MALONE O'REGAN
CONSULTING ENGINEERS

PROPOSED PART 8 RESIDENTIAL DEVELOPMENT BALALLY, SANDYFORD, DUBLIN.

ENGINEERING REPORT

DUN LAOGHAIRE-RATHDOWN COUNTY COUNCIL

Job: 23006

Contents Amendment Record

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MALONE O'REGAN

Title: Proposed Part 8 Residential Development - Balally, Sandyford, Dublin / Engineering Report / Dun Laoghaire-Rathdown County Council

Job Number: 23006

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1 INTRODUCTION

1.1 Introduction

This report is prepared on behalf of the National Development Finance (NDFA) in consultation with Dún Laoghaire-Rathdown County Council for the construction of a residential development on a site located in the townland of Balally, Blackthorn Drive, Sandyford, Dublin 16. The site is bound by Cedar Road to the north, Balally Shopping Centre to the west, Blackthorn Drive to the south and open space to the east.

The proposed development includes:

i. 62 no. apartment units in a 5-6 storey building over undercroft area, including 31 no. one bed units; 21 no. two bed units; and 10 no. three bed units;
ii. 1 no. community facility of 249sqm;
iii. Energy Centre at sixth floor level and an external plant area set back at fifth floor roof level.
iv. Undercroft area at lower ground level comprising (a) 1 no. ESB substation (b) car and bicycle parking; (c) bin storage; (d) bulk storage area; and (e) supporting mechanical, electrical and water infrastructure.
v. Landscaping works including provision of (a) communal open space; (b) new pedestrian and cycle connections linking Blackthorn Dive with Cedar Road; and (c) public realm area fronting onto Blackthorn Drive.
vi. All associated site development works including (a) vehicular access off Cedar Road; (b) pedestrian and cycle access off Blackthorn Drive; (c) public lighting; (d) varied site boundary treatment comprising walls and fencing; and (e) temporary construction signage.

The purpose of this document is to describe the engineering proposals associated with the new development. These proposals are indicated on the drawings prepared by Malone O'Regan which accompany the planning submission. Where reference is made to drawings and drawing numbers within this report these should be taken as meaning those drawings produced by Malone O'Regan unless specifically stated otherwise.

1.2 Site Description

The proposed site is located at Balally, a townland and residential are between Dundrum Village and the Sandyford Industrial Estate. The site is located approximately 8.25km to the south of Dublin City Centre and 1.70km to the southwest of Dundrum as displayed in Figure 1-1.

Figure 1-1– Site Location showing the indicative Site Boundary and Adjacent Developments

There are existing detached two storey houses opposite the development on the southern side of the site on the opposite side of Blackthorn Drive. To the east of the site the new development faces onto the R825 Drummartin Link Road. The west side of the development is facing onto Supervalu Shopping Centre. The proximity of the site to natural watercourses is outlined in Figure 1-2 below.

Figure 1-2 – Surrounding Watercourse (Extract from the EPA Maps)

2 SURFACE WATER DRAINAGE DESIGN

2.1 Introduction

This chapter follows the guidelines set out in Greater Dublin Strategic Drainage Study (GDSDS) and the CIRIA 2015 SuDS Manual.

The aim of any SuDS strategy is to ensure that a new development does not negatively affect surrounding watercourse systems, existing surface water networks and groundwater systems. This SuDS strategy will achieve these aims by using a variety of SuDS measures within the site. These measures include water interception, treatment, infiltration and attenuation.

The SuDS strategy will be developed with the following steps:

1. The existing greenfield run-off of the development site will be calculated and used as the minimum benchmark for the SuDS design. This run-off calculation is based on the drained area of the new development. The post development run-off will not exceed the greenfield run-off.
2. A set of SuDS measures will be chosen based on their applicability and usage for the site.
3. A "FLOW" model will be created to analyse the rainfall on the site and the effectiveness of the proposed SuDS measures.
4. If effective, these SuDS measures will be incorporated into the proposed design.

Table 2.1 outlines the parameters adopted in the design of the surface water drainage infrastructure.

2.2 Existing Services

An existing network of drainage runs around the perimeter of the site on two sides. These underground sewers carry surface water runoff towards existing catchment areas in the Dublin area. Due to the relative levels of the existing drainage within the road and the proposed site levels, it is possible to achieve a gravity connection to the surface water drainage pipework installed. There is a 225mm concrete sewer running parallel to the northeastern boundary of the site. there is a 375mm uPVC running along Blackthorn Drive to the southern side of the site.

Table 2-1 - Surface Water Design Parameters

Parameter Description	Assigned Value
Surface Water Drainage Pipework Design Return Period	2 years (Ref IS EN 752 Table 2 for 'City centres / industrial / commercial areas')
Attenuation Design Return Period	100 years
Allowance for climate change	20% (Ref. OPW Flood Risk Management Climate Change Sectoral Adaptation Plan, High-End Future Scenario)
M5-60	18.2mm (Met Eireann data)
M5-2D	67.9mm (Met Eireann data)
Ratio, r	0.27
Time of Entry	4 min
Pipe roughness, Ks	0.6mm (Ref. GDSDS Volume 2, Table 6.4)
Minimum velocity	1.0 m/s (Ref. GDSDS Volume 2, Table 6.4)

2.3 Proposed Services

The proposed surface water drainage system is designed to comply with the 'Greater Dublin Strategic Drainage Study (GDSDS) Regional Drainage Policies Technical Document – Volume 2, New Developments, 2005' and the 'Greater Dublin Regional Code of Practice for Drainage Works, V6.0 2005'. CIRIA Design Manuals C753, C697 and C609 have also been used to design the surface water drainage system within the site.

The proposed surface water drainage layout for the development is indicated on Malone O'Regan drawings SHB4-BDR-DR-MOR-CS-P3-130, 150 and 151. Surface water runoff from new internal road surfaces, footpaths, other areas of hardstanding and the roofs of buildings will be collected within a gravity drainage network and directed towards an attenuation storage system. The attenuation storage is sized to cater for a 1 in 100-year storm event.

The outfall from the attenuation storage system will be restricted to the applicable 'greenfield' runoff rate using a Hydrobrake flow control device.

A number of sustainable drainage systems (SuDS) are proposed in order to minimise the volume and rate of runoff from the site. Further details on these SuDS measures are provided in Section 2.5.

All surface water drainage will be designed and installed in accordance with the Greater Dublin Regional Code of Practice for Drainage Works.

The runoff coefficients used in the calculations are as outlined in the table 2.2 below.

Table 2-2 - Runoff Coefficients

Type of Areas	CV
Landscaping (Grass / Soft)	0.200
Intensive Green Roof	0.834
Extensive Green Roof	0.917
Blue Roof	0.917
Permeable Paving	0.500
Impermeable Surface (Incl. tree pits)	0.900
Standard Roof (Impermeable)	0.95

Calculations for the Surface Water Pipe Network are provided in Appendix C.

2.4 Permissible Runoff

The regression equation recommended for use by the Greater Dublin Strategic Drainage Study 2005 calculates a value, $QBAR_{rural}$, which is sourced from the Institute of Hydrology Report 124. This value is the mean annual flood flow from a rural catchment in m^3/s and is given by the equation,

$$QBAR_{rural} = 0.00108[Area^{0.89}] \times [SAAR^{1.17}] \times [Soil^{2.17}]$$

Where:

$QBAR_{rural}$	Mean annual flood flow from a rural catchment in m^3/s
Area	Area of the catchment in km^2
SAAR	Standard Average Annual Rainfall in mm.
Soil	Soil index

For catchments smaller than 50 hectares, $QBAR_{rural}$ is first calculated assuming an area of 50ha and then $QBAR_{rural}$ for the site area is calculated on a pro rata basis.

Standard Average Annual Rainfall for the site in Balally was taken from the Flood Studies Report as 997mm.

The 1975 Flood Studies Report included a Soil Index map, a digitised version of which available at www.uksuds.com. This map indicated that the site lies within an area of Soil Type 1, which has a corresponding Standard Percentage Runoff (SPR) coefficient of 0.1. Soil Type 1 is typically described as well drained soil with very low runoff potential.

In December 2023, Causeway Geotech Ltd. completed a comprehensive programme of site investigations for the site. These investigations showed that ground conditions varied across the site. Generally, 100-300mm of topsoil over made ground from 0.3-1m below finished ground level over a firm sandy gravelly clay over bedrock. Bedrock consists of medium strong to strong grey granite at depths of 2-2.5m below finished ground level.

2 no. infiltration tests were conducted across the site. The results of these tests varied with an infiltration rate of f=0.05 to 0.06m/hr for IT01 but no rate was achieved for the second location, the water level dropped too slowly to allow calculation of the soil infiltration rate. The report prepared by Causeway Geotech Ltd. concludes that the site is suitable for soakaway design.

Given the permeable nature of the subsoils it is considered appropriate to adopt a Soil Index value of 2, which has a corresponding Standard Percentage Runoff (SPR) coefficient of 0.3. Soil Type 2 is typically described as permeable soil, sand and gravel with low runoff potential.

When this equation is applied to the proposed development, the following value for $QBAR_{rural}$ is obtained.

For 50ha area $QBAR_{rural}$ $= 0.00108\ [0.5]^{0.89} \times [997]^{1.17} \times [0.3]^{2.17}$

$= 0.138\ m^3/s$

$QBAR_{rural}$ **= 2.757l/s/ha** > 2l/s/ha

$QBAR_{rural}$ for the subject site (overall catchment area) = 2.757 l/s/ha x 0.329ha

$QBAR_{rural}$ **= 0.907l/s**

According to the GDSDS Chapter 6.3.14 if the separate long-term storage cannot be provided and temporary flood storage forms part of the single attenuation system, all the runoff from the site should be discharged at a rate of 2 l/s/ha or the average annual peak flow rate QBAR, whichever is greater. In this case QBAR is the higher value and has been adopted as the limiting discharge rate.

For the purposes of surface water attenuation design, the site is dealt with as one catchment as shown in Figure 2-1 and is draining to an existing catchment/treatment system via existing public sewers. A breakdown of the impermeable areas contributing to the surface water drainage network in each catchment with applied runoff coefficients is provided in Table 2-3 and Table 2-4.

Table 2-3 - Breakdown of Impermeable Areas for Proposed Development for the Main Site

<table>
<tr><th>Total Area sq.m</th><th colspan="2">Type of Surface</th><th>Area sq.m</th><th>Run-off Coefficient</th><th>Equivalent Impermeable</th><th>Urban Creep Allowance</th><th>Overall Impermeable</th></tr>
<tr><td rowspan="3">3289.81</td><td rowspan="2">Roof - Apartments</td><td>Standard - 25%</td><td>312.20</td><td>0.95</td><td>296.59</td><td>326.25</td><td rowspan="3">1314.44</td></tr>
<tr><td>Blue/Green Roof - 75%</td><td></td><td>0.60</td><td>0.00</td><td>0.00</td></tr>
<tr><td colspan="2">Permeable Paving inc. areas from hardstanding</td><td>545.81</td><td>0.50</td><td>272.91</td><td>300.20</td></tr>
<tr><td>ha</td><td colspan="2" rowspan="2">Landscaped Areas inc. areas from hardstanding</td><td rowspan="2">1028.89</td><td rowspan="2">0.20</td><td rowspan="2">205.78</td><td rowspan="2">226.36</td><td>ha</td></tr>
<tr><td rowspan="2">0.329</td><td>0.13</td></tr>
<tr><td colspan="2">Hardstanding</td><td>466.30</td><td>0.90</td><td>419.67</td><td>461.64</td><td></td></tr>
</table>

Table 2-4 - Breakdown of Impermeable Areas for Proposed Development for the Blue/Green Roof

Total Area sq.m	Type of Surface		Area sq.m	Run-off Coefficient	Equivalent Impermeable	Urban Creep Allowance	Overall Impermeable
1248.81	Roof - Apartments	Standard - 25%		0.95	0.00	0.00	618.16
		Blue/Green Roof - 75%	936.61	0.60	561.96	618.16	
	Permeable Paving inc. areas from hardstanding			0.50	0.00	0.00	
ha	Landscaped Areas inc. areas from hardstanding			0.20	0.00	0.00	ha
0.125							0.06
	Hardstanding			0.90	0.00	0.00	

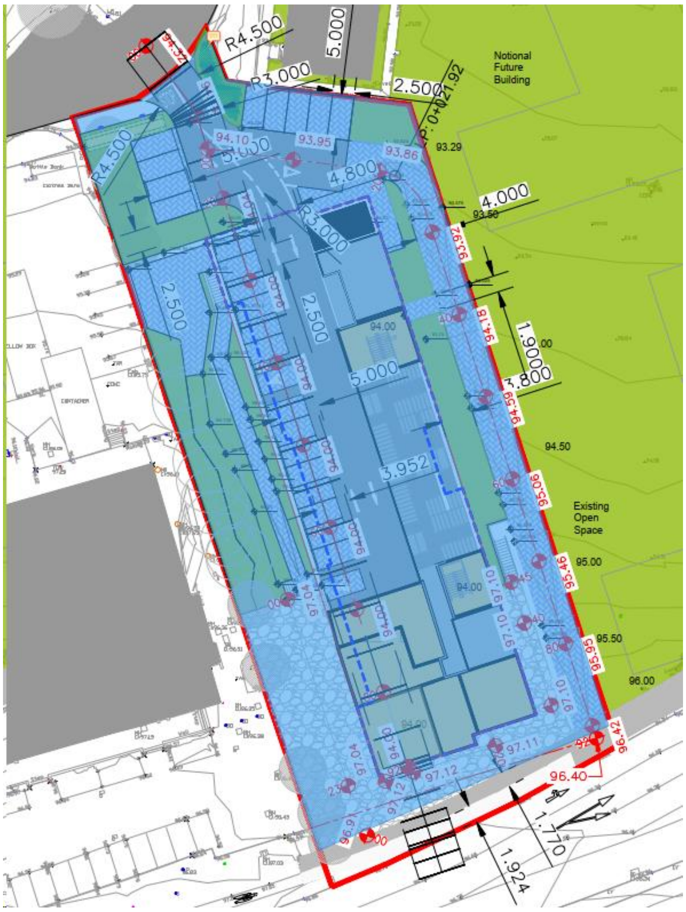


Figure 2-1 – Surface Water Drainage Catchment Area

2.5 Sustainable Drainage Systems (SuDS)

The proposed development will be designed in accordance with the principles of Sustainable Drainage Systems (SuDS) as embodied in the recommendations of the Greater Dublin Strategic Drainage Study (GDSDS) and will significantly reduce run-off rates and improve storm water quality discharging to the public storm water system. The GDSDS addresses the issue of sustainability by requiring designs to comply with a set of drainage criteria which aim to minimize the impact of urbanization by replicating the run-off characteristics of the greenfield site. The criteria provide a consistent approach to addressing the increase in both rate and volume of run-off, as well as ensuring the environment is protected from any pollution from roads and buildings. These drainage design criteria are as follows:

- Criterion 1 – River Water Quality Protection
- Criterion 2 – River Regime Protection
- Criterion 3 – Flood Risk Assessment
- Criterion 4 – River Flood Protection

The requirements of SuDS are typically addressed by provision of the following:

- Interception storage
- Treatment storage (commonly addressed in interception storage)
- Attenuation storage
- Long term storage (not applicable if growth factors are not applied to Qbar when

  designing attenuation storage)

2.5.1 Compliance with the principles of the CIRIA C753 SuDS Manual

The C753 SuDS Manual explains that the primary function of SuDS measures is to protect watercourses from any impact due to the new development. However, SuDS can also improve the quality of life in a new development and urban spaces by making them more vibrant, visually attractive, sustainable and more resilient to change. This document explains the wider social context of SuDS and how SuDS can deliver high quality drainage while supporting urban areas to cope better with sever rainfall both in present and future.

There are four main categories of benefits that can be achieved by SuDS:

1. Water Quantity (mitigate flood risk & protect natural water cycle)
2. Water Quality (manage the quality of the runoff to prevent pollution)
3. Amenity (create and sustain better places for people)
4. Biodiversity (create and sustain better places for nature)

Table 2-5 includes a list of all current SuDS measures which would typically be considered when designing a new residential development such as that which is now proposed. This table also outlines the rationale behind the selection of SuDS measures and why other measures would not be appropriate.

The runoff generated from the catchment will be attenuated in storage structures within and below ground and in the blue roof attenuation systems. The proposed attenuation systems are explained in section 2.5. A wide range of SuDS measures are proposed across the site to maximise interception and treatment.

Table 2-5 - Proposed SuDS Features

SUDS Measure	Measure Adopted?	Rationale for Selecting / Not Selecting Measure
Bioretention Swales *Shallow landscaped depressions that serve to reduce runoff rates / volumes as well as providing interception storage, treatment of runoff and encouraging biodiversity*	Yes	Bioretention swales are proposed in areas beside roads and green spaces within the site.
Tree pits *Attenuate surface water runoff by utilising voids within the root zone*	Yes	Tree pits have been specified in this development.
Green Roofs *Vegetated roofs used to reduce the rate and volume of runoff as well as encouraging biodiversity*	Yes	It is proposed to provide green roofs for flat roofs above apartment buildings.
Blue Roofs *Provide attenuation storage, reducing requirement for storage elsewhere on site*	Yes	It is proposed to provide blue roofs for flat roofs above apartment buildings.
Green Living Walls *Planted walls which improve air quality and encourage biodiversity*	No	Green walls are not considered appropriate given the proposed residential building use.
Rain Gardens *Localised depressions in the ground that collect runoff from roofs/roads and allow infiltration and absorption*	Yes	The proposed residential development will provide rain gardens.
Rainwater harvesting *Runoff captured from roofs is reused for non-potable purposes, thereby reducing overall runoff volume.*	No	In the case of the proposed residential development, it is not considered viable to gather the water for grey water use.
Permeable paving *Allows runoff to percolate into the subsoil, reducing overall runoff volume*	Yes	Permeable paving is proposed within the development for car parking spaces.
Porous asphalt *Allows runoff to percolate into the subsoil, reducing overall runoff volume*	No	Porous asphalt is not considered suitable for use in roads within the development as it does not comply with the Local Authority roads standards.
Integrated Constructed Wetlands (ICWs) *System of shallow ponds, planted to treat water, removing nutrients and harmful impurities*	No	ICWs are not considered appropriate due to the limited space available.

Further details of the principal SuDS features proposed for this development are provided in the following sections

2.5.2 Bioretention Swales

It is proposed to provide a number of discrete, shallow landscaped areas, adjacent to the paved courtyard in the central area of the apartment development. Runoff from the surface will be directed towards these bioretention swales. Refer to the details on drawings SHB4-BDR-DR-MOR-CS-P3-150 and 151. These features will provide a level of storage to attenuate the runoff flows and also permit settlement of coarse silts. As described in Section 2.3 above, the permeability of the underlying soils varies across the site. However, it is anticipated that runoff from minor rainfall events will be able to percolate directly into the soil. An overflow from the swales will be provided. This will take the form of a manhole with an open-grated access cover. During larger storm events, the water in the bioretention areas will be able to overflow through the grated access cover and will then drain towards the attenuation system.

The bioretention swales will be planted in order to promote settlement of silt particles. Runoff will also be treated through the adsorption of particles by vegetation or by soil, and by biological activity. Swales can reduce the runoff rates and volumes of surface water. They are very effective in delivering interception and treatment storage.

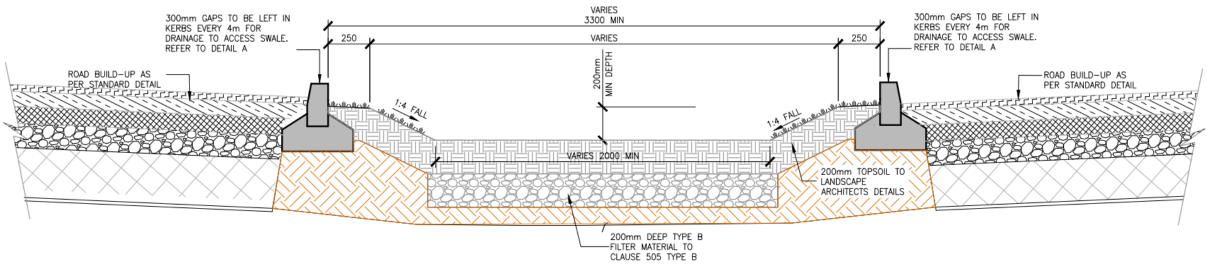


Figure 2-2 - Bio-Retention Area Detail

2.5.3 Tree Pit

It is proposed to provide a number of tree pits adjacent to car parking and footpaths where feasible within the development. Runoff from the roads and footpaths will be directed towards these tree pits. Refer to landscape architects detailed drawings for Tree Pit details.

These features will provide a level of storage to attenuate the runoff flows. It is anticipated that runoff from minor rainfall events will be able to percolate directly into the soil. An overflow from the tree pits will be provided. During larger storm events, the water in the bioretention areas will be able to overflow and drain towards the attenuation system.

The bioretention areas will be planted in order to promote biodiversity. Runoff will also be treated through the adsorption of particles by vegetation or by soil, and by biological activity. Tree pits can reduce the runoff rates and volumes of surface water although the area contributing is small. They are effective in delivering interception and treatment storage.

2.5.4 Intensive Green/ Blue Roofs

As part of the proposed development, it is intended to provide intensive green / blue roofs to appropriate areas of the building. Green roofs provide ecological, aesthetic and amenity benefits and intercept and retain rainfall, at source, reducing the volume of runoff and attenuating peak flows. Details from the suppliers of green roof systems indicate that they will typically provide interception storage of 38 litres per square metre of roof covering.

Green roofs absorb most of the rainfall that they receive during normal rainfall events and treat surface water through removal of atmospherically deposited urban pollutants. They also reduce building heating requirements (by adding mass and thermal resistance value) and cooling requirements (by evaporative cooling). Intensive green roofs typically have a growing medium of 200mm allowing for a wider array of planting possibilities than extensive (sedum) green roof coverings.

The green roofs will be underlaid by a storage medium so that they also perform as blue roofs, capable of attenuating rainwater. The proposed green / blue roofs will provide initial storage of rainwater, while also reducing the rate at which rainwater from heavier rainfall events discharges to the attenuation systems.

Flow restrictor outlets will be provided to control the rate of runoff from the roof. Since the green / blue roofs provide their own attenuation with flow restrictor outlet on the roof, these areas will not drain towards the main attenuation system on site. Runoff from the green / blue roofs will connect to the surface water drainage pipework downstream of the main attenuation system and associated Hydrobrake.

It is proposed to provide intensive green / blue roofs over at least 70% of the total roof area, which exceeds the minimum coverage requirement of 50% as outlined in the Dublin City Council Green & Blue Roof Guidelines 2021. Refer to Figure 2.4 below for Green/ Blue Roof location.

Roof structures will be designed to cater for the additional loads associated with the blue roof storage layer and the overlying green roof build-up. Details of the proposed green / blue roof build-up are provided on Malone O'Regan drawing no. SHB5-BDR-DR-MOR-CS-P3-150 and 151 an extract from which is provided below.

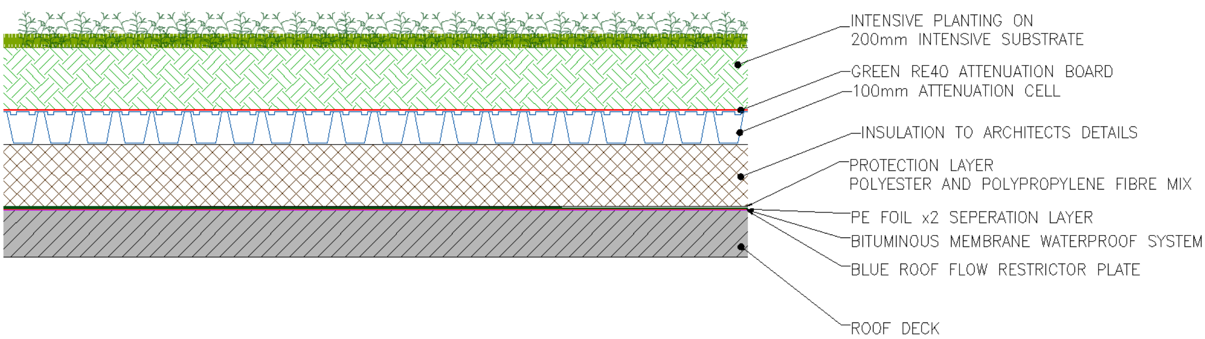


Figure 2-3 – *Typical Intensive Green/ Blue Roof Landscaping*

2.5.5 Rain Garden / Bioretention Area

It is proposed to provide a number of bioretention rain gardens in the green open spaces of the development. A bioretention rain garden employs an engineered topsoil and is used to manage polluted urban rainfall runoff from hard surfaces areas. Refer to the Malone O'Regan SuDS detail drawing no. SHB5-BDR-DR-MOR-CS-P3-151 for typical rain garden detail.

The report prepared by Causeway Geotech imply that the subsoil may be considered suitable media for infiltration. It is anticipated that runoff from minor rainfall events will be able to percolate directly into the soil.

Key design aspects for bioretention raingardens include:

1. Silt collection in forebays to allow for easy removal of silt.
2. Space above the soil profile for water collection and stilling before infiltration through the engineered soil.
3. A surface mulch of organic matter, grit or gravel protects the infiltration capacity of the soil.
4. A free draining soil, typically 450 – 600mm deep, with 20 – 30% organic matter cleans, stores and conveys runoff to a drainage layer.
5. A transition layer of grit and/ or sand protects the under-drained drainage layer.
6. A surface overflow for heavy rain or in the event of blockage.
7. Perforated underdrain pipe.

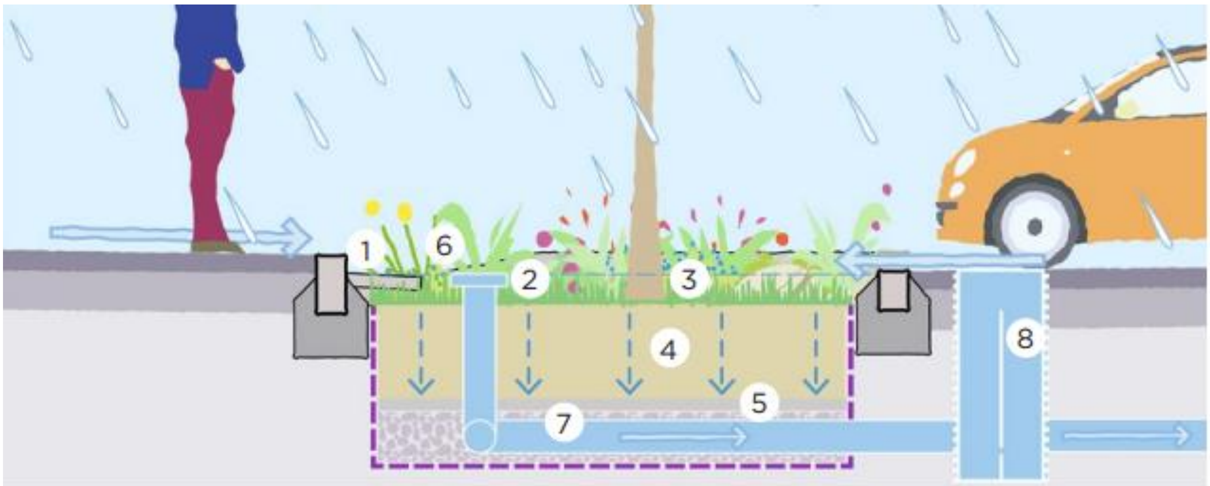


Figure 2.4 – Typical Section through Bioretention Rain Garden
(Extract from South Dublin County Council – Sustainable Drainage Explanatory Design & Evaluation Guide 2022)

2.5.6 Permeable Paving

It is proposed to use permeable paving to surface the private curtilage areas, parking spaces and footpaths in the development. It is anticipated that most of the rainwater will be able to percolate through the permeable paving and infiltrate into the underlying soils. However, it is proposed to provide a number of overflow outlets within the permeable paving build-up which will ensure the permeable area is not flooded during severe rainfall events. The outlet from the permeable paving areas will be raised 100-150mm above formation level to provide interception storage within the stone sub-base; this gives 30mm interception storage @ 30% voids in the gravel.

These permeable surfaces, together with their associated substructures, are an efficient means of managing surface water runoff close to source – intercepting runoff, reducing the volume and frequency of runoff, and providing treatment medium. Refer to the Malone O'Regan SuDS detail drawing no. SHB5-BDR-DR-MOR-CS-P3-151 for typical permeable paving details.

Permeable paving will be provided with a perforated underdrain pipe. The pipe shall be raised above the base of the stone sub-base so that minor accumulations of runoff water can percolate through the stone sub-base. During significant rainfall events, excess water will disperse through the perforated underdrain preventing flooding at surface level. The underdrain will connect to inspection manholes which will facilitate maintenance of the drainage pipework.

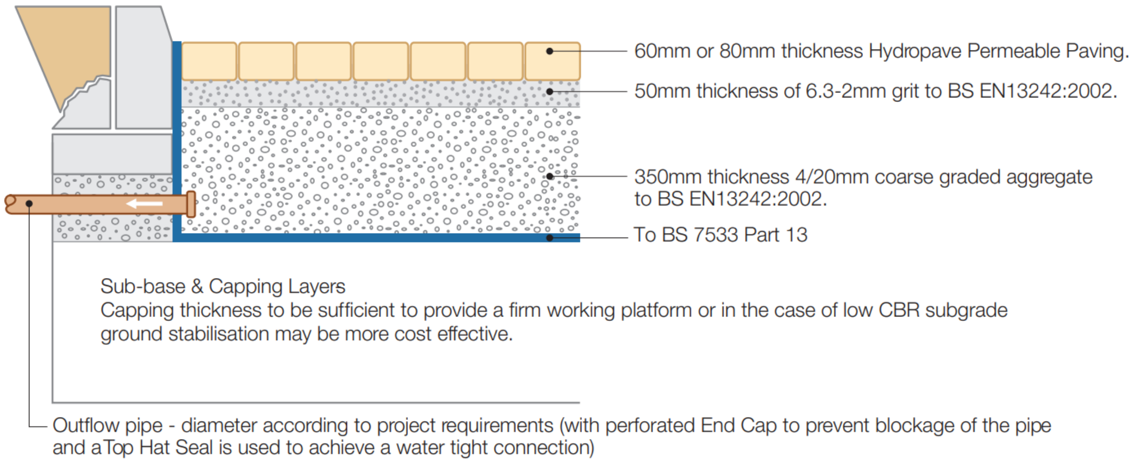


Figure 2-5 - Typical Section Through Permeable Paving in Parking Spaces

2.6 Interception Storage

To prevent pollutants or sediments discharging into watercourses the GDSDS requires "interception storage" to be incorporated into the drainage design for the development. The volume of interception required is based on 5-10mm of rainfall depth from 80% of the runoff from impermeable areas as defined in GDSDS. The interception volume attributable to each SuDS feature consists of the volume of water that can infiltrate to the ground, the quantity that evaporates into the atmosphere and the volume lost through transpiration in plants and vegetation. Additionally, there will be some loses of water due to absorption and wetting of stone and soil media.

The required interception storage and provided interception storage is provided in Appendix B of the report.

2.7 Attenuation Design

Attenuation storage is provided on the site using an attenuation tank. For the purposes of surface water attenuation design, the site is one single catchment as shown in Figure 2-1 draining to the storage system. The volume of surface water storage required has been calculated in accordance with the SuDS Manual Ciria C697, taking account of design invert levels, ground levels and allowable discharge rate. Calculations for the attenuation storage system is provided in Appendix B.

Surface water runoff from the site areas will drain by gravity to an attenuation storage area located in the northern end of the site. The attenuation tank has a calculated storage capacity of 72.60m^3. The calculated 1:100-year flood event is 64.352m^3.

The attenuation volumes have been calculated accommodating a 20% increase in future rainfall intensities as a result of climate change allowing for 10% urban creep. The attenuation storage has been assessed using the average annual peak flow rate QBAR. Based on those calculations, the volume runoff water that will be generated during the 1 in 100-year storm event for the site and the value at which the flow control device will restrict the flow is shown in the table below.

Due to the confined space on the site a natural form of infiltration such as a detention basin was not feasible. The available space could not accommodate the basin and communal open space as required. In the very limited space, it would have allowed for a very deep basin with steep sloping sides which was deemed unsafe within a housing development and so close to a busy retail area. Thus, an underground storage tank was chosen as the main backup for the surface water runoff after passing through permeable paving, swales and rain gardens.

2.8 GDSDS Criterion Compliance

2.8.1 Criterion 1 River Water Quality Protection

Run-off from natural greenfield areas contributes very little pollution and sediment to rivers and for most rainfall events direct run-off from greenfield sites to rivers does not take place as rainfall percolates into the ground. By contrast, urban run-off, when drained by pipe systems, results in run-off from virtually every rainfall event with high levels of pollution, particularly in the first phase of run-off, with little rainfall percolating to the ground. To prevent this happening, Criterion 1 requires that interception storage and/or treatment storage is provided, thereby replicating the run-off characteristics of the pre-development greenfield site.

2.8.2 Criterion 2 River Regine Protection

Attenuation storage is provided to limit the discharge rate from the site into the public network. As per the GDSGS, the required attenuation volume has been calculated for the 1-year, 30-year and 100-year return periods, identifying the critical storm for each – refer to the calculations included in Appendix B.

Standard Average Annual Rainfall for the site in Balally was taken from the Flood Studies Report as 997mm.

The 1975 Flood Studies Report included a Soil Index map, a digitised version of which available at www.uksuds.com. This map indicated that the site lies within an area of Soil Type 1, which has a corresponding Standard Percentage Runoff (SPR) coefficient of 0.1. Soil Type 1 is typically described as well drained soil with very low runoff potential.

In December 2023, Causeway Geotech Ltd. completed a comprehensive programme of site investigations for the site. These investigations showed that ground conditions varied across the site. Generally, 100-300mm of topsoil over made ground from 0.3-1m below finished ground level over a firm sandy gravelly clay over bedrock. Bedrock consists of medium strong to strong grey granite at depths of 2-2.5m below finished ground level.

2 no. infiltration tests were conducted across the site. The results of these tests varied with an infiltration rate of f=0.05 to 0.06m/hr for IT01 but no rate was achieved for the second location, the water level dropped too slowly to allow calculation of the soil infiltration rate. The report prepared by Causeway Geotech Ltd. concludes that the site is suitable for soakaway design.

Given the permeable nature of the subsoils it is considered appropriate to adopt a Soil Index value of 2, which has a corresponding Standard Percentage Runoff (SPR) coefficient of 0.3. Soil Type 2 is typically described as permeable soil, sand and gravel with low runoff potential.

Based on these calculations, the 1:100year flood event calculated is 64.352m^3. The attenuation tank has a storage capacity of 72.60m^3.

Surface water runoff will be restricted via a Hydro-brake or similar approved flow control device with discharge from the site limited to the greenfield equivalent rate of 0.907l/s, before discharging to the public sewer.

2.8.3 Criterion 3 Site Flooding

The GDSDS requires that no flooding should occur on site for storms up to and including the 1 in 30-year event. The pipe network and the attenuation storage volumes should, therefore, be checked for such storms to ensure that no site flooding occurs although partial surcharging of the system is allowed if it does not threaten to flood.

For the 1 in 100-year event, the pipe network can fully surcharge and cause the site flooding, but the top water level due to any such flooding must be at least 500mm below any vulnerable internal floor levels, and the flood waters should be contained within the site. In addition, the top water level in any attenuation device during the 100-year storm must be at least 500mm below any vulnerable internal floor levels.

Surface water drains have been sized to ensure the following:

- The system does not surcharge for the 2-year event.
- The system surcharges but does not flood for the 30-year event,
- The system surcharges but does not flood for the 100-year event.
- Detailed modelling of the surface water sewer network has been carried out using the Causeway Flow software to confirm the above criteria is adequately met. The outputs of the Causeway flow report are included in Appendix C for Surface Water calculations and Appendix D for Foul Water calculations.

2.8.4 Criterion 4 River Flood Protection

The long-term storage volume is a comparison of pre- and post- development runoff volumes. The objective is to limit the runoff discharged after development to the same as that which occurred prior to the development.

Of the three methods described in the GDSDS for establishing River Flood Protection by comparison of the pre- and post- development runoff volumes, (Criteria 4.1, 4.2 and 4.3 respectively), Criteria 4.3 is selected for use as the most practical criteria at this stage in the design.

The Criteria 4.3 approach is for all runoff to be limited to either QBAR or to 2l/s/ha, whichever is greater. As noted in Section 2.4, in this instance, the QBAR is greater than 2l/s/ha and has been adopted as the limiting discharge rate.

The proposed drainage system includes a flow control device to ensure that the discharge rate is limited to the greenfield equivalent and ample attenuation is provided for the 1 in 100-year flood event, accounting for 20% increase due to climate change.

2.9 Enhanced Biodiversity

Bioretention areas will be included as part of the proposed development. Biodiversity has been carefully considered when determining both the location and the detailed design of these elements. The proposed bioretention area offers the opportunity to create a planted vegetation zone for plants and animals which will encourage biodiversity on the site.

2.10 SuDS CIRIA Pillars of Design

2.10.1 Water Quantity

The "Water Quantity" design objective is to ensure that the surface water runoff from a developed site does not have a detrimental impact on people, property, or the environment, it is important to control:

- How fast the runoff is discharged from the site (i.e., the peak runoff rate) and
- How much runoff is discharged from the site (i.e., the runoff volume)

2.10.2 Water Quality

The "Water Quality" design objective seeks to ensure the surface water runoff from the site does not compromise the groundwater or surrounding water courses relating to the site.

2.10.3 Amenity

The "Amenity" design objective aims to deliver attractive, pleasant, useful and above all liveable urban environments. SuDS measures should be designed to replicate the existing natural environment and blend in with the urban development.

MOR have worked closely with the landscaping architect throughout the SuDS strategy design process to ensure that the measures which have been suggested and incorporated have a high sense of public use. Throughout the site, there are green roofs, bio-retention areas and tree pits.

2.10.4 Biodiversity

The encouragement of biodiverse environments within urban environments is incredibly important. The SuDS measures must not only replicate the pre-development surface water runoff systems and treatment for rainfall, but they should also aim to replicate the existing habitats from the pre- development stage.

By incorporating large, landscaped areas, green/blue roofs throughout the site and the bio-retention areas, biodiversity on site is promoted.

2.10.5 SuDS Conclusion

This section of the report has comprehensively discussed the various SuDS measures which can be applied to the site and then selected the applicable systems, based on the site layout. A wide range of measures have been employed.

Finally, the chosen SuDS measures have been analysed for various rainfall scenarios to ensure that all the SuDS design criteria are met an extensive range of SuDS measures are proposed with extensive coverage of the developed area of the site. These measures will be effective in treating rainfall on the site to meet GDSDS and CIRIA.

2.11 Maintenance and Management Plan

Refer to appendix E for details of maintenance requirements for individual SuDS drainage measures on the site.

2.12 Potential Future Expansion

No future expansion has been considered for the proposed drainage networks for the development.

3 FOUL WATER DRAINAGE DESIGN

3.1 General

The foul water drainage infrastructure has been designed in accordance with Irish Water Technical Standard for Wastewater Gravity Sewers (Document Number: IW-TEC-800-01) and the Irish Water Code of Practice for Wastewater Infrastructure (Document Number: IW-CDS-5030-03).

A Pre-Connection Enquiry Form was submitted to Irish Water in respect of this development. Irish Water provided a Confirmation of Feasibility (CoF) letter was received on the 28th of May 2024, this CoF confirms that, subject to a valid connection agreement being put in place, the proposed connection to the public sewer network can be facilitated. The letter further notes that Irish Water have reviewed the wastewater characteristics and hydraulic discharge load and determined that the connection was feasible subject to upgrades.

A Copy of the Irish Water Confirmation of Feasibility Letter is provided in Appendix A.

Table 3-1 outlines the parameters adopted in the design of the foul and process water drainage infrastructure.

Table 3-1 - Foul Water Design Parameters

Parameter Description	Assigned Value
Hydraulic Loading (Foul associated with domestic)	150 litres / person / day
Pipe Friction	1.5 mm
Minimum Velocity	0.7 m/s
Maximum Velocity	3.0 m/s
Peaking Factor (for domestic foul flows only)	6.0

Calculations for the foul and process water pipe networks are provided in Appendix D.

3.2 Existing Services

An existing network of drainage runs around the perimeter of the site on two sides. These underground sewers carry foul water towards existing treatment areas in the Dublin area. Due to the relative levels of the existing drainage within the road and the proposed site levels, it is possible to achieve a gravity connection to the foul water drainage pipework installed. There is a 225mm uPVC sewer running parallel to the southern boundary on the Blackthorn Drive. There is also a 450mm concrete sewer running 90deg across Blackthorn Drive and running diagonally along the site from the southern end to the northeastern boundary connecting in to a 225mm concrete sewer.

3.3 Proposed Services

The proposed foul water drainage system is designed to comply with the 'Greater Dublin Strategic Drainage Study (GDSDS) Regional Drainage Policies Technical Document – Volume 2, New Developments, 2005' and the 'Greater Dublin Regional Code of Practice for Drainage Works, V6.0 2005'.

The proposed foul water drainage layout for the development is indicated on Malone O'Regan drawings SHB4-BDR-DR-MOR-CS-P3-130. Foul water from new housing units will be collected within a gravity drainage network and directed towards the existing public sewer system.

3.4 Foul Water Demand Calculations

3.4.1 Residential Foul Water Demand

In accordance with the Irish Water Code of Practice for Wastewater Infrastructure works which carry domestic wastewater shall be designed to carry a wastewater volume of between 6 times the dry weather flow.

Dry weather flow (DWF) should be taken as 446 litres per dwelling.

DWF = 62 units x 446 l/dwelling = 27,652 l/day = **0.320 l/sec**

Peak discharge = 6 x DWF = **1.920 l/sec**

3.4.2 Community Centre/ Retail Commercial Foul Water Demand

There is provision of 1no. community facility of 249m^2.

The average and peak water demand rates were calculated in accordance with the Irish Water Code of Practice for Water Infrastructure guidelines which assumes a loading rater of 40 l/person/day for a Local Community Sports Club.

Total persons = 125 people (Assumed 1 person per 2m^2 of floor area)

Average water demand = 40litres/person/day

Total daily discharge = 125 people x 40litres/person/day = 5000 litres/day

Average Hour Demand = 5000 litres/day / (24hr x 60min x 60sec)
= **0.058 l/s**

In accordance with Table 2.7 Commercial Peaking Factors, the peaking factor applied to commercial wastewater flow for an area of 0 – 5.5ha is 4.5 x DWF.

Peak discharge = 4.5 x DWF = **0.260 l/s**

Average and peak discharge rates for all existing and proposed developments are summarised in the Table below.

Development Description	Average Demand (l/s)	Peak Demand (l/s)
Proposed development of residential units	0.320	1.920
Community Centre/ Retail Commercial	0.058	0.260
Total	**0.378**	**2.180**

Table 3.2 – Average and Peak Foul Discharge Rates for All Developments

3.5 Potential Future Expansion

No future expansion has been considered for the proposed drainage networks for the development.

4 WATER SUPPLY

4.1 General

The Proposed Development will use mains water. The proposed water supply infrastructure has been designed in accordance with the Irish Water Code of Practice for Water Infrastructure (Document Number: IW-CDS-5020-03).

A Pre-Connection Enquiry Form was submitted to Irish Water in respect of this development. Irish Water provided a Confirmation of Feasibility (CoF) letter was received on the 28th of May 2024, which confirms that, subject to a valid connection agreement being put in place, the proposed connection to the public water supply network can be facilitated. A Copy of the Irish Water Confirmation of Feasibility Letter is provided in Appendix A.

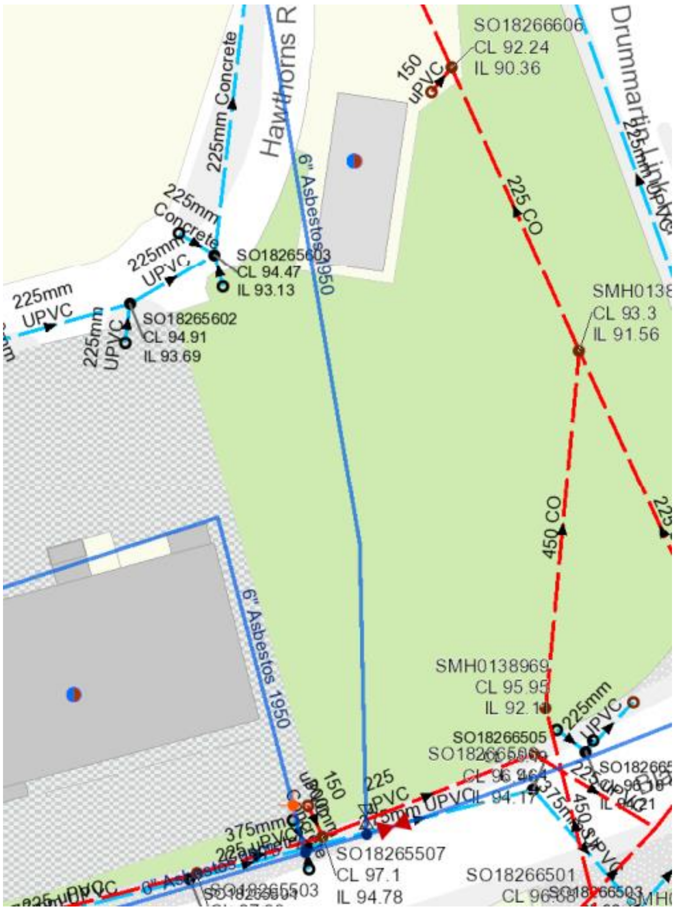


Figure 4-1 - Extract from Irish Water maps

4.2 Existing & Proposed Services

A 150mm diameter asbestos watermain is located running diagonally across the site. It is proposed to use this watermain and divert it around the new building as required.

The proposed watermain layout is indicated on drawing SHB4-BDR-DR-MOR-CS-P3-140 which accompanies this planning application.

4.3 Water Demand Calculations

4.3.1 Residential Water Demand

The average and peak water demand rates were calculated in accordance with the Irish Water Code of Practice for Water Infrastructure guidelines which assumes a loading rate of 150 litres per person per day and an occupancy rate of 2.7 persons per dwelling.

The average day/ peak week demand is taken as 1.25 times the average daily domestic demand. The peak demand is taken to be 5 times the average day/ peak week demand.

Total Daily Water Demand = 62 units x 2.7 persons x 150 litres per day per person
= 25,110 litres/day

Average Hour Demand = 25,110 litres/day / (24hr x 60min x 60sec)
= 0.291 litres/sec

Average Day / Peak Week Demand = 0.291 litres/sec x 1.25
= **0.363 litres/sec**

Peak Demand = 5 x 0.363 litres/sec = **1.816 litres/sec**

4.3.2 Community Centre/ Retail Commercial Foul Water Demand

There is provision of 1no. community facility of 249m^2.

The average and peak water demand rates were calculated in accordance with the Irish Water Code of Practice for Water Infrastructure guidelines which assumes a loading rater of 40 l/person/day for a Local Community Sports Club.

Total persons = 125 people (Assumed 1 person per 2m^2 of floor area)

Average water demand = 40litres/person/day

Total daily discharge = 125 people x 40litres/person/day = 5000 litres/day = 0.058 litres/sec

Average Day Peak Week Demand = 1.25 x 0.058 = **0.072 litres/sec**

Peak Demand = 5 x 0.072 = **0.362 litres/sec**

Average and peak discharge rates for the proposed development is summarised in the Table below.

Development Description	Average Demand (l/s)	Peak Demand (l/s)
Proposed development of residential units	0.363	1.816
Community Centre/ Retail Commercial	0.072	0.362
Total	**0.435**	**2.178**

Table 4.1 – Average and Peak Discharge Rates for All Developments

APPENDIX A – IRISH WATER CONFIRMATION OF FEASIBILITY

CONFIRMATION OF FEASIBILITY

Ray O'Connor

Malone O'Regan
2B Richview Office Park
Clonskeagh
Dublin 14
D14 XT57

Uisce Éireann
Bosca OP 448
Oifig Sheachadta na
Cathrach Theas
Cathair Chorcaí

Uisce Éireann
PO Box 448
South City
Delivery Office
Cork City

www.water.ie

28 May 2024

Our Ref: CDS23009025 Pre-Connection Enquiry
New Apartments at Balally, Ceddar Road, Dublin 16, Dublin

Dear Applicant/Agent,

We have completed the review of the Pre-Connection Enquiry.

Uisce Éireann has reviewed the pre-connection enquiry in relation to a Water & Wastewater connection for a Multi/Mixed Use Development of 63 unit(s) at New Apartments at Balally, Ceddar Road, Dublin 16, Dublin, (the **Development)**.

Based upon the details provided we can advise the following regarding connecting to the networks;

- **Water Connection** - Feasible without infrastructure upgrade by Uisce Éireann

- The proposed Development indicates that Uisce Éireann assets are present on the site. The Developer has to demonstrate that proposed structures and works will not inhibit access for maintenance or endanger structural or functional integrity of the assets during and after the works. Drawings (showing clearance distances, changing to ground levels) and Method Statements should be included in the Detailed Design of the Development. A wayleave in favour of Uisce Éireann will be required over the assets that are not located within the Public Space. For design submissions and queries related to diversion/build near or over, please contact UÉ Diversion Team via email address diversions@water.ie

- **Wastewater Connection** - Feasible Subject to upgrades

- In order to accommodate the proposed connection at the Premises, upgrade works are required downstream of the site. Uisce Éireann currently has a project on our current investment plan which will provide the necessary upgrade and capacity. Estimated completion date for the project is Q3 2027 (subject to change).
- Exact connection point for the Development will be determined at a connection application stage.

This letter does not constitute an offer, in whole or in part, to provide a connection to any Uisce Éireann infrastructure. Before the Development can be connected to our network(s) you must submit a connection application and be granted and sign a connection agreement with Uisce Éireann.

As the network capacity changes constantly, this review is only valid at the time of its completion. As soon as planning permission has been granted for the Development, a completed connection application should be submitted. The connection application is available at www.water.ie/connections/get-connected/

Where can you find more information?

- **Section A -** What is important to know?
- **Section B -** Details of Uisce Éireann's Network(s)

This letter is issued to provide information about the current feasibility of the proposed connection(s) to Uisce Éireann's network(s). This is not a connection offer and capacity in Uisce Éireann's network(s) may only be secured by entering into a connection agreement with Uisce Éireann.

For any further information, visit **www.water.ie/connections**, **email newconnections@water.ie** or contact 1800 278 278**.**

Yours sincerely,

Dermot Phelan
Connections Delivery Manager

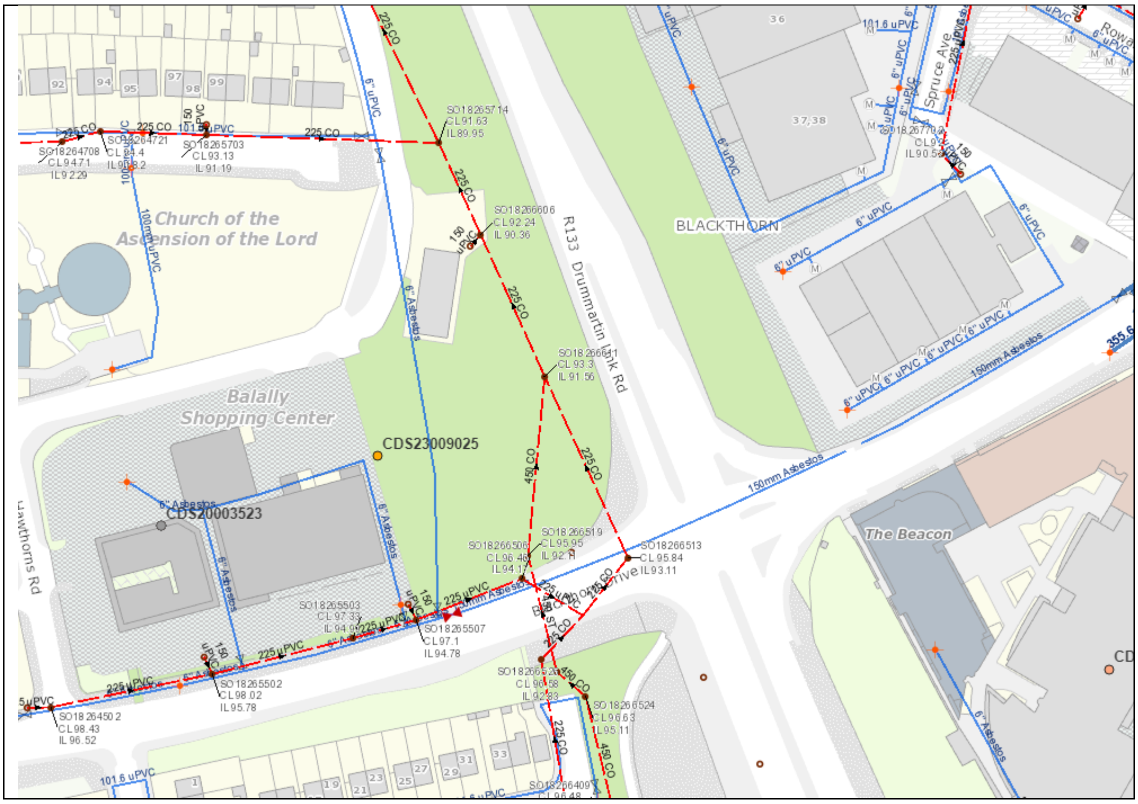
Section A - What is important to know?

What is important to know?	Why is this important?
Do you need a contract to connect?	• Yes, a contract is required to connect. This letter does not constitute a contract or an offer in whole or in part to provide a connection to Uisce Éireann's network(s). • Before the Development can connect to Uisce Éireann's network(s), you must submit a connection application and be granted and sign a connection agreement with Uisce Éireann.
When should I submit a Connection Application?	• A connection application should only be submitted after planning permission has been granted.
Where can I find information on connection charges?	• Uisce Éireann connection charges can be found at: https://www.water.ie/connections/information/charges/
Who will carry out the connection work?	• All works to Uisce Éireann's network(s), including works in the public space, must be carried out by Uisce Éireann*. *Where a Developer has been granted specific permission and has been issued a connection offer for Self-Lay in the Public Road/Area, they may complete the relevant connection works
Fire flow Requirements	• The Confirmation of Feasibility does not extend to fire flow requirements for the Development. Fire flow requirements are a matter for the Developer to determine. • **What to do?** - Contact the relevant Local Fire Authority
Plan for disposal of storm water	• The Confirmation of Feasibility does not extend to the management or disposal of storm water or ground waters. • **What to do?** - Contact the relevant Local Authority to discuss the management or disposal of proposed storm water or ground water discharges.
Where do I find details of Uisce Éireann's network(s)?	• Requests for maps showing Uisce Éireann's network(s) can be submitted to: datarequests@water.ie

What are the design requirements for the connection(s)?	• The design and construction of the Water & Wastewater pipes and related infrastructure to be installed in this Development shall comply with ***the Uisce Éireann Connections and Developer Services Standard Details and Codes of Practice,*** available at www.water.ie/connections
Trade Effluent Licensing	• Any person discharging trade effluent** to a sewer, must have a Trade Effluent Licence issued pursuant to section 16 of the Local Government (Water Pollution) Act, 1977 (as amended). • More information and an application form for a Trade Effluent License can be found at the following link: https://www.water.ie/business/trade-effluent/about/ **trade effluent is defined in the Local Government (Water Pollution) Act, 1977 (as amended)

Section B – Details of Uisce Éireann's Network(s)

The map included below outlines the current Uisce Éireann infrastructure adjacent the Development: To access Uisce Éireann Maps email datarequests@water.ie



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Note: The information provided on the included maps as to the position of Uisce Éireann's underground network(s) is provided as a general guide only. The information is based on the best available information provided by each Local Authority in Ireland to Uisce Éireann.

Whilst every care has been taken in respect of the information on Uisce Éireann's network(s), Uisce Éireann assumes no responsibility for and gives no guarantees, undertakings or warranties concerning the accuracy, completeness or up to date nature of the information provided, nor does it accept any liability whatsoever arising from or out of any errors or omissions. This information should not be solely relied upon in the event of excavations or any other works being carried out in the vicinity of Uisce Éireann's underground network(s). The onus is on the parties carrying out excavations or any other works to ensure the exact location of Uisce Éireann's underground network(s) is identified prior to excavations or any other works being carried out. Service connection pipes are not generally shown but their presence should be anticipated.

APPENDIX B – ATTENUATION VOLUME CALCULATIONS

Job Title	B5 03 Balally	Job no.	23006
By:	Kezia Adanza	Checked by:	
Date		Rev number	

Part 1 **Permissible Runoff**

The regression equation recommended for use by the Greater Dublin Strategic Drainage Study 2005 calculates a value, QBARural, which is sourced from the Institute of Hydrology Report 124. This value is the mean annual flood flow from a rural catchment in m^3/s and is given by the equation:

QBARrural = 0.00108[Area^0.89] x [SAAR^1.17] x [Soil^2.17]

Rainfall Data	
M5-60 (1 hour - 5 years) mm	18.2
M5-2D (2 days - 5 years) mm	67.9
Ratio "r" (M5-60/ M5-2D)	0.27
SAAR mm	997
Soil/ SPR mm	0.3

For 50 Ha Area ~ QBARrural =	0.138	m^3/s	
For 0.329 Ha Area ~ QBARrural =	2.757	l/s/ha	Discharge should be limited to QBAR or 2 l/s/ha
For 0.329 Ha Area ~ QBARrural =	0.907	l/s	whichever is greater.

Part 2 **Impermeable Area**

Breakdown of the impermeable areas contributing to the surface water drainage network in each catchment with applied runoff coeifficients is provided in the table below

Total Area sq.m	Type of Surface		Area sq.m	Run-off Coefficient	Equivalent Impermeable	Urban Creep Allowance	Overall Impermeable
3289.81	Roof - Apartments	Standard - 25%	312.20	0.95	296.59	326.25	1314.44
		Blue/Green Roof - 75%		0.60	0.00	0.00	
	Permeable Paving inc. areas from hardstanding		545.81	0.50	272.91	300.20	
ha	Landscaped Areas inc. areas from hardstanding		1028.89	0.20	205.78	226.36	ha
0.329							0.13
	Hardstanding		466.30	0.90	419.67	461.64	

Part 3 **Attenuation Volume Required**

1 in 10 Years								
Time	%	M5	Growth	Area	MT	Inflow	Outflow	Capacity Required
			Factor (10 Years)	Factor	Factor	"I"	"O"	"I"-"O" ="S"
note	1	2	3	4	5	6	7	8
1 min	3.3	2.2	1.15	1	2.577	3.387	0.054410859	3.333
2min	5.7	3.9	1.16	1	4.490	5.901	0.108821717	5.792
5 min	10.3	7.0	1.18	1	8.253	10.848	0.272054293	10.575
10 min	14.8	10.0	1.18	1	11.858	15.587	0.544108587	15.043
15 min	17.7	12.0	1.18	1	14.182	18.641	0.81616288	17.825
30 min	23.3	15.8	1.18	1	18.668	24.539	1.63232576	22.906
60 min	30	20.4	1.17	1	23.833	31.327	3.264651521	28.062
2 hour	38	25.8	1.16	1	29.930	39.342	6.529303042	32.812
4 hour	48	32.6	1.15	1	37.481	49.266	13.05860608	36.208
6 hour	55	37.3	1.14	1	42.573	55.960	19.58790913	36.372
12 hour	68	46.2	1.14	1	52.636	69.187	39.17581825	30.011
24 hour	85	57.7	1.13	1	65.218	85.725	78.3516365	7.374
48 hour	106	72.0	1.12	1	80.611	105.958	156.703273	-50.745
Size of Attenuation for 1 in 10 year flood event m³								**36.372**

1 in 30 Years								
Time	%	M5	Growth	Area	MT	Inflow	Outflow	Capacity Required
			Factor (30 Years)	Factor	Factor	"I"	"O"	"I"-"O" ="S"
note	1	2	3	4	5	6	7	8
1 min	3.3	2.2	1.39	1	3.115	4.094	0.054410859	4.040
2min	5.7	3.9	1.41	1	5.457	7.173	0.108821717	7.064
5 min	10.3	7.0	1.44	1	10.071	13.238	0.272054293	12.966
10 min	14.8	10.0	1.46	1	14.672	19.285	0.544108587	18.741
15 min	17.7	12.0	1.48	1	17.787	23.380	0.81616288	22.564
30 min	23.3	15.8	1.49	1	23.573	30.985	1.63232576	29.353
60 min	30	20.4	1.48	1	30.148	39.627	3.264651521	36.363
2 hour	38	25.8	1.47	1	37.929	49.855	6.529303042	43.326
4 hour	48	32.6	1.45	1	47.258	62.118	13.05860608	49.060
6 hour	55	37.3	1.44	1	53.777	70.686	19.58790913	51.099
12 hour	68	46.2	1.42	1	65.564	86.180	39.17581825	47.005
24 hour	85	57.7	1.38	1	79.647	104.691	78.3516365	26.339
48 hour	106	72.0	1.34	1	96.445	126.771	156.703273	-29.932
Size of Attenuation for 1 in 30 year flood event m³								**51.099**

1 in 100 Years								
Time	%	M5	Growth	Area	MT	Inflow	Outflow	Capacity Required
			Factor (30 Years)	Factor	Factor	"I"	"O"	"I"-"O" ="S"
note	1	2	3	4	5	6	7	8
1 min	3.3	2.2	1.87	1	4.190	5.508	0.054410859	5.453
2min	5.7	3.9	1.88	1	7.276	9.564	0.108821717	9.455
5 min	10.3	7.0	1.97	1	13.778	18.110	0.272054293	17.838
10 min	14.8	10.0	1.98	1	19.897	26.154	0.544108587	25.610
15 min	17.7	12.0	1.95	1	23.436	30.805	0.81616288	29.989
30 min	23.3	15.8	1.91	1	30.218	39.719	1.63232576	38.087
60 min	30	20.4	1.85	1	37.685	49.534	3.264651521	46.269
2 hour	38	25.8	1.78	1	45.928	60.369	6.529303042	53.840
4 hour	48	32.6	1.73	1	56.384	74.114	13.05860608	61.055
6 hour	55	37.3	1.71	1	63.860	83.940	19.58790913	64.352
12 hour	68	46.2	1.62	1	74.799	98.318	39.17581825	59.143
24 hour	85	57.7	1.58	1	91.190	119.863	78.3516365	41.512
48 hour	106	72.0	1.53	1	110.120	144.747	156.703273	-11.957
Size of Attenuation for 1 in 100 year flood event m³								**64.352**

Part 4 **Interception Storage**

To prevent pollitant or sediments discharging into water courses the GDSDS required "interception storage" to be incorporated into the drainage design for the development. The volume of interception required is based on the 5-10mm of rainfall depth from 80% of the runoff from impermeable areas. The interception volume attributable to each of the SuDS features consists of the volyme of water that can infiltrate to the ground, the quanity that evaporates into the atmosphere and the volyme lost through transpiration in plants and vegitation. Additionally, there will be some loses of water due to absorption and westting of stone and soil media.

Required Interception Storage

Overall Impermeable area is 1314.4 m² including 10% for urban creep

Therefore, the total interception storage required is 'overall impermeable area x 80% x 0.005 x 1.2 for climate change' 6.31 m³

Interception Storage Provided *Only fill in SuDS on your site

Permeable Paving	Area	383.8	m²
	Stone Layer 100mm deep	0.1	m
	Void Ratio	30%	
	Storage Volume	11.5149	m³

*Storage depth will depend on your site

Swale	Area	12.0	m²
	*75mm	0.075	m
	Storage Volume	0.9	m³

Bio-Retention Area/ Raingarden	Area	16.0	m²
	Depth of subgrade	0.075	m
	Storage Volume	1.2	m³

Total interception volume provided for the overall site 13.61 m³
which exceeds the required volume calculated of 6.31 m³

Job Title	B5 03 Balally - Blue/Green Roof	Job no.	23006
By:	Kezia Adanza	Checked by:	
Date		Rev number	

Part 1 **Permissible Runoff**

The regression equation recommended for use by the Greater Dublin Strategic Drainage Study 2005 calculates a value, QBARural, which is sourced from the Institute of Hydrology Report 124. This value is the mean annual flood flow from a rural catchment in m³/s and is given by the equation:

QBARrural = 0.00108[Area^0.89] x [SAAR^1.17] x [Soil^2.17]

Rainfall Data	
M5-60 (1 hour - 5 years) mm	18.2
M5-2D (2 days - 5 years) mm	67.9
Ratio "r" (M5-60/ M5-2D)	0.27
SAAR mm	997
Soil/ SPR mm	0.3

For 50 Ha Area ~ QBARrural =	0.138	m³/s	
For 0.329 Ha Area ~ QBARrural =	2.757	l/s/ha	Discharge should be limited to QBAR or 2 l/s/ha
For 0.329 Ha Area ~ QBARrural =	0.344	l/s	whichever is greater.

Part 2 **Impermeable Area**

Breakdown of the impermeable areas contributing to the surface water drainage network in each catchment with applied runoff coeifficients is provided in the table below

Total Area sq.m	Type of Surface		Area sq.m	Run-off Coefficient	Equivalent Impermeable	Urban Creep Allowance	Overall Impermeable
1248.81	Roof - Apartments	Standard - 25%		0.95	0.00	0.00	618.16
		Blue/Green Roof - 75%	936.61	0.60	561.96	618.16	
	Permeable Paving inc. areas from hardstanding			0.50	0.00	0.00	
ha	Landscaped Areas inc. areas from hardstanding			0.20	0.00	0.00	ha
0.125							0.06
	Hardstanding			0.90	0.00	0.00	

Part 3 **Attenuation Volume Required**

1 in 10 Years								
Time	%	M5	Growth	Area	MT	Inflow	Outflow	Capacity Required
			Factor (10 Years)	Factor	Factor	"I"	"O"	"I"-"O" ="S"
note	1	2	3	4	5	6	7	8
1 min	3.3	2.2	1.15	1	2.577	1.593	0.020654331	1.572
2min	5.7	3.9	1.16	1	4.490	2.775	0.041308662	2.734
5 min	10.3	7.0	1.18	1	8.253	5.101	0.103271655	4.998
10 min	14.8	10.0	1.18	1	11.858	7.330	0.206543309	7.124
15 min	17.7	12.0	1.18	1	14.182	8.767	0.309814964	8.457
30 min	23.3	15.8	1.18	1	18.668	11.540	0.619629928	10.920
60 min	30	20.4	1.17	1	23.833	14.733	1.239259856	13.493
2 hour	38	25.8	1.16	1	29.930	18.502	2.478519711	16.023
4 hour	48	32.6	1.15	1	37.481	23.169	4.957039423	18.212
6 hour	55	37.3	1.14	1	42.573	26.317	7.435559134	18.882
12 hour	68	46.2	1.14	1	52.636	32.538	14.87111827	17.666
24 hour	85	57.7	1.13	1	65.218	40.315	29.74223654	10.573
48 hour	106	72.0	1.12	1	80.611	49.830	59.48447307	-9.654
Size of Attenuation for 1 in 10 year flood event m³								**18.882**

1 in 30 Years								
Time	%	M5	Growth	Area	MT	Inflow	Outflow	Capacity Required
			Factor (30 Years)	Factor	Factor	"I"	"O"	"I"-"O" ="S"
note	1	2	3	4	5	6	7	8
1 min	3.3	2.2	1.39	1	3.115	1.925	0.020654331	1.905
2min	5.7	3.9	1.41	1	5.457	3.373	0.041308662	3.332
5 min	10.3	7.0	1.44	1	10.071	6.225	0.103271655	6.122
10 min	14.8	10.0	1.46	1	14.672	9.070	0.206543309	8.863
15 min	17.7	12.0	1.48	1	17.787	10.995	0.309814964	10.685
30 min	23.3	15.8	1.49	1	23.573	14.572	0.619629928	13.952
60 min	30	20.4	1.48	1	30.148	18.636	1.239259856	17.397
2 hour	38	25.8	1.47	1	37.929	23.446	2.478519711	20.968
4 hour	48	32.6	1.45	1	47.258	29.213	4.957039423	24.256
6 hour	55	37.3	1.44	1	53.777	33.243	7.435559134	25.807
12 hour	68	46.2	1.42	1	65.564	40.529	14.87111827	25.658
24 hour	85	57.7	1.38	1	79.647	49.234	29.74223654	19.492
48 hour	106	72.0	1.34	1	96.445	59.619	59.48447307	0.134
Size of Attenuation for 1 in 30 year flood event m³								**25.807**

1 in 100 Years								
Time	%	M5	Growth	Area	MT	Inflow	Outflow	Capacity Required
			Factor (30 Years)	Factor	Factor	"I"	"O"	"I"-"O" ="S"
note	1	2	3	4	5	6	7	8
1 min	3.3	2.2	1.87	1	4.190	2.590	0.020654331	2.570
2min	5.7	3.9	1.88	1	7.276	4.498	0.041308662	4.457
5 min	10.3	7.0	1.97	1	13.778	8.517	0.103271655	8.413
10 min	14.8	10.0	1.98	1	19.897	12.300	0.206543309	12.093
15 min	17.7	12.0	1.95	1	23.436	14.487	0.309814964	14.177
30 min	23.3	15.8	1.91	1	30.218	18.679	0.619629928	18.060
60 min	30	20.4	1.85	1	37.685	23.295	1.239259856	22.056
2 hour	38	25.8	1.78	1	45.928	28.391	2.478519711	25.912
4 hour	48	32.6	1.73	1	56.384	34.854	4.957039423	29.897
6 hour	55	37.3	1.71	1	63.860	39.476	7.435559134	32.040
12 hour	68	46.2	1.62	1	74.799	46.238	14.87111827	31.366
24 hour	85	57.7	1.58	1	91.190	56.370	29.74223654	26.628
48 hour	106	72.0	1.53	1	110.120	68.072	59.48447307	8.588
Size of Attenuation for 1 in 100 year flood event m³								**32.040**

Part 4 Interception Storage

To prevent pollitant or sediments discharging into water courses the GDSDS required "interception storage" to be incorporated into the drainage design for the development. The volume of interception required is based on the 5-10mm of rainfall depth from 80% of the runoff from impermeable areas. The interception volume attributable to each of the SuDS features consists of the volyme of water that can infiltrate to the ground, the quanity that evaporates into the atmosphere and the volyme lost through transpiration in plants and vegitation. Additionally, there will be some loses of water due to absorption and westting of stone and soil media.

<u>Required Interception Storage</u>

Overall Impermeable area is 618.2 m^2 including 10% for urban creep

Therefore, the total interception storage required is 'overall impermeable area x 80% x 0.005 x 1.2 for climate change' 2.97 m^3

<u>Interception Storage Provided</u> *Only fill in SuDS on your site

Green Roof A 'Bauder Sedume' or equivalent design to retain 30 l/m^2 of rainwater will be used on roof level	Area	936.6	m^2
	Interception Store 30 l/m^2	0.03	l/m^2
	Storage Volume	28.10	m^3

Total interception volume provided for the overall site 28.10 m^3
which exceeds the required volume calculated of 2.97 m^3

APPENDIX C – SURFACE WATER PIPE NETWORK CALCULATIONS

Drainage Design Report

Flow+

v10.8

Network	Storm Network
Filename	2024-07-24 Flow.pfd
Username	Kezia Adanza
Last analysed	24/07/2024 14:26:57
Report produced on	24/07/2024 14:28:57

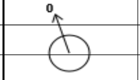
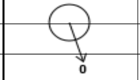
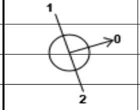
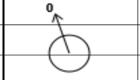
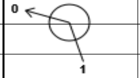
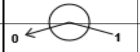
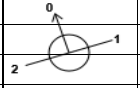
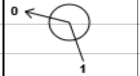
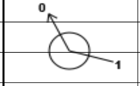
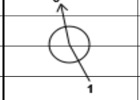
Rainfall Methodology	FSR
Return Period (years)	2
Additional Flow (%)	0
FSR Region	Scotland and Ireland
M5-60 (mm)	18.200
Ratio-R	0.270
CV	1.000
Time of Entry (mins)	4.00
Maximum Time of Concentration (mins)	30.00
Maximum Rainfall (mm/hr)	50.0
Minimum Velocity (m/s)	1.00
Connection Type	Level Inverts
Minimum Backdrop Height (m)	0.500
Preferred Cover Depth (m)	1.000
Include Intermediate Ground	No
Enforce best practice design rules	No

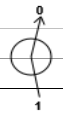
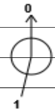
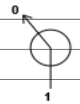
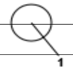
	Name	Area (ha)	T of E (mins)	Add Inflow (l/s)	Cover Level (m)	Node Type	Manhole Type	Diameter (mm)	Width (mm)	Sump (m)	Easting (m)	Northing (m)	Depth (m)	Notes
✓	SW01	0.019	4.00		97.040	Manhole	Adoptable	1200			718510.684	726591.773	1.225	
✓	SW02	0.019	4.00		94.200	Manhole	Adoptable	1200			718486.322	726667.018	1.225	
✓	SW03	0.019	4.00		94.200	Manhole	Adoptable	1200			718490.094	726655.369	1.298	
✓	SW04	0.019	4.00		96.230	Manhole	Adoptable	1200			718541.085	726600.462	1.225	
✓	SW05	0.019	4.00		93.870	Manhole	Adoptable	1200			718521.017	726662.444	1.225	
✓	SW06	0.019	4.00		93.870	Manhole	Adoptable	1200			718516.357	726663.872	1.300	
✓	SW07	0.019	4.00		93.930	Manhole	Adoptable	1200			718508.591	726661.357	1.394	
✓	SW08				93.930	Manhole	Adoptable	1200			718507.658	726664.238	1.407	
✓	SW09				94.140	Manhole	Adoptable	1200			718497.525	726667.040	1.660	
✓	SW10-HB				94.200	Manhole	Adoptable	1200			718494.285	726673.506	1.750	
✓	SW11				93.960	Manhole	Adoptable	1200			718492.698	726681.893	1.561	
✓	SW12				92.590	Manhole	Adoptable	1200			718497.169	726702.046	1.225	
✓	SW13				92.325	Manhole	Adoptable	1200			718497.135	726718.265	1.225	
✓	EXSW MH				92.170	Manhole	Adoptable	1200			718493.808	726722.670	1.225	

	Name	US Node	DS Node	Length (m)	ks (mm) / n	Velocity Equation	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	Link Type	T of C (mins)	Rain (mm/hr)	Con Offset (m)	Min DS IL (m)	Lateral Area (ha)	Lateral Ins Point (%)	Lateral T of E (mins)
✓	1.000	SW01	SW03	66.846	0.600	Colebrook-White	95.815	92.902	2.913	22.9	225	Circular	4.41	50.0					
✓	2.000	SW02	SW03	12.244	0.600	Colebrook-White	92.975	92.902	0.073	167.7	225	Circular	4.20	50.0					
✓	1.001	SW03	SW07	19.442	0.600	Colebrook-White	92.902	92.536	0.366	53.1	225	Circular	4.59	50.0					
✓	3.000	SW04	SW05	65.150	0.600	Colebrook-White	95.005	92.645	2.360	27.6	225	Circular	4.43	50.0					
✓	3.001	SW05	SW06	4.874	0.600	Colebrook-White	92.645	92.570	0.075	65.0	225	Circular	4.48	50.0					
✓	3.002	SW06	SW07	8.163	0.600	Colebrook-White	92.570	92.536	0.034	240.1	300	Circular	4.62	50.0					
✓	1.002	SW07	SW08	3.028	0.600	Colebrook-White	92.536	92.523	0.013	232.9	300	Circular	4.67	50.0					
✓	1.003	SW08	SW09	10.513	0.600	Colebrook-White	92.523	92.480	0.043	244.5	300	Circular	4.84	50.0					
✓	1.004	SW09	SW10-HB	7.232	0.600	Colebrook-White	92.480	92.450	0.030	241.1	300	Circular	4.96	50.0					
✓	1.005	SW10-HB	SW11	8.536	0.600	Colebrook-White	92.450	92.399	0.051	167.4	225	Circular	5.10	50.0					
✓	1.006	SW11	SW12	20.643	0.600	Colebrook-White	92.399	91.365	1.034	20.0	225	Circular	5.22	50.0					
✓	1.007	SW12	SW13	16.219	0.600	Colebrook-White	91.365	91.100	0.265	61.2	225	Circular	5.38	50.0					
✓	1.008	SW13	EXSW MH	5.520	0.600	Colebrook-White	91.100	90.945	0.155	35.6	225	Circular	5.42	50.0					

	Name	US Node	DS Node	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Minimum Depth (m)	Maximum Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)	Notes
✓	1.000	SW01	SW03	2.743	109.1	3.4	1.000	1.073	1.000	1.073	0.019	0.0	27	1.245	Fall increased to remove backdrop
✓	2.000	SW02	SW03	1.006	40.0	3.4	1.000	1.073	1.000	1.073	0.019	0.0	44	0.619	
✓	1.001	SW03	SW07	1.798	71.5	10.3	1.073	1.169	1.073	1.169	0.057	0.0	58	1.289	Fall increased to remove backdrop
✓	3.000	SW04	SW05	2.499	99.4	3.4	1.000	1.000	1.000	1.000	0.019	0.0	29	1.180	
✓	3.001	SW05	SW06	1.625	64.6	6.9	1.000	1.075	1.000	1.075	0.038	0.0	50	1.070	
✓	3.002	SW06	SW07	1.010	71.4	10.3	1.000	1.094	1.000	1.094	0.057	0.0	76	0.723	
✓	1.002	SW07	SW08	1.026	72.5	24.0	1.094	1.107	1.094	1.107	0.133	0.0	119	0.924	
✓	1.003	SW08	SW09	1.001	70.7	24.0	1.107	1.360	1.107	1.360	0.133	0.0	120	0.908	
✓	1.004	SW09	SW10-HB	1.008	71.2	24.0	1.360	1.450	1.360	1.450	0.133	0.0	120	0.912	
✓	1.005	SW10-HB	SW11	1.008	40.1	24.0	1.525	1.336	1.336	1.525	0.133	0.0	126	1.053	
✓	1.006	SW11	SW12	2.941	117.0	24.0	1.336	1.000	1.000	1.336	0.133	0.0	69	2.329	
✓	1.007	SW12	SW13	1.674	66.6	24.0	1.000	1.000	1.000	1.000	0.133	0.0	94	1.544	
✓	1.008	SW13	EXSW MH	2.199	87.4	24.0	1.000	1.000	1.000	1.000	0.133	0.0	80	1.884	

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)	US Node	Dia (mm)	Width (mm)	Sump (m)	Node Type	MH Type	DS Node	Dia (mm)	Width (mm)	Sump (m)	Node Type	MH Type
1.000	66.846	22.9	225	Circular	97.040	95.815	1.000	94.200	92.902	1.073	SW01	1200			Manhole	Adoptable	SW03	1200			Manhole	Adoptable
2.000	12.244	167.7	225	Circular	94.200	92.975	1.000	94.200	92.902	1.073	SW02	1200			Manhole	Adoptable	SW03	1200			Manhole	Adoptable
1.001	19.442	53.1	225	Circular	94.200	92.902	1.073	93.930	92.536	1.169	SW03	1200			Manhole	Adoptable	SW07	1200			Manhole	Adoptable
3.000	65.150	27.6	225	Circular	96.230	95.005	1.000	93.870	92.645	1.000	SW04	1200			Manhole	Adoptable	SW05	1200			Manhole	Adoptable
3.001	4.874	65.0	225	Circular	93.870	92.645	1.000	93.870	92.570	1.075	SW05	1200			Manhole	Adoptable	SW06	1200			Manhole	Adoptable
3.002	8.163	240.1	300	Circular	93.870	92.570	1.000	93.930	92.536	1.094	SW06	1200			Manhole	Adoptable	SW07	1200			Manhole	Adoptable
1.002	3.028	232.9	300	Circular	93.930	92.536	1.094	93.930	92.523	1.107	SW07	1200			Manhole	Adoptable	SW08	1200			Manhole	Adoptable
1.003	10.513	244.5	300	Circular	93.930	92.523	1.107	94.140	92.480	1.360	SW08	1200			Manhole	Adoptable	SW09	1200			Manhole	Adoptable
1.004	7.232	241.1	300	Circular	94.140	92.480	1.360	94.200	92.450	1.450	SW09	1200			Manhole	Adoptable	SW10-HB	1200			Manhole	Adoptable
1.005	8.536	167.4	225	Circular	94.200	92.450	1.525	93.960	92.399	1.336	SW10-HB	1200			Manhole	Adoptable	SW11	1200			Manhole	Adoptable
1.006	20.643	20.0	225	Circular	93.960	92.399	1.336	92.590	91.365	1.000	SW11	1200			Manhole	Adoptable	SW12	1200			Manhole	Adoptable
1.007	16.219	61.2	225	Circular	92.590	91.365	1.000	92.325	91.100	1.000	SW12	1200			Manhole	Adoptable	SW13	1200			Manhole	Adoptable
1.008	5.520	35.6	225	Circular	92.325	91.100	1.000	92.170	90.945	1.000	SW13	1200			Manhole	Adoptable	EXSW MH	1200			Manhole	Adoptable

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Width (mm)	Sump (m)	Node Type	MH Type	Connections		Link	IL (m)	Dia (mm)	Link Type
SW01	718510.684	726591.773	97.040	1.225	1200			Manhole	Adoptable						
											0	1.000	95.815	225	Circular
SW02	718486.322	726667.018	94.200	1.225	1200			Manhole	Adoptable						
											0	2.000	92.975	225	Circular
SW03	718490.094	726655.369	94.200	1.298	1200			Manhole	Adoptable		1	2.000	92.902	225	Circular
											2	1.000	92.902	225	Circular
											0	1.001	92.902	225	Circular
SW04	718541.085	726600.462	96.230	1.225	1200			Manhole	Adoptable						
											0	3.000	95.005	225	Circular
SW05	718521.017	726662.444	93.870	1.225	1200			Manhole	Adoptable		1	3.000	92.645	225	Circular
											0	3.001	92.645	225	Circular
SW06	718516.357	726663.872	93.870	1.300	1200			Manhole	Adoptable		1	3.001	92.570	225	Circular
											0	3.002	92.570	300	Circular
SW07	718508.591	726661.357	93.930	1.394	1200			Manhole	Adoptable		1	3.002	92.536	300	Circular
											2	1.001	92.536	225	Circular
											0	1.002	92.536	300	Circular
SW08	718507.658	726664.238	93.930	1.407	1200			Manhole	Adoptable		1	1.002	92.523	300	Circular
											0	1.003	92.523	300	Circular
SW09	718497.525	726667.040	94.140	1.660	1200			Manhole	Adoptable		1	1.003	92.480	300	Circular
											0	1.004	92.480	300	Circular
SW10-HB	718494.285	726673.506	94.200	1.750	1200			Manhole	Adoptable		1	1.004	92.450	300	Circular
											0	1.005	92.450	225	Circular

SW11	718492.698	726681.893	93.960	1.561	1200			Manhole	Adoptable		1	1.005	92.399	225	Circular
											0	1.006	92.399	225	Circular
SW12	718497.169	726702.046	92.590	1.225	1200			Manhole	Adoptable		1	1.006	91.365	225	Circular
											0	1.007	91.365	225	Circular
SW13	718497.135	726718.265	92.325	1.225	1200			Manhole	Adoptable		1	1.007	91.100	225	Circular
											0	1.008	91.100	225	Circular
EXSW MH	718493.808	726722.670	92.170	1.225	1200			Manhole	Adoptable		1	1.008	90.945	225	Circular

Rainfall Methodology	FSR		Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
FSR Region	Scotland and Ireland		2	20	0	0
M5-60 (mm)	18.200		30	20	0	0
Ratio-R	0.270		100	20	0	0
Summer CV	1.000					
Winter CV	1.000					
Analysis Speed	Normal					
Skip Steady State	No					
Drain Down Time (mins)	240					
Additional Storage (m³/ha)	20.0					
Storm Durations (mins)	15					
	30					
	60					
	120					
	180					
	240					
	360					
	480					
	600					
	720					
	960					
	1440					
	2160					
	2880					
	4320					
	5760					
	7200					
	8640					
	10080					
Check Discharge Rate(s)	No					
Check Discharge Volume	No					
100 year 360 minute (m³)						

Hydro-Brake®													
Node	Flap Valve	Online / Offline	Downstream Link	Replaces Downstream Link	Loop to Node	Invert Level (m)	Design Depth (m)	Design Flow (l/s)	Objective	Sump Available	Product Number	Min Outlet Diameter (m)	Min Node Diameter (mm)
SW10-HB	No	Online		Yes		92.450	1.000	0.9	(HE) Minimise upstream storage	Yes	CTL-SHE-0044-9000-1000-9000	0.075	1200

Depth/Area/Inf Area									
Node	**Base Inf Coefficient (m/hr)**	**Side Inf Coefficient (m/hr)**	**Safety Factor**	**Porosity**	**Invert Level (m)**	**Time to half empty (mins)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
SW08	0.00000	0.00000	2.0	1.00	92.523		0.000	113.0	0.0
							0.760	113.0	0.0
							0.761	0.0	0.0

Default Values			Overrides					
Entry Loss (manhole)	0.250		**Link**	**Entry Loss**	**Exit Loss**		**Node**	**Flood Risk (m)**
Exit Loss (manhole)	0.250							
Entry Loss (junction)	0.000							
Exit Loss (junction)	0.000							
Apply Recommended Losses	No							
Flood Risk (m)	0.300							

Node Size	Yes
Node Losses	Yes
Link Size	Yes
Minimum Diameter (mm)	150
Link Length	Yes
Maximum Length (m)	100.000
Coordinates	Yes
Accuracy (m)	1.000
Crossings	Yes
Cover Depth	Yes
Minimum Cover Depth (m)	
Maximum Cover Depth (m)	3.000
Backdrops	Yes
Minimum Backdrop Height (m)	
Maximum Backdrop Height (m)	1.500
Full Bore Velocity	Yes
Minimum Full Bore Velocity (m/s)	
Maximum Full Bore Velocity (m/s)	3.000
Proportional Velocity	Yes
Return Period (years)	
Minimum Proportional Velocity (m/s)	0.750
Maximum Proportional Velocity (m/s)	3.000
Surcharged Depth	Yes
Return Period (years)	
Maximum Surcharged Depth (m)	0.100
Flooding	Yes
Return Period (years)	30
Time to Half Empty	No
Return Period (years)	
Discharge Rates	Yes
Discharge Volume	Yes
100 year 360 minute (m^3)	

Event	Peak Intensity (mm/hr)	Average Intensity (mm/hr)
2 year +20% CC 15 minute summer	140.671	39.805
2 year +20% CC 15 minute winter	98.717	39.805
2 year +20% CC 30 minute summer	96.813	27.395
2 year +20% CC 30 minute winter	67.939	27.395
2 year +20% CC 60 minute summer	69.122	18.267
2 year +20% CC 60 minute winter	45.923	18.267
2 year +20% CC 120 minute summer	44.940	11.876
2 year +20% CC 120 minute winter	29.857	11.876
2 year +20% CC 180 minute summer	35.797	9.212
2 year +20% CC 180 minute winter	23.269	9.212
2 year +20% CC 240 minute summer	29.148	7.703
2 year +20% CC 240 minute winter	19.365	7.703
2 year +20% CC 360 minute summer	23.137	5.954
2 year +20% CC 360 minute winter	15.040	5.954
2 year +20% CC 480 minute summer	18.761	4.958
2 year +20% CC 480 minute winter	12.465	4.958
2 year +20% CC 600 minute summer	15.727	4.302
2 year +20% CC 600 minute winter	10.746	4.302
2 year +20% CC 720 minute summer	14.293	3.831
2 year +20% CC 720 minute winter	9.606	3.831
2 year +20% CC 960 minute summer	12.116	3.190
2 year +20% CC 960 minute winter	8.026	3.190
2 year +20% CC 1440 minute summer	9.164	2.456
2 year +20% CC 1440 minute winter	6.159	2.456
2 year +20% CC 2160 minute summer	6.838	1.890
2 year +20% CC 2160 minute winter	4.712	1.890
2 year +20% CC 2880 minute summer	5.856	1.569
2 year +20% CC 2880 minute winter	3.935	1.569
2 year +20% CC 4320 minute summer	4.607	1.204
2 year +20% CC 4320 minute winter	3.034	1.204

2 year +20% CC 5760 minute summer	3.895	0.997
2 year +20% CC 5760 minute winter	2.521	0.997
2 year +20% CC 7200 minute summer	3.375	0.861
2 year +20% CC 7200 minute winter	2.179	0.861
2 year +20% CC 8640 minute summer	2.997	0.765
2 year +20% CC 8640 minute winter	1.934	0.765
2 year +20% CC 10080 minute summer	2.712	0.692
2 year +20% CC 10080 minute winter	1.750	0.692
30 year +20% CC 15 minute summer	259.519	73.435
30 year +20% CC 15 minute winter	182.118	73.435
30 year +20% CC 30 minute summer	178.067	50.387
30 year +20% CC 30 minute winter	124.959	50.387
30 year +20% CC 60 minute summer	124.409	32.878
30 year +20% CC 60 minute winter	82.654	32.878
30 year +20% CC 120 minute summer	79.323	20.963
30 year +20% CC 120 minute winter	52.700	20.963
30 year +20% CC 180 minute summer	62.197	16.006
30 year +20% CC 180 minute winter	40.430	16.006
30 year +20% CC 240 minute summer	49.913	13.191
30 year +20% CC 240 minute winter	33.161	13.191
30 year +20% CC 360 minute summer	38.951	10.023
30 year +20% CC 360 minute winter	25.319	10.023
30 year +20% CC 480 minute summer	31.183	8.241
30 year +20% CC 480 minute winter	20.717	8.241
30 year +20% CC 600 minute summer	25.871	7.076
30 year +20% CC 600 minute winter	17.677	7.076
30 year +20% CC 720 minute summer	23.309	6.247
30 year +20% CC 720 minute winter	15.665	6.247
30 year +20% CC 960 minute summer	19.485	5.131
30 year +20% CC 960 minute winter	12.907	5.131
30 year +20% CC 1440 minute summer	14.499	3.886
30 year +20% CC 1440 minute winter	9.745	3.886
30 year +20% CC 2160 minute summer	10.637	2.940

30 year +20% CC 2160 minute winter	7.329	2.940
30 year +20% CC 2880 minute summer	8.992	2.410
30 year +20% CC 2880 minute winter	6.043	2.410
30 year +20% CC 4320 minute summer	6.961	1.820
30 year +20% CC 4320 minute winter	4.584	1.820
30 year +20% CC 5760 minute summer	5.824	1.491
30 year +20% CC 5760 minute winter	3.769	1.491
30 year +20% CC 7200 minute summer	5.006	1.277
30 year +20% CC 7200 minute winter	3.231	1.277
30 year +20% CC 8640 minute summer	4.411	1.125
30 year +20% CC 8640 minute winter	2.847	1.125
30 year +20% CC 10080 minute summer	3.964	1.011
30 year +20% CC 10080 minute winter	2.558	1.011
100 year +20% CC 15 minute summer	337.357	95.460
100 year +20% CC 15 minute winter	236.742	95.460
100 year +20% CC 30 minute summer	232.344	65.745
100 year +20% CC 30 minute winter	163.048	65.745
100 year +20% CC 60 minute summer	161.195	42.599
100 year +20% CC 60 minute winter	107.094	42.599
100 year +20% CC 120 minute summer	101.792	26.901
100 year +20% CC 120 minute winter	67.628	26.901
100 year +20% CC 180 minute summer	79.294	20.405
100 year +20% CC 180 minute winter	51.543	20.405
100 year +20% CC 240 minute summer	63.317	16.733
100 year +20% CC 240 minute winter	42.067	16.733
100 year +20% CC 360 minute summer	49.049	12.622
100 year +20% CC 360 minute winter	31.883	12.622
100 year +20% CC 480 minute summer	39.055	10.321
100 year +20% CC 480 minute winter	25.947	10.321
100 year +20% CC 600 minute summer	32.265	8.825
100 year +20% CC 600 minute winter	22.046	8.825
100 year +20% CC 720 minute summer	28.969	7.764
100 year +20% CC 720 minute winter	19.469	7.764

100 year +20% CC 960 minute summer	24.084	6.342
100 year +20% CC 960 minute winter	15.954	6.342
100 year +20% CC 1440 minute summer	17.784	4.766
100 year +20% CC 1440 minute winter	11.952	4.766
100 year +20% CC 2160 minute summer	12.939	3.576
100 year +20% CC 2160 minute winter	8.915	3.576
100 year +20% CC 2880 minute summer	10.870	2.913
100 year +20% CC 2880 minute winter	7.305	2.913
100 year +20% CC 4320 minute summer	8.338	2.180
100 year +20% CC 4320 minute winter	5.491	2.180
100 year +20% CC 5760 minute summer	6.929	1.774
100 year +20% CC 5760 minute winter	4.485	1.774
100 year +20% CC 7200 minute summer	5.925	1.511
100 year +20% CC 7200 minute winter	3.824	1.511
100 year +20% CC 8640 minute summer	5.199	1.326
100 year +20% CC 8640 minute winter	3.355	1.326
100 year +20% CC 10080 minute summer	4.655	1.188
100 year +20% CC 10080 minute winter	3.005	1.188

Results for 2 year +20% CC Critical Storm Duration. Lowest mass balance: 98.81%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m^3)	Flood (m^3)	Status	Link Event (Upstream Depth)	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m^3)	Discharge Vol (m^3)	Notes
15 minute summer	SW01	10	95.847	0.032	4.9	0.0466	0.0000	OK	15 minute summer	1.000	SW03	4.9	0.748	0.045	0.4551		
15 minute summer	SW02	10	93.029	0.054	4.9	0.0776	0.0000	OK	15 minute summer	2.000	SW03	4.9	0.574	0.123	0.1065		
15 minute summer	SW03	10	92.970	0.068	14.7	0.0970	0.0000	OK	15 minute summer	1.001	SW07	14.4	0.770	0.201	0.4322		
15 minute summer	SW04	10	95.039	0.034	4.9	0.0487	0.0000	OK	15 minute summer	3.000	SW05	4.9	0.728	0.049	0.5539		
2160 minute summer	SW05	1680	92.822	0.177	0.8	0.2546	0.0000	OK	2160 minute summer	3.001	SW06	0.8	0.318	0.013	0.1784		
2160 minute summer	SW06	1680	92.822	0.252	1.2	0.3581	0.0000	OK	2160 minute summer	3.002	SW07	1.3	0.210	0.018	0.5401		
2160 minute summer	SW07	1680	92.822	0.286	2.9	0.4011	0.0000	OK	2160 minute summer	1.002	SW08	2.9	0.522	0.040	0.2113		
2160 minute summer	SW08	1680	92.822	0.299	2.9	34.0862	0.0000	OK	2160 minute summer	1.003	SW09	0.9	0.226	0.013	0.7399		
2160 minute summer	SW09	1680	92.823	0.343	0.9	0.3878	0.0000	SURCHARGED	2160 minute summer	1.004	SW10-HB	1.0	0.112	0.014	0.5093		Surcharge due to flow behind Hydrobrake-Acceptable
2160 minute summer	SW10-HB	1680	92.820	0.370	1.0	0.4185	0.0000	SURCHARGED	2160 minute summer	Hydro-Brake®	SW11	0.7					Surcharge due to flow behind Hydrobrake-Acceptable
15 minute summer	SW11	12	92.412	0.013	0.7	0.0145	0.0000	OK	15 minute summer	1.006	SW12	0.7	0.998	0.006	0.0233		
15 minute summer	SW12	13	91.382	0.017	0.7	0.0194	0.0000	OK	15 minute summer	1.007	SW13	0.7	0.647	0.011	0.0201		
30 minute summer	SW13	65	91.115	0.015	0.7	0.0170	0.0000	OK	30 minute summer	1.008	EXSW MH	0.7	0.660	0.008	0.0061	10.9	
30 minute summer	EXSW MH	65	90.960	0.015	0.7	0.0000	0.0000	OK									

Results for 30 year +20% CC Critical Storm Duration. Lowest mass balance: 98.81%																
Node Event	**US Node**	**Peak (mins)**	**Level (m)**	**Depth (m)**	**Inflow (l/s)**	**Node Vol (m³)**	**Flood (m³)**	**Status**	**Link Event (Upstream Depth)**	**Link**	**DS Node**	**Outflow (l/s)**	**Velocity (m/s)**	**Flow/Cap**	**Link Vol (m³)**	**Discharge Vol (m³)**
15 minute summer	SW01	10	95.859	0.044	9.0	0.0627	0.0000	OK	15 minute summer	1.000	SW03	9.0	0.881	0.082	0.7088	
600 minute winter	SW02	585	93.069	0.094	0.9	0.1349	0.0000	OK	600 minute winter	2.000	SW03	0.9	0.344	0.022	0.2882	
600 minute winter	SW03	585	93.068	0.166	2.7	0.2368	0.0000	OK	600 minute winter	1.001	SW07	2.7	0.305	0.038	0.6925	
15 minute summer	SW04	10	95.051	0.046	9.0	0.0656	0.0000	OK	15 minute summer	3.000	SW05	9.0	0.769	0.090	0.7858	
600 minute winter	SW05	570	93.069	0.424	1.8	0.6106	0.0000	SURCHARGED	600 minute winter	3.001	SW06	3.1	0.362	0.047	0.1938	
600 minute winter	SW06	585	93.068	0.498	3.9	0.7087	0.0000	SURCHARGED	600 minute winter	3.002	SW07	3.9	0.225	0.055	0.5748	
600 minute winter	SW07	570	93.069	0.533	7.1	0.7483	0.0000	SURCHARGED	600 minute winter	1.002	SW08	6.9	0.630	0.095	0.2132	
600 minute winter	SW08	570	93.068	0.545	6.9	62.1963	0.0000	SURCHARGED	600 minute winter	1.003	SW09	1.5	0.286	0.022	0.7403	
600 minute winter	SW09	585	93.067	0.587	1.5	0.6644	0.0000	SURCHARGED	600 minute winter	1.004	SW10-HB	1.9	0.183	0.026	0.5093	
600 minute winter	SW10-HB	555	93.067	0.617	1.9	0.6981	0.0000	SURCHARGED	600 minute winter	Hydro-Brake®	SW11	0.7				
15 minute winter	SW11	10	92.412	0.013	0.7	0.0150	0.0000	OK	15 minute winter	1.006	SW12	0.7	0.898	0.006	0.0234	
15 minute summer	SW12	12	91.382	0.017	0.7	0.0195	0.0000	OK	15 minute summer	1.007	SW13	0.7	0.644	0.011	0.0202	
600 minute winter	SW13	570	91.115	0.015	0.7	0.0170	0.0000	OK	600 minute winter	1.008	EXSW MH	0.7	0.661	0.008	0.0061	32.4
600 minute winter	EXSW MH	570	90.960	0.015	0.7	0.0000	0.0000	OK								

Results for 100 year +20% CC Critical Storm Duration. Lowest mass balance: 98.81%																
Node Event	**US Node**	**Peak (mins)**	**Level (m)**	**Depth (m)**	**Inflow (l/s)**	**Node Vol (m³)**	**Flood (m³)**	**Status**	**Link Event (Upstream Depth)**	**Link**	**DS Node**	**Outflow (l/s)**	**Velocity (m/s)**	**Flow/Cap**	**Link Vol (m³)**	**Discharge Vol (m³)**
15 minute summer	SW01	10	95.864	0.049	11.6	0.0711	0.0000	OK	15 minute summer	1.000	SW03	11.6	0.939	0.106	0.8544	
960 minute winter	SW02	840	93.254	0.279	0.8	0.4025	0.0000	SURCHARGED	960 minute winter	2.000	SW03	0.8	0.333	0.020	0.4870	
960 minute winter	SW03	840	93.255	0.353	2.4	0.5020	0.0000	SURCHARGED	960 minute winter	1.001	SW07	2.4	0.296	0.034	0.7732	
15 minute summer	SW04	10	95.057	0.052	11.6	0.0745	0.0000	OK	15 minute summer	3.000	SW05	11.6	0.779	0.117	1.0518	
960 minute winter	SW05	825	93.255	0.610	1.6	0.8791	0.0000	SURCHARGED	960 minute winter	3.001	SW06	2.0	0.358	0.030	0.1938	
960 minute winter	SW06	825	93.255	0.685	2.7	0.9747	0.0000	SURCHARGED	960 minute winter	3.002	SW07	2.7	0.220	0.038	0.5748	
960 minute winter	SW07	840	93.258	0.722	5.7	1.0136	0.0000	SURCHARGED	960 minute winter	1.002	SW08	5.4	0.591	0.075	0.2132	
960 minute winter	SW08	825	93.254	0.731	5.4	83.4563	0.0000	SURCHARGED	960 minute winter	1.003	SW09	1.8	0.280	0.025	0.7403	
960 minute winter	SW09	825	93.255	0.775	1.8	0.8770	0.0000	SURCHARGED	960 minute winter	1.004	SW10-HB	1.6	0.183	0.023	0.5093	
960 minute winter	SW10-HB	825	93.255	0.805	1.6	0.9100	0.0000	SURCHARGED	960 minute winter	Hydro-Brake®	SW11	0.8				
960 minute winter	SW11	825	92.413	0.014	0.8	0.0153	0.0000	OK	960 minute winter	1.006	SW12	0.8	0.676	0.007	0.0253	
960 minute winter	SW12	825	91.383	0.018	0.8	0.0204	0.0000	OK	960 minute winter	1.007	SW13	0.8	0.607	0.012	0.0219	
960 minute winter	SW13	825	91.116	0.016	0.8	0.0179	0.0000	OK	960 minute winter	1.008	EXSW MH	0.8	0.683	0.009	0.0066	50.1
960 minute winter	EXSW MH	825	90.961	0.016	0.8	0.0000	0.0000	OK								

Results for 2 year +20% CC 15 minute summer. 255 minute analysis at 1 minute timestep. Mass balance: 100.00%																
Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status	Link Event	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	SW01	10	95.847	0.032	4.9	0.0466	0.0000	OK	15 minute summer	1.000	SW03	4.9	0.748	0.045	0.4551	
15 minute summer	SW02	10	93.029	0.054	4.9	0.0776	0.0000	OK	15 minute summer	2.000	SW03	4.9	0.574	0.123	0.1065	
15 minute summer	SW03	10	92.970	0.068	14.7	0.0970	0.0000	OK	15 minute summer	1.001	SW07	14.4	0.770	0.201	0.4322	
15 minute summer	SW04	10	95.039	0.034	4.9	0.0487	0.0000	OK	15 minute summer	3.000	SW05	4.9	0.728	0.049	0.5539	
15 minute summer	SW05	8	92.732	0.087	9.8	0.1256	0.0000	OK	15 minute summer	3.001	SW06	11.7	0.649	0.181	0.1088	
15 minute summer	SW06	8	92.731	0.161	16.6	0.2296	0.0000	OK	15 minute summer	3.002	SW07	17.2	0.526	0.241	0.3467	
15 minute summer	SW07	8	92.724	0.188	36.5	0.2634	0.0000	OK	15 minute summer	1.002	SW08	38.9	1.939	0.536	0.0738	
15 minute summer	SW08	20	92.622	0.099	38.9	11.3099	0.0000	OK	15 minute summer	1.003	SW09	6.9	0.568	0.097	0.2829	
15 minute summer	SW09	16	92.627	0.147	6.9	0.1664	0.0000	OK	15 minute summer	1.004	SW10-HB	2.8	0.488	0.040	0.2794	
15 minute summer	SW10-HB	21	92.628	0.178	2.8	0.2012	0.0000	OK	15 minute summer	Hydro-Brake®	SW11	0.7				
15 minute summer	SW11	12	92.412	0.013	0.7	0.0145	0.0000	OK	15 minute summer	1.006	SW12	0.7	0.998	0.006	0.0233	
15 minute summer	SW12	13	91.382	0.017	0.7	0.0194	0.0000	OK	15 minute summer	1.007	SW13	0.7	0.647	0.011	0.0201	
15 minute summer	SW13	22	91.115	0.015	0.7	0.0170	0.0000	OK	15 minute summer	1.008	EXSW MH	0.7	0.659	0.008	0.0061	10.3
15 minute summer	EXSW MH	22	90.960	0.015	0.7	0.0000	0.0000	OK								

Results for 2 year +20% CC 15 minute winter. 255 minute analysis at 1 minute timestep. Mass balance: 100.00%																
Node Event	**US Node**	**Peak (mins)**	**Level (m)**	**Depth (m)**	**Inflow (l/s)**	**Node Vol (m³)**	**Flood (m³)**	**Status**	**Link Event**	**Link**	**DS Node**	**Outflow (l/s)**	**Velocity (m/s)**	**Flow/Cap**	**Link Vol (m³)**	**Discharge Vol (m³)**
15 minute winter	SW01	10	95.845	0.030	4.3	0.0438	0.0000	OK	15 minute winter	1.000	SW03	4.3	0.716	0.039	0.4155	
15 minute winter	SW02	10	93.025	0.050	4.3	0.0722	0.0000	OK	15 minute winter	2.000	SW03	4.3	0.551	0.108	0.0967	
15 minute winter	SW03	10	92.966	0.064	12.9	0.0909	0.0000	OK	15 minute winter	1.001	SW07	12.7	0.749	0.177	0.4222	
15 minute winter	SW04	10	95.037	0.032	4.3	0.0458	0.0000	OK	15 minute winter	3.000	SW05	4.3	0.722	0.043	0.6693	
15 minute winter	SW05	8	92.748	0.103	8.6	0.1487	0.0000	OK	15 minute winter	3.001	SW06	11.6	0.644	0.179	0.1229	
15 minute winter	SW06	8	92.743	0.173	15.9	0.2455	0.0000	OK	15 minute winter	3.002	SW07	17.9	0.521	0.251	0.3671	
15 minute winter	SW07	8	92.729	0.193	33.6	0.2716	0.0000	OK	15 minute winter	1.002	SW08	38.1	1.816	0.525	0.0737	
15 minute winter	SW08	20	92.622	0.099	38.1	11.3340	0.0000	OK	15 minute winter	1.003	SW09	5.7	0.535	0.081	0.2839	
15 minute winter	SW09	16	92.626	0.146	5.7	0.1654	0.0000	OK	15 minute winter	1.004	SW10-HB	3.6	0.465	0.050	0.2791	
15 minute winter	SW10-HB	21	92.629	0.179	3.6	0.2025	0.0000	OK	15 minute winter	Hydro-Brake®	SW11	0.7				
15 minute winter	SW11	18	92.412	0.013	0.7	0.0145	0.0000	OK	15 minute winter	1.006	SW12	0.7	0.981	0.006	0.0233	
15 minute winter	SW12	13	91.382	0.017	0.7	0.0194	0.0000	OK	15 minute winter	1.007	SW13	0.7	0.645	0.011	0.0201	
15 minute winter	SW13	25	91.115	0.015	0.7	0.0170	0.0000	OK	15 minute winter	1.008	EXSW MH	0.7	0.659	0.008	0.0061	10.3
15 minute winter	EXSW MH	22	90.960	0.015	0.7	0.0000	0.0000	OK								

Results for 2 year +20% CC 30 minute summer. 270 minute analysis at 1 minute timestep. Mass balance: 99.82%																
Node Event	**US Node**	**Peak (mins)**	**Level (m)**	**Depth (m)**	**Inflow (l/s)**	**Node Vol (m^3)**	**Flood (m^3)**	**Status**	**Link Event**	**Link**	**DS Node**	**Outflow (l/s)**	**Velocity (m/s)**	**Flow/Cap**	**Link Vol (m^3)**	**Discharge Vol (m^3)**
30 minute summer	SW01	17	95.846	0.031	4.5	0.0442	0.0000	OK	30 minute summer	1.000	SW03	4.4	0.722	0.040	0.4215	
30 minute summer	SW02	17	93.026	0.051	4.5	0.0737	0.0000	OK	30 minute summer	2.000	SW03	4.4	0.556	0.111	0.0980	
30 minute summer	SW03	18	92.967	0.065	13.3	0.0921	0.0000	OK	30 minute summer	1.001	SW07	13.0	0.775	0.182	0.3295	
30 minute summer	SW04	17	95.037	0.032	4.5	0.0462	0.0000	OK	30 minute summer	3.000	SW05	4.4	0.764	0.044	0.3837	
30 minute summer	SW05	18	92.704	0.059	8.9	0.0856	0.0000	OK	30 minute summer	3.001	SW06	8.7	0.644	0.134	0.0664	
30 minute summer	SW06	18	92.678	0.108	12.9	0.1539	0.0000	OK	30 minute summer	3.002	SW07	12.9	0.488	0.181	0.2167	
30 minute summer	SW07	18	92.669	0.133	30.1	0.1871	0.0000	OK	30 minute summer	1.002	SW08	30.2	1.588	0.417	0.0860	
30 minute summer	SW08	35	92.656	0.133	30.2	15.2293	0.0000	OK	30 minute summer	1.003	SW09	5.2	0.442	0.074	0.3893	
30 minute summer	SW09	33	92.659	0.179	5.2	0.2028	0.0000	OK	30 minute summer	1.004	SW10-HB	2.7	0.333	0.038	0.3494	
30 minute summer	SW10-HB	33	92.660	0.210	2.7	0.2376	0.0000	OK	30 minute summer	Hydro-Brake®	SW11	0.7				
30 minute summer	SW11	63	92.412	0.013	0.7	0.0145	0.0000	OK	30 minute summer	1.006	SW12	0.7	0.789	0.006	0.0232	
30 minute summer	SW12	64	91.382	0.017	0.7	0.0193	0.0000	OK	30 minute summer	1.007	SW13	0.7	0.596	0.011	0.0201	
30 minute summer	SW13	65	91.115	0.015	0.7	0.0170	0.0000	OK	30 minute summer	1.008	EXSW MH	0.7	0.660	0.008	0.0061	10.9
30 minute summer	EXSW MH	65	90.960	0.015	0.7	0.0000	0.0000	OK								

Results for 2 year +20% CC 30 minute winter. 270 minute analysis at 1 minute timestep. Mass balance: 99.82%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m^3)	Flood (m^3)	Status	Link Event	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m^3)	Discharge Vol (m^3)
30 minute winter	SW01	17	95.842	0.027	3.4	0.0390	0.0000	OK	30 minute winter	1.000	SW03	3.3	0.664	0.031	0.3510	
30 minute winter	SW02	17	93.019	0.044	3.4	0.0633	0.0000	OK	30 minute winter	2.000	SW03	3.4	0.515	0.084	0.0808	
30 minute winter	SW03	18	92.959	0.057	10.1	0.0807	0.0000	OK	30 minute winter	1.001	SW07	10.0	0.718	0.140	0.2755	
30 minute winter	SW04	17	95.033	0.028	3.4	0.0407	0.0000	OK	30 minute winter	3.000	SW05	3.3	0.711	0.034	0.3155	
30 minute winter	SW05	18	92.696	0.051	6.7	0.0742	0.0000	OK	30 minute winter	3.001	SW06	6.7	0.623	0.104	0.0531	
30 minute winter	SW06	9	92.662	0.092	10.0	0.1309	0.0000	OK	30 minute winter	3.002	SW07	10.0	0.467	0.140	0.1917	
30 minute winter	SW07	9	92.664	0.128	23.3	0.1797	0.0000	OK	30 minute winter	1.002	SW08	23.3	1.468	0.322	0.0857	
30 minute winter	SW08	35	92.656	0.133	24.1	15.2084	0.0000	OK	30 minute winter	1.003	SW09	4.5	0.463	0.064	0.3880	
30 minute winter	SW09	37	92.659	0.179	4.5	0.2020	0.0000	OK	30 minute winter	1.004	SW10-HB	2.9	0.353	0.041	0.3479	
30 minute winter	SW10-HB	33	92.659	0.209	2.9	0.2369	0.0000	OK	30 minute winter	Hydro-Brake®	SW11	0.7				
30 minute winter	SW11	62	92.412	0.013	0.7	0.0145	0.0000	OK	30 minute winter	1.006	SW12	0.7	0.815	0.006	0.0232	
30 minute winter	SW12	63	91.382	0.017	0.7	0.0193	0.0000	OK	30 minute winter	1.007	SW13	0.7	0.601	0.011	0.0201	
30 minute winter	SW13	64	91.115	0.015	0.7	0.0170	0.0000	OK	30 minute winter	1.008	EXSW MH	0.7	0.660	0.008	0.0061	11.0
30 minute winter	EXSW MH	64	90.960	0.015	0.7	0.0000	0.0000	OK								

Results for 2 year +20% CC 60 minute summer. 300 minute analysis at 1 minute timestep. Mass balance: 99.83%																
Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status	Link Event	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
60 minute summer	SW01	32	95.842	0.027	3.4	0.0390	0.0000	OK	60 minute summer	1.000	SW03	3.3	0.664	0.031	0.3510	
60 minute summer	SW02	32	93.019	0.044	3.4	0.0633	0.0000	OK	60 minute summer	2.000	SW03	3.4	0.515	0.084	0.0808	
60 minute summer	SW03	33	92.959	0.057	10.1	0.0807	0.0000	OK	60 minute summer	1.001	SW07	10.0	0.718	0.140	0.2998	
60 minute summer	SW04	32	95.033	0.028	3.4	0.0407	0.0000	OK	60 minute summer	3.000	SW05	3.3	0.711	0.034	0.3155	
60 minute summer	SW05	33	92.696	0.051	6.7	0.0742	0.0000	OK	60 minute summer	3.001	SW06	6.7	0.623	0.104	0.0714	
60 minute summer	SW06	62	92.694	0.124	10.0	0.1769	0.0000	OK	60 minute summer	3.002	SW07	10.0	0.467	0.140	0.2649	
60 minute summer	SW07	64	92.693	0.157	23.3	0.2207	0.0000	OK	60 minute summer	1.002	SW08	23.0	1.213	0.317	0.1190	
60 minute summer	SW08	63	92.693	0.170	23.0	19.4272	0.0000	OK	60 minute summer	1.003	SW09	3.0	0.351	0.043	0.4987	
60 minute summer	SW09	61	92.694	0.214	3.0	0.2425	0.0000	OK	60 minute summer	1.004	SW10-HB	1.6	0.269	0.023	0.4175	
60 minute summer	SW10-HB	61	92.695	0.245	1.6	0.2770	0.0000	SURCHARGED	60 minute summer	Hydro-Brake®	SW11	0.7				
60 minute summer	SW11	203	92.412	0.013	0.7	0.0145	0.0000	OK	60 minute summer	1.006	SW12	0.7	0.656	0.006	0.0232	
60 minute summer	SW12	204	91.382	0.017	0.7	0.0193	0.0000	OK	60 minute summer	1.007	SW13	0.7	0.585	0.011	0.0201	
60 minute summer	SW13	205	91.115	0.015	0.7	0.0170	0.0000	OK	60 minute summer	1.008	EXSW MH	0.7	0.660	0.008	0.0061	12.0
60 minute summer	EXSW MH	205	90.960	0.015	0.7	0.0000	0.0000	OK								

Results for 2 year +20% CC 60 minute winter. 300 minute analysis at 1 minute timestep. Mass balance: 99.83%																	
Node Event	**US Node**	**Peak (mins)**	**Level (m)**	**Depth (m)**	**Inflow (l/s)**	**Node Vol (m³)**	**Flood (m³)**	**Status**	**Link Event**	**Link**	**DS Node**	**Outflow (l/s)**	**Velocity (m/s)**	**Flow/Cap**	**Link Vol (m³)**	**Discharge Vol (m³)**
60 minute winter	SW01	33	95.838	0.023	2.4	0.0333	0.0000	OK	60 minute winter	1.000	SW03	2.4	0.600	0.022	0.2777	
60 minute winter	SW02	33	93.012	0.037	2.4	0.0535	0.0000	OK	60 minute winter	2.000	SW03	2.4	0.463	0.060	0.0640	
60 minute winter	SW03	33	92.950	0.048	7.2	0.0683	0.0000	OK	60 minute winter	1.001	SW07	7.2	0.639	0.101	0.3046	
60 minute winter	SW04	33	95.029	0.024	2.4	0.0348	0.0000	OK	60 minute winter	3.000	SW05	2.4	0.657	0.024	0.2465	
60 minute winter	SW05	61	92.697	0.052	4.8	0.0755	0.0000	OK	60 minute winter	3.001	SW06	4.9	0.590	0.075	0.0723	
60 minute winter	SW06	63	92.695	0.125	7.2	0.1781	0.0000	OK	60 minute winter	3.002	SW07	7.2	0.434	0.100	0.2673	
60 minute winter	SW07	63	92.694	0.158	16.7	0.2221	0.0000	OK	60 minute winter	1.002	SW08	16.4	1.104	0.226	0.1199	
60 minute winter	SW08	62	92.694	0.171	16.5	19.5466	0.0000	OK	60 minute winter	1.003	SW09	2.9	0.366	0.042	0.5025	
60 minute winter	SW09	64	92.696	0.216	2.9	0.2438	0.0000	OK	60 minute winter	1.004	SW10-HB	1.6	0.281	0.023	0.4195	
60 minute winter	SW10-HB	64	92.696	0.246	1.6	0.2782	0.0000	SURCHARGED	60 minute winter	Hydro-Brake®	SW11	0.7				
60 minute winter	SW11	206	92.412	0.013	0.7	0.0145	0.0000	OK	60 minute winter	1.006	SW12	0.7	0.656	0.006	0.0232	
60 minute winter	SW12	206	91.382	0.017	0.7	0.0193	0.0000	OK	60 minute winter	1.007	SW13	0.7	0.585	0.011	0.0201	
60 minute winter	SW13	207	91.115	0.015	0.7	0.0170	0.0000	OK	60 minute winter	1.008	EXSW MH	0.7	0.660	0.008	0.0061	12.0
60 minute winter	EXSW MH	207	90.960	0.015	0.7	0.0000	0.0000	OK								

Adoptable						
Max Width (mm)	**Diameter (mm)**	**Width (mm)**		**Max Depth (m)**	**Diameter (mm)**	**Width (mm)**
374	1200			1.500	1050	
499	1350			99.999	1200	
749	1500					
900	1800					
>900	Link+900 mm					

Circular			
Shape	Circular		**Dia (mm)**
Barrels	1		100
Height (mm)			150
Width (mm)			
Side Slope (1:X)			
Auto Increment (mm)	75		
Preferred Cover (m)			
Steep Slope (1:X)			
Follow Ground	No		
Velocity	Default		
ks (mm) / n			
uPVC			
Shape	Circular		**Dia (mm)**
Barrels	1		225
Height (mm)			
Width (mm)			
Side Slope (1:X)			
Auto Increment (mm)	75		
Preferred Cover (m)			
Steep Slope (1:X)			
Follow Ground	No		
Velocity	Colebrook-White		
ks (mm) / n	0.150		

APPENDIX D – FOUL WATER PIPE NETWORK CALCULATIONS

Drainage Design Report

Flow+

v10.8

Network	Foul Network
Filename	2024-07-24 Flow.pfd
Username	Kezia Adanza

Report produced on	24/07/2024 14:28:35

Causeway Sales

Tel:	+44(0) 1628 552000
Fax:	+44(0) 1628 552001
Email:	marketing@causeway.com
Web:	www.causeway.com

Technical support web portal:

http://support.causeway.com

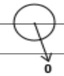
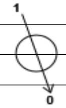
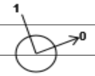
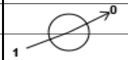
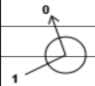
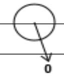
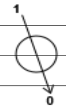
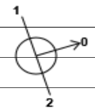
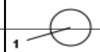
Frequency of use (kDU)	0.50
Flow per dwelling per day (l/day)	446
Domestic Flow (l/s/ha)	0.0
Industrial Flow (l/s/ha)	0.0
Additional Flow (%)	10
Minimum Velocity (m/s)	0.75
Connection Type	Level Inverts
Minimum Backdrop Height (m)	0.500
Preferred Cover Depth (m)	1.200
Include Intermediate Ground	Yes

	Name	Area (ha)	Dwellings	Units	Add Inflow (l/s)	Cover Level (m)	Node Type	Manhole Type	Diameter (mm)	Width (mm)	Easting (m)	Northing (m)	Depth (m)	Notes
✓	FW01			7.8		95.400	Manhole	Adoptable	1200		718493.794	726648.811	1.425	
✓	FW02			7.8		97.040	Manhole	Adoptable	1200		718507.672	726605.946	3.816	
✓	FW03			7.8		96.910	Manhole	Adoptable	1200		718514.641	726584.423	3.837	
✓	FW04			7.8		97.000	Manhole	Adoptable	1200		718527.566	726589.825	4.020	
✓	FW05			7.8		96.400	Manhole	Adoptable	1200		718540.662	726596.899	3.519	
✓	FW06			7.8		93.870	Manhole	Adoptable	1200		718520.477	726659.244	0.825	
✓	FW07			7.8		95.140	Manhole	Adoptable	1200		718531.517	726625.146	2.692	
✓	FW08			7.8		96.760	Manhole	Adoptable	1200		718539.168	726601.512	4.478	
✓	EXFW MH					95.950	Manhole	Adoptable	1200		718544.463	726603.226	3.696	

	Name	US Node	DS Node	Length (m)	ks (mm) / n	Velocity Equation	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	Link Type	Con Offset (m)	Min DS IL (m)
?	1.000	FW01	FW02	45.056	1.500	Colebrook-White	93.975	93.224	0.751	60.0	225	Circular		
?	1.001	FW02	FW03	22.623	1.500	Colebrook-White	93.224	93.073	0.151	150.0	225	Circular		
?	1.002	FW03	FW04	14.008	1.500	Colebrook-White	93.073	92.980	0.093	150.0	225	Circular		
?	1.003	FW04	FW05	14.884	1.500	Colebrook-White	92.980	92.881	0.099	150.0	225	Circular		
?	1.004	FW05	FW08	4.849	1.500	Colebrook-White	92.881	92.849	0.032	150.0	225	Circular		
?	2.000	FW06	FW07	35.841	1.500	Colebrook-White	93.045	92.448	0.597	60.0	225	Circular		
?	2.001	FW07	FW08	24.842	1.500	Colebrook-White	92.448	92.282	0.166	150.0	225	Circular		
?	1.005	FW08	EXFW MH	5.566	1.500	Colebrook-White	92.282	92.254	0.028	200.0	225	Circular		

<table>
<tr><th></th><th>Name</th><th>US Node</th><th>DS Node</th><th>Pro Vel @ 1/3 Q (m/s)</th><th>Vel (m/s)</th><th>Cap (l/s)</th><th>Flow (l/s)</th><th>US Depth (m)</th><th>DS Depth (m)</th><th>Minimum Depth (m)</th><th>Maximum Depth (m)</th><th>Σ Area (ha)</th><th>Σ Dwellings (ha)</th><th>Σ Units (ha)</th><th>Σ Add Inflow (l/s)</th><th>Pro Depth (mm)</th><th>Pro Velocity (m/s)</th><th>Notes</th></tr>
<tr><td>?</td><td>1.000</td><td>FW01</td><td>FW02</td><td>0.448</td><td>1.483</td><td>59.0</td><td>1.5</td><td>1.200</td><td>3.591</td><td>1.200</td><td>3.591</td><td>0.000</td><td>0</td><td>7.8</td><td>0.0</td><td>25</td><td>0.626</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>1.001</td><td>FW02</td><td>FW03</td><td>0.365</td><td>0.936</td><td>37.2</td><td>2.2</td><td>3.591</td><td>3.612</td><td>3.591</td><td>3.612</td><td>0.000</td><td>0</td><td>15.6</td><td>0.0</td><td>37</td><td>0.511</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is more than twice the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>1.002</td><td>FW03</td><td>FW04</td><td>0.385</td><td>0.936</td><td>37.2</td><td>2.7</td><td>3.612</td><td>3.795</td><td>3.612</td><td>3.795</td><td>0.000</td><td>0</td><td>23.4</td><td>0.0</td><td>41</td><td>0.540</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is more than twice the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>1.003</td><td>FW04</td><td>FW05</td><td>0.403</td><td>0.936</td><td>37.2</td><td>3.1</td><td>3.795</td><td>3.294</td><td>3.294</td><td>3.795</td><td>0.000</td><td>0</td><td>31.2</td><td>0.0</td><td>44</td><td>0.561</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is more than twice the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>1.004</td><td>FW05</td><td>FW08</td><td>0.421</td><td>0.936</td><td>37.2</td><td>3.4</td><td>3.294</td><td>3.686</td><td>3.294</td><td>3.686</td><td>0.000</td><td>0</td><td>39.0</td><td>0.0</td><td>46</td><td>0.582</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is more than twice the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>2.000</td><td>FW06</td><td>FW07</td><td>0.448</td><td>1.483</td><td>59.0</td><td>1.5</td><td>0.600</td><td>2.467</td><td>0.600</td><td>2.467</td><td>0.000</td><td>0</td><td>7.8</td><td>0.0</td><td>25</td><td>0.626</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is less than the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>2.001</td><td>FW07</td><td>FW08</td><td>0.365</td><td>0.936</td><td>37.2</td><td>2.2</td><td>2.467</td><td>4.253</td><td>2.467</td><td>4.253</td><td>0.000</td><td>0</td><td>15.6</td><td>0.0</td><td>37</td><td>0.511</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is more than twice the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
<tr><td>?</td><td>1.005</td><td>FW08</td><td>EXFW MH</td><td>0.408</td><td>0.810</td><td>32.2</td><td>4.3</td><td>4.253</td><td>3.471</td><td>3.471</td><td>4.253</td><td>0.000</td><td>0</td><td>62.4</td><td>0.0</td><td>56</td><td>0.564</td><td>Proportional Velocity @ 1/3 Flow is less than the specified minimum | Upstream Depth is more than twice the specified minimum | Downstream Depth is more than twice the specified minimum</td></tr>
</table>

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)	US Node	Dia (mm)	Width (mm)	Sump (m)	Node Type	MH Type	DS Node	Dia (mm)	Width (mm)	Sump (m)	Node Type	MH Type
1.000	45.056	60.0	225	Circular	95.400	93.975	1.200	97.040	93.224	3.591	FW01	1200			Manhole	Adoptable	FW02	1200			Manhole	Adoptable
1.001	22.623	150.0	225	Circular	97.040	93.224	3.591	96.910	93.073	3.612	FW02	1200			Manhole	Adoptable	FW03	1200			Manhole	Adoptable
1.002	14.008	150.0	225	Circular	96.910	93.073	3.612	97.000	92.980	3.795	FW03	1200			Manhole	Adoptable	FW04	1200			Manhole	Adoptable
1.003	14.884	150.0	225	Circular	97.000	92.980	3.795	96.400	92.881	3.294	FW04	1200			Manhole	Adoptable	FW05	1200			Manhole	Adoptable
1.004	4.849	150.0	225	Circular	96.400	92.881	3.294	96.760	92.849	3.686	FW05	1200			Manhole	Adoptable	FW08	1200			Manhole	Adoptable
2.000	35.841	60.0	225	Circular	93.870	93.045	0.600	95.140	92.448	2.467	FW06	1200			Manhole	Adoptable	FW07	1200			Manhole	Adoptable
2.001	24.842	150.0	225	Circular	95.140	92.448	2.467	96.760	92.282	4.253	FW07	1200			Manhole	Adoptable	FW08	1200			Manhole	Adoptable
1.005	5.566	200.0	225	Circular	96.760	92.282	4.253	95.950	92.254	3.471	FW08	1200			Manhole	Adoptable	EXFW MH	1200			Manhole	Adoptable

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Width (mm)	Sump (m)	Node Type	MH Type	Connections		Link	IL (m)	Dia (mm)	Link Type
FW01	718493.794	726648.811	95.400	1.425	1200			Manhole	Adoptable						
											0	1.000	93.975	225	Circular
FW02	718507.672	726605.946	97.040	3.816	1200			Manhole	Adoptable		1	1.000	93.224	225	Circular
											0	1.001	93.224	225	Circular
FW03	718514.641	726584.423	96.910	3.837	1200			Manhole	Adoptable		1	1.001	93.073	225	Circular
											0	1.002	93.073	225	Circular
FW04	718527.566	726589.825	97.000	4.020	1200			Manhole	Adoptable		1	1.002	92.980	225	Circular
											0	1.003	92.980	225	Circular
FW05	718540.662	726596.899	96.400	3.519	1200			Manhole	Adoptable		1	1.003	92.881	225	Circular
											0	1.004	92.881	225	Circular
FW06	718520.477	726659.244	93.870	0.825	1200			Manhole	Adoptable						
											0	2.000	93.045	225	Circular
FW07	718531.517	726625.146	95.140	2.692	1200			Manhole	Adoptable		1	2.000	92.448	225	Circular
											0	2.001	92.448	225	Circular
FW08	718539.168	726601.512	96.760	4.478	1200			Manhole	Adoptable		1	2.001	92.282	225	Circular
											2	1.004	92.849	225	Circular
											0	1.005	92.282	225	Circular
EXFW MH	718544.463	726603.226	95.950	3.696	1200			Manhole	Adoptable		1	1.005	92.254	225	Circular

APPENDIX E – MAINTENANCE AND MANAGEMENT PLAN

Maintenance and Management Plan			
Project	NDFA Social Housing Bundles 4 & 5	Analysed by	Kezia Adanza
Job no.	23006	Date	

SuDS Component	Maintenance Responsibility	Maintenance Schedule	Required Action	Typical Frequency
Permeable Paving	PPP management company for 25 years then Dublin City Council	Regular Maintenance	Brushing (Standard cosmetic sweep over whole surface) Visual check on inspection chambers and removal of debris.	Once a year or reduced frequency as required
		Occasional Maintenance	Removal of weeds or management using glyphosate or other suitable weed killer.	As required – once a year on less frequently used pavements
		Remedial Action	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing materials.	As required
			Remediate any landscaping which has been raised within the level of the paving.	As required
			High pressure jetting of permeable pavement underdrains in the event of blockages. Inspections chambers provided to facilitate this work.	As required
			Rehabilitation of surface and upper sub-structure by remedial sweeping.	Every 10 to 15 years or as required (if performance is reduced due to significant flooding)
		Monitoring	Initial Inspection	Monthly for three months after installation
			Inspect for evidence of poor operation and/ or weed growth – if required, take remedial action,	Every 3 months, 48 hours after large storms in first six months

			Inspect slit accumulation rates and establish appropriate brushing frequencies.	Annually
			Monitor inspection chambers	Annually

Maintenance and Management Plan			
Project	NDFA Social Housing Bundles 4 & 5	Analysed by	Kezia Adanza
Job no.	23006	Date	

SuDS Component	Maintenance Responsibility	Maintenance Schedule	Required Action	Typical Frequency
Bioretention Areas - Swales / tree pits / Rain Gardens	PPP management company for 25 years then Dublin City Council	Regular Inspections	Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain to determine if maintenance is necessary.	Quarterly
			Check operation of underdrains by inspection of flows after rain.	Annually
			Assess plants for disease infection, poor growth, invasive species etc. and replace as necessary.	Quarterly
			Inspect inlets and outlets for blockage.	Quarterly
		Regular Maintenance	Remove litter, surface debris and weeds.	Quarterly (or more frequently for tidiness or aesthetic reasons)
			Replace any plants to maintain plant density.	Quarterly to bi-annually
			Remove sediment, litter and debris build-up from around inlets.	As required
		Occasional Maintenance	Infill any holes or scour in the filter medium, improve erosion protection if required.	As required
			Repair minor accumulations of silt by raking away surface mulch, scarifying surface of medium and replacing mulch.	As required
		Remedial Actions	Remove and replace filter medium and vegetation.	As required but likely to be > 20 years

Maintenance and Management Plan			
Project	NDFA Social Housing Bundles 4 & 5	Analysed by	Kezia Adanza
Job no.	23006	Date	

SuDS Component	Maintenance Responsibility	Maintenance Schedule	Required Action	Typical Frequency
Attenuation Storage	PPP management company for 25 years then Dublin City Council	Regular Inspections	Inspect infiltration surfaces for silting, record de-watering time of the facility and assess standing water levels in underdrain to determine if maintenance is necessary.	Quarterly
			Check operation of underdrains by inspection of flows after rain.	Annually
			Inspect inlets and outlets for blockage.	Quarterly
		Regular Maintenance	Remove sediment, litter and debris build-up from around inlets.	As required