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Flood Risk Assessment

Barnhill Garden Village SHD

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1 INTRODUCTION

1.1 Terms of Reference

This Flood Risk Assessment (FRA) was commissioned by Alanna Homes and Alcove Ireland Four Ltd. to support a planning application for the proposed development of 'Barnhill Garden Village SHD' in Barnhill, Dublin 15. The proposed development site is hereafter referred to as 'the site'.

1.2 Statement of Authority

This report and assessment have been prepared and reviewed by qualified professionals with appropriate experience in the fields of flood risk, surface water drainage, and hydraulic modelling studies. The key staff members involved in this project are as follows:

- Duncan Hartwick BEng (Hons) BSc (Hons) MIEI – Project Engineer with experience in flood risk assessment, hydrology, and hydraulic modelling.
- Paul Singleton BEng (Hons) MSc CEng MIEI – Chartered Civil / Environmental Engineer specialising in hydrology, flood risk assessment, drainage, and SuDS, and a recognised industry professional providing training courses on these topics to the public and private sectors in Ireland and the UK.

1.3 Purpose

This assessment is intended to produce a detailed site-specific FRA (SSFRA) to ensure that all relevant issues related to flooding are addressed. This Stage 3 FRA will assess the adequacy of existing information and present analysis undertaken to supplement existing data.

The assessment will ultimately determine potential sources of flooding at the site and their associated risk to life and property. It will also determine the suitability of the site for future development based on relevant flood risk management planning policy guidelines and propose appropriate design and mitigation measures, where appropriate, to be considered as part of the development proposal.

1.4 Approach to the Assessment

Consideration has been given to the sources and extent of fluvial flooding at the site, as well as flooding from overland flow and ponding of localised rainfall at the site.

The method of assessment applied complies with the Source-Pathway-Receptor model and provides a spatial assessment of flood risk to people, property, and the environment at the site. Existing runoff characteristics and the potential impact of the proposed development on pluvial (surface water) runoff are also considered.

1.4.1 Hydraulic Model Status

For the purposes of this assessment, the primary stakeholders are the Office of Public Works (OPW) and The site and surrounding environs are included in the Preliminary Flood Risk Assessment (PFRA); the first stage of the CFRAM process that included national-scale flood mapping. The PFRA is a preliminary-only assessment based on available or readily-derivable information. The indicative analysis was undertaken to identify areas prone to flooding and mapping is considered to be coarse and is designed to inform further stages in the CFRAM process.

Therefore, to facilitate better understanding of flood risk at the site and to inform future development, detailed hydraulic modelling has been undertaken and is summarised in this report. <u>The model results summarised in this report are intended to supersede existing flood maps / data and are considered fit-for-purpose for this assessment.</u>

1.4.2 Planning Guidelines

The requirements for Flood Risk Assessments are generally as set out in the OPW's 'The Planning System and Flood Risk Management – Guidelines for Planning Authorities', 2009 (hereafter referred to as the 'OPW Guidelines') and accompanying technical appendices. Further guidance is provided in the OPW's 'Climate Change Sectoral Adaptation Plan', 2019, and CIRIA Research Project 624 'Development and Flood Risk – Guidance for the Construction Industry', 2004.

Planning guidelines applicable to the site are set out in the 'Fingal Development Plan 2017-2023', specifically through the 'Strategic Flood Risk Assessment for the Fingal Development Plan 2017-2023' (hereafter referred to as 'the SFRA').

The SFRA was prepared in accordance with the requirements of the OPW Guidelines and adopts an identical Flood Zone standard. Flood Zones are the extents of design flood events that determine whether development is appropriate from a flood risk point of view. They are defined in the OPW Guidelines and SFRA as follows:

- Flood Zone A – where the probability of flooding from rivers and the sea is highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding).
- Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 and 0.5% or 1 in 200 for coastal flooding).
- Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding).

The OPW Guidelines and SFRA clarify that Flood Zones are to be used to determine the suitability of proposed developments and are to be derived from 'present day' hydrological estimates. The OPW Guidelines and SFRA also state that Flood Zones are generated without the inclusion of climate change and that, in addition to flood zoning, developments should be designed to be resilient to the effects of climate change.

2 DEVELOPMENT AND SITE DETAILS

2.1 Site Location and Boundary

Figure 2.1: Site Location

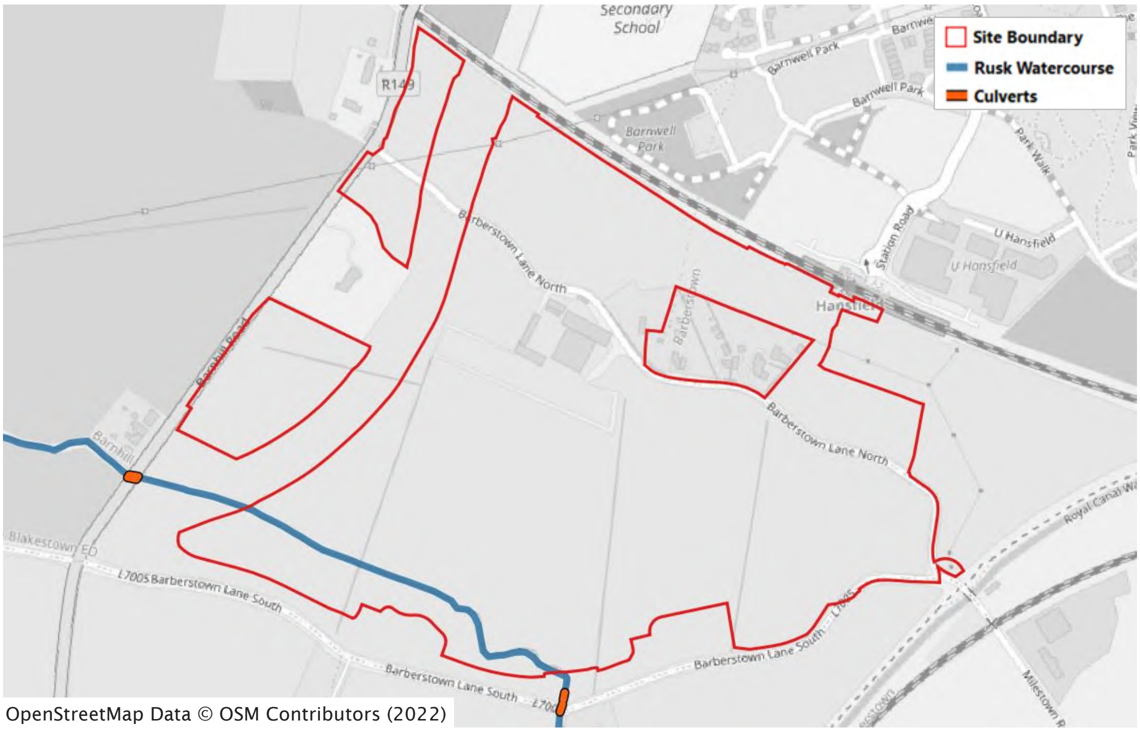


Figure 2.2: Site Boundary

2.2 Affecting Waterbodies

As shown in Figure 2.2, a watercourse flows in a south-east direction through the southern extent of the site and discharges to the River Liffey approximately 3 km downstream. This watercourse is called the Rusk Watercourse in EPA datasets and known locally as the Barnhill Stream and is hereafter referred to as the 'Rusk Watercourse'.

Upstream of and through the site, the watercourse flows through agricultural land and is heavily overgrown. The watercourse passes through a number of crossings in the vicinity of the site

To the south-east of the site, the watercourse passes through a culvert beneath the Royal Canal and Irish Rail train line which are situated at a significantly higher elevation. Downstream of the site, the Rusk watercourse flows alongside the car park of Westmanstown Sports Centre and discharges to a series of lakes within Luttrelstown Golf Course before passing onto the River Liffey to the south-east.

2.3 Existing Site Description

The site under consideration is located in Barnhill, Co. Dublin approximately 2 km west of Clonsilla. Existing site characteristics are summarised below:

- Site currently comprises primarily agricultural land and areas of existing development (buildings and roads).
- Site access is via Barberstown Lane North and Barberstown Lane South.
- Site levels generally fall from west to east.

Ground levels are based on a topographical survey commissioned and undertaken by a third party. A survey drawing showing existing ground levels at the site was provided and is included in Appendix A.

Photographs of the site and surrounding area were taken during a walkover survey conducted by McCloy Consulting and are included in Appendix F.

2.4 Development Proposals

The current development proposals on which this assessment is based are as follows:

> *The proposed development will consist of the demolition of the existing vacant industrial buildings and the construction of 1,243 residential units, commercial and community facilities, railway plaza providing access to Hansfield railway station; land set aside for a primary school, a public park and a series of pocket parks throughout the development and all associated infrastructure and ancillary development works. The proposed commercial and community development provides for a variety of uses including commercial, retail, creche, medical, community and office space along with high-quality recreation and amenity space throughout the site.*

Drawings showing the current proposals are provided in Appendix A.

2.5 Vulnerability Classification

Based on the classification criteria outlined in Table 2.1 of the OPW Guidelines, the proposal comprises development with the vulnerability classification shown in Table 2.1 below.

Table 2.1: Vulnerability Classification

Part	Use	Classification
Built Development	Residential	Highly Vulnerable
	Creche	Highly Vulnerable
	Commercial	Less Vulnerable
Access Roads / Car Parking	Local Transport Infrastructure	Less Vulnerable
Green Areas	Open Amenity Space	Water-Compatible Development

3 BACKGROUND INFORMATION REVIEW

As part of the data collection phase of this assessment, several available sources of information generally as set out in the OPW Guidelines were investigated to build an understanding of the potential risk of flooding to the site. The following review highlights the key findings of this background information.

3.1 Office of Public Works

3.1.1 Preliminary Flood Risk Assessment

The Office of Public Works (OPW) have developed draft Flood Maps as part of the Catchment Flood Risk Assessment and Management (CFRAM) Programme.

The first stage of the CFRAM process was to produce a Preliminary Flood Risk Assessment (PFRA) that included flood mapping for the entire country. The PFRA is only a preliminary assessment based on available or readily-derivable information. The analysis was undertaken to identify areas prone to flooding, but the analysis is purely indicative, and mapping is considered to be coarse and is designed to inform further stages in the CFRAM process.

The site and surrounding area have been shown to be prone to flooding as part of the PFRA but has not been subject to any further, more detailed assessment. Extract from the above referenced flood map is shown in Figure 3.1. A copy of the PFRA flood map from which this extract is taken is included in Appendix B.

Figure 3.1: PFRA Indicative Flood Mapping

3.1.2 Past Flood Events Mapping

OPW 'Past Flood Event' mapping available through floodinfo.ie has no records of historic flooding in Barnhill and surrounding areas.

3.2 Fingal County Council

3.2.1 Fingal Development Plan 2017-2023

The 'Fingal Development Plan 2017-2023' has been reviewed as part of this assessment and the following objectives are considered pertinent to the development proposals:

- **SW02** – Allow no new development within floodplains other than developments that satisfy the criteria of the Justification Test, as outlined in the OPW Guidelines.
- **SW04** – Require the use of Sustainable Drainage Systems (SuDS) to minimise and limit the extent of hard surfacing and paving and require the use of sustainable drainage techniques, where appropriate, for new development or for extensions to existing developments to reduce the potential impact of existing and predicted flood risks.
- **SW07** – Implement the OPW Guidelines or any updated version of these. A site-specific Flood Risk Assessment with an appropriate level of detail and that addresses all potential sources of flood risk is required for lands identified in the SFRA as being susceptible to flooding, including Mulhuddart. Consideration should be given to residual flood risks and any proposed site-specific flood management measures.
- **SW08** – Implement the recommendations of the FEM FRAMS.
- **SW09** – Implement the recommendations of the Eastern CFRAMS.

3.2.2 Strategic Flood Risk Assessment for the Fingal Development Plan 2017-2023

The SFRA does not contain any reference to lands in the vicinity of the site. However, the SFRA does contain the following guidance which is considered pertinent to the Flood Study:

- Existing flood mapping, including OPW PFRA maps, are considered appropriate for use as a strategic overview of flood risk within the County (i.e., in most cases, not suitable for site-specific applications).
- Flood Zones (as outlined previously) are generated without the inclusion of climate change factors and should ignore flood defences.
- A precautionary approach to climate change includes recommendations to ensure that levels of structures designed to protect against flooding (such as flood defences or raised floor levels) are sufficient to cope with the effects of climate change over the lifetime of the development.
- The minimum finished floor level (FFL) for highly vulnerable development should be above the Flood Zone B level plus suitable freeboard, whereby the recommended level of freeboard is 500 mm over and above the adjacent Flood Zone B fluvial flood level.
- The minimum FFL for less vulnerable development should be above the Flood Zone A level plus suitable freeboard whereby the recommended level of freeboard is 500 mm over and above the adjacent Flood Zone A fluvial flood level.

3.2.3 Barnhill Local Area Plan SFRA

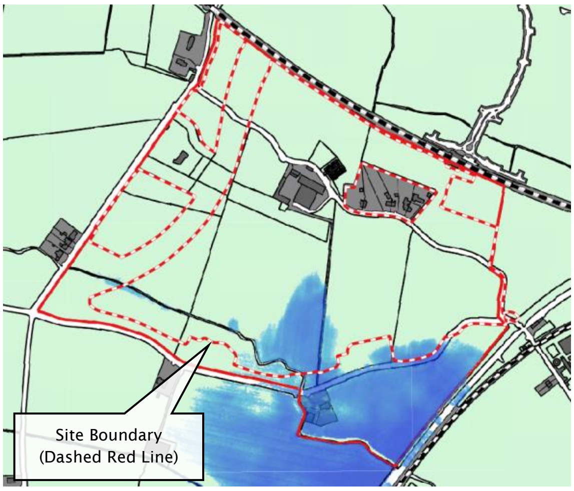
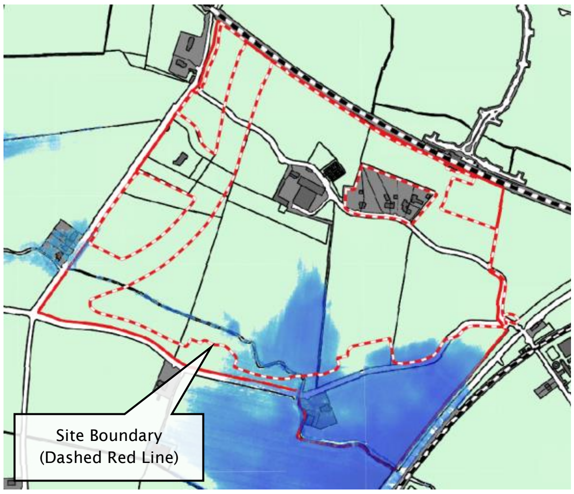
Fingal County Council has undertaken a Local Area Plan (LAP) for "Barnhill (lands south of the Dublin-Dunboyne Rail Line) for lands in the townlands of Barnhill, Barberstown, and Passifyoucan, Dublin 15." The LAP included a Strategic Flood Risk Assessment (SFRA) which has been published as part of the LAP.

The LAP SFRA concluded that the overriding flood mechanism at the site is fluvial flooding as a result of the restriction caused by a 1000 mm dia. Culvert extension at the downstream end of a larger arch culvert under the canal / railway. This conclusion was corroborated by a McCloy Consulting Flood Study undertaken in 2018 which shows flooding of areas in the south of the site.

However, Irish Rail has informed that the 1 m pipe was a temporary measure installed to permit remedial retaining wall works and was removed in May 2019. The temporary 1 m pipe has been replaced with a section of culvert that is the same size as the main length of culvert beneath the embankment. This has been confirmed by updated survey (undertaken by Murphy Surveys) and during a site visit by McCloy Consulting staff.

The site-specific modelling and subsequent results presented in this report are the existing scenario at the site which includes the re-instated culvert beneath the canal / railway, so flood extents differ to those presented in the LAP SFRA and shown in Table 3.1. It is noted that LAP land zoning has been based on the LAP SFRA wider flood extents and proposals for the site have been developed is accordance with the land zoning so despite being superseded and therefore not required, the proposed development does comply with the LAP SFRA flood mapping.

Table 3.1: Barnhill LAP SFRA Flood Maps

Barnhill LAP SFRA 1% AEP Flood Map	Barnhill LAP SFRA 0.1% AEP Flood Map
	

3.3 Greater Dublin Strategic Drainage Study

The Greater Dublin Strategic Drainage Study (GDSDS) was commissioned in 2001 to carry out a strategic analysis of the existing foul and surface water systems in the local authority areas of Dublin (including Fingal) and adjacent catchments. The objectives of the Study were to identify policies, strategies, and projects for the development of a sustainable drainage system for the Greater Dublin Region.

The GDSDS report includes information relating to the areas surrounding the site and mentions that developments to the south of Clonsilla are served by a storm water drain, which discharges to a tributary of the River Liffey. The location of the watercourse receiving storm discharge from the area is not stated and no further details relating to the site and its environs are covered.

3.4 Internet / Media Search

A media search comprising internet media and archived newspaper articles found evidence of flooding occurring in the Barnhill / Westmanstown area in February 2019[1] and November 2009[2]. These events were caused by heavy rainfall (surface water flooding) and caused localised road / overland flooding. No evidence of flooding within the site boundary was found.

3.5 Walkover Survey

Walkover surveys of the site and adjacent lands were conducted by McCloy Consulting Ltd. during which a photographic survey of the site and adjacent areas was undertaken. The unnamed watercourse was found to generally be heavily overgrown and there was no evidence of recent out-of-bank flooding. Culverts and bridges in the vicinity of the site were observed to be flowing freely with no evidence of blockage.

[1] https://www.thejournal.ie/barnhill-dublin-houses-4493740-Feb2019/ [accessed 28th June 2022]

[2] https://www.irishtimes.com/news/motorists-warned-over-flooding-1.849922 [accessed 28th June 2022]

4 ASSESSMENT OF FLOOD MECHANISMS

4.1 Initial Assessment

Development control procedures advise against inappropriate development in areas at risk of flooding and aim to avoid new development that increases flood risk elsewhere, in accordance with the OPW Guidelines. Table 4.1 presents a screening assessment of the site for potential flooding mechanisms requiring further detailed assessment. It is based on the background information review and consultations.

Table 4.1: Possible Flooding Mechanisms

Source/Pathway	Significant?	Reason
Fluvial Floodplain	Yes	OPW PFRA flood mapping suggests the site may be at risk of flooding from the watercourse that flows through the site.
Coastal Flooding	No	N/A
Urban Drainage	No	No indication of urban drainage flooding / sewer incapacity in an initial evidence search and limited development exists in the vicinity of the site.
Surface Water Flooding	No	OPW PFRA flood mapping indicates that the site is not anticipated to be affected by surface water flooding. The site lies at a higher or similar elevation to surrounding agricultural lands.
Surface Water Discharge	Possible	Any development has the potential to increase the impermeable area at a site causing an increase in the rate and volume of surface water runoff from the site.
Groundwater	No	OPW PFRA flood mapping indicates that the site is not anticipated to be affected by groundwater flooding. Due to the site topography, there are no areas which would cause impoundment of groundwater.
Reservoirs / Canals / Artificial Sources	No	A screening assessment based on OSI mapping indicates there to be no impoundments or reservoirs in close proximity or which drain toward the site.

Flooding mechanisms screened as being potentially significant are assessed further in the following sections. Mitigation of flood hazards, where required, is discussed in Section 5.2.

4.2 Pre-Development Fluvial Flooding (Existing Scenario)

4.2.1 Preamble

A detailed site-specific hydraulic model was built using a linked 1D-2D approach in Innovyze InfoWorks ICM. The model is based on hydrology estimates from best available techniques, and the modelling methodology is consistent with and exceeds the detailed CFRAM model standards. The model is intended to supersede existing models (PFRA) and is used to inform this assessment. Details on the modelling methodology are provided in Appendix C.

4.2.2 Flood Zoning / Existing Flood Risk (Present Day)

It has been determined by site-specific hydraulic modelling that there is no out-of-bank 1% AEP (Flood Zone A) flooding within the site but areas in the south adjacent to the watercourse are affected by the 0.1% AEP floodplain (Flood Zone B).

An extract from the existing scenario, present day Flood Zone Map is shown in Figure 4.1; the full Flood Zone Map is provided in Appendix E.

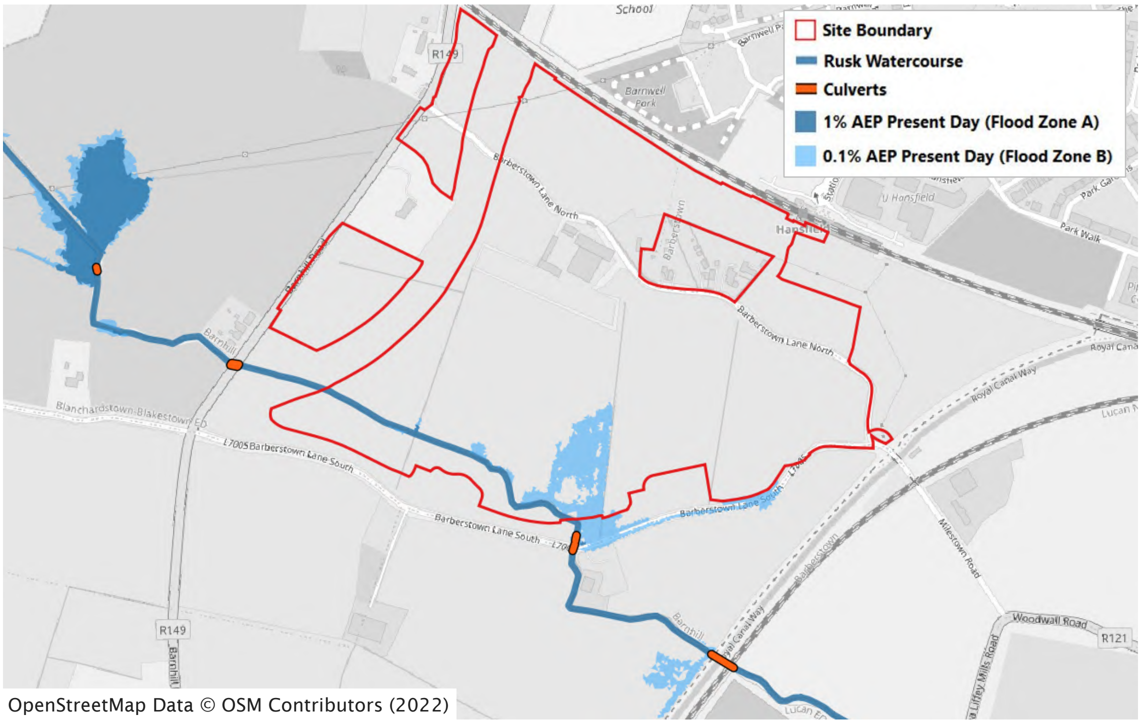


Figure 4.1: Flood Zone Map – Existing Scenario Present Day

Table 4.2 shows the modelled flood levels determined at model nodes at a number of locations through the site.

Mitigation of flood risk will be achieved by siting the proposed development outside the 1% AEP and 0.1% AEP flood extents and ensuring proposed finished ground floor levels provide sufficient freeboard. Mitigation is discussed in Section 5.2.

Table 4.2: Modelled Flood Levels – Existing Scenario Present Day

Node Location	1% AEP / Flood Zone A Level (mOD)	0.1% AEP / Flood Zone B Level (mOD)
Upstream extent of the Site	57.36	57.64
Centre of the Site	56.88	57.23
Downstream extent of the Site	56.60	57.05

4.3 Post-Development Fluvial Flooding (Proposed Scenario)

4.3.1 Preamble

Proposals for the site have been developed on the basis of the Flood Zone Map provided in Appendix E, in line with the OPW Guidelines and Fingal CC requirements. The following sections assess flood risk to the proposed development and determine the effect of the proposals on flood risk elsewhere.

In addition it is noted that, despite being superseded and therefore not required, the proposed development also complies with the LAP SFRA flood mapping which shows a previous / out-dated Flood Zone A and Flood Zone B extent at the site.

4.3.2 Effect of Development (Present Day)

The proposed development comprises residential development and associated access roads including watercourse crossings to facilitate access to / from and within the site. In line with the OPW Guidelines, development has been sited in 'appropriate' Flood Zones (i.e., highly vulnerable development in Flood Zone C and less vulnerable development in Flood Zone C and Flood Zone B). It is noted that watercourse crossings have been designed to OPW Section 50 standards, i.e., 1% AEP + CC plus freeboard.

The effect of development has been determined by modelling a geometry scenario to reflect the proposed development (proposed ground levels and bridges / culverts). Flood modelling is described in Appendix C.

An extract from the proposed scenario, present day Flood Extents Map is included in Figure 4.2. The Flood Extents Map for the full site is provided in Appendix E. As shown, all proposed development (with the exception of watercourse crossings) is situated in Flood Zone C and as such, can have no impact on flood risk elsewhere.

Table 4.3 shows the modelled flood levels determined at model nodes at a number of locations through the site. As shown, there is no change to flood levels throughout the site due to siting of development in Flood Zone C and providing sufficient freeboard to design levels for watercourse crossings.

Details relating to proposed mitigation of residual risk and ensuring freeboard to design flood levels is discussed in Section 5.2.

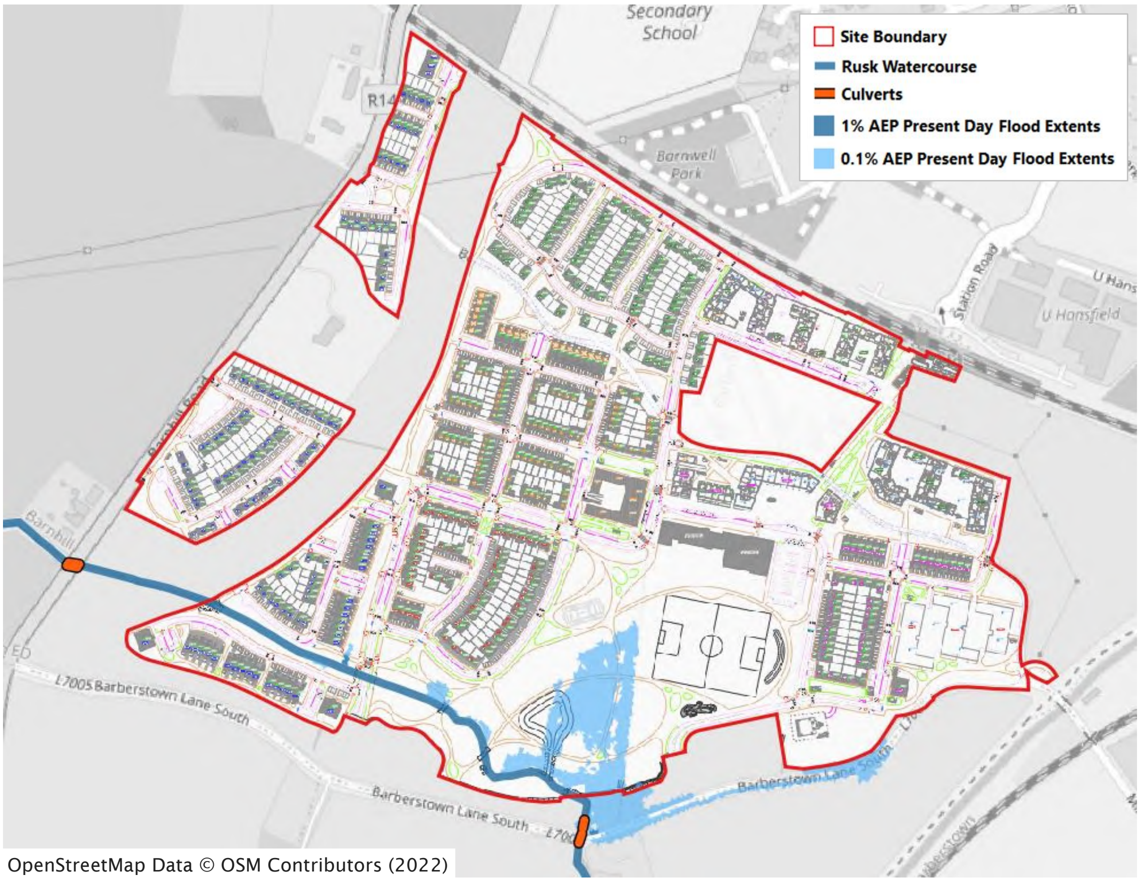


Figure 4.2: Flood Extents Map – Proposed Scenario Present Day

Table 4.3: Modelled Flood Levels – Proposed Scenario Present Day

Node Location	1% AEP Flood Level (mOD)	0.1% AEP Flood Level (mOD)
Upstream extent of the Site	57.36	57.64
Centre of the Site	56.88	57.23
Downstream extent of the Site	56.60	57.05

4.3.3 Effect of Climate Change

The OPW Guidelines and the SFRA require site-specific FRAs to consider increased flood risk to proposed developments under climate change (CC) scenarios. OPW guidance suggests using a Mid-Range Future Scenario, which represents a 20% increase in flood flows.

An estimation of the effect of climate change on flooding at the site has been derived from the detailed site-specific hydraulic model by adding 20% to the present day design flows. An extract from the resulting flood map is shown in Figure 4.3 which demonstrates that the proposed development is not at risk of flooding in the climate change scenario.

Table 4.4 shows the predicted post-development climate change flood levels at the site. Allowance for climate change causes a maximum increase in flood level of 0.11 m for the 0.1% AEP + CC event compared to the present day scenario.

Mitigation of the estimated effect of climate change will be achieved through selection of an appropriate freeboard and is discussed in Section 5.2.

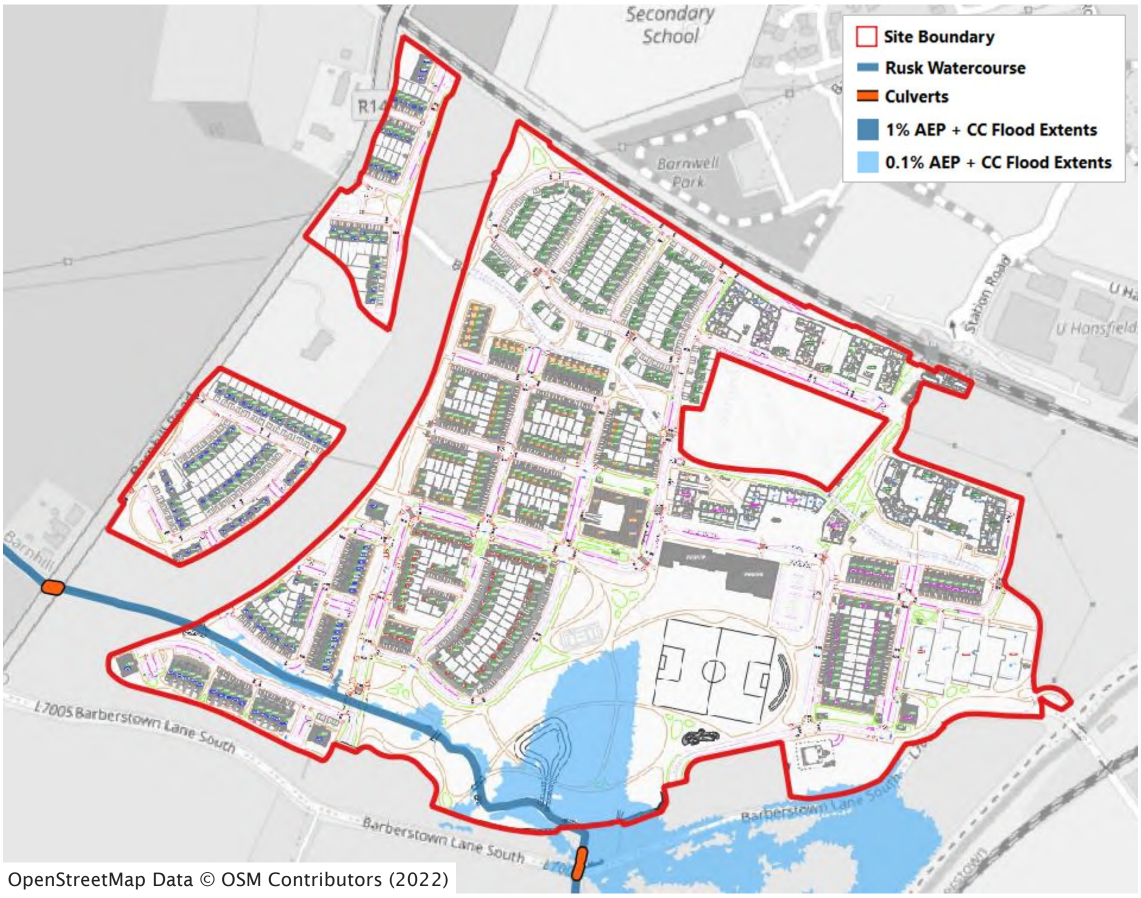


Figure 4.3: Flood Extents Map – Proposed Scenario Climate Change

Table 4.4: Modelled Flood Levels – Proposed Scenario Climate Change

Node Location	1% AEP Flood Level (mOD)	0.1% AEP Flood Level (mOD)
Upstream extent of the Site	57.49	57.75
Centre of the Site	57.03	57.30
Downstream extent of the Site	56.79	57.13

4.3.4 Effect of Culvert Blockage

The OPW Guidelines also require site-specific Flood Risk Assessments to consider increased flood risk to proposed developments arising from potential culvert blockage. Detailed analysis of culverts at the site indicates that the primary risk from culvert blockage at the site is from the canal / railway culvert downstream as other culverts adjacent to the site are upstream and / or subject to OPW Section 50 design guidelines (1% AEP + CC).

Table 4.5 shows the predicted flood levels at the site in the event of 50% culvert blockage of the downstream canal / railway culvert. Allowance for culvert blockage causes a maximum increase in flood level of 0.41 m for the 0.1% AEP event compared to the present day scenario.

Details relating to proposed mitigation is discussed in Section 5.2.

Table 4.5: Modelled Flood Levels – Proposed Scenario Culvert Blockage

Node Location	1% AEP Flood Level (mOD)	0.1% AEP Flood Level (mOD)
Upstream extent of the Site	57.54	57.77
Centre of the Site	57.22	57.48
Downstream extent of the Site	57.16	57.46

4.4 Pluvial (Surface Water) Flooding

4.4.1 Surface Water Flooding onto the Site

OPW and Fingal CC flood mapping indicates that the site is not affected by pluvial flooding.

Lands surrounding the site are at a similar or lower elevation and would therefore not contribute to surface water flooding (from pluvial or urban drainage sources) at the site. Surface water originating from the surrounding lands would instead follow the natural lower-lying flow paths provided by the public roads, if not intercepted by local drainage. No records of local drainage / sewer infrastructure have been provided as part of this assessment.

Further mitigation of surface water / pluvial flooding to the site from the drainage system related to pipe blockage and exceedance is discussed in Section 5.2.

4.4.2 Surface Water Flooding from the Site

Any development has the potential to increase the impermeable area at a site and thereby cause an increase in the rate and volume of surface water runoff from the site. Pluvial flooding risk elsewhere may also be caused by blockage and exceedance of the surface water drainage network.

Mitigation of any change in impermeable area at the site and any residual risk of surface water flooding to the development will be achieved by means of an effective surface water drainage network and effective surface water management / maintenance. Mitigation is discussed in Section 5.2.

5 SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1 Summary of Findings

It has been determined through detailed site-specific hydraulic modelling that parts of the site are affected by flooding during the present day, climate change, and culvert blockage events.

Development proposals have been developed in accordance with the Flood Zones at the site and have been shown to be resilient to flooding during climate change and culvert blockage events. The proposals are therefore acceptable under the OPW Guidelines, will have no negative impact on the existing floodplain or on flood risk elsewhere and are not required to be the subject of a Justification Test.

No other significant flood mechanisms are anticipated at the site.

5.2 Design Considerations

This section details design measures incorporated into the proposed development. These measures are to be further developed in any detailed design or variation post-determination of the planning application.

5.2.1 Land Use

The proposed development is considered to comprise 'appropriate' in terms of land use as per the OPW Guidelines and FRA:

- All highly vulnerable development (residential) is located in Flood Zone C.
- All less vulnerable development (access roads, car parking) is located in Flood Zone B with the exception of watercourse crossing which by definition must be within / over the floodplain.
- Water compatible open amenity space is located in Flood Zone A.

It is noted that recent correspondence from Fingal CC has indicated that less vulnerable development such as car parking and access roads (as defined by the OPW Guidelines) should be considered 'highly vulnerable' if serving 'highly vulnerable' development. As stated previously, all proposed development at the site is in Flood Zone C so complies with this more onerous requirement.

5.2.2 Design Levels

The OPW Guidelines and SFRA require freeboard to be applied to relevant design flood levels when setting finished floor levels (FFLs) and finished ground levels (FGLs). Generally, the industry standard / best practice freeboard of 500 mm is applied as a minimum requirement. Freeboard is applied to Flood Zone A for less vulnerable development (access roads, commercial units) and to Flood Zone B for highly vulnerable development (residential units, creche).

Proposed levels and the freeboard they provide are as follows:

- The lowest proposed FFL within the site is **58.20 mOD** which is 560 mm above the 0.1% AEP flood level at the upstream extent of the site.
- The lowest proposed FGL in the western half of the site is **57.93 mOD** which is 570 mm above the 1% AEP flood level at the upstream extent of the site.
- The lowest proposed FGL in the eastern half of the site is **57.39 mOD** which is 510 mm above the 1% AEP flood level at the centre of the site.

It is noted that in addition to the above, FFLs and FGLs are set above relevant climate change and culvert blockage flood levels.

Therefore, FFLs and FGLs are compliant with stated OPW Guidelines and Fingal SFRA requirements.

5.2.3 Access Levels

In line with the OPW Guidelines, access to and egress from the proposed development should be sited in Flood Zone C (i.e., outside the 0.1% AEP fluvial floodplain / Flood Zone B).

All proposed development and surrounding public roads are in Flood Zone C / above the Flood Zone B level, so safe access to and egress from the proposed development will be possible during an extreme flood event.

5.2.4 Proposed Watercourse Crossing

In order to facilitate access to / from and within the site, the crossing of watercourses at the site will be required. In line with OPW stated requirements and in compliance with Section 50 design criteria, the proposed bridges have been set at a minimum 300 mm above the 1% AEP + CC flood level.

It is noted that consent from the OPW for watercourse crossings at the site has been applied for and granted.

5.2.5 Drainage Design

Surface water drainage design should be per the requirements of the ‘Fingal Development Plan 2017-2023’ and to the standards of Fingal CC’s Water Services Department as well as in line with GDSDS and the ‘Greater Dublin Regional Code of Practice for Drainage Works’ guidance.

The Fingal Development Plan 2017 – 2023 stated that the use of SuDS is required as well as minimising and limiting the extent of impermeable development to reduce the potential impact of existing and predicted flooding risks.

SuDS components, including but not limited to green roofs, rain harvesting, permeable pavement, infiltration trenches and soakaways, should be considered in relation to the nature and character of the site. The type of SuDS deemed suitable for the site will be subject to outline and detailed design. The SuDS design should demonstrate how water quantity and quality are dealt with as well as make provision for amenity and biodiversity, where practicable.

Surface water drainage systems should be maintained in line with best practice, manufacturers specification(s) and requirements outlined in Section 5.3.1. In the event of blockage or exceedance (in excess of the 1% AEP + CC design event), surface water will have an available overland flow path away from built development towards the lower lying watercourse through the site.

5.3 Maintenance Requirements

5.3.1 Watercourse Maintenance

The ultimate owner / occupier(s) of the site shall be required to include general watercourse / culvert maintenance which will reduce the risk of blockage at downstream culverts and screens and maintain the capacity of the channels. The following measures are intended to inform any future maintenance programme for watercourses and culverts:

- Maintenance should consist of removal of any items within the channel that can impede its flow including (small) trees, excess vegetation etc.
- Riverbanks should be due adequate attention which would normally consist of removal of brambles, bushes, and stiff vegetation; these reduce flow capacity and can encourage collection of debris increasing the risk of blockages. Grass and nettles do not always need removing as they will lay flat during high flows.
- Weed growth should be removed from the centre of the channel as this will impede the flow and increase water levels up stream. Hand picking is best but cutting off under the water level is acceptable if it is done on an annual basis.
- Build-up of silt in watercourse channels and at culvert inlets should be removed and disposed of appropriately.
- Cyclical (min. annual) visual inspection of culvert inlets and screens and removal of debris as required, ensuring debris removed is not deposited in an area likely to fall back into the channel.

5.3.2 Drainage System Maintenance

The owner / occupier(s) will be responsible for the maintenance of site drainage systems. Where drainage assets have not been taken in charge, provision for the maintenance of these assets should be made as part of the overall site management plan. The detailed drainage layout for the site should ensure that key SuDS features requiring maintenance are situated in accessible locations.

Maintenance plans for drainage assets should, where applicable, include:

- Cyclical (min. annual) check of all surface water drainage features (in particular, clearing of debris).
- Cyclical (min. annual) visual inspection of any surface or underground features (blockages and obstructions should be removed by jetting as required).

5.4 Summary of Flood Risk and Mitigation

Table 5.1 summarises the mechanisms of flooding identified by this study and their associated hazards / consequence (per the OPW Guidelines) as well as proposed measures to mitigate the predicted risk.

Table 5.1: Summary of Risks and Mitigation

Identified Flood Mechanism	Consequence	Summary and Proposed Mitigation Measures
Fluvial Flooding	Risk to life and property	All proposed development is sited in an 'appropriate' Flood Zone. FFLs and FGLs at the site provide more than the required minimum freeboard to adjacent flood levels.
Effect of the Development	Increased risk to adjacent lands / property	All proposed development is located in Flood Zone C and therefore cannot increase flood risk elsewhere.
Effect of Climate Change	Risk to life and property	FFLs ensure a standard of protection exceeding the 0.1% AEP + CC flood levels.
Effect of Culvert Blockage	Risk to life and property	FFLs ensure a standard of protection exceeding the 0.1% AEP + culvert blockage flood levels.
Surface Water Flooding	Risk to property and risk to adjacent lands / property	On-site surface water flooding will be mitigated by a site drainage system compliant with local authority drainage standards. Off-site surface water effects will be mitigated by provision of SuDS to ensure no increase in the rate or volume of runoff of surface water from the site as a result of development.

5.5 Justification Test

Based on the requirements of the OPW Guidelines and Fingal CC SFRA, the proposed development does not require a Justification Test given that all proposed development is in Flood Zone C and in line with the flood and land zoning of the Barnhill LAP. However, where a Justification Test is still required by the Planning Authority, relevant information relating to the proposal is included in Table 5.2.

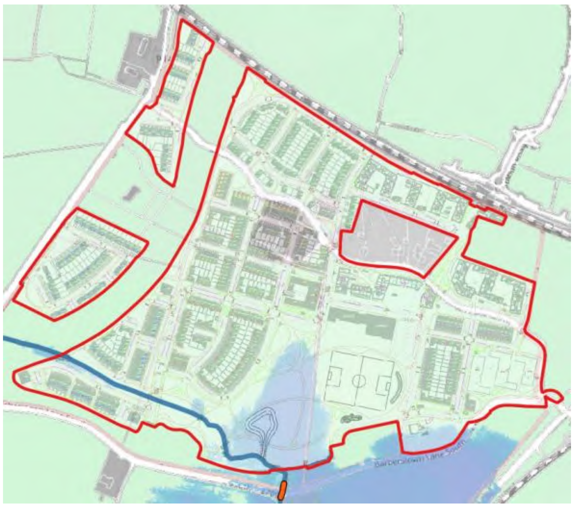
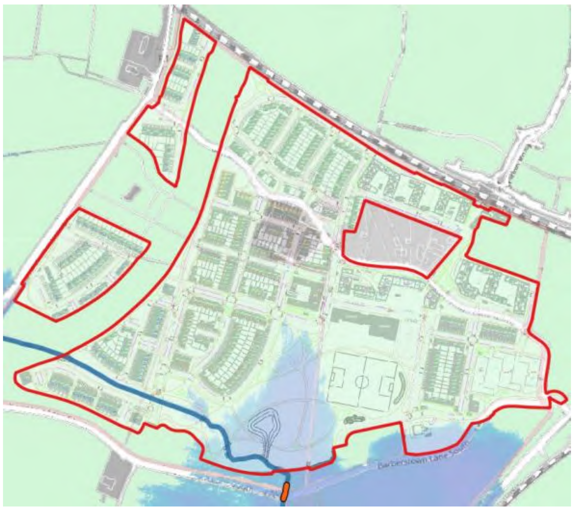
This report has described how flood mapping produced as part of the Barnhill LAP SFRA is no longer correct / relevant due to infrastructure changes downstream. However, for completeness, the proposed development is overlain on the SFRA LAP flood mapping and presented in Table 5.3. As shown, there is no development within the delineated (out-dated) floodplain, primarily due to land zoning at the site.

Table 5.2: Justification Test for Development Management

Part	Item	Response
1	The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative plan, which has been adopted or varied taking account of these Guidelines.	The subject lands are currently zoned, within the Fingal County Development Plan 2017-2023, as objective RA Residential Area and it can be concluded that the lands are suitable for development because they are: • zoned for the uses proposed within the Dublin Metropolitan area; • located well adjacent to the existing built up area of Hansfield, Ongar and Clonsilla which have many services and facilities; • currently underutilized; • will optimise the efficient use of existing and proposed infrastructure including the Dublin-Dunboyne rail corridor (inc. future DART+ upgrade), Hansfield Train Station, the Royal Canal Greenway and the Ongar Barnhill Distributor Road; • supports the delivery of development on key public transport corridor
2	*The proposal has been subject to an FRA that demonstrates:*	*The site has been subject to a site-specific flood risk assessment*
2 (i)	The development proposed will not increase flood risk elsewhere, and, if practicable will reduce overall flood risk	This FRA demonstrates that the proposed development will not increase flood risk elsewhere as all proposed development is located in Flood Zone C. Post-development runoff from the site is likely to be reduced compared to the existing scenario, which should reduce overall flood risk.
2 (ii)	The development proposal includes measures to minimise flood risk to people, property, the economy, and the environment as far as reasonably possible.	The principal measure taken to minimise flood risk is ensuring development is kept to 'appropriate' Flood Zones. FFLs are set above adjacent flood levels. The surface water runoff will be attenuated to pre-development rate, thereby not increasing flood risk elsewhere.

2 (iii)	The development proposed includes measures to ensure that residual risks to the area and / or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provisions for emergency services access.	FFLs provide more than required freeboard to adjacent flood levels. The access / egress routes to and from the site are located in Flood Zone C, so emergency and resident access will be possible during a flood event. The proposed development does not rely on any existing or future OPW / Local Authority Flood Relief Scheme.
2 (iv)	The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant active streetscapes.	The development put forward for permission is an appropriate form of development and offers a high standard of residential amenity to future occupants. The design, scale, pattern of development and layout is appropriate in the context of the site and will provide a sustainable use of zoned land. The proposed development takes into consideration the policies and objectives of the National Planning Framework, Fingal County Development Plan 2017-2023, the Barnhill LAP 2019 and the Sustainable Urban Housing Guidelines.

Table 5.3: Barnhill LAP SFRA Flood Maps with Proposed Development

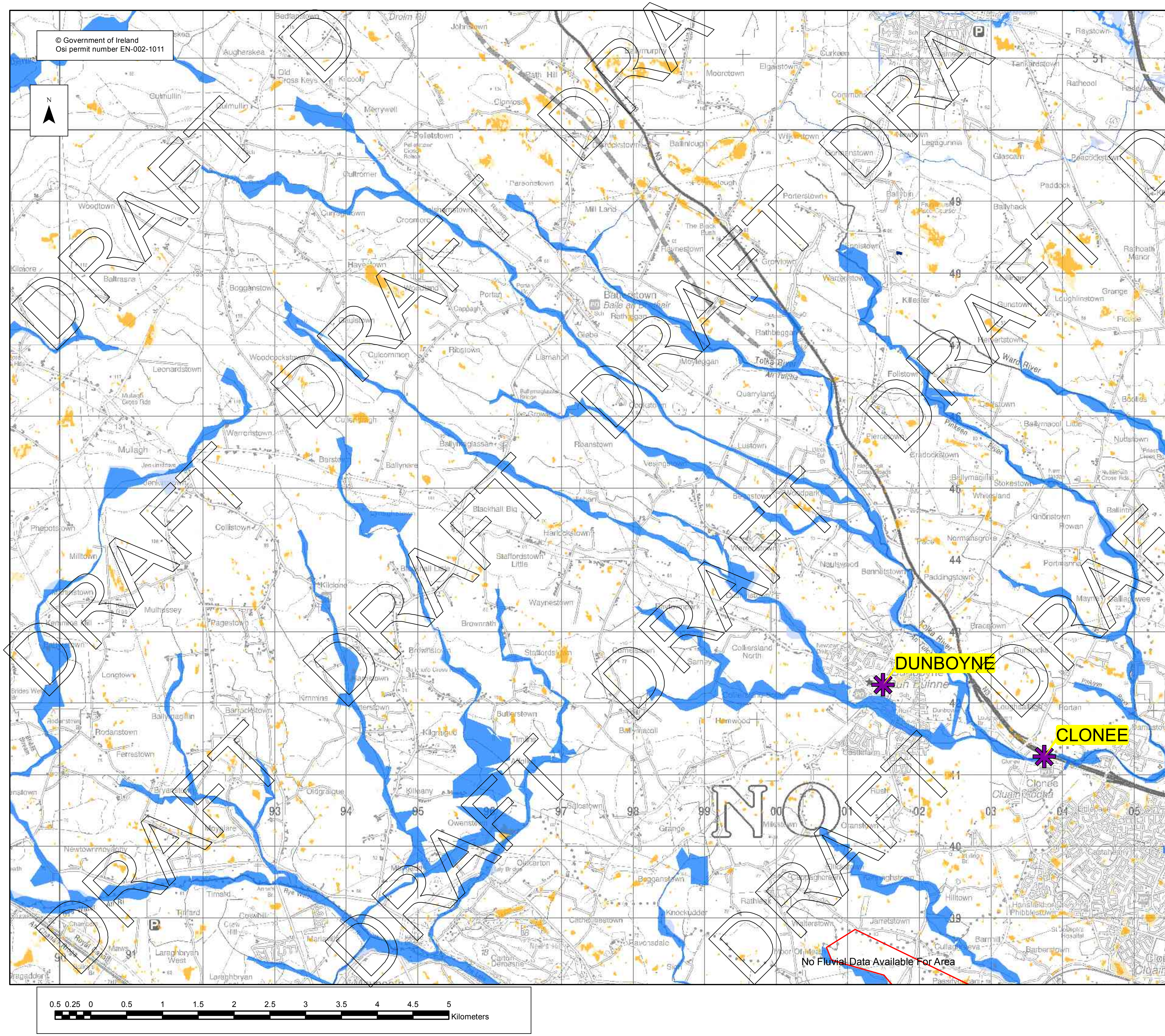
Barnhill LAP SFRA 1% AEP Flood Map	Barnhill LAP SFRA 0.1% AEP Flood Map
	

Appendix A

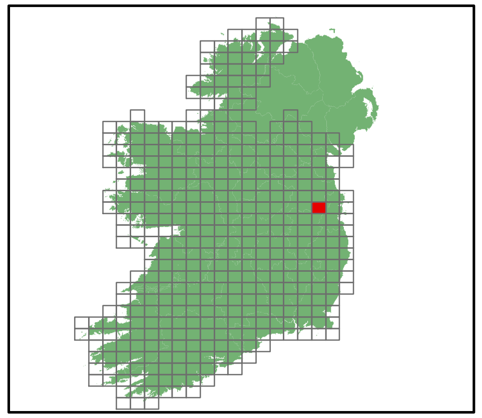
Site Drawings

Appendix B

OPW / Fingal CC Flood Mapping



Location Plan :



Legend:

Flood Extents

- Fluvial - Indicative 1% AEP (100-yr) Event
- Fluvial - Extreme Event
- Coastal - Indicative 0.5% AEP (200-yr) Event
- Coastal - Extreme Event
- Pluvial - Indicative 1% AEP (100-yr) Event
- Pluvial - Extreme Event
- Groundwater Flood Extents
- Lakes / Turloughs

PFRA Outcomes

- Probable Area for Further Assesment
- Possible Area for Further Assesment

Important User Note:

The flood extents shown on these maps are based on broad-scale simple analysis and may not be accurate for a specific location. Information on the purpose, development and limitations of these maps is available in the relevant reports (see www.cfram.ie). Users should seek professional advice if they intend to rely on the maps in any way.

If you believe that the maps are inaccurate in some way please forward full details by contacting the OPW (refer to PFRA Information leaflets or 'Have Your Say' on www.cfram.ie).

Office of Public Works
Jonathon Swift Street
Trim
Co Meath
Ireland

Project :
PRELIMINARY FLOOD RISK ASSESMENT (PFRA)

Map :
PFRA Indicative extents and outcomes
- Draft for Consultation

Figure By :	PJW	Date :	July2011
Checked By :	MA	Date :	July 2011
Figure No. :	2019 / MAP / 255 / A	Revision	0
Drawing Scale :	1:50,000	Plot Scale :	1:1 @ A3

PROJECT: BARNHILL SFRA **DRAWING:** 100-YEAR	**STATUS:** DRAFT **ISSUE:** KC1407-FM-100-V2	**V1 -** 27/03/18 - **Drawn:** GP - **Checked:** YK - **Approved:** YK **V2 -** 18/10/18 - **Drawn:** GP - **Checked:** YK - **Approved:** YK	0 100 200 m Scale 1 in 6,500 @ A4	**Comhairle Contae Fhine Gall** Fingal County Council

PROJECT: BARNHILL SFRA

DRAWING: 1000-YEAR

STATUS: DRAFT

ISSUE: KC1407-FM-1000-V2

V1 - 27/03/18 - **Drawn:** GP - **Checked:** YK - **Approved:** YK
V2 - 18/10/18 - **Drawn:** GP - **Checked:** YK - **Approved:** YK

0 100 200 m

Scale 1 in 6,500 @ A4

Comhairle Contae
Fhine Gall
Fingal County
Council

Appendix C

Hydraulic Modelling

PREAMBLE

Since no existing modelled data was available for the Rusk Watercourse, a detailed site-specific hydraulic model was built for the site. It is suitable to the scale and nature of the proposed development and associated risk and considered fit for the purpose of this Flood Risk Assessment. The model was built using a linked 1D-2D approach in Innovyze InfoWorks ICM, allowing for accurate determination of flood levels at the site.

HYDROLOGICAL ASSESSMENT

The estimation of peak flow for the required design annual probability has been necessary to determine the peak inflow and hydrograph for input to an unsteady state hydraulic model. A precautionary principle has been adopted for the hydrological analysis.

The derivation of the 1% AEP and 0.1% AEP event peak flows was determined using the OPW Flood Studies Update (FSU) method.

1% AEP and 0.1% AEP flows derived from OPW FSU Portal. Four flow extraction points have been used for the modelled watercourse as indicated on Figure C-1. Each of the extraction points relates to an ungauged catchment and a calculation using the FSU methodology has been carried out for each point.

Figure C-1: FSU Flow Extraction Points

No gauged catchment data is available for the modelled watercourse and the flow derivation therefore is based on ungauged locations. The pivotal site chosen was based on the geographical adjacent 09001 Leixlip catchment, which provided a conservative predicted flow comparted to the suggested 09011 Frankfort hydrologically similar catchment. It is noted that the Leixlip catchment had better correlation with the subject site for S1085 and URBEXT parameters than the Frankfort catchment.

QMED has been calculated from the full record based on the Euclidean scheme.

Growth curves have been derived using the GEV statistical distribution based on guidance within the FSU handbook that suggests that the GEV distribution provides a better fit for ungauged catchments. In addition, the GEV distribution provides a conservative estimation of flows compared to alternative distributions.

The most hydrologically similar hydrograph pivotal site of 30020 Ballyhaunis was selected to adjust the shape of the hydrograph. It is noted that the selected hydrograph had the shortest duration of the suggested hydrographs, however the hydrograph still had a significant duration of c. 70 hours with 35 hours to the peak.

A summary of the calculated flows for each extraction point is provided in Table C-1.

Table C-1: Flows at Flow Extraction Points

Location	1% AEP Flow (m^3/s)	0.1% AEP Flow (m^3/s)
US Model Extents	1.86	2.70
Barnhill Road	2.09	3.04
Barberstown Lane South	2.37	3.41
Canal	2.76	4.10

A point inflow has been applied at the upstream model extents and the relevant inflows have been applied as lateral inflows along each downstream reach.

For comparison purposes, the design flow at the canal was also calculated using the Flood Studies Report (FSR) and Institute of Hydrology (IoH 124) methods. The respective flows are indicated in the following table.

Table C-2: Hydrology Summary and Comparison

Analysis Method	1% AEP Flow (m^3/s)	0.1% AEP Flow (m^3/s)
FSU	2.76	4.10
FSR	1.96	2.26
IoH 124	1.77	2.35

The FSU methodology provides the most conservative estimate of peak flows for the watercourse. The FSU methodology has also been developed to supersede the FSR as the main method of rainfall and flow estimation in Ireland. The site-specific FSU estimates prepared for purposes of this assessment have therefore been used for input into the model.

HYDRAULIC MODEL SIMULATION

The site and affecting watercourse is not included within any existing CFRAM area for further / detailed investigation (i.e. PFRA flood mapping only). In order to provide a more accurate and up-to-date (present day) assessment of flood risk in the vicinity of the area of interest, a location-specific detailed 1D-2D model has been developed for the site using InfoWorks ICM software (version 8.5) to a standard equivalent to that of the detailed OPW CFRAM studies. ICM solves full two-dimensional depth averaged shallow water equations to produce a virtual representation of flow paths, velocities, volumes, and depths. The watercourse channel and structures have been represented in 1D, while the floodplain / overland flow path has been represented in 2D.

The modelling approach is summarised as follows:

- The watercourses have been modelled using detailed cross section survey data derived from ground based topographical survey.
- The natural floodplain has been modelled as a 2D meshed ground model, to allow the accurate representation of out of bank flooding and the resulting overland flow routes. Terrain is based on OSI LiDAR data and ground-based topographic survey in areas of greatest interest.
- Structures have been included in the model based on detailed survey information.
- Design flows for the 1% AEP and 0.1% AEP events have been calculated using OPW FSU methodologies and applied to the model.

The following sections provide detail on the modelling methodology and the hydrological assessment.

Model Geometry

1-Dimensional Surface Model Areas

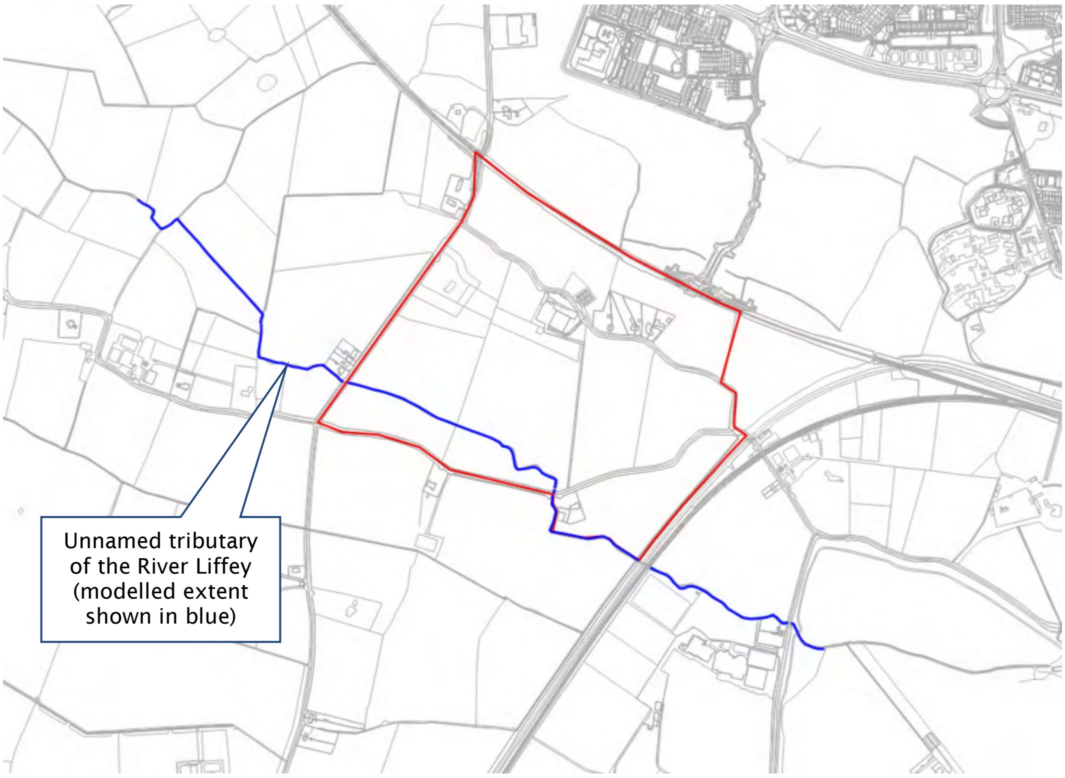
Watercourses

The area of interest has potential to be affected by flooding from the watercourse that flows through the site. A topographical survey of the watercourse reach was undertaken that included details on structures within the watercourse.

Cross section data is derived from detailed ground-based topographic and bathymetric survey data undertaken by a specialist survey contractor. The cross-section data was incorporated into the model as a 1D watercourse reach.

The 1-dimensional watercourse network is shown on the following figure and extends 700 m upstream of Barnhill Road and 450 m downstream of the railway / canal.

Figure C-2: Modelled Watercourses



Structures

A number of structures are located within the modelled extents as shown on the following figure and as shown in Figure C-3 and as detailed in Table C-3. Structure details have been taken from the watercourse survey.

Figure C-3: Modelled Structures

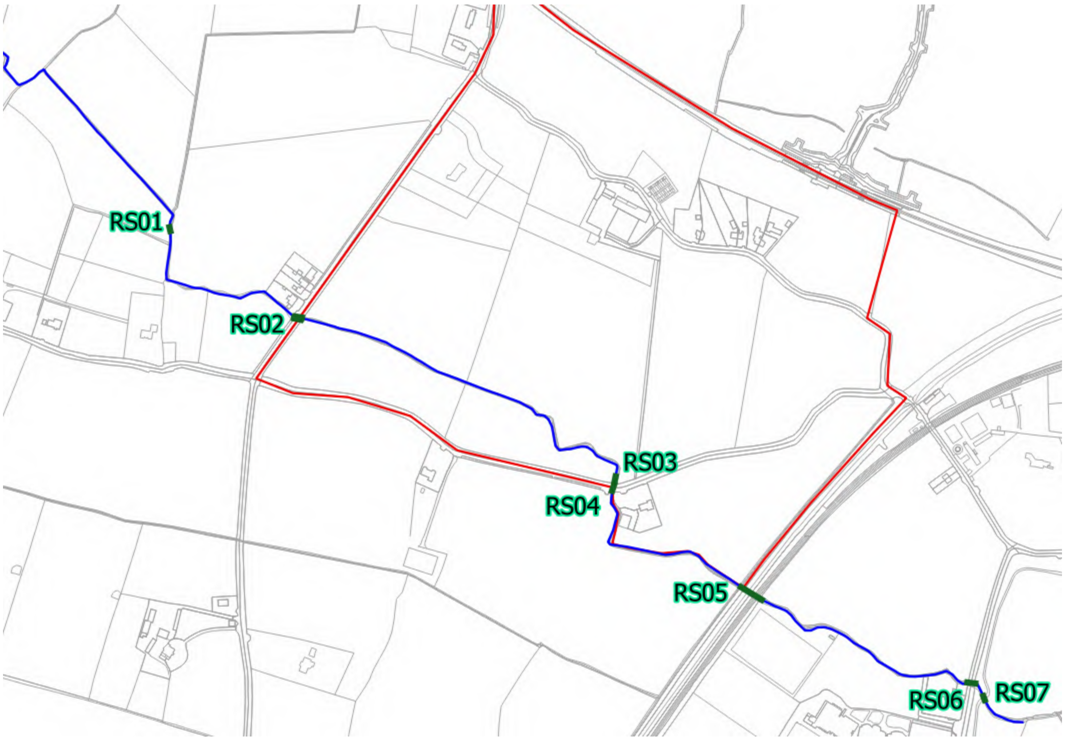


Table C-3: Culvert Register

Culvert Ref:	Shape	Size (mm)	Upstream Invert Level (mOD)	Downstream Invert Level (mOD)	Manning's 'n' roughness value
RS01	CIRC	600	57.50	57.49	0.011
RS02	ARCH	1200 x 1370	57.02	56.96	0.011
	CIRC	600	57.32	57.34	0.011
	CIRC	600	57.29	57.19	0.011
RS03	CIRC	1200	55.25	55.18	0.013
RS04	ARCH	1900 x 1600	55.11	55.09	0.025
RS05	ARCH	17500 x 1200	52.93	52.83	0.025
RS06	RECT	1400 x 1600	53.18	53.15	0.011
RS07	CIRC	1600	52.92	52.92	0.011

Roughness Values

A roughness value of 0.08 was used for the watercourse reach based on visual observations during the site visit.

Structure roughness values were based on material and site visit observations.

2-Dimensional Surface Model Areas

Topography

A terrain model was generated to represent the topography of the area, primarily defined using 2 m resolution LiDAR data provided by Ordnance Survey Ireland for use in the project. The LiDAR data in grid format was utilised as the surface used for the base conditions of the model.

The LiDAR data terrain was supplemented with on-site topographic survey to create a combined surface which included improved definition within and surrounding the site.

2D Zone

The composite terrain model was used to create a ground model in InfoWorks ICM, and subsequently converted into a 2D mesh. The 2D zone has a maximum triangle size of 20 m^2, with a more detailed mesh zone with a maximum triangle size of 10 m^2 used to provide additional detail in the vicinity of the site.

Boundary Conditions

Boundary conditions for the edge of the 2D surface area have been set to normal depth. The 2D surface has been sized conservatively to ensure that the boundary condition is of sufficient distance from the areas of interest so as not to have an impact on flood levels.

The Royal Canal and railway embankment, east of the site is raised relative to surrounding ground. The mesh size is of sufficient detail to allow the raised elevation of the canal and railway to be represented within the mesh data. The 2D zone is extended sufficiently that water does not 'leak off the edge' of the 2D zone in areas of broad floodplains.

Roads

The model indicates that the Barberstown Road is located within the fluvial floodplain.

A separate mesh zone has been created for the Barberstown Road to provide the same effect as break lines to force triangulation to follow the road edge.

Roughness Values

Manning's n Roughness values have been applied to the 2D zone. The majority of the modelled area comprises agricultural land and a constant Manning's n value of 0.04 has therefore been applied to the 2D Zone to represent the rural nature of the catchment. A separate roughness zone with a roughness value of 0.015 was used for the Barberstown Road.

Model Sensitivity

Model sensitivity analysis was carried out to assess the sensitivity of the simulation to changes in base parameters. The sensitivity testing makes comparisons to the base model using the 1% AEP and 0.1% AEP design flows.

Sensitivity to Roughness

The sensitivity of the modelled water levels to channel and floodplain roughness was assessed by varying the standard values of Manning's n for the base model.

Increasing the roughness value of the watercourse reaches by 0.02 causes a maximum increase in flood level of 0.35 m for the 1% AEP event and 0.31 m for the 0.1% AEP event at the upstream extents of the site. An increased roughness value of the channel causes an increase in flood level of less than 0.05 m at the downstream site extents due to the out of bank nature of the flooding. Results for the sensitivity testing show no significant differences within the model output – flow paths and areas identified as flooding remain largely the same. Some additional flooding is noted along the watercourse banks for the 0.1% AEP event.

Increasing the roughness value of the 2D Zone by 0.02 causes an increase in flood level of 0.005 m for the 1% AEP event and 0.015 m for the 0.1% AEP event.

It is therefore considered that the model is sensitive to channel roughness values but is not overly sensitive to the 2D Zone roughness values. Careful consideration has been given to conservatively specifying Manning's n values for the watercourse channel and there is therefore reasonable confidence in model results.

Sensitivity to Downstream Boundary Condition

The sensitivity of the modelled water levels to downstream boundary condition was assessed by artificially increasing the downstream water level of the watercourse. In order to investigate the potential effect of the model downstream boundary the downstream boundary level has been increased by 1.0 m. The resulting increase in downstream flood level in the watercourse has been shown to cause a maximum increase of 0.005 m for both the 1% AEP and 0.1% AEP events.

It is therefore considered that the model is not sensitive to the downstream boundary condition. Careful consideration has been given to siting the downstream model extent sufficiently downstream of the site so as not to cause an impact on flood levels in the vicinity of the site.

Sensitivity to Flow

The design flows were derived using best industry techniques and the most conservative flows were selected and there is therefore reasonable confidence in the results. In order to determine the effect of underestimation of flows on the model and what could be expected if an extreme event were to occur, the flows in the model have been increased by 20%.

An increase of 20% in the design flows causes an increase of 0.08 m at the upstream extents of the site and 0.2 m at the downstream extents of the site for the 1% AEP event. An increase of 20% in the design flows for the 0.1% AEP causes an increase of between 0.1 m at the upstream extents of the site and 0.1 m at the downstream extents of the site.

The increased flood levels caused by increasing the flow in the model would cause increased flooding along the banks of the watercourse and at the south eastern extents of the site. The increased flood levels are used to set proposed finished floor levels and proposed development would therefore be resilient to the increased flood levels.

Sensitivity to DTM Accuracy

The 2 m LiDAR used in the McCloy flood study has an accuracy of +/- 25 cm. A review of areas with a depth of less than 25 cm indicates that a variation of ground levels of +/- 25 cm would not result in the removal of any significant flow paths across the area of interest. The model is therefore not considered to be sensitive to the quoted tolerances of accuracy of the underlying LiDAR data.

Sensitivity Analysis Summary

The results of the sensitivity analysis are generally within acceptable limits and the sensitivity analysis has demonstrated that the model can be deemed reliable.

In addition, freeboard requirements set out in the SFRA exceed the effects of the model sensitivity analysis.

Assumptions and Limitations

The representation of any complex system by a model requires a number of assumptions to be made. In the case of the hydraulic model developed for the purposes of the study it is assumed that:

- The terrain model (based on LiDAR and site topographical survey information) accurately represents the surface topography and associated flow paths.
- The design flows are an accurate representation of flows of a given return period.
- Roughness does not vary with time.

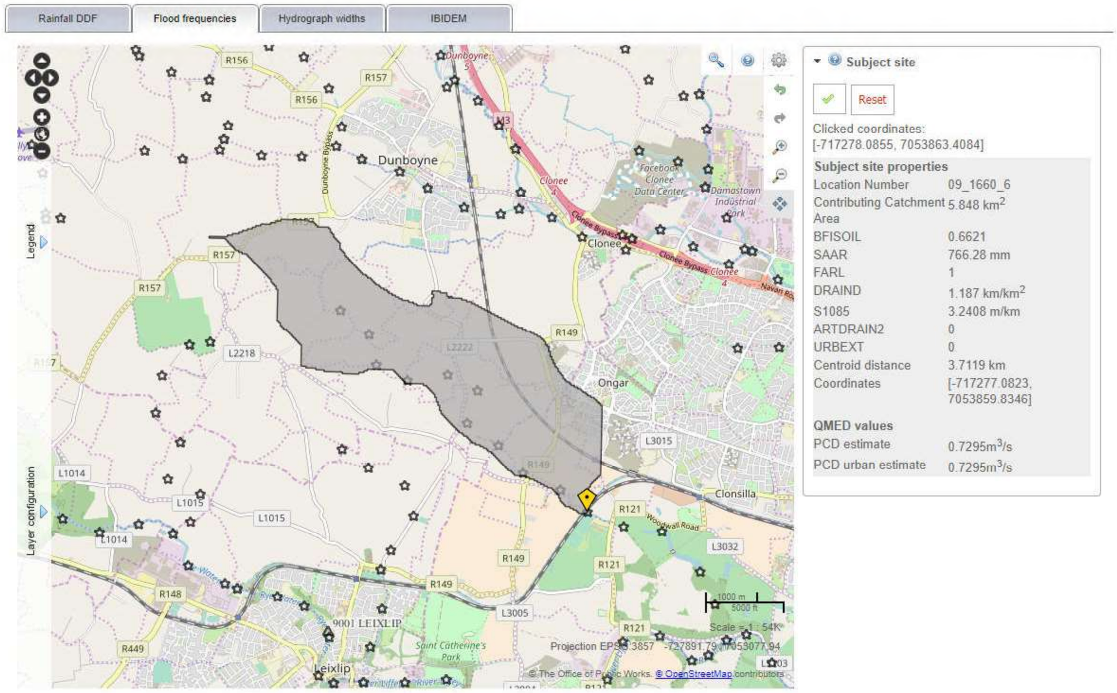
The primary limitations of the study are noted as follows:

- Sewerage and culverted surface water drainage has not been modelled.
- No allowance has been made for any potential railway drainage that may contribute to flows within the watercourse downstream of the site.
- No allowance has been made for any potential controlled spill from the canal that may contribute to flows within the watercourse downstream of the site.
- No allowance for infiltration has been made within the model.
- The model does not represent any topographic features smaller than the minimum resolution of the underlying terrain model derived for the site.

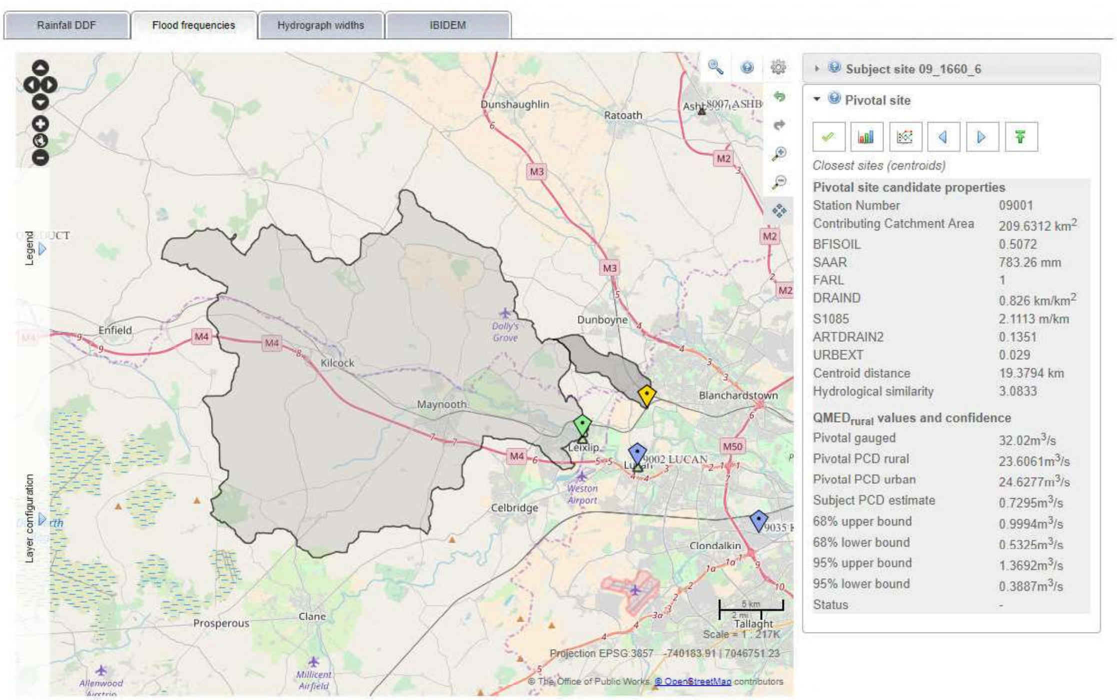
Appendix D

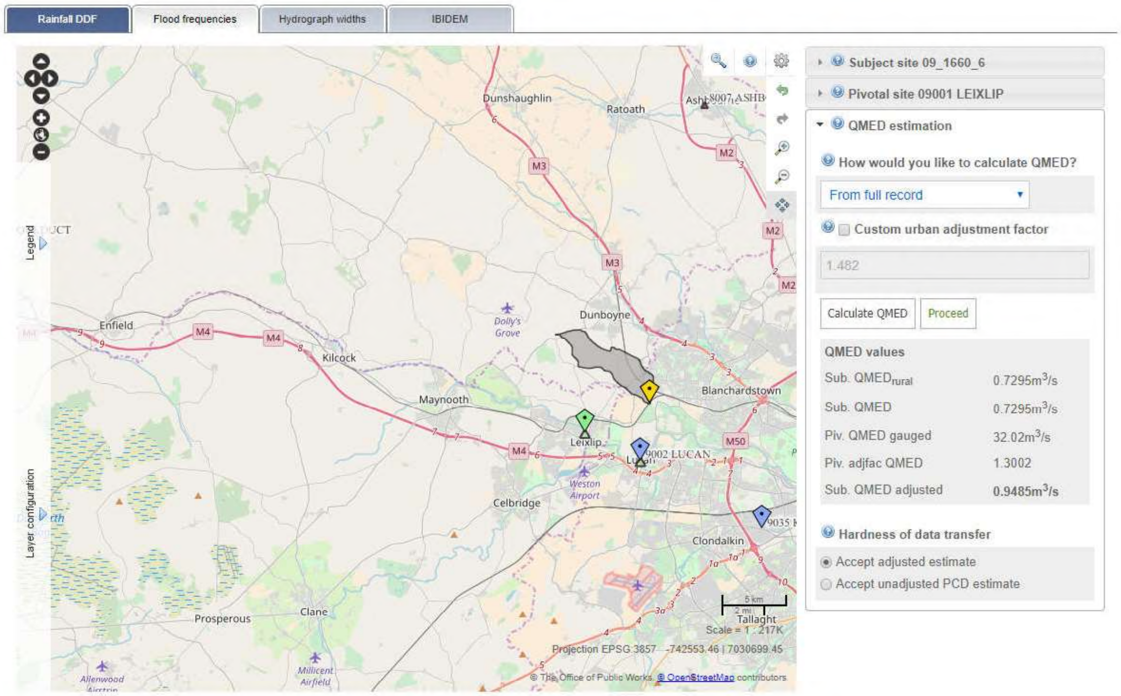
Hydrological Calculations

FSU Summary – Unnamed Watercourse to Canal / Railway crossing



Pivotal site chosen from map (Geographical)





Rainfall DDF
Flood frequencies
Hydrograph widths
IBIDEM
Subject site 09_1660_6
Pivotal site 09001 LEIXLIP
QMED estimation
How would you like to calculate QMED?
From full record
Custom urban adjustment factor
1.482
Calculate QMED
Proceed
QMED values
Sub. QMEDrural 0.7295m3/s
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Piv. QMED gauged 32.02m3/s
Piv. adjfac QMED 1.3002
Sub. QMED adjusted 0.9485m3/s
Hardness of data transfer
Accept adjusted estimate
Accept unadjusted PCD estimate
Legend
Layer configuration
Dunshaughlin
Ratoath
Enfield
Kilcock
Maynooth
Dunboyne
Blanchardstown
Leixlip
Celbridge
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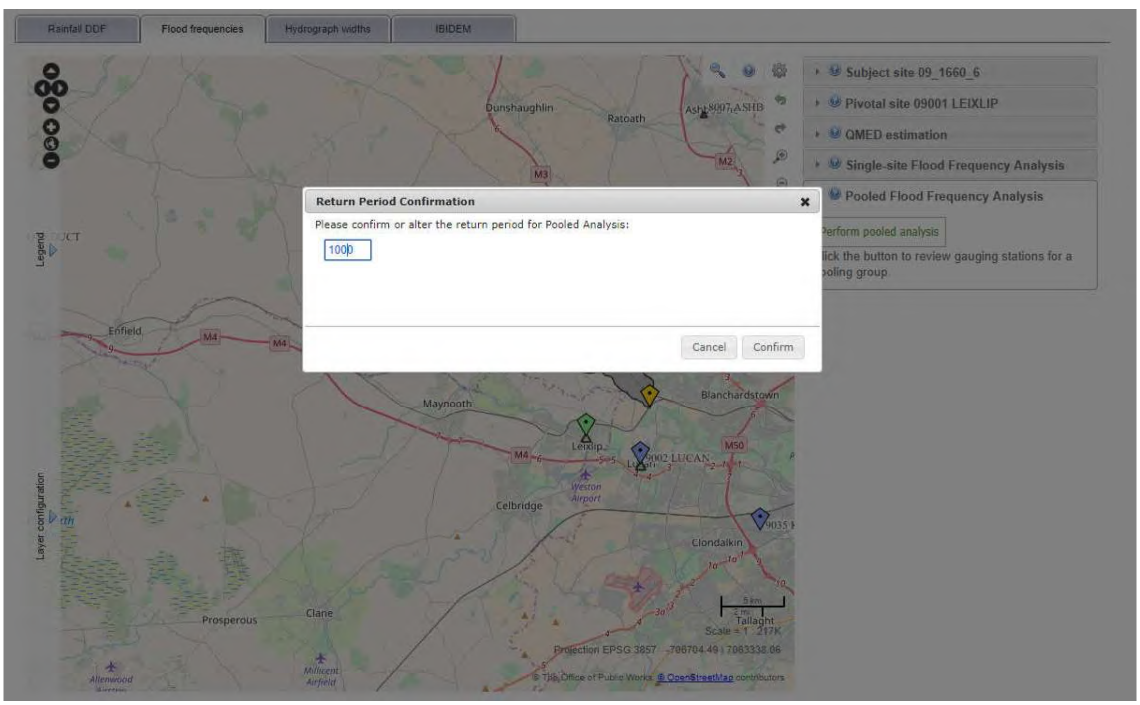
Prosperous
Clane
Tallaght
Projection EPSG:3857 -742553.46 | 7030699.45
© The Office of Public Works, © OpenStreetMap contributors



Rainfall DDF
Flood frequencies
Hydrograph widths
IBIDEM
Subject site 09_1660_6
Pivotal site 09001 LEIXLIP
QMED estimation
Single-site Flood Frequency Analysis
Pooled Flood Frequency Analysis
Return Period Confirmation
Please confirm or alter the return period for Pooled Analysis:
1000
Cancel
Confirm
Projection EPSG:3857 -706704.49 | 7063338.06
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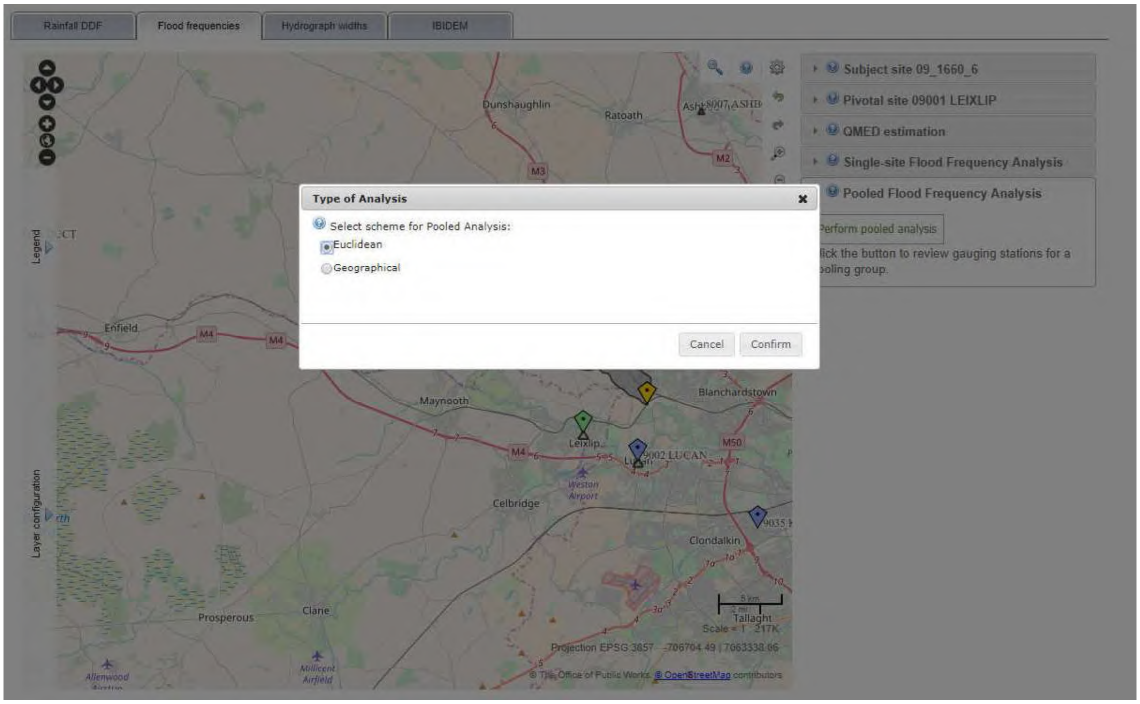
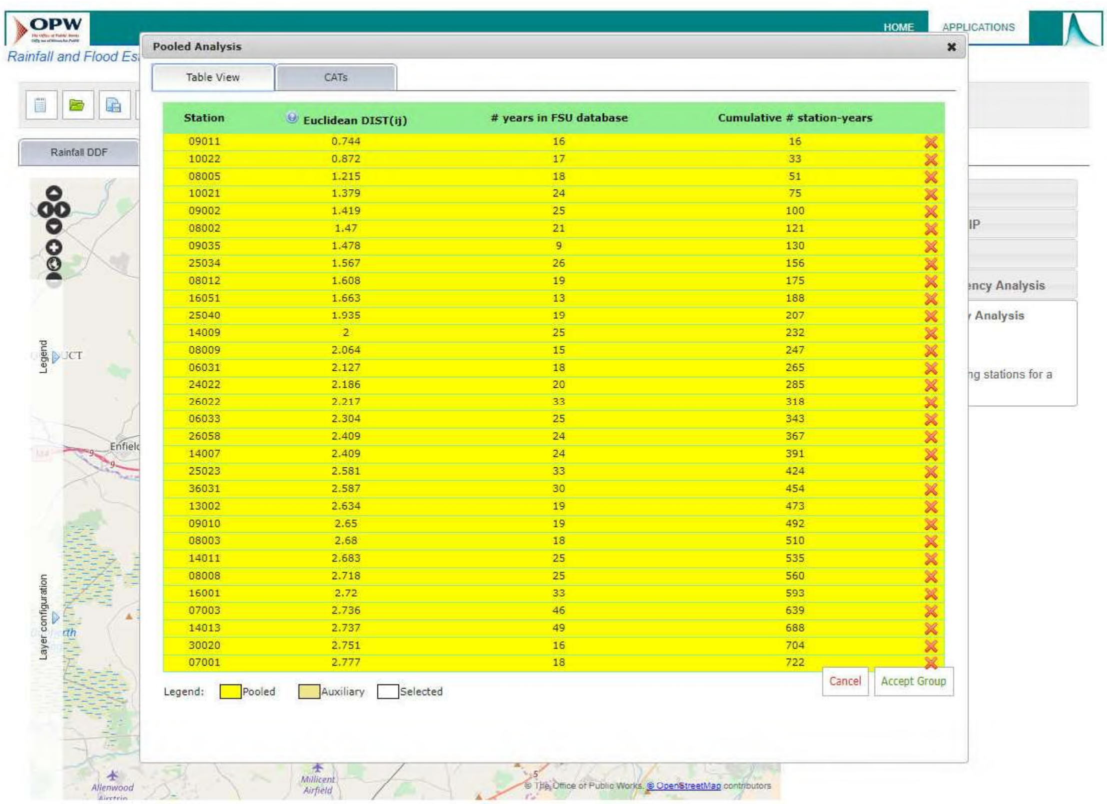
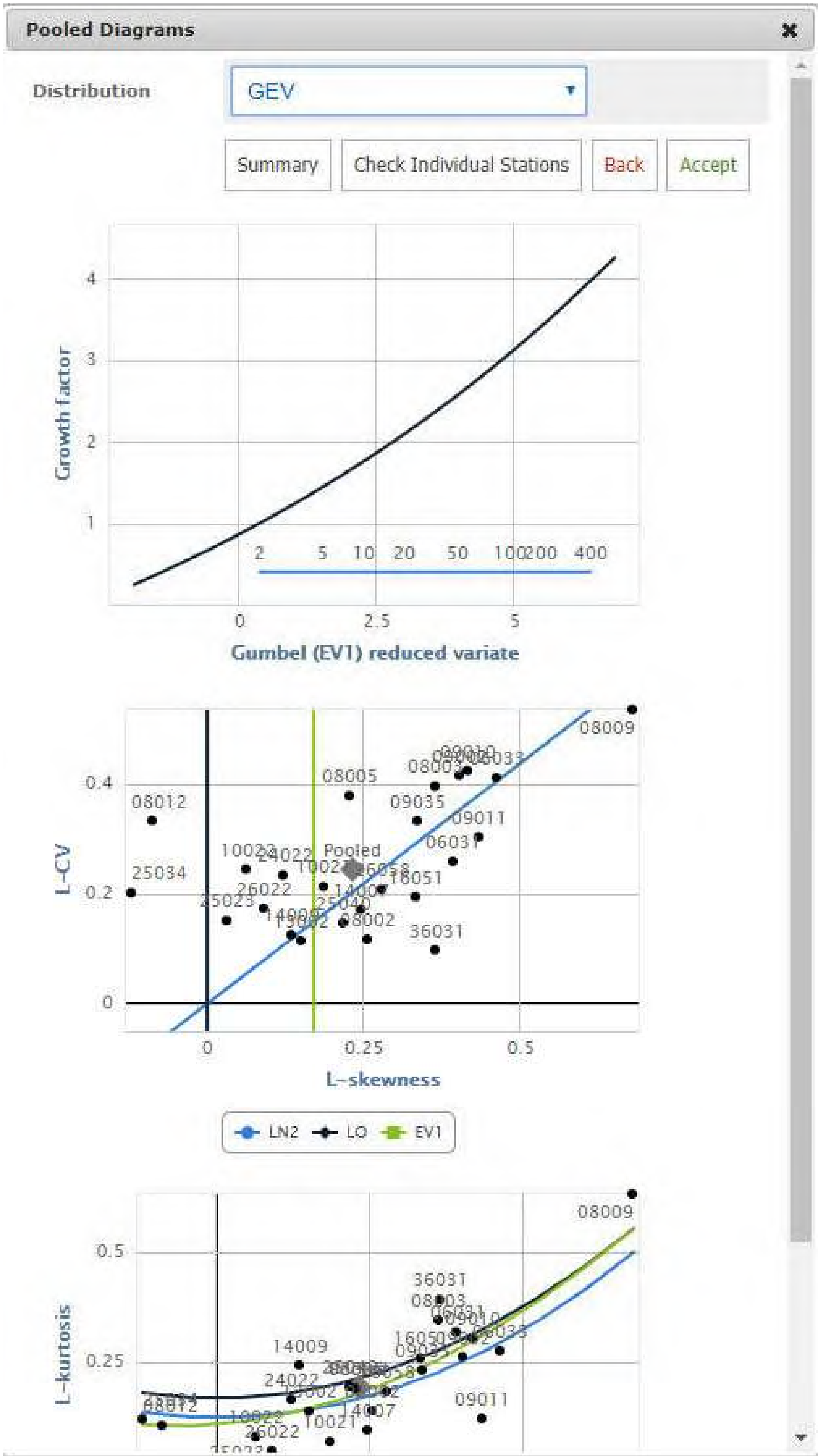




Station	Euclidean DIST(ij)	# years in FSU database	Cumulative # station-years
09011	0.744	16	16
10022	0.872	17	33
08005	1.215	18	51
10021	1.379	24	75
09002	1.419	25	100
08002	1.47	21	121
09035	1.478	9	130
25034	1.567	26	156
08012	1.608	19	175
16051	1.663	13	188
25040	1.935	19	207
14009	2	25	232
08009	2.064	15	247
06031	2.127	18	265
24022	2.186	20	285
26022	2.217	33	318
06033	2.304	25	343
26058	2.409	24	367
14007	2.409	24	391
25023	2.581	33	424
36031	2.587	30	454
13002	2.634	19	473
09010	2.65	19	492
08003	2.68	18	510
14011	2.683	25	535
08008	2.718	25	560
16001	2.72	33	593
07003	2.736	46	639
14013	2.737	49	688
30020	2.751	16	704
07001	2.777	18	722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Distribution
GEV
Summary
Check Individual Stations
Back
Accept
Growth factor
Gumbel (EV1) reduced variate
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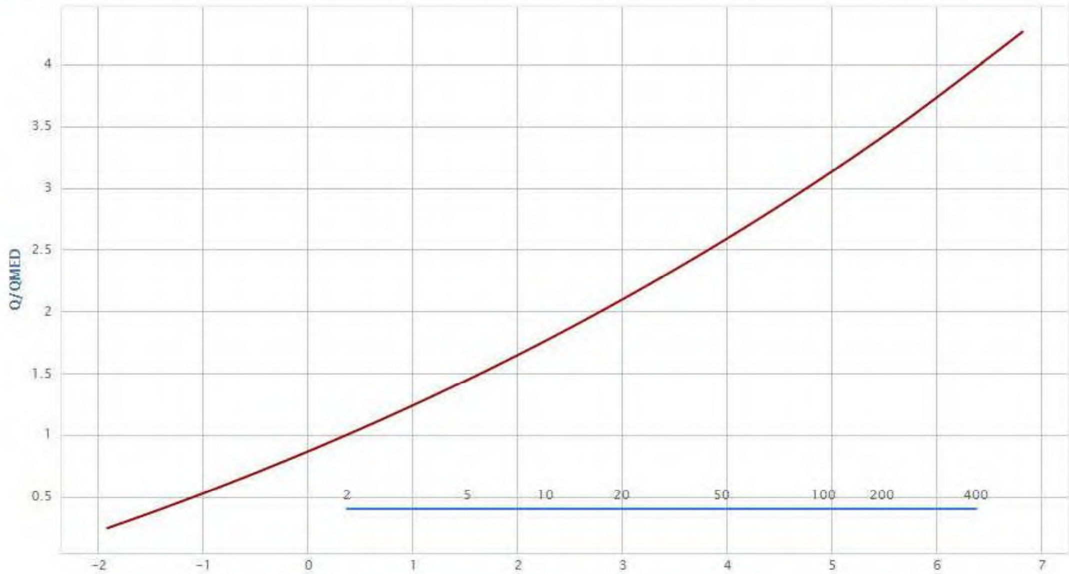
5
10
20
50
100
200
400
L-CV
L-skewness
08009
08005
08012
09035
09011
25034
Pooled
36031
LN2
LO
EV1
L-kurtosis
14009

Final Analysis ✖

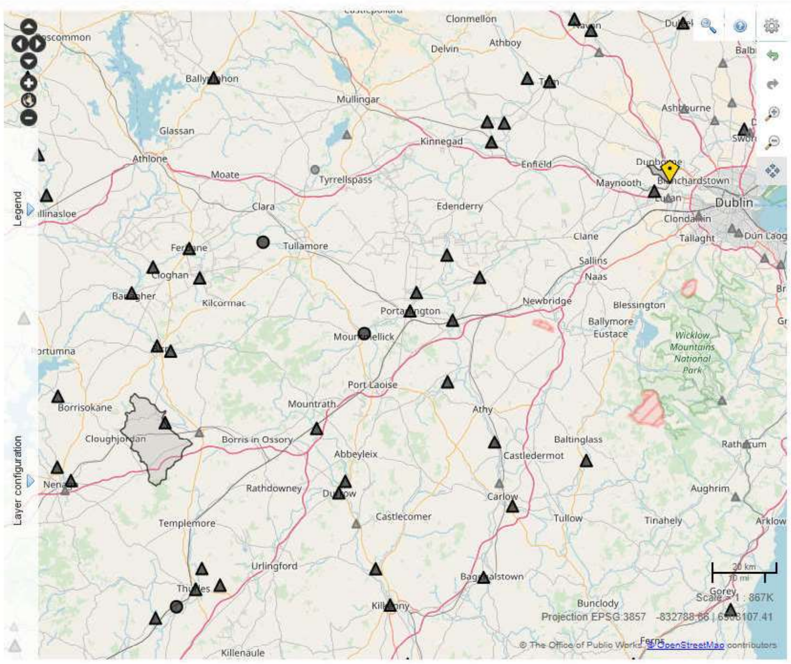


Distribution GEV

	t=1.3	t=2	t=5	t=10	t=20	t=30	t=50	t=100	t=200	t=500	t=1000
Growth Factors	0.73	1	1.44	1.76	2.08	2.28	2.54	2.91	3.31	3.87	4.32
Design Peak Flows (m^3/s)	0.7	0.95	1.37	1.67	1.98	2.16	2.41	2.76	3.14	3.67	4.1

Filter Cancel Finish

Rainfall DDF | Flood frequencies | Hydrograph widths | IBIDEM



Subject site 09_1660_6

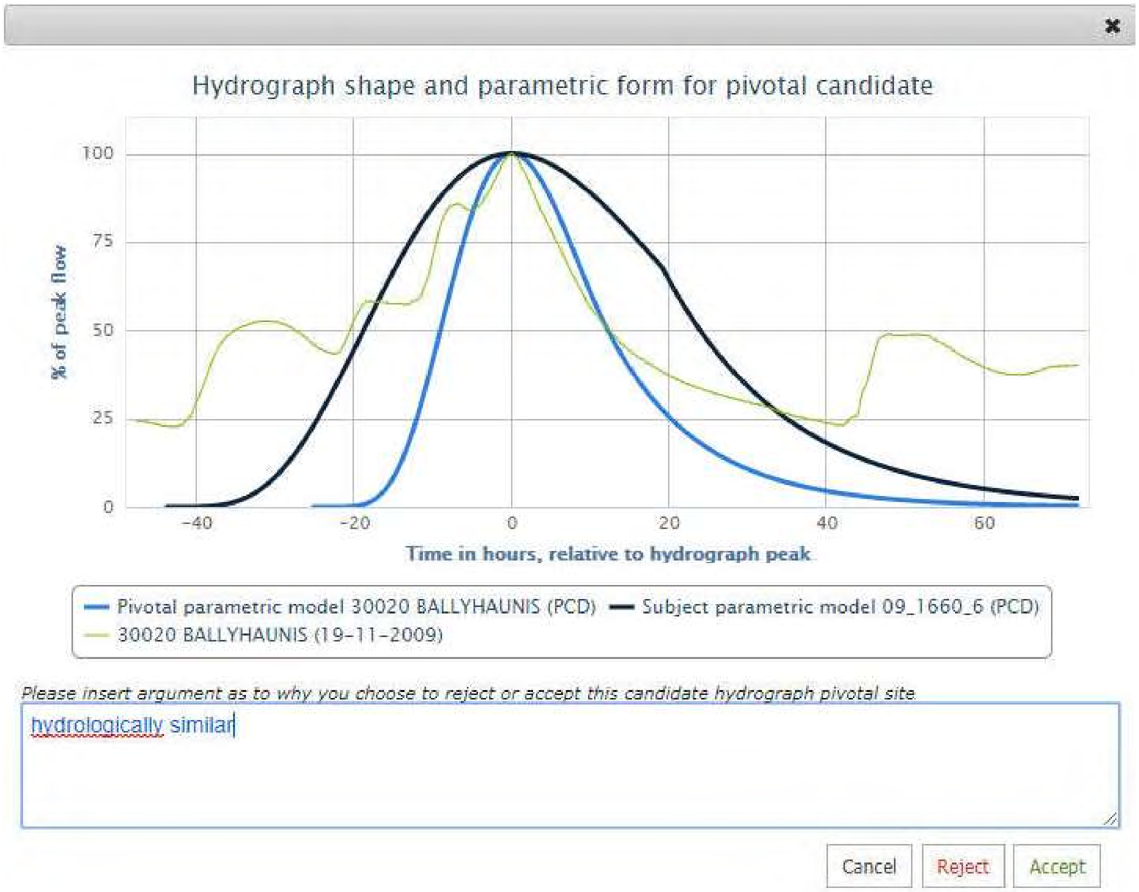
Hydrograph pivotal site

Hydrologically closest sites

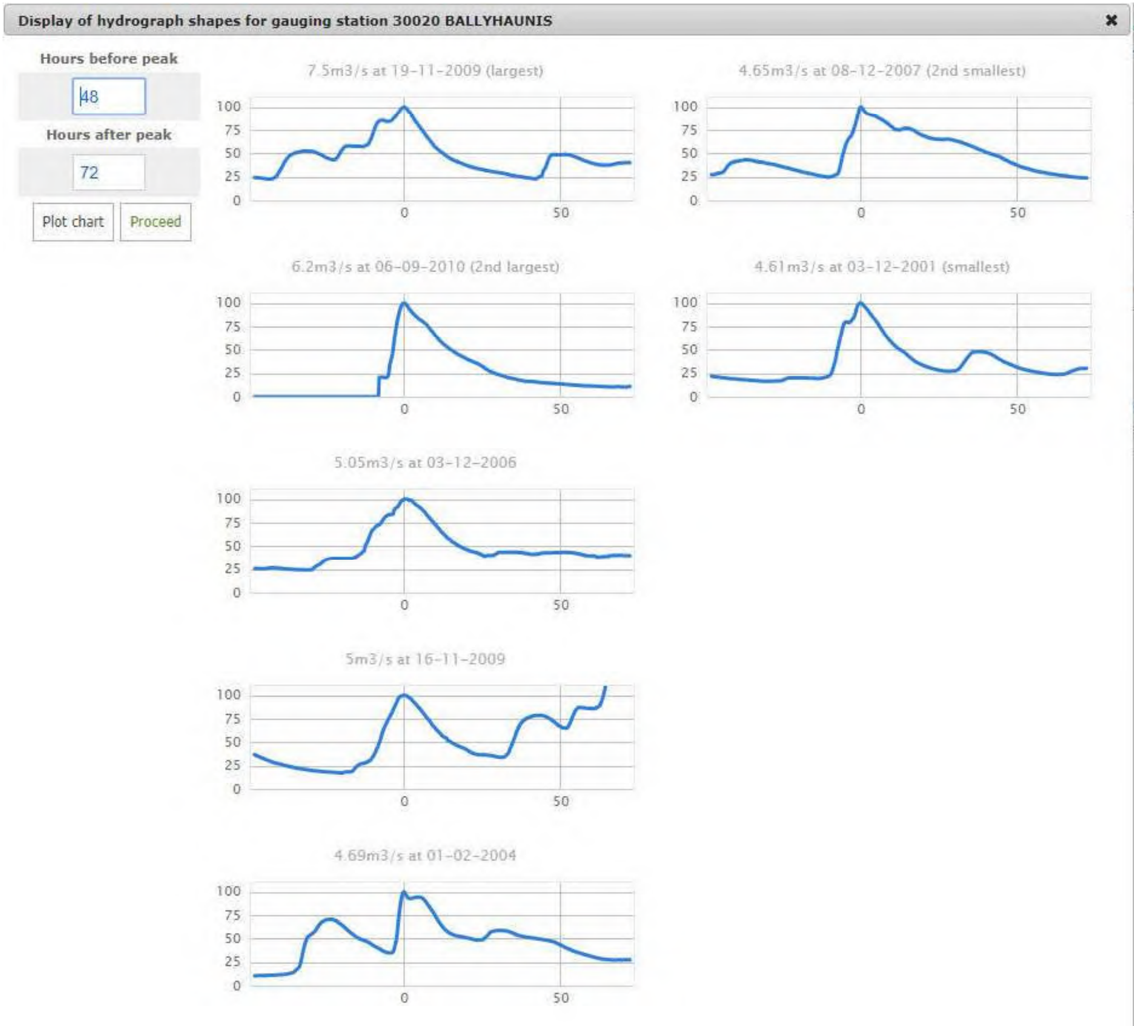
Station number	30020
Station name	BALLYHAUNIS
Drainage area	21.4073km^2
Hydrological similarity	0.2149
Hydrographs	100 (7 > QMED)
Period	17-10-2000 to 06-04-2011
Hydrograph date	05-07-2013
Hydrograph org.	FSU
Hydrograph type	Peaks-over-threshold
HWA date	-
HWA org.	-
Floods for HWA	-

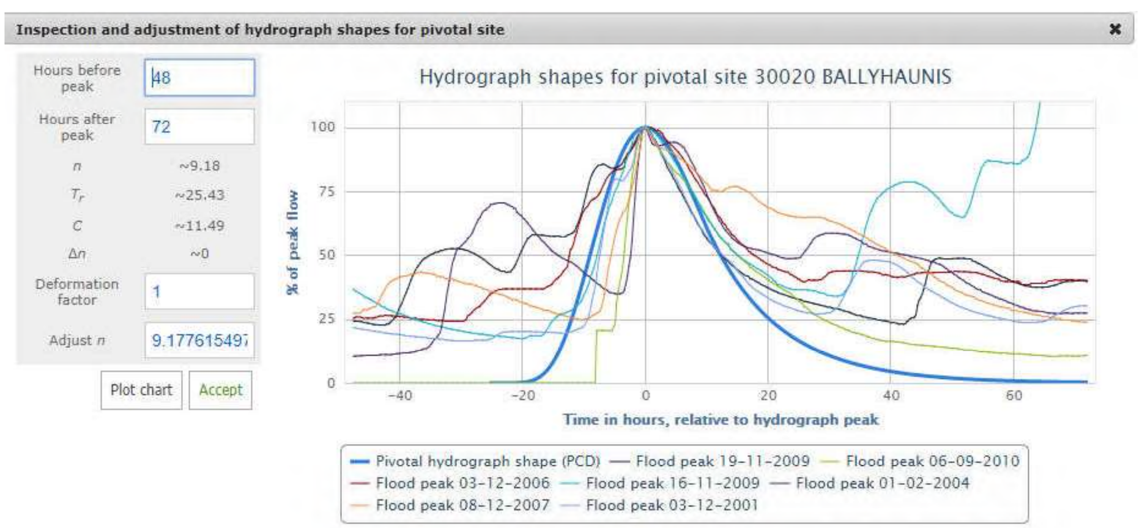
QMED values

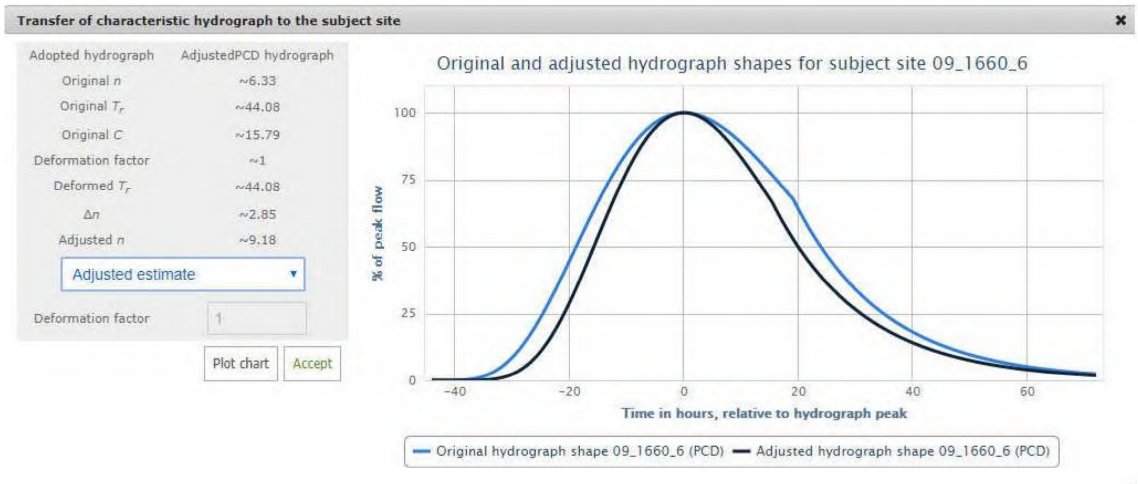
QMED Gauged	4.42m^3/s
QMED PCD estimate	
Status	-



Hydrograph shape and parametric form for pivotal candidate
% of peak flow
100
75
50
25
0
-40
-20
0
20
40
60
Time in hours, relative to hydrograph peak
Pivotal parametric model 30020 BALLYHAUNIS (PCD)
Subject parametric model 09_1660_6 (PCD)
30020 BALLYHAUNIS (19-11-2009)
Please insert argument as to why you choose to reject or accept this candidate hydrograph pivotal site
hydrologically similar
Cancel
Reject
Accept


Display of hydrograph shapes for gauging station 30020 BALLYHAUNIS
Hours before peak
48
Hours after peak
72
Plot chart
Proceed
7.5m3/s at 19-11-2009 (largest)
4.65m3/s at 08-12-2007 (2nd smallest)
6.2m3/s at 06-09-2010 (2nd largest)
4.61m3/s at 03-12-2001 (smallest)
5.05m3/s at 03-12-2006
5m3/s at 16-11-2009
4.69m3/s at 01-02-2004


Inspection and adjustment of hydrograph shapes for pivotal site
Hours before peak
48
Hours after peak
72
n
~9.18
Tr
~25.43
C
~11.49
Δn
~0
Deformation factor
1
Adjust n
9.17761549
Plot chart
Accept
Hydrograph shapes for pivotal site 30020 BALLYHAUNIS
% of peak flow
Time in hours, relative to hydrograph peak
Pivotal hydrograph shape (PCD)
Flood peak 19-11-2009
Flood peak 06-09-2010
Flood peak 03-12-2006
Flood peak 16-11-2009
Flood peak 01-02-2004
Flood peak 08-12-2007
Flood peak 03-12-2001


Transfer of characteristic hydrograph to the subject site
Adopted hydrograph
AdjustedPCD hydrograph
Original n
~6.33
Original Tr
~44.08
Original C
~15.79
Deformation factor
~1
Deformed Tr
~44.08
Δn
~2.85
Adjusted n
~9.18
Adjusted estimate
Deformation factor
1
Plot chart
Accept
Original and adjusted hydrograph shapes for subject site 09_1660_6
% of peak flow
Time in hours, relative to hydrograph peak
Original hydrograph shape 09_1660_6 (PCD)
Adjusted hydrograph shape 09_1660_6 (PCD)

Completing the flood estimation ✖

Characteristic hydrographs

Click on one of the buttons to show the hydrograph for that return period

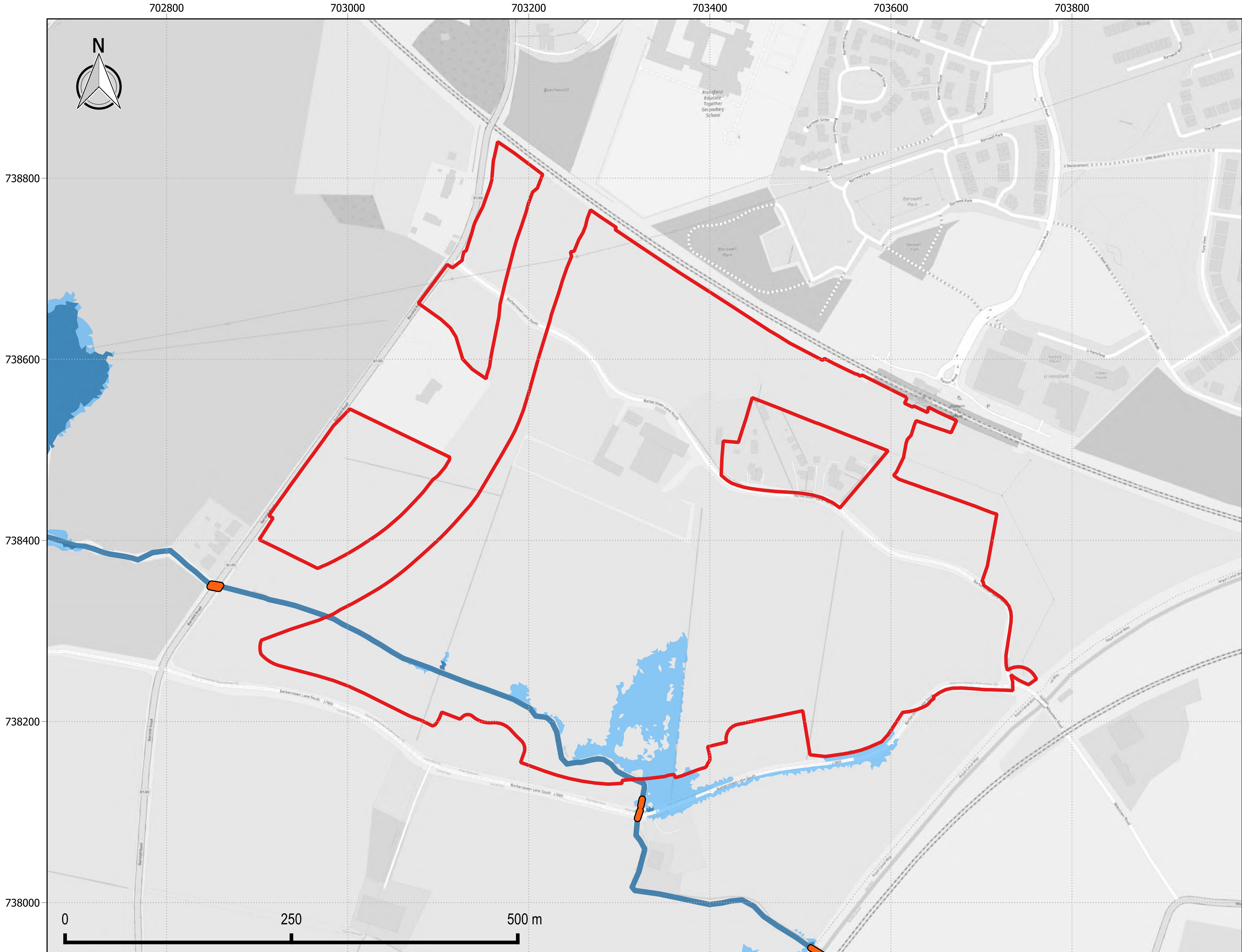
Finish

Hours relative to peak	T=5	T=10	T=25	T=50	T=100	T=200	**T=1000**
-44.08	0	0	0	0	0	0	**0**
-44	0	0	0	0	0	0	**0**
-43	0	0	0	0	0	0	**0**
-42	0	0	0	0	0	0	**0**
-41	0	0	0	0	0	0	**0**
-40	0	0	0	0	0	0	**0**
-39	0	0	0	0	0	0	**0**
-38	0	0	0	0	0	0	**0**
-37	0	0	0	0	0	0	**0**
-36	0	0	0	0	0	0	**0**
-35	0	0	0	0	0	0.01	**0.01**
-34	0	0.01	0.01	0.01	0.01	0.01	**0.01**
-33	0.01	0.01	0.01	0.01	0.02	0.02	**0.02**
-32	0.01	0.02	0.02	0.02	0.03	0.03	**0.04**
-31	0.02	0.03	0.03	0.04	0.04	0.05	**0.06**
-30	0.03	0.04	0.05	0.06	0.06	0.07	**0.09**
-29	0.05	0.06	0.07	0.08	0.09	0.11	**0.14**
-28	0.06	0.08	0.1	0.11	0.13	0.15	**0.19**
-27	0.09	0.11	0.13	0.15	0.18	0.2	**0.26**
-26	0.12	0.14	0.18	0.2	0.23	0.27	**0.35**
-25	0.15	0.18	0.23	0.26	0.3	0.34	**0.45**
-24	0.19	0.23	0.29	0.33	0.38	0.43	**0.57**
-23	0.23	0.29	0.36	0.41	0.47	0.54	**0.7**
-22	0.28	0.35	0.43	0.5	0.57	0.65	**0.85**
-21	0.34	0.41	0.52	0.6	0.68	0.78	**1.02**
-20	0.4	0.49	0.61	0.7	0.8	0.91	**1.19**
-19	0.46	0.56	0.7	0.81	0.93	1.06	**1.38**
-18	0.53	0.64	0.8	0.93	1.07	1.21	**1.58**
-17	0.59	0.73	0.91	1.05	1.2	1.37	**1.79**
-16	0.66	0.81	1.01	1.17	1.34	1.53	**2**
-15	0.74	0.9	1.12	1.3	1.49	1.69	**2.21**
-14	0.81	0.98	1.23	1.42	1.63	1.85	**2.42**
-13	0.87	1.07	1.33	1.54	1.77	2.01	**2.63**
-12	0.94	1.15	1.43	1.66	1.9	2.16	**2.83**
-11	1	1.23	1.53	1.77	2.03	2.31	**3.02**
-10	1.06	1.3	1.62	1.88	2.15	2.44	**3.2**
-9	1.12	1.37	1.71	1.98	2.27	2.57	**3.37**
-8	1.17	1.43	1.78	2.07	2.37	2.69	**3.52**
-7	1.22	1.48	1.85	2.15	2.46	2.79	**3.65**
-6	1.26	1.53	1.91	2.22	2.54	2.88	**3.77**
-5	1.29	1.57	1.96	2.28	2.61	2.96	**3.87**
-4	1.32	1.61	2.01	2.33	2.66	3.03	**3.96**
-3	1.34	1.63	2.04	2.36	2.71	3.07	**4.02**
-2	1.35	1.65	2.06	2.39	2.74	3.11	**4.07**
-1	1.36	1.66	2.07	2.41	2.76	3.13	**4.09**
0	1.37	1.67	2.08	2.41	2.76	3.14	**4.1**
1	1.36	1.66	2.08	2.41	2.76	3.13	**4.09**
2	1.35	1.65	2.06	2.39	2.74	3.11	**4.07**
3	1.34	1.64	2.04	2.37	2.71	3.08	**4.03**
4	1.32	1.61	2.01	2.34	2.68	3.04	**3.97**
5	1.3	1.59	1.98	2.3	2.63	2.99	**3.91**
6	1.27	1.55	1.94	2.25	2.58	2.92	**3.83**
7	1.24	1.52	1.89	2.2	2.52	2.86	**3.74**
8	1.21	1.48	1.84	2.14	2.45	2.78	**3.64**
9	1.17	1.43	1.79	2.07	2.38	2.7	**3.53**
10	1.14	1.39	1.73	2.01	2.3	2.61	**3.42**
11	1.1	1.34	1.67	1.94	2.22	2.52	**3.3**
12	1.06	1.29	1.61	1.86	2.14	2.42	**3.17**
13	1.01	1.24	1.54	1.79	2.05	2.33	**3.04**
14	0.97	1.18	1.48	1.71	1.96	2.23	**2.91**
15	0.93	1.13	1.41	1.64	1.87	2.13	**2.78**
16	0.88	1.07	1.33	1.55	1.77	2.01	**2.63**
17	0.82	1	1.25	1.45	1.66	1.89	**2.47**
18	0.77	0.94	1.17	1.36	1.56	1.77	**2.32**
19	0.72	0.88	1.1	1.28	1.46	1.66	**2.17**
20	0.68	0.83	1.03	1.2	1.37	1.56	**2.04**
21	0.64	0.78	0.97	1.13	1.29	1.46	**1.92**
22	0.6	0.73	0.91	1.06	1.21	1.37	**1.8**
23	0.56	0.69	0.86	0.99	1.14	1.29	**1.69**
24	0.53	0.64	0.8	0.93	1.07	1.21	**1.58**
25	0.49	0.6	0.75	0.87	1	1.14	**1.49**
26	0.46	0.57	0.71	0.82	0.94	1.07	**1.4**
27	0.44	0.53	0.66	0.77	0.88	1	**1.31**
28	0.41	0.5	0.62	0.72	0.83	0.94	**1.23**
29	0.38	0.47	0.59	0.68	0.78	0.88	**1.15**
30	0.36	0.44	0.55	0.64	0.73	0.83	**1.08**
31	0.34	0.41	0.52	0.6	0.68	0.78	**1.02**
32	0.32	0.39	0.48	0.56	0.64	0.73	**0.95**

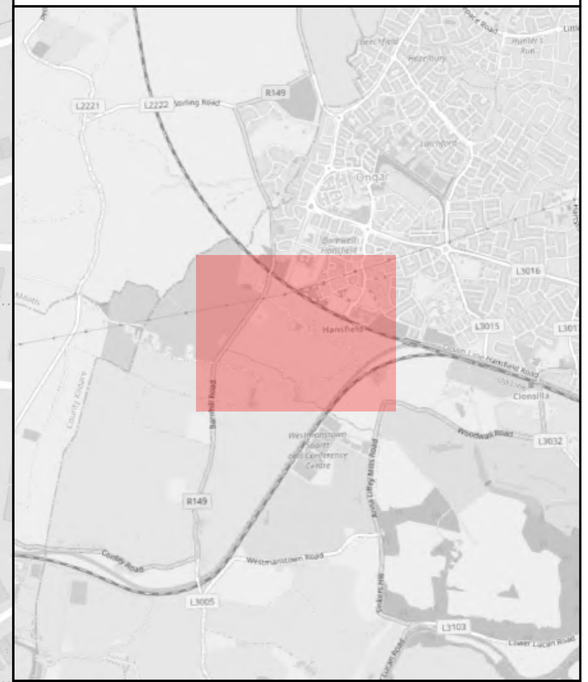
Finish

Appendix E

Flood Maps



MODEL OVERVIEW



LEGEND

- SITE BOUNDARY
- RUSK WATERCOURSE
- CULVERTS
- FLOOD ZONE A
- FLOOD ZONE B

NOTES

1 ALL LEVELS INDICATED ARE TO ORDNANCE DATUM MALIN.

2. ALL GRID COORDINATE INFORMATION IS TO IRISH TRANSVERSE MERCATOR.

3. FLOOD EXTENTS ARE SHOWN ONLY IN THE IMMEDIATE VICINITY OF THE SITE. FLOOD MODELLING IS BASED ON A COMBINATION OF GROUND-BASED TOPOGRAPHIC SURVEY AT AND AROUND THE SITE AND LIDAR FOR THE WIDER CATCHMENT.

McCloy Consulting

Unit 12,
The Beat Centre,
Stephenstown Industrial Estate,
Balbriggan, Co. Dublin

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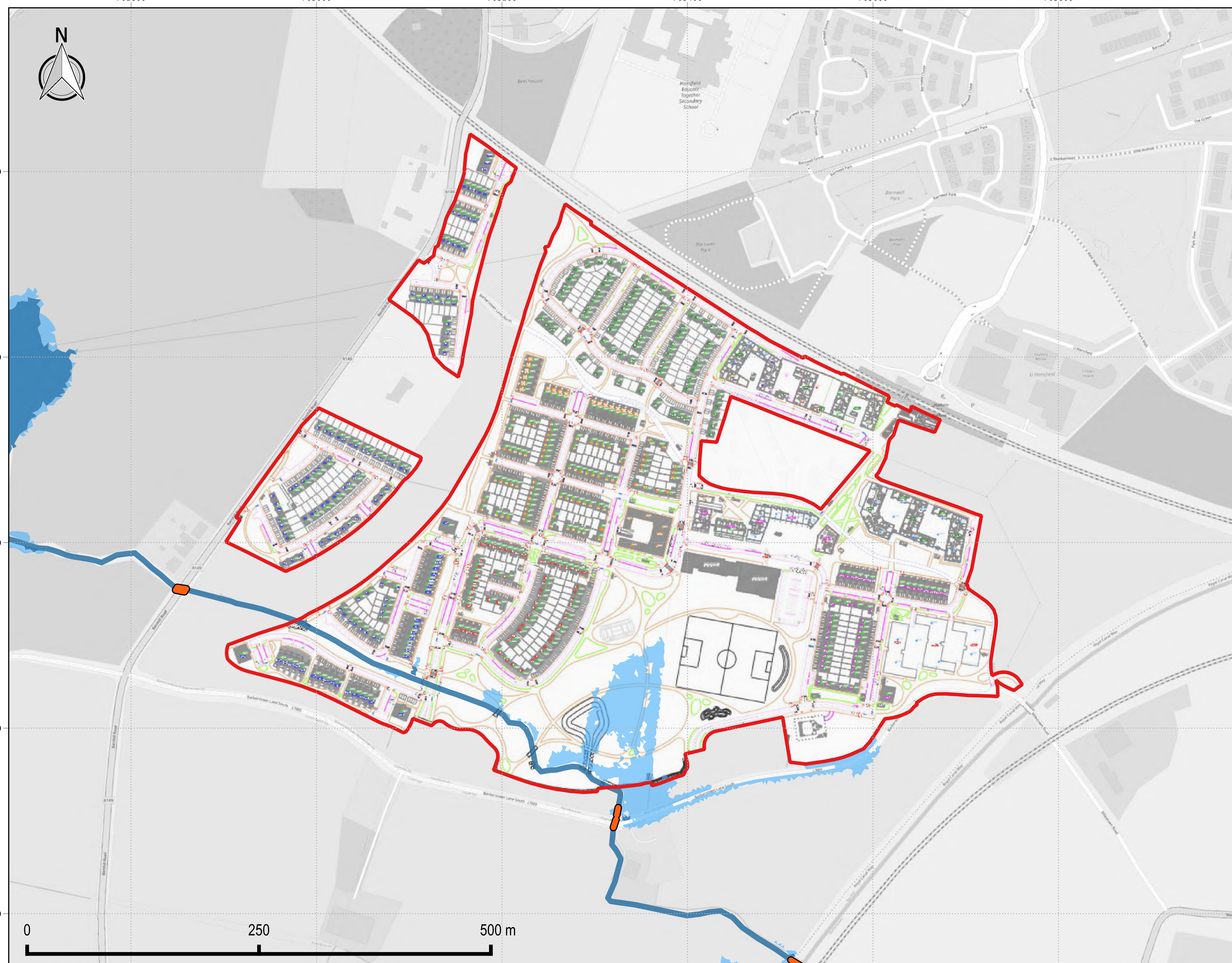
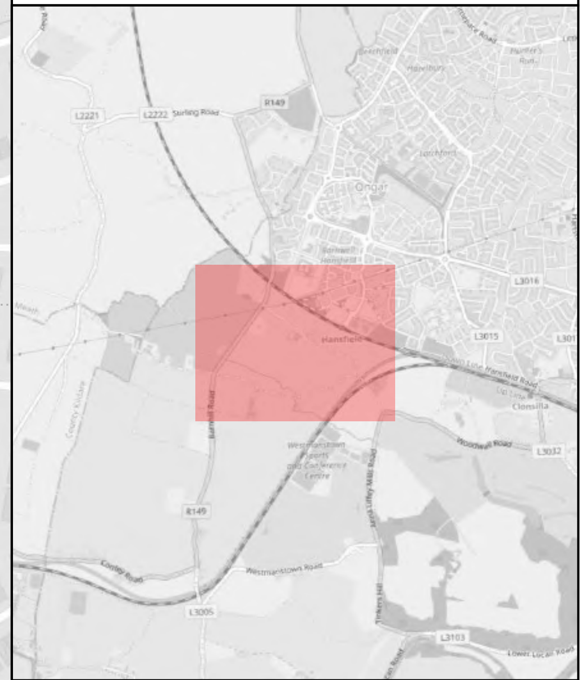
E: info@mccloyconsulting.ie
W: www.mccloyconsulting.ie

PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BARNHILL, DUBLIN 15		PRESENT DAY	1:4000	A3
MAP TYPE		**GEOMETRY SCENARIO**	**DRAWN BY**	**APPROVED**
FLOOD ZONE MAP		EXISTING	DH	PS
SOURCE	**FLOOD EVENT**	**FIGURE NUMBER**	**REVISION**	**DATE**
FLUVIAL	1% AEP / 0.1% AEP	M02124-04_FIG_FL01	1	05/07/2022



MODEL OVERVIEW



LEGEND

SITE BOUNDARY

RUSK WATERCOURSE

CULVERTS

1% AEP PRESENT DAY FLOOD EXTENTS

0.1% AEP PRESENT DAY FLOOD EXTENTS

NOTES

1 ALL LEVELS INDICATED ARE TO ORDNANCE DATUM MALIN.

2. ALL GRID COORDINATE INFORMATION IS TO IRISH TRANSVERSE MERCATOR.

3. FLOOD EXTENTS ARE SHOWN ONLY IN THE IMMEDIATE VICINITY OF THE SITE. FLOOD MODELLING IS BASED ON A COMBINATION OF GROUND-BASED TOPOGRAPHIC SURVEY AT AND AROUND THE SITE AND LIDAR FOR THE WIDER CATCHMENT.

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PROJECT		HYDROLOGY SCENARIO	SCALE	ORIGINAL SIZE
BARNHILL, DUBLIN 15		PRESENT DAY	1:4000	A3
MAP TYPE		GEOMETRY SCENARIO	DRAWN BY	APPROVED
FLOOD EXTENTS MAP		PROPOSED	DH	PS
SOURCE	FLOOD EVENT	FIGURE NUMBER	REVISION	DATE
FLUVIAL	1% AEP / 0.1% AEP	M02124-04_FIG_FL02	1	05/07/2022

Appendix F

Site Visit Photographs

Photo Location 1: View of Site from South-West	Photo Location 2: View of Site from South-East
	
Photo Location 3: Watercourse Crossing at Upstream Extent of Site	**Photo Location 4: Watercourse Crossing at Downstream Extent of Site**
	
Photo Location 5: Watercourse Crossing at Canal / Railway	**Photo Location 6: View of Watercourse Downstream of Site**