Project

Proposed Development at Glenamuck Road, Dublin 18

Report Title

Site Specific Flood Risk Assessment

Client

Bowbeck DAC

INFRASTRUCTURE

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Author: Prinavan Chetty

Reviewed by: Nick Fenner

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DBFL Consulting Engineers

Dublin Office
Ormond House
Upper Ormond Quay
Dublin 7

Tel 01 4004000
Fax 01 4004050
Email info@dbfl.ie
Web www.dbfl.ie

Waterford Office
Suite 8b The Atrium
Maritana Gate,
Canada Street
Waterford

Tel 051 309500
Email info@dbfl.ie
Web www.dbfl.ie

Cork Office
Phoenix House
Monahan Road
Cork

Tel 021 2024538
Email info@dbfl.ie
Web www.dbfl.ie

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1.0 EXECUTIVE SUMMARY

DBFL Consulting Engineers Ltd were appointed to undertake a Site Specific Flood Risk Assessment to accompany a planning submission for a proposed residential development on a site at Glenamuck Road, Dublin 18. This report has been compiled with reference to the requirements of OPW document *"The Planning System and Flood Risk Management (November 2009)"* and its technical appendices. The proposed type development is categorised by the OPW Guidelines as 'highly vulnerable development', therefore, it is appropriate and will meet the Sequential Test if it is located within Flood Zone C.

A stage 1 assessment, identification of flood risk for the proposed site was undertaken. From all sources of information consulted it was apparent the site is located partially within Flood Zone A due to the Carrickmines River; however, only water compatible development such as footpaths and landscaped open space is located in Flood Zone A, which is not ancillary to the residential development. The presence of another watercourse the Golf/Glenamuck Stream is also located around the northern boundary of the site, although this watercourse was not part of the flood modelling project CFRAMS.

As part of the SSFRA, initial and detailed assessments were undertaken and a hydrological model was created to predict the flood extents of the Golf Stream, to ensure the residential development is wholly located in Flood Zone C. The flood extents are shown in DBFL drawing 170063-9120 and prove the proposed residential development is outside these flood extents and the required freeboard is provided at a series of critical points around the development.

It was noted that in the recent past the levels to the north of the development have been filled, this was undertaken after the CFRAMS study was undertaken and impedes an overland flow path onto the M50 that is shown in the CFRAMS flood map. As part of the development it is proposed to restore these original levels to ensure the flood mechanism of this area is consistent with CFRAMS.

At the request of the Local Authority a sensitivity analysis on the Glenamuck Stream flows to compare results with a third party flood risk assessment undertaken as part of a planning application for The Park which had proposed significant changes to estimated flows used by the OPW CFRAMS flood maps. It was concluded that the increased flows would result in a larger Flood Zone A and B with higher flood levels. However critically the third party had not allowed for the reinstatement of ground levels along the northern boundary of the site which limits any increase in flood levels. An analysis of flood levels for the 0.1%AEP event indicates that the development is still wholly within Flood Zone C and that majority of the development would still have required freeboards around the development.

We conclude that the proposed development is appropriate for the existing site and its associated flood risk and that it is designed in accordance with the requirements of the necessary Flood Management Guidelines.

2.0 INTRODUCTION

2.1 Background

DBFL Consulting Engineers were commissioned by the applicant to prepare a Site Specific Flood Risk Assessment (SSFRA) for the proposed development at Glenamuck Road, Dublin 18. This SSFRA was prepared to comply with current planning legislation and forms part of the proposed planning application for the subject site.

2.2 Objectives

The objectives of this report are to inform the Planning Authority regarding flood risk for the potential development of the lands. The report will assess the site and development proposals in accordance the requirements of *"The Planning System and Flood Risk Management Guidelines for Planning Authorities".*

The report will provide the following:

- The site's flood zone category.
- Information to allow an informed decision of the planning application in the context of flood risk.
- Appropriate flood risk mitigation and management measures for any residual flood risk

2.3 Flood Risk Assessment Scope

This SSFRA relates only to the proposed development site at Glenamuck Road and its immediate surroundings. This report uses information obtained from various sources, together with an assessment of flood risk for the existing land and proposed development. The report follows the requirements of *'The Planning System & Flood Risk Management – Guidelines for Planning Authorities'*, (referred to as the Guidelines for the remainder of this report).

2.4 Approach

Chapter 2 of this report considers *'The Planning System & Flood Risk Management – Guidelines for Planning Authorities'* as they relate to the proposed application.

Flood risk identification is presented in Chapter 3 and initial flood risk assessment in Chapter 4. Leading from this a more detailed assessment of specific flood risk and residual risk relating to the proposed development is presented Chapter 5.

Conclusions and recommendations are presented in Chapter 6.

2.5 Existing Site

The subject site, approximately 1.78 hectares in size, is located south of junction 15 of the M50 Motorway (as shown in Figure 2-1); and includes DLRCoCo's land to the north and west of the development.

The site is bounded by Glenamuck Road to the west, Golf Lane to the south east and the M50 slip lane to the north. The Dun Laoghaire-Rathdown County Council Development Plan designates the site as Zone A, which is to protect and improve residential amenity.

Figure 2-1: Site Location (Site Boundary Indicative Only).

EPA designated watercourses in the vicinity of the site include the Carrickmines River which enters and exits at the north west corner of the site and the Glenamuck / Golf Stream runs within the site parallel to the Glenamuck Road. The two watercourses converge in the north west corner of the site.

The topography of the site generally falls from south-east to north-west towards the stream, ranging from approximately 80m AOD in the south to 75m AOD at the top of the river embankment and 70m AOD at the lowest stream level. Refer to topographical survey in Appendix C.

2.6 Proposed Development

The proposed development comprises a residential development of 482 no. units (all apartments), along with ancillary residential amenities, and provision of a childcare facility, gym, and local shop. The proposed residential units comprise 31 no. studio units, 183 no. 1-bedroom units, 229 no. 2-bedroom units, and 39 no. 3-bedroom units (including 2 no. duplex type units).

The proposed development is set out in 7 no. blocks which comprise the following:

- Block A1 comprises 62. no, apartments within a part four, part six storey building, including 10 no. studio units, 7 no. 1-bedroom units, 41 no. 2 bedroom units, and 4 no. 3-bedroom units. An ESB substation is provided at ground floor level.
- Block A2 comprises 85 no. apartments within a part four, part eight storey building, including 25 no. 1-bedroom units, 45 no. 2-bedroom units, and 15 no. 3-bedroom units.
- Block A3 comprises 79 no. apartments within a part four, part twelve storey building, including 21 no. studio units, 19 no. 1-bedroom units, 28 no. 2-bedroom units, and 11 no. 3-bedroom units.
- Block B0 comprises 150 no. apartments and resident's amenities within a part four, part eighteen, part twenty-one and part twenty-two storey building. The apartments include 76 no. 1-bedroom units, 68 no. 2-bedroom units, and 6 no. 3-bedroom units (including 2 no. duplex type units). An ESB substation, resident's concierge area and amenity space (171 sq.m sq.m) are provided at ground floor level. A further resident's amenity / event space is provided at the twentieth and twenty-first floor levels (83 sq.m).
- Block B1 comprises 8 no. apartments and is four storeys in height, directly abutting Block B. The apartments include 4 no. 1-bedroom units, and 4 no. 2-bedroom units.
- Block C comprises 42 no. apartments and a local shop within a part five, part seven storey building. The apartments include 30 no. 1-bedroom units, 9 no. 2-bedroom units, and 3 no. 3-bedroom units. A local shop (154 sq.m) and an ESB substation are provided at ground floor level.
- Block D comprises 56 no. apartments, a commercial gym, resident's concierge area, resident's lounge, and a childcare facility in a part four, part seven storey building. The apartments include 22 no. 1-bedroom units, and 34 no. 2-bedroom units. The resident's concierge area (99 sq.m), commercial gym (340 sq.m), and childcare facility (300 sq.m) units are located at ground floor level. The resident's lounge (292 sq.m) is located at first floor level.

Two basement levels are proposed, providing car parking spaces (299 no.), bin stores, plant rooms, bicycle parking (1,000 no. spaces), and circulation areas. A further 240 no. bicycle parking spaces and 4 no. car parking spaces are provided at ground level. The proposed development includes landscaping, boundary treatments, public, private and communal open space (including roof terraces), two cycle / pedestrian crossings over the stream at the western side of the site,

along with a new pedestrian and cycle crossing of Glenamuck Road South at the west of the site, cycle and pedestrian facilities, play facilities, and lighting. The proposed buildings include the provision of private open space in the form of balconies and winter gardens to all elevations of the proposed buildings. The development also includes vehicular, pedestrian, and cycle accesses, drop off areas, boundary treatments, services, and all associated ancillary and site development works.

3.0 PLANNING GUIDELINES & FLOOD RISK ASSESSMENT

3.1 The Planning System and Flood Risk Management, Guidelines for Planning Authorities

The FRM Guidelines provide "mechanisms for the incorporation of flood risk identification, assessment and management into the planning process….". They ensure a consistent approach throughout the country requiring identification of flood risk and flood risk assessment to be key considerations when preparing development plans, local area plans and planned development.

"The core objectives of The FRM Guidelines are to:

- Avoid inappropriate development in areas at risk of flooding;
- Avoid new developments increasing flood risk elsewhere;
- 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 the requirements of EU and national law in relation to the natural environment and nature conservation are complied with for flood risk management."

The key principles of The FRM Guidelines are to apply the Sequential Approach to the planning process i.e.:

- "Avoid the risk, where possible,
- Substitute less vulnerable uses, where avoidance is not possible, and
- Mitigate and manage the risk, where avoidance and substitution are not possible."

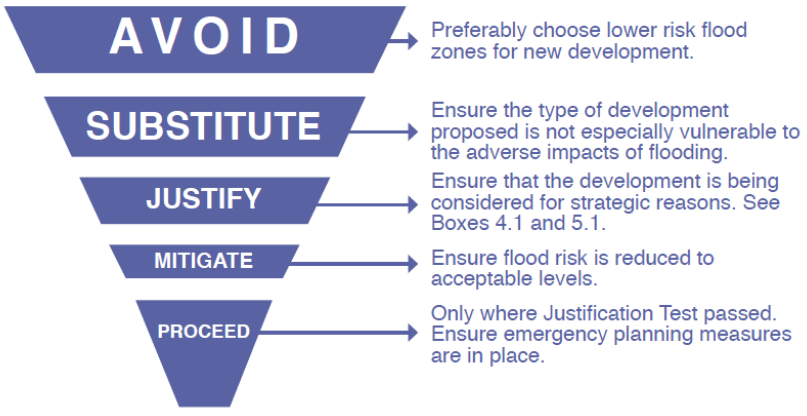


Figure 3-1: Sequential Approach Principles in Flood Risk Management

Where the *Sequential Test's* **avoid** and **substitute** principals are not appropriate then the FRM Guidelines propose that a *Justification Test* be applied to assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk.

3.2 Flood Risk Assessment

The assessment of flood risk requires an understanding of where water comes from (the source), how and where it flows (the pathways) and the people and assets affected by it (the receptors).

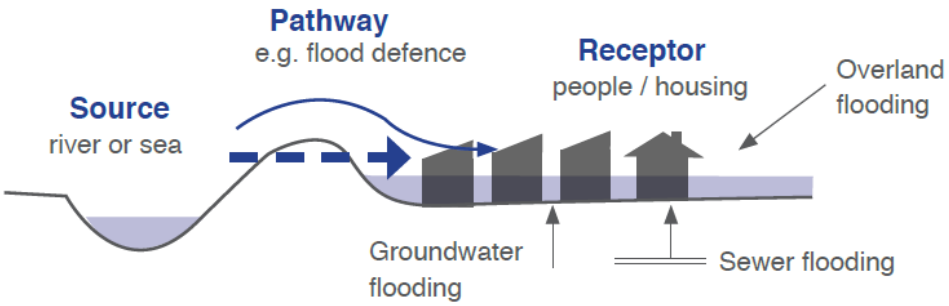


Figure 3-2: Source-Pathway-Receptor Model

The principal source is rainfall and the principal pathways are rivers, drains, sewers, overland flow and river floodplains and defence assets. The receptors can include people, their property and the environment. All three elements are examined as part of the flood risk assessment including the vulnerability and exposure of receptors to determine potential consequences. Mitigation measures typically used in development management can reduce the impact of flooding on people and communities e.g. by blocking or impeding pathways. The planning process is primarily concerned with the location of receptors and potential sources and pathways that might put those receptors at risk.

Risks to people, property and the environment should be assessed over the full range of probabilities, including extreme events. Flood risk assessment should cover all sources of flooding, including effects of run-off from a development locally and beyond the development site.

3.3 Flood Risk Assessment Stages

This site specific flood risk assessment will initially use existing flood risk information to determine the flood zone category of the site i.e. to check if the Guidelines Sequential Approach has been applied, see Figure 3-3 for details. The development includes a range of development types e.g. highly vulnerable residential apartments, highly vulnerable creche and water compatible open spaces. These will be assessed for their suitability compared to the existing site's flood risk zonings.

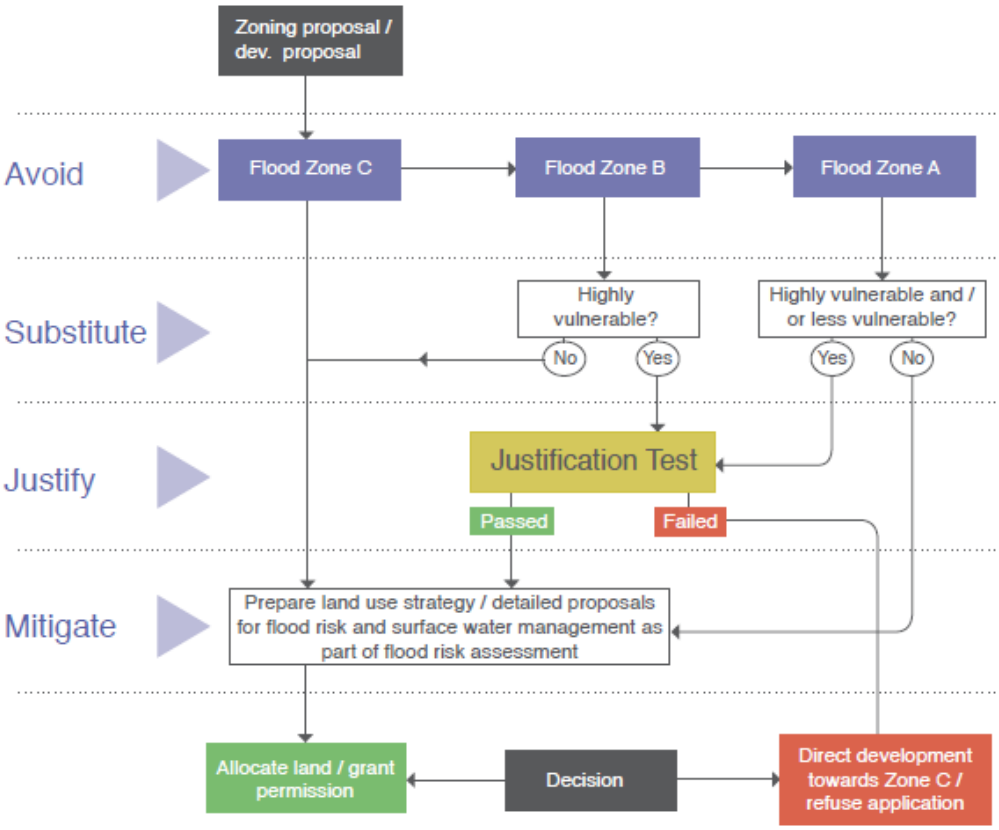


Figure 3-3: Sequential Approach mechanism in the Planning Process

Flood risk is normally assessed by a flood risk identification stage followed by an initial flood risk assessment. A more detailed flood risk assessment stage then follows which includes an assessment of surface water management, flood risk and mitigation measures to be applied.

The following report sections outline the flood risk assessment stages for the proposed development which follow the requirements of the Guidelines Technical Appendices.

4.0 STAGE 1 FLOOD RISK IDENTIFICATION

4.1 Available Flood Risk Information

The initial flood risk identification stage uses existing information to identify and confirm whether there may be flooding or surface water management issues for the lands in question that may warrant further investigation. To initially identify potential flood risks for the existing site and surrounding area, a number of available data sources were consulted, these are listed in Table 4-1.

Table 4-1: Review of Available Flood Risk Information

	Information Source	Coverage	Quality	Confidence	Identified Flood Risks	Flood Risk
Primary Data Source & Modelled Data	OPW ECFRAM	Regional	High	High	Flood maps identify Flood Zones A, B & C in site	√
	ICPSS	Nationwide	High	High	None	X
	DLRCC SFRA	Local	High	High	Small amount of Flood risk at northern tip of site.	√
Secondary Data Source	Walkover Survey	Local	Varies	Varies	Partly developed. Stream passes through part of site / adjoining lands. No evidence of flooding. Existing sewers in area. Large level difference / fall from south to north boundary. Stream is located in a deep valley.	X
	OPW Historic Flood Records & Benefitting Lands	Nationwide	Varies	Varies	No records of flooding on site. Nearest flooding to the North of the M50 in 2002 & 1997.	X
	LA Staff. Historic Flood Events.	Local	Varies	Varies	No history of flooding noted for lands by Local Area Office.	X
	Historic OSI Maps	Nationwide	Moderate	Low	None	X
	EPA Ex. Rivers	Nationwide	Moderate	Moderate	Carrickmines River in north east of site	√
	Drainage Records	County	Moderate	Moderate	No major sewers passing through or in close proximity of site.	X
	Geological Survey Ireland Maps	Nationwide	Moderate	Low	Till soils identified on site above granite. No groundwater issues.	X
	Future drainage schemes	Local	Moderate	Low	No planned works	X
	Site Investigation	Local	High	High	Rock at 1.5m-2m. No known groundwater issues.	X
	Topographic Survey	Local	High	High	Levels fall from south to north, with low lying area at northern boundary	√

4.2 Identified Flood Risks/Flood Sources

4.2.1 Existing Watercourses

There are a number of existing streams / rivers in the general area which are presented in Figure 4-1 and include the following:

- Glenamuck Stream,
- Golf Stream,
- Shanganagh River / Ballyogan Stream
- Racecourse Stream,
- Carrickmines River.

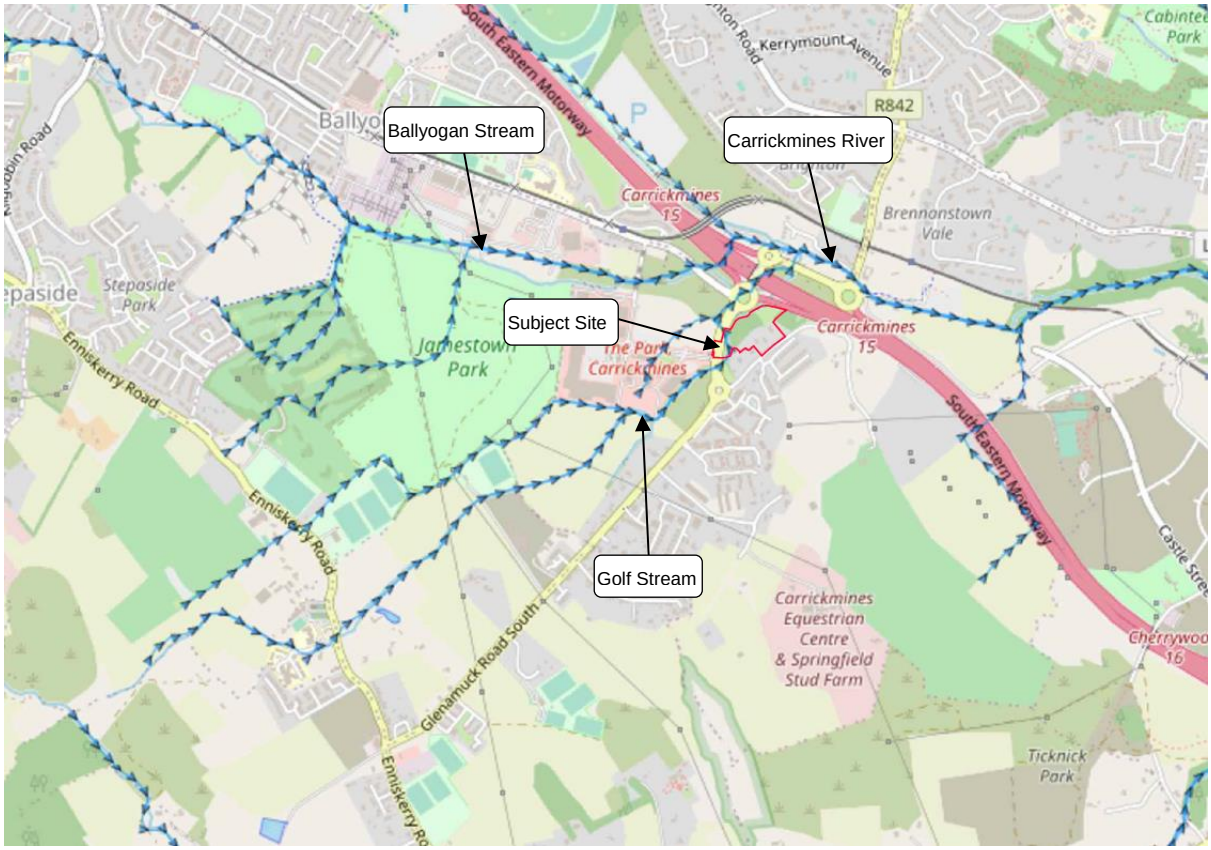


Figure 4-1: Overview of Watercourses in the vicinity of the site

4.2.2 OPW Predictive, Historic & Benefiting Lands Maps & Flood Hazard Information

The OPW CFRAM project produced flood extents maps for the Shanganagh River which indicate the subject site is partially in Flood Zones A and B, refer to Figure 4-2 for extract. Most of the site is located within Flood zone C, although the Glenamuck Stream was not included in the assessment. An overland flow path exists to the north of the site where it joins another flow path on the M50.

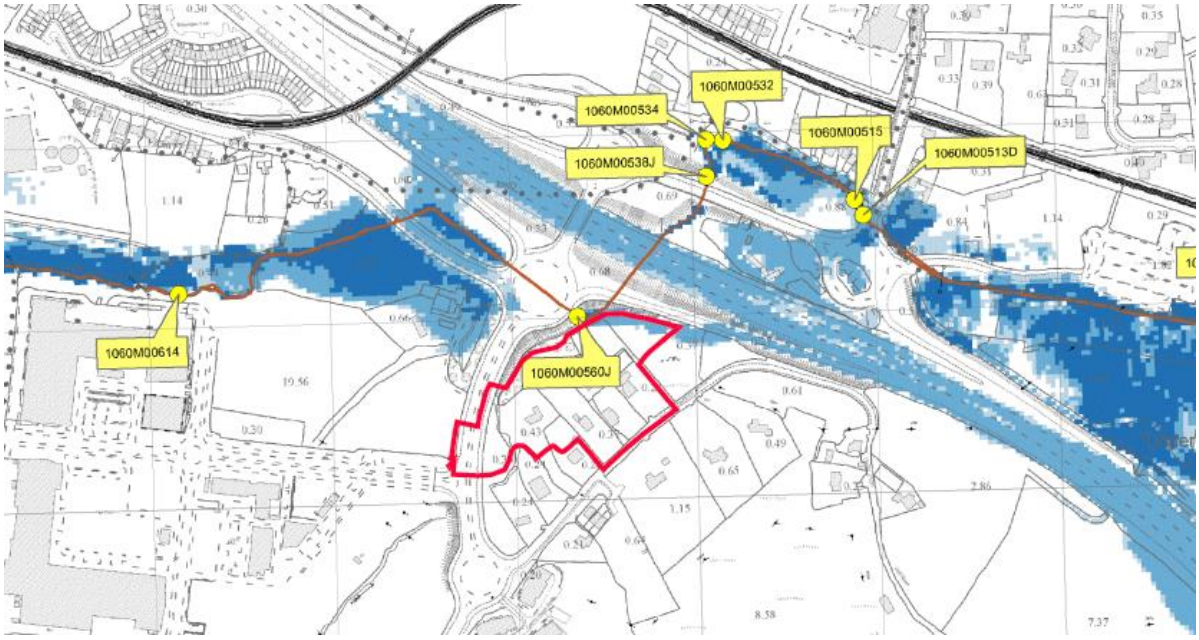


Figure 4-2: Extent of Flood Zone A within Site (extract from ECFRAM Flood Extents Map)

From consultation of flood information on the OPW's floodmaps.ie website, the site has not suffered from known flooding in the past although there were historic flood events downstream related to the Shanganagh River. A review of this report shows that although there have been 11 flood events recorded within 2.5km of the site since 1978, there are no records of flooding within the subject site. The nearest events were to what is now north of the M50 where flooding occurred in 2002 and 1997 before the motorway was constructed. In the interim, the river has been culverted several times along its alignment and therefore the flood mechanisms that occurred in 2002 and 1997 would have altered significantly.

The site is located far above and outside the extent of predicted tidal flooding and groundwater flooding is not a characteristic of the geology of the Carrickmines area.

4.2.3 Dun Laoghaire-Rathdown County Council Strategic Flood Risk Assessment

Appendix 13 of the County Development Plan 2016-2022 comprises the Strategic Flood Risk Assessment (SFRA) which uses the draft ECFRAM mapping as its basis for identifying areas at flood risk.

It identifies areas in Carrickmines/Cherrywood as having significant flood risk, although the subject site has a relatively low flood risk with only the stream valley in the north-west corner identified as in flood zone A, refer to Figure 4-3.

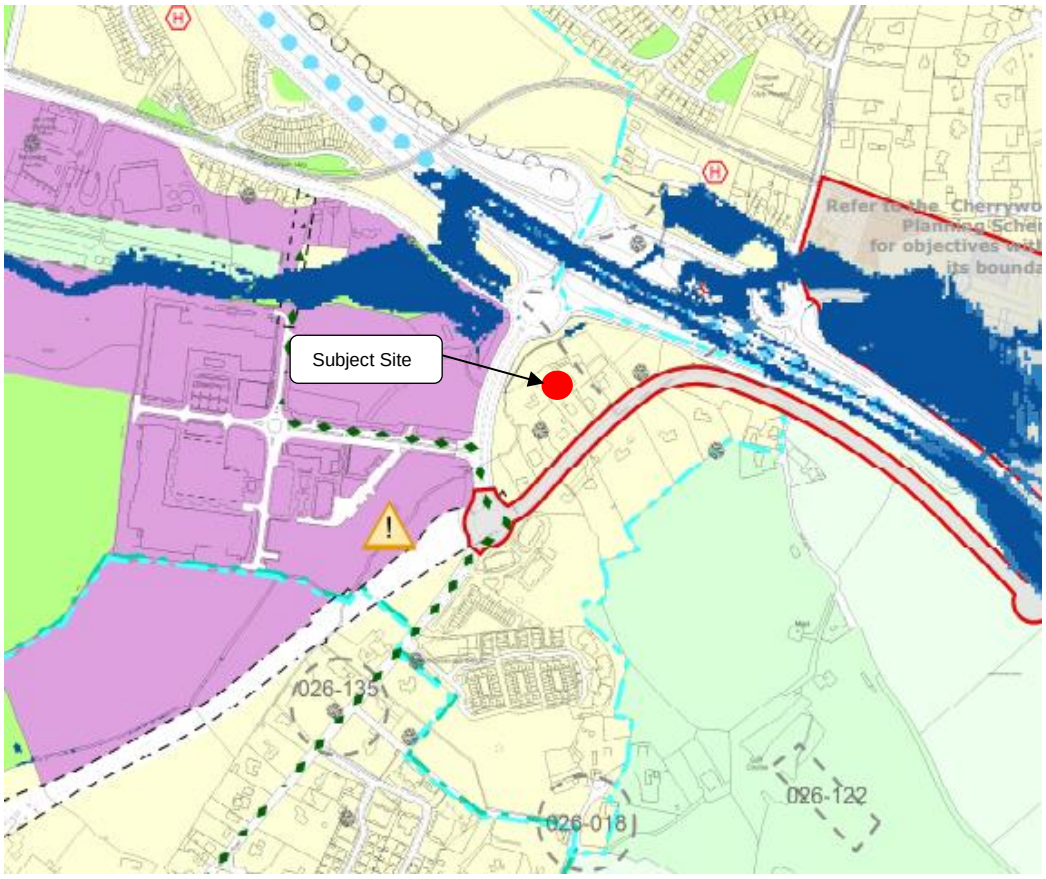


Figure 4-3: Extent of Flood Risk from Carrickmines River (extract from DLRCC Strategic Flood Risk Assessment, County Development Plan 2016-2022)

4.2.4 Walkover Survey

From a walkover of the site it is clear that the lands to the north have been filled since the original topographical survey was undertaken in 2007 and also since the creation of the CFRAMs LIDAR data. The original 2007 survey data supports the CFRAMs overland flow route and the walkover survey confirmed that the area has recently been filled.

The walkover survey confirmed the rest of the site is as expected and ties in with the topographical survey and the existing culverts entering and leaving the site. A visual survey of the culvert trash guards identified significant debris (wheelie bins, trollies) partially blocking the culvert.

4.3 Summary of Flood Risks Identified

The primary flood information source for the site is the Eastern CFRAM maps which predict a 10%, 1% and 0.1% AEP storm as causing flooding to a small area of the subject site with the 1% and 0.1 % AEP events causing an overland flow onto the M50 Motorway. The flooding is related to backwatering effects of the downstream culvert causing the river level to rise and spill out of bank, initiating an over-land flow along the north boundary of the site.

As the Stage 1 flood risk identification indicates Flood Zone A within the site and because the 'more vulnerable' classified proposed residential development is 'Appropriate' only in Flood Zones C without a Justification Test, then a more detailed Stage 2 and 3 flood risk assessment was undertaken to define the flood extents and ensure the proposed residential development is located within Flood Zone C on the subject site.

5.0 STAGE 2 INITIAL FLOOD RISK ASSESSMENT

The main sources of flooding identified from Stage 1 are:

- Fluvial flood risk from the Carrickmines River & Glenamuck / Golf Stream flowing through the north-western part of the site.
- Pluvial flood risk associated with the proposed developments proposed drainage network.

5.1 Initial Fluvial Flood Risk Assessment

The OPW CFRAM flood extents map is the most up to date and accurate fluvial flood risk information available which identifies parts of the subject site being at risk for 1% and 0.1% AEP events, refer to Figure 5-1. It also identifies an overland flow route along the northern site boundary onto the M50 for these events.

As identified in stage 1, the Carrickmines and Cherrywood areas have significant flood risk associated with the Carrickmines River which has been altered over the years notably with the M50 construction which constructed culverts, diversions and embankments. As such the site has a limited associated flood risk with the Carrickmines River which is able to pass through the Glenamuck Road culvert and into the site.

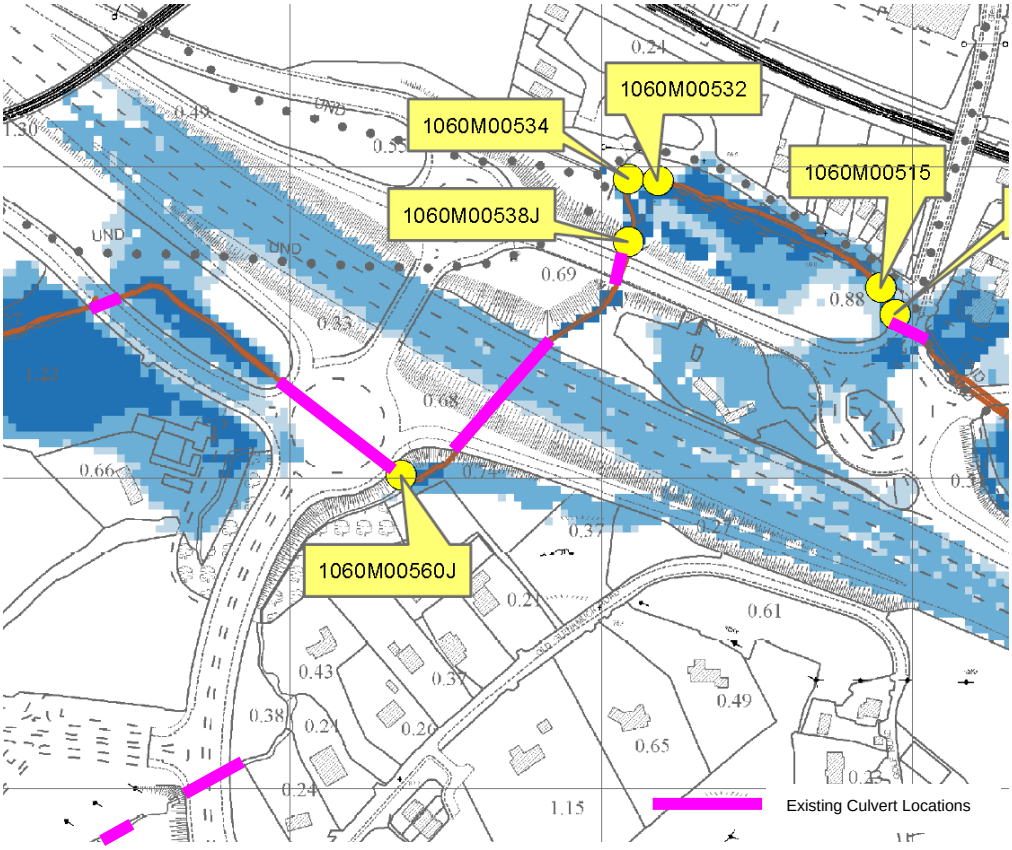


Figure 5-1: Extent of ECFRAM Flood Extents Map with highlighted culverts on surrounding watercourses

In addition to the Carrickmines River, the Glenamuck / Golf Stream is a source of fluvial flood risk to the site which enters via an upstream culvert next to the roundabout, refer to Figure 5-1. The

OPW CFRAMS flood map does not hydraulically model this stream but it does take account of its flows at the confluence with the Carrickmines River. The overland flood route and the map extents of flooding at the culverts are therefore considered to be representative of the predicted flooding in these areas and have been used to inform the development design proposals.

OPW CFRAM node 1060M00560J located within the subject site provides an accurate flood level for the 10%, 1% and the 0.1% AEP flood events which are 71.83m OD, 73.07m OD and 73.15m OD respectively.

From a review the flood depth maps and the topographic survey (refer to Figure 5-2), it is considered that the site's overland flow route is initialised by a low point within the topography which results in a 0.25m-0.5m depth of flood water overtopping the low point and flowing towards the M50.

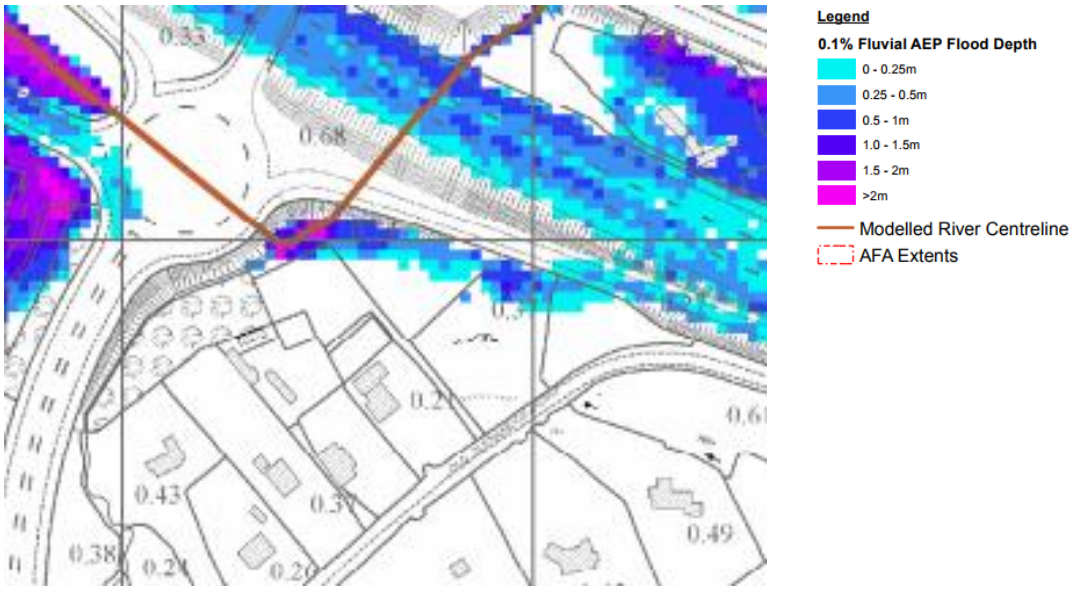


Figure 5-2: Depth of Flood Risk from Carrickmines River (extract from Final CFRAMs Maps)

The topographical survey indicates a level of 72.48m OD in this area, which with the addition of 500m depth of flood water the flood level would be equivalent to a flood level of 73.00m OD which is comparable to the CFRAM predicted levels. (As the overland flow path is initialised downstream of the CFRAMS node 1060M00560J the level for the 0.1%AEP would be lower than 73.15m OD.)

5.2 Initial Pluvial Flood Risk Assessment

Pluvial flood risk associated with the proposed development has been addressed in detail within DBFL Infrastructure design report which incorporates the following:

- Surface water to be designed in accordance with GDSDS recommendations and incorporate 10% climate change.
- New drainage collection system incorporating SUDS features such as bio-swales and filter drains.

- Existing runoff rates will be reduced by the provision of a surface water network with attenuated outlet and flood volume storage.
- Drainage design is undertaken to comply with the GDSDS recommendations with attenuation of run-off for a 100-year return period event plus 10% climate change allowance.

5.3 Flood Zone Category

Following the initial assessment of the flood risks to the site using the available information, it is considered that the majority of the proposed site is located within Flood Zone C as defined by the Guidelines. This is consistent with the OPW CFRAM and ICPSS flood risk maps. However, the site and adjacent lands also contain Flood Zones A and B associated with the Glenamuck / Golf Stream and Carrickmines River.

It was further noted that the OPW CFRAM and DLRCC SFRA flood maps do not model the Glenamuck / Golf Stream through the site or indicate the flood extents to same. As such it is considered that a detailed assessment to define the Glenamuck / Golf Stream flood extents is required which will require hydraulic modelling to assess the proximity and level of the development relative to flood levels.

6.0 Detailed Flood Risk Assessment Stage

As the Glenamuck / Golf Stream passes through and adjacent to the proposed development and given the absence of detailed flood mapping for it, a hydraulic model was developed to ascertain its predicted flood levels and check freeboard to the proposed development's design levels.

This stage will also assess pluvial flood risk in relation to the following:

- Proposed Surface Water Management measures.
- Flood Exceedance of the proposed drainage network.
- Impact of proposals on flood risk to adjacent areas.
- Sustainable Urban Structure.
- Residual risks.

6.1 Detailed Fluvial Flood Risk Assessment

6.1.1 Hydraulic Modelling

As part of the detailed flood risk assessment, a hydraulic model was created to verify the flood extents of the Glenamuck / Golf Stream through the site. HEC-RAS software was selected because it was considered suitable for the relatively short river length and well-defined channel / floodplain. Limitations of the software include:

- The modelling was 1-D along the direction of flow which prevents accurate accounting of flow directions, magnitudes and energy losses at locations where the actual channel flow has strongly two-dimensional (or possibly three-dimensional) characteristics.
- The model is a simplified version of the reality of flow in river channels and culverts and must be treated as a conceptual model even though the equations are physically based. Many of the parameters and values inputted are lumped or averaged for each reach length between sections. Values such as Manning's "n" may vary across a flood plain, for example the value for any single section will have varying values from top of bank to the extent of flooding comprising grassed surfaces, concrete footpath, shrubs, vegetation etc. The Manning's "n" value in HEC-RAS is an averaged value for estimating energy lost by water flowing across a surface.
- The model developed simulates steady flow only and does not estimate any unsteady element of flow through hydraulic structures or time varying flow.

6.1.2 Model Construction

The site specific HEC-RAS hydraulic model was constructed using multiple cross-sections along the river and stream's length including sections at key structural features. The extent of the model was limited upstream to the far side of the upstream culvert entering the site and the Shanaghagh

/ Carrickmines River downstream including culverts and overland flow path along the northern boundary.

Flows equivalent to the peak 1% and 0.1% AEP return events were calculated from a hydrological assessment and input to the model with downstream boundary conditions checked to coincide with CFRAM node points for established water surface levels during the specified return events.

The model assumes that chainage 0m is the downstream discharge point. Floodplain roughness values for the model were estimated from a walkover survey in June 2017.

6.1.3 Hydrological Assessment

Shanganagh / Carrickmines River:

The Shanganagh / Carrickmines River was extensively modelled and analysed by the OPW CFRAM project. The hydraulic model uses available flow and level data from the CFRAM study as such a further hydrological assessment of the Shanganagh / Carrickmines River section was not undertaken.

Glenamuck / Golf Stream:

A hydrological assessment for Glenamuck / Golf Stream's catchment was undertaken to quantify flows for the predictive 10%, 1% and 0.1% AEP return events at the site. As required, flows were calculated using OPW's FSU portal for ungauged catchments. This was deemed the most appropriate method following review of Technical Research reports and is the favoured method for calculating Flood Estimation in Ireland. The FSU portal indicates the Glenamuck / Golf stream at the site has an upstream catchment of 2.906km^2 which originates in the eastern foothills of 3 Rock / 2 Rock mountain as indicated in Figure 6-1. The OPW FSU report is provided in Appendix B.

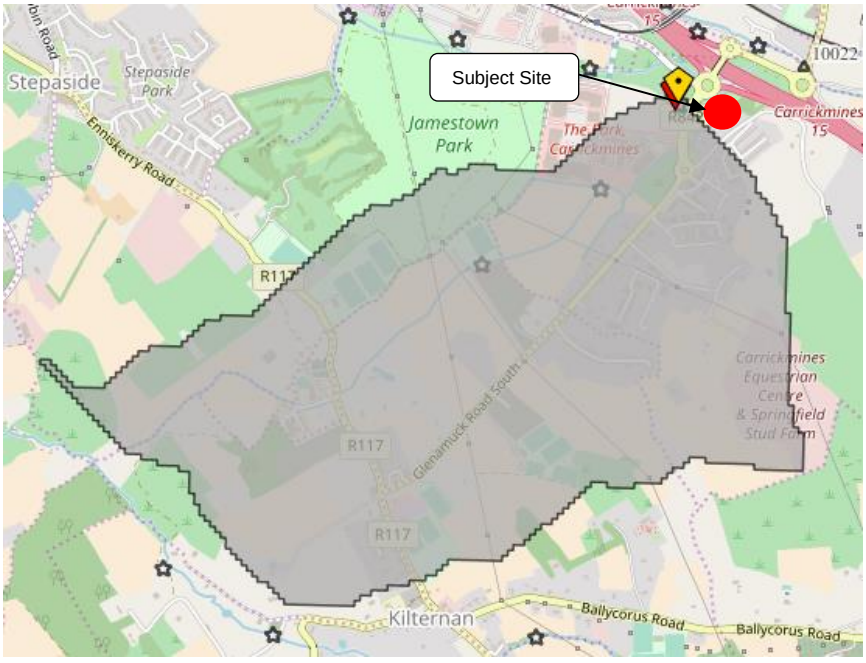


Figure 6-1: Catchment for Glenamuck / Golf Stream

Calculated flows for the stream at this location are outlined in Figure 6-1 with flows increased by 20% for climate change allowance in accordance with the Local Authority's Strategic Flood Risk Assessment (SFRA).

Table 6-1: Calculated FSU Glenamuck / Golf Stream Flows from OPW FSU Portal

Return Period (AEP (%))	FSU Design Peak Flow (m^3/s)	Growth Factor
50% AEP	0.94	1
20% AEP	1.33	1.41
10% AEP	1.61	1.71
2% AEP	2.3	2.45
1% AEP	2.63	2.8
1% AEP +20% allowance on flows for Climate Change	3.16	2.8
0.1% AEP	3.87	4.11

6.2 Existing Site's Flood Zone Extents

Predicted flows were input to the site specific hydraulic model and depth and flood extent results at various cross-sections along the Glenamuck Stream were derived. The results indicate close correlation with flow and level data from the CFRAM flood maps at the downstream model extents. HEC-RAS cross-sections for the 1% and 0.1% AEP are provided in Appendix D.

The 1% AEP and 0.1% AEP flood levels and extents for the site are presented on drawing 170063-9120 in Appendix C. They show that the site is impacted by flooding from the Shanganagh River and Glenamuck/Golf Stream they also show that the downstream culvert is undersized resulting in surcharging and an overland flow path to the east along the M50 off-slip. Within the upper parts of the site the Glenamuck/Golf Stream is well channelled except in the location of the proposed pedestrian bridge. Flood levels in general drop more than 4m through the site in the 0.1% AEP event indicating a reasonable gradient and channel capacity. The results indicate that the majority of the existing site is within Flood zone C.

6.3 Post Development Impact

The proposed residential based development is categorised by the Guidelines as **highly vulnerable** development and suitable for Flood Zone C only. Drawing 170063-9120 indicates that the highly vulnerable development proposals are fully within Flood Zone C and do not encroach into the predicted flood extents. It is noted that the development proposals include removing the fill material along the northern boundary to the historic levels resulting in topography consistent with the CFRAMs study maps. The associated amenity space to the fringes of the proposed

development, which are not ancillary to the development, located in Flood Zone A is classified as water compatible and therefore deemed appropriate under the guidelines and a justification test is not required.

6.4 Flood Risk Assessment of Development Proposals

An assessment of the impact on the development for the 1% AEP, 1% AEP +20% Climate change and 0.1% AEP flood events concluded the following:

- Surcharging of the downstream culvert exiting at the site boundary was identified for the 10%, 1% and 0.1% AEP events indicating it is undersized for the predicted flows. The model also verified that this under sizing results in the overland flow route along the site's northern boundary which is consistent with the CFRAM study. Downstream water levels for the 1% and 0.1% AEP events returned similar water levels to the CFRAM flood data.

Figure 6-2: Block Layout of the Proposed Development

- The development is located wholly within Flood Zone C to minimise flood risk.
- The ground floor level of 79.45m OD is in excess of maximum flood levels on the site with resulting freeboard heights of between 1.5m to 6m.
- All residential units are located at ground floor level and upwards, placing them well above the flood levels.
- The lower basement carpark extends under the area between Blocks A3 and B1, and has a FFL of 72.15 OD. There are no residential units at this level and no flow path route from the Glenamuck Stream into this basement level.

- The CFRAMs map node *1060M00560J* within the site defines a flood level of 73.15m for the 0.1%AEP event. The proposed development extents at Block B are located outside this level i.e. wholly located in Flood Zone C.
- The development podium and upper basement levels are well in excess of flood levels of 73.15 OD along the northern site perimeter. Due to the proximity of the lower basement (FFL 72.15m) to Flood Zone B, the northern elevation of the development is designed to be flood resilient up to a level of 73.65m (500mm freeboard above the 0.1% AEP level of 73.15m). Mitigation measures include all ventilation openings on the elevation at a minimum level of 73.65m.
- The development does not increase pre-development flows in the Carrickmines River downstream.
- Areas of the site located in Flood Zone A have been limited to water compatible uses such as a shared pathway which are not ancillary to the proposed residential development.

6.5 Assessment of Development & Pluvial Flood Risk

The following design characteristics of the development's drainage design in a flood risk context are also noted:

- **Proposed Surface Water Management**– the development's drainage network (refer to full design and calculations within DBFL Consulting Engineers Infrastructure Design Report) is designed with reference to the GDSDS and provides a drainage network for the required 1 in 100-year rainfall event with additional allowance for 10% climate change on rainfall intensities. The drainage network includes attenuated outlets and associated storage on all surface water discharges from the site to the existing Glenamuck / Golf Stream. Surface water management measures include the following design features:
  - Attenuation storage locations for the development's pluvial events are located within Flood Zone C.
  - The surface water outlet to the Glenamuck / Golf Stream is designed to discharge above invert level and via Tideflex flap valves so that the development's storage areas are used only for the site's drainage / run-off.
- **Sustainable Urban Infrastructure** – the development includes SuDS features in accordance with the GDSDS and SuDS Manual including green-roofs, bioretention areas and detention basins. Existing high rock levels, development density, podium and basement extents preclude the suitability of many other SUDS features for large parts of the development.

6.6 Flood Exceedance

For storms greater than the 1% AEP storm event, the development's layout is designed to direct overland flow paths away from buildings and towards downstream open space / flood zone areas, refer to Figure 6-3. For events larger than the 100-year design storm, there will be additional

volume within the development's surface water network which will facilitate a level of surcharging before flooding.

Figure 6-3: Overland Flow path diagram (Ground Level)

Floodwater in these scenarios will be generated when attenuation features exceed their design parameters and flood. The following mitigation measures to facilitate overland flow paths for exceedance:

- External access will be open along the northern building edge to facilitate drainage down the access and into the open space adjacent to Glenamuck / Golf Stream.
- Raised tables will be used at the basement entrances to ensure flood water is directed past basement entries protecting them from flood paths.
- Building and landscaping levels around the perimeter of the site are designed to ensure flood water moves past the development and doesn't collect in low points near entrances.
- Building and landscaping levels around the perimeter of the site are designed to ensure flood water moves past the development and doesn't collect in low points

7.0 SENSITIVITY ANALYSIS

At the request of DLRCoCo, a Sensitivity Analysis was undertaken as part of this flood risk assessment with the objective of providing a robust appraisal and comparison with flood risk assessments undertaken for adjacent lands. A flood risk assessment undertaken as part of the development proposals for the adjacent Carrickmines Shopping Centre indicates greater flood extents associated with the Glenamuck / Golf Stream within the site.

Therefore, this chapter will analyse the third-party flood data and assessment methodology to ascertain differences between the results, points of consistency and recommendations for the proposed development.

7.1 Assessment of Third-Party Data

From a review of the third-party flood risk assessment report the following comments and differences were noted:

- Survey Information: The third-party hydraulic model for the Glenamuck Stream relied on LIDAR survey information only. Although it states that the survey was augmented with cross-sections through the Shanganagh River it is unclear if any cross-sections were collected for the *Glenamuck* / Golf Stream. Therefore, the hydraulic model for this section will not be as accurate as one based on a detailed topographic survey with detailed cross sections.
- The DBFL hydraulic model created for the subject site used a topographical survey to create a digital terrain model for the hydraulic cross-sections. Also, several hydraulic structures (weirs) located at the confluence of the water courses were included in the DBFL model. It was not clear if these had been modelled by the third party.
- Removal of Fill Material - the topography of the site was altered since the CFRAMS data was collected, raising the existing ground level in the northern area of the site, where CFRAMS modelling shows an overland flow onto the M50. The development proposals are to remove this area of fill and return the ground levels to their historic levels. The DBFL hydraulic model takes this into account which has a large impact on flood levels and flood extents. The third-party hydraulic model does not take this into account which has the effect of blocking the overland flow path here.
- *Hydrological Data* - the third party calculates flows for the Glenamuck / Golf Stream using several methods (FSU, FSR, FSR RR, and IH124) and selected the highest of these, the FSR RR value to ensure a conservative method for a small catchment. A hydraulic flow of 9.8m^3/s was selected for the Glenamuck Stream catchment area of 2.9km^2 while 13.1m^3/s was used for the much larger Shanganagh River catchment area of 5.5km^2. The FSR RR value is almost 3 times larger than the FSU method recommended by the OPW for small ungauged catchments.

7.2 Glenamuck Stream Hydraulic Model Sensitivity Analysis

As part of the sensitivity analysis, the DBFL hydraulic model was run using the higher FSR RR flow used by the third party to assess the impact of the increased flow rate on the proposed development. The hydraulic model still assumed that the fill material along the northern boundary was removed and historic levels reinstated.

Table 7-1 shows the results of the 0.1% AEP water level differences between the FSU flows and FSR RR Flows at the chainages corresponding to those shown on DBFL drawing 170063-9120.

Table 7-1: Comparison of DBFL Hydraulic Model Results for FSU and FSR RR flows

Hydraulic Model Chainage	Difference between 0.1%AEP water levels of FSU Flow and FSR RR Flow (m)
CH 390	+0.61
CH 360	+0.56
CH 320	+0.21
CH 290	+0.33
CH 260	+0.49
CH 230	+0.45
CH 200	+0.36
CH 160	+0.14
CH 130	+0.16
Ch 110	+0.14

It is noted that most of the increases in level as a result of the increased flows are confined within large section of the steep stream channels. Also that due to the overland flow route along the northern boundary that the increased flow downstream of CH 160 results in only a minor increase in water level for the 0.1% AEP flood event. Figure 7-1 demonstrates that for cross-sections at chainages 320m and 200m that 0.1% AEP flood levels are still confined within the main stream alignment.

Figure 7-2 shows the extents of Flood Zone B for the increased FSR RR flows within the site. It demonstrates that the development is still located in Flood Zone C.

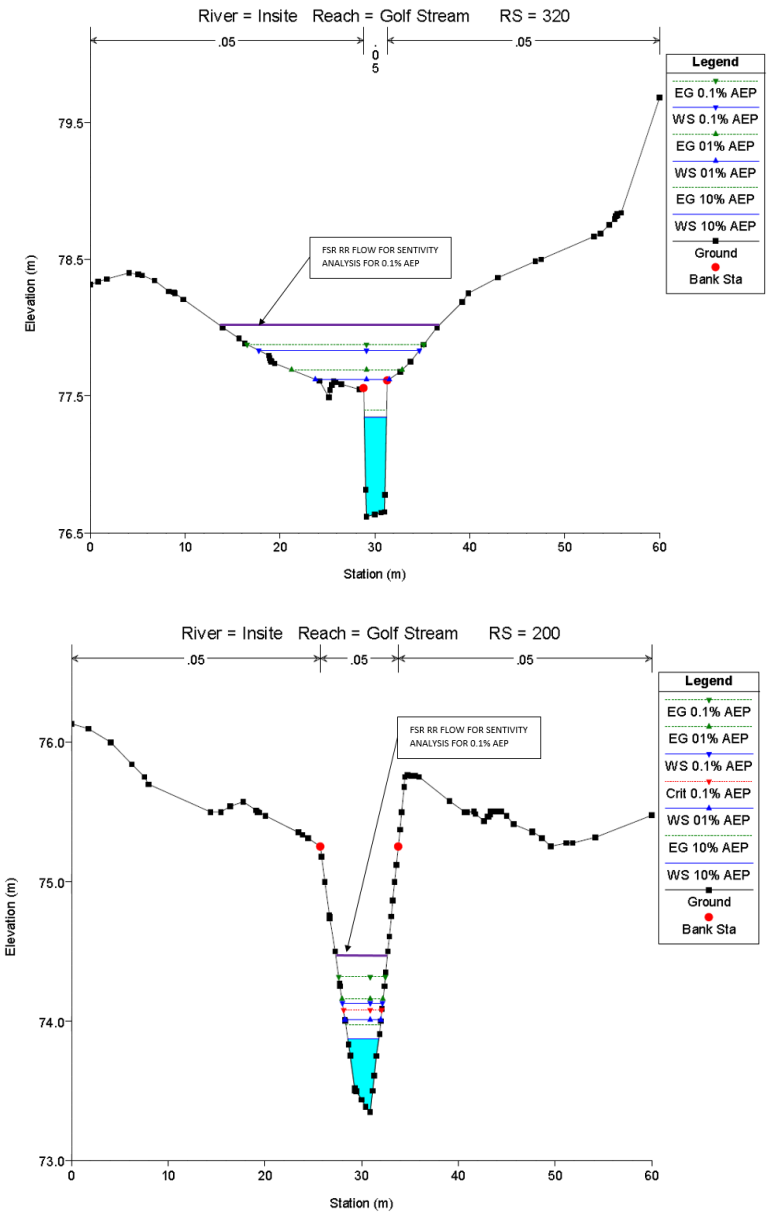


Figure 7-1: Example Cross-Sections showing FSR 0.1% AEP Level

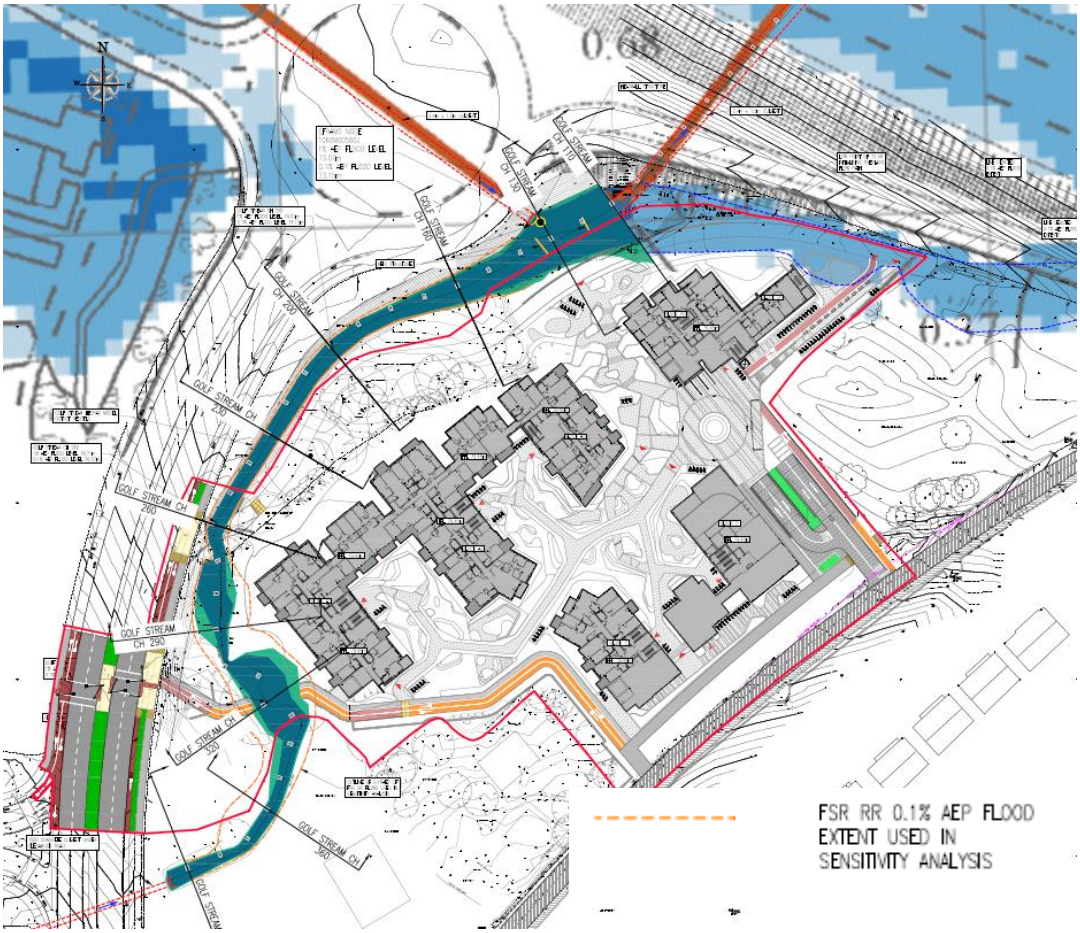


Figure 7-2: FSR RR Flood extents

7.3 Sensitivity Analysis Summary

The use of the FSR RR rather than the FSU method would result in an increased Glenamuck Stream flow from 3.87m^3/s to 9.8 m^3/s for the 0.1%AEP event. When applied to the hydraulic model for the site this would have the impact of increasing flood extents and flood levels as demonstrated in Figure 7-2. However, it has been demonstrated that the development would still be located outside of the flood extents i.e. within Flood Zone C.

With regards to the sensitivity check on the impact of increased flood levels for freeboard levels on the development the following were found:

- Ch 320m – at the proposed pedestrian bridge the 0.1%AEP flood level increases by 0.21m to 78.04m which still provides 410mm freeboard to the FFL at Block A1. The ground floor level of Block A is a further 1m higher with a freeboard of 1.41m.
- Ch230 – at Block A2 the 0.1%AEP flood level increased by 0.45m to 75.84m, although the upper basement is FFL is 75.55m in this area, the topography will not allow a flow path to the building. At this point the 0.1%AEP event is wholly within channel.
- Ch 160 – At Block A3 the 0.1% AEP flood level increased by 0.14m to 73.36m, giving a freeboard of 6.09m to the nearest residential units.
- Ch 130 – At Block B0 the 0.1%AEP flood level increased by 0.16m to 73.36m, as noted in the previous chapters this elevation will be flood resilient up to 73.65m to ensure the lower

basement (car parking only) will not flood during these events. The lowest residential units at this part of the development is at 79.45m and has an excess of 6.09m freeboard.

It must also be noted that the third-party flows used for the Shanganagh River are considerably less than the CFRAMs flows with a flow of approximately 13m^3/s compared to a CFRAMs flow of 25m^3/s. As such the downstream junction with the Shanganagh River the DBFL model has a higher flow assigned here than the third party. For a conservative estimate of flood levels, we have assumed that the increased flow is fully applied to the Glenamuck Stream without any reduction in the Shanganagh River flow.

It is noticeable that the main difference between the flood extents of each model mostly relates to the omission of the overland flow of the M50 due to the infilling of this area in the recent past. In addition, the use of surveyed topography and stream will be more accurate than the use of LIDAR survey data for topographical features, watercourses and areas covered in vegetation.

It is noted that when comparing the third-party's flows for the Shanganagh River with the *Glenamuck* / Golf Stream that the flows are similar for the 50% AEP event (a difference of only 0.8m^3/s) even though the catchment size is nearly twice the size. It is questionable whether the Glenamuck Stream flows are comparable to the Shanganagh River and if a lower flow would be more appropriate.

8.0 CONCLUSION

The main source of flood risk to the existing site is fluvial flooding from the Shanganagh / Carrickmines River and Glenamuck Stream which enter the site via culverts and exit at the northern downstream end to pass under the M50 off-slip in a box culvert. Due to the steep topography of the site fluvial flood risk is confined to the western and northern boundaries with an important overland flow path along the northern boundary which initiates following surcharging of the M50 culvert and provides a relieving route for flood waters that cannot pass through the undersized culvert. This overland flow path is dependent on existing ground levels in this area which had been filled to a level of 74.9m but for which the long-term plan is to remove and return topography to historic levels consistent with the CFRAMS maps.

Hydraulic modelling was undertaken using HEC-RAS software to construct a 1D river network model of the Glenamuck Stream to ascertain existing flood risk and levels. It was necessary as the CFRAMS had not provided flood mapping for the Glenamuck Stream. The model results determined flood levels and extents for 1% AEP and 0.1%AEP and defined Flood Zones A and B. Hydraulic modelling used predicted flows derived from the OPW FSU method.

From the model results it was demonstrated that the development is located within Flood Zone C i.e. low risk of flooding. Also that the backwatering effect of the downstream culvert causes flood levels to increase to a level of 72.48m OD before then overtopping the lowest bunding level and cascading as an overland flow path across the northern boundary of the site and onto the M50 Motorway.

The following was concluded:

- The residential development is located outside the 0.1% AEP Flood Zone B extents i.e. within low risk Flood zone C.
- All residential dwellings FFLs are located above the 0.1% AEP flood level with minimum freeboards of 500mm.
- Flood mitigation measures are incorporated into the design which includes the northern elevation to be flood resilient with ventilation grill levels set at 73.65m minimum to ensure the lower basement car park is protected.
- Block A western elevation will be protected by the use of existing and proposed ground levels in the open space thus maintaining separation of flood extents from the proposed development.

At the request of the Local Authority a sensitivity analysis on the Glenamuck Stream flows to compare results with a third-party flood risk assessment undertaken as part of a planning application for the Park which had proposed significant changes to estimated flows used by the OPW CFRAMS flood maps. It was concluded that the increased flows would result in a larger Flood Zone A and B with higher flood levels. However critically the third-party had not allowed for the reinstatement of ground levels along the northern boundary of the site which limits any increase in

flood levels. An analysis of flood levels for the 0.1%AEP event indicates that the development would still be within Flood Zone C and that majority of the development would still have freeboards in excess of 500mm with a minimum freeboard of 410mm at Block A1.

We conclude that the proposed development is appropriate for the existing site and its associated flood risk and that it is designed in accordance with the requirements of the necessary Flood Management Guidelines.

Appendix A

OPW Flood Hazard Report

OPW National Flood Hazard Mapping

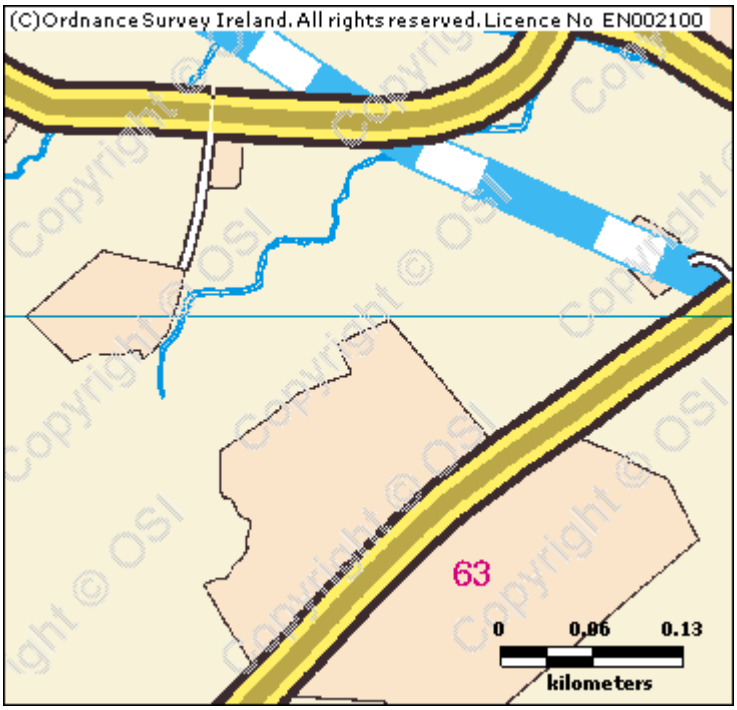
Summary Local Area Report

This Flood Report summarises all flood events within 2.5 kilometres of the map centre.

The map centre is in:

County: Dublin

NGR: O 216 239



Map Scale 1:5,201

Map Legend	
	Flood Points
	Multiple / Recurring Flood Points
	Areas Flooded
	Hydrometric Stations
	Rivers
	Lakes
	River Catchment Areas
	Land Commission *
	Drainage Districts *
	Benefiting Lands *

* Important: These maps do not indicate flood hazard or flood extent. Thier purpose and scope is explained in the Glossary.

11 Results

1. Shanganagh Carrickmines Nov 2002
Start Date: 26/Nov/2002
County: Dublin
Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

2. Shanganagh Carrickmines Dec 1997
Start Date: 18/Dec/1997
County: Dublin
Flood Quality Code:3
Additional Information: Reports (1) More Mapped Information

3. Shanganagh Carrickmines May 1993
Start Date: 26/May/1993
County: Dublin
Flood Quality Code:1
Additional Information: Photos (3) Reports (4) More Mapped Information

4. Shanganagh Carrickmines Nov 1982
Start Date: 06/Nov/1982
County: Dublin
Flood Quality Code:3
Additional Information: Reports (3) More Mapped Information

5. Torquay Road Foxrock Nov 1982
Start Date: 05/Nov/1982
County: Dublin
Flood Quality Code:3

Additional Information: Reports (1) More Mapped Information

---

6. Brighton Terrace Jan 1980 — Start Date: 01/Jan/1980
County: Dublin — Flood Quality Code:3

Additional Information: Reports (1) More Mapped Information

---

7. Brighton Cottages Dec 1978 — Start Date: 26/Dec/1978
County: Dublin — Flood Quality Code:3

Additional Information: Reports (2) More Mapped Information

---

8. Torquay Road Recurring — Start Date:
County: Dublin — Flood Quality Code:3

Additional Information: Reports (4) More Mapped Information

---

9. Brighton Cottages Foxrock Recurring — Start Date:
County: Dublin — Flood Quality Code:3

Additional Information: Reports (7) More Mapped Information

---

10. Glenamuck Stream Glenamuck Road Recurring — Start Date:
County: Dublin — Flood Quality Code:4

Additional Information: Reports (2) More Mapped Information

---

11. Kilgobbin Road Recurring — Start Date:
County: Dublin — Flood Quality Code:4

Additional Information: Reports (2) More Mapped Information

Appendix B

OPW FSU Flood Report

Flood Estimation Report #5881 (Glenamuck Road (Golf Stream))

Generated 06-12-2017 16:53

Subject site

Attributes

Name	Unit	Value
Coordinate [X]		-688427.635120875
Coordinate [Y]		7029294.20293112
Distance	km	6.66393450276056
Station Number		10_1104_1
Location		
Water Body		
Catchment		
Hydrometric Area		
Organisation		
FSU Rating Classification		
Drainage works	year	
Contributing Catchment Area	km^2	2.055
Center Northing	m	222900
Center Easting	m	320250
Northing	m	223643
Easting	m	321248
A-Max series gap in years	year	
A-Max series number of years	year	
A-Max series number of usable years	year	
A-Max series end year	year	
A-Max series start year	year	
FARL		1
ALLUV		0.0025
PEAT		0
FOREST		0.0029
PASTURE		0.8029
S1085	m/km	33.50077
MSL	km	2.055
DRAIND	km/km^2	1.912
ALTBAR		127.6
NETLEN	km	3.928
T4		
T3		

SAAPE	mm	546.91
T2		
ARTDRAIN2		0
ARTDRAIN		0
TAYSLO		1.716412
STMFRQ		3
BFISOIL		0.639809994
SAAR	mm	820.5
RWSEG_CD		10_1104
TOP_RWSEG		
Bankfull		
HGF	m^3/s	
MAF	m^3/s	
FAI		0.4842
FLATWET		0.54
URBEXT		0.181
HGF/QMED		
centroidx3857		-689697.489771272
centroidy3857		7028055.90022453
x3857		-688427.635120875
y3857		7029294.20293112

Pivotal site

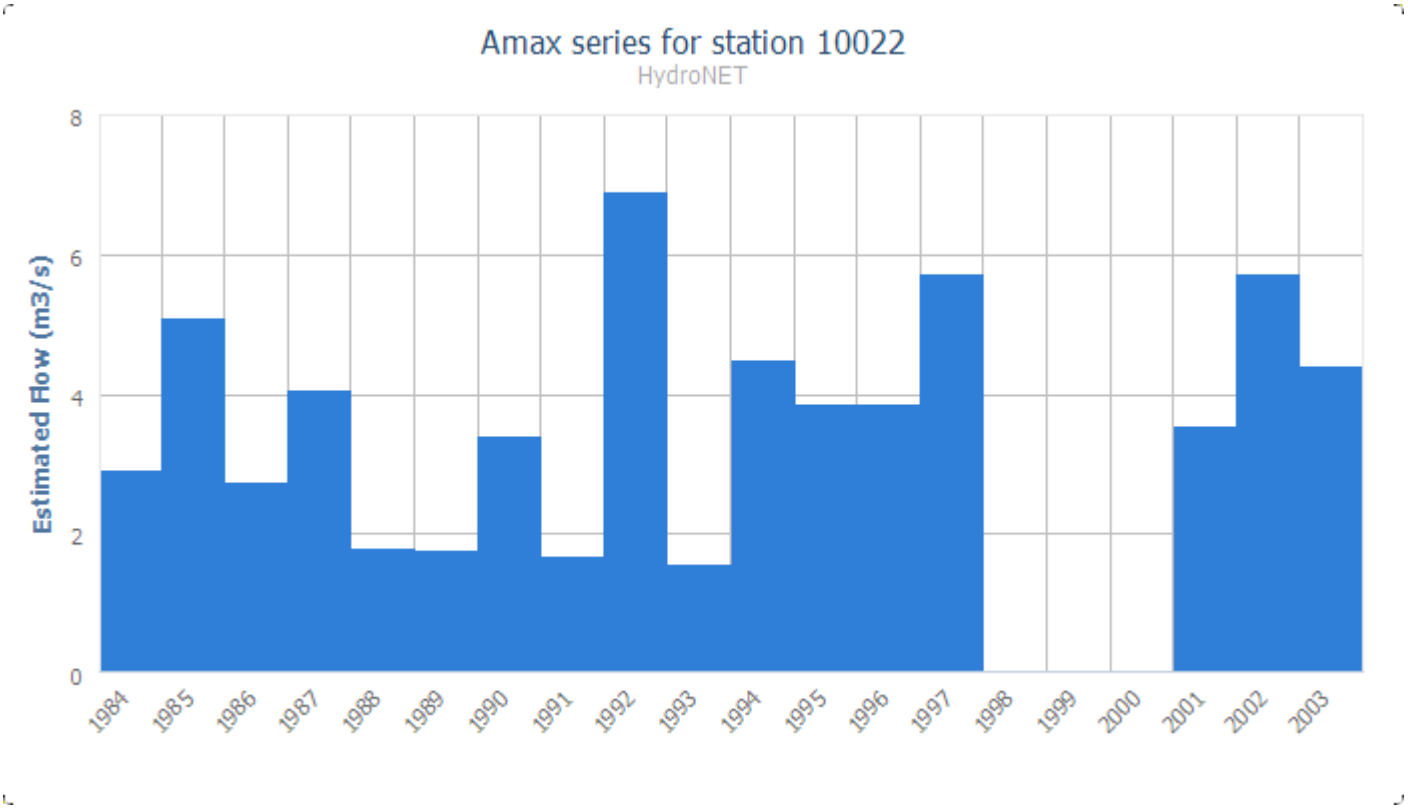
Attributes

Name	Unit	Value
Coordinate [X]		-687178.912979023
Coordinate [Y]		7030058.16580458
Station Number		10022
Location		CARRICKMINES
Water Body		CABINTEELY
Catchment		Coastal
Hydrometric Area		10
Organisation		EPA
FSU Rating Classification		A1
Drainage works	year	No
Contributing Catchment Area	km^2	12.9376
Center Northing	m	224210
Center Easting	m	319740
Northing	m	224119
Easting	m	321985
A-Max series gap in years	year	0
A-Max series number of years	year	20
A-Max series number of usable years	year	17
A-Max series end year	year	2003
A-Max series start year	year	1984
FARL		1
ALLUV		0.0176
PEAT		0
FOREST		0.0643
PASTURE		0
S1085	m/km	11.16578
MSL	km	5.946
DRAIND	km/km^2	1.671
ALTBAR		0
NETLEN	km	21.615
T4		0.078995523126678
T3		0.063787964231047
SAAPE	mm	545.74
T2		0.24458149432535
ARTDRAIN2		0
ARTDRAIN		0
TAYSLO		1.162561
STMFRQ		23
BFISOIL		0.6
SAAR	mm	821.92
RWSEG_CD		10_1519
TOP_RWSEG		10_1497
Bankfull		?
HGF	m^3/s	5.88
MAF	m^3/s	3.27
FAI		0.28
FLATWET		0.54
URBEXT		0.2972
HGF/QMED		1.5272727272727
x3857		-687178.912979023
y3857		7030058.16580458

centroidx3857		-690977.044978237
centroidy3857		7030250.46198193
Distance	km	2.54034699100399

Map

Amax Series Chart



QMED Estimates

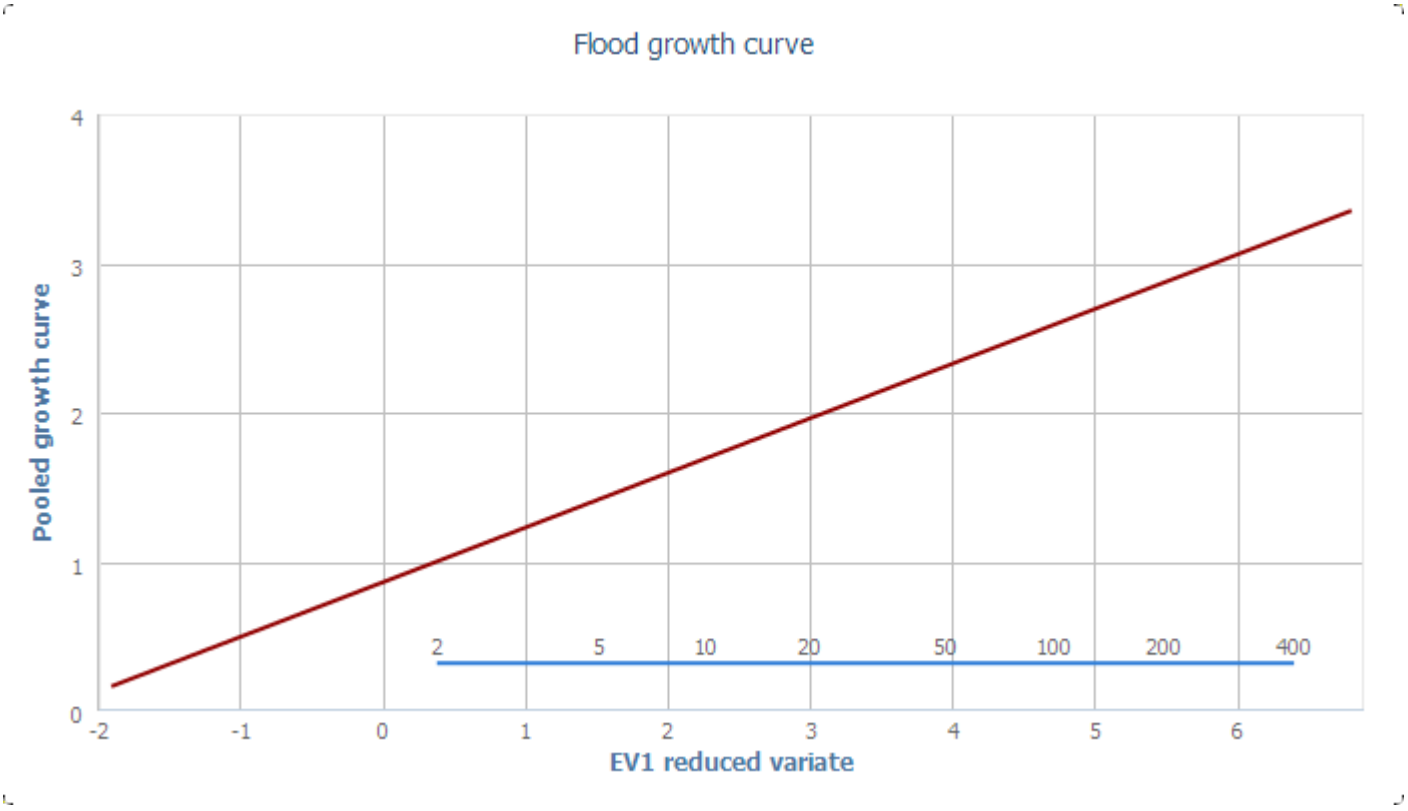
Subject rural QMED	0.56
Subject urban QMED	0.72
Pivotal gauged QMED	3.85
Pivotal adjustment factor QMED	1.01
Subject adjusted QMED	**0.72**

Pooling Group

Station	Amax years
09011 FRANKFORT (Post 21/08/19	16
10022 CARRICKMINES	17
08005 KINSALEY HALL	18
25034 ROCHFORT	26
10021 COMMONS ROAD	24
08012 BALLYBOGHIL	19
08002 NAUL	21
16051 CLOBANNA	13
09002 LUCAN	25
09035 KILLEEN ROAD	9

25040 ROSCREA	19
24022 HOSPITAL	20
06031 CURRALHIR	18
14009 CUSHINA	25
26022 KILMORE	33
08009 BALHEARY	15
30020 BALLYHAUNIS	16
06033 CONEYBURROW BR.	25
06030 BALLYGOLY	27
26058 BALLINRINK BR.	24
22009 WHITE BRIDGE	24
36031 LISDARN	30
13002 FOULKS MILL	19
08007 ASHBOURNE	15

Selected Flood Growth Curve



Pooled growth curve	EV1 reduced variate
0.16	-1.92
0.22	-1.75
0.26	-1.66
0.28	-1.6
0.3	-1.55
0.32	-1.5
0.33	-1.47
0.34	-1.43
0.35	-1.4
0.36	-1.37
0.37	-1.35
0.38	-1.33
0.39	-1.3
0.4	-1.28
0.4	-1.26
0.41	-1.24
0.42	-1.22
0.42	-1.21
0.43	-1.19
0.44	-1.17
0.44	-1.16
0.45	-1.14
0.45	-1.13
0.46	-1.12
0.46	-1.1
0.47	-1.09
0.47	-1.08
0.48	-1.06
0.48	-1.05

0.49	-1.04
0.49	-1.03
0.49	-1.01
0.5	-1
0.5	-0.99
0.51	-0.98
0.51	-0.97
0.51	-0.96
0.52	-0.95
0.52	-0.94
0.53	-0.93
0.53	-0.92
0.53	-0.91
0.54	-0.9
0.54	-0.89
0.54	-0.88
0.55	-0.87
0.55	-0.86
0.55	-0.85
0.56	-0.85
0.56	-0.84
0.56	-0.83
0.57	-0.82
0.57	-0.81
0.57	-0.8
0.57	-0.79
0.58	-0.79
0.58	-0.78
0.58	-0.77
0.59	-0.76
0.59	-0.75
0.59	-0.75
0.6	-0.74
0.6	-0.73
0.6	-0.72
0.6	-0.71
0.61	-0.71
0.61	-0.7
0.61	-0.69
0.61	-0.68
0.62	-0.68
0.62	-0.67
0.62	-0.66
0.63	-0.66
0.63	-0.65
0.63	-0.64
0.63	-0.63
0.64	-0.63
0.64	-0.62
0.64	-0.61
0.64	-0.61
0.65	-0.6
0.65	-0.59
0.65	-0.59
0.65	-0.58
0.66	-0.57
0.66	-0.57

0.66	-0.56
0.66	-0.55
0.67	-0.55
0.67	-0.54
0.67	-0.53
0.67	-0.53
0.68	-0.52
0.68	-0.51
0.68	-0.51
0.68	-0.5
0.68	-0.5
0.69	-0.49
0.69	-0.48
0.69	-0.48
0.69	-0.47
0.7	-0.46
0.7	-0.46
0.7	-0.45
0.7	-0.45
0.7	-0.44
0.71	-0.43
0.71	-0.43
0.71	-0.42
0.71	-0.41
0.72	-0.41
0.72	-0.4
0.72	-0.4
0.72	-0.39
0.72	-0.39
0.73	-0.38
0.73	-0.37
0.73	-0.37
0.73	-0.36
0.74	-0.36
0.74	-0.35
0.74	-0.34
0.74	-0.34
0.74	-0.33
0.75	-0.33
0.75	-0.32
0.75	-0.31
0.75	-0.31
0.75	-0.3
0.76	-0.3
0.76	-0.29
0.76	-0.29
0.76	-0.28
0.77	-0.27
0.77	-0.27
0.77	-0.26
0.77	-0.26
0.77	-0.25
0.78	-0.25
0.78	-0.24
0.78	-0.24
0.78	-0.23
0.78	-0.22

0.79	-0.22
0.79	-0.21
0.79	-0.21
0.79	-0.2
0.79	-0.2
0.8	-0.19
0.8	-0.18
0.8	-0.18
0.8	-0.17
0.8	-0.17
0.81	-0.16
0.81	-0.16
0.81	-0.15
0.81	-0.15
0.81	-0.14
0.82	-0.14
0.82	-0.13
0.82	-0.12
0.82	-0.12
0.82	-0.11
0.83	-0.11
0.83	-0.1
0.83	-0.1
0.83	-0.09
0.83	-0.09
0.84	-0.08
0.84	-0.07
0.84	-0.07
0.84	-0.06
0.84	-0.06
0.85	-0.05
0.85	-0.05
0.85	-0.04
0.85	-0.04
0.85	-0.03
0.86	-0.03
0.86	-0.02
0.86	-0.01
0.86	-0.01
0.86	0
0.87	0
0.87	0.01
0.87	0.01
0.87	0.02
0.87	0.02
0.88	0.03
0.88	0.03
0.88	0.04
0.88	0.05
0.88	0.05
0.89	0.06
0.89	0.06
0.89	0.07
0.89	0.07
0.89	0.08
0.9	0.08
0.9	0.09

0.9	0.09
0.9	0.1
0.9	0.11
0.91	0.11
0.91	0.12
0.91	0.12
0.91	0.13
0.91	0.13
0.92	0.14
0.92	0.14
0.92	0.15
0.92	0.16
0.92	0.16
0.93	0.17
0.93	0.17
0.93	0.18
0.93	0.18
0.93	0.19
0.94	0.19
0.94	0.2
0.94	0.2
0.94	0.21
0.94	0.22
0.95	0.22
0.95	0.23
0.95	0.23
0.95	0.24
0.96	0.24
0.96	0.25
0.96	0.26
0.96	0.26
0.96	0.27
0.97	0.27
0.97	0.28
0.97	0.28
0.97	0.29
0.97	0.29
0.98	0.3
0.98	0.31
0.98	0.31
0.98	0.32
0.98	0.32
0.99	0.33
0.99	0.33
0.99	0.34
0.99	0.35
0.99	0.35
1	0.36
1	0.36
1	0.37
1	0.38
1.01	0.38
1.01	0.39
1.01	0.39
1.01	0.4
1.01	0.4
1.02	0.41

1.02	0.42
1.02	0.42
1.02	0.43
1.02	0.43
1.03	0.44
1.03	0.45
1.03	0.45
1.03	0.46
1.04	0.46
1.04	0.47
1.04	0.48
1.04	0.48
1.04	0.49
1.05	0.49
1.05	0.5
1.05	0.51
1.05	0.51
1.06	0.52
1.06	0.52
1.06	0.53
1.06	0.54
1.06	0.54
1.07	0.55
1.07	0.56
1.07	0.56
1.07	0.57
1.08	0.57
1.08	0.58
1.08	0.59
1.08	0.59
1.09	0.6
1.09	0.61
1.09	0.61
1.09	0.62
1.09	0.62
1.1	0.63
1.1	0.64
1.1	0.64
1.1	0.65
1.11	0.66
1.11	0.66
1.11	0.67
1.11	0.68
1.12	0.68
1.12	0.69
1.12	0.7
1.12	0.7
1.13	0.71
1.13	0.72
1.13	0.72
1.13	0.73
1.14	0.74
1.14	0.74
1.14	0.75
1.14	0.76
1.15	0.76
1.15	0.77

1.15	0.78
1.15	0.78
1.16	0.79
1.16	0.8
1.16	0.81
1.16	0.81
1.17	0.82
1.17	0.83
1.17	0.83
1.17	0.84
1.18	0.85
1.18	0.85
1.18	0.86
1.18	0.87
1.19	0.88
1.19	0.88
1.19	0.89
1.2	0.9
1.2	0.91
1.2	0.91
1.2	0.92
1.21	0.93
1.21	0.94
1.21	0.94
1.21	0.95
1.22	0.96
1.22	0.97
1.22	0.97
1.23	0.98
1.23	0.99
1.23	1
1.23	1.01
1.24	1.01
1.24	1.02
1.24	1.03
1.25	1.04
1.25	1.05
1.25	1.05
1.25	1.06
1.26	1.07
1.26	1.08
1.26	1.09
1.27	1.1
1.27	1.1
1.27	1.11
1.28	1.12
1.28	1.13
1.28	1.14
1.29	1.15
1.29	1.16
1.29	1.16
1.3	1.17
1.3	1.18
1.3	1.19
1.31	1.2
1.31	1.21
1.31	1.22

1.32	1.23
1.32	1.24
1.32	1.25
1.33	1.25
1.33	1.26
1.33	1.27
1.34	1.28
1.34	1.29
1.34	1.3
1.35	1.31
1.35	1.32
1.35	1.33
1.36	1.34
1.36	1.35
1.36	1.36
1.37	1.37
1.37	1.38
1.38	1.39
1.38	1.4
1.38	1.41
1.39	1.42
1.39	1.43
1.4	1.45
1.4	1.46
1.4	1.47
1.41	1.48
1.41	1.49
1.42	1.5
1.42	1.51
1.42	1.52
1.43	1.53
1.43	1.55
1.44	1.56
1.44	1.57
1.45	1.58
1.45	1.59
1.45	1.61
1.46	1.62
1.46	1.63
1.47	1.64
1.47	1.66
1.48	1.67
1.48	1.68
1.49	1.69
1.49	1.71
1.5	1.72
1.5	1.73
1.51	1.75
1.51	1.76
1.52	1.78
1.52	1.79
1.53	1.8
1.53	1.82
1.54	1.83
1.54	1.85
1.55	1.86
1.55	1.88

1.56	1.89
1.57	1.91
1.57	1.93
1.58	1.94
1.58	1.96
1.59	1.97
1.6	1.99
1.6	2.01
1.61	2.03
1.61	2.04
1.62	2.06
1.63	2.08
1.63	2.1
1.64	2.12
1.65	2.13
1.65	2.15
1.66	2.17
1.67	2.19
1.68	2.21
1.68	2.23
1.69	2.26
1.7	2.28
1.71	2.3
1.72	2.32
1.72	2.34
1.73	2.37
1.74	2.39
1.75	2.42
1.76	2.44
1.77	2.47
1.78	2.49
1.79	2.52
1.8	2.55
1.81	2.57
1.82	2.6
1.83	2.63
1.84	2.66
1.85	2.69
1.86	2.73
1.88	2.76
1.89	2.79
1.9	2.83
1.92	2.87
1.93	2.9
1.94	2.94
1.96	2.98
1.97	3.03
1.99	3.07
2.01	3.12
2.03	3.17
2.04	3.22
2.06	3.27
2.08	3.33
2.11	3.39
2.13	3.45
2.15	3.52
2.18	3.59

2.21	3.67
2.24	3.75
2.27	3.84
2.31	3.94
2.35	4.06
2.4	4.18
2.45	4.32
2.51	4.49
2.58	4.69
2.67	4.94
2.8	5.27
2.98	5.76
3.35	6.79

Adopted Growth Factors

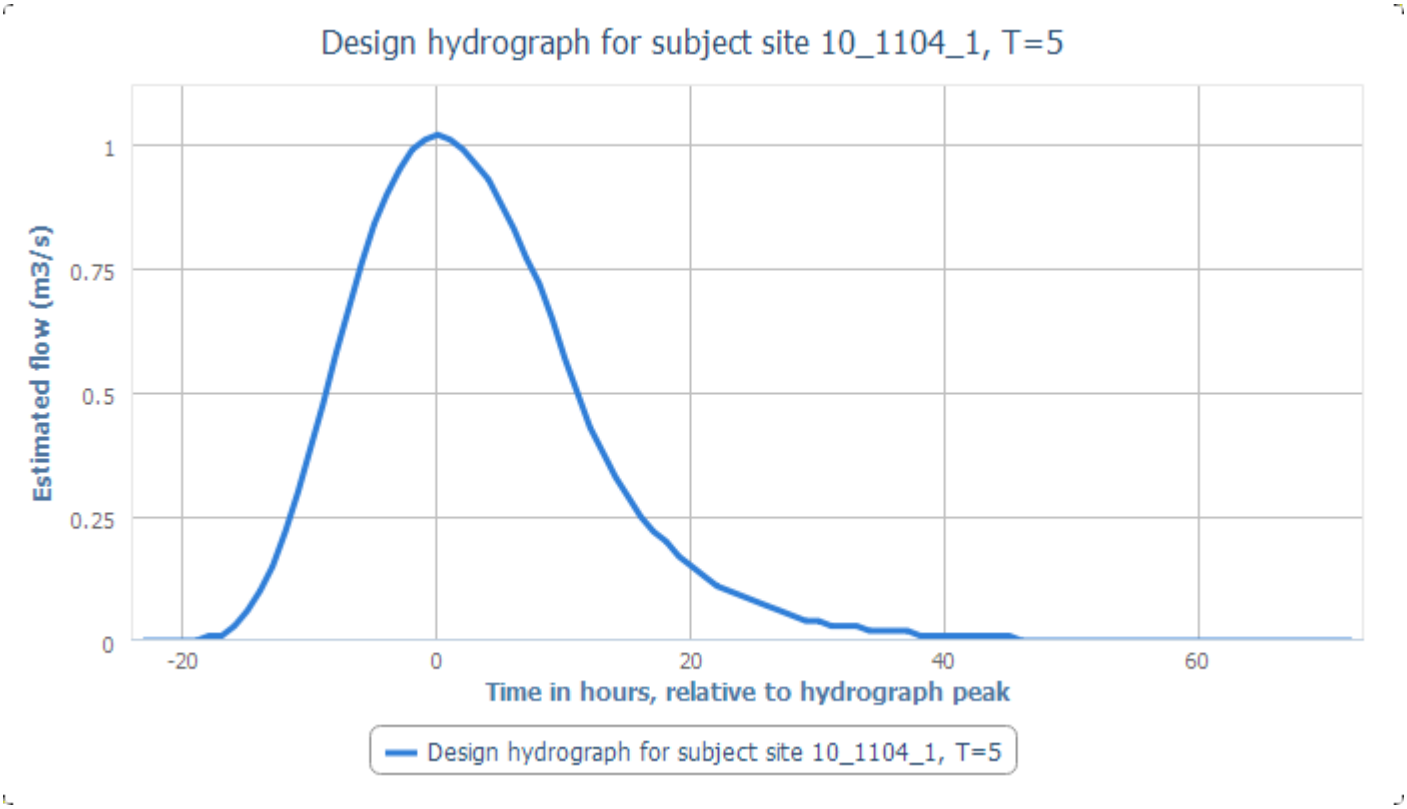
Return Period	Growth Factor	Design Peak Flow (m^3/s)
1.3	0.73	0.53
2	1	0.72
5	1.42	1.02
10	1.69	1.22
20	1.95	1.41
30	2.11	1.52
50	2.3	1.66
100	2.55	1.84
200	2.81	2.03
500	3.14	2.26
1000	3.4	2.45

Hydrograph Width Estimation Summary

Name	Value
Pivotal site	16013 "FOURMILEWATER"
Adjustment type	The user adjusted the original PCD hydrograph
Transfer type	The user adjusted the subject site estimate with the pivotal site deformation factor
Deformation factor	1
Custom deformation factor	1
Accepted n	8.24200864718418
Accepted Tr	23.2004710719827
Accepted C	7.49514222220158

Hydrograph Plots

Return Period: 5

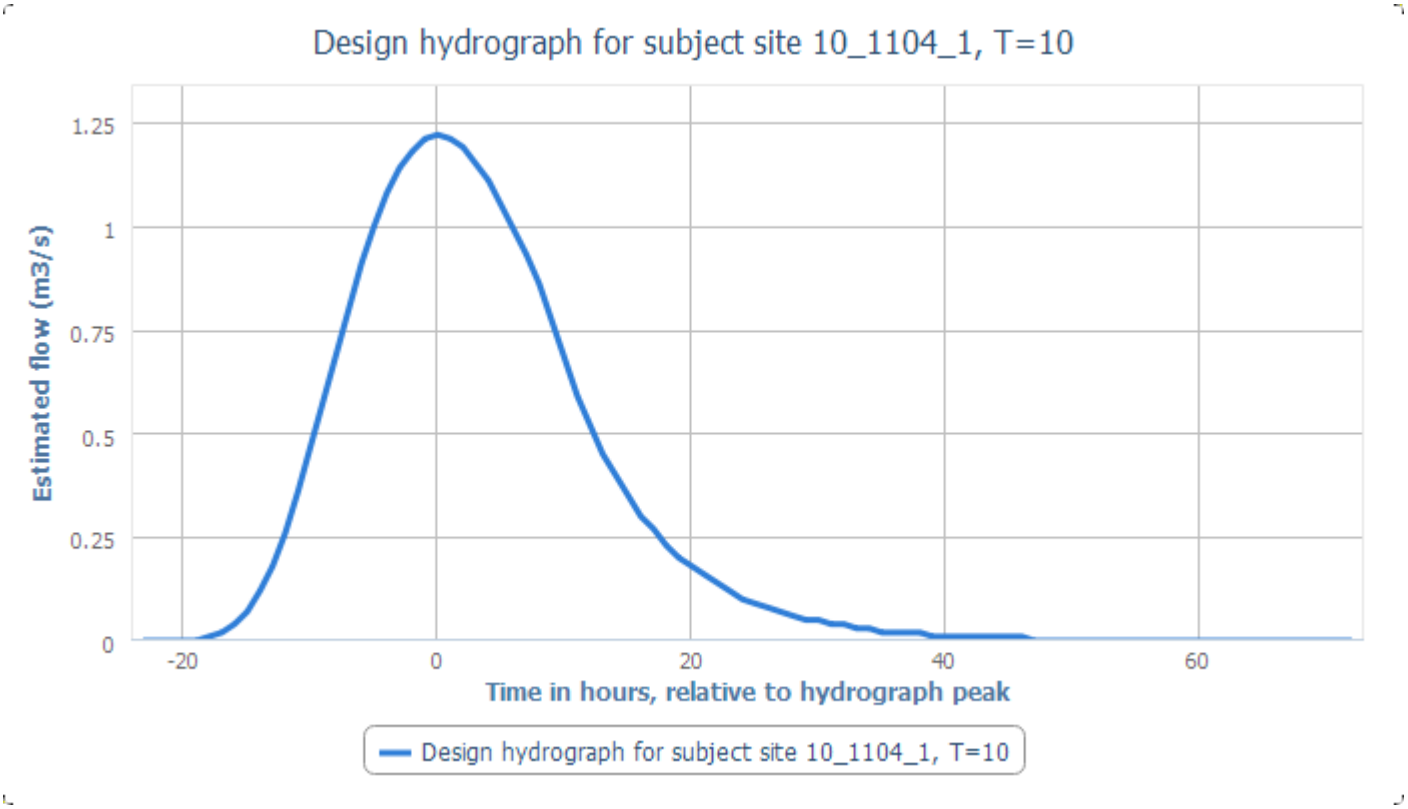


Hours relative to hydrograph peak	Estimated flow (m3/s)
-23.2	0
-23	0
-22	0
-21	0
-20	0
-19	0
-18	0.01
-17	0.01
-16	0.03
-15	0.06
-14	0.1
-13	0.15
-12	0.22
-11	0.3
-10	0.39
-9	0.48
-8	0.58
-7	0.67
-6	0.76
-5	0.84
-4	0.9
-3	0.95
-2	0.99
-1	1.01
0	1.02
1	1.01
2	0.99
3	0.96
4	0.93

5	0.88
6	0.83
7	0.77
8	0.72
9	0.65
10	0.57
11	0.5
12	0.43
13	0.38
14	0.33
15	0.29
16	0.25
17	0.22
18	0.2
19	0.17
20	0.15
21	0.13
22	0.11
23	0.1
24	0.09
25	0.08
26	0.07
27	0.06
28	0.05
29	0.04
30	0.04
31	0.03
32	0.03
33	0.03
34	0.02
35	0.02
36	0.02
37	0.02
38	0.01
39	0.01
40	0.01
41	0.01
42	0.01
43	0.01
44	0.01
45	0.01
46	0
47	0
48	0
49	0
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0

62	0
63	0
64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0

Return Period: 10

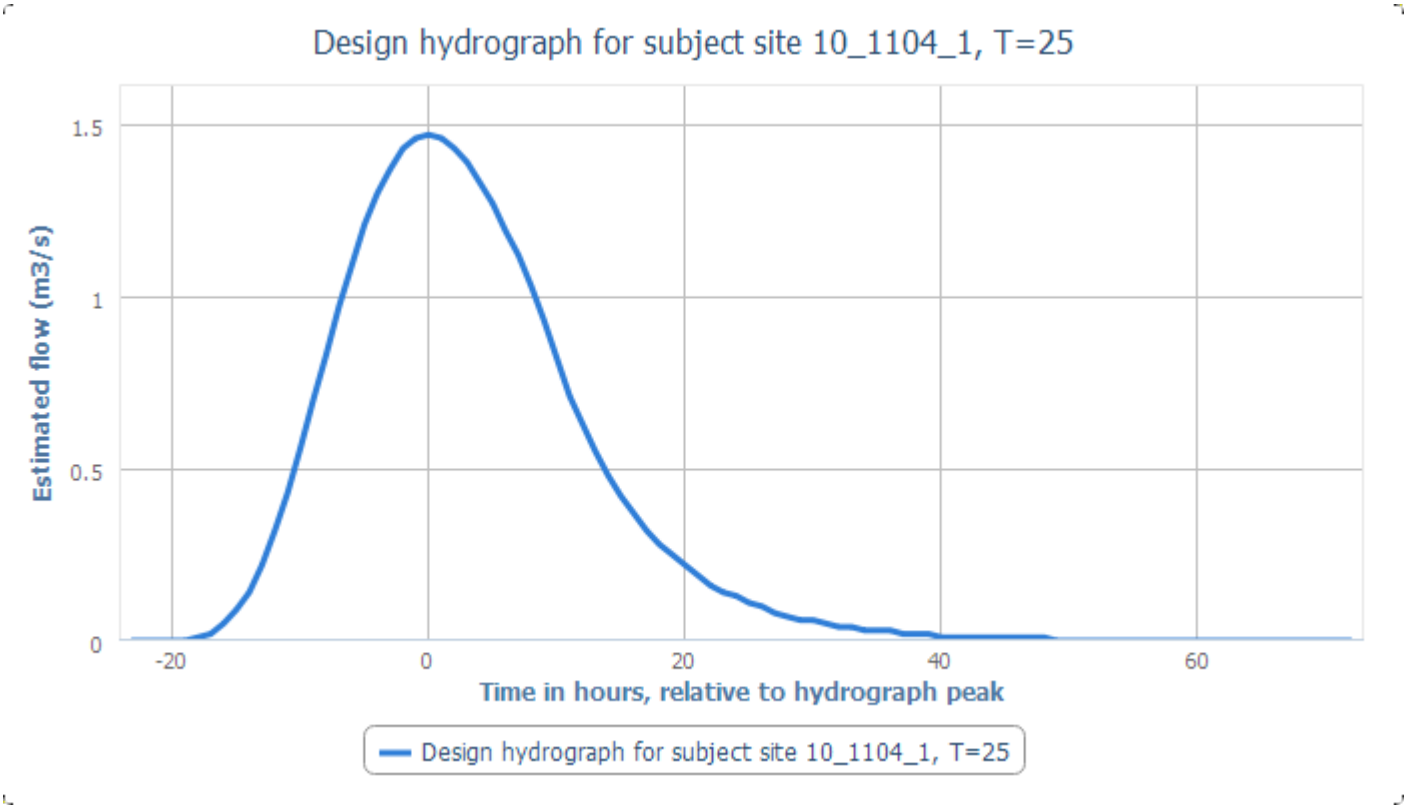


Hours relative to hydrograph peak	Estimated flow (m3/s)
-23.2	0
-23	0
-22	0
-21	0
-20	0
-19	0
-18	0.01
-17	0.02
-16	0.04
-15	0.07
-14	0.12
-13	0.18
-12	0.26
-11	0.36
-10	0.47
-9	0.58
-8	0.69
-7	0.8
-6	0.91
-5	1
-4	1.08
-3	1.14
-2	1.18
-1	1.21
0	1.22
1	1.21
2	1.19
3	1.15
4	1.11
5	1.05
6	0.99

7	0.93
8	0.86
9	0.77
10	0.68
11	0.59
12	0.52
13	0.45
14	0.4
15	0.35
16	0.3
17	0.27
18	0.23
19	0.2
20	0.18
21	0.16
22	0.14
23	0.12
24	0.1
25	0.09
26	0.08
27	0.07
28	0.06
29	0.05
30	0.05
31	0.04
32	0.04
33	0.03
34	0.03
35	0.02
36	0.02
37	0.02
38	0.02
39	0.01
40	0.01
41	0.01
42	0.01
43	0.01
44	0.01
45	0.01
46	0.01
47	0
48	0
49	0
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0

64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0

Return Period: 25

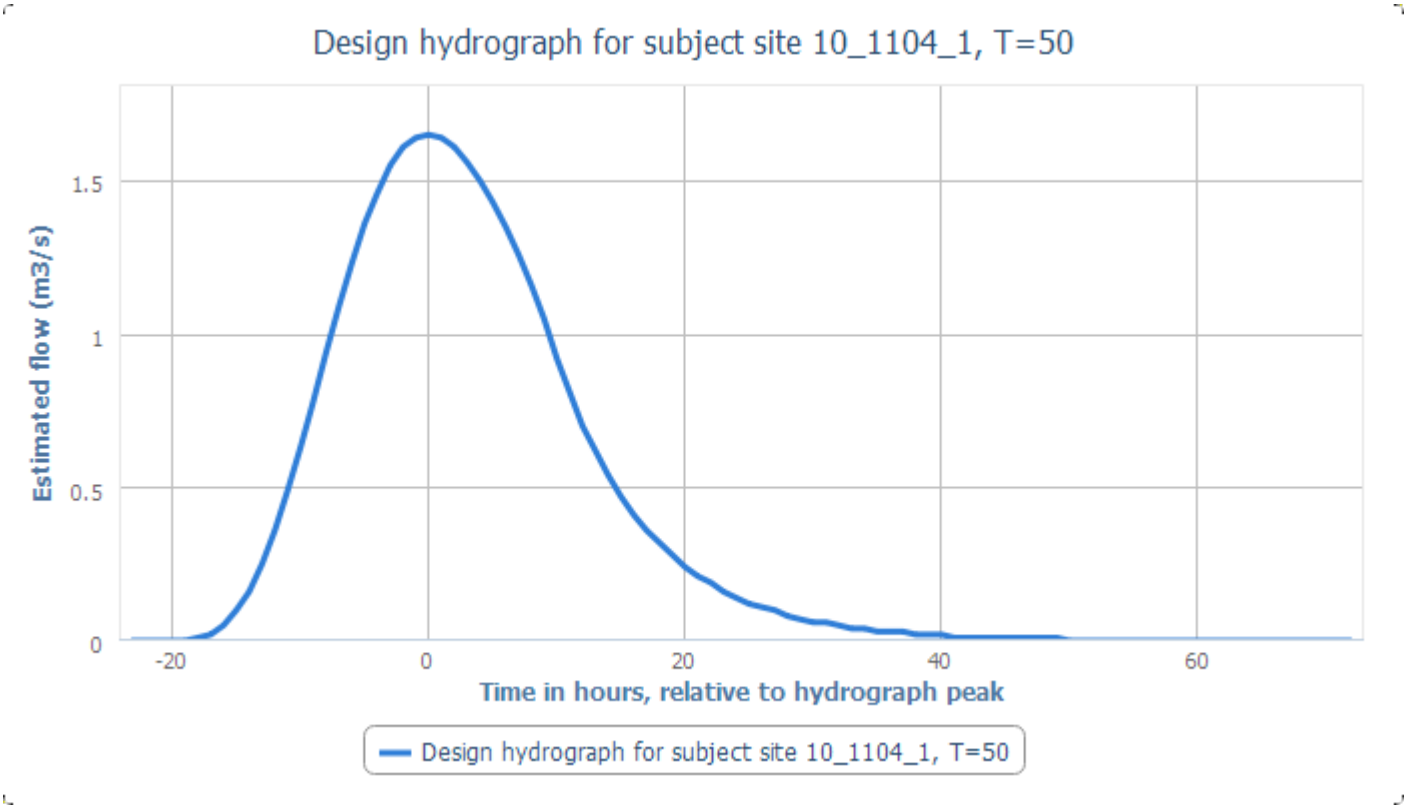


Hours relative to hydrograph peak	Estimated flow (m3/s)
-23.2	0
-23	0
-22	0
-21	0
-20	0
-19	0
-18	0.01
-17	0.02
-16	0.05
-15	0.09
-14	0.14
-13	0.22
-12	0.32
-11	0.43
-10	0.56
-9	0.7
-8	0.83
-7	0.97
-6	1.09
-5	1.21
-4	1.3
-3	1.37
-2	1.43
-1	1.46
0	1.47
1	1.46
2	1.43
3	1.39
4	1.33
5	1.27
6	1.19

7	1.12
8	1.03
9	0.93
10	0.82
11	0.71
12	0.63
13	0.55
14	0.48
15	0.42
16	0.37
17	0.32
18	0.28
19	0.25
20	0.22
21	0.19
22	0.16
23	0.14
24	0.13
25	0.11
26	0.1
27	0.08
28	0.07
29	0.06
30	0.06
31	0.05
32	0.04
33	0.04
34	0.03
35	0.03
36	0.03
37	0.02
38	0.02
39	0.02
40	0.01
41	0.01
42	0.01
43	0.01
44	0.01
45	0.01
46	0.01
47	0.01
48	0.01
49	0
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0

64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0

Return Period: 50

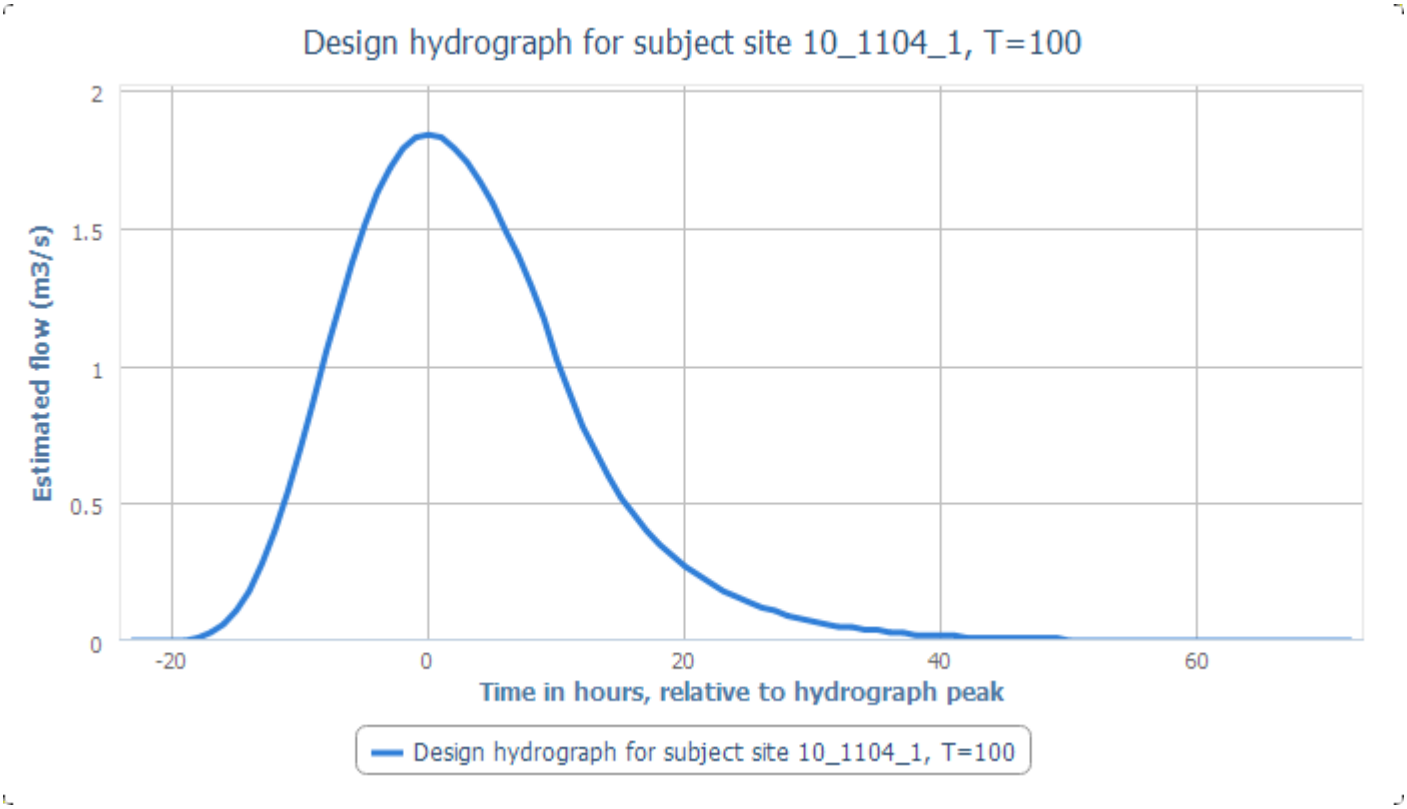


Hours relative to hydrograph peak	Estimated flow (m3/s)
-23.2	0
-23	0
-22	0
-21	0
-20	0
-19	0
-18	0.01
-17	0.02
-16	0.05
-15	0.1
-14	0.16
-13	0.25
-12	0.36
-11	0.49
-10	0.63
-9	0.78
-8	0.94
-7	1.09
-6	1.23
-5	1.36
-4	1.46
-3	1.55
-2	1.61
-1	1.64
0	1.65
1	1.64
2	1.61
3	1.56
4	1.5
5	1.43
6	1.35

7	1.26
8	1.16
9	1.05
10	0.92
11	0.81
12	0.7
13	0.62
14	0.54
15	0.47
16	0.41
17	0.36
18	0.32
19	0.28
20	0.24
21	0.21
22	0.19
23	0.16
24	0.14
25	0.12
26	0.11
27	0.1
28	0.08
29	0.07
30	0.06
31	0.06
32	0.05
33	0.04
34	0.04
35	0.03
36	0.03
37	0.03
38	0.02
39	0.02
40	0.02
41	0.01
42	0.01
43	0.01
44	0.01
45	0.01
46	0.01
47	0.01
48	0.01
49	0.01
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0

64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0

Return Period: 100

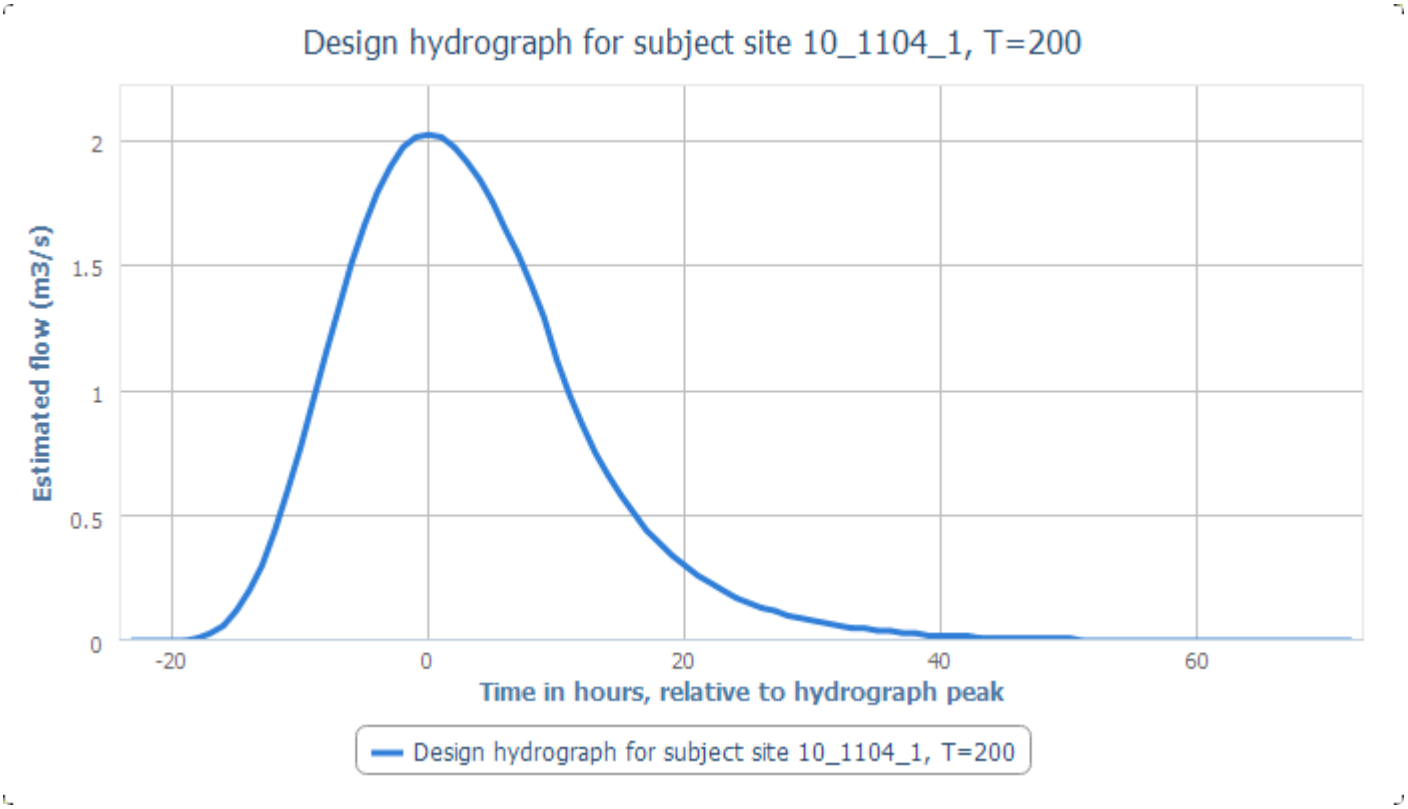


Hours relative to hydrograph peak	Estimated flow (m3/s)
-23.2	0
-23	0
-22	0
-21	0
-20	0
-19	0
-18	0.01
-17	0.03
-16	0.06
-15	0.11
-14	0.18
-13	0.28
-12	0.4
-11	0.54
-10	0.7
-9	0.87
-8	1.05
-7	1.21
-6	1.37
-5	1.51
-4	1.63
-3	1.72
-2	1.79
-1	1.83
0	1.84
1	1.83
2	1.79
3	1.74
4	1.67
5	1.59
6	1.49

7	1.4
8	1.29
9	1.17
10	1.02
11	0.9
12	0.78
13	0.69
14	0.6
15	0.52
16	0.46
17	0.4
18	0.35
19	0.31
20	0.27
21	0.24
22	0.21
23	0.18
24	0.16
25	0.14
26	0.12
27	0.11
28	0.09
29	0.08
30	0.07
31	0.06
32	0.05
33	0.05
34	0.04
35	0.04
36	0.03
37	0.03
38	0.02
39	0.02
40	0.02
41	0.02
42	0.01
43	0.01
44	0.01
45	0.01
46	0.01
47	0.01
48	0.01
49	0.01
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0

64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0

Return Period: 200



Hours relative to hydrograph peak	Estimated flow (m3/s)
-23.2	0
-23	0
-22	0
-21	0
-20	0
-19	0
-18	0.01
-17	0.03
-16	0.06
-15	0.12
-14	0.2
-13	0.3
-12	0.44
-11	0.6
-10	0.77
-9	0.96
-8	1.15
-7	1.33
-6	1.51
-5	1.66
-4	1.79
-3	1.89
-2	1.97
-1	2.01
0	2.02
1	2.01
2	1.97
3	1.91
4	1.84
5	1.75
6	1.64

7	1.54
8	1.42
9	1.29
10	1.12
11	0.98
12	0.86
13	0.75
14	0.66
15	0.58
16	0.51
17	0.44
18	0.39
19	0.34
20	0.3
21	0.26
22	0.23
23	0.2
24	0.17
25	0.15
26	0.13
27	0.12
28	0.1
29	0.09
30	0.08
31	0.07
32	0.06
33	0.05
34	0.05
35	0.04
36	0.04
37	0.03
38	0.03
39	0.02
40	0.02
41	0.02
42	0.02
43	0.01
44	0.01
45	0.01
46	0.01
47	0.01
48	0.01
49	0.01
50	0.01
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0

64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0

Audit Trail Report #5881 (Glenamuck Road (Golf Stream))

User ID:	nick.fenner@dbfl.ie
Name:	Fenner, Nick
Company:	
Address:	
Report date & time:	06-12-2017 16:53
Start of Calculation:	19-07-2017 18:55

Decisions made by the user:

Decision	User comment	System information	Date
2.1 Subject site accepted	N/A	Location 10_1104_1	19-07-2017 18:56
2.2 Subject site with area < 25km2 accepted	N/A		19-07-2017 18:56
2.4 Pivotal site accepted	Reason for accepting: N/A Reason for ignoring warnings: N/A	Station: 10022 CARRICKMINESWarnings: - Catchment urbanisation differs appreciably. Difference: (0.1162). The user has been notified that 2 candidates where either hydrologically or geographically closer to the subject site than the chosen pivotal site. The user has accepted to reject these sites in preference of the chosen pivotal site.	19-07-2017 18:57
2.8 QMED data transfer performed	N/A		19-07-2017 18:58

2.11 Pooling group accepted	N/A	Pooled group accepted with the following stations: [09011, 10022, 08005, 25034, 10021, 08012, 08002, 16051, 09002, 09035, 25040, 24022, 06031, 14009, 26022, 08009, 30020, 06033, 06030, 26058, 22009, 36031, 13002, 08007] and distribution: EV1	19-07-2017 18:58
2.13 Module 2 finalized	N/A	Finished pooled analysis with the following distribution selected: EV1.	19-07-2017 18:58
3.1 Hydrograph pivotal site rejected	N/A	Station: 16013 FOURMILEWATER	19-07-2017 18:58
3.3 Proceeded from hydrograph display	N/A		19-07-2017 18:59
3.3 Proceeded from hydrograph display	N/A		19-07-2017 18:59
3.4 Hydrograph inspected and adjusted	N/A	The user adjusted the original PCD hydrograph with n = 5, Tr = 25 and C = 100	19-07-2017 18:59
3.5 Hydrograph transferred to subject site	N/A	The user adjusted the subject site estimate with n = 8.24200864718418, Tr = 23.2004710719827, C = 7.49514222220158	19-07-2017 18:59

Appendix C

Drawings

ON ORIGINAL

0 5 10 15 20 25 30 40 50mm

NOTES:

MODELLED GOLF STREAM LEGEND

- 1% Fluvial AEP Event
- 0.1% Fluvial AEP Event
- FSR RR 0.1% AEP FLOOD EXTENT USED IN SENSITIVITY ANALYSIS

N W E S

2.4m x 1.5m CULVERT

CFRAMS NODE
1060M00560J
1% AEP FLOOD LEVEL
73.07m
0.1% AEP FLOOD LEVEL
73.15m

GOLF STREAM CH 110

GOLF STREAM CH 130

GOLF STREAM CH 160

GOLF STREAM CH 200
1% AEP FLOOD LEVEL 74.01m
0.1% AEP FLOOD LEVEL 74.13m

WEIR STRUCTURE

GOLF STREAM CH 230

GOLF STREAM HECRAS MODEL OUTPUT RESULTS

GOLF STREAM CH 260
1% AEP FLOOD LEVEL 76.71m
0.1% AEP FLOOD LEVEL 76.57m

GOLF STREAM CH 290

GOLF STREAM CH 320

GOLF STREAM CH 360

GOLF STREAM CH 390

1500 CONCRETE CULVERT UNDER GLENAMUCK ROAD

HEADWALL STRUCTURE

2.4m x 1.5m CULVERT

LOW POINT OF 72.48 INITIALISING OVERLAND FLOW PATH

LINE DENOTES 0.1% AEP FLOOD EXTENTS

LINE DENOTES 0.1% AEP FLOOD EXTENTS

OUTLINE OF 0.1%AEP OF FSR RR FLOWS USED IN SENSITIVITY ANALYSIS

BLOCK B1
BLOCK B2
BLOCK D
BLOCK A2
BLOCK A1
BLOCK C
BLOCK A3
FFL 79.45m

rev	date	description	by	chkd
P02	06-11-20	PLANNING ISSUE	BS	NJF
P01	26-03-20	PRE-PLANNING ISSUE	BS	NJF

client approval
- A - Approved
- B - Approved with comments
- C - Do not use

suitability: S2 - INFORMATION
issue purpose: PRE-PLANNING

DBFL Consulting Engineers
Civil, Structural & Transportation Engineering
www.dbfl.ie

DUBLIN OFFICE: Ormond House, Upper Ormond Quay, Dublin 7, D07 W704
PHONE +353 1 400 4000

CORK OFFICE: Phoenix House, Monahan Road, Cork, T12 H1XY
PHONE +353 (0) 21 2324836

WATERFORD OFFICE: Suite 8b The Atrium, Maritana Gate, Canada Street, Waterford, X91 W028
PHONE +353 51 309 500

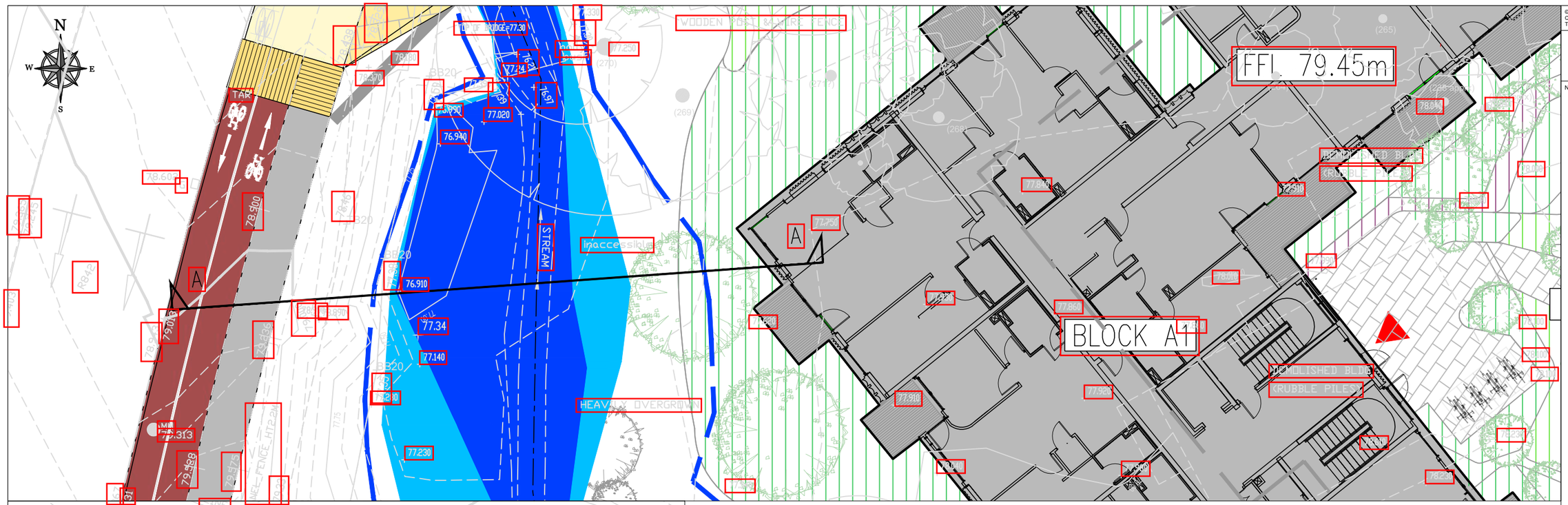
project ref.
RESIDENTIAL DEVELOPMENT AT GLENAMUCK ROAD

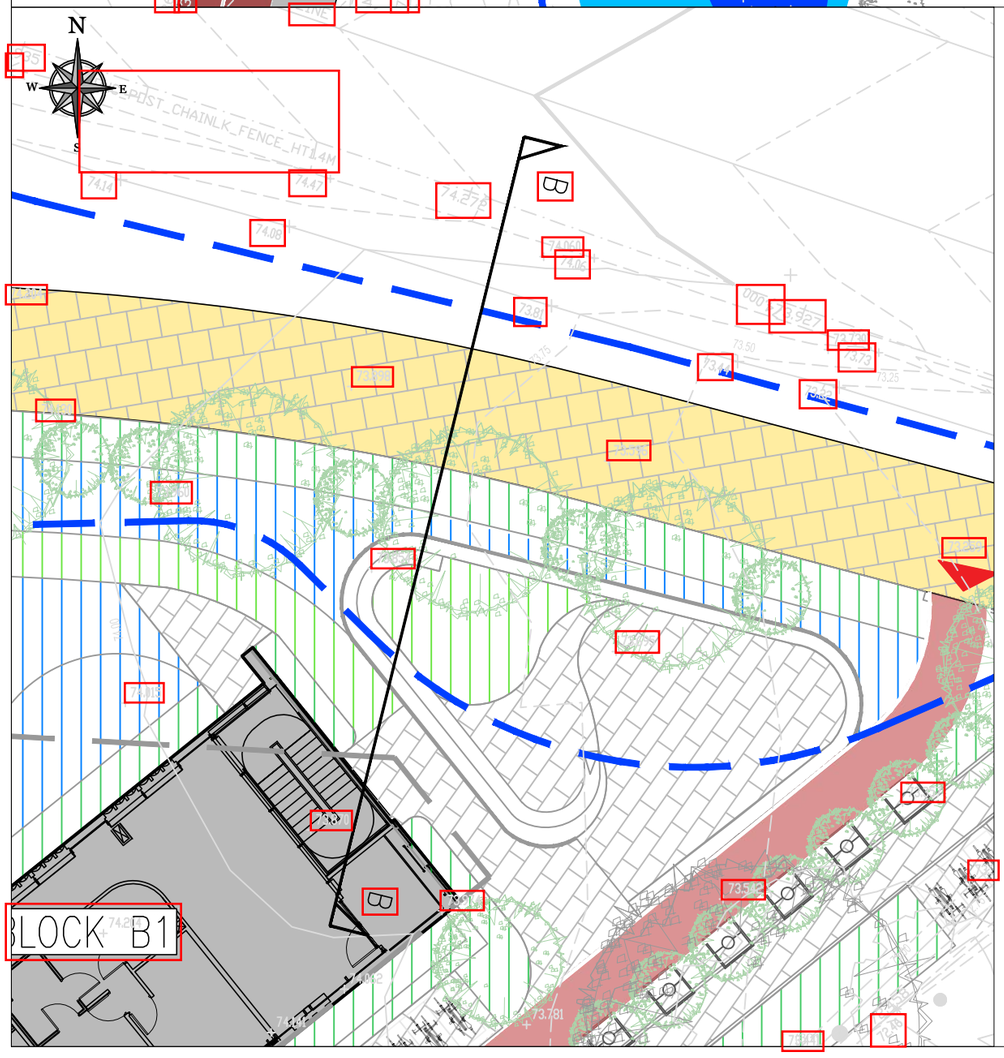
drawing title
FLOOD EXTENTS MAP

architect
HENRY J. LYONS ARCHITECTS

designed by	author	scale	sheet size
PCC	BS	1:500	A1

drawing no. 17063-9120
revision P01

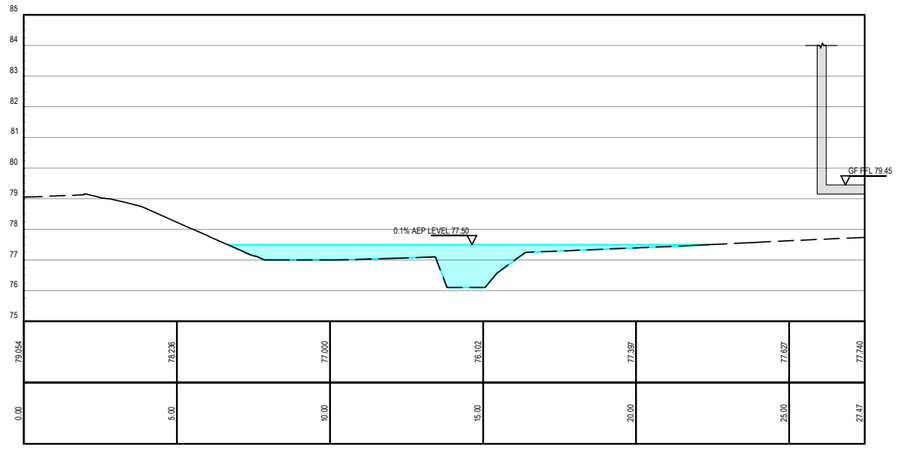




SCALES:
Horizontal 1:100
Vertical 1:100

DATUM 75.000

Existing Ground Levels	79.054	78.236	77.000	76.102	77.397	77.687	77.740
Chainage Distance (m)	0.00	5.00	10.00	15.00	20.00	25.00	27.47

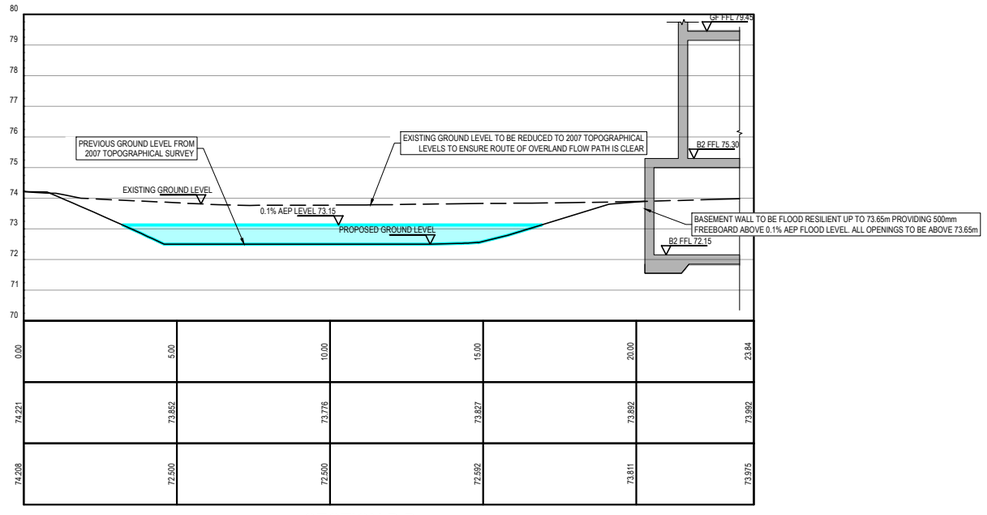


SECTION A-A

SCALES:
Horizontal 1:100
Vertical 1:100

DATUM 70.000

Chainage Distance (m)	0.00	5.00	10.00	15.00	20.00	23.84
Existing Ground Levels	74.221	73.652	73.776	73.827	73.992	73.992
Proposed Levels	74.208	72.600	72.600	72.992	73.811	73.975



SECTION B-B

ON ORIGINAL

0 5 10 15 20 30 40 50mm

NOTES:

rev	date	description	by	chkd.
				NJF

client approval
- A - Approved
- B - Approved with comments
- C - Do not use

suitability: S2 - INFORMATION
issue purpose: PLANNING

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DUBLIN OFFICE: Ormond House, Upper Ormond Quay, Dublin 7, D07 W704
PHONE +353 1 400 4000

CORK OFFICE: Phoenix House, Monahan Road, Cork, T12 H1XY
PHONE +353 (0) 21 2024536

WATERFORD OFFICE: Suite 8b The Atrium, Maritana Gate, Canada Street, Waterford, X91 W028
PHONE +353 51 309 500

project ref.
RESIDENTIAL DEVELOPMENT AT GLENAMUCK ROAD

drawing title
STREAM CROSS-SECTIONS

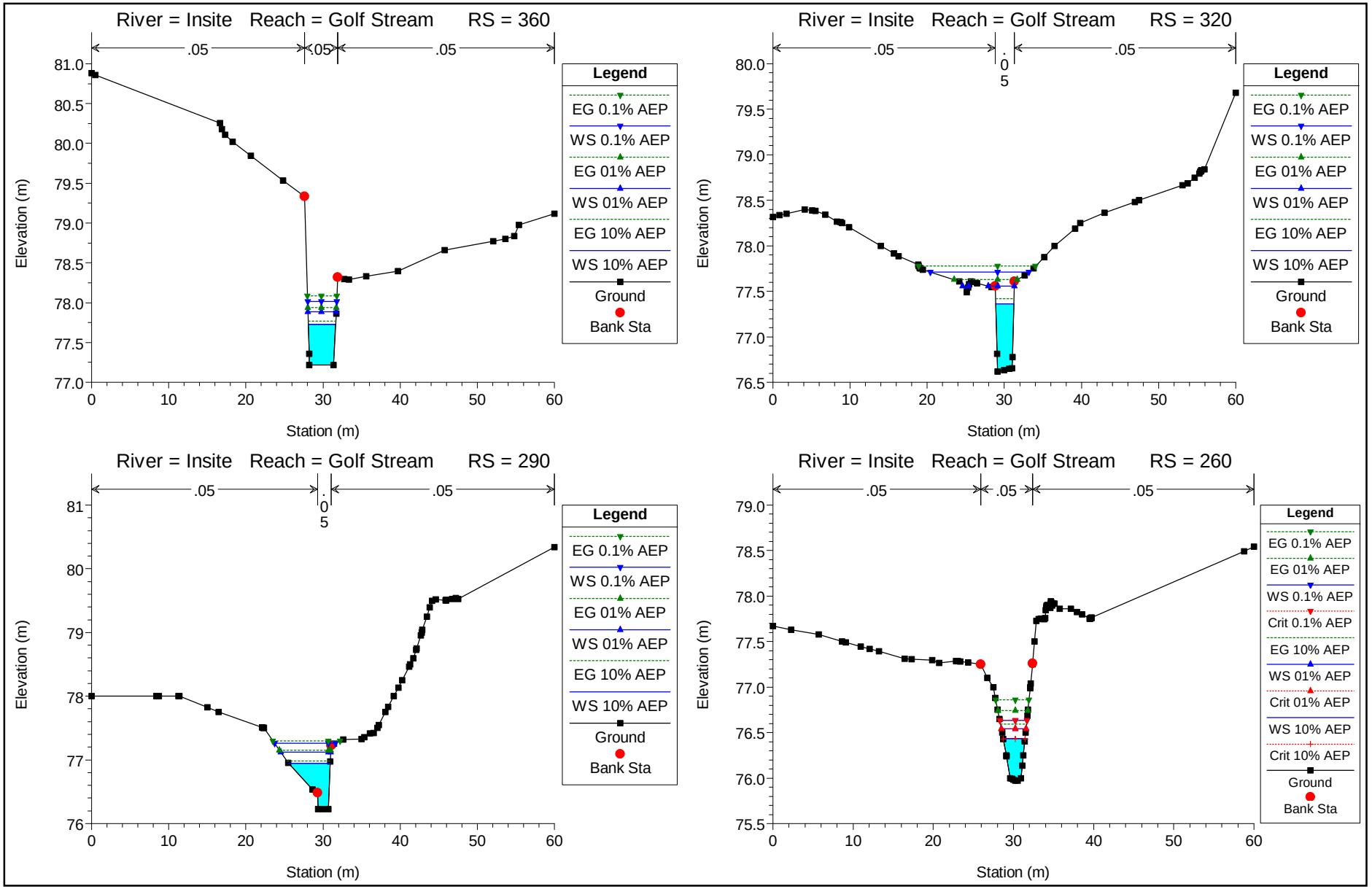
client
AXIS CONSTRUCTION

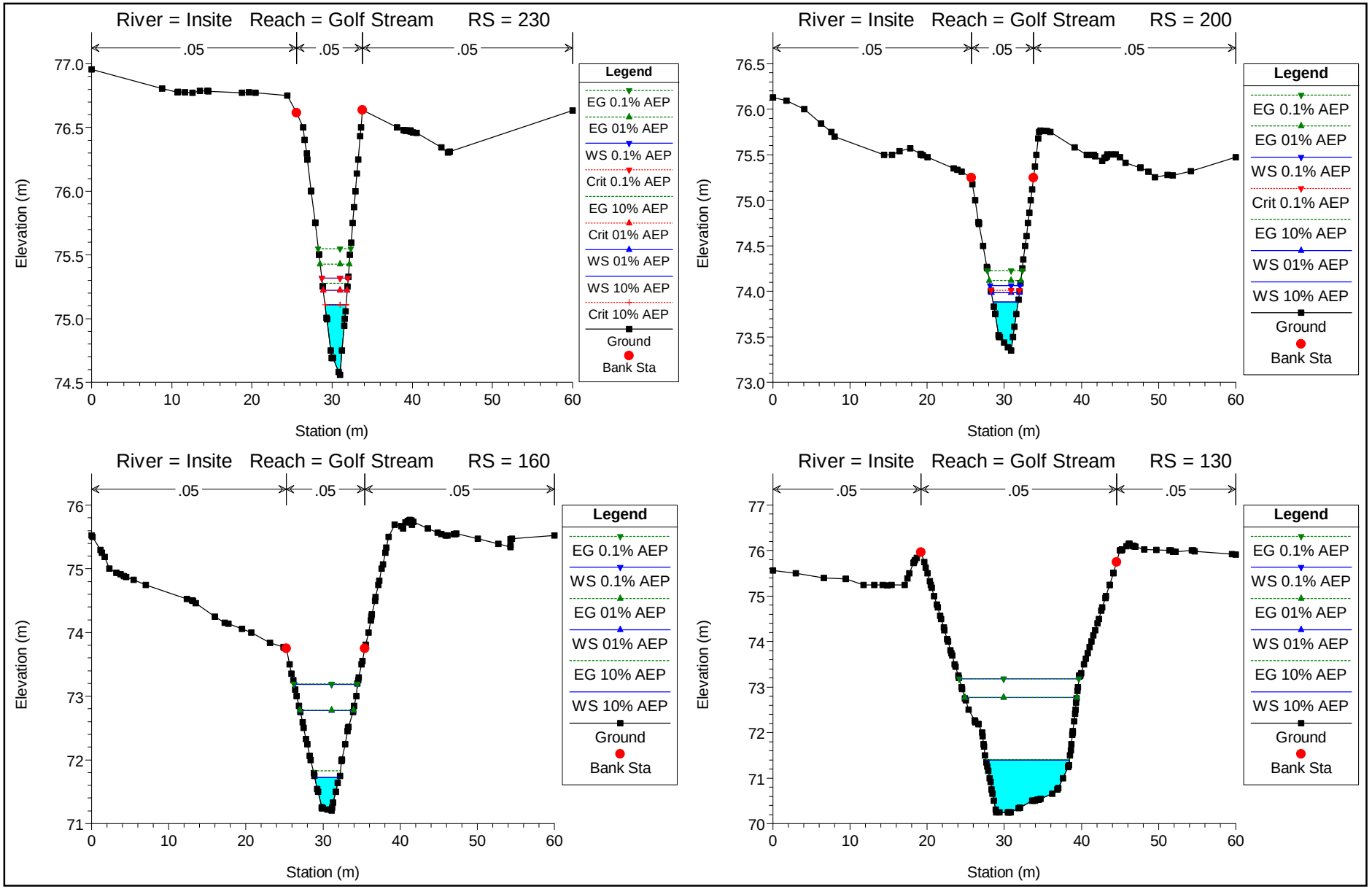
designed by	author	scale	sheet size
PCC	BS	AS SHOWN	A1

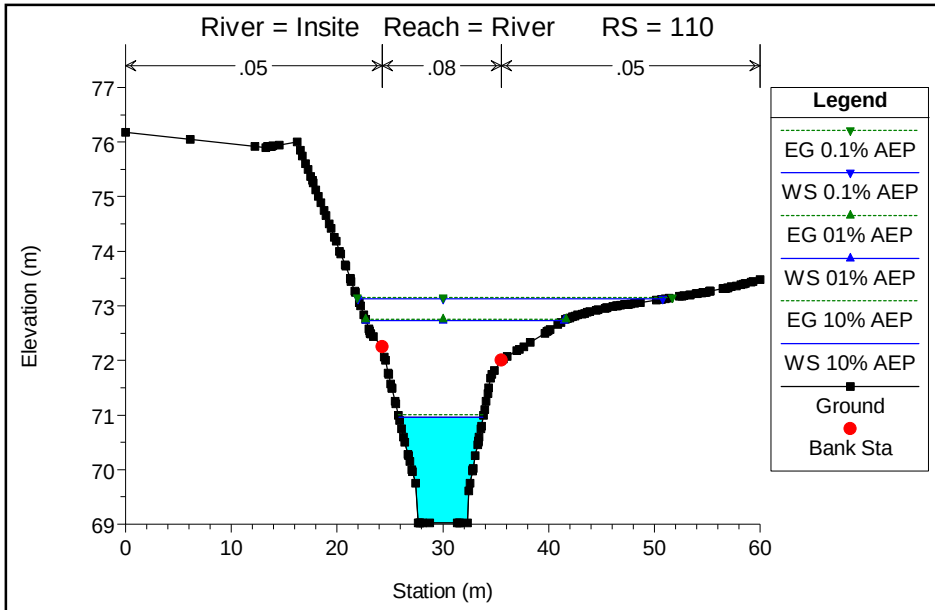
drawing no. 170063-3140
revision P01

Appendix D

HEC-RAS Model Sections


River = Insite Reach = Golf Stream RS = 360
.05
.05
.05
Elevation (m)
Station (m)
Legend
EG 0.1% AEP
WS 0.1% AEP
EG 01% AEP
WS 01% AEP
EG 10% AEP
WS 10% AEP
Ground
Bank Sta
River = Insite Reach = Golf Stream RS = 320
.05
.05
.05
Elevation (m)
Station (m)
Legend
EG 0.1% AEP
WS 0.1% AEP
EG 01% AEP
WS 01% AEP
EG 10% AEP
WS 10% AEP
Ground
Bank Sta
River = Insite Reach = Golf Stream RS = 290
.05
.05
.05
Elevation (m)
Station (m)
Legend
EG 0.1% AEP
WS 0.1% AEP
EG 01% AEP
WS 01% AEP
EG 10% AEP
WS 10% AEP
Ground
Bank Sta
River = Insite Reach = Golf Stream RS = 260
.05
.05
.05
Elevation (m)
Station (m)
Legend
EG 0.1% AEP
EG 01% AEP
WS 0.1% AEP
Crit 0.1% AEP
EG 10% AEP
WS 01% AEP
Crit 01% AEP
WS 10% AEP
Crit 10% AEP
Ground
Bank Sta


River = Insite Reach = Golf Stream RS = 230
.05
.05
.05
Elevation (m)
Station (m)
Legend
EG 0.1% AEP
EG 01% AEP
WS 0.1% AEP
Crit 0.1% AEP
EG 10% AEP
Crit 01% AEP
WS 01% AEP
WS 10% AEP
Crit 10% AEP
Ground
Bank Sta
River = Insite Reach = Golf Stream RS = 200
River = Insite Reach = Golf Stream RS = 160
River = Insite Reach = Golf Stream RS = 130


River = Insite Reach = River RS = 110
.05
.08
.05
77
76
75
74
73
72
71
70
69
Elevation (m)
0
10
20
30
40
50
60
Station (m)
Legend
EG 0.1% AEP
WS 0.1% AEP
EG 01% AEP
WS 01% AEP
EG 10% AEP
WS 10% AEP
Ground
Bank Sta