostly a Metropolitan County, housing delivery should focus on strengthening the urban form of the County through building up town and district centres at public transport nodes…" The focus in the RPGs is very much on consolidation within the existing footprint of Dublin City and suburbs. Dundrum falls into this area and is further enhanced as a growth area by the fact that it has excellent pubic transport links with the city centre via the Luas line B. The Retail Planning Strategy for the Greater Dublin Area 2008 – 2016 identifies Dundrum as a Major Town Centre Level 2 – one of only two in Dún Laoghaire-Rathdown. There is only one level one destination, Dublin city. In accordance with the principles of sustainable urban development future town centre growth is very much based on mixed-use development with retail and residential in close proximity allowing a vibrant living and active townscape develop.
2. The zoning or designation of the lands for the particular use or development type is required to achieve the proper planning and sustainable development of the urban settlement and, in particular:		
2 (i)	Is essential to facilitate regeneration and/or expansion of the centre of the urban settlement:	It is considered that the lands at Dundrum that are the subject of the Flood Zone A & B status are an essential element of the planned expansion of the Dundrum Major Town Centre area.
2(ii)	Comprises significant previously developed and/or under-utilised lands:	The subject lands consist of significant under-utilised zoned land suitable for a higher density mixed-use type development, proximate to the LUAS line and a LUAS stop.
2(iii)	Is within or adjoining the core of an established or	The lands at Dundrum are zoned Major Town Centre and are located in a Metropolitan Consolidation Town as

	Criteria	Response
	designated urban settlement:	identified in the RPGs.
2(iv)	Will be essential in achieving compact and sustainable urban growth; and,	The future development of these lands will allow Dundrum further develop as a vibrant active Major Town Centre for the County.
2(v)	There are no suitable alternative lands for the particular use or development type, in areas at lower risk of flooding within or adjoining the core of the urban settlement. (Criteria can be set aside where section 4.27b of Circular PL2.2014 applies. This section would appear to relate to regeneration areas although the circular does not clearly identify Section 4.27b)	There are no suitable alternative lands identified in the Major Town Centre zoning.
3	A flood risk assessment to an appropriate level of detail has been carried out as part of the Strategic Environmental Assessment as part of the development plan preparation process, which demonstrates that flood risk to the development can be adequately managed and the use or development of the lands will not cause unacceptable adverse impacts elsewhere.	See attached flood risk assessment.

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Dundrum MTC Stage 3 Flood Risk Assessment

Report

March 2016

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Revision History

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V1.0 23 March 2015	First Issue	DLR
V2.0 17 July 2015	Alterations to Sections 5 & 6 following development of SFRA	DLR

Contract

This report describes work commissioned by Dún Laoghaire Rathdown County Council (DLR) under Purchase Order 400292394 dated 27/11/2014. Jonathan Cooper, Ross Bryant, Mark Bentley, Joanne Cullinane and David Forde of JBA Consulting carried out this work.

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Purpose

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Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
AEP	Annual Exceedance Probability
CCTV	Closed Circuit Television
CFRAM	Catchment Flood Risk Assessment and Management
CFRAMS	Catchment-Based Flood Risk Assessment and Management Study
DECLG	Department of Environment, Community and Local Government
DoEHLG	Department of the Environment, Heritage and Local Government
EPA	Environmental Protection Agency
FRA	Flood Risk Assessment
FSR	Flood Studies Report
FSU	Flood Studies Update
GDSDS	Greater Dublin Strategic Drainage Strategy
HR	Hydraulic Research, Wallingford
HSE	Health & Safety Executive
ID	Identifier
IH	Institute of Hydrology
ISIS	Hydrology and hydraulic modelling software
NAM	Rainfall Runoff Direct Simulation Model
OPW	Office of Public Works
PFRA	Preliminary Flood Risk Assessment
SFRA	Strategic Flood Risk Assessment
TUFLOW	Two-dimensional Unsteady FLOW (a hydraulic model)

1 Introduction

1.1 Terms of Reference

Under *The Planning System and Flood Risk Management: Guidelines for Planning Authorities* DoEHLG & OPW, 2009 (the Planning Guidelines), proposed development must undergo a Flood Risk Assessment to ensure sustainable development and effective management of flood risk. The study is in relation to Chapter 4 of the Planning Guidelines, which specifically considers *Flooding and Spatial Impacts*.

JBA Consulting was appointed by Dún Laoghaire Rathdown County Council (DLR) to prepare a Stage 3 Flood Risk Assessment (FRA) in support of Appendix 13 of the Dún Laoghaire-Rathdown County Development Plan 2016-2022; Strategic Flood Risk Assessment (SFRA). More specifically the report will focus on the proposed Major Town Centre (MTC) draft land use zoning objective for;

- **Site 1;** the Phase Two lands at Dundrum Shopping Centre,
- **Site 2;** the Dundrum Library site and
- **Site 3;** the site opposite the Library (referred as the 'Gym' site).

The proposals form part of the draft Dun Laoghaire Rathdown County Development Plan 2016 – 2022.

The report is intended to be read as a companion document to Appendix 13 (SFRA) of the draft Dun Laoghaire Rathdown County Development Plan 2016 – 2022.

1.2 Background

This report specifically addresses the requirement for Part 3 of the Justification Test for Development Plans, as applied to the specific MTC zoned land. Details of Parts 1 and 2 of the Justification Test can be found in Section 5 of the SFRA (Appendix 13 of the draft Dun Laoghaire Rathdown County Development Plan 2016 – 2022). To assess Part 3 of the Justification Test a detailed (Stage 3) Detailed FRA is required to support the wider SFRA.

The draft Development Plan has identified three specific areas of proposed MTC zoning that are subject to existing built development but are highlighted as a potential area for regeneration.

The draft MTC land use zoning objective is a mixed use zone that combines residential and commercial uses. Under the Planning Guidelines, these uses are considered to be highly vulnerable and less vulnerable to the impacts of flooding respectively.

The proposed MTC zoning is also identified as an area potentially at risk of flooding (partly within Flood Zone A and B) according to the OPW Dodder CFRAM mapping. As a result the draft Development Plan has applied the Justification Test for Development Plans, outlined within Section 5 of the SFRA. Parts 1 and 2 of the Justification Test are demonstrated to have been met for the three areas.

1.2.1 DECLG Circular PL 2/2014

In August 2014 the Department of Environment, Community and Local Government issued Circular PL2/2014. The document concerns two areas for clarification;

I. Use of OPW Flood Mapping in assessing planning applications, and

II. Clarifications of advice contained in the 2009 DECLG Guidelines for planning authorities – “The Planning System and Flood Risk Management”.

Of particular pertinence to the MTC lands subject to the Justification Test is point II which clarifies the approach within urban centres subject to potential regeneration:

Regeneration areas

As indicated in section 3.7, development plans have identified various strategically located urban centres and particularly city and town centre areas whose continued consolidation, growth, and development or regeneration is being encouraged.

Where an existing residential area is proposed for residential regeneration, and is located in a flood zone A/B, the planning authority should in the first instance consider the relocation of the residential use and where in the opinion of the planning authority this is not feasible, the development plan (or any variation) must specify the matters above, i.e. the nature and design of structural or non-structural flood risk management measures required prior to future development in such areas to ensure that flood hazard and risk to the area and other locations will not be increased or, if practicable, will be reduced, with a particular emphasis on the overall design of the area following the core principles set out in section 2.1 of Appendix B on planning and design for flood risk.

Where more extensive regeneration is to take place, including site clearances, and where new mixed development is proposed i.e. a docklands site, again the planning authority must specify the nature and design of structural or non-structural flood risk management measures required prior to future development in such areas to ensure that flood hazard and risk to the area and other locations will not be increased or, if practicable, will be reduced, with a particular emphasis on the overall design of the area to integrate flood risk management as a central core of the design, ensuring that as far as possible vulnerable uses are not located in flood zone A/B areas.

1.3 Study Area

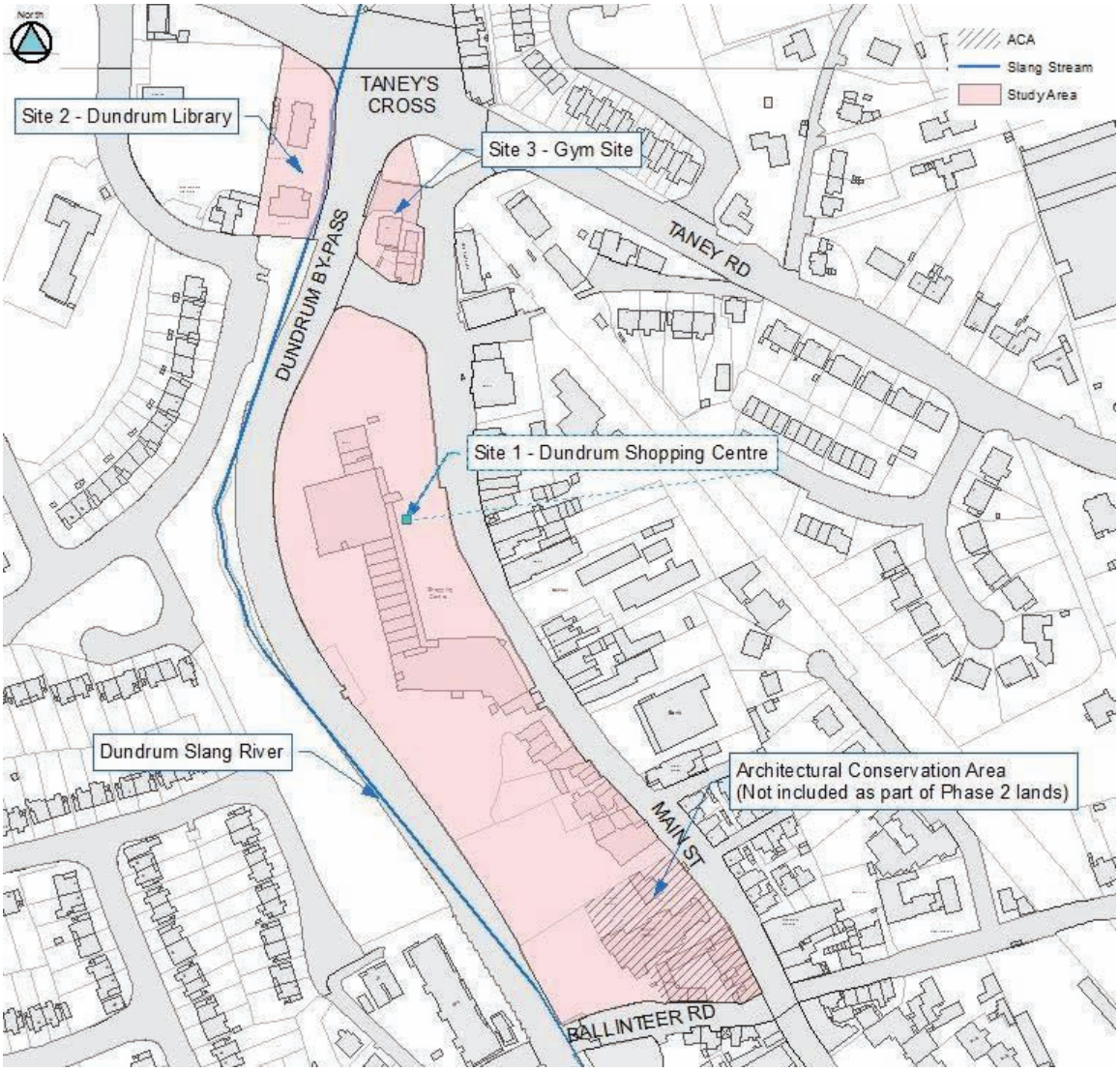
The focus of the study is on three MTC zoning objective sites listed below and presented in Figure 1-1;

- Site 1 - Dundrum Shopping Centre Phase 2 lands;
- Site 2 - Dundrum Library;
- Site 3 - Opposite Library (Gym).

It is noted that the MTC zoning for the Dundrum Shopping Centre Phase 2 lands includes the entire block of development, some of which includes the Post Office and Holy Cross Church. Whilst the study highlights the entire MTC zoning the findings and tests are in relation to just the Phase 2 lands identified for redevelopment.

The Slang River flows in a northerly direction and is noted as being intermittently in open channel and closed culvert sections to the west of the subject lands. The Slang has flooded the MTC lands previously and existing predictive flood studies confirm the potential risk of flooding from the watercourse. Figure 1-1 (over page) provides an overview of the area.

Figure 1-1 Study Area



1.4 Flood Risk Assessment: Aims and Objectives

This study is being completed as a Stage 3 Detailed Flood Risk Assessment (FRA) to support the SFRA and the Justification Test for the MTC zoned lands. It aims to identify, quantify and communicate the risk of flooding to land, property and people. The purpose is to provide sufficiently detailed information to determine whether the proposed draft land use zoning objective is appropriate through the application of both proper planning and flood risk management principles.

The objectives are to:

- Identify potential sources of flood risk;
- Identify and verify Flood Zones (flood probability mapping);
- Investigate flood risk to the site;
- Inform the draft zoning objective decision;
- Specify the nature and potential design of appropriate flood risk mitigation and management measures (structural and non-structural).

1.5 Report Structure

The initial FRA is presented in Section 2, it includes background information on the sites, catchment and appropriateness of previous studies. Section 3 introduces the detailed site specific FRA with results and analysis in Section 4. Discussion of the Justification Test and Flood Risk Management strategy is provided in Section 5. Section 6 contains a discussion on site specific measures and FRA. Section 7 contains the flood mapping.

1.6 Terminology

The first step in understanding the flood risk is to investigate the likely frequency and magnitude of a range of floods which are to be investigated at the sites.

The probability of a flood event (whether tidal or fluvial) is classified by its Annual Exceedance Probability (AEP) or return period (in years). A 0.5% AEP flood will occur on average once every 200 years and has a 1 in 200 chance of occurring in any given year.

In this report, flood frequency will primarily be expressed in terms of return period, which is the inverse of the AEP, as shown in Table 1-1 and explained above. This can be 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 1-1 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

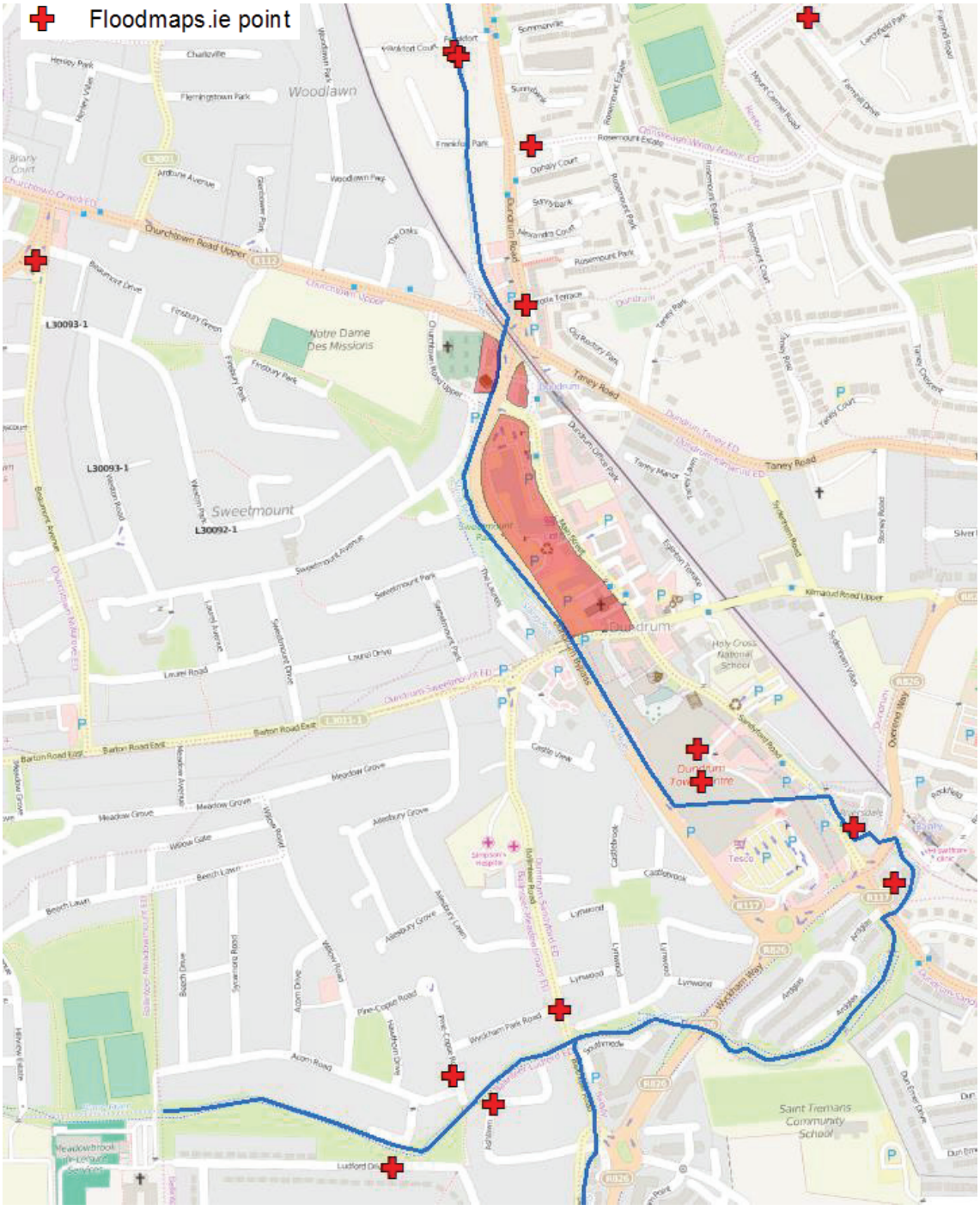
2 Initial FRA

The initial FRA for the subject lands is effectively presented within Section 4 of the SFRA document and summarises the flood risk areas impacting the MTC zoning. This section provides an expanded summary of both the historic and predictive flooding information. It is also reviews the appropriateness of the hydrology and production of the flood mapping.

2.1 Historic Information

Output from the floodmaps.ie website is included below in Figure 2-1 and confirms historic flooding from the Dundrum Slang River in the immediate vicinity of the study site. There are 16 records of flooding from the watercourse and two additional records that are not directly related to the Slang.

Figure 2-1 Historic Flooding Incidents



The records of flooding have been collated into a table of flood events that is provided below.

Table 2-1 Historic Flooding Summary

Date	Source	Areas impacted
24 Sept 1957	Fluvial	Dundrum River
11 June 1963	Fluvial/Surface Water	Dundrum
7 Nov 1982	Unknown	Pine Copse Road, Ballinteer
27 Aug 1986	Fluvial	Slang Frankfort (Hurricane Charlie)
11 June 1993	Unknown	Ashlawn Ballinteer Road
24 Oct 2011	Fluvial/Surface Water	Frankfort, Dundrum Shopping Centre, Taney's Cross, Willow Bank Apartments (Sandyford Road), Riverdale (Linden & Blackthorn Apartments).
Recurring	Unknown	Old Ballinteer Road - 'floods frequently, not impassable'
Recurring	Unknown	Pine Copse, Willow Road. Road & gardens flood.
Recurring	Fluvial	Slang Pyelands
Recurring	Unknown	Ludford Area Ballinteer
Recurring	Unknown	Old railway line, Dundrum (1950's?)
Recurring	Surface Water	Rosemount, Dundrum - now mitigated

The source of flooding is not always able to be ascertained from the available information, however it is most likely that the unknown sources will be related to fluvial and surface water flood sources. The most information is available for the 24 October 2011 flood event, which caused extensive damage to local residential property and Dundrum Shopping Centre itself. It is the most extreme of the recent events and is estimated to have resulted from rainfall return periods as high as 1% AEP which generated fluvial flows of approximately 2% AEP[1].

Flooding in Dundrum was caused by ponding of surface water and the exceedance of channel and culvert capacity which resulted on overland flows. Blockage of trash screens is also understood to have contributed to the event severity. From a review of available information it is clear that there was surcharging of a number of culverts/channels upstream of and including the Dundrum Shopping Centre culvert, the Sandyford Road culvert (which resulted in the flooding of the Riverdale - Linden & Blackthorne Apartments and flow escaped along Sandyford Road) and Overend Way (which resulted in the flooding of the Willow Bank Apartments). The Dundrum Shopping Centre itself was flooded when the Slang overtopped the culvert inlet and entered through Butlers Coffee shop, flooding the ground floor of the centre. The Pembroke District was also impacted as well as the Red Car Park where the lowest level (-3) was flooded to 'ankle depth'. The waters continued their overland flow route along Sandyford Road and ponded at Taney's Cross, near to the Library, where there is a local low spot, see Figure 2-2 below.

[1] OPW Eastern CFRAM Study, Overarching Report on The October 2011 Flood Event, IBE0600Rp0014

Figure 2-2 Photo from thejournal.ie October 2011 road flooding adjacent to Taney's Cross and the Library

2.2 The Dodder Catchment Flood Risk Assessment & Management Study

In 2006, the Office of Public Works (OPW), Dublin City Council, Dún Laoghaire-Rathdown County Council and South Dublin County Council commenced work on a Catchment-based Flood Risk Assessment and Management Study (CFRAM) for the Dodder Catchment.

The CFRAM adopts a catchment-based, pro-active approach for identifying and managing existing, and potential future, flood risk to the catchment which encompasses the River Dodder and its five main tributaries; the Dundrum Slang, the Little Dargle, the Owendoher, the Whitechurch and the Tallaght Stream. Draft deliverables were published in February 2012 and pertinent information for this study includes the flood hazard mapping as well as the flood risk management plan.

Deliverables for the CFRAM are more detailed than the OPW PFRA mapping and take precedence for the purposes of this FRA.

The Dundrum / Slang model stretches from Wesley College in Ballinteer to the confluence with the River Dodder in Milltown. The total length of the modelled river is 4.6km and includes 70 topographical survey cross-sections. There are 3 weir structures and 7 culvert / bridge structures along this length that affect the hydrodynamic characteristics of the river and have been included in the model.

The hydraulic model has been provided to JBA for the purposes of hydraulic analysis and verification of the flood mapping.

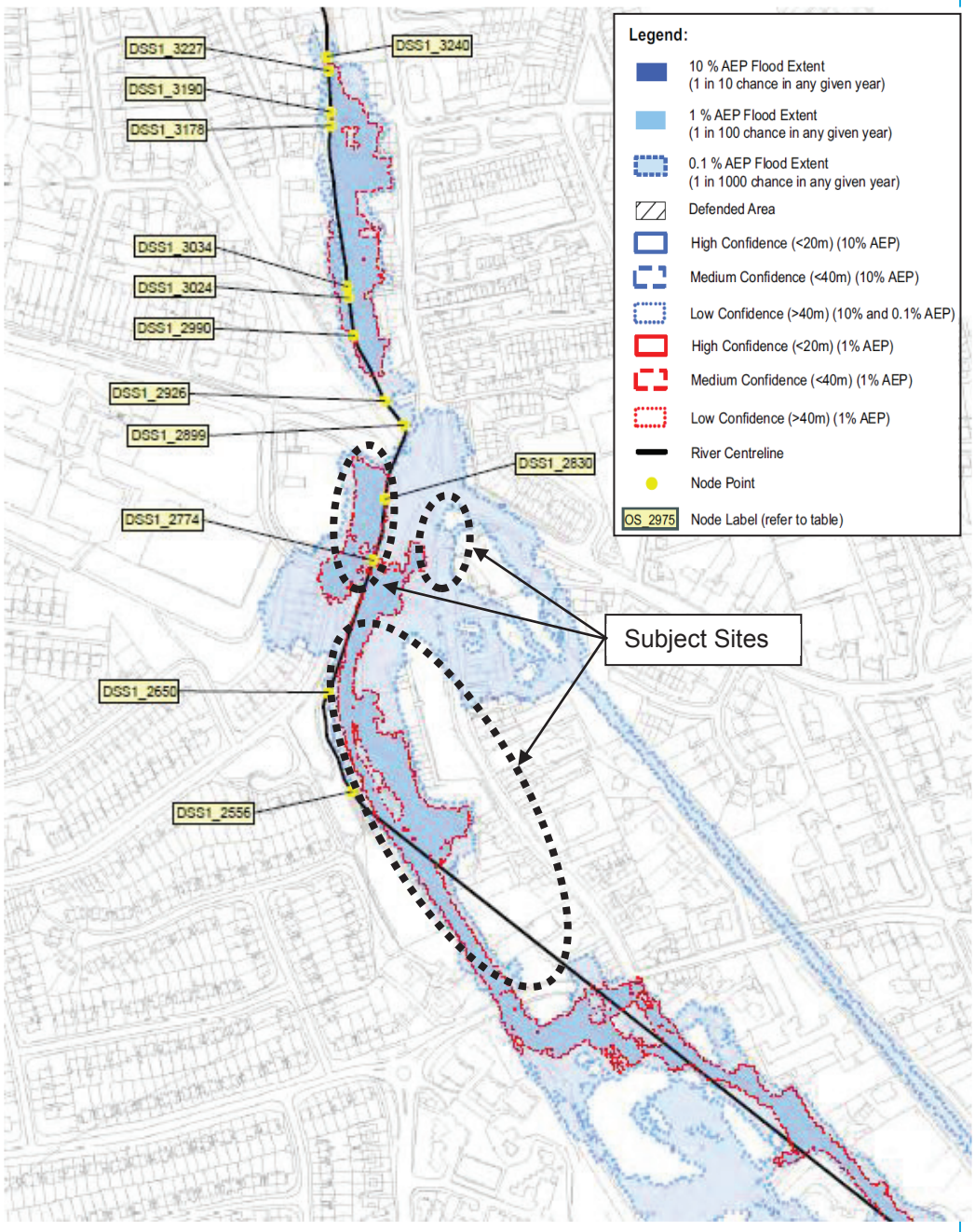
2.2.1 Predicted Flood Extent

One of the key deliverables of the CFRAM is flood extent, depth and hazard mapping, which is detailed in nature and can be used for the purposes of site based flood risk assessment in line with a review of the appropriateness.

Output from the 1 in 1000 year and 1 in 100 year flood events will be used for the purposes of this FRA to provide an initial assessment of the flood extent and level in relation to Flood Zones A and B as defined by the Planning Guidelines. Further information on the Guidelines and the definition of Flood Zones is presented within the main DLR SFRA document referred to in Section 1.1. The appropriateness of the hydrology and hydraulic analysis (for use in this site specific FRA) conducted within the Dodder CFRAM is discussed in Section 2.4.

Flood extent (Flood Zone) mapping is provided over the page (Figure 2-3).

Figure 2-3 Dodder CFRAMS Flood Extent Mapping



Source: Dodder CFRAMS Draft Mapping, OPW/Dublin City Council

2.2.2 Management Measures (Dodder CFRAM)

The resulting flood risk in Dundrum has prompted the following flood risk management measures to be carried forward for further consideration[2]. The report identifies that 20 properties are at risk of flooding throughout the entire model reach. It is important that this study recognises and considers the potential management measures included within the Dodder CFRAM when considering the nature of any potential management and mitigation measures, this is more fully discussed later in the report.

Table 2-2 Summary of Dodder CFRAM Management Measures

Measure Carried Forward	Comment
Improvement of channel conveyance	Watercourse is heavily culverted limited scope to improve conveyance without large capital spend. BCR <1
Hard defences	Hard defences over relatively short section will alleviate the majority of flooding. BCR>1
Proactive maintenance regime	Will reduce the likelihood of localised flood events. BCR>1
Reactive maintenance regime	Will reduce the likelihood of localised flood events. BCR>1
Public awareness campaign	Technically straightforward, requires only a few properties to benefit to have positive BCR. May cause concern to public to know property is at risk.
Rehabilitation of existing defences	Technically straightforward to repair defects in existing flood wall to ensure current level of flood protection is maintained
Individual property protection or flood proofing	Only 20 properties to protect and would provide full protection.

2.3 Summary

The initial stage of an FRA requires the identification and consideration of probable sources of flooding.

2.3.1 Fluvial

The Slang River is urbanised, steeply sloping and heavily culverted through Dundrum. The Dodder CFRAM mapping suggests that many of the culverts are under capacity and the 1% AEP and 0.1% AEP model results indicate that there are significant overland flow routes along Sandyford Road, Dundrum By-pass and the LUAS line. All of these overland flow routes lead towards the lowest levels in the area which are on the road adjacent to the entrance to the existing Library building at Taney's Cross.

The result of the flood mechanism described above is that that the subject sites are is located within the 1% AEP and the 0.1% AEP flood extents and as such is partly within Flood Zone A, B and C. Areas of the site are therefore at high and moderate probability of flooding from the Dundrum Slang Stream. Flooding to the site is typically characterised by overland flow resulting from surcharging of upstream channel and multiple upstream culverts. This mechanism is confirmed by the events witnessed in October 2011 when many of the overland flow routes predicted by the Dodder CFRAM mapping actually occurred, however it is noted that culvert blockage may have amplified the impacts of flooding beyond which would normally be associated with a 2% AEP flood event. The appropriateness of the CFRAM mapping for the subject site is reviewed in Section 2.4.

[2] River Dodder Catchment Flood risk Management Plan, Option Development Process Preliminary Screening of Measures, January 2009, OPW.

2.3.2 Pluvial

Pluvial flooding is the result of rainfall-generated overland flows which arise before run-off can enter any watercourse or sewer. It is usually associated with high intensity rainfall. Flood risk from pluvial sources exists in all areas and is closely linked to the operation of the surface water drainage system and local topography.

A review the OPW PFRA pluvial mapping did not suggest that there were any areas of high probability of pluvial flooding close to the sites, however it is clear from site observations that the low spot on the Dundrum Bypass in between the Library (Site 2) and the Gym (Site 3) is a topographic low spot that collects surface water that is unable to overtop the kerb and low wall that separates the Slang River from the Bypass.

The impacts of pluvial flooding are likely to be masked by those of fluvial flooding and overland flows from culvert exceedance. This is due to the catchment being sensitive to short duration rainfall events that simultaneously generate a rapid increase in peak flow and also surcharge the surface water and combined sewer network. Whilst pluvial flooding is an important consideration it can largely be tackled by site specific drainage measures and management measures that are aimed at mitigating the fluvial impacts.

For the above reason it is important that any new development does not increase the potential for runoff and as such; storm water drainage systems in line with the GDSDS will generally minimise the risk from pluvial flooding sources. These measures are appropriately catered for under the stormwater design requirements and auditing process specified by DLR under the planning application process.

2.4 Appropriateness of Flood Zone Information

This section will examine the hydrological and hydraulic processes undertaken in the Dodder CFRAM to derive the current Flood Zone information for the site.

2.4.1 Hydrology

A review of available hydrological analyses has been carried out on the following reports;

1. River Dodder Catchment Flood Risk Management - Hydrological Analysis Report (RPS, 2009)
2. River Dodder Catchment Flood Risk Management - Hydraulic Analysis Report (RPS, 2010)

The purpose of the review was to determine if the hydrology used to create the available flood maps for the site location was an appropriate estimation of the flow rates in the Slang River. A summary of the overarching process is presented below:

- A hydrological model was created for the catchment draining to the Frankfort gauging station. This hydrological model was produced using the rainfall-runoff module of the MIKE11 software package (NAM).
- This model was then calibrated against recorded discharge data from the gauging station.
- As Section 4.2.1 (page 34) in the Dodder CFRAMS Hydrological Analysis Report states: "(*When the NAM model alone was applied)….the Summer and some of the large Winter events were not predicting accurately. A response such as this is indicative of runoff from an urbanised catchment with a large amount of impervious surface area and cannot be reproduced using a NAM hydrological model. For this reason urban models were produced and joined with the NAM models to produce combined hydrological models. (The urban runoff models were constructed)…. for each of the gauge catchments to reflect the rainfall runoff characteristics of the contributing urban area under current catchment conditions."* The urban models were constructed using the 'Urban' component of the RR module in MIKE11.
- According to the Dodder hydrology report, individual flood events [at Frankfort] calibrated well with discharge records using the combined model and a calibration factor (R^2) of 0.767 was achieved, which indicates a good correlation.

The Dodder CFRAM presents a number of flow estimation and calibration exercises, many of which vary in the magnitude of the return period event. Table 2-3 below indicates the flow rate from the single site (EVA) analysis and simulated analysis for the Frankfort Gauge (downstream of the MTC sites), taken from Section 5.4.3 and 5.7.6.3 of the Dodder Hydrological Analysis Report, it also includes the FSR design flood estimation at Frankfort (Section 5.6.3 of the Dodder Hydrological Analysis Report).

Table 2-3 Flow rate (m^3/s) comparison of EVA and EVA of Simulated Discharge for Frankfort Gauge Catchment, FSR estimate at Frankfort taken from the Dodder Hydrology Report

Return Period	EVA Frankfort	EVA simulated	FSR
50% AEP (2yr)	3.88	3.88	3.99
20% AEP (5yr)	5.57	5.57	4.94
10% AEP (10yr)	6.82	6.82	5.30
2% AEP (50yr)	10.25	10.25	6.10
1% AEP (100yr)	12.07	12.07	6.55
0.1% AEP (1000yr)	20.20	20.26	6.88

Included below in Table 2-4 are reported peak modelled flows taken from the hydraulic model as presented in Appendix D of the Dodder Hydraulics Report.

Table 2-4 Peak Modelled Flow output at three Nodes local to the MTC sites - Appendix D, Dodder Hydraulics Report

Return Period	Node 1565.95	Node 1688.14	Node 2555.68
50% AEP (2yr)	5.39	5.77	5.80
20% AEP (5yr)	7.43	7.96	8.01
10% AEP (10yr)	9.45	10.15	10.22
2% AEP (50yr)	15.62	16.85	16.97
1% AEP (100yr)	18.77	20.28	20.43
0.1% AEP (1000yr)	26.55	72.52	70.56

Flows presented in the three model nodes (1565.95, 1688.14 and 2555.68) appear to vary significantly at the 0.1% AEP and are inconsistent with the estimates presented for Frankfort gauge within the Dodder hydrology report (above). The flow estimates of the 1% AEP are close to double that presented by the EVA estimate and more than double of that presented by the FSR. Comparing 1% to 0.1% AEP the increase in magnitude is more than a factor of three, which is extremely unusual compared to other gauging stations in Ireland.

The difference between Table 2-3 and Table 2-4 occurs because the calibrated RR model for Frankfort was not used as an input in the Slang CFRAMS model. Instead, the Slang (Dundrum) catchment was sub-divided into three distinct hydrological areas; each with a different RR model. The parameters in these models were based on the calibrated RR models for the three gauged catchments, with alterations to the catchment length and time of concentrations as required. Historic rainfall data from the rainfall gauging stations within the RR boundary was entered into each model and weighted according to their contribution relative to the catchment area. Therefore, there is a disconnect between the flow estimation at Frankfort and the model discharge files.

The use of the Frankfort gauging station, even with improvements to the rating curve may not be providing valid results;

- The EPA (who operate the Frankfort gauge) has a rating curve based on observed gaugings with a maximum flow of just $2m^3/s$.
- This flow rate is less than the median annual flood (Q_{med}) derived by the CFRAM methodology.
- Beyond the gauged flow of $2m^3/s$, the rating curve was extrapolated using a 1D hydrodynamic model of the local reach.

- The new, extrapolated rating curve was used to provide the flow rates for the model calibration.

In summary, flow estimates vary between those detailed at the Frankfort gauging station and those used in the hydraulic model simulations, as reported in the Hydraulics Report, Appendix D. Where the flows are stated they are inconsistent and are much higher than expected, the 0.1% flow in particular, with a factor of three increase from the 1% AEP flow is extremely unusual. As such our confidence in the design flows used to create the Dodder CFRAM flood maps is limited and further analysis of the hydrology is required prior to establishing revised flood mapping for the MTC sites.

2.4.2 Hydraulics

A review of the CFRAM hydraulic model was completed to provide additional opinion on the appropriateness of the derived flood outlines. The following observations were made:

- The open channel cross-sections were compared with the raw CFRAM survey data; no discrepancies were found.
- The culverts were similarly compared with the following comments;
- The model combines the Dundrum Shopping Centre Culvert, the downstream section of open rectangular channel, access bridges adjacent to the Dundrum Bypass and the culvert under the Dundrum Bypass in a single 865m culvert with an outlet at Sweetmount Park.
- The modelled inlet dimensions to the Dundrum Shopping Centre Culvert represent a smaller area than suggested by the design drawings for the culvert. As such, the conveyance capacity of the structure is likely to have been under estimated.
- The culvert under the Sandyford Road has been overestimated in size compared to survey comparison; therefore the conveyance capacity through the culvert is likely to be over represented in the model.
- Only four of the nine culverts in the CFRAM model have allowed water to spill over the top of the structures. A check of the model results from the hydraulic modelling report indicates that all of the culverts without an overtopping spill are surcharged in the higher return periods. This will force all flow through the culvert and create unachievably high water levels at the culvert inlets.
- Finally, Table 2-4 suggests that the flows in the model are excessively high and inconsistent, which will impact on the appropriateness of the modelled water levels for given return periods.

As a result of the above findings the model representation of the culverts and general river system are limited in detail. Our confidence in the representation of surcharging and water levels is therefore limited. It is the overland flow routes (created by culvert exceedance) that drive most of the flood impacts generated from upstream of Dundrum Shopping Centre right down to Taney's Cross. It is therefore essential that the flood mechanism is appropriately presented in any further analysis. Therefore, additional topographic channel and culvert survey is required to accurately represent the Dundrum Slang River.

2.4.3 Summary

A review of the hydrology and hydraulics confirms that the Dodder CFRAM model presents a conservative estimation of flood extent and depth. This is due to significantly higher than expected flow volumes leading to greater exceedance volumes at many of the culverts.

The representation of the system is also simplified by the combination of a number of key structures upstream of Sweetmount Park and Dundrum Shopping Centre. The result being that the confidence in the model representation is reduced.

Overall, the low confidence in the flow estimates and model geometry/representation requires that this study must conduct additional hydrological analysis and modelling in order to present an appropriately detailed analysis of flow and modelled water levels for the MTC sites.

3 Detailed FRA - Background

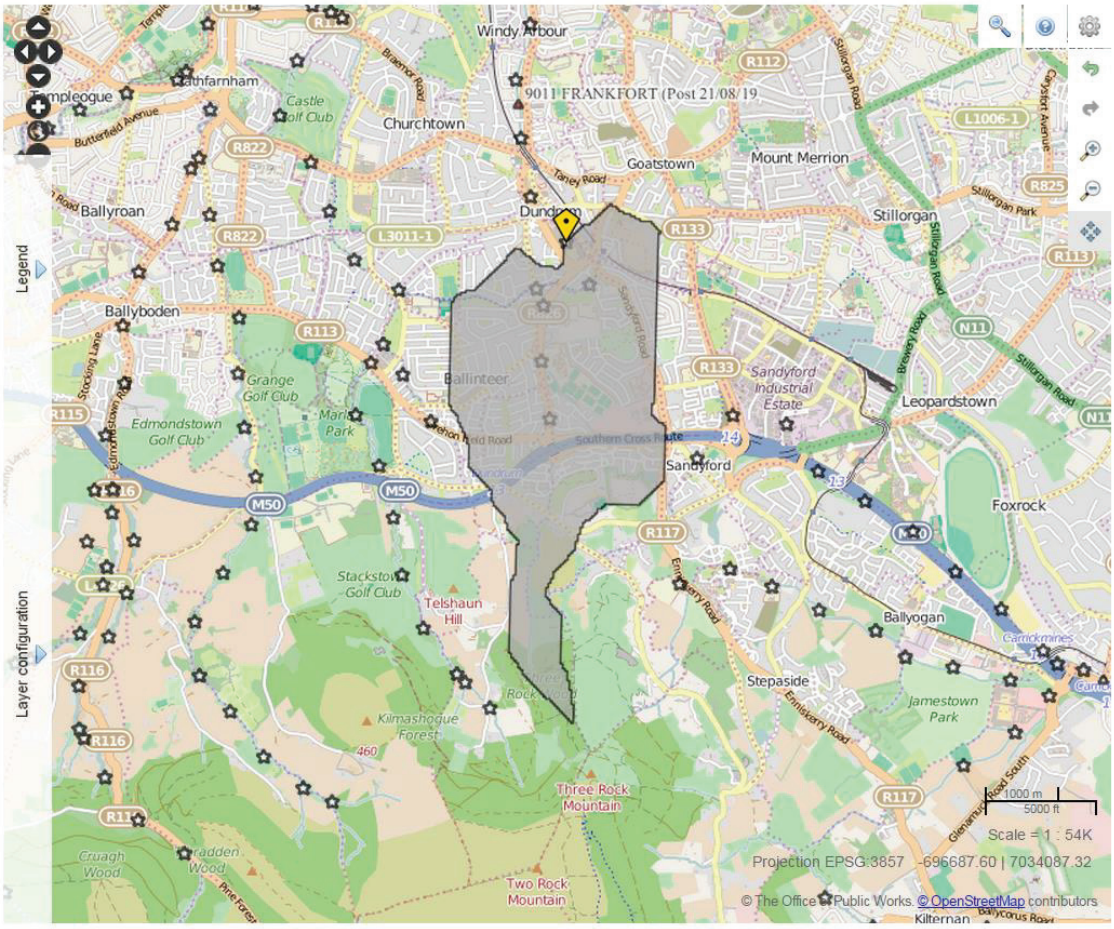
This section of the report will provide a full appraisal of flood risk to the site, outlining the hydrological and hydraulic operations undertaken to derive a revised suite of flood maps for the MTC sites.

3.1 Hydrology

3.1.1 Catchment overview

The Slang River is a major tributary of the Dodder River in south Co. Dublin. The Slang rises at Three Rock Mountain at an approximate elevation of 430mOD. The stream is approximately 8km in length and falls at an average gradient of 1 in 20. At Dundrum Town Centre, it drains a catchment area of approximately 4.41km^2. The catchment is highly urbanised and is particularly vulnerable to short, high-intensity rainfall-generated flood events. An overview of the study catchment is presented in Figure 3-1.

Figure 3-1 Overview of study catchment (OPW FSU Web Portal)



3.1.2 Calculation Methodology

A flow estimation was completed using the FSR Rainfall Runoff Method, taking into account FSSR 16. A full breakdown of the FSR flood estimation methodology is presented in Appendix A. The calculated flows for a range of return periods are displayed in Table 3-1 over the page.

Estimation methods using the gauged record at Frankfort, such as employed by the Dodder CFRAM have been rejected based on our appraisal of the rating curve, which is limited to flow recordings of 2m^3/s or less. Results from the FSR Rainfall Runoff model are still comparable

with the EVA and simulated EVA analysis presented in the Dodder CFRAM for the Frankfort gauge but peak flows are higher using the FSR Rainfall Runoff method.

Other estimation methods such as the FSR statistical and FSU approaches are unsuitable for a catchment less than 5km^2. These estimates are also significantly lower than the FSR Rainfall Runoff results. The IH 124 method, whilst suitable for small catchments, also returns a lower estimates of peak flow and has also been rejected.

Table 3-1 Flow Estimation Results, FSR Rainfall Runoff - Study Catchment

Return Period	Flow Rate (m^3/s)
50% AEP (2yr)	4.93
20% AEP (5yr)	6.48
10% AEP (10yr)	7.65
5% AEP (20yr)	8.90
1% AEP (100yr)	12.59
0.1% AEP (1000yr)	21.82

The flow estimates, whilst in line with some of the flow estimation work completed in the Dodder CFRAM, are still subject to uncertainty and further work on the Frankfort Gauging Station rating curve and monitoring would be required to improve confidence in the hydrology.

3.2 Hydraulics

A revised hydraulic model has been constructed using additional in-fill survey collected in March 2015. The in-fill survey has replaced and updated the previous (and incomplete) survey data collected under the Dodder CFRAM, which dates from 2007, as discussed in Section 2.2.

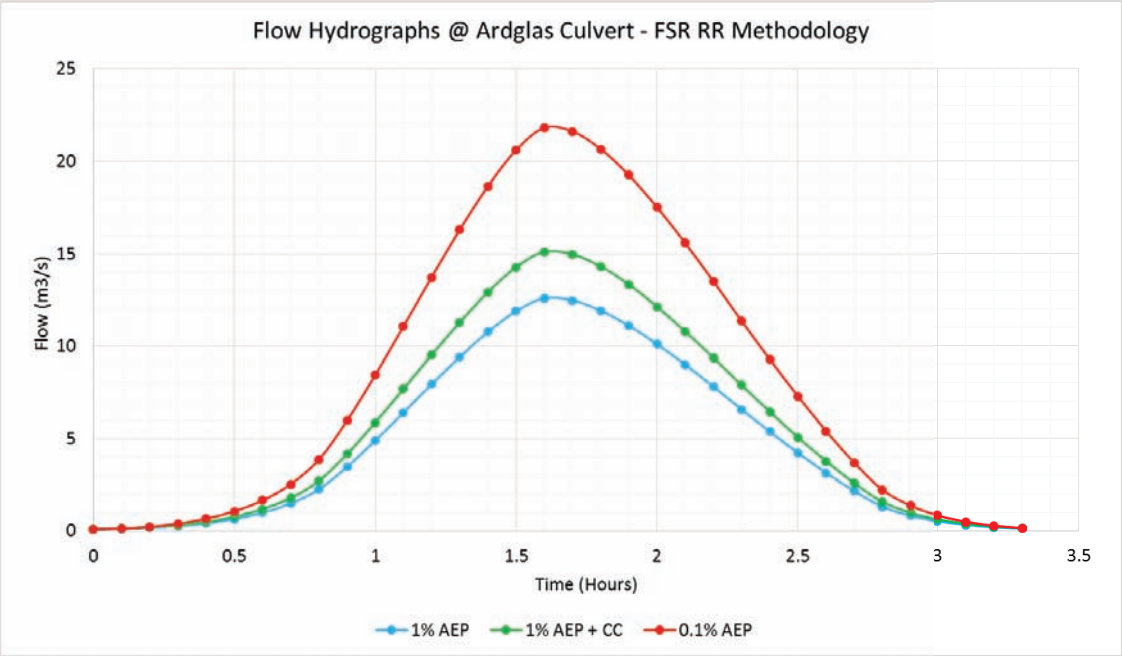
3.2.1 Modelling approach

The 1D-2D (ISIS-TUFLOW) hydraulic model incorporates LIDAR data provided by DLR and channel survey data provided by APEX Surveys Ltd.

A 1D-2D linked hydrodynamic hydraulic model is required so that both channel and culvert capacity can adequately represented and used to generate appropriate 2D overland flow routes (that are far removed from the culverted route of the watercourse). It is only through this linked modelling approach that the system can be appropriately represented.

The model specifically investigates flooding generated by the Slang River through the centre of Dundrum village. The model uses the hydrology described in Section 3.1 and a selection of hydrographs is shown below in Figure 3-2.

Figure 3-2 Summary of hydrological input into the ISIS-TUFLOW hydraulic model



The model has been run for three return periods:

- 1% AEP event (Flood Zone A);
- 0.1% AEP event (Flood Zone B);
- 1% AEP Climate Change event (1% AEP + 20%).

Manning's roughness values have been assigned to the floodplain using OSi NTF data. This data represents elements such as buildings, roads, inland water and vegetation. Building footprints have not been physically raised, but flow paths have been verified on site by JBA staff.

3.2.2 Schematisation

An overview of the model representation is provided below in Figure 3-3. The 1D-2D model begins in Ardglass Park and continues under Sandyford Road, past Willowbank Apartments, under Overend Way, the Riverbank Apartments under Sandyford Road (again) and then under Dundrum Shopping Centre. The model continues in open channel alongside the Shopping Centre before entering the Dundrum Bypass culvert. The culvert extends to Sweetmount Park before flowing through the second Sweetmount Park culvert and into open channel by the Library, before passing under Taney's Cross and towards Frankfort Gauge. The 1D model terminates downstream of Taney's Cross, whilst the 2D domain continues further downstream.

The model schematisation includes a significant portion of the channel upstream of the MTC sites because the CFRAM mapping clearly identifies culverts upstream of the Dundrum Shopping Centre as potentially generating a significant overland flow pathway down the Bypass, with flow collecting on the Dundrum Bypass prior to Taney's Cross - potentially impacting all three sites.

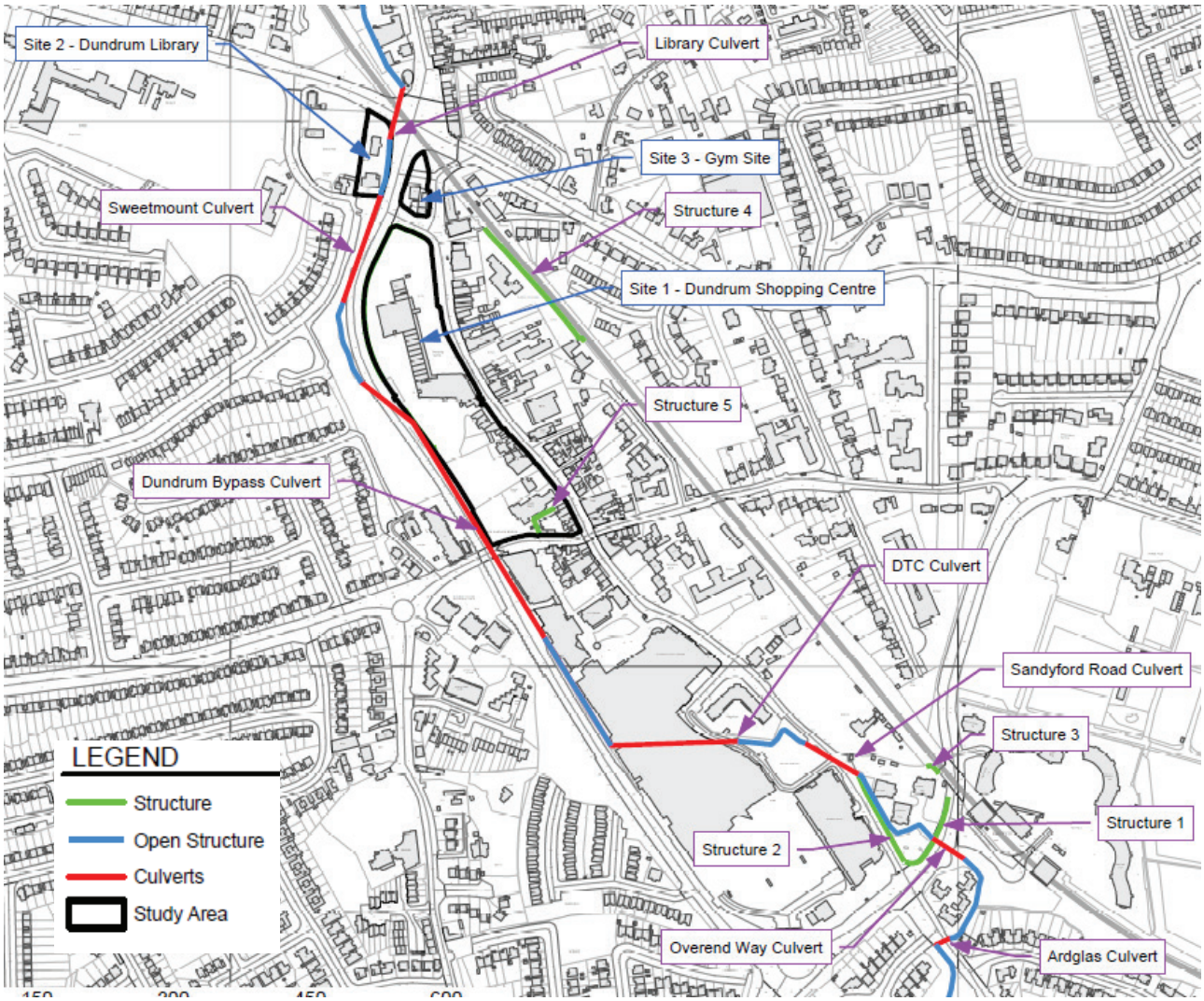


Figure 3-3 Location of walls and conveyance structures included in the hydraulic model

3.2.3 Model Scenarios

Five model scenarios have been presented by the hydraulic model;

- Existing Conditions (Baseline - March 2015);
- Existing Conditions - 50% Culvert Blockage(s) (residual risk);
- Option A (see Table 3-2);
- Option B (see Table 3-2);
- Option C (see Table 3-2).

These five scenarios have been run with a combination of return period events:

- 1% AEP
- 0.1% AEP
- 1% AEP + Climate Change (20% flow increase - residual risk)

The aim of the modelling is to determine the revised existing/baseline conditions (Flood Zone A & B) and assess the potential negative impacts on surrounding development. This will allow an appraisal of the sites in relation to the Justification Test. Two residual risk factors (climate change & culvert blockage) are also investigated.

Option A, B and C represent three different future development scenarios across the three MTC potential re-development sites that were introduced in Section 1.3.

The Options represent development by excluding flooding from each site by raising of ground levels above maximum flood levels. This represents (in broad terms) a potential development scenario - and tests the potential impact of development on risk elsewhere and will indicate where risk is acceptable and how mitigation may be achieved, if required.

Table 3-2 below confirms how development within Sites 1-3 is represented within each Option.

Table 3-2 Summary of development options tested in TUFLOW hydraulic model

Development Site	Option A	Option B	Option C
1. Dundrum Shopping Centre Phase 2 Lands	●		●
2. Dundrum Library		●	●
3. Site opposite Library (Gym)	●	●	●

The potential impact on water level for each scenario can then be easily assessed by comparing Options model results with the Existing (baseline) Conditions using extents or depth difference maps. Residual risks of climate change (+20% flow) and 50% culvert blockage are also investigated.

4 Detailed FRA - Results and Analysis

Model results are discussed below and presented as a series of maps within Section 7. Tables of the mapping contained in Section 7 are provided below in **Table 4-1** to **Table 4-4**. There are 21 maps included.

Discussion in relation to the revised Existing Condition model and the new Flood Zone maps for the site is addressed first in Section 4.1.

Analysis is then based around the comparison of the Existing Condition (baseline) with Options A, B and C in Section 4.2.

Section 4.3 discusses the residual risk modelling for climate change and culvert blockage.

Table 4-1 JBA Flood Zone Maps - Existing Condition Scenario

Scale	Description	Link to Map
Overview of Model Area	Flood Zone A & B	**Section 7.1**
Study Area (Sites 1-3)	Flood Zone A & B	**Section 7.1**

Table 4-2 JBA Flood Maps - DEPTH DIFFERENCE (with Existing Scenario)

Scenario	1% AEP	0.1% AEP
Option A	**Section 7.3**	**Section 7.4**
Option B	**Section 7.5**	**Section 7.6**
Option C	**Section 7.7**	**Section 7.8**

Table 4-3 JBA Flood Maps - DEPTH

Scenario	1% AEP	0.1% AEP	1% AEP + CC
Existing	**Section 7.9**	**Section 7.9**	**Section 7.11**
Blockage	**Section 7.12**	n/a	n/a
Option A	**Section 7.13**	**Section 7.14**	n/a
Option B	**Section 7.15**	**Section 7.16**	n/a
Option C	**Section 7.17**	**Section 7.18**	n/a

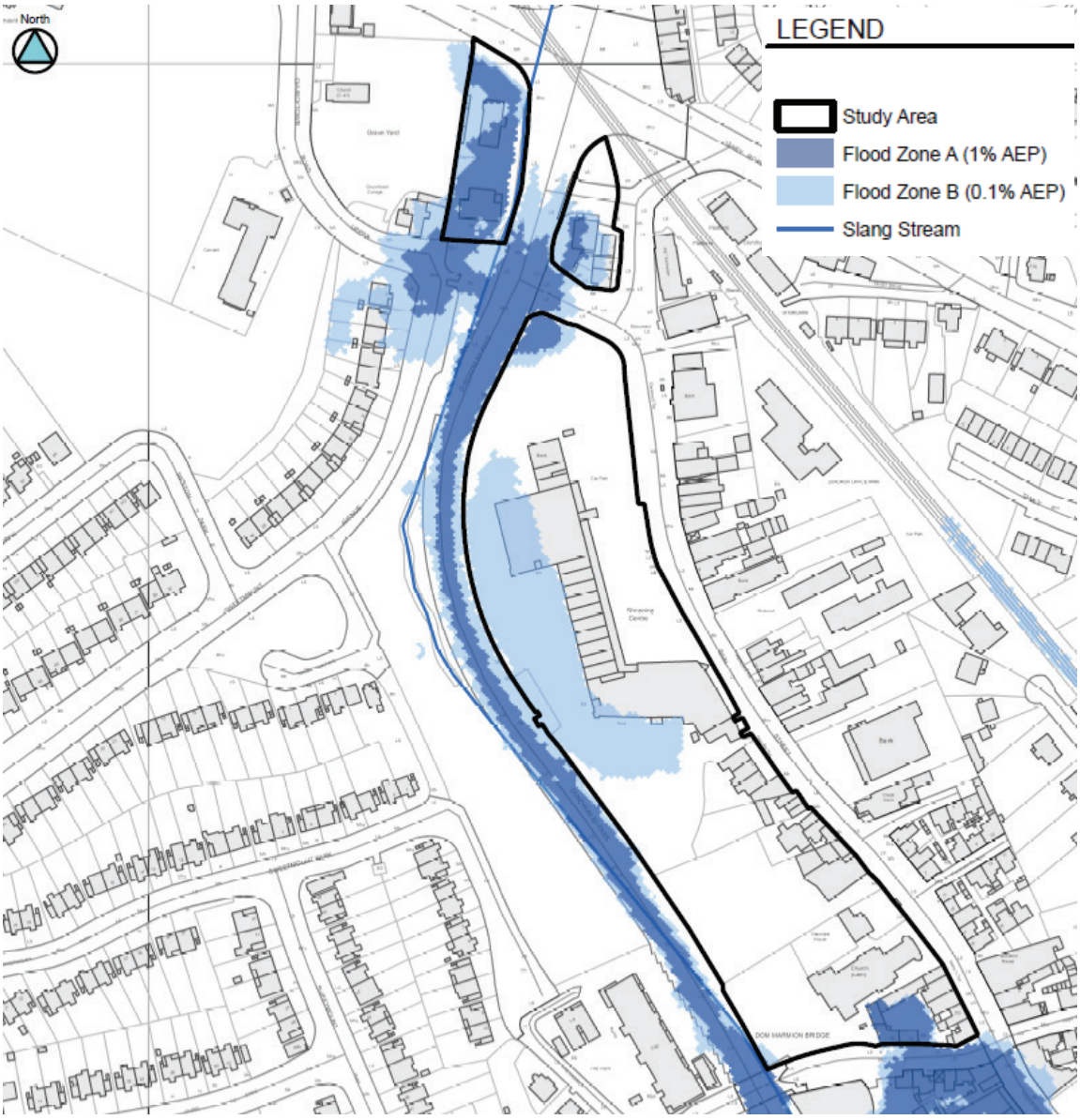
Table 4-4 JBA Flood Maps - HAZARD

Scenario	1% AEP	0.1% AEP	1% AEP + CC
Existing	**Section 7.19**	**Section 7.20**	**Section 7.21**

4.1 Existing Condition Scenario & Flood Zone Mapping

The existing conditions are presented as Flood Zone A and B, this refers to the flood extent for the 1% AEP and 0.1% AEP events. The mapping is presented in Section 7, with links to the mapping in **Table 4-1**. An excerpt of the map is provided below in Figure 4-1.

Figure 4-1 Flood Zone Map - Existing Conditions



4.1.1 Overview of Results

Compared to the original Dodder CFRAM flood mapping (see Figure 2-3), the extent of flooding is smaller and the impacts are therefore less severe, but are still significant. Reducing flood volumes is the main reason for the reduction in extent but there are also large differences in the representation of culverts and flow exceedance.

The table below confirms the percentage of each site area within Flood Zone A and B. The greater the area of the site within Flood Zone A and B the more the likelihood is that there will be negative impacts to surrounding lands from any re-development because of the accumulated loss in floodplain storage. Assuming re-development involves a policy of land raising to mitigate the risk for less vulnerable or highly vulnerable land uses.

Site 1 has the least percentage area within Flood Zone A and overall. Sites 2 and 3 both have significant percentages of the site within Flood Zone A & B, however the area of Site 3 is small compared to the other sites and does not interrupt any flow paths, or store significant volumes of flood water.

Site 2 is located adjacent to the open section of channel prior to Taney's Cross. Development of the site can potentially reduce flood storage and influence flow conveyance. The conveyance of flow back into the channel from the overland ponding witnessed on the Dundrum Bypass adjacent to the Library and Sweetmount Avenue is an important factor that controls flood levels in the area.

Table 4-5 Percentage and Area of each site within Flood Zone A and B

Site	Total Site Area (m^2)	% site in Zone A	Area (m^2) site in Zone A	% site in Zone B	Area (m^2) site in Zone B	TOTAL A+B % (area m^2)
1. Shopping Centre Phase 2 lands	30,107	3	903	19	5,720	22 (6,623)
2. Dundrum Library	2,636	52	1,371	25	659	77 (2,030)
3. Opposite Library (Gym)	1,551	13	202	35	543	48 (745)
TOTALS	34,294	68	2,476	79	6,922	n/a (9,398)

4.1.2 Summary of Flood Mechanism and Property Impacts - Existing Scenario

- The heavily culverted nature of the Dundrum Slang River and the capacity of the culverts located upstream of the Dundrum Shopping Centre are responsible for generating an overland flow route that causes flood water to flow down the Dundrum Bypass.
- Flow enters the Dundrum Bypass by exceeding culvert capacity at the Sandyford Road culvert and the Ardglass culvert and flowing down Sandyford Road until the junction with Ballinteer Road. At this low point flow then passes along Ballinteer Road, inundates the courtyard (Maher's Terrace) and continues through the open pedestrian access in the Dundrum Shopping Centre onto the Dundrum Bypass, towards Taney's Cross.
- Flow pathways represented in the model have been verified by a number of site visits carried out by JBA staff.
- Flow into Site 1 is limited by the low wall extending along the boundary with the bypass, but a gap in the wall is exploited above the 1% AEP event and flow then begins to significantly pond on the site.
- Overland flows collect/pond in the vicinity of the Dundrum Library and can re-enter the open channel at this point.
- This area around the Library is a topographic low spot. Ground levels subsequently increase underneath Taney's Cross and the LUAS Bridge. The Slang flows under Taney's Cross in a section of culvert.
- The ponding of water extends in front of the Library and also impacts Sweetmount Avenue and Churchtown Road Lower.
- For the floodwaters to be removed from this low spot, the flow must re-enter the open section of channel adjacent to the Library building. This is an important control on local water levels.

- The Dundrum Bypass kerb and railing plinth have a combined height of around 0.3m greater than the road level; **which water must overtop before it can re-enter the River Slang at this point.**
- As a consequence, flow quickly rises to the overtopping point where it can re-join the Slang River channel. This involves a flood route that flows into the area in front of the Library at the junction of Sweetmount Avenue and Churchtown Road Upper. Water then extends around the library and back into channel.

The impacts of flooding within Flood Zone A & B extend to the properties listed over the page in Table 4-6 over page.

Table 4-6 Existing Property Flooding in the area surrounding the MTC Sites

Area	Properties in FZ A	Properties in FZ B	TOTAL
1. Shopping Centre Phase 2 lands	0	1	1
2. Dundrum Library* (includes vacant HSE building)	1	1	2
3. Opposite Library (Gym)	1	3	4
Sweetmount Avenue	0	3	3
Church Road Upper	0	1	1
TOTAL	**2**	**9**	**11**

* note the Dundrum Library has an FFL of 44.67mOD which is greater than the potential Flood Zone A depths, but less than Flood Zone B. The building footprint has not been raised within the model and therefore the Flood Zone A mapping extends over the building footprint.

4.1.3 Confirmation of Flood Sources

From the analysis of the existing scenario information and flood mechanisms it is clear that the three MTC sites can be impacted from the following;

1. **FLUVIAL & SURFACE WATER OVERLAND FLOW;** All three sites are potentially at risk from the overland flow routes generated by fluvial flows exceeding culvert capacity above Dundrum Shopping Centre.
2. **CULVERT BLOCKAGE;** The existing scenario assumes culverts are operating without blockage, however the system is very sensitive to culvert capacity and further decreases in culvert capacity will generate increases in overland flow and flood depths to all three MTC sites. This applies to culverts upstream and downstream of the MTC sites.
3. **PLUVIAL;** Direct runoff from extreme rainfall events. Pluvial flooding from direct rainfall not entering the surface water drainage network could also threaten the three MTC sites in a similar manner to overland ponding noted in the first two sources. However, impacts would be more severe for sites two and three in this case. Pluvial flooding is potentially an issue but it can be effectively tackled by site specific drainage design and fluvial mitigation measures. The report will therefore focus on fluvial, surface water overland flows and residual risk management.

4.2 Baseline Comparison of Development Options

To compare the potential impact of additional development/re-development for Options A, B and C depth difference maps have been produced. The maps are found in Section 7 and a link to the maps is contained in **Table 4-2**.

- A significant increase in flood depth (as a result of development work to one of the Options sites is defined as an increase in flood depth >0.01m).
- Increase in flood depth is measured at an existing receptor (property) and is not in relation to new areas of flooding.
- The 1% AEP is the main reference point for significant impacts of flooding to aid the Justification Test.
- The 0.1% AEP is a reference point for exceedance flows (residual risk) for testing the impacts of development beyond the normal standard of flood protection methods. It is intended to be used to guide residual risk management rather than be used to appraise the Justification Test directly.

Results are summarised in Table 4-7 over page and show that development within the various Options combinations of Sites 1, 2 and 3.

Table 4-7 Impacts of Options Development of MTC Sites

Scenario	1% AEP Max WL Increase (m)	1% AEP Additional Properties Flooded?	0.1% AEP Max WL Increase (m)	0.1% AEP Additional Properties Flooded?
Option A (Site 1 + 3)	<0.01	No	0.1-0.25 **	Yes (2)
Option B (Site 2 + 3)	0.01-0.05 *	No	0.25-0.5 **	Yes (3)
Option C (Sites 1, 2 & 3)	0.01-0.05 *	No	0.25-0.5 **	Yes (3)

* Typical increase in front of Library is 0.01-0.05m, 0.25-0.5m increase in depth is limited to the rear of the Library.
** A >0.5m increase in depth is limited to an area west of properties on Sweetmount Avenue, however this is a new area of flooding where water overtops into a low spot that contains no properties.

4.2.1 Summary of Impacts

- At the 1% AEP no new properties are impacted and the two properties noted as being within the flood extent (see Table 4-6) will not be subject to an increase in flood depth.
- The depth increase at this AEP is limited to roads or open space.
- The HSE building is not impacted, it is also noted that the building also happens to be vacant. The 'Gym' building is removed from the floodplain in all three options, but would be unlikely to suffer significant increase in water levels at the 1% AEP for development of other options.
- Typical depths of flooding at the front of the Library on the Bypass and Sweetmount Road/Churchtown Road Lower would increase in depth by 0.01 to 0.05m at the 1% AEP for Options that include development of the Library (Options B & C).
- At the 0.1% AEP (an increase in flow from approximately 13m^3/s to approximately 22m^3/s), the impacts from additional development (Option A, B and C) increases significantly.
- At the 0.1% AEP additional properties are flooded along Sweetmount Avenue (1 or 2no.) and Churchtown Road Upper (1no.) and flood depths increase.

4.3 Residual Risk

Consideration of residual risk has been extended towards the impacts of climate change and an increase in culvert blockage to 50% (at all structures). The impact of the 0.1% AEP flow (also a residual risk from exceedance) is included within Section 4.2.

Climate change and blockage modelling has only been run with the Existing Scenario and all comments are in relation to a comparison between the impacts on this scenario.

Flood maps are included in Section 7 and mapping output for climate change extends to both DEPTH and HAZARD, blockage extends only to DEPTH. There are links to the maps in **Table 4-3** and **Table 4-4**. Hazard is discussed separately in Section 4.4, this section focusses on the residual impacts on flood depth.

4.3.1 Climate Change Impacts

Flooding as a result of potential future climate change is represented by an increase in peak flow at the 1% AEP of approximately 2.5m^3/s (20%), as can be seen in Figure 3-2. It is noted that this increase is significantly less than the flow increase of over 9m^3/s between the 1% and 0.1% AEP.

The increase in flood depth and extent across the MTC lands is generally less than 0.1m, but with isolated areas (within Site 3) displaying an increase of 0.5m. Specific details include;

- An increase in extent and depth across Site 1 (0.1m maximum) is caused as a result of flows encroaching through the gap in the low wall adjacent to the bypass.
- An increase in the depth of flooding at the topographic low spot in front of the Library of 0.1m maximum.
- Within Site 2 (Library) flood depth increases by up to 0.5m.
- Within Site 3 the increase is >0.5m.
- No new property flooded

Climate change levels will generally guide the design of appropriate FFLs for any proposed re-development of the three MTC sites. This is discussed further in Section 6.

4.3.2 50% Culvert Blockage Impacts

Increasing the culvert blockage to 50% for all structures forces more flow along the main overland route along the Dundrum bypass, into Site 1 through the gap in the low wall and into Sites 2 and 3 from an increase in ponding in the topographic low spot near to the Library.

Increases in flood depth and extent are significant;

- 0.1m to 0.25m increase consistently along the Dundrum Bypass and in the topographic low spot;
- Up to 0.5m increase in flood depth within Site 1;
- Up to 0.25m increase in flood depth in Site 2;
- Greater than 0.5m increase in Site 3.

It is noted that the increase in flood depth and extent is still less than that represented by the 0.1% AEP event.

4.3.3 Conclusion on Residual Risk (including 0.1% AEP)

It is clear from the consideration of the suite of residual risks (climate change, blockage and flow exceedance - 0.1% AEP) that the potential impact of development within the combination of Sites 1-3 poses significant impact to others, which cannot be ignored. With the aim of ensuring that the residual impacts are minimised then it is necessary to compensate fully for the loss of floodplain storage (to the 0.1% AEP standard) on each site or alternatively, avoid developing within Flood Zone A or B. Both options limit the amount of space within the MTC lands available for highly and less vulnerable land use.

The Planning Guidelines recommend a precautionary approach and a simple application of this principle would result in a zoning objective that ensures lands within Flood Zone A and B are retained as open space/water compatible use with no change in ground levels.

However, if wider consideration is given to the potential mitigation options, that extends beyond the boundary of the three MTC sites (to a catchment based solution) then it is possible, in theory, to offer a solution that allows mitigation of the negative impacts to others and increases the amount of space within the MTC lands available for highly and less vulnerable land use.

The decision as to the adoption of this approach can be informed by the guidance contained within Section 5 and 6.

It is worth noting that the current fluvial design standard is normally the 1% AEP plus climate change. In this situation, due to the significance of the residual risks and uncertainty in the hydrology, mitigation is recommended to the 0.1% AEP standard. This brings with it significant challenges as will be discussed in subsequent sections of this report.

4.4 Flood Hazard

Flood hazard provides an important indicator of the danger caused to human life by the combined impacts of flood velocity and depth. It is used to highlight in a single map where a combination of fast and deep flow will pose a risk to human life. It is useful for identifying the requirement for adequate mitigation measures and emergency planning. Table 4-8 provides further information.

Hazard is calculated using the Defra FD2321[1] formula as used in the OPW CFRAM studies. The Flood Hazard rating is a function of depth and velocity of flooding with a debris factor added. It is calculated using the following equation:

HR = d x (v + 0.5) + DF

- where, HR = (flood) hazard rating;
- d = depth of flooding (m);
- v = velocity of floodwaters (m/sec); and
- DF = calculated debris factor

Table 4-8 Hazard to People as a Function of Velocity and Depth

d * (v +0.5)	Degree of Flood Hazard	Description
<0.75	Low	**Caution** "Flood Zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	**Dangerous for some (i.e. children)** "Danger: flood zone with deep or fast flowing water"
1.25 – 2.5	High	**Dangerous for most people** "Danger: flood zone with deep fast flowing water"
>2.5	Significant	**Dangerous for all** "Extreme danger: flood zone with deep fast flowing water"

Flood maps are included in Section 7. Links to HAZARD maps are provided in **Table 4-4** and these are limited to results from the Existing Scenario.

4.4.1 Comment on Hazard

Hazard is most significant in the topographic low spot adjacent to and also behind the Library. Here we see large depths of flooding even at the 1% AEP which result in 'high' or in some smaller areas 'significant' hazard. Flows passing down the Dundrum Bypass exerts a moderate hazard at the 1% AEP.

At the 0.1% AEP flood hazard increases to 'significant' for much of the Dundrum Bypass and topographic low spot as both velocity and depth increase. As well as the risk to human life, vehicular access (including emergency services vehicles) along the Dundrum Bypass will not be possible under the 1% or 0.1% AEP.

In summary the risk to human life as a result of flooding from the 1% and 0.1% AEP are a serious consideration for future risk management and mitigation in Dundrum. The impacts from October 2011 clearly illustrate the potential for significant flood depth and velocity.

The hazard maps confirm that access and egress from the three MTC sites must be an important consideration for existing risk and future development. Emergency planning will form a crucial aspect of this consideration.

[1] Defra / Environment Agency Flood and Coastal Defence R&D Programme, R&D OUTPUTS: FLOOD RISKS TO PEOPLE Phase 2, FD2321/TR2, Guidance Document, March 2006

4.5 Summary

The new Flood Zone mapping presents an estimate of the baseline probability of flooding. Flood extent and depth are both less than previously suggested by the Dodder CFRAM. The differences mainly stem from a decrease in estimated flow.

The primary source of flooding to the three MTC sites is from fluvial flow exceedance at upstream culverts generating overland flow that extends down the Dundrum Bypass and collects in a topographic low spot near the Library. The flow down/along the Dundrum Bypass and subsequent ponding causes flooding to the MTC sites. Flood depths are largely controlled by the ability of the flood water to re-enter the channel at the Library.

Impacts from potential future development at the 1% AEP are limited to a maximum of 0.05m increase in flood depth to open space and roads with no increase in flood depth to existing flooded property (assuming site 3 is raised in all three options). Flood hazard is still high or significant and will require consideration for existing and future development risk/emergency management.

Residual risk impacts at the 0.1% AEP exceedance flows are most significant. However, all residual risks are important considerations for future risk management and mitigation. The way in which the risk is managed, either through avoidance or wider catchment based mitigation is discussed in the next Section.

5 Planning Guidelines & Strategy

Building on the identification of existing and potential flood risk associated with development in the MTC zoned lands, this section will comment on vulnerability and appropriate uses, highlight potential management, emergency planning and mitigation measures and comment on the application of the Justification Test.

5.1 Application of the Planning Guidelines

5.1.1 Risk Review

Proposed Options for the development of Sites 1, 2 and 3 have been assessed in relation to potential development scenarios discussed within Section 4. The results of the impacts are summarised in Table 5-1 below.

Significant negative impacts are only generated to existing or new flood receptors (properties) at the 0.1% AEP which is beyond the current design standard of flood mitigation design, but is an important consideration. As such it is a residual risk consideration that is used to assist both our recommendations for risk management and application of the Sequential Approach to zoning.

Residual risk of climate change and 50% culvert blockage are less severe that the 0.1% exceedance model tests.

Table 5-1 Summary of changes to flood risk as a result of various development options

Scenario	1% AEP Significant Impact?	Significant Residual Risk Impact?
Option A (Site 1 + 3)	No	Yes
Option B (Site 2 + 3)	No	Yes
Option C (Sites 1, 2 & 3)	No	Yes

The increase in residual risk at the 0.1% AEP and under blockage scenarios will require significant flood risk management measures for the wider Dundrum Slang River catchment, rather than piecemeal measures within the specific sites. If wider measures are not implemented then residual risk to others will be significantly increased. Consideration of any potential wider measures should include floodplain storage to reduce peak flow volumes rather than increase conveyance, otherwise risk downstream will be increased.

5.1.2 Planning Strategy

The Planning Guidelines stipulate that the Sequential Approach should be applied within a given site boundary to aid the management of flood risk and development, the application of this approach is discussed within Appendix B, Section 3 of the Planning Guidelines Technical Appendices.

The DECLG Circular PL2/2014 also provides clarification under Section 4.27a that where regeneration is to occur within Flood Zone A/B the Planning Authority must specify the nature and design of structural or non-structural flood management measures prior to development.

It is clear from the consideration of the suite of risks (climate change, blockage and flow exceedance - 0.1% AEP) that the potential impact of development within the combination of Sites 1-3 poses significant impact to others, and that any mitigation must cater for the 0.1% AEP flood event. Structural flood management methods would involve catchment scale measures including storage and attenuation to reduce flow volumes.

There is currently no formal specification of the nature and design of catchment management measures and the MTC lands remain at potential risk of flooding. **In this case a policy of avoidance of highly or less vulnerable land uses within Flood Zone A & B has been adopted.** Further, where water compatible uses are proposed, such as surface level car

parking, all existing conveyance routes and floodplain storage volumes must be retained. This policy will also safeguard areas for mitigation.

Considering the principles discussed above, the three subject sites (which all include varying percentages of land within Flood Zone A & B) must follow the stated approach for any future re-development proposals:

1. Substitute water compatible uses for lands within Zones A/B. These must avoid any net loss of floodplain volume and should have no impact on flood risk;
2. Within areas of Flood Zone C, ensure that surface water management measures are in line with DLR policy and that an emergency plan is formulated to ensure access and egress to Flood Zone C can be maintained from any development within MTC sites.

Specific guidance for each site is provided in Section 6.

5.2 Comment on Risk and Potential Non-Structural/Structural Responses

Whilst the detailed nature and design of any potential risk management measures are not formally specified for the MTC lands, it is important to consider the current position of the Dodder CFRAM and the potential requirements for mitigation.

The source of risk to the MTC sites and the wider area is related to the exceedance of culvert capacity further upstream on the Slang River which causes overland flows and ponding at the topographic low spot near the Library. The risk of flooding is therefore transferred downstream towards Taney's Cross (and potentially further downstream) by surcharging culverts and will be most effectively mitigated in Dundrum by adopting a catchment based approach.

Non-structural responses focus on reducing the impact to people by warning, planning and preparedness, and through development management and planning. Structural responses focus on physical works to constrain or attenuate flows. Structural and non-structural responses were considered under the Dodder CFRAM, however this does not satisfy the requirements of the DoECLG Circular PL2/2014. Based on the findings of this report the CFRAM management measures have been commented on in Table 5-2 below.

Table 5-2 Summary of Dodder CFRAM Management Measures and JBA Measures/Comment

Measure	Dodder CFRAM Comment	JBA Comment
CFRAM: Improvement of channel conveyance	Watercourse is heavily culverted limited scope to improve conveyance without large capital spend. BCR <1	Requires a review, channel conveyance would not work on its own without consideration of culvert capacity and downstream impacts, which suggests flood storage is a requirement.
CFRAM: Hard defences	Hard defences over relatively short section will alleviate the majority of flooding. BCR>1	As above; review and consider feasibility under a wider scheme or Minor Works applications (see below).
CFRAM: Proactive maintenance regime	Will reduce the likelihood of localised flood events. BCR>1	Management of blockage and debris is essential and has been implemented at Dundrum Shopping Centre Culvert with CCTV and level monitoring. Consider expanding to other culverts at risk of exceedance.
CFRAM: Reactive maintenance regime	Will reduce the likelihood of localised flood events. BCR>1	As above.
CFRAM: Public awareness campaign	Technically straightforward, requires only a few properties to benefit to have positive BCR. May cause concern to public to know property is at risk.	Essential that risk is communicated to the public and options provided to inform and warn residents/businesses.
CFRAM: Rehabilitation of	Technically straightforward to repair defects in existing flood	Review and consider feasibility. Possible Minor Works application.

existing defences	wall to ensure current level of flood protection is maintained	
CFRAM: Individual property protection or flood proofing	Only 20 properties to protect and would provide full protection.	This has been employed at Dundrum Shopping Centre and it is recommended that Property Level Protection is recommended to at risk residents/businesses as part of the Public Awareness Campaign

To satisfy the requirement of Circular PL2/2014 a more detailed investigation of structural/non-structural responses would need to be carried out. Present analysis suggests that the Dodder CFRAM mitigation measures may be difficult to achieve or very costly to implement due to the highly urbanised nature of the catchment and limited options for attenuation/storage. Table 5-3 below provides recommendations for wider management of risk in Dundrum.

Table 5-3 Recommended Risk Management Approach

Potential Approach	Comment
Strategic Review of Options	As part of a pre-feasibility/options study an informed decision should be made to either; adopt local measures to protect existing property or conduct a comprehensive review the Dodder CFRAM options, increase the options/scope and investigate a series of Minor Works / Strategic Catchment scale measures. The current level of information is not sufficient to allow the potential success of the measures to be made.
Local Measures	Possible development of formal overland flow route (incorporating the existing roadway) from upstream of Dundrum Shopping Centre to Taney's Cross. Improved conveyance back into channel in open sections. Aim is to reduce risk from current overland flow route and ensure ponding at Taney's Cross is minimised. Initial modelling suggests that directing more flow back into the channel at the Library culvert may not be effective at the 0.1% AEP due to the limited capacity of the Library culvert. Improved flood storage and/or other local measures may need to be combined in a more detailed investigation of this/these options.
Catchment wide schemes culvert/channel conveyance	Consider potential schemes relating to upstream storage and/or culvert capacity increases at Dundrum Library Culvert, Sandyford Road Culvert and Ardglass Culvert. This will seek to review, revise and expand on existing options suggested by Dodder CFRAM. Initial modelling suggests that without some kind of attenuation storage (to replace that lost at Taney's Cross) the increased conveyance will increase flood risk further downstream, negatively impacting property. SuDS retrofitting may also be considered. Any considerations must therefore extend to the confluence with the River Dodder. The aim should be to reduce channel and culvert peak flow and reduce culvert and channel exceedance over a wider area. The potential benefits are more wide ranging but this is likely to incur very high capital costs.
Flood Warning	Extend level warning sensors to culverts upstream of Dundrum Shopping Centre to provide additional proactive maintenance measures. Consider using level sensors to provide warning to residents/businesses at risk of downstream overland flow routes/flooding. A useful measure but the lack of warning time may not prove effective.

6 Site Specific Flood Risk Management

When approaching the management of flood risk on individual sites, a number of factors should be considered to ensure the response to the risks is appropriate and proportional to the scale of both the probability of flooding, and the consequences of the flood. These general design considerations are then strengthened by site specific recommendations for each MTC site and guidance on how site specific FRAs will be tendered.

6.1 Design Considerations

Considerations and guidance for site design/analysis are summarised in Table 6-1 below. The considerations are then given added context from specific recommendations for each site in Section 6.2.

Table 6-1 Management Considerations and Guidance

Consideration	Guidance
ulnerability of Use	Adopt the avoidance principle noted within 5.1.1 and follow the applicable considerations below.
Maintenance of Flow Paths and no Loss of Floodplain Volume	Flow conveyance pathways (such as at the Library Site and along the Dundrum Bypass) must be retained or improved when implementing water compatible land uses within Flood Zone A/B. There must be no loss of floodplain within these zones.
Reduction of Surface Water Runoff	All sites should seek to reduce surface water runoff by considering SuDS options (including retrofitting) and complying with the GDSDS and general DLR policies on surface water design.
Modelling Detail	The approach of avoiding development in Flood Zone A and B will not require hydraulic modelling, but if improvements to flow paths or increases in floodplain storage are proposed as part of a development, the benefits must be demonstrated through detailed hydraulic modelling. In this case, the model must include the Ardglass Culvert (see Figure 3-3) at the upstream model extent and continue downstream of Taney's Cross. The model should include appropriate consideration of hydrology and sensitivity to flow. Hydrology should include a balanced assessment of potential flow estimation methods and seek to justify the choice of flow.
Manage Residual Risk	Guide FFLs are provided in Section 6.2. With development focussed within Flood Zone C the potential impacts of culvert blockage, climate change and exceedance flows (0.1% AEP) are appropriately managed. Basement levels or levels beneath potential flood levels should only consider water compatible land uses and not be used for critical electrical or mechanical purposes. Access to basements should not be considered unless it is raised above potential flood levels - to prevent the ingress of floodwater to the basement.
Flood Risk Management and Design	Appendix B of the Technical Appendices to the Planning System and Flood Risk Management Guidelines should be consulted when considering design and layout.
Emergency Planning	All sites must consider emergency planning for potential flood events on neighbouring lands within Flood Zone A/B. Issues of access, egress and warning/preparedness should be tackled.
Impact on Others	The above considerations must be achieved in a manner that will not increase flood risk elsewhere, and, if practicable, will reduce overall flood risk. Applying the Sequential Approach should ensure this but water compatible uses within Flood Zone C must adhere to the guidance above in relation to flow paths and floodplain volume.

6.2 Suggested Site Specific Approach

1. All sites must follow the overarching strategy highlighted in Section 5.1.1.
2. Site design must be progressed according to the considerations listed in Table 6-1.
3. All development must submit an appropriately detailed site specific FRA and emergency plan that should be completed in accordance with Table 6-1 (above) and; Table 6-2 (below) as well as the Planning System and Flood Risk Management Guidelines. Further Guidance is provided in Appendix A of the Technical Appendices of the Planning Guidelines.
4. Prior to completing any detailed design or FRA it is recommended that a pre-planning consultation is undertaken to fully discuss the design requirements and considerations.

Specific comments on individual sites are included below in Table 6-2.

Table 6-2 Site Specific Design Requirements

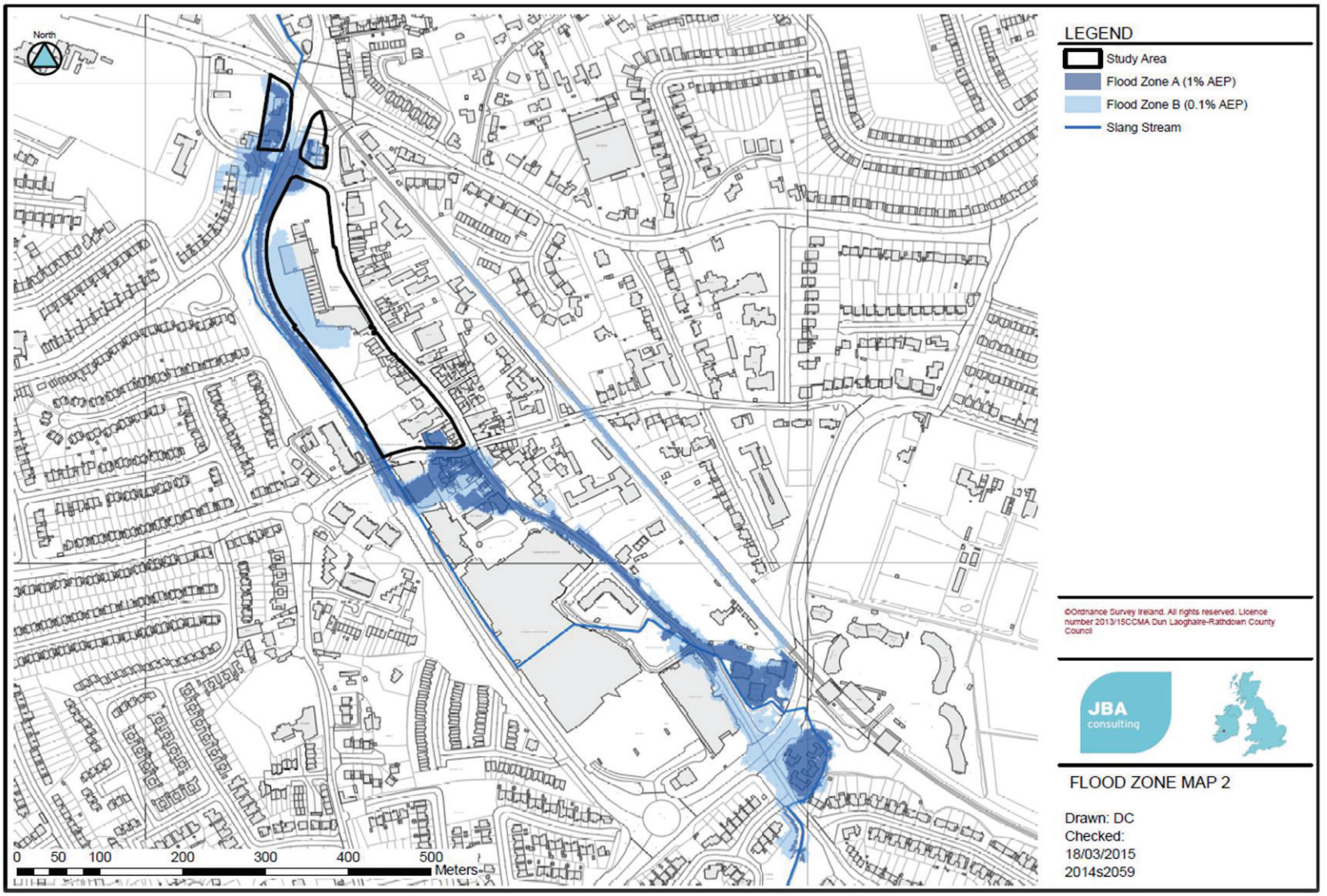
Site	Summary/Approach	Minimum FFLs (including freeboard)
1. Shopping Centre Phase 2 Lands	Sequential Approach; water compatible land use only within Flood Zone A/B. All less vulnerable/vulnerable development to be kept within Flood Zone C. The size of the site presents the most significant potential for large scale mixed use development within the local area, but the nature and extent of possible development is limited by the Sequential Approach. Care must be taken when considering the road/access and ventilation requirements to preclude flow from entering any basement excavated below flood level. A full emergency plan with access and egress to Main Street is compulsory. Worst case residual flood level to north of site related to overtopping of the road at Taney's Cross. Finished Floor Levels for commercial units and access to any below ground basements should be above the Dundrum Bypass, at its appropriate corresponding level, as this road remains an overland flow route. Existing flow paths along the Dundrum Bypass should be maintained. The guidance listed 1-6 in Section 6.2 must also be applied.	46mOD Malin at northern end of site. Rising to 47mOD. No levels to be lower than Dundrum Bypass.
2. Dundrum Library	Large percentage of the site is within Flood Zone A/B and the application of the Sequential Approach is not possible. Options are limited to managing existing development (minor alterations or renovations) on the site, future redevelopment is not possible under the current high flood risk conditions. The maximum flood level at the site is sensitive to culvert blockage and in the worst case; flood levels are controlled overtopping of the road at Taney's Cross. The position of the site is at an important conveyance point where overland flow can re-enter the open channel. Any changes to the site configuration could have a significant negative local impact and cannot be implemented without wider flood relief measures. A full emergency plan with access and egress to higher ground on Main Street should be implemented as a priority for the existing development, if possible. The guidance listed 1-6 in Section 6.2 must also be applied.	46mOD Malin - freeboard adjusted to raise levels above that of the maximum road level at Taney's Cross.

Site	Summary/Approach	Minimum FFLs (including freeboard)
3. Opposite Library (Gym)	The site is small in area but is situated within a low spot and has a high percentage area within Flood Zone A/B and the application of the Sequential Approach is not possible. The site does not impede conveyance routes. Options are limited to managing existing development (minor alterations or renovations) on the site, future redevelopment is not possible under the current high flood risk conditions. A full emergency plan with access and egress to higher ground within the adjacent site should be implemented as a priority for the existing development, if possible. The guidance listed 1-6 in Section 6.2 must also be applied.	46mOD Malin - freeboard adjusted to raise levels above that of the maximum road level at Taney's Cross.

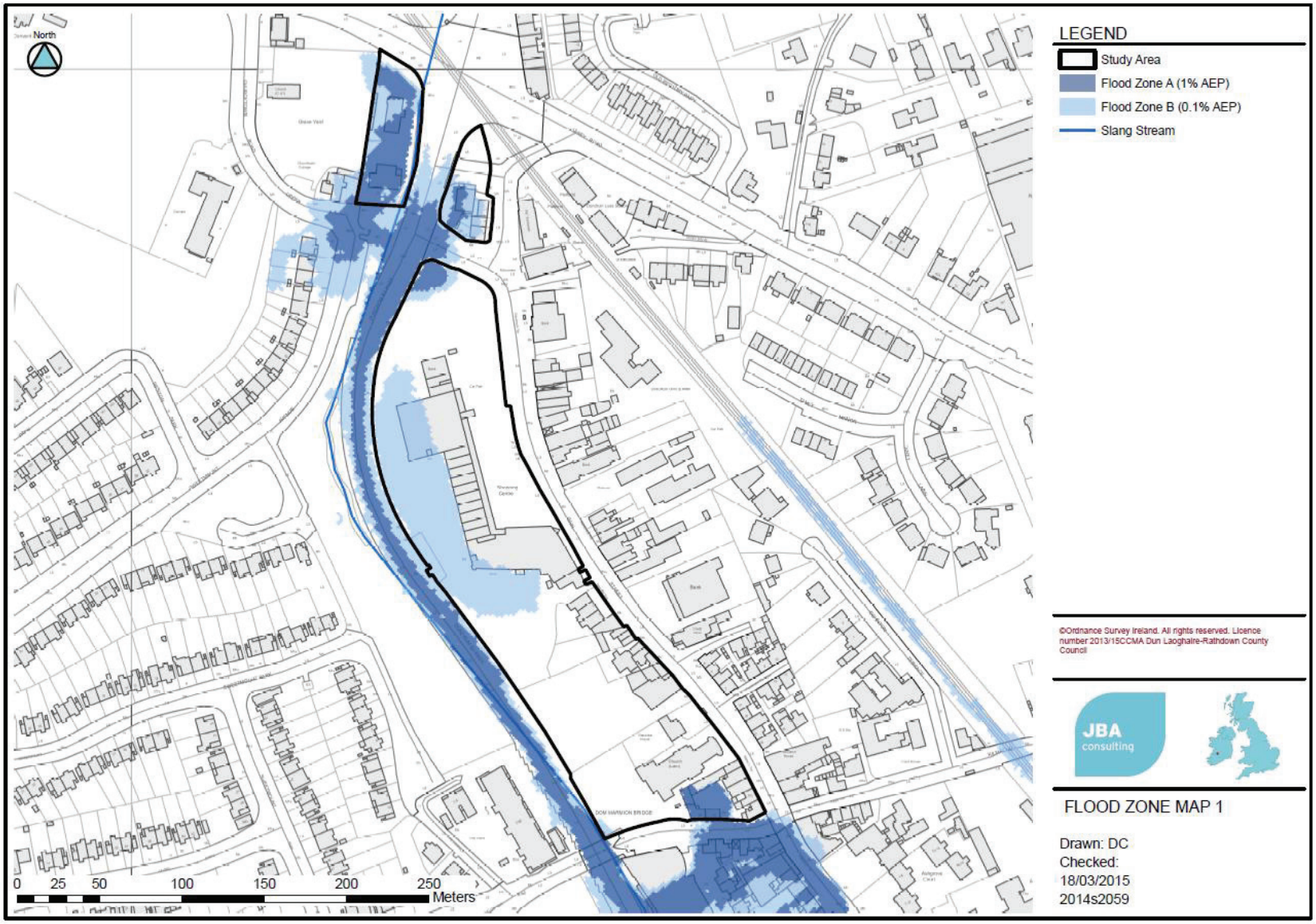
7 JBA Flood Mapping

The following pages present the suite of Flood Zone, Flood Depth, Depth Difference and Flood Hazard maps for the various scenarios and AEP events.

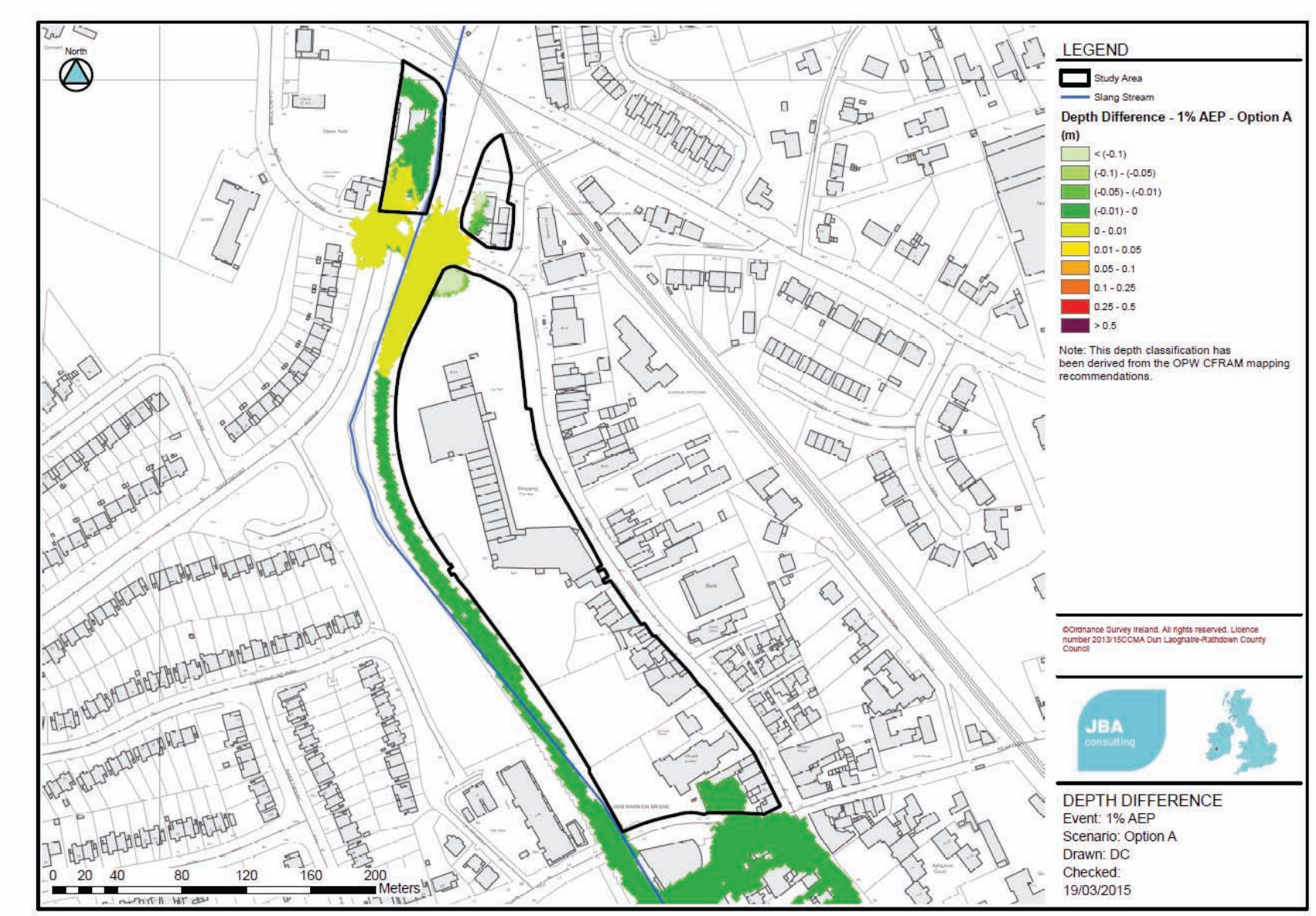
7.1 Flood Zone Map - Overview



7.2 Flood Zone Map - Site Specific

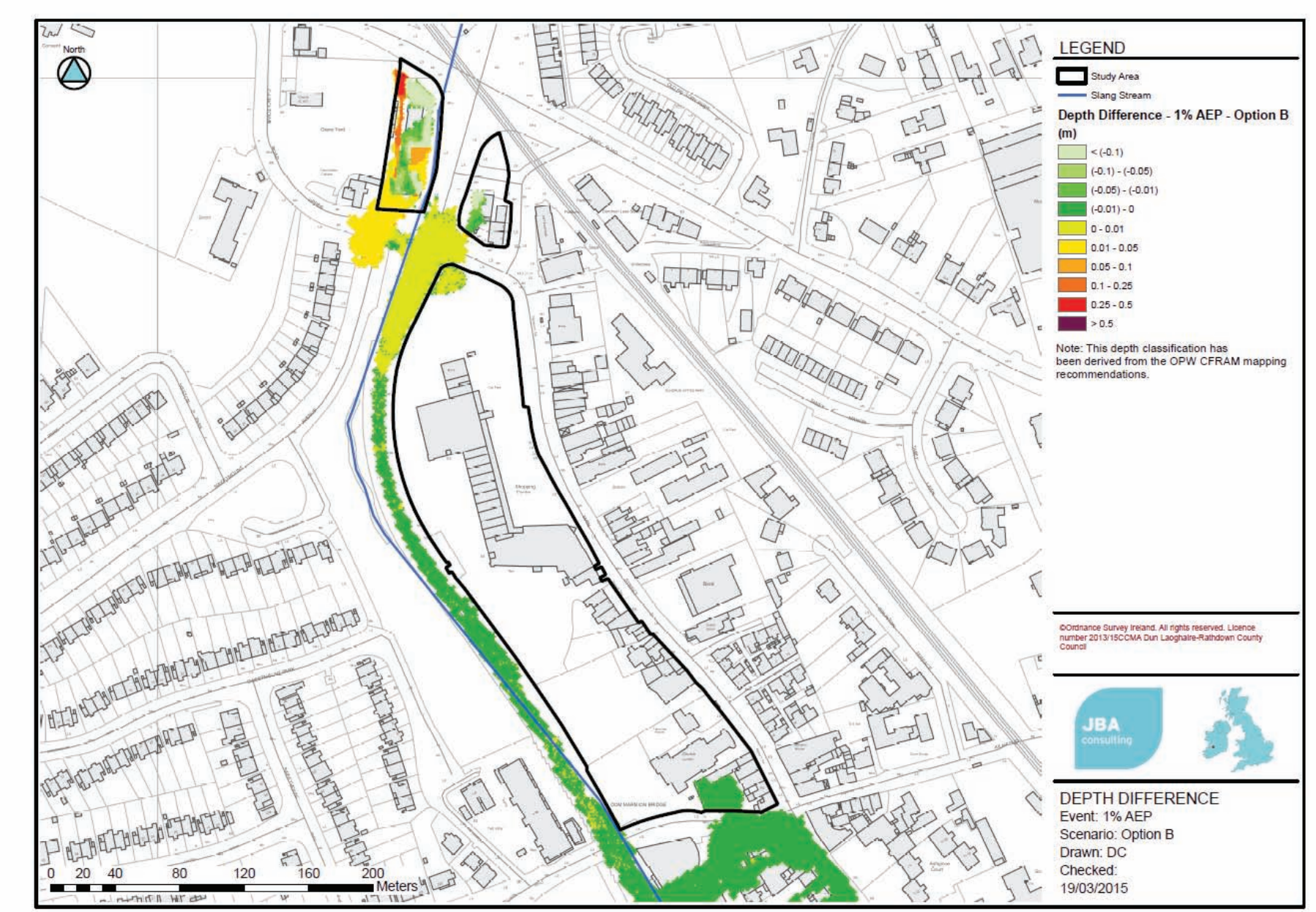


7.3 Depth Difference - 1% AEP - Option A

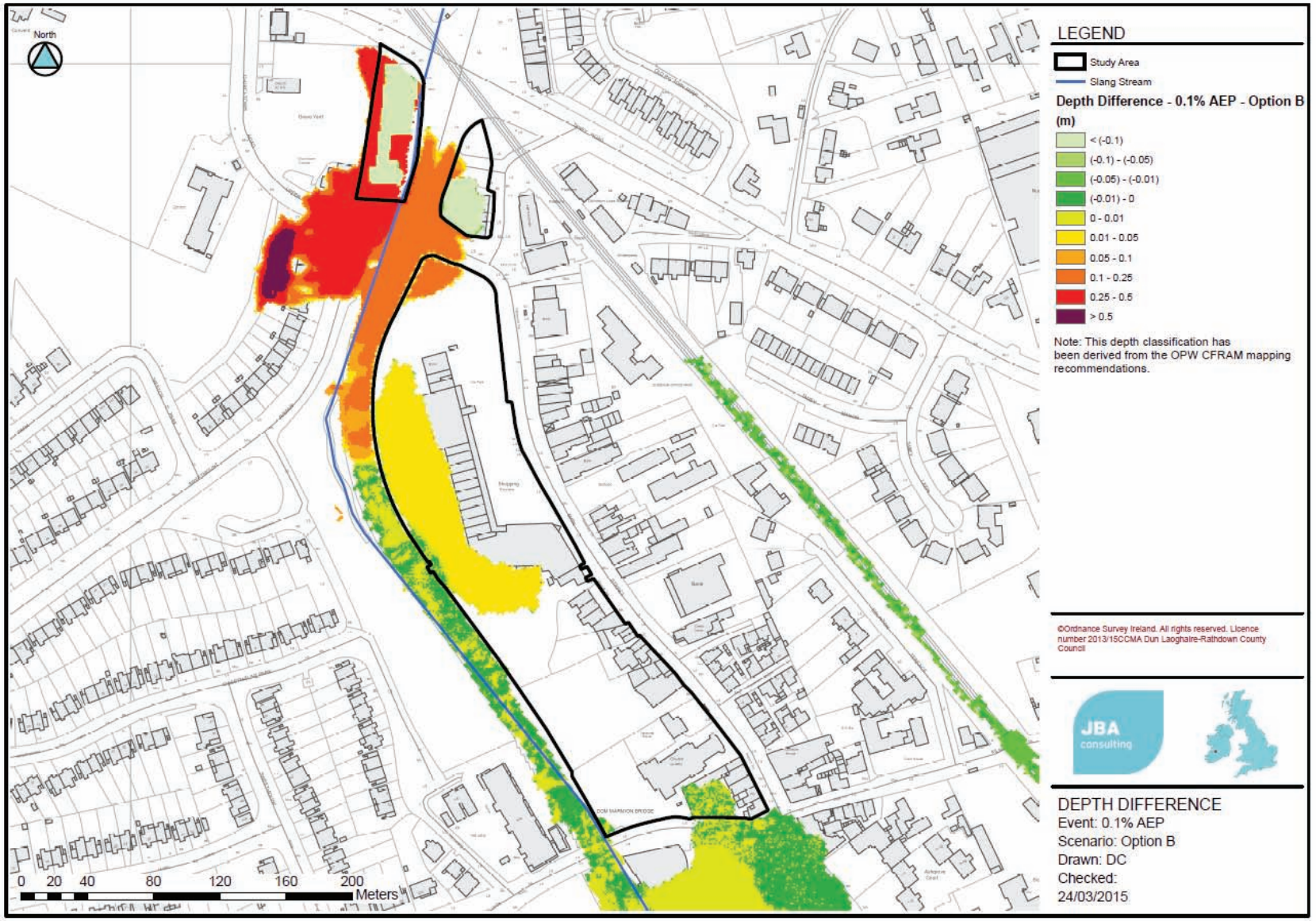


7.4 Depth Difference - 0.1% AEP - Option A

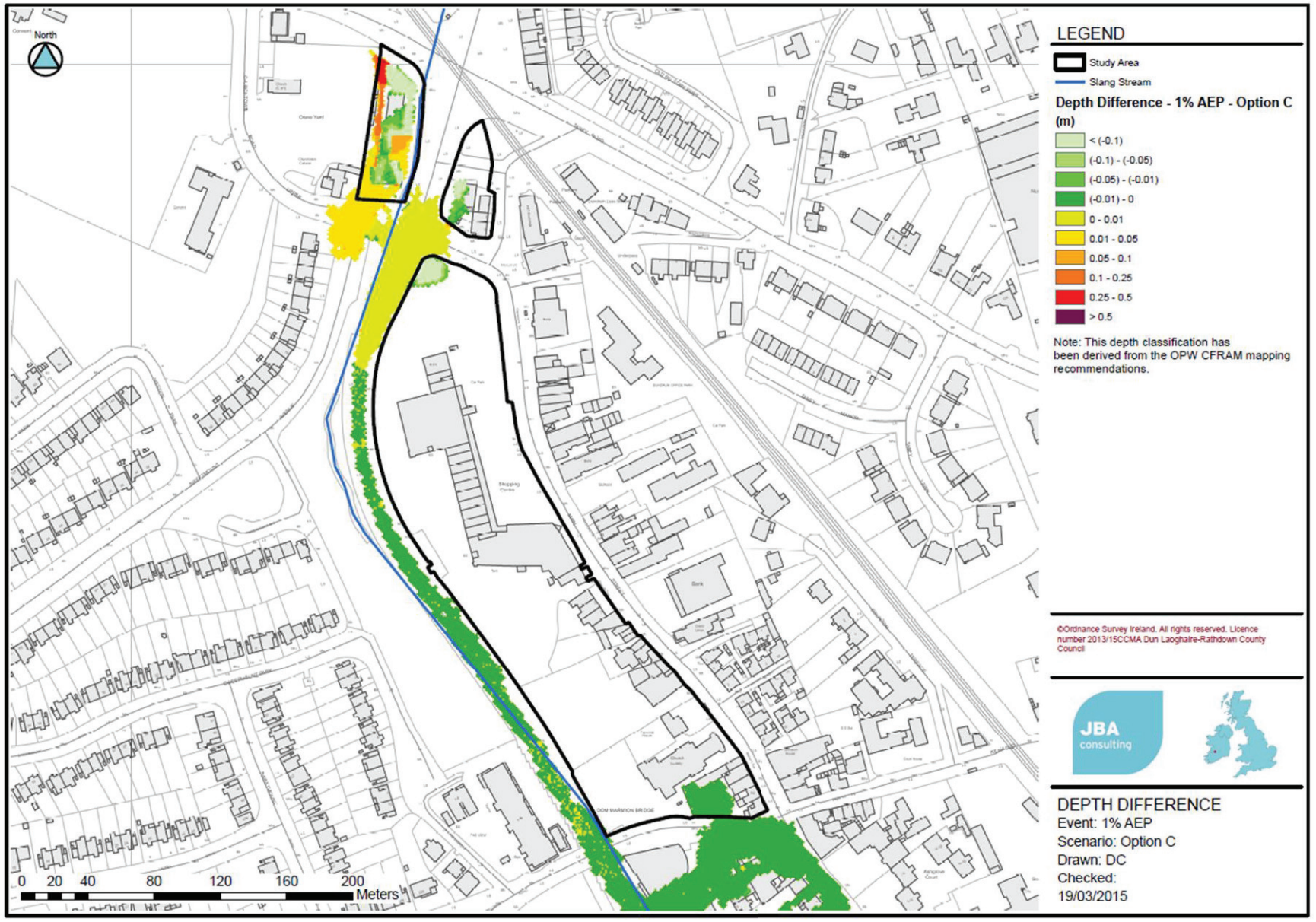
7.5 Depth Difference - 1% AEP - Option B



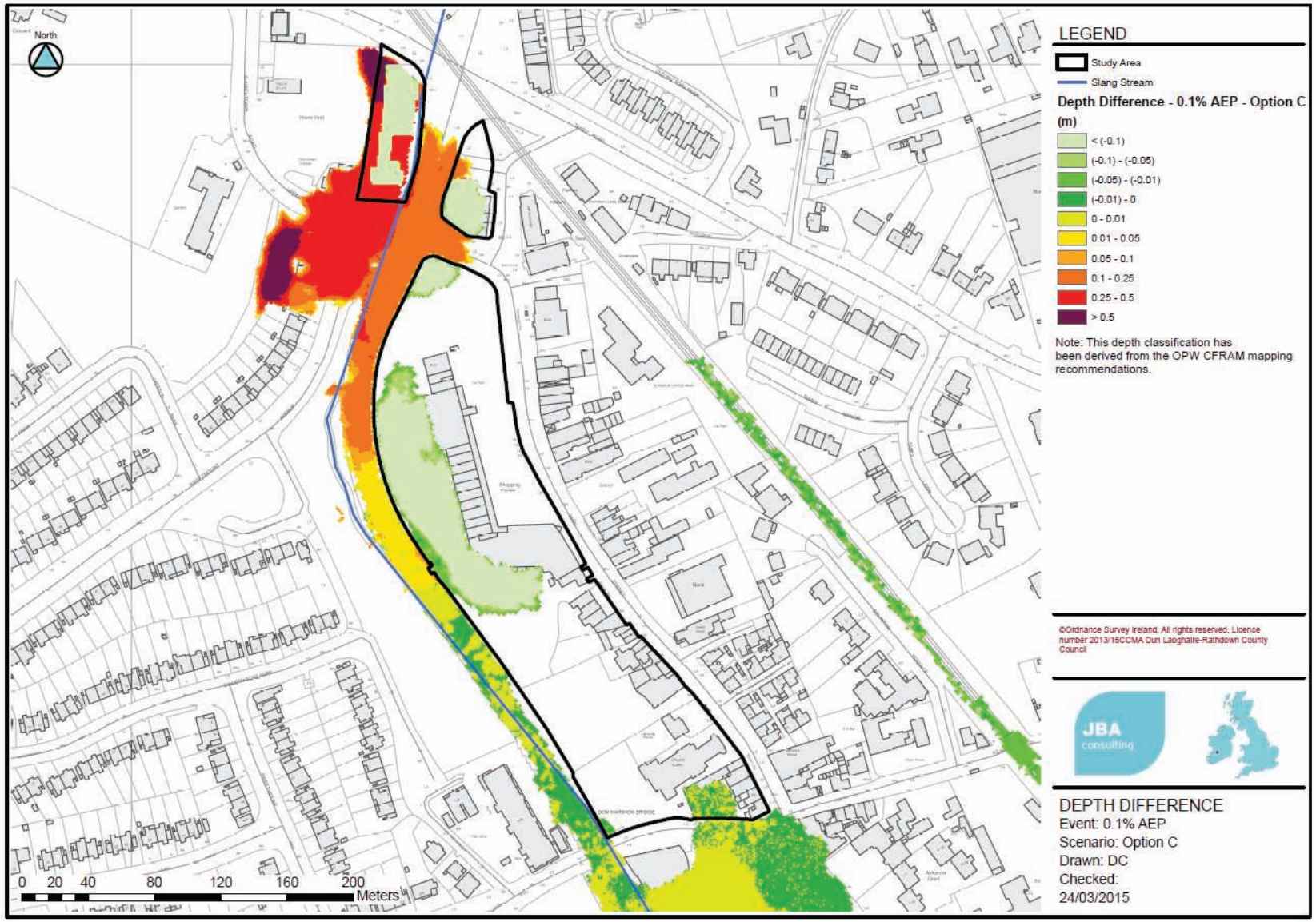
7.6 Depth Difference - 0.1% AEP - Option B



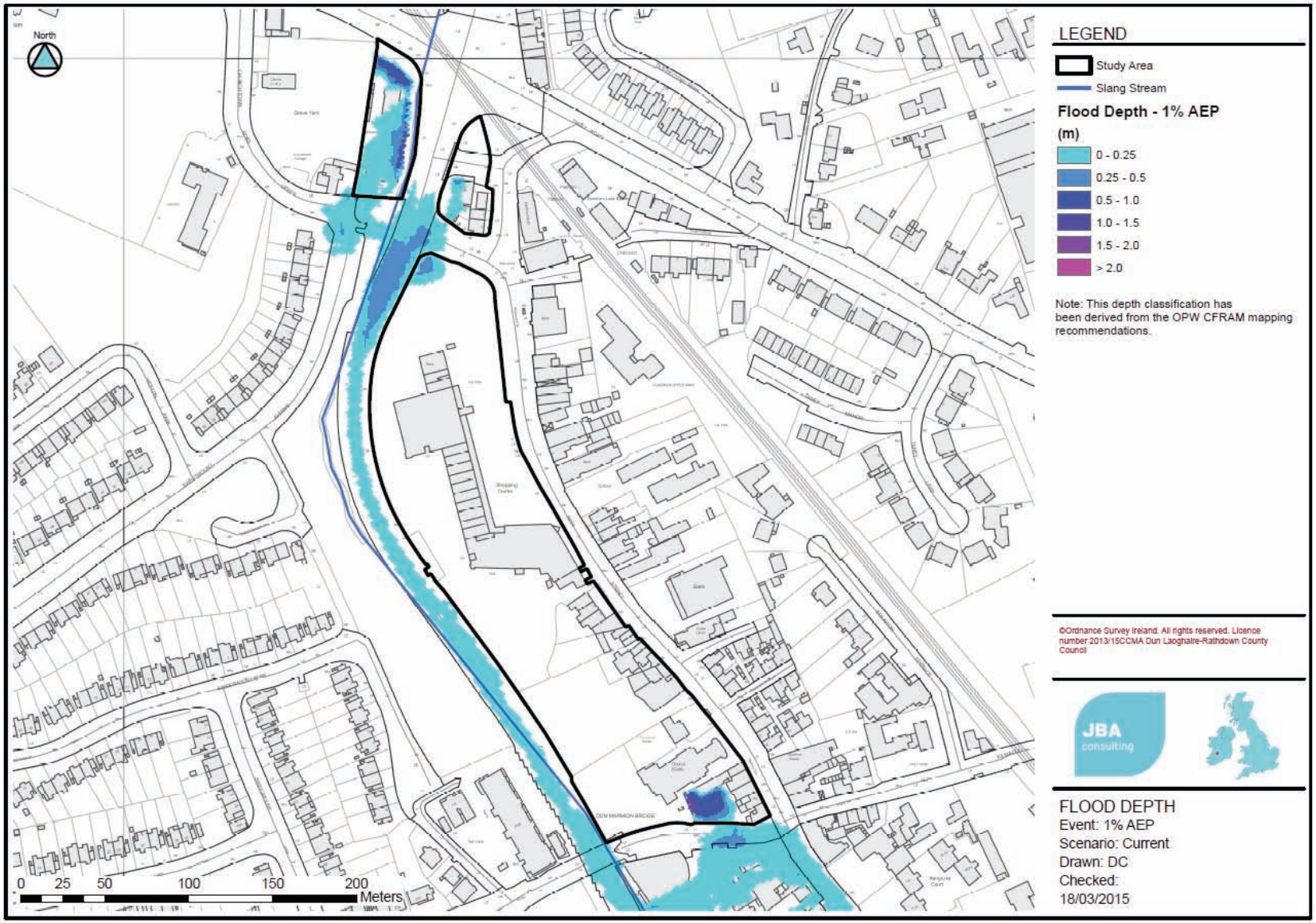
7.7 Depth Difference - 1% AEP - Option C



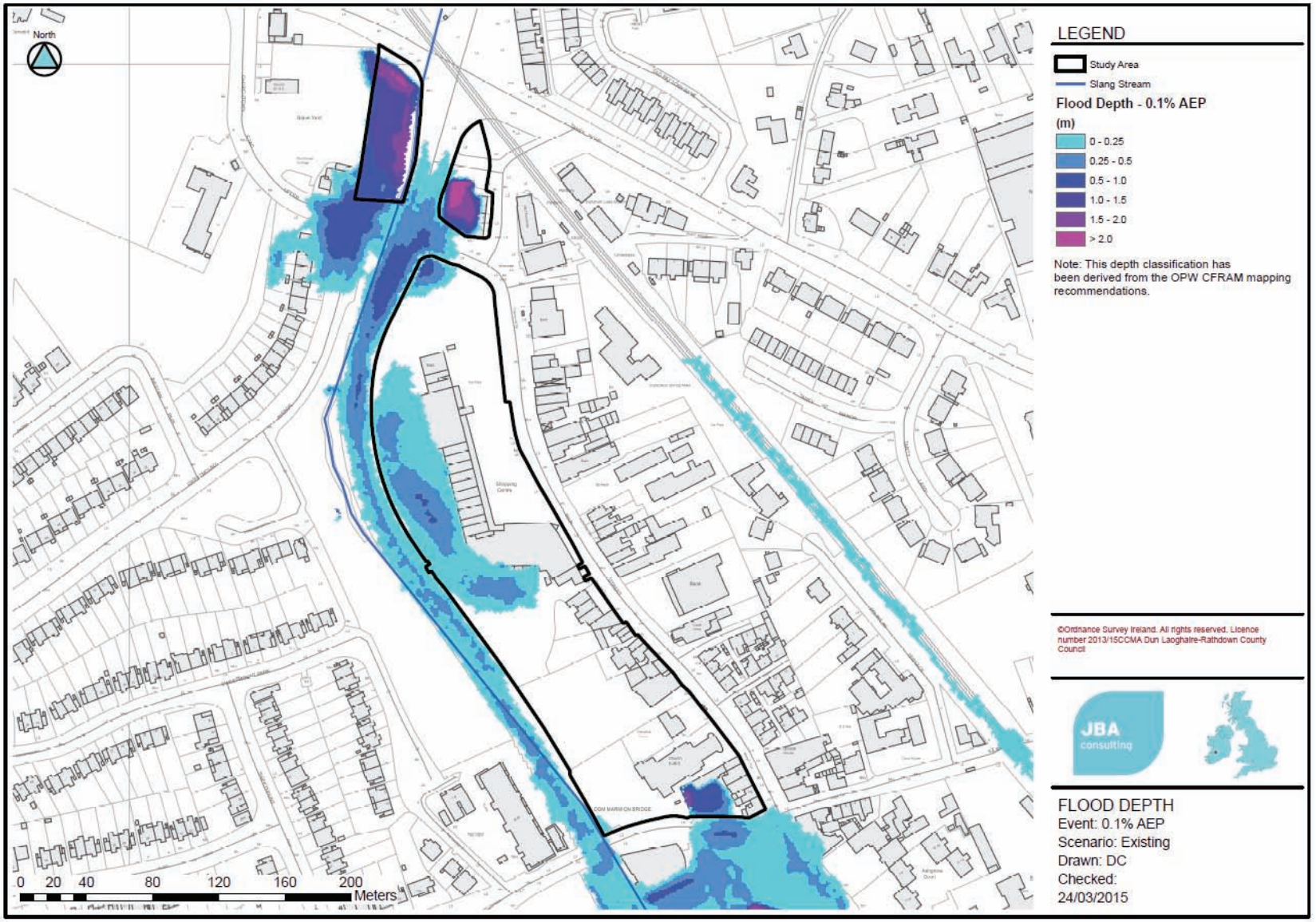
7.8 Depth Difference - 0.1% AEP - Option C



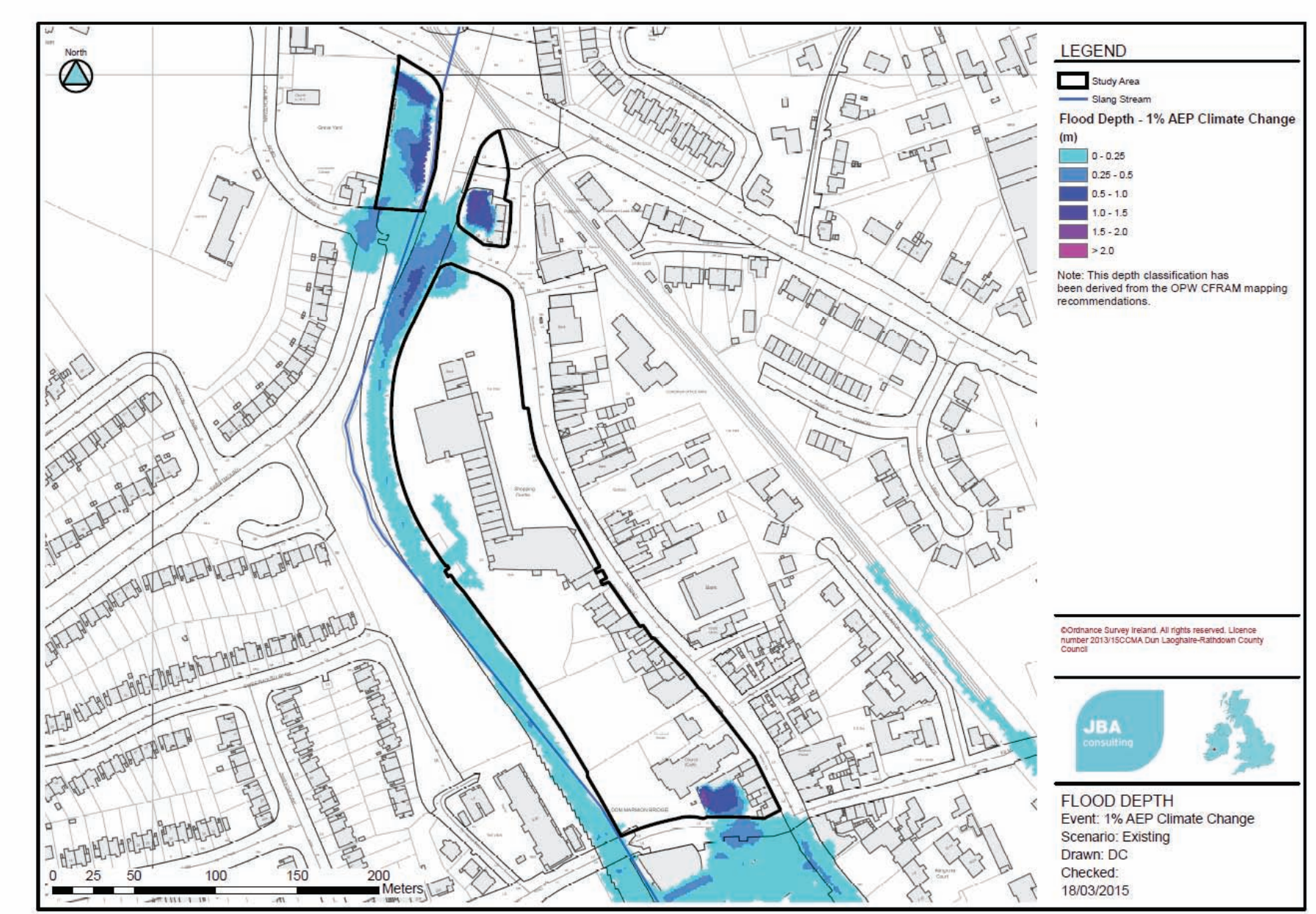
7.9 Depth - 1% AEP - Existing



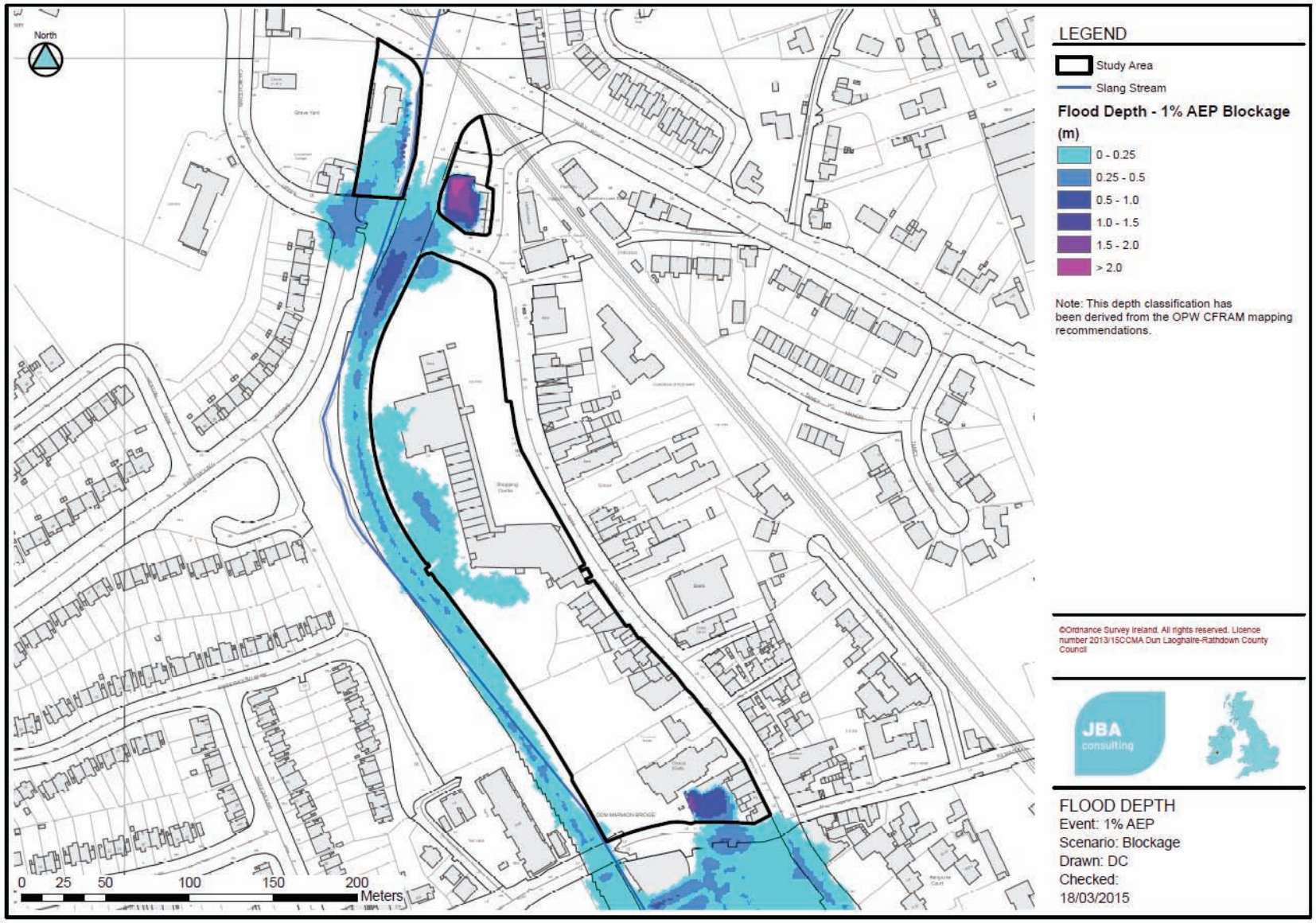
7.10 Depth - 0.1% AEP - Existing



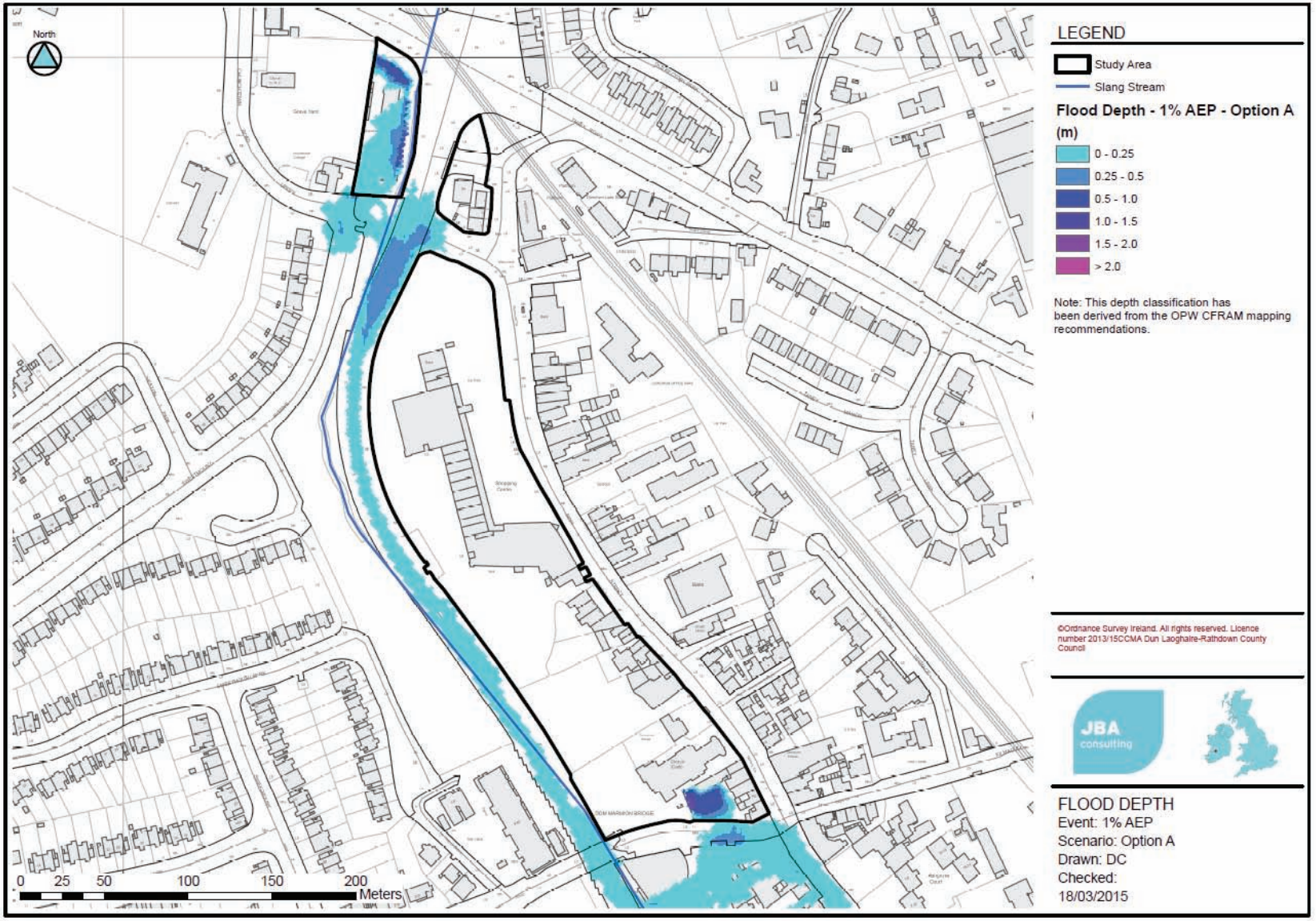
7.11 Depth - 1% AEP + Climate Change - Existing



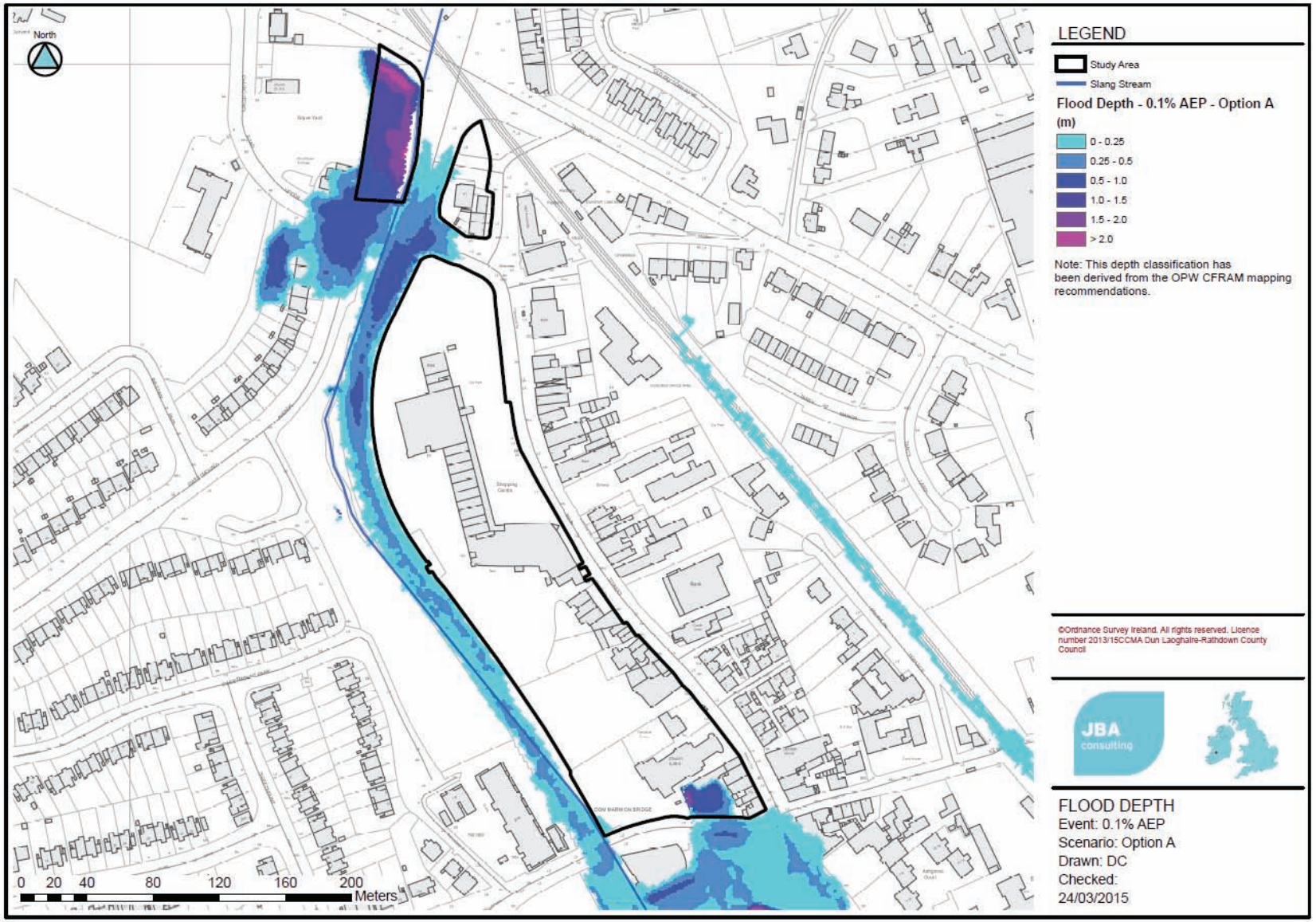
7.12 Depth - 1% AEP - Blockage



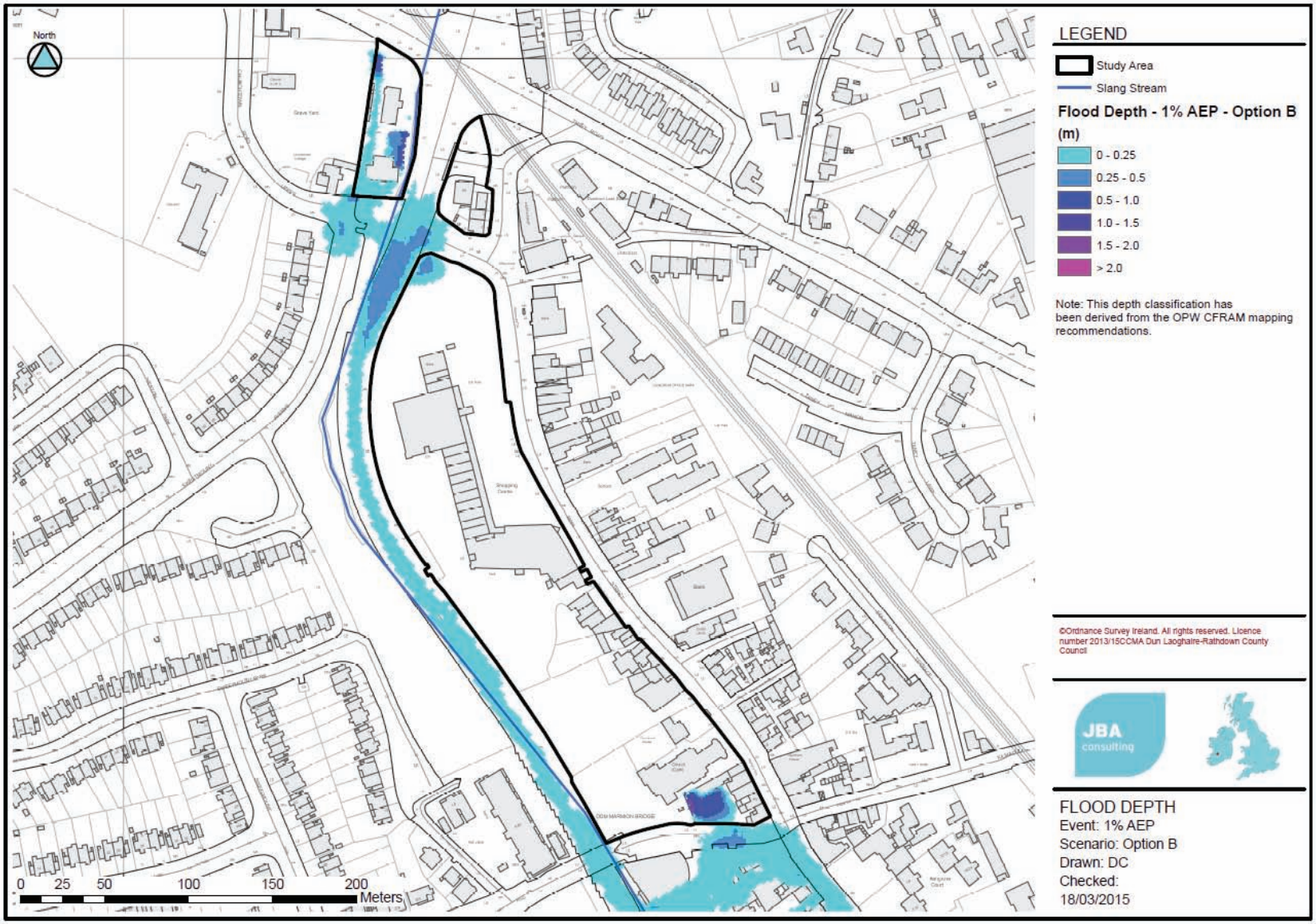
7.13 Depth - 1% AEP - Option A



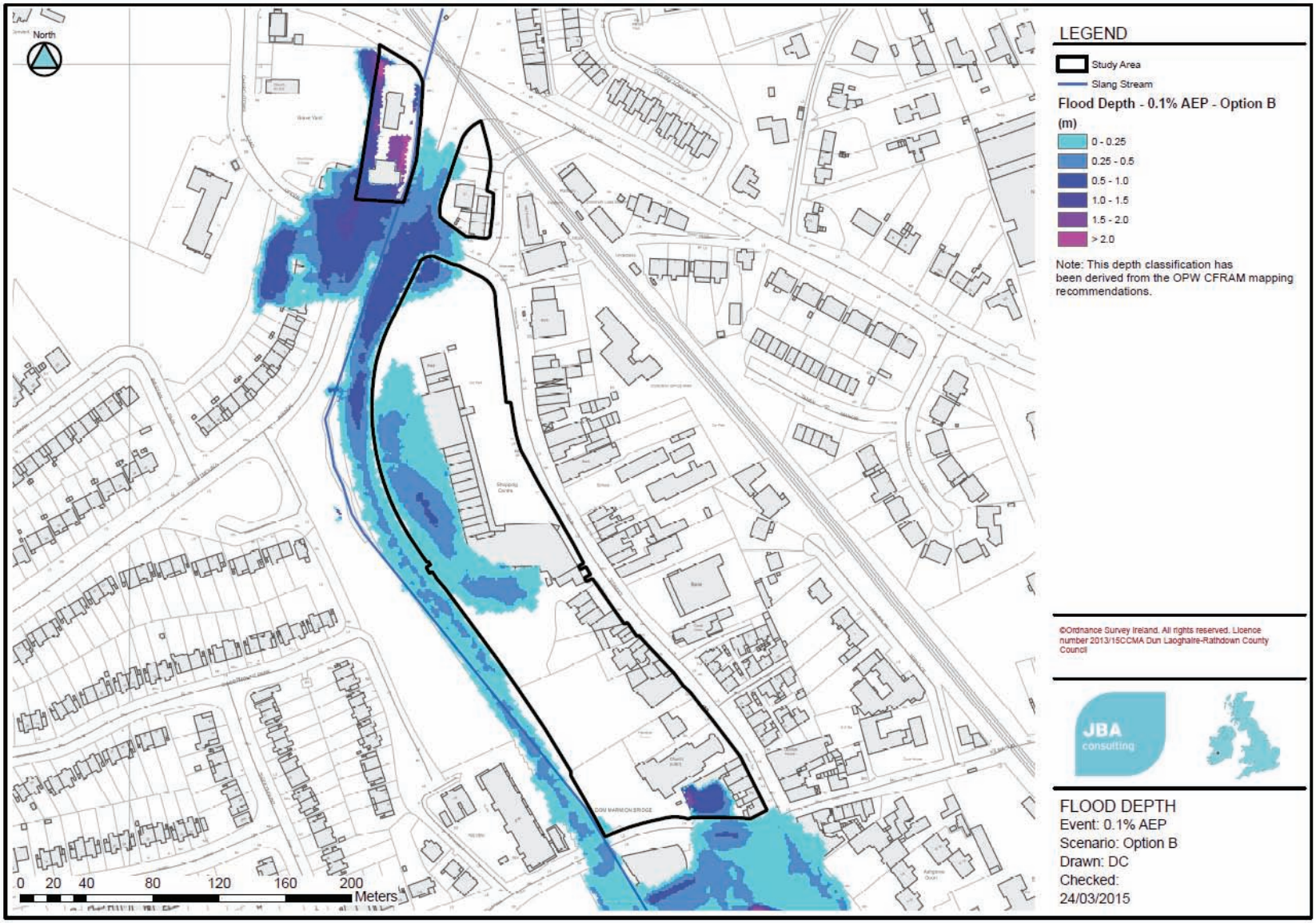
7.14 Depth - 0.1% AEP - Option A



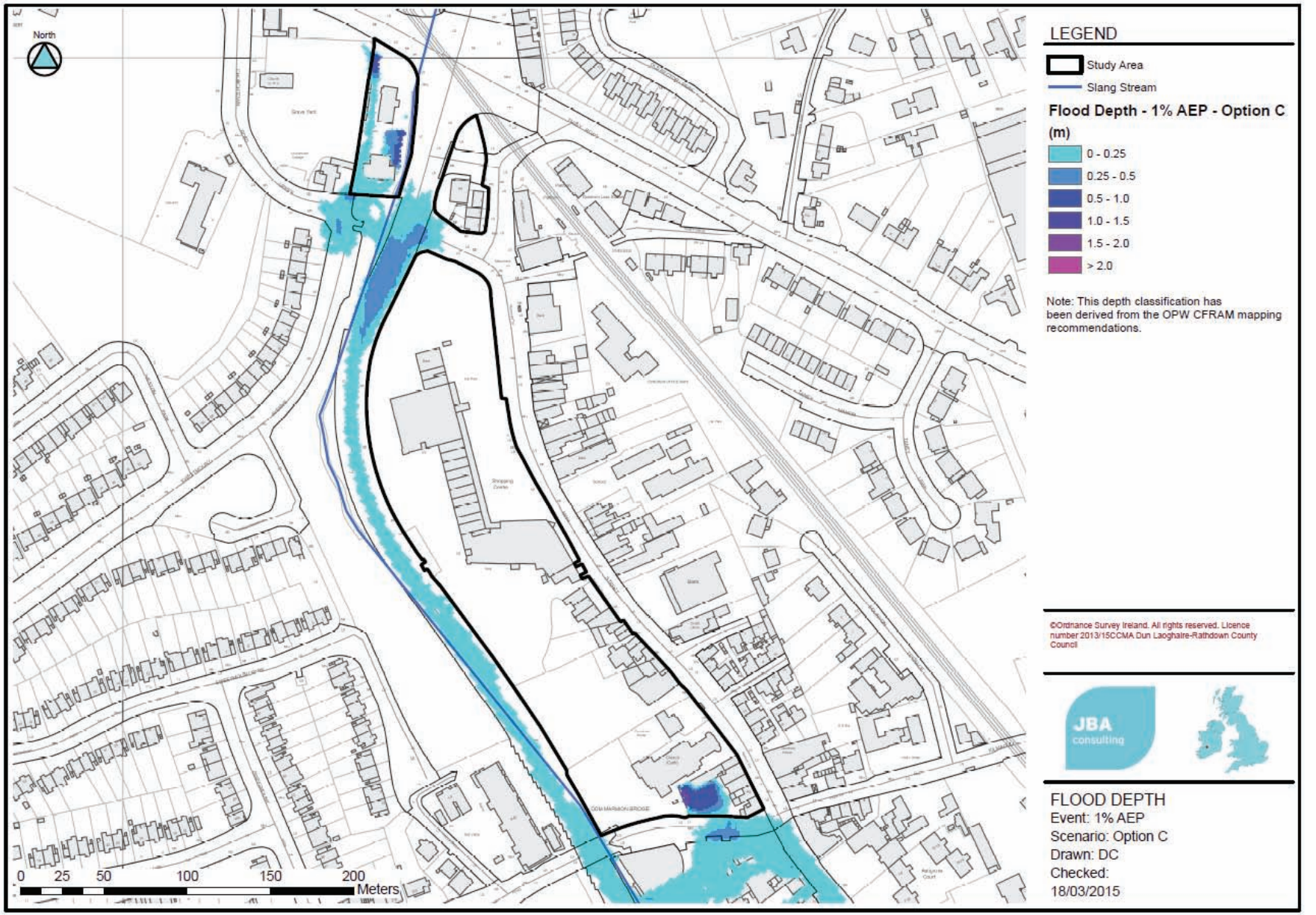
7.15 Depth - 1% AEP - Option B



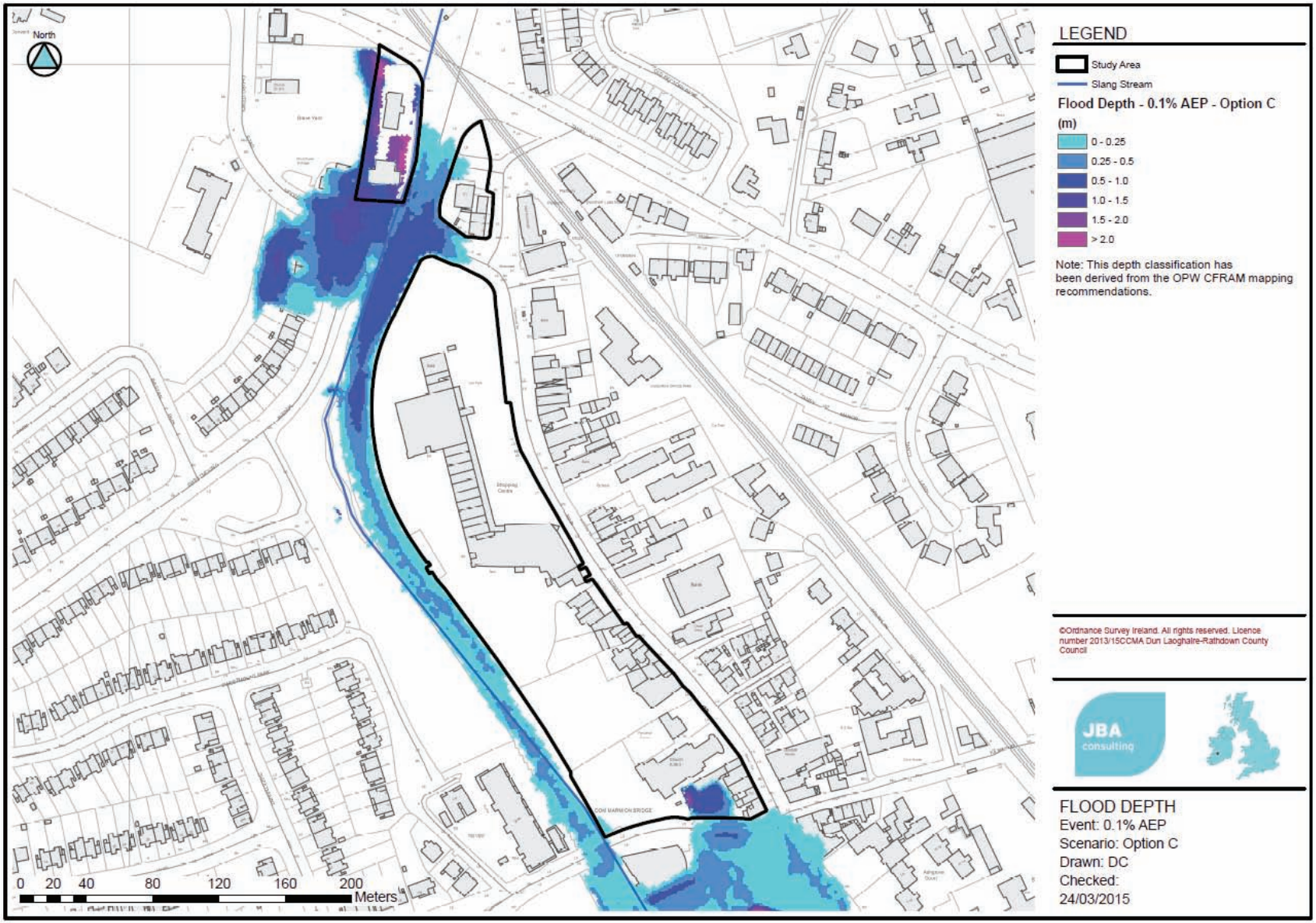
7.16 Depth - 0.1% AEP - Option B



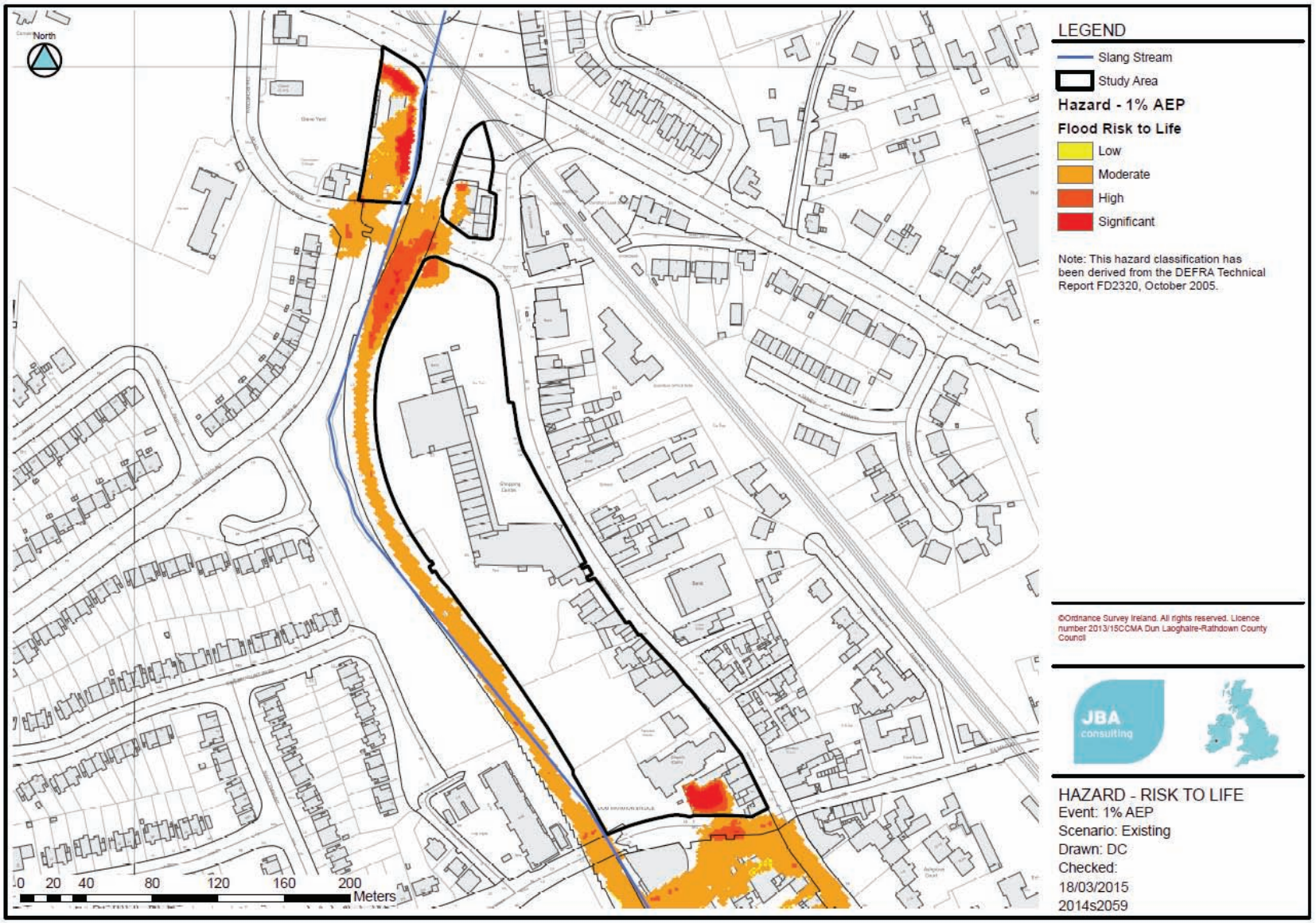
7.17 Depth - 1% AEP - Option C



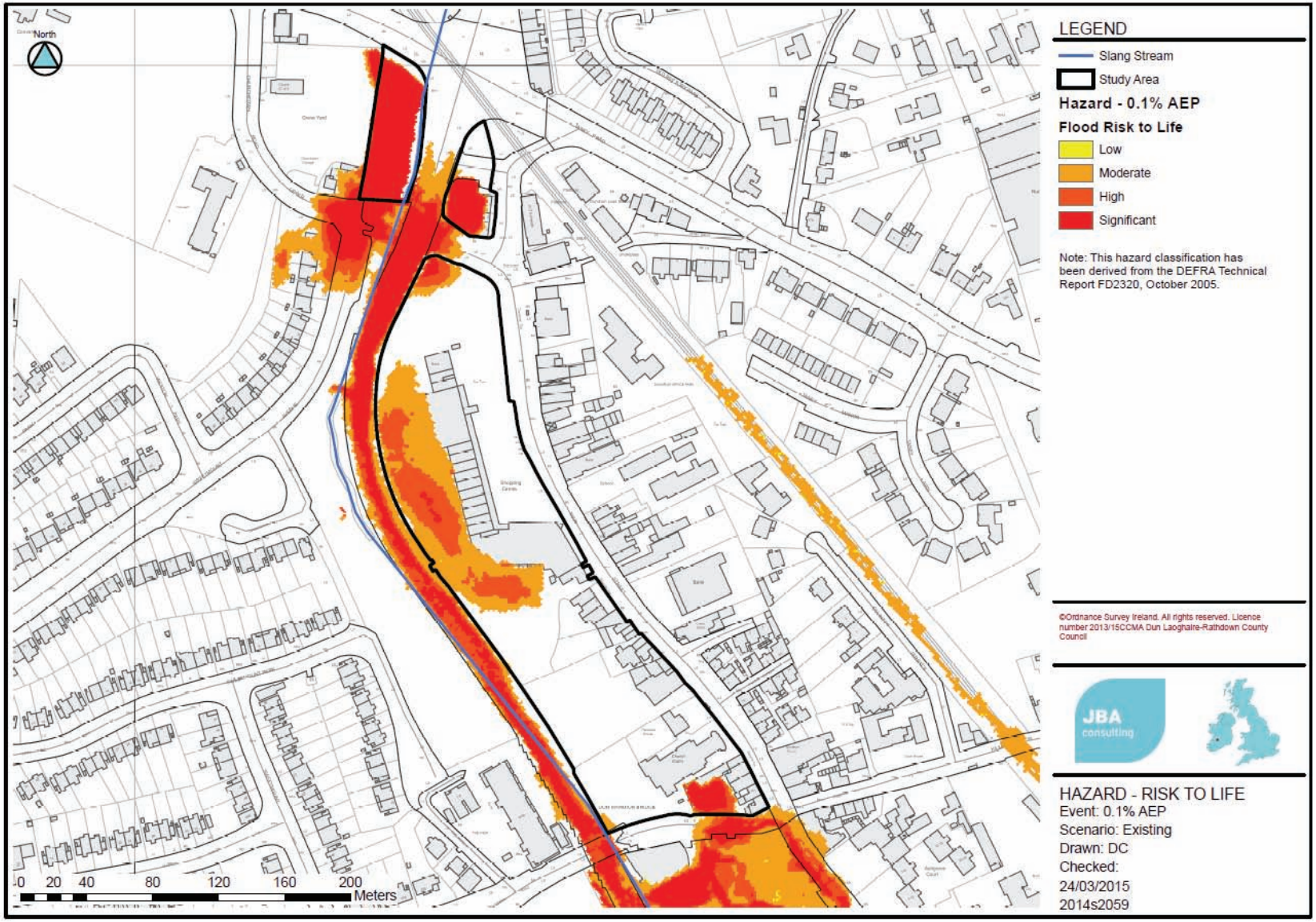
7.18 Depth - 0.1% AEP - Option C



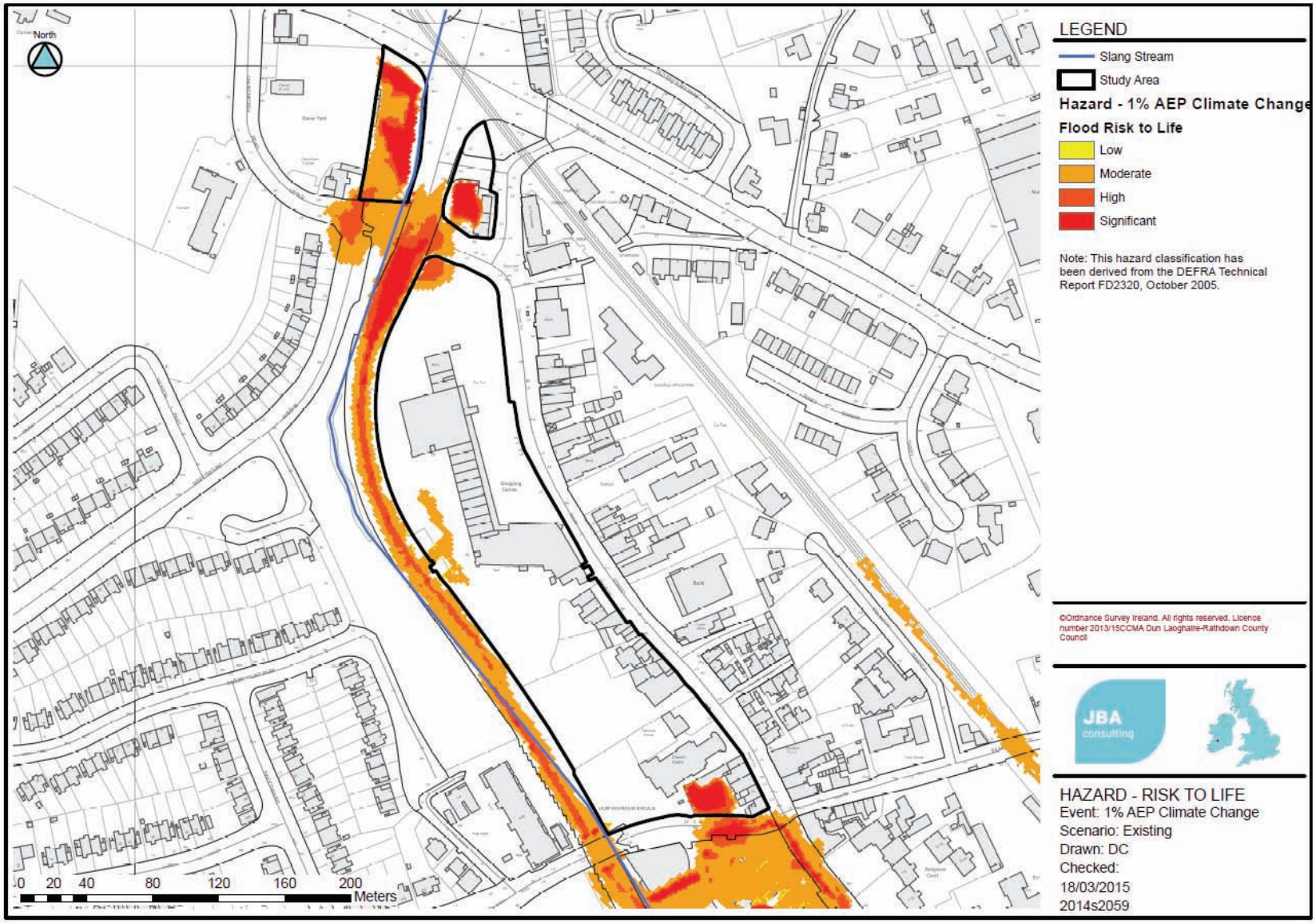
7.19 Hazard - 1% AEP - Existing



7.20 Hazard - 0.1% AEP - Existing



7.21 Hazard - 1% AEP + Climate Change- Existing



Appendices

A Hydrology

1 PROJECT

1.1 Project

Internal Reviewer	Ross Bryant
Office	Limerick
Project Manager	Ross Bryant
Analyst	D Forde
Project Title	Dundrum DP FRA
Client Name	DLR CoCo
Client Contact	DLR

2 SITE

2.1 Site Details

Site Code	LIMERICK_20/01/2015 15:29:47
Site Name	Dundrum Development
Site Location	Ireland
Site Description	This particular development is downstream of the Dundrum Town Centre and is susceptible to overland flooding from the Slang.
Watercourse Catchment	Dodder
Watercourse Name	Slang

2.2 Catchment

AREA (km2)	4.406
SAAR (mm)	776.68
FARL	1
S1085 (m/km)	37.0228
BFIsoil	0.5566
DRAIND (km/km2)	1.137
URBEXT	0.6135

3 FSR Rainfall-Runoff

3.1 Parameters

S1085 (m/km)	37.0228004455566
URBAN	0.961354498505592
MSL (km)	4.278
M5-2day (mm)	62
r	0.25
Catchment wetness index (mm)	112.7
WRAP Soil Class 1	0
WRAP Soil Class 2	1
WRAP Soil Class 3	0
WRAP Soil Class 4	0
WRAP Soil Class 5	0
Instantaneous unit hydrograph time-to-peak (hours)	0.750
Timestep (hours)	0.1
Standard Percentage Runoff (%)	30
Baseflow (m3/s)	0.085
Comments	
Storm Duration (hours)	1.5
Profile	Summer
Areal reduction factor (hours)	0.943

3.2 Results

Flow return period (years)	Rainfall return period (years)	Rainfall Depth (including ARF) (mm)	Peak Flow (m3/s)	Volume (000m3)	Specific Discharge (l/s/ha)	Growth Factor
2	2	12.817	4.93	23	11.19	1
5	5	16.911	6.48	30	14.71	1.31
10	10	20.007	7.65	36	17.36	1.55
20	20	23.297	8.9	41	20.2	1.81
75	75	26.943	10.28	47	23.33	2.09
100	100	33.066	12.59	58	28.57	2.55
1000	1000	54.198	21.82	100	49.52	4.43

3.3 Hydrographs

Return Period- 2 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.147	0.061	0.000	0.085
0.100	0.194	0.081	0.009	0.094
0.200	0.258	0.108	0.031	0.116
0.300	0.348	0.145	0.069	0.154
0.400	0.478	0.199	0.128	0.213
0.500	0.673	0.281	0.218	0.303
0.600	0.990	0.413	0.351	0.436
0.700	1.601	0.668	0.546	0.631
0.800	3.005	1.254	0.842	0.927
0.900	1.601	0.668	1.312	1.397
1.000	0.990	0.413	1.863	1.948
1.100	0.673	0.281	2.450	2.535
1.200	0.478	0.199	3.043	3.128
1.300	0.348	0.145	3.616	3.701
1.400	0.258	0.108	4.141	4.226
1.500	0.194	0.081	4.578	4.663
1.600			4.848	4.933
1.700			4.804	4.889
1.800			4.591	4.677
1.900			4.275	4.360
2.000			3.888	3.973
2.100			3.456	3.541
2.200			2.995	3.080
2.300			2.517	2.602
2.400			2.053	2.138
2.500			1.608	1.693
2.600			1.188	1.273
2.700			0.805	0.890

2.800			0.478	0.564
2.900			0.287	0.372
3.000			0.166	0.251
3.100			0.088	0.173
3.200			0.040	0.125
3.300			0.012	0.098

Return Period- 5 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.194	0.081	0.000	0.085
0.100	0.256	0.107	0.012	0.097
0.200	0.340	0.142	0.041	0.126
0.300	0.459	0.191	0.091	0.176
0.400	0.630	0.263	0.169	0.254
0.500	0.888	0.371	0.288	0.373
0.600	1.306	0.545	0.463	0.548
0.700	2.112	0.881	0.720	0.805
0.800	3.965	1.654	1.111	1.196
0.900	2.112	0.881	1.731	1.816
1.000	1.306	0.545	2.459	2.544
1.100	0.888	0.371	3.233	3.318
1.200	0.630	0.263	4.015	4.100
1.300	0.459	0.191	4.771	4.856
1.400	0.340	0.142	5.463	5.548
1.500	0.256	0.107	6.040	6.125
1.600			6.396	6.482
1.700			6.338	6.423
1.800			6.058	6.143
1.900			5.641	5.726
2.000			5.129	5.214
2.100			4.559	4.644
2.200			3.952	4.037
2.300			3.321	3.406
2.400			2.709	2.794
2.500			2.121	2.206
2.600			1.567	1.652
2.700			1.062	1.147
2.800			0.631	0.716
2.900			0.378	0.463

3.000			0.219	0.304
3.100			0.117	0.202
3.200			0.053	0.138
3.300			0.016	0.101

Return Period- 10 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.230	0.096	0.000	0.085
0.100	0.302	0.126	0.015	0.100
0.200	0.402	0.168	0.048	0.133
0.300	0.543	0.226	0.107	0.192
0.400	0.746	0.311	0.200	0.285
0.500	1.051	0.438	0.341	0.426
0.600	1.545	0.644	0.548	0.633
0.700	2.499	1.042	0.852	0.937
0.800	4.691	1.957	1.314	1.399
0.900	2.499	1.042	2.048	2.133
1.000	1.545	0.644	2.909	2.994
1.100	1.051	0.438	3.825	3.910
1.200	0.746	0.311	4.750	4.835
1.300	0.543	0.226	5.645	5.730
1.400	0.402	0.168	6.464	6.549
1.500	0.302	0.126	7.146	7.231
1.600			7.568	7.653
1.700			7.498	7.583
1.800			7.167	7.252
1.900			6.674	6.759
2.000			6.069	6.154
2.100			5.394	5.479
2.200			4.675	4.760
2.300			3.930	4.015
2.400			3.205	3.290
2.500			2.509	2.594
2.600			1.854	1.939
2.700			1.256	1.341
2.800			0.747	0.832
2.900			0.448	0.533

3.000			0.259	0.344
3.100			0.138	0.223
3.200			0.063	0.148
3.300			0.019	0.105

Return Period- 20 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.267	0.112	0.000	0.085
0.100	0.352	0.147	0.017	0.102
0.200	0.469	0.196	0.056	0.141
0.300	0.632	0.264	0.125	0.210
0.400	0.868	0.362	0.233	0.318
0.500	1.224	0.510	0.397	0.482
0.600	1.799	0.750	0.638	0.723
0.700	2.910	1.214	0.992	1.077
0.800	5.463	2.279	1.530	1.615
0.900	2.910	1.214	2.385	2.470
1.000	1.799	0.750	3.387	3.472
1.100	1.224	0.510	4.454	4.539
1.200	0.868	0.362	5.531	5.616
1.300	0.632	0.264	6.573	6.658
1.400	0.469	0.196	7.527	7.612
1.500	0.352	0.147	8.322	8.407
1.600			8.812	8.897
1.700			8.731	8.816
1.800			8.346	8.431
1.900			7.771	7.856
2.000			7.066	7.151
2.100			6.281	6.366
2.200			5.444	5.529
2.300			4.576	4.661
2.400			3.732	3.817
2.500			2.922	3.007
2.600			2.159	2.244
2.700			1.463	1.548
2.800			0.870	0.955
2.900			0.521	0.606

3.000			0.302	0.387
3.100			0.161	0.246
3.200			0.073	0.158
3.300			0.023	0.108

Return Period- 75 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.309	0.129	0.000	0.085
0.100	0.407	0.170	0.020	0.105
0.200	0.542	0.226	0.065	0.150
0.300	0.731	0.305	0.144	0.229
0.400	1.004	0.419	0.270	0.355
0.500	1.415	0.590	0.459	0.544
0.600	2.080	0.868	0.737	0.822
0.700	3.365	1.404	1.147	1.232
0.800	6.318	2.636	1.769	1.854
0.900	3.365	1.404	2.758	2.843
1.000	2.080	0.868	3.917	4.002
1.100	1.415	0.590	5.151	5.236
1.200	1.004	0.419	6.397	6.482
1.300	0.731	0.305	7.602	7.687
1.400	0.542	0.226	8.705	8.790
1.500	0.407	0.170	9.624	9.709
1.600			10.191	10.276
1.700			10.098	10.183
1.800			9.652	9.737
1.900			8.987	9.072
2.000			8.172	8.257
2.100			7.265	7.350
2.200			6.296	6.381
2.300			5.292	5.377
2.400			4.316	4.401
2.500			3.379	3.464
2.600			2.497	2.582
2.700			1.691	1.776
2.800			1.006	1.091
2.900			0.603	0.688

3.000			0.349	0.434
3.100			0.186	0.271
3.200			0.084	0.169
3.300			0.026	0.111

Return Period- 100 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.380	0.158	0.000	0.085
0.100	0.500	0.208	0.024	0.109
0.200	0.665	0.277	0.079	0.165
0.300	0.897	0.374	0.177	0.262
0.400	1.232	0.514	0.331	0.416
0.500	1.737	0.724	0.563	0.648
0.600	2.553	1.065	0.905	0.990
0.700	4.130	1.723	1.408	1.493
0.800	7.754	3.235	2.171	2.257
0.900	4.130	1.723	3.385	3.470
1.000	2.553	1.065	4.807	4.892
1.100	1.737	0.724	6.321	6.406
1.200	1.232	0.514	7.851	7.936
1.300	0.897	0.374	9.329	9.414
1.400	0.665	0.277	10.683	10.768
1.500	0.500	0.208	11.811	11.896
1.600			12.507	12.592
1.700			12.393	12.478
1.800			11.845	11.930
1.900			11.030	11.115
2.000			10.030	10.115
2.100			8.915	9.000
2.200			7.727	7.812
2.300			6.494	6.579
2.400			5.297	5.382
2.500			4.147	4.232
2.600			3.064	3.149
2.700			2.076	2.161
2.800			1.234	1.319
2.900			0.740	0.825

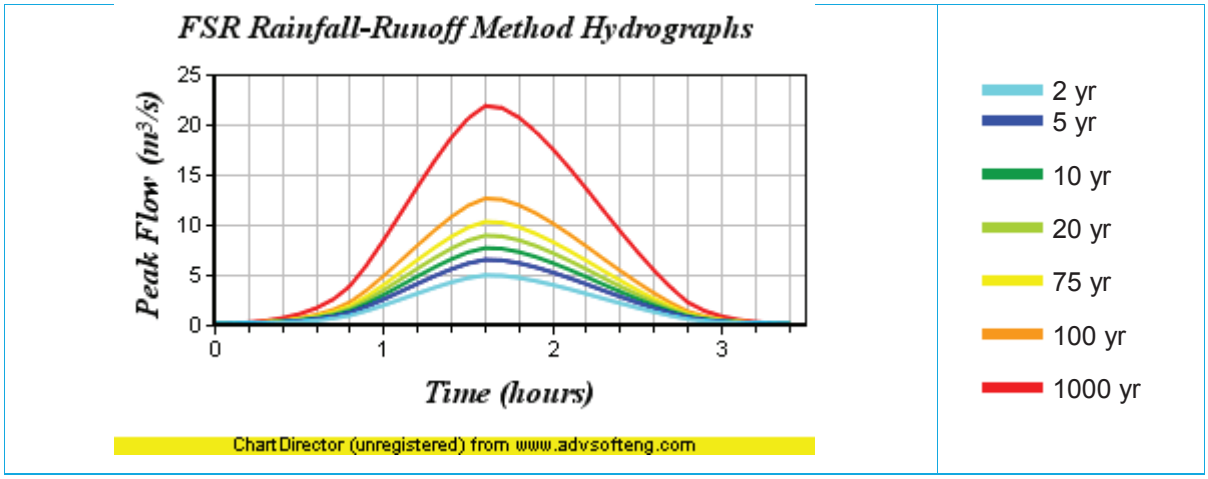
3.000			0.428	0.513
3.100			0.228	0.313
3.200			0.103	0.188
3.300			0.032	0.117

Return Period- 1000 yr

Time (hr)	Total Rainfall (mm)	Net Rainfall (mm)	Surface Runoff (m3 s-1)	Total Flow (m3 s-1)
0.000	0.622	0.275	0.000	0.085
0.100	0.819	0.362	0.042	0.127
0.200	1.090	0.482	0.138	0.223
0.300	1.471	0.651	0.308	0.393
0.400	2.020	0.893	0.576	0.661
0.500	2.846	1.259	0.979	1.064
0.600	4.185	1.851	1.573	1.658
0.700	6.769	2.994	2.447	2.532
0.800	12.709	5.622	3.774	3.859
0.900	6.769	2.994	5.883	5.968
1.000	4.185	1.851	8.355	8.440
1.100	2.846	1.259	10.985	11.070
1.200	2.020	0.893	13.644	13.729
1.300	1.471	0.651	16.213	16.298
1.400	1.090	0.482	18.565	18.650
1.500	0.819	0.362	20.526	20.611
1.600			21.736	21.821
1.700			21.537	21.622
1.800			20.585	20.670
1.900			19.168	19.253
2.000			17.430	17.515
2.100			15.494	15.579
2.200			13.428	13.513
2.300			11.287	11.372
2.400			9.205	9.290
2.500			7.207	7.292
2.600			5.325	5.410
2.700			3.608	3.693
2.800			2.145	2.230
2.900			1.286	1.371

3.000			0.744	0.829
3.100			0.396	0.481
3.200			0.180	0.265
3.300			0.056	0.141

Figure 3-1: FSR Rainfall-Runoff Results Chart



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