FLOOD RISK ASSESSMENT ADDENDUM

Grange Castle Business Park, County Dublin

Prepared for: **Hanley Pepper Consulting Engineers.**

SLR Ref: 501.00111.0002
Version No: Rev.6 ADDENDUM
July 2021

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ADDENDUM

This addendum has been added to the original SLR Report 501.0111.0002.Rev6 dated October 2020.

This Flood Risk Assessment Report is being resubmitted in support of Planning Permission for the proposed Data Centre at Grangecastle Co. Dublin.

Arup have undertaken a site ground investigation (post planning) since our report was prepared and submitted in October 2020; new information has become available from the ground investigation relating to the potential for groundwater flooding at the site. This new additional information from the investigation relating to groundwater was not available at the time our assessment was prepared.

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1.0 INTRODUCTION

SLR Consulting (SLR) has been appointed by Hanley Pepper Consulting Engineers (the Client) to prepare a Flood Risk Assessment (FRA) Report to support a planning application in respect of a proposed development at Grange Castle Business Park, County Dublin.

This FRA Report has been prepared for Hanley Pepper Consulting Engineers for the existing site, the baseline scenario, to assist with planning for the site.

1.1 Project Description

Microsoft Ireland is applying for development at lands at Grange Castle Business Park, Kilmahuddrick, Dublin 22 on a site of c. 11.95 ha. located immediately to the West of the existing Microsoft Data Centre Campus (SD16A-0088). The Proposed development will comprise site enabling works including the construction of a new bridge and entrance over the Griffeen River linking the site to the northern estate road, demolition of existing vacant house and outbuildings (total floor area c.140 sq.m), and modification works to previously approved (SD16A/0088) below ground attenuation. Construction of the following proposed new buildings:

a) Central Administration / MS Campus Gateway Building
- 4 - storey landmark building at Park Entrance;
- G.I.F.A. c. 3,400 m^2, maximum height 86.75 O.D. / 19.5m above ground level;
- Staff Cafeteria, Gym and Reception at Ground Level;
- Staff Office accommodation above associated with management and operations of MS Grange Castle Campus;
- Associated landscaping, car (96 no. spaces) & bicycle parking, shuttle bus drop-off zone, waste compound; and
- Associated attenuation & drainage works.

b) Data Centre to North of Site (DUB 14)
- 2 –storey Data Hall including ancillary admin block;
- G.I.F.A. c. 26,414m^2, roof parapet height 82.250m O.D. / c.15 m above ground level;
- 10 no. flues - flue heights extend to 98.00 O.D. / 30.75 m above ground level;
- Ancillary works including landscaping, parking (38 no. staff / visitor spaces), vehicular & pedestrian routes, external plant including 10 no. diesel generators and pump house at ground level; and
- Associated attenuation & drainage works including modifications to previously approved drainage works (SD16A-0088).

c) Data Centre to South of Site (DUB 15)
- 2 –storey Data Hall including ancillary admin block;
- G.I.F.A. c. 26,414m^2, roof parapet height 83.750m O.D. / c.15.75 m above ground level;
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- Ancillary works including landscaping, parking (38 no. staff / visitor spaces), vehicular & pedestrian routes, external plant including 10 no. diesel generators and pump house at ground level; and
- Associated attenuation & drainage works including modifications to previously approved drainage works (SD16A-0088).

Ancillary site works for connection to infrastructural services, as well as fencing, landscaping, perimeter service roads around the buildings.

1.2 Site Location and Setting

The Site location and immediate surroundings are shown on Figure FRA-1.

The development site is located on a roughly triangular parcel of undeveloped land within Grange Castle Business Park, Co. Dublin, which is located approximately 4 km west of Clondalkin and 4 km north east of Newcastle. The overall landholding encompasses a land area of some 11.95 ha.

The main vehicular access to the site is located off Grange Castle Business Park road to the north. The Grange Castle Business Park road forms the northern and western site boundary and links to the R134 Regional Road immediately south west of the site. The R134 Regional road forms the southern boundary and a small grassed area is located along the eastern boundary. Agricultural fields are located beyond the western and southern boundary and other buildings which comprises the business park extends further north and east.

The application site of 11.95 ha. relates only to the location of the proposed development and is shown on Figure FRA-2.

1.3 Existing Site Drainage

The site is currently undeveloped comprising open land, so it is considered that no drains or other formal drainage infrastructure is observed at the site. However, there have been earthworks at the site and there are a number of topsoil / overburden storage piles at the site

Combined sewers are expected to be located on the roads which surround the site.

1.4 Nominated Hydrologists

This FRA report has been prepared by:

- *David Wright BEng. CEng. - SLR Technical Director Hydrology; and*
- *EurGeol Dr. Peter Glanville PGeo. PhD (Geomorphology) MSc (GIS) - SLR Principal Hydrologist*

David is a Technical Director with SLR associated with the Hydrology and Hydrogeology team and is responsible for leading on flood and water management. With a background in flood management and civil engineering, he has over 25 years' experience in the design and management of major civil engineering projects, including flood protection schemes, hydropower, wind energy, highways and port facilities.

He has led multi-disciplinary teams of engineers, hydrologists and water scientists in the UK and Australia, in the Water, Renewable Energy and Ports sectors. This has included developing business and managing design and EIA projects and programmes across urban development, flood and surface water management, water and wastewater, highways, ports & coastal protection, and renewable energy.

Peter is a Principal (Hydrology) with SLR and has over 20 years' experience in the area of Hydrology and Flood Risk Assessments.

Peter has undertaken and prepared flood risk assessments for a wide range of projects and has also prepared Section 4 Discharge Licences for a variety of developments. He has also been involved as a hydrologist in a range of environmental monitoring projects for Environmental Baseline Studies, exploration operations, quarry site operations and infrastructure projects – this work has typically included hydrology monitoring (flow) and water quality sampling and testing.

2.0 FLOOD PLANNING GUIDELINES

In November 2009 the Office of Public Works (OPW) and Department of the Environment, Heritage and Local Government (DoEHLG) issued guidelines for planning authorities addressing the management of flood risk in the planning system[1] (hereinafter referred to as the 'Flood Planning Guidelines').

The flood planning guidelines introduced comprehensive mechanisms for the incorporation of flood risk identification, assessment and management into the planning process. Implementation of the guidelines will be achieved through actions at national, regional, local authority and site-specific levels, depending on the plan or development project being considered.

2.1 Planning Objectives in Relation to Flooding

The consultation guidelines for planning authorities relating to The Planning System and Flood Risk Management issued in 2009 require the planning system at national, regional and local level to:

- Avoid development in areas at risk of flooding by not permitting development in flood risk areas, particularly floodplains, unless where it can be fully justified, there are wider sustainability grounds for appropriate development and unless the flood risk can be managed to an acceptable level, without increasing flood risk elsewhere and, where possible, reducing flood risk overall;
- Adopt a sequential approach to flood risk management based on avoidance, reduction and then mitigation of flood risk as the overall framework for assessing the location of new development in the development planning processes; and
- Incorporate flood risk assessment into the process of making decisions on planning applications and planning appeals.

A sequential approach is adopted in the flood planning guidelines in order to guide development away from areas at risk of flooding, this entails the following actions:

- **Avoid** Locate new development in lower risk flood zones;
- **Substitute** Ensure that the type of development is not particularly vulnerable to the adverse impacts of flooding;
- **Justify** Ensure that the development is considered for strategic reasons;
- **Mitigate** Ensure that flood risk is reduced to acceptable levels; and
- **Proceed** Development to proceed only where Justification Test passed and emergency planning measures are in place.

The sequential approach identifies and defines three different flood zones (designated Zones A, B and C) in order to guide development at a particular site. The flood zones are:

Zone A *High probability of flooding. This zone defines areas with the highest risk of flooding from rivers (i.e. more than 1% probability or more than 1 in 100) and the coast (i.e. more than 0.5% probability or more than 1 in 200).*

Zone B *Moderate probability of flooding. This zone defines areas with a moderate risk of flooding from rivers (i.e. 0.1% to 1% probability or between 1 in 100 and 1 in 1000) and the coast (i.e. 0.1% to 0.5% probability or between 1 in 200 and 1 in 1000).*

Zone C *Low probability of flooding. This zone defines areas with a low risk of flooding from rivers and the coast (i.e. less than 0.1% probability or less than 1 in 1000).*

[1] 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (2009): Office of Public Works and the Department of the Environment, Heritage and Local Government.

2.2 Flood Risk Management

Technical Appendix B of the flood planning guidelines addresses the incorporation of flood risk management in the design of developments, and sets out practical measures, with the aid of design examples, which can be incorporated into the development design in order to reduce the risk of flooding in areas where a potential flood risk has been identified. The design examples match flood risk with appropriate land uses, while also protecting flood conveyance routes and preserving floodplain storage.

A number of core principles are outlined in the flood planning guidelines regarding design for, and management of, flood risk. These follow a sequential approach to flood risk management, and involve:

- Locating development away from areas at risk of flooding, where possible;
- Substitution of less vulnerable land uses for the more vulnerable ones that are to be replaced, where the principle of development within flood risk areas has been established; and
- Identifying and protecting land required for current and future flood risk management, such as conveyance routes, flood storage areas and flood protection schemes etc. where the principle of development within flood risk areas has been established.

In the flood planning guidelines, Section 3.4 of Appendix B outlines practical landscape and drainage measures which can be closely integrated to play a key role in effective flood-reduction measures if incorporated into the design of developments. Key elements which can be incorporated include:

- Creating a permeable network and hierarchy of green space providing for direct access to areas of lower flood risk;
- Planting and shaping the land surrounding individual buildings and groups of buildings to encourage drainage away from a property;
- The use of "higher-risk" low-lying ground in waterside areas for recreation, amenity and environmental purposes;
- Modest land-raising of a part of the area at high risk of flooding accompanied by compensatory provision of flood storage in areas of existing lower risk of flooding having considered other natural and built heritage issues;
- Recontouring of edge of floodplain;
- Use of earth bunds to provide local flood defence;
- The use of surface runoff attenuation measures / sustainable drainage systems (SuDS) to manage run-off from rain falling on a development can be an effective means of reducing its impact reflecting natural drainage processes and removing pollutants from urban run-off at source; and
- Avoiding structures in the floodplain.

3.0 FLOOD RISK ASSESSMENT - METHODOLOGY

A methodology for the identification and assessment of flood risk is outlined in Technical Appendix A of the flood planning guidelines. The aim of the FRA is to identify and quantify the risk of flooding to land, property and people and also to provide sufficient information to assess whether the proposed development is appropriate at a specific site.

The FRA is undertaken over a number of stages which each progressing to a more detailed assessment, dependant on the outcome of each stage, until the level of detail in the FRA is appropriate to support the planning application or it has been demonstrated that flooding is not a relevant issue for the site. The stages in the assessment are typically;

- **Stage 1:** Flood Risk Identification;
- **Stage 2:** Initial Flood Risk Assessment; and
- **Stage 3:** Detailed Flood Risk Assessment (including quantitative model).

At the end of Stages 1 and 2 a decision is taken as to whether it is necessary to proceed to the next stage in the assessment process, in relation to flood risk at a site.

3.1 Flood Risk Assessment Conceptual Model

In order to assess the flood risk for a particular site it is essential to understand what the risk is, and this is undertaken using a conceptual Source-Pathway-Receptor (SPR) model, which is widely used in understanding and managing environmental risks.

In order to develop a conceptual SPR model for the purpose of risk assessment it is necessary to understand the origin and magnitude of potential flooding (the **Source**), the mechanism or route of flooding (the **Pathway**) and the nature / scale of the proposed development (the **Receptor**).

3.2 Data Sources

In order to assess the flood risk at a site it is necessary to understand both the flood Source and Pathway for flooding at a site and this is done based on available desktop data for Stages 1 and 2 of the FRA. Desktop data sources for Stages 1 and 2 include:

- **The Office of Public Works** (Flood Risk Assessment Maps, flood study reports and flood hazard mapping);
- **Environmental Protection Agency** (hydrology flow / levels, catchment boundaries);
- **Ordnance Survey of Ireland** (historical mapping);
- **Geological Survey of Ireland** (soils / subsoil /karst); and
- **Site Walkover and Topographic Surveys** (site water management and topographic survey).

This report follows the methodology for a Stage 1 flood risk identification, Stage 2 initial flood risk assessment and Stage 3 detailed flood risk assessment at the site-specific level as outlined in the flood planning guidelines, for the proposed development at Grange Castle.

4.0 STAGE 1: FLOOD RISK IDENTIFICATION

The potential sources of flooding to any site are varied and can include one or more of the following:

- Flooding from rivers (fluvial);
- Flooding from the sea or tidal (coastal);
- Flooding from land (pluvial);
- Flooding from groundwater and karst;
- Flooding from sewers; and
- Flooding from manmade impoundments (reservoirs, canals, and other artificial sources).

A desk top review of potential flooding at the site is undertaken in Section 4.1 here and each potential source of flooding at the site are screened in Section 4.2.

4.1 Desktop review of potential flooding sources

4.1.1 Historical Mapping

Available Ordnance Survey of Ireland historical mapping indicates that the Griffeen River is located within the vicinity of the site and flows generally north eastward along the north western boundary of the site. The Baldonnel Stream is a tributary of the Griffeen River and is shown to flow in a north-westerly direction to the south of R134. Historically, to the north of the R134, the Baldonnel Stream continued to flow generally northward (approximately 0.4 km east of the site), before discharging into the Griffeen River approximately 0.7 km north of the site.

As noted below, the Baldonnel Stream has been realigned and now joins the Griffeen River south of the R134.

No areas of the site are marked as being liable to flood in the historical past.

4.1.2 Topographic Surveys

A topographic survey of the site and a section of the Griffeen River channel was provided to us by Hanley Pepper and in addition SLR undertook a survey of the Baldonnell Stream channel and culverts in June and October 2020 which also extended downstream of the Hanley Pepper survey along the Griffeen river to the roundabout to the north of the site. The topographic surveys used are:

i. Grange Castle 3D ITM, dated 2013 (source Hanley Pepper);
ii. Grange Castle June 2020 Combined ITM, dated June 2020 (source Hanley Pepper); and
iii. SLR surveys of Baldonnell Stream channel and Griffeen River channel, dated June and October 2020.

Ground elevations across the site generally vary from approximately 69 mOD along the southern boundary of the site to 66 mOD in the northern corner.

Elevation decrease towards the banks of the Griffeen River, which is located along the north west boundary of the site, to a level of 64.4 mOD in the southwest of the site immediately after the attenuation pond to 63 mOD within the north eastern extent of the site before it is culverted under the road.

A 'u' shaped raised bank is noted within the north eastern extent of the site and has a maximum elevation of 70 mOD and this area appears to have been created as a hard stand area for temporary parking / laydown.

In the middle part of the site there is an existing hard standing area which is currently used as a site office compound and for site vehicle parking. In order to provide for the site office and parking the topsoil across this area has been stripped and replaced with hard core material; The topsoil has been stockpiled around the northern, astern and southern edge of this area.

4.1.3 Local Surface Water Features

The principal water feature in the vicinity of the site is the Griffeen River. The river flows generally north eastward along the north western boundary of the site, before discharging into the River Liffey approximately 4 km north of the site.

The Baldonnel Stream is a tributary of the Griffeen River which flows in a north-westerly direction south of the site (i.e. south of the R134).

It is noted that the local hydrology has been significantly modified to facilitate the development of the Grange Castle business park, see Figure FRA-1. Within the vicinity of the site, there are at least five culverts along the Griffeen River and Baldonnel Stream. The Griffeen River has been culverted under the Realigned Baldonnel Road and the R134 to the south west of the site as well as the Grange Castle Business Park road to the north. The Baldonnel Stream has been culverted approximately 50 m south east of the site and discharges into the Griffeen River 40 m south west of the site, south of the R134.

There is a small basin area on the south side of the R134 road where the Baldonnel Stream joins the Griffeen River, and an ornamental pond with low weir just downstream (north) of the R134.

4.1.4 OPW Flood Mapping

The Office of Public Works (OPW) is the government agency with statutory responsibility for flooding. The OPW website (www.floodinfo.ie) indicates that there are no recorded recurring flood events at the site.

A review of the OPW national coastal / tidal flood mapping indicates that the site is not at risk from coastal or tidal flooding.

The OPW CFRAM flood mapping indicates that a section of the development site is liable to flood from the Griffeen River. The extent of OPW modelled Medium probability flood event at the development site is shown within the western extent of the site and along parts of the R134, see Figure FRA-3. The Medium probability flood events have approximately 1-in-a-100 chance of occurring or being exceeded in any given year, this is also referred to as an Annual Exceedance Probability (AEP) of 1%.

It is noted that a single past flood event is shown on the OPW flood mapping within the Griffeen catchment. The event occurred on the 5th and 6th November 2000 and caused flooding the housing areas of the Old Forge and Grange Manor estates and within areas of Lucan, which are located approximately 2 km and 4 km north of the site respectively.

The OPW CFRAM flood mapping was undertaken before the realignment of the Baldonnell Stream at the site and the construction / realignment of the R134 road. Therefore, there is no existing OPW CFRAM flood mapping available for the Baldonnell Stream.

4.1.5 Soils and Subsoils

The Environmental Protection Agency (EPA) website publishes soil and subsoil maps created by the Spatial Analysis Unit and Teagasc in collaboration with the Geological Survey of Ireland (GSI). Published soil mapping indicates that the soils at the site are predominately fine loamy limestone glacial till deposits. These subsoils do not suggest or indicate flooding at the site.

4.1.6 Groundwater and Karst

There is no indication of any groundwater springs at the site or on the Ordnance Survey of Ireland historical maps for the site which indicates that there is no potential for groundwater flooding to the site.

There are no identified karst features on the site or in the vicinity of the site and the site is not considered at risk from karst related groundwater flooding.

4.2 Flood Screening

The potential sources of flooding are:

- Flooding from rivers or fluvial flooding;
- Flooding from the sea or tidal flooding;
- Flooding from land;
- Flooding from groundwater and karst;
- Flooding from sewers; and
- Flooding from reservoirs, canals, and other artificial sources.

The sources of flooding and the flood risk from each of these are considered in Table 4-1 below and the potential flood risk from each source is screened here.

Table 4-1
Flood Screening at the Proposed Restoration Site

Source of Flooding	Potential to Flood at the Site	Flood Screening – Potential Impact from Flooding
Flooding from rivers (fluvial)	The OPW fluvial flood mapping indicates that the development is liable to flood from the Griffeen River.	Potential risk of flooding from the River Griffeen
Flooding from the sea (coastal / tidal)	The OPW tidal / coastal flood mapping indicates that the site is not at risk from coastal or tidal flooding.	None
Flooding from land (rainfall – pluvial)	Any rainwater falling directly on the site is likely to fall towards the Griffeen River along the north western boundary of the site. Any flooding of the river has been considered under fluvial flood risk and the development will be designed to readily drain off any surface water flows. It is therefore considered that the site is not at pluvial flood risk.	None
Flooding from groundwater	There are no historical groundwater springs in the vicinity of the site which would have resulted in flooding in the past.	None
Flooding from karst	There are no identified karst features at the site.	None
Flooding from sewers	There are no sewers running across the site.	None
Flooding from Impoundments - reservoirs and artificial sources	There are no artificial sources of water in the vicinity of the site.	None

4.3 Requirement for a Stage 2 Flood Risk Assessment

The flood planning guidelines state that if a flood risk at the site is identified at this Stage 1, it is necessary to progress and undertake a Stage 2 Initial Flood Risk Assessment for the site and proposed development.

Each of the potential flooding sources have been considered here based on the desktop study of the potential flooding at the site. The potential flood risk at the site has been screened out at this initial flood risk identification stage except for the residual flood risk from fluvial flooding.

5.0 STAGE 2: Initial Flood Risk Assessment

This initial flood risk assessment for the site at Grange Castle is based on available desktop information and site information.

The Stage 2 Initial FRA undertaken in relation to the application site has involved the following elements:

- Delineation of flood zones at the site;
- Conceptual Site Model: Source - Pathway – Receptor;
- Assessment of flood risk to the site;
- The potential impact of the proposed development on flooding elsewhere in the catchment
- Potential mitigation measures at the site;
- Sequential approach;
- The Justification Test; and
- Stage 2 findings and assessment of the requirement to proceed to a Stage 3 detailed FRA.

5.1 Development site and Flood Zones

The proposed site development comprises a Central Administration / MS Campus Gateway Building and two data Centre buildings (DUB 14 & DUB15), see Section 1.1 above for detailed project description.

The OPW CFRAM flood maps indicate proposed flooding extents of the High (1-in-10 or 10% AEP), Medium (1-in-100 or 1% AEP) and Low (1-in-1000 or 0.1% AEP) probability fluvial flooding events. The extent of the OPW modelled High and Medium probability events are shown to be within or close to the banks of the Griffeen River within the north western extent of the site and across the attenuation basin located within the south western corner of the site, north of the R134. The Low probability event is shown to have a greater extent across the western extent of the site and along the southern boundary and the R134.

It is noted that the OPW flood mapping resource provides indications of the potential for flood risk at a local or "community" level. It is not considered suitable to assess flood risk at a site-specific level.

The Planning Guidelines for Flood Risk Management[1] set out the flood zones for the purpose of development, and are described as Flood Zones A, B and C. The guidelines state:

Flood zones are geographical areas within which the likelihood of flooding is in a particular range and they are a key tool in flood risk management within the planning process as well as in flood warning and emergency planning. There are three types or levels of flood zones defined for the purposes of these Guidelines:

***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 year and 0.5% or 1 in 200 for coastal flooding); and*

***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). Flood Zone C covers all areas of the plan which are not in zones A or B.*

5.2 Conceptual Site Model for Flood Risk

A review of the published desktop information relating to the application site is applied in the formulation of a Source-Pathway-Receptor conceptual flood model in respect of the proposed development. The SPR model includes the following:

Source - The potential source of flooding is fluvial flooding from the Griffeen River.

Pathway - Overflow of the watercourse in times of flood within along the north western boundary of the site.

Receptor - The infrastructure at the application site.

5.3 Assessment of flood risk

Using the available data in relation to fluvial flooding, the application site and infrastructure, an initial flood risk assessment in respect of coastal / tidal flooding is summarised here using a SPR conceptual model.

Table 5-1 -
Initial Flood Risk Assessment

Conceptual Site Model			Likelihood of Site Flooding	Consequence of Site Flooding	Residual Risk
Source	Pathway	Receptor			
Fluvial modelled 1% and 0.1% AEP	Overflow of the Griffeen River in the north western extent of the site	Site infrastructure	Low - Medium likelihood of flooding based on OPW flood maps	Highly vulnerable development	**High** for those parts of the development which are considered vulnerable

Based on the Source-Pathway-Receptor model outlined here, and the location, nature, scale and type of activity proposed at the site, it is considered that the residual risk to the highly vulnerable development within the application site presented by fluvial flooding is **High**.

5.4 The potential impact on flooding elsewhere

There is the potential for development to result in increased flood risk elsewhere in a catchment if surface water and flood waters are not managed appropriately.

Surface water runoff from across the site will be managed via a suitable drainage system which will incorporate the use of SuDS; it is therefore not considered that this discharge will result in increased flood risk elsewhere.

Site drainage measures will be compliant with the requirements of the Greater Dublin Strategic Drainage Study.

5.5 Mitigation measures at the site for flood risk

The development is shown to be partially located in Flood Zone A based on OPW flood modelling. The development is considered to be highly vulnerable and during construction it has the potential to give rise to water pollution if they were flooding. Therefore, specific flood risk mitigation measures are required and discussed in Section 6.0 below.

5.6 Requirement for a Stage 3 Flood Risk Assessment

The purpose of this initial Flood Risk Assessment is to ensure that all relevant flood risk issues are assessed in relation to the application site, the flood zoning and the proposed development, and that the potential conflicts between flood risk and development are addressed to the appropriate level of detail, to enable the proposed development to be considered for planning.

This initial FRA has assessed existing baseline information in relation to fluvial flooding at the site and determined that the residual risk from flooding is **High** with sections of Highly Vulnerable development at the site and parts of the site being located within Flood Zone A and B as identified by the OPW CFRAM mapping along the Griffeen River.

It is therefore considered necessary to proceed and undertake a Stage 3 assessment for the site and proposed development.

6.0 STAGE 3: Detailed Flood Risk Assessment

This detailed flood risk assessment for the site at Grange Castle is based on a 2D HEC-RAS (version 5.0.7) hydraulic model.

The Stage 3 Detailed FRA undertaken in relation to the application site has involved the following elements:

- Design Flood Levels;
- Modelling Approach;
- Modelling Parameters;
- Sensitivity Analysis;
- Model Outcomes;
- Detailed Flood Risk;
- Stage 3 Findings.

6.1 Design Flood Levels

6.1.1 Design Flood Event

The purpose of the modelling is to delineate Flood Zone A and B across the site. Flood Zone A represents the area where the probability of flooding from rivers is greater than 1% AEP or 1-in-100 event and Flood Zone B represents the area where the probability of flooding from rivers is between 0.1% and 1% AEP or between the 1-in-1000 and 1-100 events.

In accordance with OPW recommendations for the Mid-Range Future Scenario (MRFS) for the assessment of climate impacts on flooding, a 20% increase in design flood flows has been made in the flood modelling undertaken here.

The 1:1000 AEP flood event plus Climate Change is used as the design flood event for the proposed development, as agreed with the project engineers.

6.1.2 Hydrology

The estimation of design flows and hydrographs has followed the OPW Flood Studies Update (FSU) methods and processes as set out in the FSU Web Portal (https://opw.hydronet.com/).

The Site is located immediately downstream of the junction of the Griffeen River and the Baldonnel Channel.

The catchment area of the Griffeen River is some 21.6 km^2 at this junction, and the catchment area of the Baldonnel is some 1.2 km^2. These catchments, and the location the principal gauging site used in flood flow estimation (9002 Lucan, at the downstream end of the Griffeen) are shown below on Figure 6-1 and Figure 6-2. It should be noted that the base mapping indicates the old routing of the Baldonnel Stream.

Figure 6-1
Griffeen River Catchment Area at the Grange Castle Site

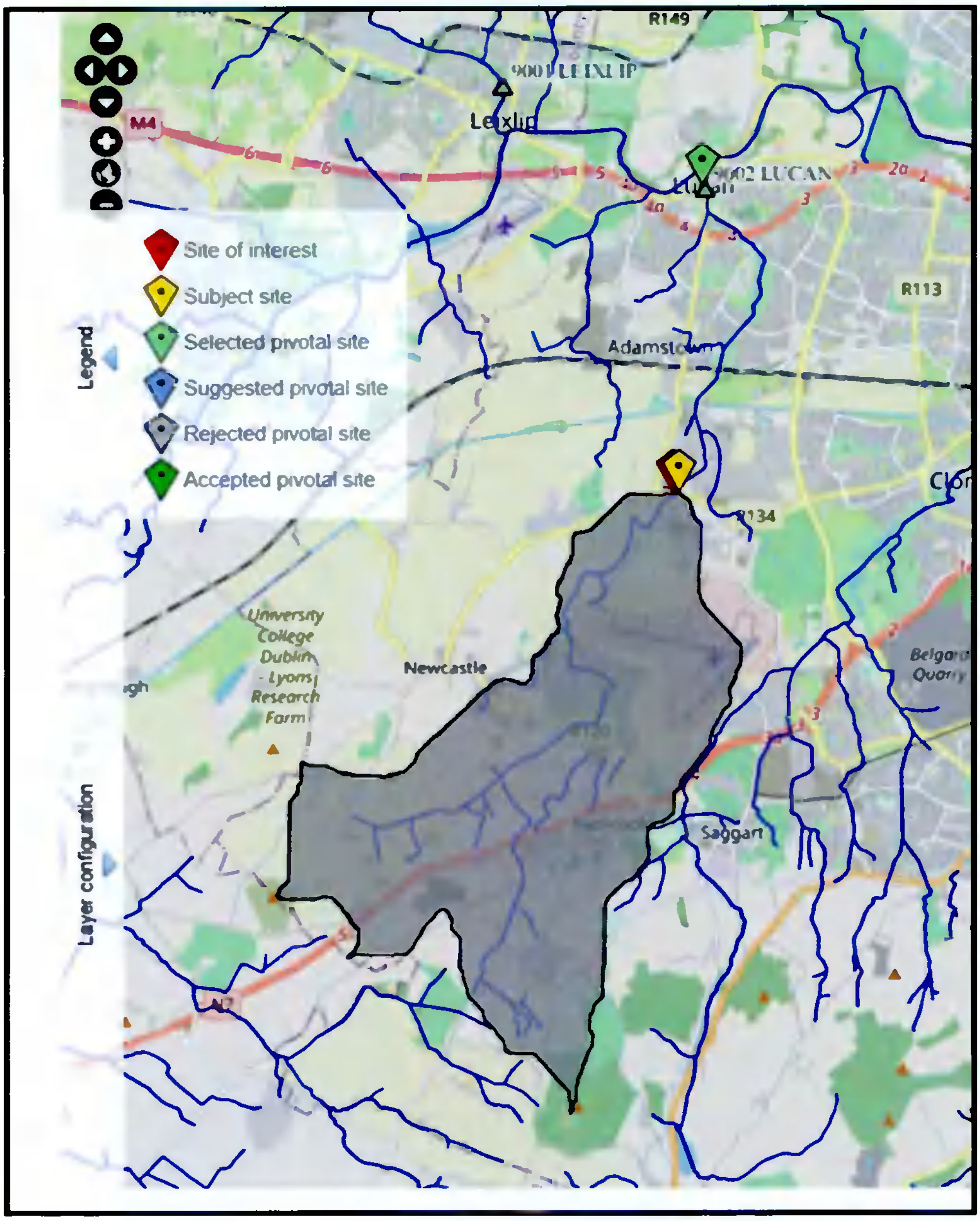

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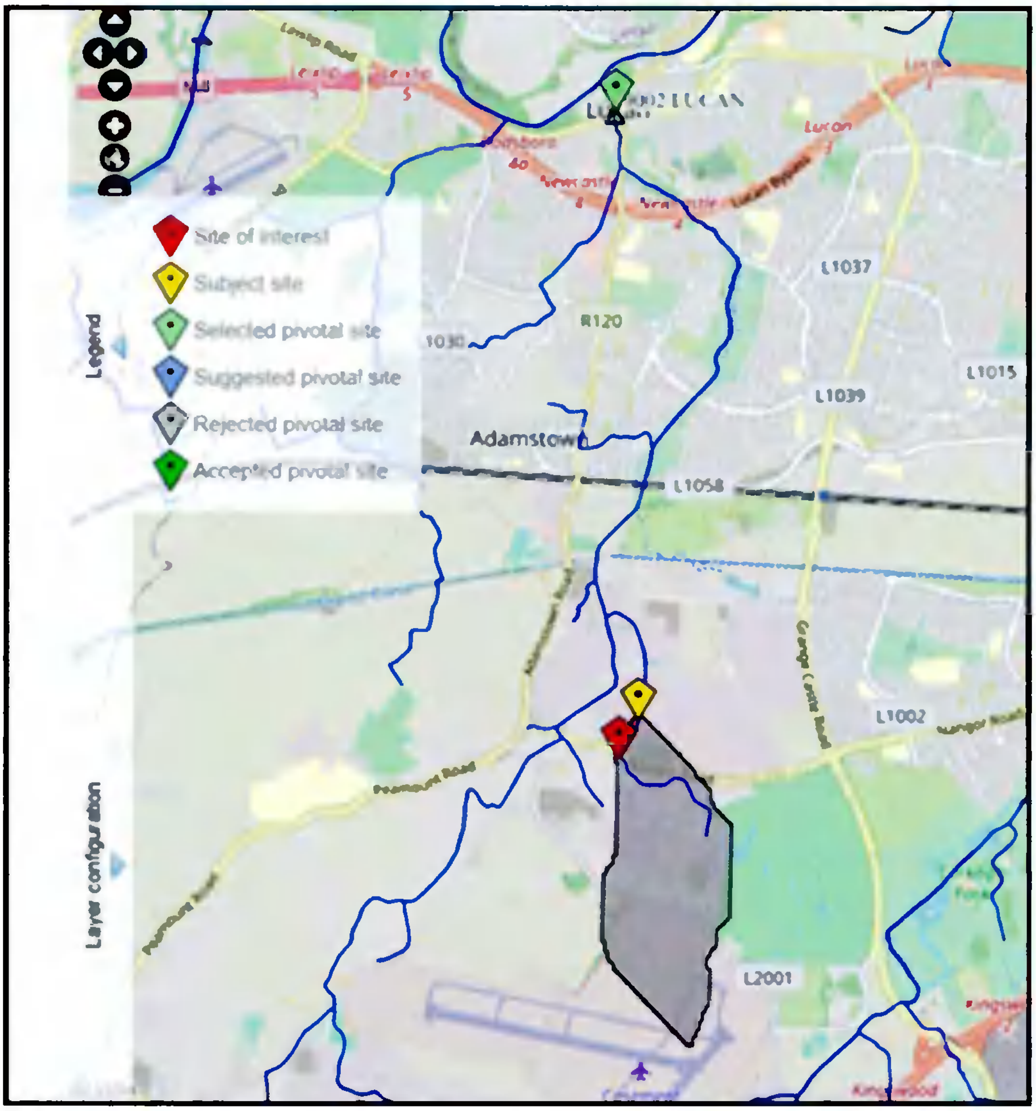
Figure 6-2
Baldonnel Stream Catchment (old alignment still used in FSU)



The principal flood estimation method set out in the FSU is a statistical method, using donor (pivotal) gauged sites and pooling groups of hydrologically similar catchments in order to estimate the peak flowrates of probabilistic events.

Since both of these catchments have catchment areas less than 25 km^2, the FSU methods indicate that alternative methods should also be employed to estimate flood flows. Such methods are typically based on regression equations linking flood flows to key catchment descriptors. In this present study, the “FSU4.2a” approach[2] was used in order to provide comparable peak event flowrates.

The FSU4.2a approach provides an alternative means of estimating the median flowrate or “QMED”, compared to the donor adjustment methods encompassed in the FSU Web Portal procedures.

The key details of the FSU4.2 method are provided in Appendix A.

[2] Office of Public Works, Flood Studies Update Programme – WP4.2 – Flood Estimation in Small and Urbanised Catchments, 30/01/2012

The outcomes of the different forms of analysis, in terms of peak flowrate for the 1% and 0.1% AEP events, are shown below in Table 6-1.

Table 6-1: Summary of Estimated Flowrates

Watercourse	QMED Estimation Method	Annual Exceedance Probability	Peak Flowrate (m^3/s)
Griffeen	Donor Adjustment	QMED	3.4
		1%	9.0
		0.1%	14.0
	FSU4.2a	QMED	4.7
		1%	12.3
		0.1%	19.2
Baldonnel	Donor Adjustment	QMED	0.28
		1%	0.9
		0.1%	1.7
	FSU4.2a	QMED	0.29
		1%	1.0
		0.1%	1.7

Analysis of the QMED (and hence the peak flow) derived from the two methods indicated that the FSU4.2a method resulted in higher values than the donor adjustment method. Given that the FSU4.2a approach is recommended for catchments of the size in this study, and that this approach results in higher peak flows than the donor adjustment method, the results derived from using the FSU4.2a approach were adopted. This therefore provides a conservative approach.

6.2 Modelling Approach

The key hydraulic controls have been noted above, and Figure 6-3 below provides further detail.

Figure 6-3
Key Hydraulic Features at the Area of Interest Site

Flood heights and extents in the area of interest are affected by the following elements:

- The flow that can be supplied into this area at Culvert G2 from the River Griffeen (supplemented by the inflow from the Baldonnel Stream via Culvert B1) either through the culvert itself, or by overtopping the R134;
- The risk that flows in the Baldonnel Stream may not be accommodated in the culvert B1, and may pond and overtop the R134 to the east of the road junction; and

- The downstream constraint to outflows from the study area afforded by the Culvert G3 and the watercourse downstream of that culvert.

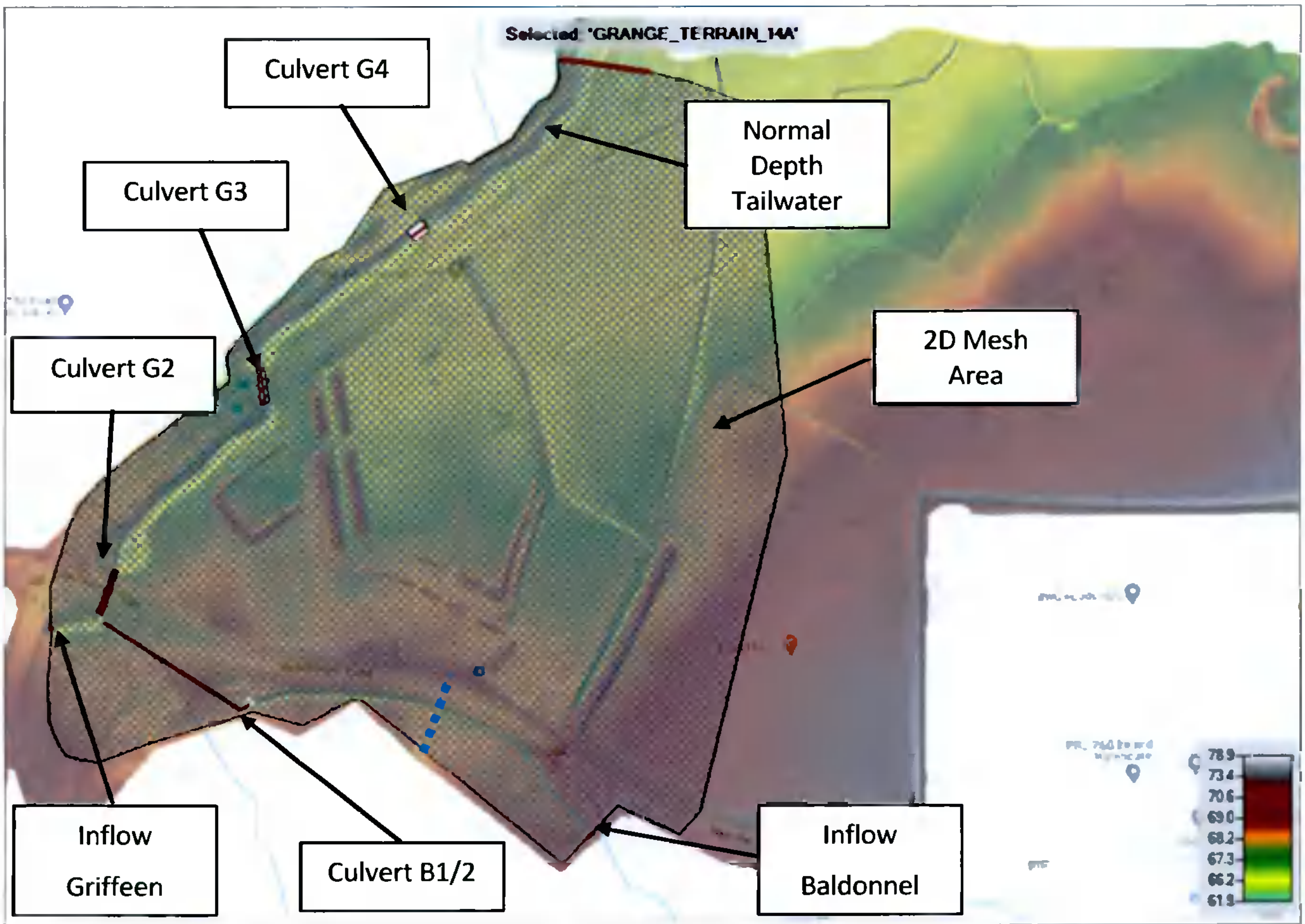
It was considered that although culvert G1 may also have an effect on flows in the Griffeen River, it was conservative and a simpler representation to assume flows in that watercourse arrived directly to the head of Culvert G2.

It was also noted that along a significant section of the reach of the Baldonnel Stream of interest, the watercourse was predominantly culverted, and there was only a small daylighted zone between Culverts B1 and B2. Given the proximity between this daylighted area and the open channel upstream of Culvert B1, it was decided to model both Culverts B1 and B2 as a single culvert element, i.e. Culvert B1.

Based on the above considerations, a two-dimensional (2D) modelling approach adopted, with two hydrograph inputs at the south end of the model, a single Normal Depth boundary condition downstream of Culvert G4, and three culvert elements in the model (B1/2 combined, G2, G3 and G4).

The adopted model configuration is shown in Figure 6-4 below.

Figure 6-4
Model Diagrammatic



The topography for the 2D area was developed from a ground-based survey provided by Hanley Pepper and augmented by further ground-based survey carried out by SLR in June and October 2020 which included the realigned Baldonnell Stream and Culverts. The details of the culverts on both the Griffeen and Baldonnel were based on the SLR 2020 survey.

The base ground model derived from the survey was adjusted in the following ways to reflect the true topography in the area of interest and facilitate the modelling:

- Manual adjustments were made to the invert of the Griffeen River channel downstream of the R134 road to more accurately reflect the true invert shape;
- A small low flow channel was created in the ground model at the outfall of the Baldonnel culvert to avoid instabilities that would otherwise occur due to super-critical flow conditions at low flows; and
- The bed of the streams was lowered locally at the entrances and exits of the culvert structures to comply with the modelling software requirements.

6.3 Modelling Parameters

The key modelling parameters adopted in the modelling were as follows:

- 2D mesh: 1.0m nominally square mesh across the whole area.
- Culvert sizing:
  - B1/2: 1.2m diameter, reflecting the dominant B2 culvert dimensions.
  - G2: 4.64m span by 2.4m rise – this was adjusted down from the surveyed span of 6m, to account for permanent blocking elements at one side of the culvert which provide dry passage for fauna.
  - G3: 6m span by 1.5 m rise – as surveyed.
  - G4: 16m span which is trapezoidal shape with 1.5m / 1.9m rise – as surveyed
- Tailwater characteristics: a Normal Depth relationship was adopted, reflecting the generally uniform flow conditions that would pertain downstream of Culvert G4, based on the surveyed stream and overbank slope of 0.001 (i.e. 1 in 1000).
- Inflow characteristics: initial runs adopted a full hydrograph, but for convenience later runs used a short ramp up to a plateau of constant (peak) flowrate. Comparison runs indicated no difference between the modelled flood levels of these two approaches. Again, as a conservative position, the peaks of the two streams were assumed to coincide.
- Surface roughness values:
  - A value of 0.07 was adopted as a uniform value across the 2D area. This was principally reflective of the overgrown nature of the watercourse between Culverts G2 and G3, and downstream of G3, and provided a conservative position in respect of any flows across overbank areas.
  - A value of 0.032 was adopted for the three culverts, reflecting reasonably good quality concrete surfaces.
- Timestep: Adopted 0.5s, to provide a Courant Number of generally less than 1.0.

6.4 Modelling Outcomes

A number of preliminary runs were carried out to understand the flow regime at the site and allow suitable provisions in the modelling. The final suite of runs (Suite 12) consisted of seven individual model runs, covering the following events:

Base Runs

- 1% (1:100) AEP;
- 1% (1:100) AEP, with 20% Climate Change allowance added to both inflows;
- 0.1% (1:1000) AEP; and
- 0.1% (1:1000) AEP, with 20% Climate Change allowance added to both inflows,

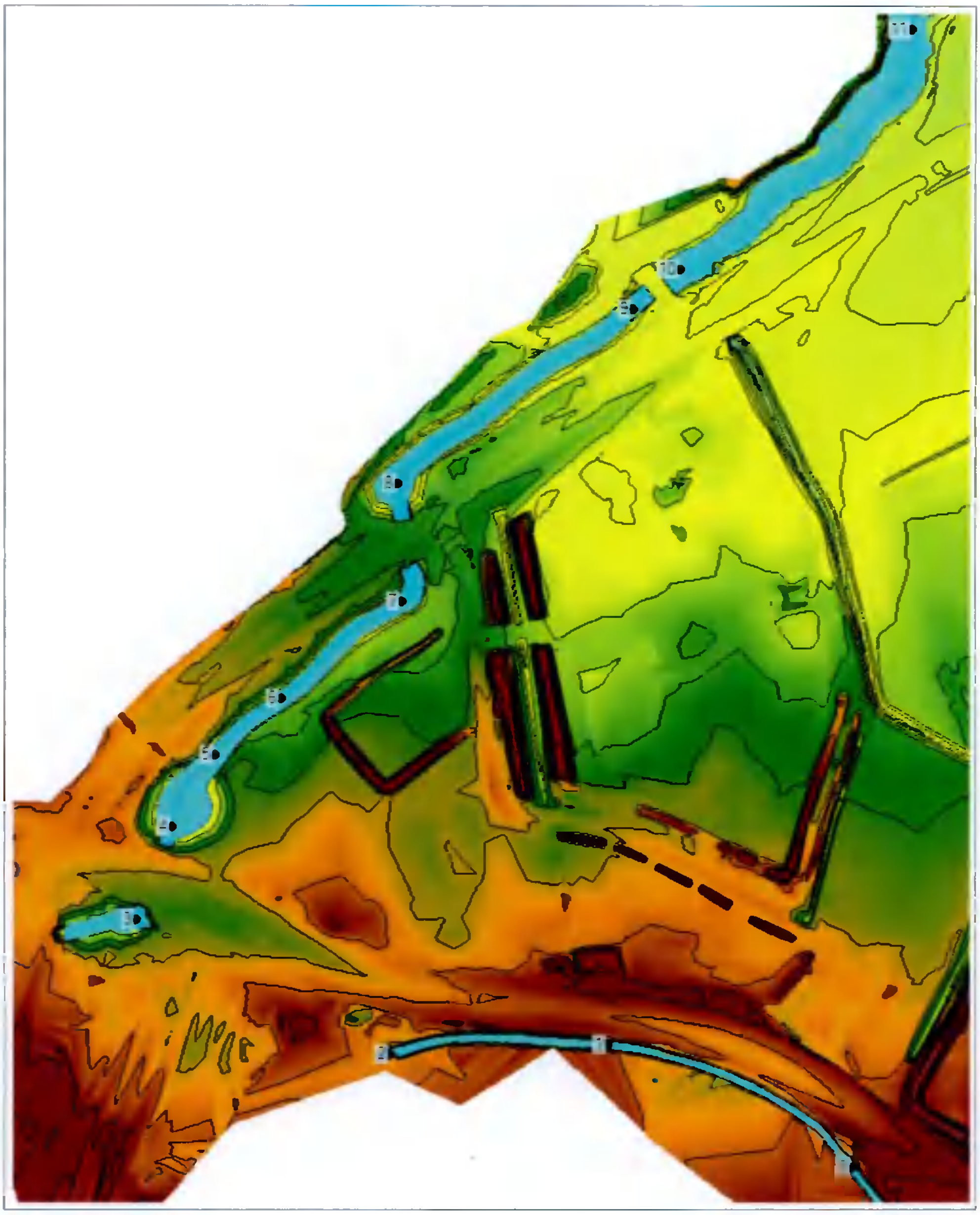
Sensitivity Test Runs (see further below)

- 1:1000 AEP event, using the full momentum equations for calculating water levels, rather than the diffusion wave equations (as used in the Base runs). The former set can be more accurate but increase run times. It is reasonably standard to use the diffusion equation set, but a check was made as to the difference it might make in resulting water levels.
- 1:1000 AEP event, with a degree of blockage applied to culverts, as follows:
    - Culvert B1/2 – reduced waterway area by 40%, to assess how much effect this might have in forcing flows over the R134 roadway;
    - Culvert G2 – no reduction applied to this culvert, since this would be likely to reduce water levels in the site, rather than increase them;
    - Culvert G3 – a degree of reduction in both the width and height of the culvert was applied to mimic blockage and accumulation of debris against the leading edges of the culvert inlet; and
    - Culvert G4 - a degree of reduction in both the width and height of the aperture under the bridge was applied to mimic blockage and accumulation of debris against the leading edges of the aperture inlet.
- 1:1000 AEP event, with approximately 20% increase in surface roughnesses.

Flooding Extents

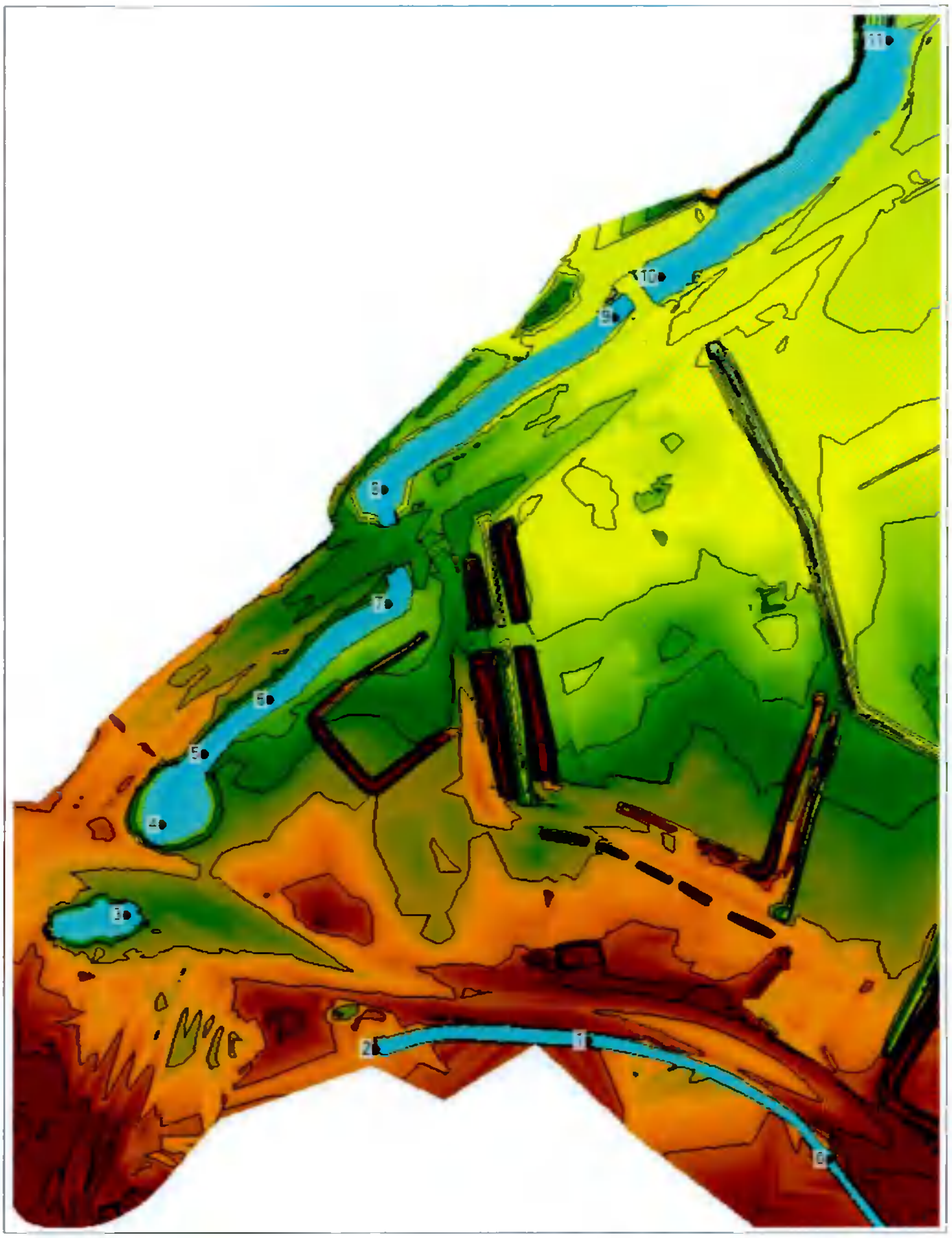
The extents of flooding that may occur in the key 1:100 AEP and 1:1000 AEP flood events are shown in the following Figure 6-5 and Figure 6-6.

Figure 6-5
Flood Extents - 1:100 AEP Event



The above flood map shows that in the 1:100 AEP event, the culverts and channels are able to accommodate the flows without breaking out overland.

Figure 6-6
Flood Extents - 1:1000 AEP Event



The above flood map shows that with the increased flowrates in the 1:1000 AEP event, the culverts and channels are still able to accommodate the flows without breaking out overland.

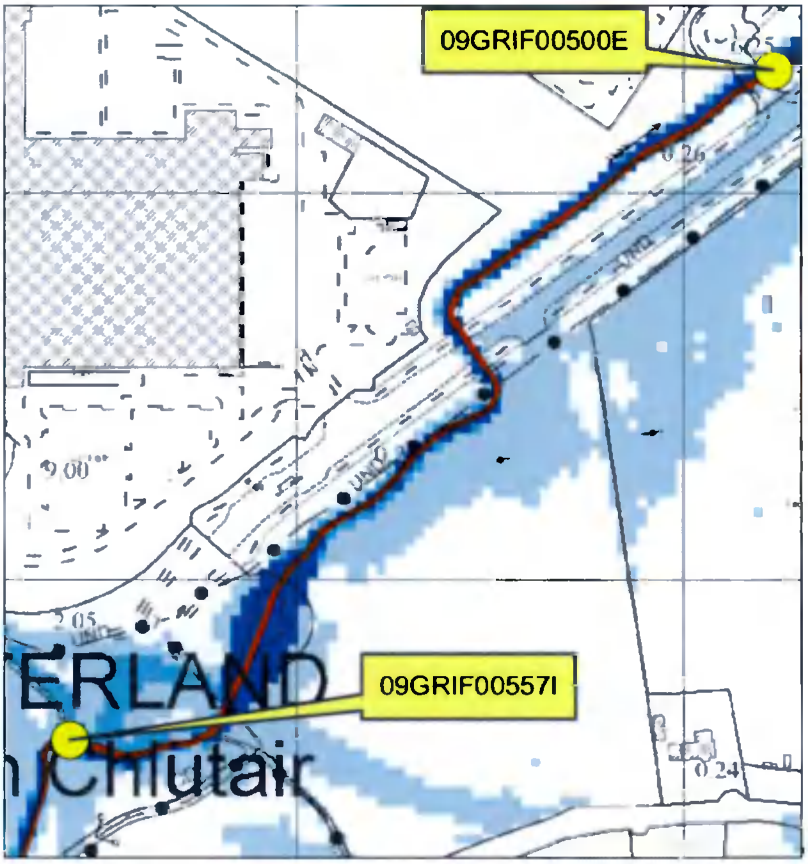
The flood extents shown above may be compared to the results of the CFRAM modelling carried out by OPW, see extract in Figure 6-7 below. Inspection of the peak flowrates used in the CFRAM and present study indicate that the flowrates are similar. The CFRAM flood extents for the 1:100 AEP event are similar to those provided by the present study. However, for the 1:1000 AEP event, the CFRAM extents appear to break out of the watercourse channel and spread laterally at and downstream of the subject site.

The reason for this difference is not completely clear, but it is noted that there have been modifications to roads, culverts and terrain since the CFRAM study was carried out, which will likely have a bearing on the distribution of flow along the river corridor.

It is also noted that the CFRAM reported flood levels just downstream of structure G4 (point 09GRIF0050E) were 64.33m AOD (1:100 AEP) and 65.03m AOD (1:1000 AEP), compared to the presently modelled levels (point 10) of 64.96m AOD (1:100 AEP) and 65.41m AOD (1:1000 AEP). Notwithstanding the apparent differences in spread of flood waters, the present study is reporting predicted flood levels some 400mm to 600mm higher than those of the CFRAM study, indicating a degree of conservatism in the present results compared to those reported as part of the CFRAM study.

The flood risk assessment undertaken here is a site-specific assessment for the site of the proposed development.

Figure 6-7
CFRAM Flood Mapping



Detailed Flood Modelling Results

The detailed results, in terms of flood levels, depths and velocities, are given at a range of locations across the study area, in Table 6-2 below. The particular points referenced in the table are shown on the Figures above.

Table 6-2
Suite 014 Modelling Outcomes

Point		0	1	2	3	4	5
Description		Baldonnel Stream Upstream End	Baldonnel Stream Midway	Baldonnel Stream upstream of Culvert B1/B2	Griffeen River upstream of R134	Griffeen River 10m downstream of culvert G2	Griffeen River 55m downstream of culvert G2 and pond
Ground Level		66.84	66.17	64.96	64.29	64.03	64.30
Run							
BASE MODEL RUNS							
1:100	Water Level	67.32	66.78	66.51	66.23	66.01	65.94
	Water Depth	0.48	0.61	1.55	1.94	1.98	1.64
	Maximum Velocity	0.50	0.40	0.20	1.50	1.00	1.50
1:100+20% CC	Water Level	67.39	66.97	66.88	66.49	66.26	66.19
	Water Depth	0.55	0.80	1.92	2.20	2.23	1.89
	Increment over 1:100	0.07	0.19	0.37	0.26	0.25	0.25
1:1000	Water Level	67.92	67.86	67.85	66.97	66.58	66.53
	Water Depth	1.08	1.69	2.89	2.68	2.55	2.23
	Increment over 1:100	0.60	1.08	1.34	0.74	0.57	0.59
	Maximum Velocity	0.70	0.90	0.30	1.50	1.00	1.50
1:1000+20% CC	Water Level	68.50	68.48	68.47	67.40	66.87	66.83
	Water Depth	1.66	2.31	3.51	3.11	2.84	2.53
	Increment over 1:1000	0.58	0.62	0.62	0.43	0.29	0.30
	Increment over 1:100 +CC	1.11	1.51	1.59	0.91	0.61	0.64
SENSITIVITY RUNS							
1:1000 Flatter Tailwater	Water Level	67.93	67.88	67.87	66.99	66.60	66.55
	Water Depth	1.09	1.71	2.91	2.70	2.57	2.25
	Increment over 1:1000	0.01	0.02	0.02	0.02	0.02	0.02
1:1000 Blockage	Water Level	68.63	68.62	68.62	67.22	66.84	66.81
	Water Depth	1.79	2.45	3.66	2.93	2.81	2.51
	Increment over 1:1000	0.71	0.76	0.77	0.25	0.26	0.28
1:1000 High Roughness	Water Level	68.40	68.38	68.37	67.23	66.79	66.74
	Water Depth	1.56	2.21	3.41	2.94	2.76	2.44
	Increment over 1:1000	0.48	0.52	0.52	0.26	0.21	0.21

Point		6	7	8	9	10	11
Description		Griffeen River midway between culverts G2 and G3	Griffeen River upstream of culvert G3	Griffeen River downstream of culvert G3	Griffeen River upstream of bridge / culvert G4	Griffeen River downstream of bridge / culvert G4	Griffeen River at downstream end of model
Ground Level		64.32	63.06	62.86	62.89	63.28	62.77
Run							
BASE MODEL RUNS							
1:100	Water Level	65.79	65.50	65.30	65.06	64.96	64.67
	Water Depth	1.47	2.44	2.44	2.17	1.68	1.90
	Maximum Velocity	1.70	1.30	0.70	0.85	0.90	1.00
1:100+20% CC	Water Level	66.07	65.85	65.58	65.39	65.31	65.01
	Water Depth	1.75	2.79	2.72	2.50	2.03	2.24
	Increment over 1:100	0.28	0.35	0.28	0.33	0.35	0.34
1:1000	Water Level	66.42	66.22	65.78	65.53	65.41	65.11
	Water Depth	2.10	3.16	2.92	2.64	2.13	2.34
	Increment over 1:100	0.63	0.72	0.48	0.47	0.45	0.44
	Maximum Velocity	1.70	1.30	0.80	2.30	1.00	1.10
1:1000+20% CC	Water Level	66.73	66.57	65.95	65.69	65.52	65.21
	Water Depth	2.41	3.51	3.09	2.80	2.24	2.44
	Increment over 1:1000	0.31	0.35	0.17	0.16	0.11	0.10
	Increment over 1:100 +CC	0.66	0.72	0.37	0.30	0.21	0.20
SENSITIVITY RUNS							
1:1000 Flatter Tailwater	Water Level	66.43	66.25	65.81	65.58	65.45	65.19
	Water Depth	2.11	3.19	2.95	2.69	2.17	2.42
	Increment over 1:1000	0.01	0.03	0.03	0.05	0.04	0.08
1:1000 Blockage	Water Level	66.73	66.63	65.77	65.51	65.31	65.01
	Water Depth	2.41	3.57	2.91	2.62	2.03	2.24
	Increment over 1:1000	0.31	0.41	-0.01	-0.02	-0.10	-0.10
1:1000 High Roughness	Water Level	66.62	66.42	65.93	65.64	65.52	65.21
	Water Depth	2.30	3.36	3.07	2.75	2.24	2.44
	Increment over 1:1000	0.20	0.20	0.15	0.11	0.11	0.10

The key points noted from these results are as follows:

- The 1:1000 AEP event results in flood levels some 590mm higher than the 1:100 event, in the reach between Culvert G2 and Culvert G3; and
- The flow along this same reach is between 1.3 to 1.7 m/s in the channel.

Design Flood Level

The proposed design flood level for the site has been discussed with the project engineers. Based on the Highly Vulnerable nature of parts of the proposed development the 1:1000 AEP flood event plus climate change has been selected as the design flood level for the buildings.

Therefore, the design flood level for the 1:1000 AEP flood event plus climate change is 66.83mOD at point number 5.

Sensitivity Analysis

We are not aware of any useful historical flood event data, such as surveyed flood marks, which would allow the model to be calibrated or verified. On that basis, a number of model runs were carried out (at the 1:1000 AEP level) to test the sensitivity of the modelled flood levels to key parameters adopted in the model. The key parameters tested, and the outcomes of the sensitivity runs, are noted below in Table 6-3.

Table 6-3
Sensitivity Analysis Outcomes

Parameter	Details	Outcomes
Surface roughness of 2D mesh area	Global increase of 20%	Some 100-200mm increase in flood levels over the reach G2 to G4.
Culvert blockage	See above – culverts B1/2, G3 and G4 partially blocked.	Some 300-400mm increase in flood level noted over this same reach.
Inflow	Increase of 20%	Approximately 150-300mm increase in this reach.
Calculation method	Use of full momentum equation set	Approximately 300mm of increase noted.

The effect of different calculation methods has been separately assessed but not reported in Table 6-2 above.

Overall, this analysis shows that the uncertainty range that should be accommodated within the development on this site is up to 400 mm.

Freeboard

The planning guidelines state that '*The minimum floor levels for new development should be set above the 1 in 100 river flood level (1 in 200 coastal flood level) including an allowance for climate change, with appropriate freeboard.*' However, the planning guidelines do not provide a recommendation for freeboard.

A freeboard should be applied to the adopted design flood level to arrive at suitable design floor levels for the highly vulnerable parts of the development.

Freeboard allows for both uncertainty in the hydrology and hydraulic modelling that is used to derive flood levels, and other physical processes not allowed for in the design flood estimation, such as minor wave or wind effects, super-elevation of water surfaces, and settlement of defence structures.

The uncertainty component of freeboard can be informed by the above consideration. Given the situation, the other (physical) effects noted above are not as relevant, and therefore an overall freeboard of at least 600 mm is recommended in this case.

6.5 Stage 3 Findings

The purpose of the detailed flood risk assessment is to assess the flood risk issues in sufficient detail and to provide a quantitative appraisal of potential flood risk to the proposed development, of its potential impact of flood risk elsewhere and the effectiveness of any proposed mitigation measures.

The flood modelling that has been carried out confirms that the flood extents at this site are contained within channel, with the flows in the Griffeen River and the Baldonnel Channel combining before flowing past the site to the north west.

The flood extents and flood levels given above should be used to inform the development of the site and the FFL of the highly vulnerable parts of the development.

7.0 CONCLUSIONS

A site-specific FRA Report has been prepared for the existing site at Grange Castle, the baseline scenario, to support the planning application for the site.

The results of the flood risk assessment undertaken here, and the outcome of the modelling indicates that:

- for both the 1:100 AEP and 1:1000 AEP flows in the Baldonnell Stream and Griffeen River in the vicinity of and at the site, are contained within the existing river channel and culverts / bridge;
- The extent of Flood Zones A and B have been identified at the site; and
- The Highly Vulnerable parts of the proposed development are located in Flood Zone C at the site.

Due to the Highly Vulnerable nature of the proposed development the design flood level has been identified as the 1:1000 AEP flood level +20% increase for Climate Change under the Mid-Range Future Scenario for Climate Change in Ireland:

- The 1:1000 AEP event plus climate change design flood level is identified at 66.83 mOD; and
- A freeboard of at least 600 mm should be applied to the design flood level for the Highly Vulnerable parts of the development at the site.

The proposed building finished Floor Levels for Highly Vulnerable parts of the development will be set at a level of at least 67.43 mOD (66.83 mOD plus 600 mm allowance for freeboard above the design flood level).

8.0 CLOSURE

This report has been prepared by SLR Consulting (Ireland) with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

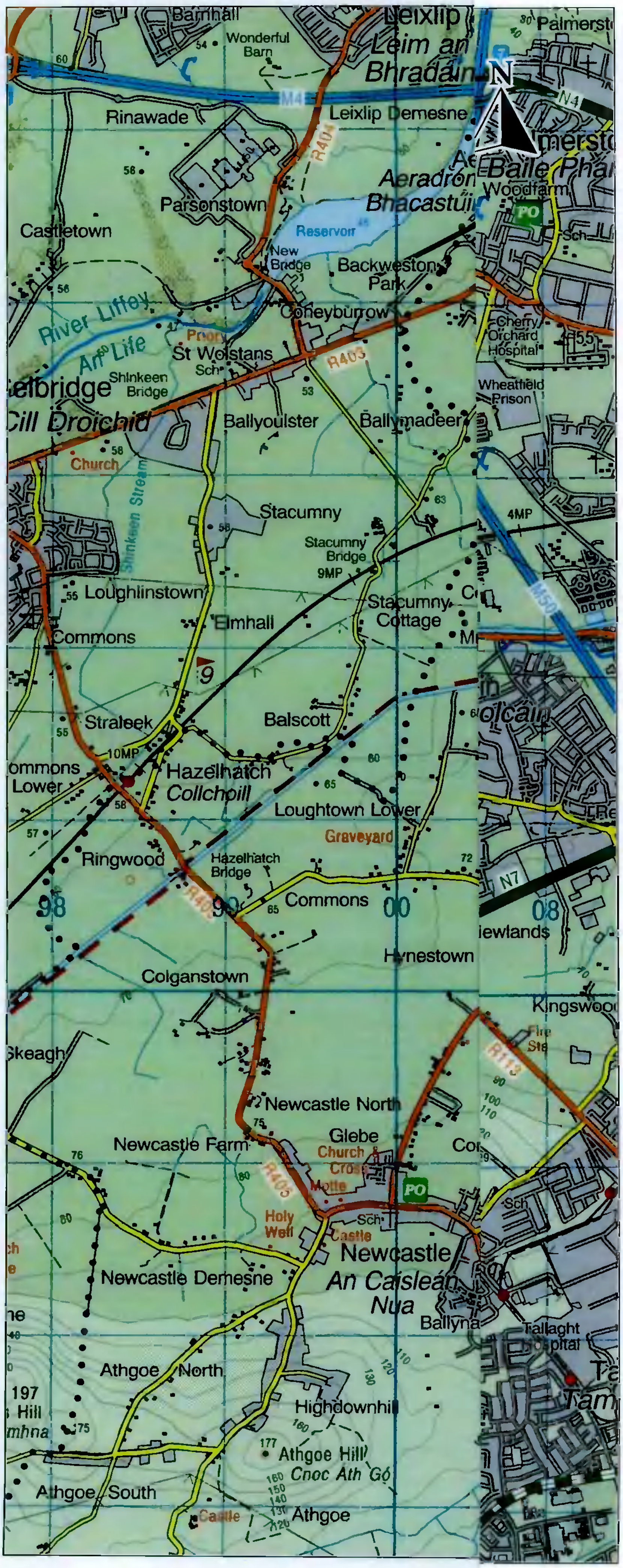
This report is for the exclusive use of Hanley Pepper Consulting Engineers; no warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

FIGURES

Figure FRA-1
Site Location, Surface Water Courses and Catchments

Figure FRA-2
Proposed Site Layout and Modelled Flood Outlines



NOTES

1. EXTRACT FROM ORDNANCE SURVEY DISCOVERY SERIES SHEET 50

2. ORDNANCE SURVEY OF IRELAND LICENCE NO. SU0000720(C) ORDNANCE SURVEY & GOVERNMENT OF IRELAND.

LEGEND

SITE LOCATION AT GRANGE CASTLE

SLR

SLR CONSULTING IRELAND
7 DUNDRUM BUSINESS PARK
WINDY ARBOUR DUBLIN 1
T: +00353-1-2964667
www.slrconsulting.com

Hanley Pepper

GRANGE CASTLE

FLOOD RISK ASSESSMENT - SITE LOCATION

FIGURE 1

1:25,000 @ A3	OCTOBER 2020

APPENDICES

Appendix A
OPW Flood Studies Update Flood Estimation for Baldonnell Stream and Griffeen River

Flood Estimation Report #10900 (Grifeen)

Generated 25-06-2020 15:39

Subject site

Attributes

Name	Unit	Value
Coordinate [X]		-718608.327113241
Coordinate [Y]		7042496.70095063
Distance	km	104.059822684576
Station Number		09_1079_5
Location		
Water Body		
Catchment		
Hydrometric Area		
Organisation		
FSU Rating Classification		
Drainage works	year	
Contributing Catchment Area	km^2	21.613
Center Northing	m	227010
Center Easting	m	300810
Northing	m	231108
Easting	m	302982
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		0.0139
PEAT		0
FOREST		0.0093
PASTURE		0.8833
S1085	m/km	11.89272
MSL	km	10.437
DRAIND	km/km^2	0.907
ALTBAR		130.7
NETLEN	km	19.608
T4		
T3		

SAAPE	mm	526.22
T2		
ARTDRAIN2		0
ARTDRAIN		0
TAYSLO		8.536798
STMFRQ		29
BFISOIL		0.635237006
SAAR	mm	770.94
RWSEG_CD		09_1079
TOP_RWSEG		
Bankfull		
HGF	m^3/s	
MAF	m^3/s	
FAI		0.4321
FLATWET		0.55
URBEXT		0.1086
HGF/QMED		
centroidx3857		-721738.117321235
centroidy3857		7035957.35061295
x3857		-718608.327113241
y3857		7042496.70095063

Pivotal site

Attributes

Name	Unit	Value
Coordinate [X]		-718053.188899404
Coordinate [Y]		7049234.50016555
Station Number		09002
Location		LUCAN
Water Body		GRIFFEEN
Catchment		Liffey
Hydrometric Area		9
Organisation		EPA
FSU Rating Classification		A1
Drainage works	year	0
Contributing Catchment Area	km^2	34.954
Center Northing	m	229020
Center Easting	m	301850
Northing	m	235137
Easting	m	303227
A-Max series gap in years	year	0
A-Max series number of years	year	28
A-Max series number of usable years	year	25
A-Max series end year	year	2004
A-Max series start year	year	1977
FARL		1
ALLUV		0.0089
PEAT		0
FOREST		0.0075
PASTURE		0
S1085	m/km	8.92668
MSL	km	15.421
DRAIND	km/km^2	0.884
ALTBAR		0
NETLEN	km	30.905
T4		0.26129552795492
T3		0.40230529852553
SAAPE	mm	531.77
T2		0.41488702315884
ARTDRAIN2		0
ARTDRAIN		0
TAYSLO		8.316482
STMFRQ		41
BFISOIL		0.674
SAAR	mm	754.75
RWSEG_CD		09_242
TOP_RWSEG		09_658
Bankfull		N/A
HGF	m^3/s	11.9
MAF	m^3/s	7.2
FAI		0.39
FLATWET		0.55
URBEXT		0.2097
HGF/QMED		2.2666666666667
x3857		-718053.188899404
y3857		7049234.50016555

centroidx3857		-720010.202893886
centroidy3857		7039277.07668444
Distance	km	3.74249508455775

Map