SuDS Strategy Report

Residential Development
Lahardane / Ballincolly
Ballyvolane
Co. Cork

November 2019

Document Control Sheet

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1.0 INTRODUCTION

1.1 INTRODUCTION

1.1.1 MHL Consulting Engineers has been instructed by Longview Estates Ltd to prepare a SuDS (Sustainable Urban Drainage Systems) Strategy Report in support of a planning application for the development of a portion of their lands at Lahardane, Ballyvolane, Cork.

1.1.2 The scheme consists of the development of 753 residential units, a 103 child creche and a local neighbour centre on a phased basis (a 10-year permission is being sought) and will be determined by way of the Strategic Infrastructure Application process to An Bord Pleanála.

1.1.3 An EIAR has been prepared as part of the overall application.

1.1.4 This document will demonstrate how the proposed development has been designed using best practice in relation to flood risk and stormwater management including compliance with the following:

- Greater Dublin Regional Code of Practice for Drainage Works (GDRCoP)
- Greater Dublin Strategic Drainage Study (GDSDS)
- 'The SuDS Manual (CIRIA C753,2015)
- IS EN752, 'Drain and Sewer Systems Outside Buildings'
- The incorporation of SuDS features to reduce run-off

1.1.5 A number of consultations have taken place with the planning authority and in particular the Water Services 'Drainage' Department of Cork City Council. It is noted that at present Cork City Council do not have a SuDS strategy that is to be followed in the development and design of residential schemes, however specific feedback has been received from this department which has informed the submitted design and is inline with the aforementioned documents.

1.1.6 Presented as part of this report are details of the site investigations carried out, pre and post development flow characteristics, storm attenuation storage capacities, pipe sizing and discharge rates. SuDS specific proposals and their implementation on site including maintenance considerations are discussed. A UKSuDS Site Evaluation Report has been carried out and is included in Appendix 1 of this report.

1.17 The proposed surface water drainage system is in accordance with Sustainable Urban Drainage Systems (SUDS) principles and divides the site into seventeen (17) drainage catchments; eight (8) catchments being proposed for infiltration, and nine (9) catchments proposed for attenuation utilising Stormtech Underground Chamber systems (refer Appendix 2) with a controlled average greenfield run-off rate of 5.0 l/s/ha (Qbar for the site). The attenuated systems will ultimately discharge into the stream located on the west side of Ballyhooly Road at two locations.

1.2 PLANNING BACKGROUND

1.2.1 The lands at Ballyvolane have been earmarked for significant population growth since the Cork Area Strategic Plan Update 2008 and the Cork County Development Plan 2009. The previous LAP, the Blarney Electoral Area Local Area Plan 2011 and 2015 Update, designated the lands as a Special Policy Area (X-01) noting that a masterplan should be prepared to inform the future development of these lands. This Masterplan was not prepared, and the objective has been superseded by the creation of a traditional zoning framework in the 2014 Cork County Local Area Plans (in this case the Cobh MD LAP).

1.2.2 The lands are zoned for development in the current Cobh Municipal District Local Area Plan 2017 as follows:

- NE-R-08 and NE-R-09 for Medium B residential development;

- NE-C-01 for proposed primary and secondary school;
- NE-O-04 for open space for public recreation as an urban park. The amenity parkland should provide passive amenity for residents of the North Eastern suburbs and the site. It should also contain the necessary walkways and cycle--ways for accessibility between residential, business, retail and community uses.

1.3 THE RECEIVING ENVIRONMENT

1.3.1 The site lies within Hydrometric Area 19, the EPA Classification for catchments flowing into the River Lee, Cork Harbour and Youghal Bay. The site lies between Water Framework Directive (WFD) River Sub Basins Glennamought Trib Bride_010 and Bride (Cork City)_20 and is within the South Western River Basin District (IESW). The Transitional Water Quality 2010-2012 had the Lee (Cork) Estuary Lower at an Intermediate Status.

1.3.2 Currently, an existing watercourse runs north to south on the western side of Ballyhooly Road. This serves as an outfall for surface water falling on the public road and new housing to the north (Dublin Pike). This watercourse is culverted over a portion of its length from the Kilbarry Link Road (Labelled Lower Dublin Hill on the EPA Mapping) south to Kempton Park where it is designated by the EPA as Bride (Cork City)_020, links with the Glen River and ultimately is culverted under the N20 Blackpool Bypass out-falling to the River Lee on Camden Quay, refer to **Figure 1.1** Watercourses.

1.3.3 As the site falls naturally from the east to the west, it is proposed to construct two surface water outfalls (Outfall 1 and Outfall 2) to the watercourse running on the western side of Ballyhooly Road. Outfall 1, which is to serve Neighbourhood 4, will facilitate recharging of this tributary during periods of low flow. The majority of the site will discharge to Outfall 2, specifically located downstream of an existing culvert under the Kilbarry Link Road. Through a combination of attenuation, infiltration and other SuDS measures the controlled flow from the site will be to an agreed Qbar rate of on average 5 l/s/ha.

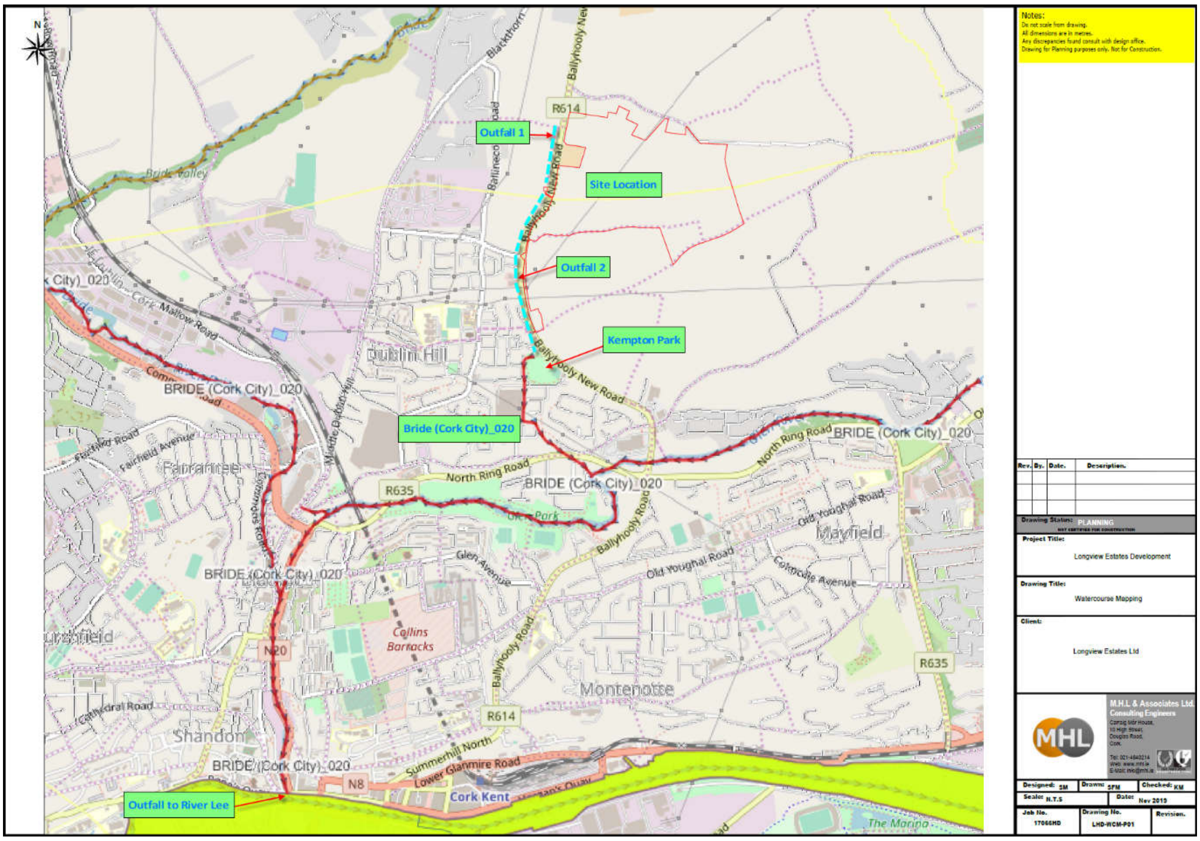


Figure 1.1 – Site Location and Watercourses

2.0 STORM WATER MANAGEMENT

2.1 The storm water management proposals for the site have been informed by site investigations carried out by Priority Geotechnical in August 2017, followed by a supplementary ground investigation in January 2019, the topography of the site and planning considerations such as residential density and compliance with the relevant design standards such as DMURS (Design Manual for Urban Roads and Streets) and Part M of the Building Regulations.

2.2 The scope of the site investigation works was defined by MHL Consulting Engineers and JBA Consulting Engineers (JBA are separately engaged to provide input into the groundwater assessment of the works) and comprised of:

- Trial pit excavations
- Rotary boreholes
- All associated sampling
- Standpipe well installations
- Laboratory testing, including improvement binder trials
- Subsoil infiltration tests

The full extent of the site investigation is detailed in the Priority Final Report (August 2019). **Fig. 2.1** shows the location of the various trail holes and rotary cores carried out since 2017.

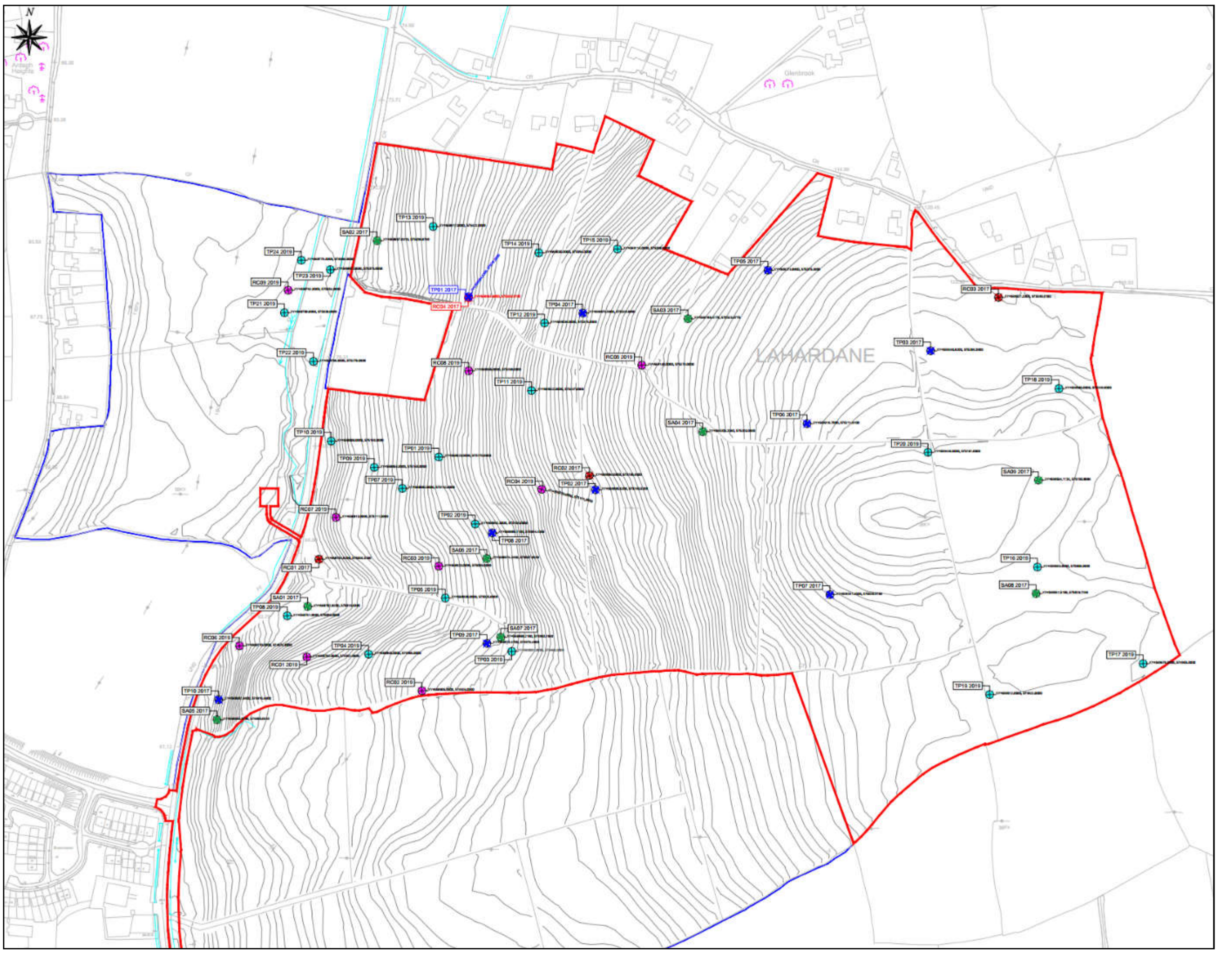


Figure 2.1 - Site investigation locations

The site investigation from 2017 comprised of ten (10) trial pits which were excavated from 4.0 to 7.0m below ground level (bgl), and four (4) boreholes which were drilled from 5.0 to 8.3m bgl. The 2019 investigation comprised of twenty-four (24) trial pits which were excavated from 1.8 to 3.5 m bgl, and nine (9) boreholes which were drilled between 3.0 and 9.5m bgl.

2.3 The subsurface ground model derived from the site investigation was such that topsoil was 200mm to 400mm thick; overlying mixed glacial deposits: firm slightly sandy gravelly SILT, firm slightly sandy (slightly) gravelly CLAY, medium dense to dense clayey gravelly SAND, medium dense to dense (very) medium dense to dense silty (very) sandy GRAVEL and medium dense to dense (very) clayey sandy GRAVEL with variable Cobble contents. The mixed glacial, superficial deposits overlay weak to medium strong SANDSTONE/ SILTSTONE 0.9m below existing ground level (bgl) to 4.3m bgl.
These findings were used to determine the soil classification as Soil Class 3 with an associated SPR value of 0.37. The QBar calculation, which relates to the allowable discharge from the site, is based on this classification.

2.4 The greenfield run-off rate and associated on-site attenuation has been agreed with the Water Services 'Drainage' Department of Cork City Council. It is noted that Cork City Council do not always require attenuation of flow to QBAR and accept higher discharge rates from certain sites based on site specific assessments, however during initial consultations it was agreed that QBAR rates for this site would be appropriate as the receiving environment (The River Bride) in Blackpool has a history of flooding. A discharge rate not exceeding 5 l/s/ha was agreed.

The following table outlines the Greenfield Runoff rates applied to the various stormwater drainage networks which are based on the individual neighbourhoods (refer to Appendix A of this report for calculation sheets based on the Wallingford Procedure for each Neighbourhood);

Storm Network (Neighbourhood)	Catchment Area (Ha)	Greenfield Runoff Rate for Catchment			
		Qbar (l/s)	1 in 1 year (l/s)	1 in 30 yr (l/s)	1 in 100 yr (l/s)
N1	5.8738	29.89	25.4	49.31	58.28
N2	8.0406	40.91	34.77	67.5	79.78
N3	5.9368	30.21	25.68	49.84	58.90
N4	5.3195	27.07	23.01	44.66	52.78
N5	6.4618	32.88	27.95	54.25	64.11
N6	1.9338	9.84	8.36	16.24	19.19
Total	33.566	170.80	145.17	281.80	333.04
Total (includes areas that will use infiltration)	45.919	233.64	198.60	385.51	455.60

Table 2.1 Greenfield Runoff Rates

The design proposes to discharge at QBAR for all rainfall events up to and including the 1 in 100-year storm event plus 20% climate change as per the requirements of Cork City Council. This exceeds the climate change factor of 10% required as part of GDSDS.

As evident in the above table, the proposed discharge rate of QBAR is considerably lower than the 30-year and 100-year greenfield runoff rates and represents a substantial reduction in the peak run-off rates from the site. Furthermore, additional SuDS elements (open swales, permeable paving and partial infiltration solutions) are proposed in areas where the designed layout and topography allow, which have not been included when sizing of the attenuation tanks.

When the overall site area is included, the resulting reduction in QBAR used in the design is considerable, 233.64 l/s to 170.80 l/s, implying that current peak fluvial flows from the site entering the watercourse are lower. The result is that the proposed control is very conservative and should result in a reduced flood risk downstream.

2.5 Based on the discharge Rate for QBAR, the associated attenuation storage for all attenuated networks is as shown in **Table 2.2**.

Neighbourhood	Area (Ha)	QBAR Attenuation Rate (l/s)	Attenuation Volume (cu.m)
N1	5.8738	29.89	1,147
N2	8.0406	40.91	1,373
N3	5.9368	30.21	1,508
N4	5.3195	27.07	1,471
N6	1.9338	9.84	951

Table 2.2 Attenuated Storage

The attenuated storage volumes are accommodated in a number of tanks located in green areas within each neighbourhood and have been 'daisy-chained' to reduce duplication of pipe runs. Each tank is preceded by a hydrocarbon interceptor implying that storm water run-off undergoes multiple 'cleanings' prior to final discharge.

2.6 The SuDS strategy for the site includes the following:

- Discharge Rate to be limited to QBAR for all rainfall events up to and including the 100-year storm event.
- Attenuation Storage to be provided up to the 100-year storm event allowing for 20% climate change.
- Hydrocarbon interceptor and silt chambers to be used upstream of each attenuation tank.
- Provision of infiltration soakpits for areas where the 'f' values are suitable.
- Provision of interception storage by means of open swales along road edges.
- Provision of permeable paving in public areas and to form 'home-zones'.
- Provision of tree-pits at suitable locations along roads and within the Park Area.
- Green roofs for Apartment Blocks in Neighbourhood 6.

Various interception measures such as open drainage swales, permeable paving, storm water storage butts for each unit, roof drainage to soakaways in rear gardens in parts of the development, green roofs for apartment blocks in neighbourhood 6 will ensure that the initial 5mm of rainfall is prevented from discharging from the site. This will ensure that the water quality of the receiving watercourse to the west is preserved.

2.7 As per section 16 of the GDRCoP and in particular the criteria as set out in section 16.3, compliance with all 4 Criteria is summarised as follows:

Criterion 1 (River Water Quality Protection):

Interception provided by way of:

- Permeable paving in public open spaces around the retail and creche area.
- Permeable paving provided to create 'home-zones' and traffic calming elements in parts of the development.
- Surface water runoff to 'Stormtech' infiltration chambers in parts of the development. These will be equipped with silt chambers and hydrocarbon interceptors.
- Open drainage swales along roads where gradients suit
- Green Roofs for Apartment Blocks in Neighbourhood 6.
- Water Butts and soakpits to rear gardens taken roof and patio drainage.

Criterion 2 (River Regime Protection):

Discharge rate restricted to QBAR for all storm events up to and including the 1 in 100-year storm event.

Criterion 3 (Level of service (flooding) for the site):

A review of the Office of Public Works (OPW) Flood Hazard Mapping website indicates that there are no records of flooding incidents at the site of the proposed development.

One report of a past flood event, from January 1988, remarks of flooding having occurred further south on Ballyhooly Road near Mervue Lawn due to a partial blockage of Glen Stream. No other report is recorded in the database for the local area.

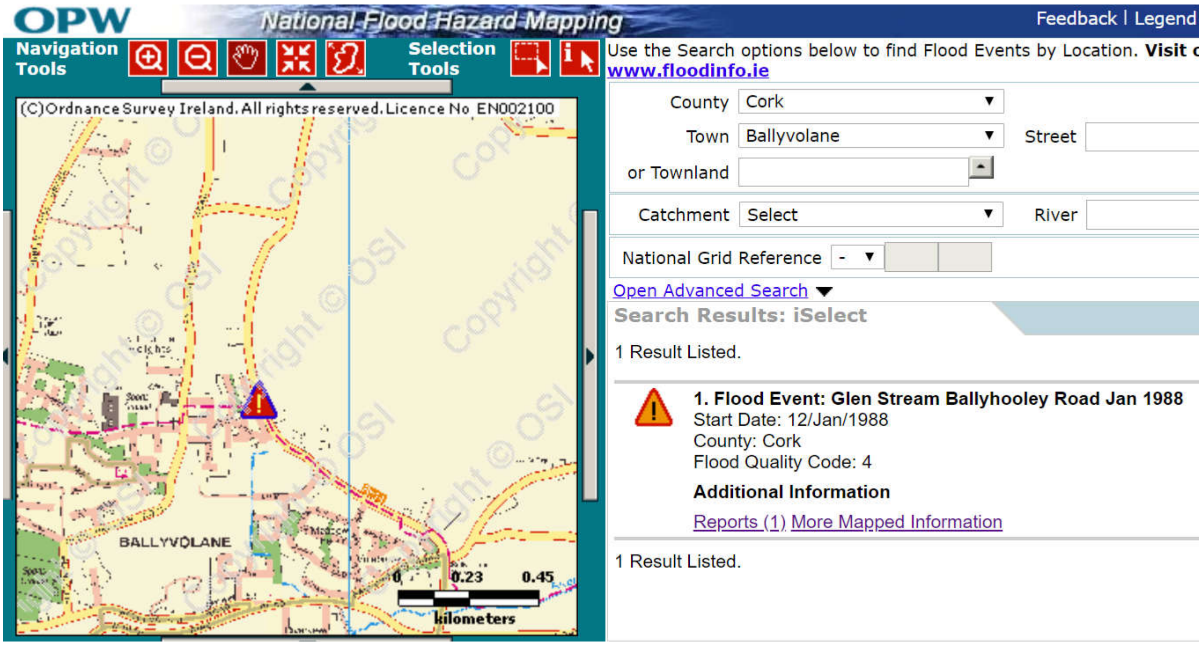


Figure 2.2 – OPW Flood Risk Mapping

- No Site Flooding.
- No internal property flooding.
- All FFL's are a minimum of 500mm above adjacent on-site attenuation/infiltration tanks.
- Flood routes have been mapped from each attenuated storage area showing overland routes away from dwellings.
- Run-off from green areas during high intensity storm events can be catered for in on-site attenuation tanks.

Criterion 4 (River Flood Protection):

Maximum discharge rate of QBAR for all attenuated storage is proposed which is considerably less than the 30-year and 100-year greenfield run-off rates as shown in **Table 2.1**. As previously outlined no reduction in terms of run-off has been allowed for in the sizing of attenuation tanks as a result of proposed SuDS measures.

2.8 Measures to avoid significant environmental effects on the quality of the existing watercourse and groundwater will be implemented as part of the construction drainage management system set out in the EIAR. These will include:

- Silt fences
- Settlement ponds
- Silt bags
- Interceptor drains
- Hydrocarbon Interceptors (from compounds/soil improvement works)
- Construction management methods

For the operational phase of the scheme the provision of SuDS interception measures for each neighbourhood will ensure that the first 5mm of rainfall is prevented from discharging from the site. It is often the case that the initial run-off from roads and hard pavement areas has a concentration of pollutants. This first-flush is being addressed on site thus ensuring the quality of the receiving waters is not impacted.

3.0 CONCLUSION

3.1 The storm water management proposals for the site have been informed by the relevant standards and comply with best practice in terms of SuDS (Sustainable Urban Drainage Design). In advance of submitting to the Board, agreement has been reached with Cork City Councils Environmental Department in terms of discharge location, discharge rate and SuDS measures proposed. Considerations such as on-going maintenance and taking in charge have also been addressed with the Local Authority.

By providing the measures as outlined the impact of the proposed development on the Hydrological area has been minimised and results in a reduced risk of flooding downstream of the discharge points. Recharge of the underlying aquifer is accommodated through the SuDS measures proposed.

APPENDIX 1: UKSUDS SITE EVALUATION REPORT

Site Drainage Evaluation

Site name: Longview Estates Dev.
Site location: Ballyvolane

Report Reference: 1574347847627
Date: 21/11/2019

1. INTRODUCTION

This is a bespoke report providing initial guidance on potential implementation of SuDS for the development site in line with current best practice.

The use of this tool should be supplemented by more detailed guidance on SuDS best practice provided in a number of sources, principally the CIRIA SUDS Manual (2007), other CIRIA documents; the Use of SUDS in High Density Developments, HR Wallingford, (2005) and other HR Wallingford documents.

The objective is to provide some early guidance on the numbers and types of components that might be suitable for consideration within the site design. This may facilitate pre-application discussions with planners and other relevant authorities.

This guidance has been provided prior to the completion of the SUDS standards and the supporting guidance. However the principles of this tool are unlikely to be very different to the aims of the SUDS standards. HR Wallingford is not liable for the use of any output from the use of this tool and the performance of the drainage system. It is recommended that detailed design using appropriately experienced engineers professionals and tools is undertaken before finalising any drainage scheme arrangement for a site.

THE CONTENT OF THE REPORT

This report is split into 8 sections as follows:

2. Generic SuDS Best Practice Principles
3. Runoff Destination
4. Hydraulic Design Criteria
5. Water Quality Design Criteria
6. Site-Specific Drainage Design Considerations
7. SuDS Construction
8. SuDS Components Performance
9. Guidance on The Use of Individual Components

2. GENERIC SuDS BEST PRACTICE PRINCIPLES

To comply with current best practice, the drainage system should:

(i) manage runoff at or close to its source;
(ii) manage runoff at the surface;
(iii) be integrated with public open space areas and contribute towards meeting the objectives of the urban plan;
(iv) be cost-effective to operate and maintain.

The drainage system should endeavour to ensure that, for any particular site:

(i) natural hydrological processes are protected through maintaining Interception of an initial depth of rainfall and prioritising infiltration, where appropriate;
(ii) flood risk is managed through the control of runoff peak flow rates and volumes discharged from the site;
(iii) stormwater runoff is treated to prevent detrimental impacts to the receiving water body as a result of urban contaminants.

In addition, it is desirable to maximise the amenity and ecological benefits associated with the drainage system where there are appropriate opportunities. SuDS are green infrastructure components and can provide health benefits, and reduce the vulnerability of developments to the impacts of climate change.

3. RUNOFF DESTINATION

Introduction

Infiltration should be prioritised as the method of controlling surface water runoff from the development site, unless it can be demonstrated that the use of infiltration would have a detrimental environmental impact.

Groundwater (via Infiltration)
Infiltration may not be appropriate for managing runoff from this site. Robust studies are reqired to confirm the significance of the following constraints to infiltration:

(1) This is a steeply sloping site and full consideration must be given to the hydrogeological infiltration pathways, to ensure that there is no risk of water re-emerging on the site or on other sites and contributing to downstream flood risk.

(2) The subsurface geology is primarily impermeable and the use of infiltration is unlikely to be suitable. Where infiltration rates are confirmed via testing to be < 1 x 10-7 m/s, infiltration will be very limited. Where infiltration rates are between 1 x 10-7 and 1 x 10-5 m/s, then soils can still provide Interception and partial infiltration. If rates are confirmed to be > 1 x 10-5 m/s, full infiltration can be considered in the design.

The groundwater beneath the site is designated as , and this designation will define the treatment requirement for any infiltrated water (See Water Quality Design Criteria).

Surface water body
All runoff that cannot be discharged to groundwater will be managed on site and discharged to a surface water body.

The receiving surface water body for runoff from the site is: the *Local stream*. The riparian owner is: *Cork City Council.*

4. HYDRAULIC DESIGN CRITERIA

Introduction
Best practice criteria for hydraulic control require Interception, runoff and volume control.

Interception
To fulfill the requirements for Interception, there should normally be no runoff from the site for an initial depth of rainfall - usually 5mm. This is achieved through the use of infiltration, evapotranspiration, or rainwater harvesting.

Flow and Volume Control
The site is a greenfield development, therefore runoff from the site needs to be constrained to the equivalent greenfield rates and volumes.

Attenuation and hydraulic controls will be used to manage flow rates.

Rainwater harvesting, or the use of Long Term Storage can be used to achieve greenfield runoff volume control. Where volume control is not practicable, flows discharged from the site will be constrained to Qbar or 2 l/s/ha (whichever is the greater).

5. WATER QUALITY DESIGN CRITERIA

Introduction
Current best practice takes a risk-based approach to managing discharges of surface runoff to the receiving environment. The following text provides guidance on the extent of water quality management likely to be appropriate for the site.

Hazard Classification
Runoff from clean roof surfaces (ie not metal roofs, roofs close to polluted atmospheric discharges, or roofs close to populations of flocking birds) is classified as Low in terms of hazard status.

Runoff from roads, parking and other areas of residential, commercial and industrial sites (that are not contaminated with waste, high levels of hydrocarbons, or other chemicals) is classified as Medium in terms of hazard status.

Treatment requirements for disposal to surface water systems
The catchment area of Local stream to the point of the discharge from the site is < 50 km2, therefore it is classified as a sensitive receptor.

The level of urbanisation of the catchment at the point of the discharge from the site is < 20%, therefore it may be classified as a sensitive receptor.

Roof runoff will require 1 treatment stage prior to discharge.

Runoff from other parts of this site such as roads, parking and other areas will require 3 treatment stages prior to discharge.

6. SITE-SPECIFIC DRAINAGE DESIGN CONSIDERATIONS

The site is a high density residential site. The HR Wallingford documenet 'SuDS for high density developments' is a useful guidance document for efficient drainage design where space is heavily constrained.

Components likely to be particularly suitable for high density sites include:

• permeable pavement parking areas which can often manage roof runoff as well as rainfall falling on the parking surface;
• green roofs which limit runoff from roof surfaces;
• bioretention areas integrated within impermeable zones;
• individual property soakaways;
• subsurface infiltration and/or detention systems (eg beneath functional, permeable surfaces);
• infiltration/detention/retention ponds/basins/channels integrated within public open space areas.

Where SuDS are being designed for sites with steep slopes, careful consideration of site layout planning and SUDS alignment is needed to minimise gradients of conveyance pathways and construction of large embankments, and to minimise flood risk when drainage systems are exceeded.

The design of SuDS with access to temporary or permanent water should consider public health and safety as well as issues associated with construction and operational management of the structures. Health and safety issues and risk mitigation features are presented in the CIRIA SuDS Manual.

Individual SuDS components should not be treated in isolation, but should be seen together as providing a suite of drainage features which are appropriate in different combinations for varying scales. It is always desirable to have a mix of SuDS components across the site as different components have different capacities for treatment of individual pollutants.

7. SuDS CONSTRUCTION

SuDS are a combination of civil engineering structures and landscaping practice. Due to the limited experience of building SuDS in the water industry, there are a number of key issues which need to be particularly considered as their construction requires a change in approach to some standard construction practices.

• SuDS components should be constructed in line with either the manufacturer's guidelines or best practice methods.
• The construction of SuDS usually only requires the use of fairly standard civil engineering construction and landscaping operations, such as excavation, filling, grading, top-soiling, seeding, planting etc. These operations are specified in various standard construction documents, such as the Civil Engineering Specification for the Water Industry (CESWI).
• Construction of soakaways is regulated by the Buildings Regulations part H (Drainage and waste disposal) which sets out the requirements for drainage of rainwater from the roofs of buildings.
• During construction, any surfaces which are intended to enable infiltration must be protected from compaction. This includes protecting from heavy traffic or storage of materials.
• Water contaminated with silt must not be allowed to enter a watercourse or drain as it can cause pollution. All parts of the drainage system must be protected from construction runoff to prevent silt clogging the system and causing pollution downstream. Measures to prevent this include soil stabilisation, early construction of sediment management basins, channelling run-off away from watercourses and surface water drains, and erosion prevention measures.
• After the end of the construction period and prior to handover to the site owner/operator:
  - Subsoil that has been compacted during construction activities should be broken up prior to the re-application of topsoil to garden areas and other areas of public open space to reinstate the natural infiltration performance of the ground;
  - Any areas of the SuDs that have been compacted during construction but are intended to permit infiltration must be completely refurbished;
  - Checks must be made for blockages or partial blockages of orifices or pipe systems;
  - Any silt deposited during the construction must be completely removed;
  - Soils must be stabilised and protected from erosion whilst planting becomes established.

Detailed guidance on the construction related issues for SuDS is available in the SuDS Manual and the associated Construction Site handbook (CIRIA, 2007).

8. SuDS COMPONENTS PERFORMANCE

	Interception	Peak flow control: Low	Peak flow control: High	Volume reduction	Volume control	Gross sediments	Fine sediments	Hydrocarbons/ PAHs	Metals	Nutrients
Rainwater	Y	Y	S	Y	N	N	N	N	N	N

Harvesting										
Pervious Pavement	Y	Y	Y	Y	Y	Y	Y	Y	Y	Var
Filter Strips	Y	N	N	N	N	Y	N	Y	Y	Var
Swales	Y	Y	S	Y(*)	N	Y	Y(+)	Y	Y	Y(-)
Trenches	Y	Y	S	Y(*)	N	N	N	Y	Y	Y(-)
Detention Basins	Y	Y	Y	N	Y	Y	Y(+)	Y	Y	Var
Ponds	N	Y	Y	N	Y	N(~)	Y	Limited	Y	Var
Wetlands	N	Y	S	N	Y	N(~)	Y	Limited	Y	Y
Green Roofs	Y	Y	N	N	N	N	N	Y	N	N
Bioretention Systems	Y	Y	S	Y(*)	N	N(~)	Y	Y	Y	Y
Proprietary Treatment Systems	N	N	N	N	N	Y	Y	Y(!)	Y(!)	Y(!)
Subsurface Storage	N	Y	Y	N	Y	N(~)	N	N	N	N
Subsurface Conveyance Pipes	N	N	N	N	Y	N(~)	N	N	N	N

Notes:
S: Not normally with standard designs, but possible where space is available and designs mitigate impact of high flow rates.
Y(*): Where infiltration is facilitated by the design.
N(~): Gross sediment retention is possible, but not recommended due to negative maintenance and performance implications.
Y(+): Where designs minimise the risk of fine sediment mobilisation during larger events.
Y(!): Where designs specifically promote the trapping and breakdown of oils and PAH based constitutents.
Y("): Where subsurface soil structure facilitates the trapping and breakdown of oils and PAH based constituents.
Var: The nutrient removal performance is variable, and can be negative in some situations.
Y(-): Good nutrient removal performance where subsurface biofiltration systems with a permanently saturated zone included within the design.

9. GUIDANCE ON THE USE OF INDIVIDUAL COMPONENTS

Rainwater Harvesting

• *High density*
For large occupancy buildings (offices, supermarkets, etc.), communal rainwater harvesting systems may provide significant stormwater management benefits.

• *Roofs*
Rainwater harvesting systems can be used to effectively drain roofs and provide both water supply and stormwater management benefits.

Pervious Pavement

• *High density*
Pervious pavement systems provide an effective way to drain, store and treat the surface runoff, all within the footprint of the car park area. Larger areas of communal parking will provide the most cost effective systems.

• *Roofs*
Roof water can be drained into pervious pavement areas using diffusers to dissipate the point inflows. Detailed design of the pavement will need to take account of the additional impermeable roof area.

• *Roads*
Some types of pervious pavement can be used for relatively highly trafficked roads and pavement manufacturers should be consulted on the appropriate specification.

• *Car parks/other impermable surfaces*
Pervious pavements provide effective drainage, storage and treatment of car park surfacing,

• *Steep site*
Pervious pavements can be used on sloping sites, with the use of internal dams in order to attenuate and store the water effectively through a cascade system.

Filter Strips

• *High density*
Filter strips can be used as treatment for road or car park runoff where space allows.

• *Roads*
Filter strips can provide treatment for road runoff, upstream of swales or trench components. They can reduce the need for kerbing and runoff collection systems.

• *Car parks/other impermable surfaces*
Filter strips can provide treatment for runoff from impermeable surfaces, upstream of swales or trench components. They can reduce the need for kerbing and runoff collection systems.

• *Site size > 50 ha*
The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

• *Steep site*
Filter strips can be used on sloping sites, where implemented parallel to the contours. The consequences of exceedance and flood flow paths will need to be considered.

Swales

• *High density*
Swales can be used for road or car park drainage where space allows. Underdrained swales (ie with a subsurface gravel filled conveyance and treatment trench) can provide a more efficient solution for hydraulic control and water quality treatment.

• *Roofs*
Swales can be used to convey roof water to other parts of the site.

• *Roads*
Swales provide treatment and conveyance of road runoff. There are a range of swale types - standard grass channels, underdrained swales, and wetland swales - depending on drainage requirements.

• *Car parks/other impermable surfaces*
Swales provide treatment and conveyance of runoff from impermeable areas. There are a range of swale types - standard grass channels, underdrained swales, and wetland swales - depending on drainage requirements.

• *Site size > 50 ha*
The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

• *Steep site*
Swales can be used on sloping sites, where implemented parallel to the contours. The consequences of exceedance and flood flow paths will need to be considered.

Trenches

• *High density*
Trenches can provide treatment and runoff control for road or car park drainage.

• *Roofs*
Trenches can be used to convey roof water to other parts of the site.

• *Roads*
Trenches can provide treatment and conveyance of road runoff. They require effective pretreatment to minimise the risk of blockage.

• *Car parks/other impermable surfaces*
Trenches can provide treatment and conveyance of runoff for impermeable areas.

• *Site size > 50 ha*
The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

• *Steep site*
Trenches can be used on sloping sites, where implemented parallel to the contours. The consequences of exceedance and flood flow paths will need to be considered.

Detention Basins

• *High density*
Detention basins can be used in high density developments when effectively integrated within public open space areas.

• *Roofs*
Detention basins can be used to attenuate and treat runoff.

• *Roads*
Detention basins can be used to attenuate and treat runoff.

• *Car parks/other impermable surfaces*
Detention basins can be used to attenuate and treat runoff.

• *Site size > 50 ha*
The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria. A risk assessment should be used to determine the maximum appropriate depth of stored water in the basin.

• *Steep site*
Large basins may require embankments that may pose a safety risk to site residents.

Ponds

• *High density*
It is unlikely that a pond would be suitable for high density development, unless it is an integral amenity feature within the public open space area.

• *Roofs*
Ponds can be used to attenuate and treat roof runoff.

• *Roads*
Ponds can be used to attenuate and treat runoff. However, they are best implemented at the lower end of the treatment train as a 'polishing' component. They should not be used as sediment management devices, as sediment and wet vegetation is relatively costly to extract and dispose of. If poor quality water remains in ponds for extended periods, nutrient concentrations can rise - particularly in the summer months, and the pond can become unattractive with poor amenity and biodiversity potential.

• *Car parks/other impermable surfaces*
Ponds can be used to attenuate and treat runoff. However, they are best implemented at the lower end of the treatment train as a 'polishing' component. They should not be used as sediment management devices, as sediment and wet vegetation is relatively costly to extract and dispose of. If poor quality water remains in ponds for extended periods, nutrient concentrations can rise - particularly in the summer months, and the pond can become unattractive with poor amenity and biodiversity potential.

• *Site size > 50 ha*
The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

• *Steep site*
Large ponds may require embankments that may pose a safety risk to site residents.

• *Other*
Ponds built in permeable soils will require lining to maintain the water level of the permanent pool. The lining may be finished 100 or 200 mm lower than the outlet invert to encourage some infiltration to take place to contribute to interception.

Wetlands

• *High density*
It is unlikely that a wetland would be suitable for high density development, unless it is an integral amenity feature within the public open space area.

• *Roofs*
Wetlands can be used to attenuate and treat roof runoff.

• *Roads*
Wetlands can be used to attenuate and treat runoff. However, they are best implemented at the lower end of the treatment train as a 'polishing' component. They should not be used as sediment management devices, as sediment and wet vegetation is relatively costly to extract and dispose of. If poor quality water remains in wetlands for extended periods, nutrient concentrations can rise - particularly in the summer months, and the wetland can become unattractive with poor amenity and biodiversity potential.

• *Car parks/other impermable surfaces*
Wetlands can be used to attenuate and treat runoff. However, they are best implemented at the lower end of the treatment train as a 'polishing' component. They should not be used as sediment management devices, as sediment and wet vegetation is relatively costly to extract and dispose of. If poor quality water remains in wetlands for extended periods, nutrient concentrations can rise - particularly in the summer months, and the wetland can become unattractive with poor amenity and biodiversity potential.

• *Site size > 50 ha*
The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

• *Steep site*
It is likely that wetlands would require embankments that may pose safety risks to site residents.

Green Roofs

• *HighDensity*
Green roofs can be implemented most cost-effectively on larger roofs. They provide a range of benefits in addition to stormwater management, including combatting the heat island effect, biodiversity and amenity functions.

• *Roofs*
Green roofs can be designed to provide interception, management and treatment of rainfall up to specified rainfall depths.

Bioretention Systems

• *High density*
Biorention systems (either cells or linear systems) can be used for road or car park drainage where space allows.

• *Roofs*
Bioretention systems can be used to attenuate and treat roof runoff.

• *Roads*
Linear bioretention systems (ie biofiltration swales) can be used to attenuate and treat road runoff.

• *Car parks/other impermable surfaces*
Bioretention systems canbe used for car park drainage.

• *Site size > 50 ha*
Bioretention systems will tend to be suitable for managing small areas only.The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

• *Steep site*
Bioretention systems can be used on sloping sites, when implemented parallel to the contours. The consequences of exceedance and flood flow paths will need to be considered.

Proprietary Treatment Systems

• *High density*
Proprietary treatment systems may be appropriate to use particularly where there is no space for surface, vegetated treatment systems. However, regular monitoring needs to be ensured so that they are maintained so that they continue to function effectively.

• *Roads*
Proprietary treatment systems can be used where surface vegetated systems are impracticable. However, regular monitoring needs to be ensured so that they are maintained so that they continue to function effectively.

• *Car parks/other impermable surfaces*
Proprietary treatment systems could be used where surface vegetated systems are impracticable. However, regular monitoring needs to be ensured so that they are maintained so that they continue to function effectively.

• *Site size > 50 ha*
Proprietary treatment systems will tend to be suitable for managing small areas only. The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

Subsurface Storage

• *High density*
Subsurface storage of runoff is likely to be needed for high density developments. This can be implemented via a range of proprietary high void systems, or within gravels beneath permeable pavements which provide treatment as well. Sub-surface storage allows the land above the storage system to be used for car parking or public open space areas.

• *Roofs*
Subsurface storage can be used to attenuate roof runoff.

• *Roads*
Subsurface storage can be used to attenuate road runoff.

• *Car parks/other impermable surfaces*
Subsurface storage can be used to attenuate car park runoff.

Subsurface Conveyance Pipes

• *High density*
Subsurface conveyance systems may be an important means of connecting drainage components together and routing flows downstream. Space constraints in high density developments are likely to constrain the use of surface conveyance options.

HR Wallingford Ltd, the Environment Agency and any local authority are not liable for the performance of a drainage scheme which is based upon the output of this report.

APPENDIX 2: STORMTECH O&M MANUAL

Save Valuable Land and Protect Water Resources

StormTech®
Detention • Retention • Recharge
Subsurface Stormwater Management℠

Isolator™ Row O&M Manual

StormTech® Chamber System for Stormwater Management

U.S. Green Building Council Member™

1.0 The Isolator™ Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR™ ROW

The Isolator Row is a row of StormTech chambers, either SC-310, SC-740 or MC-3500 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

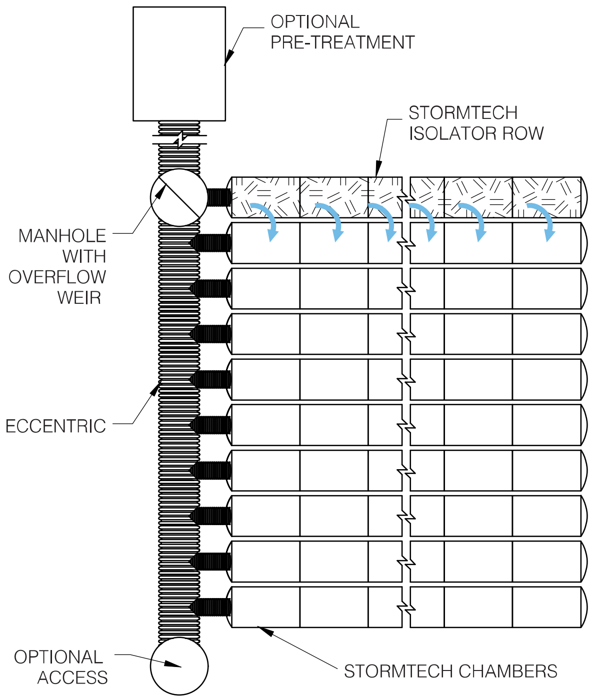
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

StormTech Isolator Row with Overflow Spillway
(not to scale)



2.0 Isolator Row Inspection/Maintenance

StormTech®

2.1 INSPECTION

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

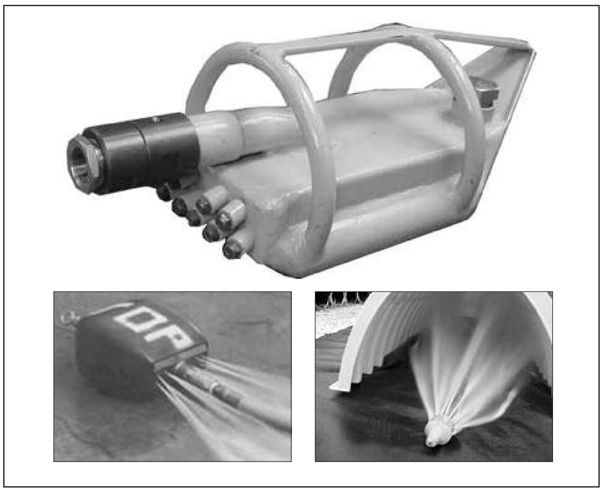
At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

2.2 MAINTENANCE

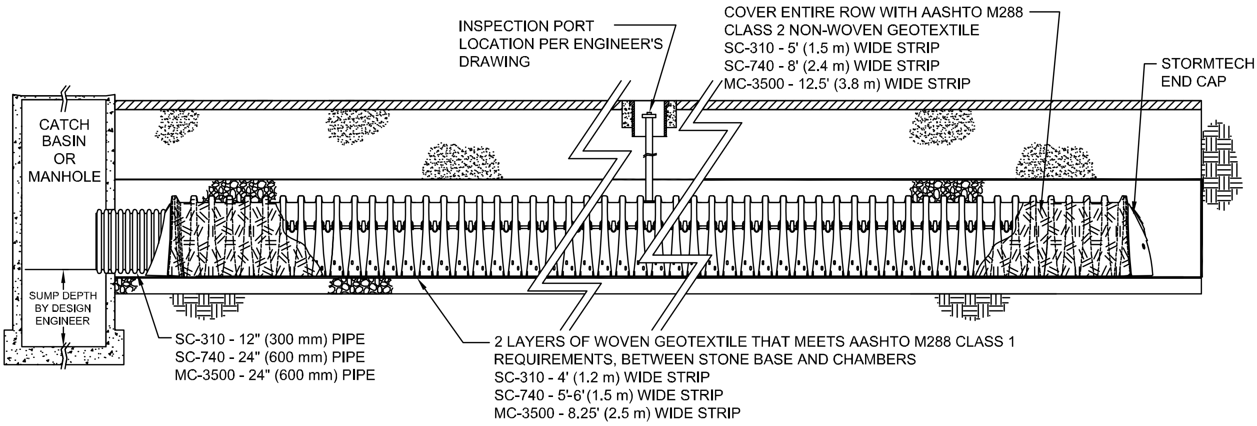
The Isolator Row was designed to reduce the cost of periodic maintenance. By "isolating" sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.



Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45" are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

StormTech Isolator Row (not to scale)



3.0 Isolator Row Step By Step Maintenance Procedures

Step 1) Inspect Isolator Row for sediment

A) Inspection ports (if present)

i. Remove lid from floor box frame

ii. Remove cap from inspection riser

iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.

iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.

B) All Isolator Rows

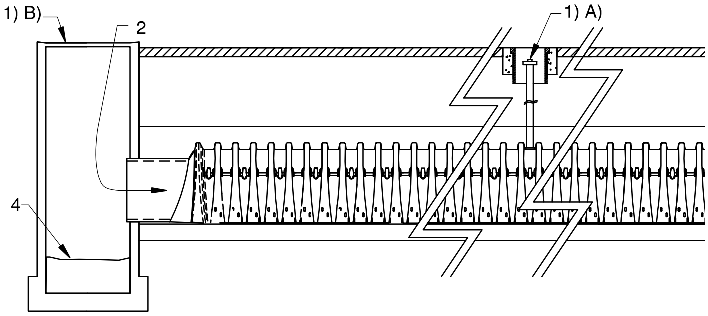
i. Remove cover from manhole at upstream end of Isolator Row

ii. Using a flashlight, inspect down Isolator Row through outlet pipe

1. Mirrors on poles or cameras may be used to avoid a confined space entry
2. Follow OSHA regulations for confined space entry if entering manhole

iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

StormTech Isolator Row (not to scale)



Step 2) Clean out Isolator Row using the JetVac process

A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable

B) Apply multiple passes of JetVac until backflush water is clean

C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system

Sample Maintenance Log

Date	Stadia Rod Readings		Sediment Depth (1) - (2)	Observations/Actions	Inspector
	Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)			
3/15/01	6.3 ft.	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft.	Some grit felt	sm
6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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