Jamestown Masterplan Stormwater Management Strategy

Final Report

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www.jbaconsulting.ie

Dublin City Council

Civic Offices,

Wood Quay,

Dublin 8

Co. Dublin

JBA Project Manager

Ross Bryant
Unit 24 Grove Island
Corbally,
Limerick,
Ireland

Revision history

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This report describes work commissioned by Dublin City Council.

Prepared by .... Paul Browne BEng (Hons) MIEI

Engineer

Reviewed by .... Michael O'Donoghue BEng CEng MIEI

Associate Director

Purpose

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Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
CFRAM	Catchment Flood Risk Assessment and Management
DCC	Dublin City Council
DCDP	Dublin County Development Plan
DTM	Digital Terrain Model
EPA	Environmental Protection Agency
FEH	Flood Estimation Handbook
FFL	Finished Floor Level
FRA	Flood Risk Assessment
FRMP	Flood Risk Management Plan
FRR	Flood Risk Review
FSU	Flood Studies Update
GIS	Geographical Information System
HEFS	High End Future Scenario
HPW	High Priority Watercourse
JFLOW	2-D hydraulic modelling package developed by JBA
JT	Justification Test
LA	Local Authority
MPW	Medium Priority Watercourse
MRFS	Medium Range Future Scenario
OPW	Office of Public Works
OSi	Ordnance Survey Ireland
PFRA	Preliminary Flood Risk Assessment
RSES	Regional Spatial and Economic Strategy
RMS	Rainwater Management Strategy
SEA	Strategic Environmental Assessment
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems

JBA consulting

1 Introduction

1.1 Terms of Reference

JBA Consulting was appointed by Dublin City Council to prepare the Stormwater (Rainwater) Management Strategy for the Jamestown Lands Masterplan. Hereafter, this will be referred to as an RMS.

1.2 Background

In June 2021, DCC re-zoned 43Ha of industrial lands between Jamestown Road and St. Margarets Road/McKee Avenue, Finglas from Land Use Zoning Objective Z6 to Land Use Zoning Objective Z14 and designated the lands a Strategic Development and Regeneration Area (SDRA). The objective that underpinned this decision was "to seek the social, economic and physical development and/or rejuvenation of an area with mixed-use, of which residential and Z6 would be the predominant uses". These lands are hereafter defined as the Jamestown Lands. These lands have subsequently been designated as part of an extended SDRA in the Dublin City Development Plan 2022-2028 The extent of the lands is identified in Figure 1-1.

Figure 1-1 Jamestown SDRA Lands (Source: DCC)

1.3 Aims & Objectives

The purpose of the Rainwater Management Strategy (RMS) is to develop a strategy for incorporating nature-based solutions into the control of surface water run-off. The Plan is to be in accordance with and founded on the principles of "*Nature-base Solutions to the Management of Rainwater and Surface Water Run-off in Urban Areas: Water Sensitive Urban Design Best Practice Interim Guidance Document*." This document promotes the approach of assessing urban area drainage on the following three key pillars:

- Environmental: The management of water quality in accordance with the EU Water Framework Directive (2000/60/EC)
- Climate Change: Incorporating projected increased intensity in rainfall events, and introducing both climate resilience and climate adaptability into the Urban Drainage design
- Flood Risk: The urgent need to address the issue of ever-increasing impermeable urban areas and the associated increase in surface water runoff that it generates.

This report will thus develop and RMS that fully integrates with the green infrastructure strategy of the whole developable lands, and not be a standalone hydraulic engineering solution. The RMS will promote sustainable habitat, improve water quality, provide social amenity as well as reducing the pass-forward flows to downstream watercourses.

1.4 Report Structure

The report follows three stages:

- An appraisal of the existing stormwater network and the draft Masterplan layout.
- Definition of SuDS design philosophy for the study area
- Development of Green Infrastructure elements
- Definition of RMS guidance notes for prospective users

All JBA drawings that are included in the report are found within Appendix A. Extended hydraulic calculations are presented in Appendix B.

1.5 Technical Principles

1.5.1 Return Periods

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

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

Table 1-1 Return Periods & Annual Exceedance Probabilities

Return Period (Years)	Annual Exceedance Probability (%)
2	50
10	10
30	3.3
50	2
100	1
200	0.5

1.5.2 Climate Change

The Planning Guidelines (originally published in 2009) recommend that a precautionary approach to climate change is adopted due to the level of uncertainty involved in the potential effects.

OPW climate change guidance is documented in the "Flood Risk Management Climate Change Sectoral Adaptation Plan", and recommends two climate change scenarios for consideration. These are the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). The MRFS is intended to represent a "likely" future scenario based on the wide range of future predictions available. The HEFS represents a more "extreme" future scenario at the upper boundaries of future projections. Based on these two scenarios the OPW recommended allowances for climate change are given in Table 1-2.

Table 1-2 Future Condition Adjustments

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

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

DCC produced the "Sustainable Drainage Design & Evaluation Guide" in 2021. This states that "SuDS design must demonstrate site containment or surface runoff for design rainfall intensities with additional 20% uplift for climate change." It also notes that this climate change allowance should be considered for both attenuation storage and conveyance calculations. This % uplift on rainfall aligns with the MRFS stated by the OPW. This is the % uplift that has been applied for the proposed GI within this study area. This is key overarching document with respect to all Sustainable Drainage Design for all DCC lands. The Jamestown RMS isn't intended to replace or supersede this but is intended to provide additional specifics where required on how this existing guidance is to be applied to the Jamestown Lands.

1.6 Legislative Requirements

1.6.1 Water Framework Directive (WFD) (2000/60/EC)

This is a European Parliament Directive and of the Council establishing a framework for Community action in the field of water policy. This directive is concerned with the protection of the aquatic ecosystem by preventing any further deterioration in status of waters, groundwater and water dependent ecosystems and where necessary the restoration of the water body, to achieve a 'good' condition. The status is based on both the ecological status as well as the natural chemical and physical characteristics. In addition to qualitive targets, the Directive also promotes the sustainable use of water resources and most notably, the elimination of the discharge of specific hazardous substances.

The legislation places onus upon stakeholders, including both the polluters and regulators, to ensure all appropriate measures are taken to protect the environment from risk.

This RMS aims to bring the WFD to the forefront of the urban drainage strategy.

1.6.2 EU Floods Directive

The founding principles for flood management throughout Ireland are based on the EU Floods Directive. The Office of Public Works are the national authority for the EU Floods Directive in Ireland. DCC have incorporated the objectives of the Catchment Flood Risk Assessment and Management Programme into its own development plan policies. These are defined under SI13 through to SI21. With respect to the stormwater drainage in Jamestown, SI21 is the most relevant policy.

SI21: *To minimise flood risk arising from pluvial (surface water) flooding in the City by promoting the use of natural or nature-based flood risk management measures as a priority, by requiring the use of sustainable drainage systems (SuDS) to minimise and limit the extent of hard surfacing and paving, and requiring the use of sustainable drainage techniques, where appropriate, for new development or for extensions to existing developments, in order to reduce the potential impact of existing and predicted flooding risk and to deliver wider environmental and biodiversity benefits, and climate adaption.*

1.6.3 The Planning & Development Act 2000

This gives local government power of sanction regarding acceptance, or otherwise, of developer proposals. This is generally enacted through defined objectives in the local authority's County/City Development Plan.

The Dublin City Development Plan 2022-2028 contains overarching Green Infrastructure principles, as well as objectives specific to Jamestown.

General SuDS policies are identified within SI22 through to SI26. These are to applied to all developments in Jamestown.

From these policies, SI22 sets out the approach to all Sustainable Drainage Systems.

SI22: *To require the use of Sustainable Drainage Systems (SuDS) in all new developments, where appropriate, as set out in the Greater Dublin Strategic Drainage Study (Vol 2: New Development)/ Greater Dublin Regional Code of Practice for Drainage Works and having regard to the guidance set out in Nature-based Solutions to the Management of Rainwater and Surface Water Runoff in Urban Areas, Water Sensitive Urban Design Best Practice Interim Guidance Document (DHLGH, 2021). Sustainable Drainage Systems (SuDS) should incorporate nature-based solutions and be designed in accordance with the Dublin City Council Sustainable Drainage Design & Evaluation Guide (2021) which is summarised in Appendix 12. SuDS should protect and enhance water quality through treatment at source while enhancing biodiversity and amenity.*

SI23 sets out the requirements for green/blue roofs. This requires all new developments with roof areas in excess of 100 sq. metres to provide for a green blue roof designed in accordance with DCC's own Green Blue Roof Guide (2021). This will be of particular importance to Jamestown where blue roof attenuation will need play a significant role.

SI25 is relevant to this exercise, stating the requirement to produce this SWMP.

SI25: *To require the preparation of a Surface Water Management Plan as part of all new developments in accordance with the requirements of Appendix 13 – the Council's Surface Water Management Guidance.*

These are complemented by Green Infrastructure policies GI1-8. The two key policies are:

GI2: *To develop an interconnected green infrastructure network of strategic natural and semi-natural areas with other environmental features including green spaces, rivers, canals, the coastal and marine area, and other physical features including streets and civic spaces that supports ecological, wildlife, and social connectivity.*

GI5: *To integrate urban greening features including nature-based solutions into the existing public realm where feasible and into the design of public realm projects for civic spaces and streets.*

This imposes a requirement to create multi-purpose green space, utilising nature-based drainage solutions as part of a green network.

This will be the intention for Jamestown, where the inter-connected green infrastructure currently presented in the draft Masterplan will also serve the purpose as stormwater corridors where possible. These corridors will be considered based on the DCC Sustainable Drainage Design & Evaluation Guide.

Note, individual site will be required to attenuate their own run-off to the requirements set out in the existing DCC guidelines. The public spaces and green corridors will attenuate their own run-off, and be used for conveyance through the development.

A key requirement for attenuation identified under SDRA 3 is:

- Future Developments on the subject lands shall allow for the control of outflow to the River Tolka, with surface water discharges limited to 0-2l/s/ha for the 1 in 100 year storm event, including an additional 20-30% to allow for climate change.

This broadly aligns with the GDSDS Requirement for River Flood Protection (Criterion 4), which states Maximum discharge rate of QBAR or *2l/s/ha, whichever is the greater, for all attenuation storage where separate "long term" storage cannot be provided.*

In order to align with the GI policies stated earlier, some attenuation will need to be considered as part of the integrated green infrastructure to attenuate flows from public realm surfaces. Individually developed sites will attenuate their own flows with their individual footprints.

2 Existing Infrastructure

2.1 Existing Stormwater Network

Dublin City Council provided the local stormwater network in GIS format to JBA Consulting. A review shows the network is largely incomplete through the Jamestown Lands. Refer to Figure 2-1. Key features such as the route of the Finglas Stream culvert through the Jamestown Lands are missing from the network. These network elements are under private control and have not been taken in charge by Dublin City Council.

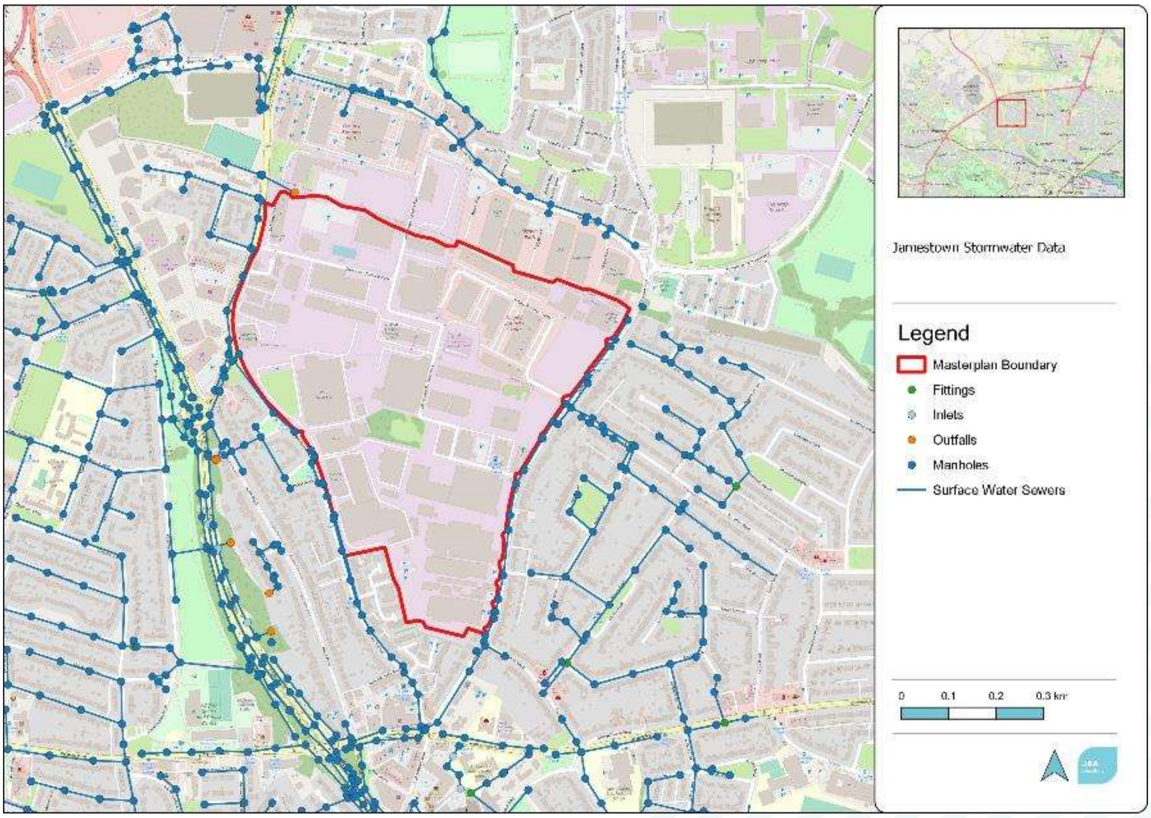


Figure 2-1 DCC Surface Water Network (Source: DCC)

However, the GDSDS Infoworks model files were provided to JBA Consulting. A review shows the Finglas Stream culvert has been captured through the Jamestown Lands. Refer to Figure 2-2.

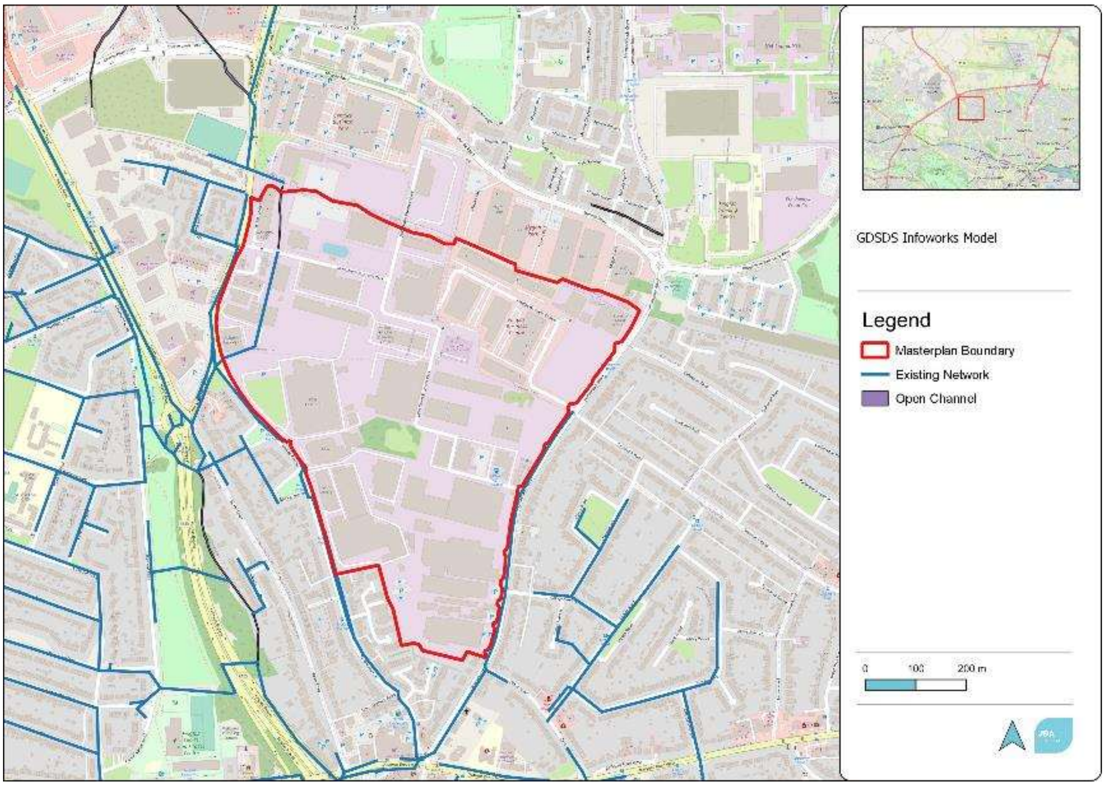


Figure 2-2 GDSDS Infoworks Model of Finglas Stream (Source: DCC)

2.2 Fluvial Data

2.2.1 Finglas Stream

The main watercourse traversing the Jamestown Lands is the Finglas Stream. The Greater Dublin Strategic Drainage Strategy (GDSDS) studies identified that the Finglas Stream originates north of the M50 as a series of undefined channels. The stream is culverted under the M50 and through the Charlestown Shopping Centre. Flowing in a general north-south direction, the Finglas Stream enters the Jamestown Lands via a c.700mmX1230mm culvert along the northern boundary before discharging to an open channel behind a series of warehouses. This open channel at present is severely overgrown and silted, with visible fly-tipping. The channel dimensions are c.3m wide by c.1m depth to bed level. The Finglas Stream gets re-culverted c.120m to the south as it passes under the Jamestown entrance road beside Van Signs Ltd. This culvert is 1200mmØ circular and runs for c.260m, emerging from the Jamestown Lands at the roundabout on St. Margaret's Road and McKee Avenue. The culvert goes through a series of transitions between circular and rectangular shapes before discharging to open channel beside the R135 / Finglas Bypass. The Finglas Stream goes through transitions between open channels and culverts before discharging to the River Tolka via bifurcation. The catchment area at the Finglas Stream outfall is approx. 1,080ha (10km^2). Refer to Figure 2-3 for an overview of the Finglas Stream.

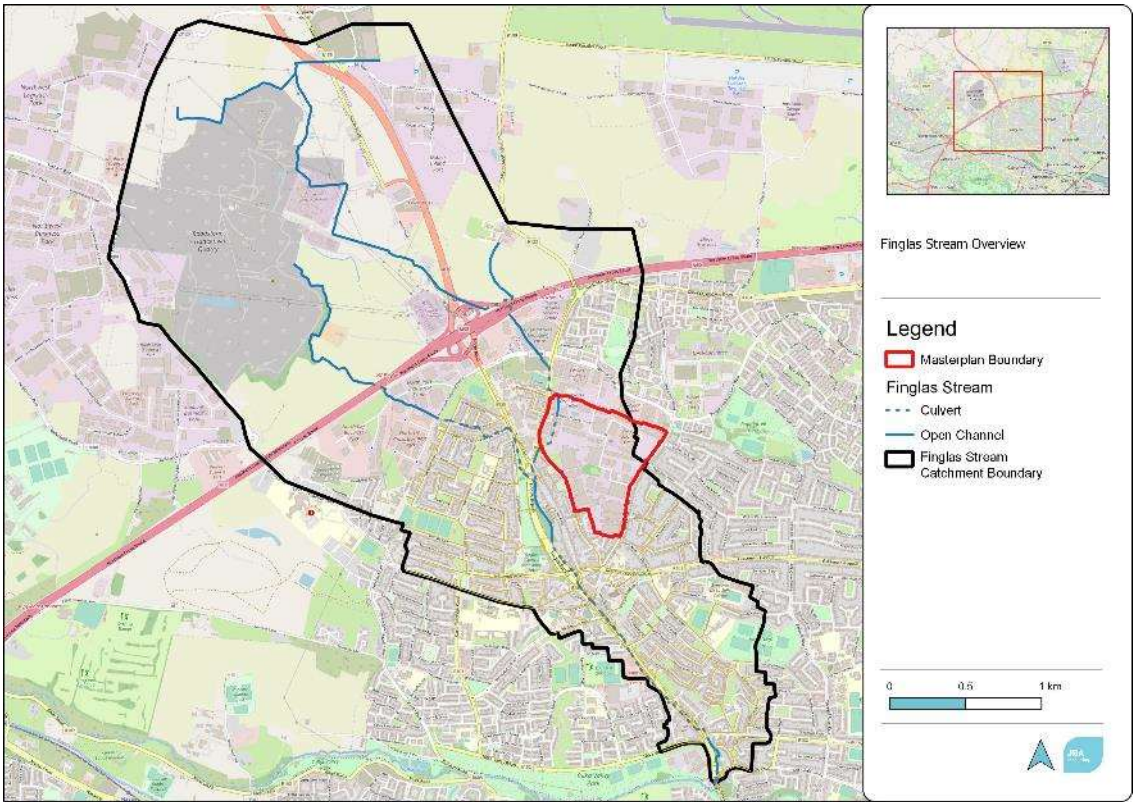


Figure 2-3 Finglas Stream Overview (Source: GDSDS)

2.2.2 Eastern Drainage Connection

Following a site walkover carried out on 25 January 2023, it was identified that there is an additional culvert traversing the Jamestown Lands falling in a general east-west direction (hereafter known as the Eastern drainage connection) and linking into the Finglas culvert to the south of the Manhattan Peanuts factory.

The culvert is not presently mapped, but initial investigations (from DCC) confirm 400mm diameter within the Manhattan Peanuts Site. It is presumed that the culvert drains the Jamestown Lands to the east of the site.

During the site walkover, an open drain was identified along the east boundary of the Jamestown Lands with Jamestown Road. The drain was overgrown, has been partially infilled but seemed to have a small diameter pipe (circa 400mm diameter) inserted.

A review of historic mapping identified the drain falling along plot boundaries towards the Finglas Stream, therefore, it is presumed the drain is positively drained to the Finglas Stream via the unmapped culvert and drains the eastern section of the Jamestown Lands. Much of the drain has been filled in, and therefore the watercourse is presumably culverted. Refer to Figure 2-4 for an overview of the watercourses through the Jamestown Lands.

It has been deduced that this drain is a stormwater infrastructure element, and not an existing watercourse. Therefore, it does not immediately inherit the same protections afforded to a recognised existing watercourse. There is, however, the intention to de-culvert this infrastructure and create an east-west watercourse that will convey flows to the Finglas Stream, forming part of the Green Infrastructure.

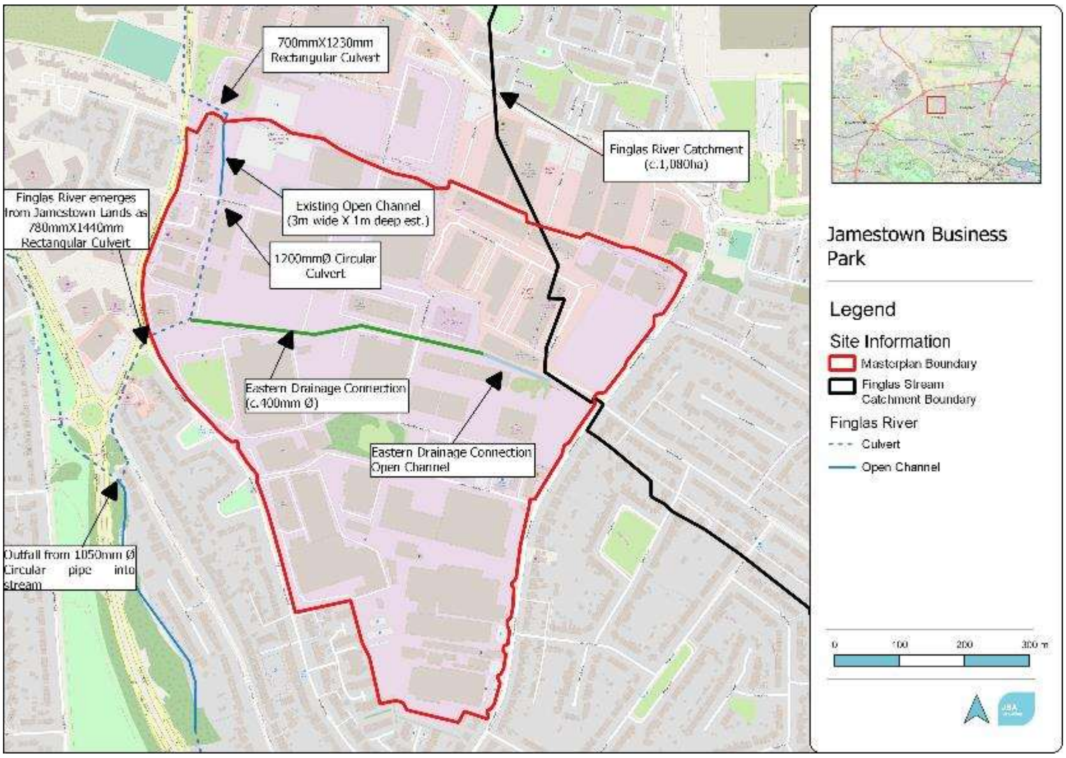


Figure 2-4 Watercourses through Jamestown Lands (Source: GDSDS and Site Walkover)

Figure 2-5 shows the open channel along the Finglas Stream south of the ESB Archives. Figure 2-6 shows the open channel section along the Eastern drainage connection.

Figure 2-5 Finglas Stream Open Channel Section (Facing East)

Figure 2-6 Eastern Drainage Connection Open Channel Section (Facing West)

2.2.3 Historic Flooding

Finglas is only mentioned in the pluvial flood events of 2008 and 2009. Table 2-1 provides details of recent flood events that have impacted on Dublin City, arising from a range of sources but primarily fluvial, pluvial and coastal. Finglas is only mentioned in the pluvial flood events of 2008 and 2009.

Table 2-1 Summary of Recent Flood Events in Dublin [1]

Date	Source of Flooding	Areas impacted
3 January 2014	Coastal: Highest tide ever 3.014m Malin	Four buildings flooded. Some coastal road flooding, Clontarf, Sandymount Promenade flooding, East Link closed, All temporary flood defences put in place.
October 2011	Fluvial, Pluvial & Coastal: Extreme rainfall combined with heavy rainfall previous day, leading to soil saturation. Dublin Airport recorded 9 hour rainfall of 66.8 mm, with Casement Airport recording a daily total of 82.2 mm.	Severe flooding in many parts of Dublin city and east coast, with many homes and businesses under water. Over 1,250 reports of property flooding in Dublin City.

1 Source: Met Éireann Major Weather Events.

Date	Source of Flooding	Areas impacted
2nd July 2009 (Midnight to 9am)	Pluvial: Spells of heavy, thundery rain affected the east and northeast of the country. 38.2mm of rainfall was recorded at Dublin Airport.	Several areas within the Dublin City Council boundary were affected. One of the worst affected areas was Donnycarney in North Dublin, where the surface water collection system draining to the Wad River culvert was overwhelmed at the Malahide Road, resulting in flooding at Collins' Avenue and Clanmoyle Road. Reports also of spot flooding at Raheny, Clontarf, Drumcondra, Finglas Sandymount, Cabra, and Glendhu Park in Ashtown.
9 August 2008	Pluvial: Dublin Airport recorded 36 mm of rainfall in the worst hour, 43 mm in two hours and over 76 mm in five hours. Records from the south city only indicate 40% of this precipitation.	Within two hours of commencement of precipitation numerous calls were placed with Dublin Fire Brigade, the Dublin Traffic Control Centre and the City Council's Drainage Division. 19 areas of North Dublin had severe flooding, many of these areas had no previous known history of such flooding. Over 150 residential properties were inundated, as well as commercial premises, public buildings, major roadways etc. Areas of Cabra, Finglas and Glendhu Park in Ashtown were badly flooded.
1 February 2002	Coastal: Rain led to high groundwater levels which was coupled with the highest tide ever recorded. This caused sea defences to be overtopped.	Over 1,100 buildings recorded as flooded. Cost estimate of reported flood insurance damages - €60M.
13 November 2000	Fluvial: Heavy rainfall in November, preceded by a very wet October, led to the ground being well saturated and unable to absorb the rain that fell over a 30 hour period on the 12 and 13 November 2000.	Significant disruption and damage, especially in the area of the Lower Tolka catchment.
25 August 1986	Fluvial: Hurricane Charlie – The heaviest rain fell on the mountains south of Dublin. At Kippure an estimated 280 mm fell, about double the normal	Extensive storm and flood damage across the city, coupled with extreme tides giving coastal flooding.

Date	Source of Flooding	Areas impacted
	rainfall in that area for the whole month of August. Record for the greatest fall of rain in a day, measuring 200mm, established at Kilcoole, south of Greystones.	
9–11 June 1963	Pluvial: Thunderstorms were widespread. Highest hourly rainfall ever recorded in Ireland.	Considerable flooding occurred in the area between Dundrum, Blackrock and Sandymount. The high value recorded at Ballsbridge indicated this area must have had exceptional rainfall.

2.3 Dublin FloodResilienCity Pluvial Mapping

Information on pluvial flood risk comes from the EU Interreg IVB FloodResilienCity Project. For the project, a city wide model provided a high-level assessment of pluvial flood risk across Dublin and five Pilot Areas were identified for further detailed investigation of potential pluvial flood risk i.e. Type 2 modelling. Figure 2-7 below shows a map with the pluvial flood outlines. The mapping indicates accumulations of stormwater in many isolated pockets throughout the Jamestown lands. The granularity of the base topographic data is course and the detail of the stormwater network is also not explicitly modelled the SWMP will provide further insight into the management of pluvial risk and the existing stormwater system.

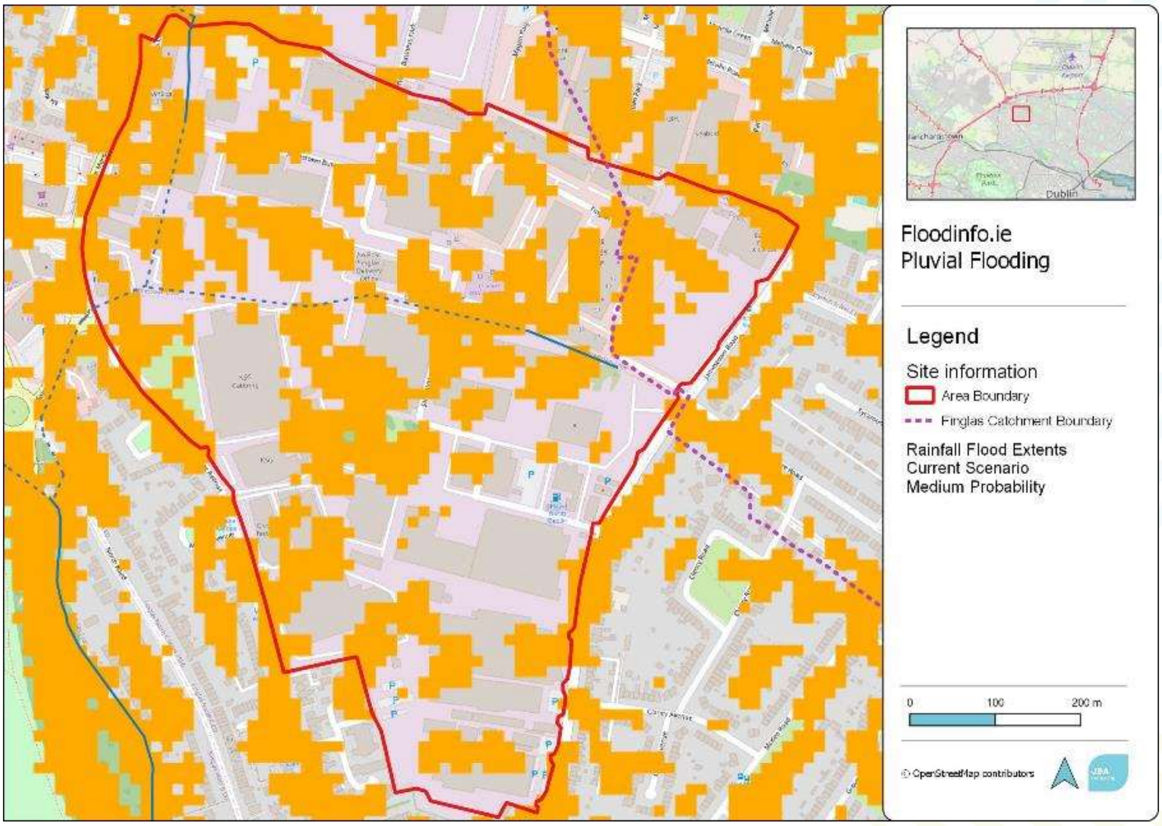


Figure 2-7 FloodResilienCity Flood Map

2.4 CFRAM

In 2011 the OPW commenced appointment of consultants to carry out a more detailed flood risk assessment on key flood risk areas. This work was undertaken under the CFRAM programme across seven river basin districts in Ireland.

Under the Eastern CFRAM Jamestown/Finglas was not identified as an AFA (Area for Further Assessment). Therefore, no CFRAM mapping exits for the Finglas Stream at this location.

2.5 PFRA & NIFM

The Preliminary Flood Risk Assessment (PFRA) is a national screening exercise that was undertaken to identify areas at potential flood risk. The PFRA is a requirement of the EU Floods Directive and the publication of this work has led to, and has informed, more detailed assessment, which is being undertaken as part of the Catchment Flood Risk Assessment and Management (CFRAM) studies. The PFRA study considered flooding from several sources, including fluvial, tidal, pluvial and groundwater, and resulted in a suite of broadscale flood maps.

The PFRA fluvial data has now been replaced by NIFM fluvial flood extents, however this is only the case where CFRAM flood outlines are not provided and where the catchment is greater than $5km^2$. Since the catchment area of the Finglas Stream is less than 5km2 though the Masterplan site there is no publicly available flood mapping.

2.6 JBA Hydraulic Modelling

To provide indicative Flood Zones for the Finglas Stream a hydraulic model of the watercourse was constructed using the culvert/network data from the GDSDS, LiDAR data and hydrological estimation of flow volumes. The model runs from upstream of the M50 culvert and has a downstream boundary to the south of the Masterplan lands where the Finglas Stream enters open channel. The modelling was undertaken using the ESTRY-TuFLOW software package and is sufficient in detail to represent the hydraulic effects of the local culverts and in particular the potential surcharging of the downstream 1200mm diameter culvert at the downstream extent of the open channel section. The hydrology has been undertaken using the IH124 urban methodology and will therefore not fully represent the attenuation impacts of the upstream drainage network within this heavily urbanised area. There is scope for future updates to the hydrology and modelling with the construction of a more detailed integrated drainage/catchment model. This could be undertaken at a stage when more detailed design is being undertaken.

2.6.1 Current Scenario Flood Zones

The results of the hydraulic modelling are displayed below in Figure 2-8. The Finglas Stream enters the Masterplan lands through the culvert outlet pictured in Figure 2-5. The flow then enters the riparian zone which is poorly represented by the OPW LiDAR data, nevertheless it is clear that the downstream culvert is only able to convey 66% of the total flow with the remaining surcharging overland (in the 1% AEP event). This overland flow route bypasses the culvert and follows the above ground topographic surface in a south to south-westerly direction back towards the open channel adjacent to the Finglas bypass. It represents a potential flood risk to property within and beyond the boundary of the Masterplan area.

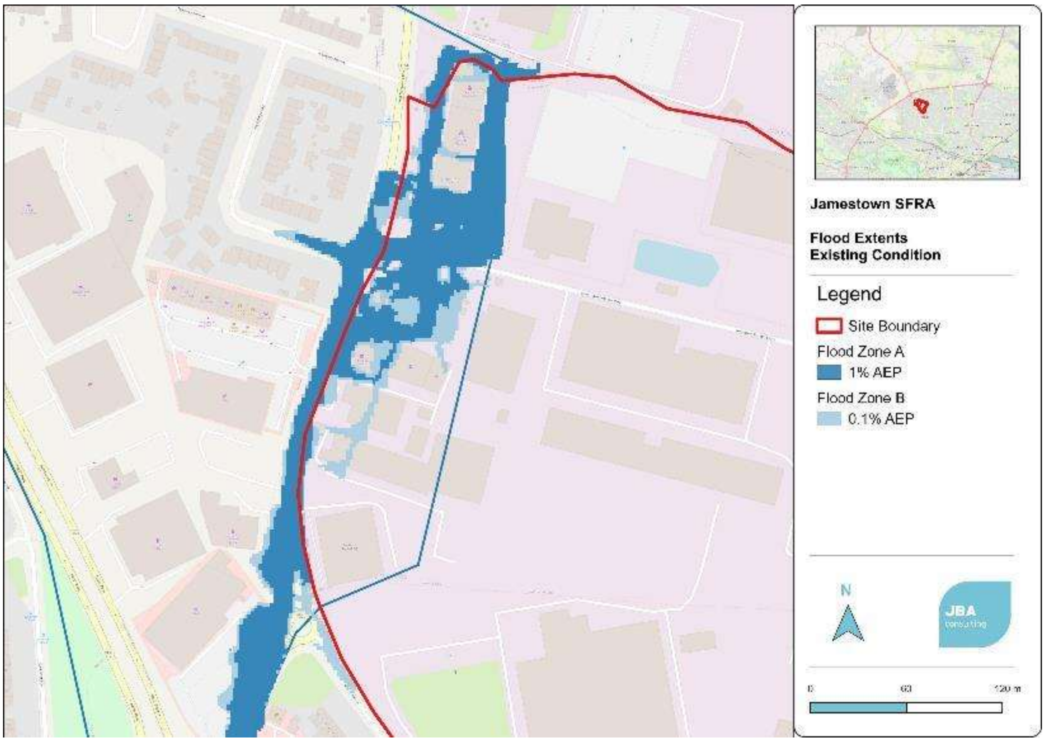


Figure 2-8 Finglas Stream Indicative Flood Zone Mapping

2.6.2 Climate Change Flood Mapping

Climate change has also been considered during the hydraulic analysis and Figure 2-9 below includes a representation of the MRFS and HEFS climate change, see Section 1.5.2 for further details on climate change allowances. The 1% AEP climate change outlines are generally still less than the extent of Flood Zone B and are indicative of increased surcharging at the 1200mm diameter culvert inlet at the downstream of the existing open channel section.

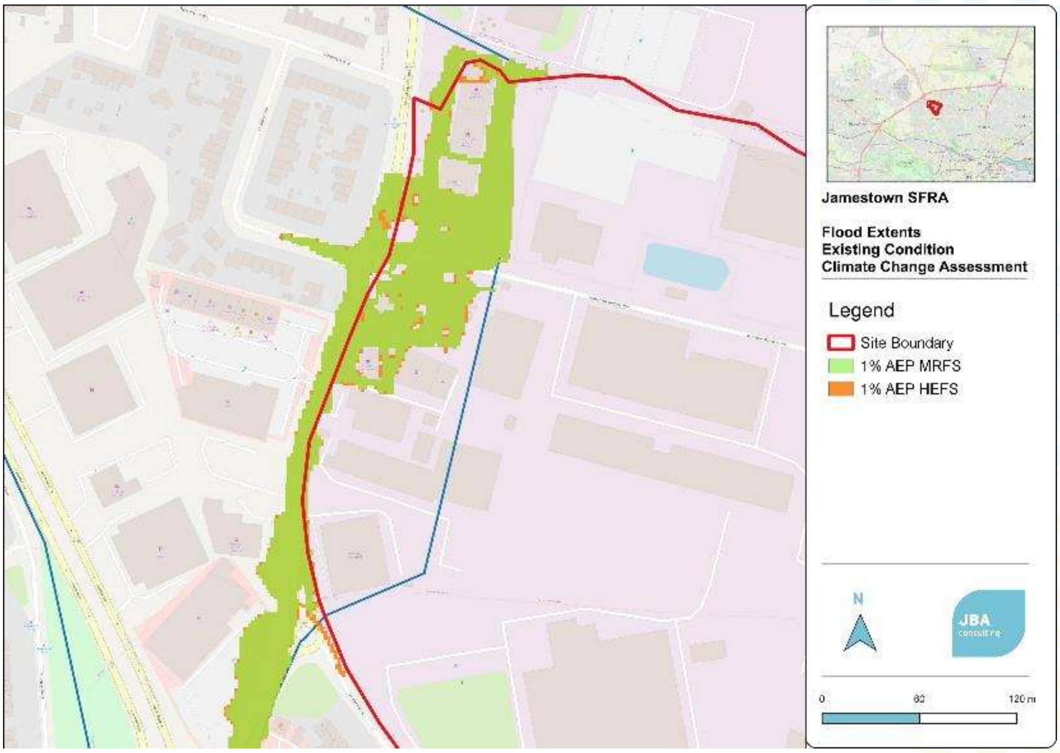


Figure 2-9 Finglas Stream Climate Change Flood Mapping 1% AEP

2.7 Finglas Stream Topography

An alternative representation of the potential on-site depressions can be presented using LiDAR data. Figure 2-10 presents the current LiDAR data for the study area, along with associated overland flowpaths.

There is a general south-westerly gradient present on the site, with some distinct low points. These are presented as blue polygons on the figure below. Two of the polygons correspond to existing fire retention ponds.

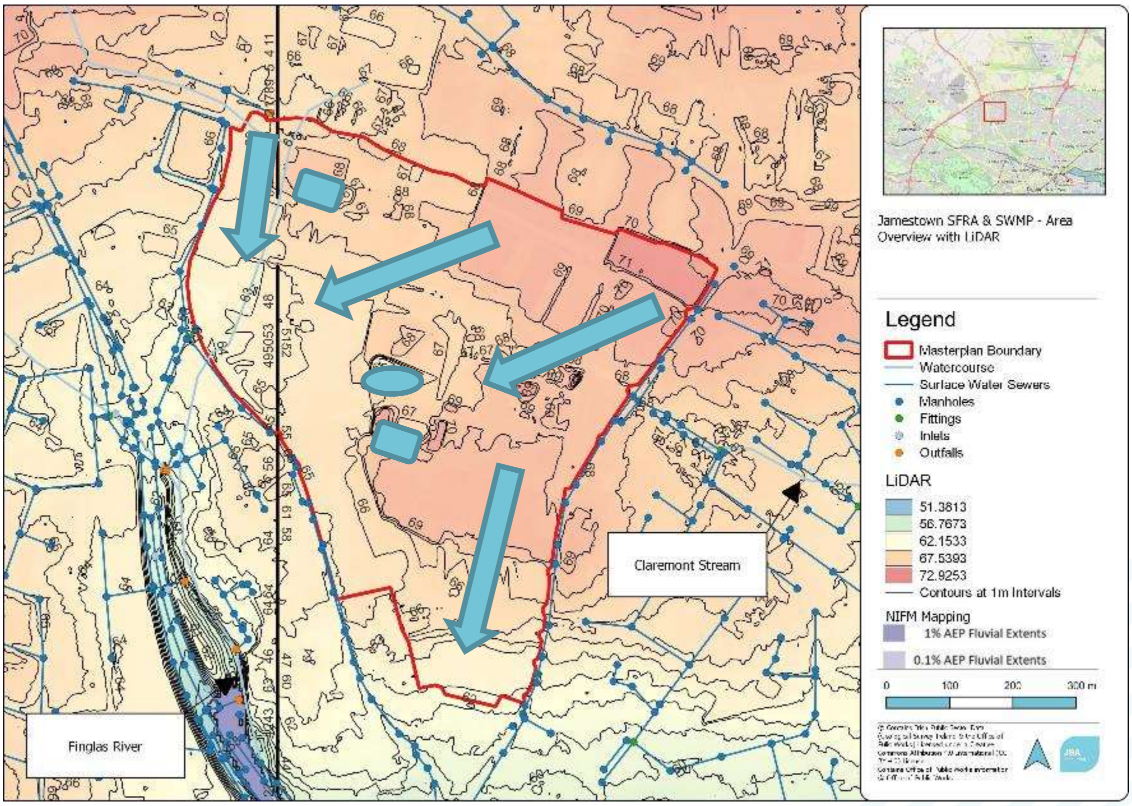


Figure 2-10 Area Overview with LiDAR and Indicative Flow Paths and Depressions

3 Proposed Green Infrastructure

3.1 Rainwater Management/GI philosophy

As aforementioned, the RMS isn't limited to providing hydraulic solutions to a proposed development. The focus is to provide a viable strategy that manages surface water in a sustainable way, providing water quality and environmental benefits as well as ensuring there is no unacceptable residual risk of flooding to each site.

Each design submission proposed within the study area will be required to adhere to the following requirements:

Table 3-1 GI Requirements

RMS Objective	Category	Ref	Standard	Note
Water Quality	Interception/ Treatment	R1	Provide 5mm interception of rainfall using nature-based solutions **at source** within private development	Interception to be in compliance with Table 24.6 of CIRIA C753
		R2	Stormwater run-off on all public thoroughfares to pass through one interception measure prior to entering network.	Interception to be in compliance with Table 24.6 of CIRIA C753
		R3	Public throughfares to incorporate open swales as stormwater carrying elements where possible to promote greater GI connectivity	
	Attenuation	R4	Provide attenuation using green/blue roofs, detention and/or retention ponds. Sub-surface attenuation may only be permitted when clear reasoning for alternatives has been provided to DCC.	
Climate Change		R5	Allow for 20% climate change on rainfall intensity and 10% for urban creep.	
Flood Risk	Flood protection	R6	Discharge rates to be restricted to the greater of QBAR or 2 l/s/ha.	

This approach is to be taken as complementary to and not a replacement for either GDSDS or DCC's own SuDS guidance documents.

3.2 Green Infrastructure Design

3.2.1 Public Realm

The public realm thoroughfares when integrated into the green infrastructure network provide increased connectivity for habitats across the study area. This directly aligns with the DP Objective GI2: *To develop an interconnected green infrastructure network of strategic natural and semi-natural areas with other environmental features including green spaces, rivers, canals, the coastal and marine area, and other physical features including streets and civic spaces that supports ecological, wildlife, and social connectivity.*

The public realm thoroughfares will have a requirement to provide interception of their own stormwater runoff and provide corridors for stormwater linkage between each sub-catchment. Open swales are very effective in creating an integrated biodiversity network. An example of this is shown in Figure 3-1.

Figure 3-1 Green Infrastructure open swale (Source: biocycle.net)

This can be scaled up as required, with both swales and rain gardens serving as GI measures within the corridors.

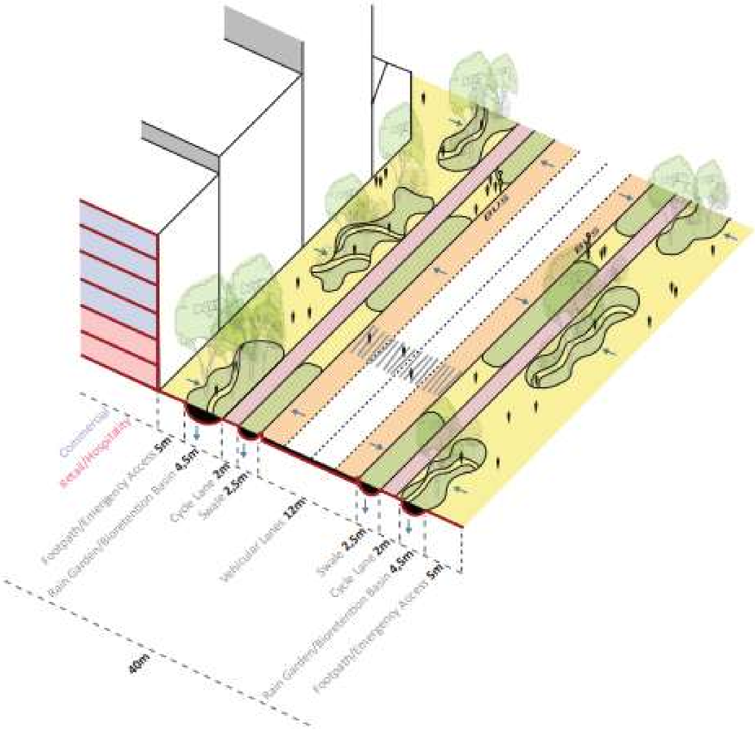
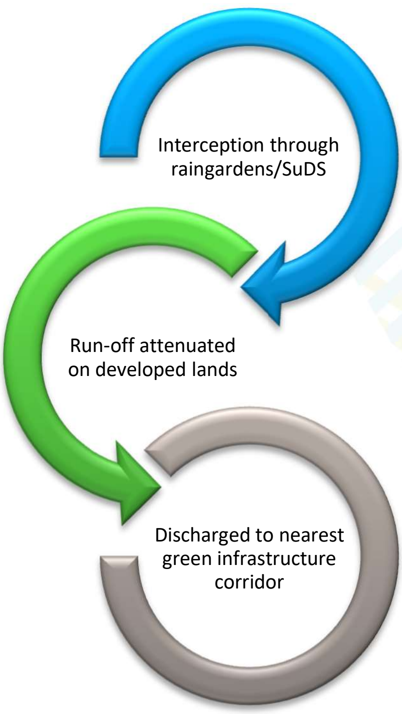


Figure 3-2 Typical Green Infrastructure Corridor (Source: City Edge Project, DCC)

It is acknowledged that the scale of swale that can be accommodated into a public thoroughfare may not be able to cater for all upstream flows received, and that some sub-surface drainage is required. The hierarchy for developing stormwater proposals on the public thoroughfares should thus follow the following hierarchy:



There will be an element of attenuation within the public realm, catering for run-off from public areas. The developed lands will attenuate their own run-off within their own individual footprints.

3.2.2 Private Development

As shown in Table 3-1, there are a number of both water quality and hydraulic requirements that are to be adhered to.

Each development must present proposals that provide 5mm interception as per CIRIA C753. These interception measures should be provided at source unless impossible to do so.

Examples of interception measures are:

- Green/Blue Roofs
- Rain gardens
- Permeable Paving
- Bioretention tree pits

A secondary means of interception is to be provided by retention or detention basins within each developed site. This is detailed further in 3.2.3. Initial capacities for the volume to be retained are also provided.

3.2.3 Hydraulic Design

The following design calculations present an indicative stormwater design approach that could be applied to the lands. Within it, it gives an indication of the extent of attenuation volumes within the defined catchment for both public and private lands.

This indicative design works on the premise that the public realm storage will only be catering for its own run-off outside the perimeters of the private boundaries.

This estimation of the attenuation requirements was carried out using Causeway Flow software. The site was broken down into 8no. drainage areas based on the site topography and available space for attenuation. These areas are shown in Figure 3-3 below.

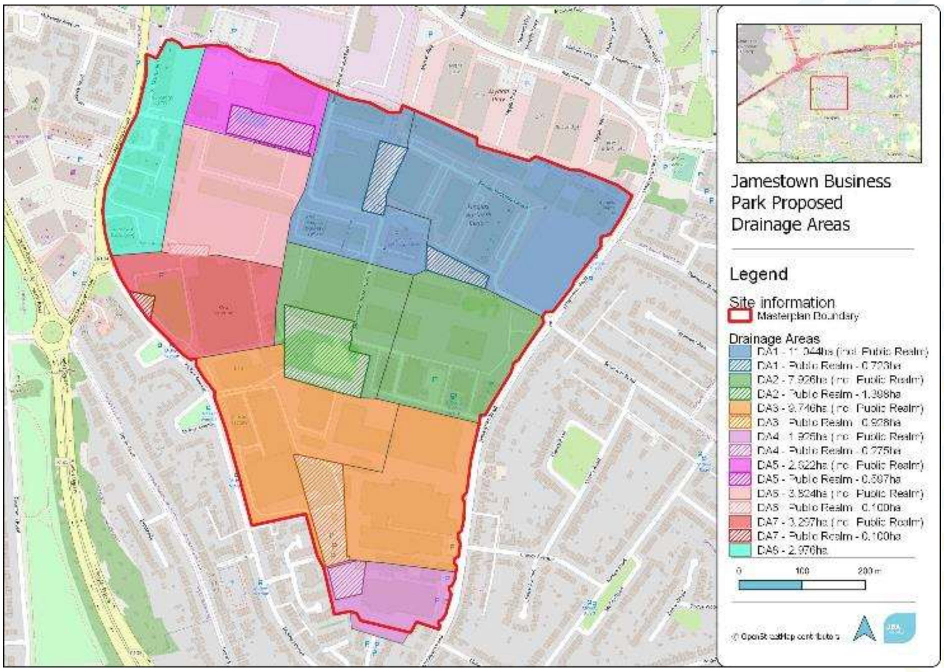


Figure 3-3 Proposed Drainage Areas

Six separate models were completed for the different drainage areas (DA), comprising: (1) DA1, (2) 3no. linked attenuation storages for DA2-4, (3) DA5, (4) DA6, (5) DA7, and (6) DA8. DA's 1, 5, 6, 7 and 8 will drain into the open channels as part of the Masterplan and therefore are not hydraulically linked to the other catchments.

Attenuation storage locations were linked in series by conduits and outflows restricted in the form of a cascading network, taking into account the increasing contributing areas. Flows were restricted by modelling a Hydro-Brake flow control device at the storage nodes. Note, this is not imposing the need for hydro-brake flow controls at this stage but merely identifies the need for some form of flow restriction. Several assumptions had to be taken to make the hydraulic model viable, namely:

- All modelled storage nodes were taken as 1m deep and the plan areas were adjusted accordingly to meet to storage requirements.
- To ensure that downstream storage water levels did not hinder the required pass forward rates of the preceding flow controls, which would skew the attenuation results, the preceding flow control invert levels were placed at a higher level than the downstream water levels (i.e. 1m above the downstream storage invert levels). This indicative only and isn't to impose a means of attenuation depths on the proposed developments.

The models included the following parameters:

- M5-60: 16.400mm
- Ratio-R: 0.274
- Cv: 1.000
- Time of Entry (te): 10mins (to account for time taken to flow through the site stormwater networks)
- Additional Storage: 0 m3/ha
- Storm Durations: 15-10,080mins
- Simulation Return Periods: 1, 2, 5, 10, 30 and 100-year
- Climate Change: 20%
- Additional Area (Urban Creep factor): 10%

The models were set up so that, for a 100-year event, outflows were restricted to QBAR. QBAR was calculated using the IH124 method using a SAAR = 791mm and Soil Type SOIL = 4 (SPR = 0.47), which gave the local QBAR as 5.57l/s/ha, and this calculation is included in Appendix B. The "central" storage nodes (public realm / "PR") for each drainage area had flows restricted to QBAR. The "dummy" nodes were designed to mimic individual plots attenuation requirements. The discharge values for each individual drainage area are summarised in Table 3-2, and are also included in the appended calculations in Appendix B:

Drainage Area	Gross Area (ha)	Open Space Allowance (ha)	Positively Drained Area (Gross - Open Space) (ha)	Positively Drained Area Percentage Impermeability (%)	Net Impermeable Area (ha)	QBAR (Positively Drained Area) (l/s)
1A	3.671	0.734 (20%)	2.937	80	2.350	16.3
1 (PR 1)	0.425	0	0.425	47 (Soil Type 4)	0.2	2.3
1B	6.650	1.330 (20%)	5.320	80	4.256	29.6
1 (PR 2)	0.298	0	0.298	47 (Soil Type 4)	0.14	1.6
2A	2.505	0.501 (20%)	2.004	80	1.603	11.1
2B	4.023	0.804 (20%)	3.219	80	2.575	17.9
2 (PR)	1.398	0	1.398	47 (Soil Type 4)	0.657	7.7
3A	4.789	0.957 (20%)	3.832	80	3.066	21.3
3B	4.029	0.805 (20%)	3.224	80	2.579	17.9
3 (PR)	0.928	0	0.928	47 (Soil Type 4)	0.436	5.1
4A	1.650	0.330 (20%)	1.320	80	1.056	7.3
4 (PR)	0.275	0	0.275	47 (Soil Type 4)	0.129	1.5
5A	2.025	0.405 (20%)	1.620	80	1.296	9.0
5 (PR)	0.597	0	0.597	47 (Soil Type 4)	0.281	3.3
6A	3.724	0.745 (20%)	2.979	80	2.383	16.5
6 (PR)	0.100 (rounded up from 0.099)	0	0.100	47 (Soil Type 4)	0.047	0.5
7A	3.197	0.639 (20%)	2.558	80	2.046	14.2
7 (PR)	0.100 (rounded up from 0.094)	0	0.100	47 (Soil Type 4)	0.047	0.5
8A	2.976	0.595 (20%)	2.381	80	1.905	13.2
Total	**43.36**	**7.85**	**35.52**		**27.05**	

Table 3-2 Calculation of QBAR for each drainage area

As DAs 2-4 are linked in series, the pass-forward rate increases as the system increases its upstream catchment. The pass-forward rates at DAs 3 and 4 will therefore be QBAR for the entire contributing areas at the respective locations. The linked network for DAs 2-4 will discharge at QBAR to the public network at Jamestown Road. This cumulative effect on flow rates is presented in Table 3-3.

Drainage Area	Combined Gross Area (ha)	Combined Open Space Allowance (ha)	Cumulative Positively Drained Area (ha)	Cumulative Net Impermeable Area (ha)	Cumulative QBAR (Positively Drained Area) (l/s)
3 (2+3 Cumulative)	17.672	3.067	14.605	10.916	81.3
4 (2+3+4 Cumulative)	19.597	3.397	16.200	12.101	90.2

Table 3-3 Calculation of cumulative QBAR for drainage areas linked in series

QBAR rates for each sub-catchment were also calculated and are presented in Table 3-4.

Drainage Area	Positively Drained Area (ha)	QBAR (Positively Drained Area) (l/s)
1	8.98	50.0
2	6.621	36.8
3	7.984	44.4
4	1.595	8.8
5	2.217	12.3
6	3.079	17.1
7	2.658	14.8

Table 3-4 Calculation of QBAR for each drainage area as a whole

The "dummy" storage nodes (representing the developed land attenuation) were placed at a higher level in the model than the downstream "central" nodes (representing the public realm attenuation) to achieve the required QBAR pass-forward rates. The catchment areas assigned to the “dummy” nodes represent the individual developments, while the catchment areas assigned to the “central” nodes represent public realm areas.

Note, the model presents these attenuation areas as sub-surface structures in the calculation outputs appended to this document. This was necessary to manage the hydraulic head requirements of the flow control units initially used in order to develop a magnitude of attenuation, as previously outlined.

The simulations produced a volume of water at each node, "dummy" and "central", which would need to be stored. The storage was sized by manipulating the plan area while keeping the depth constant. The simulation results are shown in Table 3-5 and Table 3-6 for the 100-year (1% AEP event) critical storm and include for climate change and urban creep allowances. The storage structures have been designed to fill to capacity and discharge at the required flow rates using a 1m head level on the flow controls during the 100-year event. The "dummy" node volumes represent an indicative volume only which would need to be stored in each plot by the stormwater networks and attenuation systems.

It is important to recognise that the generated volumes and flow rates are specific to this high-level model only, taking into consideration all the assumptions made. The actual attenuation volumes and flow rates of the storage structures would need to be verified during the design of same.

Drainage Area	"Dummy" Node		"Central" Node		All Nodes
	Storage (m3)	Outflow (l/s)	Storage (m3)	Outflow (l/s)	Critical Storm Duration (minutes)
1A	1766	16.3	-	-	1440
1 (PR 1)	-	-	110	18.7	960
1B	3309	29.6	-	-	2160
1 (PR 2)	-	-	50	50.0	720
2A	1175	11.6	-	-	1440
2B	1961	17.9	-	-	1440
2 (PR)	-	-	382	36.8	960
3A	2345	21.3	-	-	1440
3B	1961	17.9	-	-	1440
3 (PR)	-	-	151	81.3	960
4A	720	8.8	-	-	960
4 (PR)	-	-	152	90.2	4320

Table 3-5 Attenuation Simulation Requirements - 100-year event (1% AEP)

Drainage Area	"Dummy" Node		"Central" Node		All Nodes
	Storage (m3)	Outflow (l/s)	Storage (m3)	Outflow (l/s)	Critical Storm Duration (minutes)
5A	959	9.0	-	-	1440
5 (PR)	-	-	150	12.3	960
6A	1796	16.5	-	-	1440
6 (PR)	-	-	20	17.1	1440
7A	1533	14.2	-	-	1440
7 (PR)	-	-	14	14.8	1440
8A	1451	13.2	-	-	1440

Table 3-6 Attenuation Simulation Requirements - 100-year event (1% AEP)

As is expected, increasing volumes of runoff need to be attenuated in line with longer return periods (1, 2, 5, 10, 30 and 100-year calculations included in Appendix B). Table 3-6 provides indicative volumes required only. Both the final volumes and locations will be defined by the individual development designs.

In the public space, the model indicates a requirement for a small volume of attenuation. The means by which this is incorporated into the green space is at the discretion of the local authority, working with relevant statutory bodies and prospective the developers. There is no final design currently in place for the shape of the public green areas.

Figure 3-4 indicates the indicative volumes for each catchment, represented as 1m deep attenuation structures in plan.

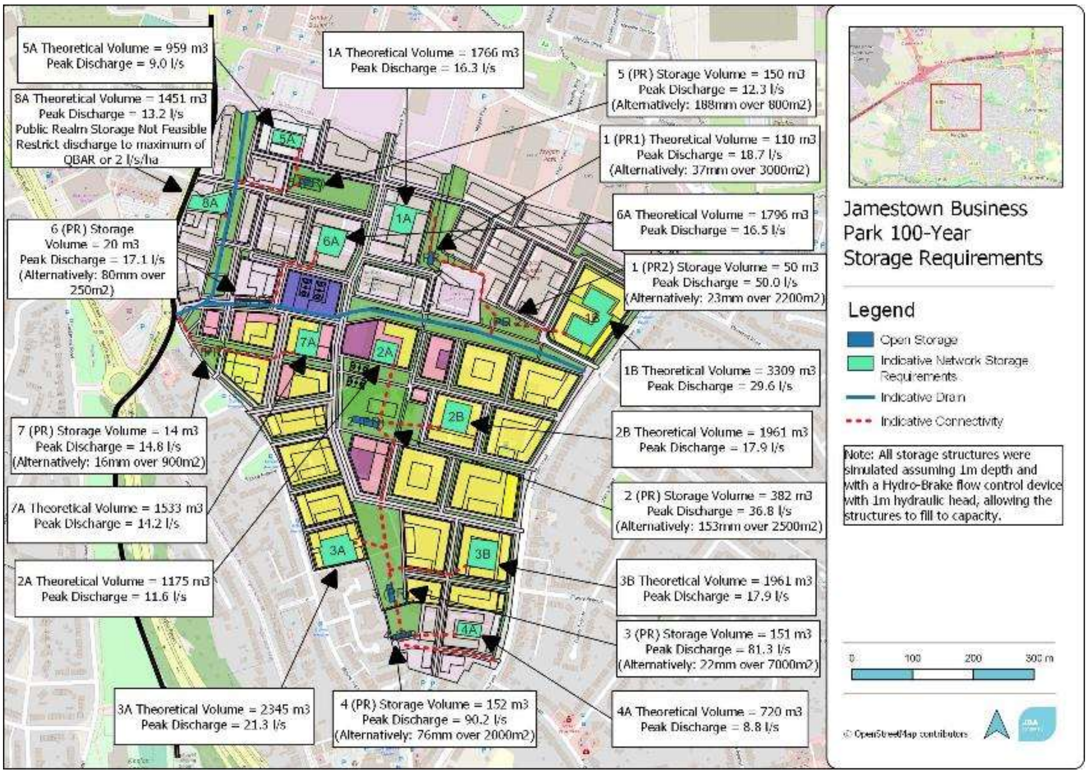


Figure 3-4 1% AEP event attenuation requirements

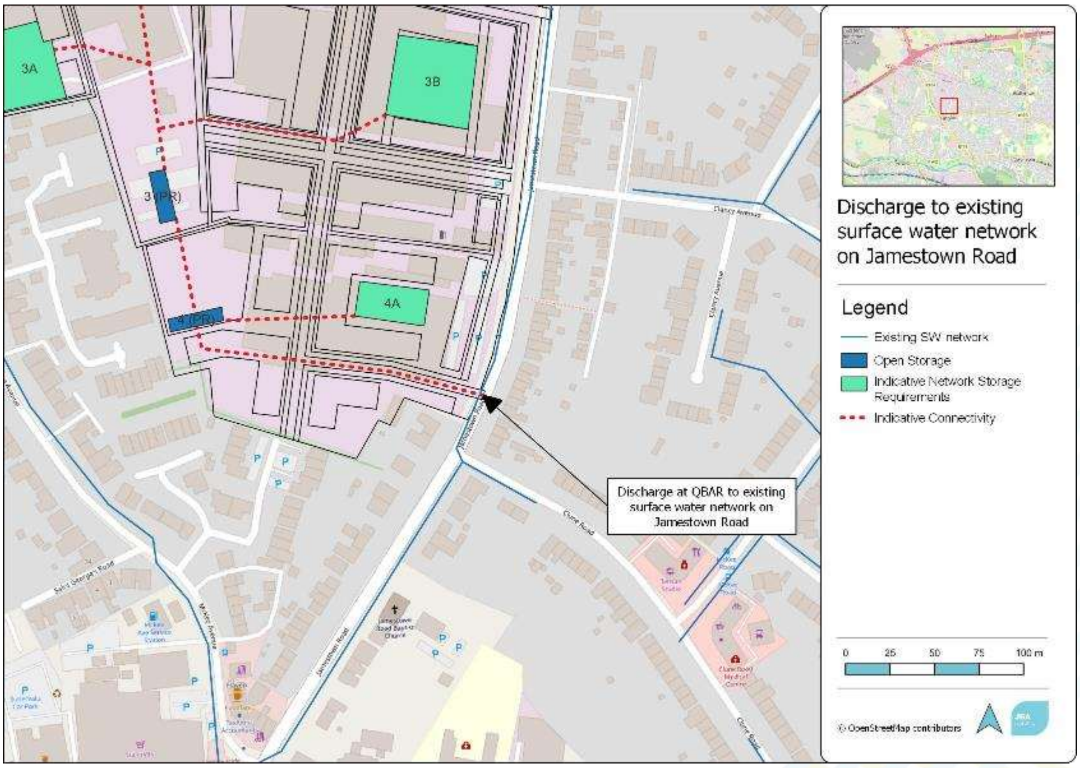


Figure 3-5 Indicative drainage connection from Jamestown Lands to existing network on Jamestown Road

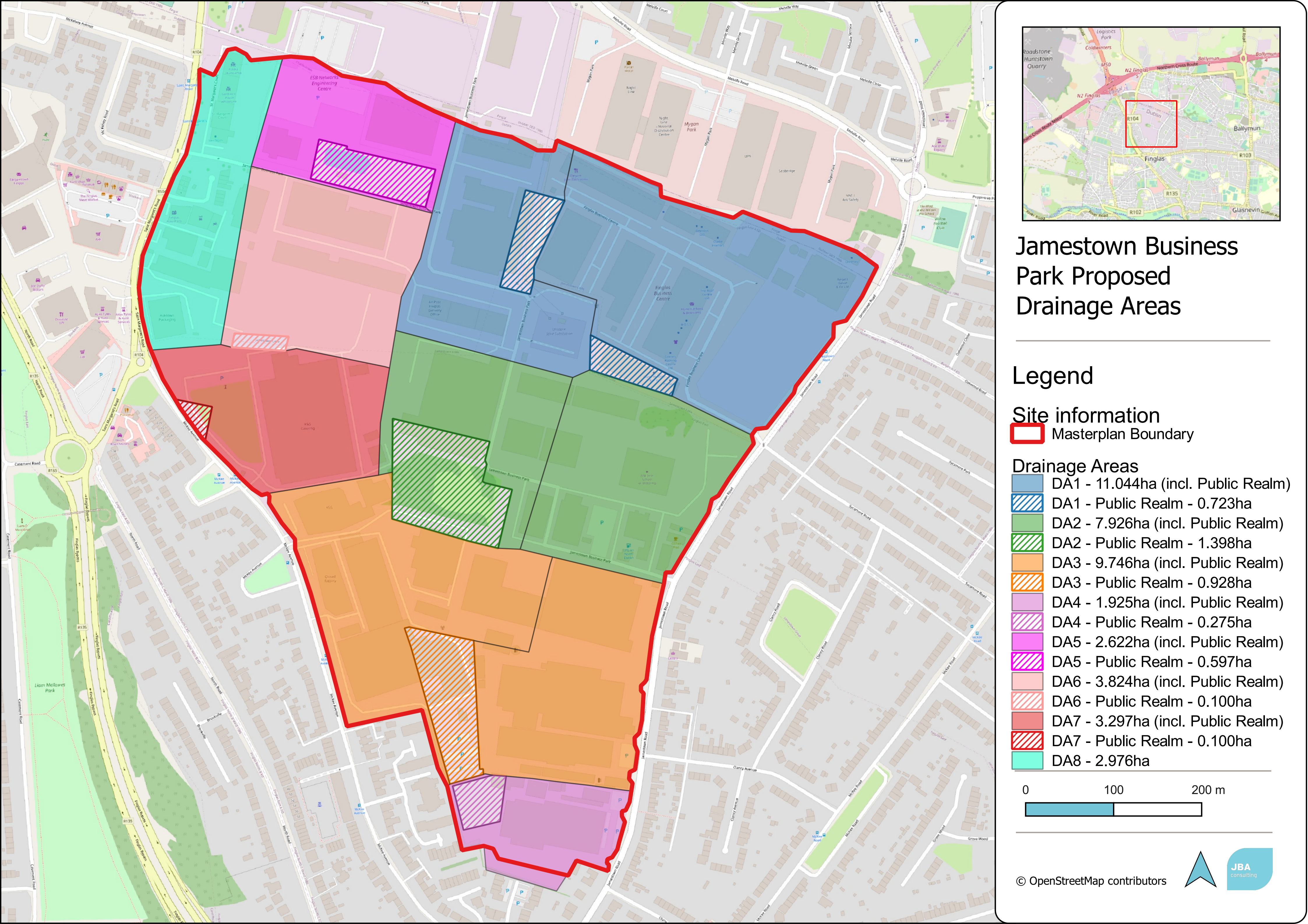
4 Conclusion

The aim of this Rainwater Management Strategy (RMS) is to develop a strategy for incorporating nature-based solutions into the control of surface water run-off.

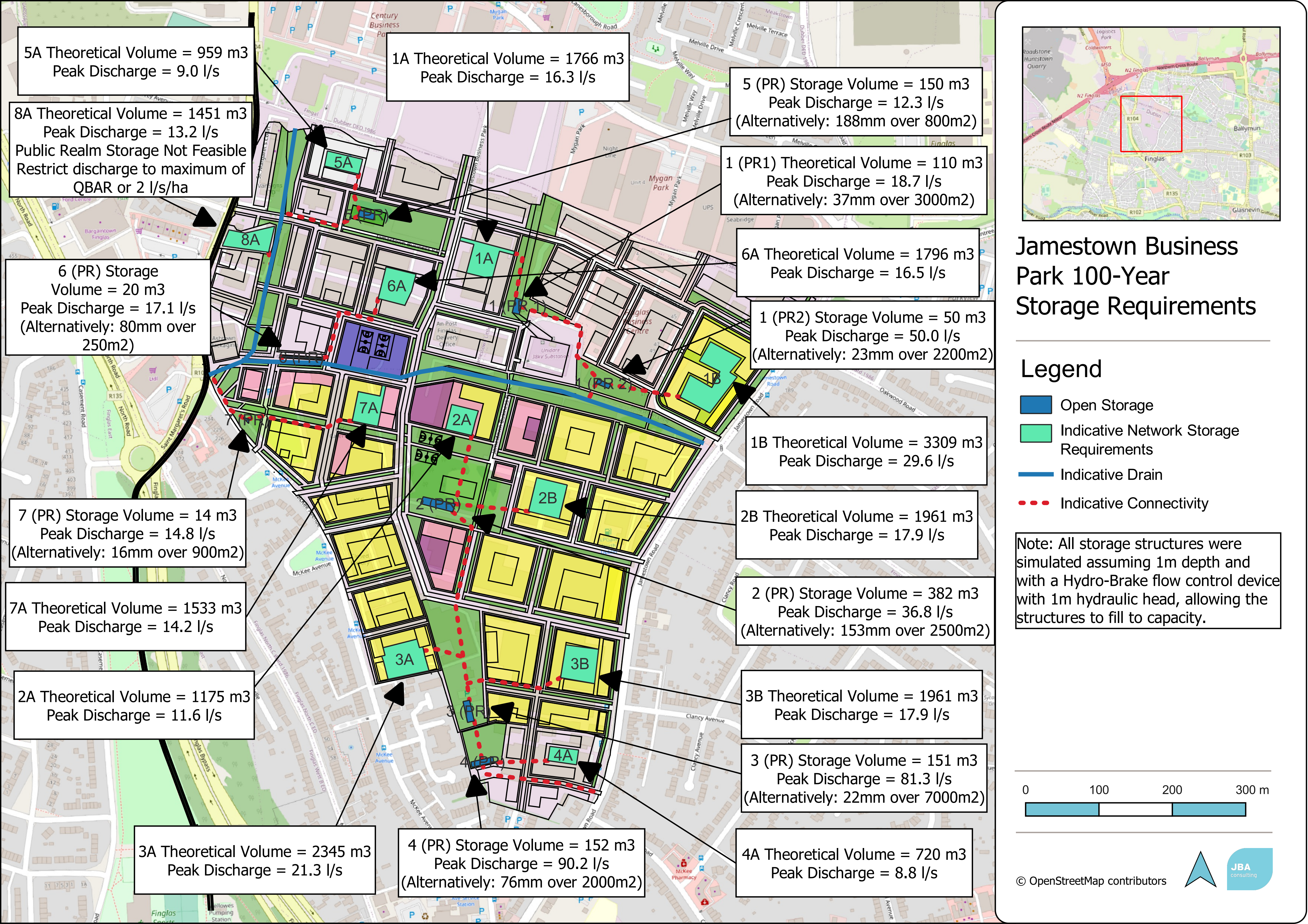
The following surmises how the RMS will implement this:

- This RMS ensures that any development in the Study Area will require SuDS to be incorporated into their design. The RMS goes one step further in that it ensures that interconnectivity of the green infrastructure network is integrated into the design philosophy.
- The public thoroughfares will provide habitat linkages between each development, bringing the development in line with DCC's green infrastructure policies.
- Site controls will ensure both water quality will be improved both at development level and further improved through the GI network.
- The attenuation network provides clear prescriptive parameters on the requirements of each prospective development in respect to their attenuation responsibilities. This aids the decision-making process at both detailed design and planning level. An indicative attenuation quantum has been provided at a catchment level. This is to give an initial overview of the extent of attenuation that may be required but is not a final design. This will be dependent on the detailed design of each development. A detailed stormwater management plan will be required to be developed as per SI25 of the DCC Development Plan.

Appendix A - Drawings



Jamestown Business Park Proposed Drainage Areas
Legend
Site information
Masterplan Boundary
Drainage Areas
DA1 - 11.044ha (incl. Public Realm)
DA1 - Public Realm - 0.723ha
DA2 - 7.926ha (incl. Public Realm)
DA2 - Public Realm - 1.398ha
DA3 - 9.746ha (incl. Public Realm)
DA3 - Public Realm - 0.928ha
DA4 - 1.925ha (incl. Public Realm)
DA4 - Public Realm - 0.275ha
DA5 - 2.622ha (incl. Public Realm)
DA5 - Public Realm - 0.597ha
DA6 - 3.824ha (incl. Public Realm)
DA6 - Public Realm - 0.100ha
DA7 - 3.297ha (incl. Public Realm)
DA7 - Public Realm - 0.100ha
DA8 - 2.976ha
0
100
200 m
© OpenStreetMap contributors
JBA consulting


5A Theoretical Volume = 959 m3
Peak Discharge = 9.0 l/s
1A Theoretical Volume = 1766 m3
Peak Discharge = 16.3 l/s
5 (PR) Storage Volume = 150 m3
Peak Discharge = 12.3 l/s
(Alternatively: 188mm over 800m2)
8A Theoretical Volume = 1451 m3
Peak Discharge = 13.2 l/s
Public Realm Storage Not Feasible
Restrict discharge to maximum of
QBAR or 2 l/s/ha
1 (PR1) Theoretical Volume = 110 m3
Peak Discharge = 18.7 l/s
(Alternatively: 37mm over 3000m2)
6A Theoretical Volume = 1796 m3
Peak Discharge = 16.5 l/s
6 (PR) Storage
Volume = 20 m3
Peak Discharge = 17.1 l/s
(Alternatively: 80mm over
250m2)
1 (PR2) Storage Volume = 50 m3
Peak Discharge = 50.0 l/s
(Alternatively: 23mm over 2200m2)
1B Theoretical Volume = 3309 m3
Peak Discharge = 29.6 l/s
7 (PR) Storage Volume = 14 m3
Peak Discharge = 14.8 l/s
(Alternatively: 16mm over 900m2)
2B Theoretical Volume = 1961 m3
Peak Discharge = 17.9 l/s
7A Theoretical Volume = 1533 m3
Peak Discharge = 14.2 l/s
2 (PR) Storage Volume = 382 m3
Peak Discharge = 36.8 l/s
(Alternatively: 153mm over 2500m2)
2A Theoretical Volume = 1175 m3
Peak Discharge = 11.6 l/s
3B Theoretical Volume = 1961 m3
Peak Discharge = 17.9 l/s
3 (PR) Storage Volume = 151 m3
Peak Discharge = 81.3 l/s
(Alternatively: 22mm over 7000m2)
3A Theoretical Volume = 2345 m3
Peak Discharge = 21.3 l/s
4 (PR) Storage Volume = 152 m3
Peak Discharge = 90.2 l/s
(Alternatively: 76mm over 2000m2)
4A Theoretical Volume = 720 m3
Peak Discharge = 8.8 l/s
5A
8A
1A
6A
1B
7A
2A
2B
3A
3B
4A
Jamestown Business Park 100-Year Storage Requirements
Legend
Open Storage
Indicative Network Storage Requirements
Indicative Drain
Indicative Connectivity
Note: All storage structures were simulated assuming 1m depth and with a Hydro-Brake flow control device with 1m hydraulic head, allowing the structures to fill to capacity.
0
100
200
300 m
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Appendix B – Calculations

Print Close Report

HR Wallingford
Working with water

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Paul Browne
Site name:	Jamestown
Site location:	Finglas

Site Details

Latitude:	53.39722° N
Longitude:	6.298° W
Reference:	1968914031
Date:	Feb 09 2023 10:15

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 1

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm):	961	791
Hydrological region:	12	12
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 30 years:	2.13	2.13
Growth curve factor 100 years:	2.61	2.61
Growth curve factor 200 years:	2.86	2.86

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	6.99	5.57
1 in 1 year (l/s):	5.95	4.73
1 in 30 years (l/s):	14.9	11.86
1 in 100 year (l/s):	18.26	14.54
1 in 200 years (l/s):	20.01	15.93

Simulation Settings

Rainfall Methodology	FSR	Skip Steady State	x
FSR Region	Scotland and Ireland	Drain Down Time (mins)	240
M5-60 (mm)	16.400	Additional Storage (m^3/ha)	0.0
Ratio-R	0.274	Check Discharge Rate(s)	x
Summer CV	1.000	Check Discharge Volume	x
Analysis Speed	Detailed		

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	20	10	0
2	20	10	0
5	20	10	0
10	20	10	0
30	20	10	0
100	20	10	0

Node 1A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	68.000	Product Number	CTL-SHE-0182-1630-1000-1630
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	16.3	Min Node Diameter (mm)	1500

Node 1 (PR1) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	67.000	Product Number	CTL-SHE-0193-1870-1000-1870
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	18.7	Min Node Diameter (mm)	1500

Node 1B Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	67.000	Product Number	CTL-SHE-0235-2960-1000-2960
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.300
Design Flow (l/s)	29.6	Min Node Diameter (mm)	1500

Node 1 (PR2) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	66.000	Product Number	CTL-SHE-0294-5000-1000-5000
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.375
Design Flow (l/s)	50.0	Min Node Diameter (mm)	1800

Node 1B Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	67.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	720

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	3309.0	0.0	1.000	3309.0	0.0

Node 1A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	68.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	1766.0	0.0	1.000	1766.0	0.0

Node 1 (PR1) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	67.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	390

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	110.0	0.0	1.000	110.0	0.0

Node 1 (PR2) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	66.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	390

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	50.0	0.0	1.000	50.0	0.0

Results for 1 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	1B	930	0.370	91.2	1225.9810
1440 minute summer	1A	930	0.354	50.4	625.5377
960 minute summer	1 (PR1)	585	0.330	21.2	36.3372
1440 minute summer	1 (PR2)	870	0.405	49.4	20.2455
1440 minute summer	OUTFALL	870	0.085	48.9	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	1B	1.000	1 (PR2)	29.2	
1440 minute summer	1A	2.000	1 (PR1)	16.3	
960 minute summer	1 (PR1)	2.001	1 (PR2)	18.6	
1440 minute summer	1 (PR2)	1.001	OUTFALL	48.9	2567.8

Results for 2 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	1B	930	0.437	105.8	1445.4810
1440 minute summer	1A	930	0.424	58.4	748.1594
960 minute summer	1 (PR1)	600	0.396	22.6	43.5195
1440 minute summer	1 (PR2)	900	0.463	50.6	23.1739
1440 minute summer	OUTFALL	900	0.085	49.7	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	1B	1.000	1 (PR2)	29.6	
1440 minute summer	1A	2.000	1 (PR1)	16.3	
960 minute summer	1 (PR1)	2.001	1 (PR2)	18.7	
1440 minute summer	1 (PR2)	1.001	OUTFALL	49.7	2926.2

Results for 5 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	1B	960	0.526	124.0	1738.8860
1440 minute summer	1A	960	0.516	68.5	911.8396
960 minute summer	1 (PR1)	615	0.489	23.9	53.8265
960 minute summer	1 (PR2)	600	0.533	53.0	26.6465
960 minute summer	OUTFALL	600	0.086	50.0	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	1B	1.000	1 (PR2)	29.6	
1440 minute summer	1A	2.000	1 (PR1)	16.3	
960 minute summer	1 (PR1)	2.001	1 (PR2)	18.7	
960 minute summer	1 (PR2)	1.001	OUTFALL	50.0	2358.0

Results for 10 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	1B	990	0.608	139.9	2010.3460
1440 minute summer	1A	990	0.601	77.3	1062.0650
720 minute summer	1 (PR1)	495	0.586	26.8	64.4955
960 minute summer	1 (PR2)	600	0.604	54.3	30.1779
2880 minute summer	OUTFALL	1680	0.086	50.0	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	1B	1.000	1 (PR2)	29.6	
1440 minute summer	1A	2.000	1 (PR1)	16.3	
720 minute summer	1 (PR1)	2.001	1 (PR2)	18.7	
960 minute summer	1 (PR2)	1.001	OUTFALL	50.0	2416.9

Results for 30 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
2160 minute summer	1B	1500	0.772	124.3	2554.4280
1440 minute summer	1A	1080	0.776	93.6	1371.2850
480 minute summer	1 (PR1)	464	0.812	33.5	89.3070
960 minute summer	1 (PR2)	600	0.773	55.7	38.6523
120 minute summer	OUTFALL	146	0.086	50.0	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
2160 minute summer	1B	1.000	1 (PR2)	29.6	
1440 minute summer	1A	2.000	1 (PR1)	16.3	
480 minute summer	1 (PR1)	2.001	1 (PR2)	18.7	
960 minute summer	1 (PR2)	1.001	OUTFALL	50.0	2435.2

Results for 100 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
2160 minute summer	1B	1560	1.000	152.3	3308.2700
1440 minute summer	1A	1110	0.999	115.6	1765.0420
960 minute summer	1 (PR1)	660	0.998	29.3	109.7840
720 minute summer	1 (PR2)	450	0.995	59.2	49.7629
120 minute summer	OUTFALL	210	0.086	50.0	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
2160 minute summer	1B	1.000	1 (PR2)	29.6	
1440 minute summer	1A	2.000	1 (PR1)	16.3	
960 minute summer	1 (PR1)	2.001	1 (PR2)	18.7	
720 minute summer	1 (PR2)	1.001	OUTFALL	50.0	2040.8

Simulation Settings

Rainfall Methodology	FSR	Skip Steady State	x
FSR Region	Scotland and Ireland	Drain Down Time (mins)	240
M5-60 (mm)	16.400	Additional Storage (m^3/ha)	0.0
Ratio-R	0.274	Check Discharge Rate(s)	x
Summer CV	1.000	Check Discharge Volume	x
Analysis Speed	Detailed		

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	20	10	0
2	20	10	0
5	20	10	0
10	20	10	0
30	20	10	0
100	20	10	0

Node 2A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	66.000	Product Number	CTL-SHE-0156-1160-1000-1160
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	11.6	Min Node Diameter (mm)	1200

Node 2B Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	66.000	Product Number	CTL-SHE-0189-1790-1000-1790
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	17.9	Min Node Diameter (mm)	1500

Node 2 (PR) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	65.000	Product Number	CTL-SHE-0258-3680-1000-3680
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.300
Design Flow (l/s)	36.8	Min Node Diameter (mm)	1800

Node 3A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	65.000	Product Number	CTL-SHE-0204-2130-1000-2130
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	21.3	Min Node Diameter (mm)	1500

Node 3B Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	65.000	Product Number	CTL-SHE-0189-1790-1000-1790
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	17.9	Min Node Diameter (mm)	1500

Node 3 (PR) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	64.000	Product Number	CTL-SHE-0361-8130-1000-8130
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.375
Design Flow (l/s)	81.3	Min Node Diameter (mm)	2100

Node 4A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	64.000	Product Number	CTL-SHE-0137-8800-1000-8800
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.150
Design Flow (l/s)	8.8	Min Node Diameter (mm)	1200

Node 4 (PR) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	63.000	Product Number	CTL-SHE-0378-9020-1000-9020
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.450
Design Flow (l/s)	90.2	Min Node Diameter (mm)	2100

Node 2A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	66.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	1175.0	0.0	1.000	1175.0	0.0

Node 2B Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	66.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	1961.0	0.0	1.000	1961.0	0.0

Node 2 (PR) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	65.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	405

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	382.0	0.0	1.000	382.0	0.0

Node 3A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	65.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	2345.0	0.0	1.000	2345.0	0.0

Node 3B Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	65.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	1961.0	0.0	1.000	1961.0	0.0

Node 3 (PR) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	64.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	375

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	151.0	0.0	1.000	151.0	0.0

Node 4A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	64.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	390

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	720.0	0.0	1.000	720.0	0.0

Node 4 (PR) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	63.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	300

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	152.0	0.0	1.000	152.0	0.0

Results for 1 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.80%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	2A	900	0.347	34.4	408.0469
1440 minute summer	2B	930	0.361	55.2	707.9335
1440 minute summer	2 (PR)	870	0.397	42.5	151.5551
1440 minute summer	3A	930	0.363	65.7	851.7892
1440 minute summer	3B	930	0.360	55.3	706.2474
1440 minute summer	3 (PR)	870	0.473	81.5	71.4847
960 minute summer	4A	615	0.338	29.8	243.0104
1440 minute summer	4 (PR)	930	0.495	89.1	75.2452
1440 minute summer	OUTFALL	930	0.099	88.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	2A	2.000	2 (PR)	11.6	
1440 minute summer	2B	1.000	2 (PR)	17.8	
1440 minute summer	2 (PR)	1.001	3 (PR)	35.9	
1440 minute summer	3A	3.000	3 (PR)	21.2	
1440 minute summer	3B	4.000	3 (PR)	17.8	
1440 minute summer	3 (PR)	1.002	4 (PR)	78.8	
960 minute summer	4A	5.000	4 (PR)	8.8	
1440 minute summer	4 (PR)	1.003	OUTFALL	88.3	4625.1

Results for 2 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.80%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	2A	930	0.417	39.9	489.9911
1440 minute summer	2B	930	0.429	64.0	841.6823
1440 minute summer	2 (PR)	870	0.449	45.3	171.5567
1440 minute summer	3A	930	0.432	76.2	1011.9590
1440 minute summer	3B	930	0.428	64.1	840.0394
1440 minute summer	3 (PR)	900	0.522	84.8	78.8064
960 minute summer	4A	630	0.406	34.6	292.3665
1440 minute summer	4 (PR)	960	0.544	90.6	82.7102
1440 minute summer	OUTFALL	960	0.099	89.5	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	2A	2.000	2 (PR)	11.6	
1440 minute summer	2B	1.000	2 (PR)	17.9	
1440 minute summer	2 (PR)	1.001	3 (PR)	36.5	
1440 minute summer	3A	3.000	3 (PR)	21.3	
1440 minute summer	3B	4.000	3 (PR)	17.9	
1440 minute summer	3 (PR)	1.002	4 (PR)	80.1	
960 minute summer	4A	5.000	4 (PR)	8.8	
1440 minute summer	4 (PR)	1.003	OUTFALL	89.5	5234.8

Results for 5 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.80%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	2A	960	0.511	46.7	600.0269
1440 minute summer	2B	960	0.520	75.1	1020.5460
960 minute summer	2 (PR)	615	0.524	54.8	200.1840
1440 minute summer	3A	960	0.522	89.3	1223.6760
1440 minute summer	3B	960	0.520	75.2	1020.1430
1440 minute summer	3 (PR)	870	0.581	88.0	87.7652
960 minute summer	4A	660	0.501	40.9	360.9297
2160 minute summer	4 (PR)	1380	0.601	91.5	91.3620
2160 minute summer	OUTFALL	1380	0.099	90.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	2A	2.000	2 (PR)	11.6	
1440 minute summer	2B	1.000	2 (PR)	17.9	
960 minute summer	2 (PR)	1.001	3 (PR)	36.8	
1440 minute summer	3A	3.000	3 (PR)	21.3	
1440 minute summer	3B	4.000	3 (PR)	17.9	
1440 minute summer	3 (PR)	1.002	4 (PR)	80.9	
960 minute summer	4A	5.000	4 (PR)	8.8	
2160 minute summer	4 (PR)	1.003	OUTFALL	90.2	7650.9

Results for 10 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.80%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	2A	990	0.597	52.7	701.3262
1440 minute summer	2B	990	0.605	84.7	1185.6750
960 minute summer	2 (PR)	630	0.597	58.3	227.9146
1440 minute summer	3A	990	0.606	100.8	1419.9140
1440 minute summer	3B	990	0.604	84.8	1184.3410
960 minute summer	3 (PR)	600	0.635	94.8	95.9385
960 minute summer	4A	675	0.589	46.4	424.2137
2160 minute summer	4 (PR)	1380	0.647	92.4	98.3378
2880 minute summer	OUTFALL	1860	0.100	90.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	2A	2.000	2 (PR)	11.6	
1440 minute summer	2B	1.000	2 (PR)	17.9	
960 minute summer	2 (PR)	1.001	3 (PR)	36.8	
1440 minute summer	3A	3.000	3 (PR)	21.3	
1440 minute summer	3B	4.000	3 (PR)	17.9	
960 minute summer	3 (PR)	1.002	4 (PR)	81.1	
960 minute summer	4A	5.000	4 (PR)	8.8	
2160 minute summer	4 (PR)	1.003	OUTFALL	90.3	8084.0

Results for 30 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.80%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	2A	1050	0.775	63.9	910.6796
1440 minute summer	2B	1080	0.775	102.6	1520.0240
960 minute summer	2 (PR)	630	0.748	64.6	285.9204
1440 minute summer	3A	1050	0.774	122.2	1815.6390
1440 minute summer	3B	1080	0.776	102.8	1520.9450
960 minute summer	3 (PR)	600	0.753	99.2	113.7122
960 minute summer	4A	735	0.770	56.6	554.1972
2880 minute summer	4 (PR)	1800	0.715	92.9	108.6410
1440 minute summer	OUTFALL	1020	0.100	90.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	2A	2.000	2 (PR)	11.6	
1440 minute summer	2B	1.000	2 (PR)	17.9	
960 minute summer	2 (PR)	1.001	3 (PR)	36.8	
1440 minute summer	3A	3.000	3 (PR)	21.3	
1440 minute summer	3B	4.000	3 (PR)	17.9	
960 minute summer	3 (PR)	1.002	4 (PR)	81.1	
960 minute summer	4A	5.000	4 (PR)	8.8	
2880 minute summer	4 (PR)	1.003	OUTFALL	90.3	10684.8

Results for 100 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.80%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	2A	1080	1.000	78.9	1174.6780
1440 minute summer	2B	1110	1.000	126.7	1960.7690
960 minute summer	2 (PR)	705	0.998	72.8	381.2310
1440 minute summer	3A	1110	1.000	150.8	2344.0520
1440 minute summer	3B	1110	1.000	126.9	1960.4870
960 minute summer	3 (PR)	675	0.995	104.5	150.2181
960 minute summer	4A	765	0.999	70.4	719.1832
4320 minute summer	4 (PR)	2760	0.991	92.7	150.6135
480 minute summer	OUTFALL	288	0.100	90.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	2A	2.000	2 (PR)	11.6	
1440 minute summer	2B	1.000	2 (PR)	17.8	
960 minute summer	2 (PR)	1.001	3 (PR)	36.8	
1440 minute summer	3A	3.000	3 (PR)	21.3	
1440 minute summer	3B	4.000	3 (PR)	17.8	
960 minute summer	3 (PR)	1.002	4 (PR)	81.1	
960 minute summer	4A	5.000	4 (PR)	8.8	
4320 minute summer	4 (PR)	1.003	OUTFALL	90.3	15669.2

Simulation Settings

Rainfall Methodology	FSR	Skip Steady State	x
FSR Region	Scotland and Ireland	Drain Down Time (mins)	240
M5-60 (mm)	16.400	Additional Storage (m^3/ha)	0.0
Ratio-R	0.274	Check Discharge Rate(s)	x
Summer CV	1.000	Check Discharge Volume	x
Analysis Speed	Detailed		

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	20	10	0
2	20	10	0
5	20	10	0
10	20	10	0
30	20	10	0
100	20	10	0

Node 5A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	68.000	Product Number	CTL-SHE-0139-9000-1000-9000
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	9.0	Min Node Diameter (mm)	1200

Node 5 (PR) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	67.000	Product Number	CTL-SHE-0160-1230-1000-1230
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	12.3	Min Node Diameter (mm)	1200

Node 5A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	68.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	959.0	0.0	1.000	959.0	0.0

Node 5 (PR) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	67.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	375

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	150.0	0.0	1.000	150.0	0.0

Results for 1 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	5A	930	0.346	27.8	331.5821
960 minute summer	5 (PR)	585	0.330	16.6	49.4844
960 minute summer	OUTFALL	585	0.068	12.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	5A	1.000	5 (PR)	9.0	
960 minute summer	5 (PR)	1.001	OUTFALL	12.2	502.7

Results for 2 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	5A	930	0.417	32.2	399.4253
960 minute summer	5 (PR)	600	0.391	18.1	58.6716
960 minute summer	OUTFALL	600	0.068	12.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	5A	1.000	5 (PR)	9.0	
960 minute summer	5 (PR)	1.001	OUTFALL	12.3	546.7

Results for 5 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	5A	960	0.510	37.8	489.3045
960 minute summer	5 (PR)	615	0.482	19.9	72.3661
240 minute summer	OUTFALL	264	0.068	12.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	5A	1.000	5 (PR)	9.0	
960 minute summer	5 (PR)	1.001	OUTFALL	12.3	582.3

Results for 10 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	5A	990	0.597	42.6	572.6187
960 minute summer	5 (PR)	630	0.570	21.3	85.5392
2880 minute summer	OUTFALL	1800	0.068	12.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	5A	1.000	5 (PR)	9.0	
960 minute summer	5 (PR)	1.001	OUTFALL	12.3	606.1

Results for 30 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	5A	1080	0.776	51.6	743.7120
720 minute summer	5 (PR)	525	0.753	27.0	113.0159
60 minute summer	OUTFALL	134	0.068	12.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	5A	1.000	5 (PR)	9.0	
720 minute summer	5 (PR)	1.001	OUTFALL	12.3	500.8

Results for 100 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	5A	1110	1.000	63.7	958.5212
960 minute summer	5 (PR)	675	0.996	27.5	149.3266
30 minute summer	OUTFALL	25	0.068	12.3	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	5A	1.000	5 (PR)	9.0	
960 minute summer	5 (PR)	1.001	OUTFALL	12.3	636.8

Simulation Settings

Rainfall Methodology	FSR	Skip Steady State	x
FSR Region	Scotland and Ireland	Drain Down Time (mins)	240
M5-60 (mm)	16.400	Additional Storage (m^3/ha)	0.0
Ratio-R	0.274	Check Discharge Rate(s)	x
Summer CV	1.000	Check Discharge Volume	x
Analysis Speed	Detailed		

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	20	10	0
2	20	10	0
5	20	10	0
10	20	10	0
30	20	10	0
100	20	10	0

Node 6A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	67.000	Product Number	CTL-SHE-0182-1650-1000-1650
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	16.5	Min Node Diameter (mm)	1500

Node 6 (PR) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	66.000	Product Number	CTL-SHE-0185-1710-1000-1710
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	17.1	Min Node Diameter (mm)	1500

Node 6A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	67.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	1796.0	0.0	1.000	1796.0	0.0

Node 6 (PR) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	66.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	540

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	20.0	0.0	1.000	20.0	0.0

Results for 1 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	6A	930	0.355	51.1	638.2138
960 minute summer	6 (PR)	600	0.317	17.2	6.3352
960 minute summer	OUTFALL	600	0.053	17.0	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	6A	1.000	6 (PR)	16.5	
960 minute summer	6 (PR)	1.001	OUTFALL	17.0	736.6

Results for 2 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	6A	930	0.424	59.2	762.3869
960 minute summer	6 (PR)	585	0.364	17.7	7.2817
960 minute summer	OUTFALL	585	0.053	17.1	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	6A	1.000	6 (PR)	16.5	
960 minute summer	6 (PR)	1.001	OUTFALL	17.1	806.6

Results for 5 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	6A	960	0.517	69.5	928.6901
720 minute summer	6 (PR)	465	0.439	18.6	8.7725
1440 minute summer	OUTFALL	780	0.053	17.1	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	6A	1.000	6 (PR)	16.5	
720 minute summer	6 (PR)	1.001	OUTFALL	17.1	680.6

Results for 10 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	6A	990	0.602	78.4	1081.5930
960 minute summer	6 (PR)	600	0.532	18.6	10.6482
720 minute summer	OUTFALL	600	0.053	17.1	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	6A	1.000	6 (PR)	16.5	
960 minute summer	6 (PR)	1.001	OUTFALL	17.1	847.5

Results for 30 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	6A	1080	0.777	95.0	1395.3070
240 minute summer	6 (PR)	480	0.943	22.6	18.8697
60 minute summer	OUTFALL	103	0.053	17.1	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	6A	1.000	6 (PR)	16.5	
240 minute summer	6 (PR)	1.001	OUTFALL	17.1	368.0

Results for 100 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.76%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	6A	1110	1.000	117.2	1795.2080
1440 minute summer	6 (PR)	1050	0.968	18.5	19.3594
60 minute summer	OUTFALL	287	0.053	17.1	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	6A	1.000	6 (PR)	16.5	
1440 minute summer	6 (PR)	1.001	OUTFALL	17.1	1218.4

Simulation Settings

Rainfall Methodology	FSR	Skip Steady State	x
FSR Region	Scotland and Ireland	Drain Down Time (mins)	240
M5-60 (mm)	16.400	Additional Storage (m^3/ha)	0.0
Ratio-R	0.274	Check Discharge Rate(s)	x
Summer CV	1.000	Check Discharge Volume	x
Analysis Speed	Detailed		

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	20	10	0
2	20	10	0
5	20	10	0
10	20	10	0
30	20	10	0
100	20	10	0

Node 7A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	67.000	Product Number	CTL-SHE-0171-1420-1000-1420
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	14.2	Min Node Diameter (mm)	1200

Node 7 (PR) Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	66.000	Product Number	CTL-SHE-0174-1480-1000-1480
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	14.8	Min Node Diameter (mm)	1200

Node 7A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	67.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	1533.0	0.0	1.000	1533.0	0.0

Node 7 (PR) Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	66.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	630

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	14.0	0.0	1.000	14.0	0.0

Results for 1 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	7A	930	0.352	43.9	539.7116
960 minute summer	7 (PR)	585	0.340	14.9	4.7595
960 minute summer	OUTFALL	585	0.072	14.6	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	7A	1.000	7 (PR)	14.2	
960 minute summer	7 (PR)	1.001	OUTFALL	14.6	643.5

Results for 2 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	7A	930	0.422	50.9	646.5808
960 minute summer	7 (PR)	585	0.395	15.4	5.5362
960 minute summer	OUTFALL	585	0.073	14.8	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	7A	1.000	7 (PR)	14.2	
960 minute summer	7 (PR)	1.001	OUTFALL	14.8	701.4

Results for 5 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	7A	960	0.515	59.6	788.9893
720 minute summer	7 (PR)	465	0.496	16.1	6.9393
360 minute summer	OUTFALL	216	0.073	14.8	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	7A	1.000	7 (PR)	14.2	
720 minute summer	7 (PR)	1.001	OUTFALL	14.8	591.0

Results for 10 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	7A	990	0.600	67.3	919.3425
480 minute summer	7 (PR)	720	0.993	17.2	13.9029
120 minute summer	OUTFALL	88	0.073	14.8	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	7A	1.000	7 (PR)	14.2	
480 minute summer	7 (PR)	1.001	OUTFALL	14.8	447.5

Results for 30 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	7A	1080	0.775	81.5	1188.5590
180 minute summer	7 (PR)	420	0.983	20.9	13.7665
60 minute summer	OUTFALL	119	0.073	14.8	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	7A	1.000	7 (PR)	14.2	
180 minute summer	7 (PR)	1.001	OUTFALL	14.8	286.5

Results for 100 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.56%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	7A	1110	0.999	100.7	1532.0640
1440 minute summer	7 (PR)	1020	0.997	16.1	13.9511
60 minute summer	OUTFALL	38	0.073	14.8	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	7A	1.000	7 (PR)	14.2	
1440 minute summer	7 (PR)	1.001	OUTFALL	14.8	1060.9

Simulation Settings

Rainfall Methodology	FSR	Skip Steady State	x
FSR Region	Scotland and Ireland	Drain Down Time (mins)	240
M5-60 (mm)	16.400	Additional Storage (m^3/ha)	0.0
Ratio-R	0.274	Check Discharge Rate(s)	x
Summer CV	1.000	Check Discharge Volume	x
Analysis Speed	Detailed		

Storm Durations

15	60	180	360	600	960	2160	4320	7200	10080
30	120	240	480	720	1440	2880	5760	8640	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	20	10	0
2	20	10	0
5	20	10	0
10	20	10	0
30	20	10	0
100	20	10	0

Node 8A Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	x	Sump Available	✓
Invert Level (m)	67.000	Product Number	CTL-SHE-0165-1320-1000-1320
Design Depth (m)	1.000	Min Outlet Diameter (m)	0.225
Design Flow (l/s)	13.2	Min Node Diameter (mm)	1200

Node 8A Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	67.000
Side Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Time to half empty (mins)	570

Depth (m)	Area (m^2)	Inf Area (m^2)	Depth (m)	Area (m^2)	Inf Area (m^2)
0.000	1451.0	0.0	1.000	1451.0	0.0

Results for 1 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	8A	930	0.360	40.8	522.0942
1440 minute summer	OUTFALL	930	0.071	13.1	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	8A	1.000	OUTFALL	13.1	725.9

Results for 2 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	8A	930	0.429	47.4	621.8341
720 minute summer	OUTFALL	480	0.071	13.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	8A	1.000	OUTFALL	13.2	821.0

Results for 5 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	8A	960	0.520	55.5	754.0192
600 minute summer	OUTFALL	345	0.071	13.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	8A	1.000	OUTFALL	13.2	880.0

Results for 10 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	8A	990	0.604	62.6	876.9419
240 minute summer	OUTFALL	152	0.071	13.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	8A	1.000	OUTFALL	13.2	892.6

Results for 30 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m^3)
1440 minute summer	8A	1080	0.777	75.9	1126.8420
60 minute summer	OUTFALL	60	0.071	13.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m^3)
1440 minute summer	8A	1.000	OUTFALL	13.2	862.5

Results for 100 year +20% CC +10% A Critical Storm Duration. Lowest mass balance: 99.92%

Node Event	US Node	Peak (mins)	Depth (m)	Inflow (l/s)	Node Vol (m³)
1440 minute summer	8A	1110	1.000	93.7	1450.5450
30 minute summer	OUTFALL	32	0.071	13.2	0.0000

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Discharge Vol (m³)
1440 minute summer	8A	1.000	OUTFALL	13.1	927.6

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