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14 April 2023

Our Reference
60659192

The Land Use, Planning and
Transportation Department,
County Hall,
Belgard Square North,
Tallaght,
Co. Dublin

Dear Sir/Madam

Application Ref. SD22A/0347 Romeville Developments Limited Residential Development at Stoney Hill Road, Rathcoole, Co. Dublin.

We write in response to the Request for Further Information (RFI) Item No. 4 & Item No. 9 sought by South Dublin County Council (SDCC) in relation to planning application ref. SD22A/0347. The proposed development includes the demolition of 1 residential property and 1 ancillary outbuilding, construction of 42no. dwellings, provision of public open space, pedestrian links, and site access.

The RFI Item No. 4 and response is detailed below.

4) **SuDS. The use of an underground tank under public open space is not supported by County Development Plan policy. The development should utilise natural SUDs to the extent that underground storage is not needed, if possible. The SUDs layout should reflect the pre-existing water flows on site, and greenfield run-off rates should be achieved, and the direction of run-off maintained where this is appropriate. The applicant is requested to submit the following:**

   i. **A drawing to show how surface water shall be attenuated to greenfield run off rates.**

   Response – Please refer to AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0520 which displays the attenuation features to be used on site with swales, filter drains, a pond and a stormtech attenuation tank proposed to attenuate the overland flow catchment and surface water generated from the development to the 7.7 L/sec greenfield run off rate.

   The runoff rate at planning stage was calculated as 6 L/sec based on the red line boundary area of 2.6ha. However, it was noted that not the entire overland catchment area was included within the red line boundary. Figure 1 shows the additional 0.7ha of catchment area, highlighted in green, that is captured within the main site drainage network.

   Considering this area is captured within the site network and attenuated the greenfield runoff rate was updated to include this additional area. Please refer to Appendix A which has the greenfield runoff calculation sheet from uksuds.com for a catchment area of 3.3ha.

Figure 1: Extent of Overland Catchment Area

ii. **Submit a drawing to show what SuDS (Sustainable Drainage Systems) are proposed. Examples of SuDS include permeable paving, filter drain, bio-retention tree pits, rain gardens, swales or other such SuDS.**

Response – Please refer to AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0520 which shows the SuDS proposed to provide treatment for the hardstanding areas throughout the development, these include:

- porous asphalt in the homezone areas;
- rainwater butts to the rear of all proposed units;
- permeable paving for all car parking spaces;
- filter drains along the edge of roadways where possible;
- grasscrete for the temporary turning head at the north east of the site (this turning head will not be required upon completed of the future phases)
- stormtech attenuation tank totalling a volume of 460m^3;

An assessment was carried out to ensure that the above proposed SuDS features will provide a minimum of 15mm treatment storage as per Sub-Criterion 1.2 from Table 6.2 GDSDS Volume 2 New Development. The proposed treatment volumes are outlined in Table 1 below.

Table 1. Proposed Treatment Volume

Feature	Area (m^2)	Treatment Storage Required (m^3)	Treatment Storage provided (m^3)
Roof Area	3066	36.8	-
Road Area	2565	30.8	-
Filter Drain **	27	-	6.0
Attenuation Tank ***	398	-	63.6
Grasscrete ****	52	0.6	4.7
Porous Asphalt *****	1140	13.7	23.5
Permeable Paving ******	1008	12.1	26.5
Treatment Provision		**94.0**	**124.2**

** Based on the first 15mm of rainfall over 80% of the total impermeable site area, as per GDSDS*
*** Based on 0.75m substrate depth for the filter drains with 30% porosity*
**** Based on 0.4m substrate depth for the attenuation tank with 40% porosity*
***** Based on 0.35m substrate depth for the grasscrete area with 30% porosity*
****** Based on 0.275m substrate depth for the porous asphalt at 30% porosity (Based on road gradients total treatment volume provided for the porous asphalt areas reduced by 75% as a conservative estimate given majority of road at gradients of 1:18/25)*
******* Based on 0.35m substrate depth for the permeable paving at 30% porosity (Similar to porous asphalt treatment reduced by 75% as a conservative estimate with spaces located on roads at the same gradients)*

As displayed above, the proposed layout provides an excess of treatment storage and for the purposes of this exercise, the volume of tree pits, rainwater butts, and oil separator have not been included.

The overland flow from the upstream catchment is proposed to be captured and attenuated through soft SuDS measures which include:

- Swales, and;
- A series of tiered ponds to maximise storage.

iii. **SUDs Management – The applicant is requested to submit a comprehensive SUDS Management Plan to demonstrate that the proposed SUDS features have reduced the rate of run off into the existing surface water drainage network. A maintenance plan should also be included as a demonstration of how the system will function following implementation.**

Response – AECOM have reviewed the potential systems that could have been proposed internally within the Phase 1 site such as: integrated constructed wetlands, filter drains, swales and basins.

All these features have been considered for inclusion in the proposed development but have been found **incompatible** with the topography of the site and the nature of the proposed development. Integrated constructed wetlands, swales and basins are designed to slow the flow of the water, store and treat the runoff while draining through the site, encouraging biodiversity. Positioning these types of SuDS within the internal site layout is difficult to achieve for the following reasons:

- The ground falls from south to north at an average gradient of approximately 1:20 (gradients vary from 1:15 to 1:25). The majority of the SuDS systems require a longitudinal slope of less than 1:100 or a maximum velocity at full flow conditions of 2m/s;
- Excluding the footprint of the houses, the majority of the remaining site area is hardstanding (i.e. covered by roads and footpaths) with the required percentage of public/communal open space. There is no room for verges along the proposed roads where swales could be proposed.
- For the wetlands/detention & basins to function they need to be relatively flat and sufficiently deep to accept runoff by gravity from the contributing impermeable areas. This would be particularly difficult to achieve considering that the inlets of the attenuation tank are very deep (i.e. the proposed invert level of the incoming pipe to the attenuation tank is 127.269m, with a cover level of 133.391m – circa 5.545m of manhole depth). If provided, the basins would be extremely deep and unsafe for children at play and the general health and safety of the public, and it would therefore be required to be fenced off, which would negate the use of the open space.

Based on these findings and the proposed Architectural layout, alternative SuDS measures have been provided to treat the surface water runoff internally within the site, to replicate the natural characteristics of the greenfield runoff and minimise the environmental impact. The proposed SuDS are listed below:

- Permeable Paving;
- Porous Asphalt;
- Grasscrete;
- Rainwater Butts;
- Filter Drains;

- Stormtech Attenuation Tank;
- Swales (overland flow catchment);
- A series of tiered pond's (overland flow catchment), and
- Petrol Interceptor.

Please refer to Appendix B for the proposed on-site Surface Water Network calculations that have been designed using Innovyze Microdrainage software which includes the swales, porous asphalt, filter drains and pond's within the model to display how the flows from the development will be attenuated and reduced for the critical storm event.

iv. **Additional natural SUDS features should be incorporated into the proposed drainage system for the development such as bio-retention/constructed tree pits, permeable paving, green roofs, filtration planting, filter strip etc. In addition, should provide the following:**

a. **Demonstrate how the proposed SUDS scheme has been designed to incorporate and adhere to the natural route of groundwater through and out of the site.**

Response – The proposed drainage and SUDS systems have been designed in accordance with GDSDS and SUDS principles and therefore takes account of the existing groundwater flow regime at the site. For further details, please refer to the site's Sustainable Urban Drainage Hydrogeological Assessment by Enviroguide Consulting.

b. **Demonstrate how the proposed natural SUDS features will be incorporated and work within the drainage design for the proposed development.**

Response – Please refer to drawings 60659192-ACM-01-00-DR-CE-10-0501 and 60659192-ACM-01-00-DR-CE-10-0520, and Appendix B which demonstrates how the SuDS features are incorporated into the drainage design for the proposed development with no flooding occurring throughout any SuDS features.

c. **Tree pits incorporating SUDS features should include a deep cellular water storage/attenuation area below the surface which acts as a soak away allowing surface water to infiltrate into the ground.**

Tree pits have been incorporated throughout the development where possible, refer to drawing 60659192-ACM-01-00-DR-CE-10-0520. These tree pits have not been included in the model however, infiltration rates provided by site investigations carried out in May 2022 were applied within the model to all the ponds, swales and attenuation tank area.

The pond and swale areas were applied with a conservative infiltration rate of 4.8 mm/hr, as the location of these areas was located between two test locations with the lowest value used as a more conservative rate.

An infiltration rate of 7.2 mm/hr was applied to the attenuation tank area as a test location was used where the tank is currently proposed. It should be noted that as part of calculating the infiltration capacity of the proposed attenuation tank within the model the tank base area contributing to infiltration was reduced to 50%. The base area was reduced to account for any construction inefficiencies that may impact the resulting infiltration rate from the attenuation tank.

d. **It is unclear how much attenuation in total is provided by the proposed bioretention tree pits for the development. The applicant shall submit a report and drawing showing how much surface water attenuation in m^3 is provided for the development.**

Response – Please refer to AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0520 which displays the attenuation features to be used on site. The following is a breakdown of the surface water attenuation in m^3 provided by each of the features:

- Swales – $89m^3$
- Filter Drains – $6m^3$
- Pond's – $388m^3$

- StormTech Attenuation Tank – 460m^3
- Porous Asphalt – 23.5m^3

AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0701 for the proposed site gradients incorporating the tiered pond's and swales within the design.

e. **The applicant is requested to refer to the recently published 'SDCC Sustainable Drainage Explanatory, Design and Evaluation Guide 2022' for acceptable SUDS tree pit details.**

Response –Proposed tree pits will be in accordance with SDCC Sustainable Drainage Explanatory Design and Evaluation Guide 2022, please refer to AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0520 for the location of these tree pits. Note, the attenuation volume provided by the tree pits has been omitted as these pits were not included in the model.

f. **The applicant is requested to submit a Landscape and SUDS Management and Maintenance Plan including long term design objectives, management responsibilities and maintenance schedules for all landscape areas and proposed SUDS features for the approval of the Public Realm Section.**

Response – Please refer to Appendix C for a typical SuDS Maintenance Inspection Checklist which includes the typical operation and maintenance requirements for the proposed SuDS measures as outlined above, this is sourced from the CIRIA SuDS Manual C753.

AECOM drawing 60659192-ACM-01-00-DR-CE-10-0530 which details the maintenance regime and identifies the key maintenance locations such as the outlets and flow control locations.

g. **Underground attenuation tanks are only permitted in exceptional circumstances and where all other natural SUDS measure have been utilized. If all other methods have been utilized and it is demonstrated that underground attenuation is required, it cannot be proposed under public open space areas and such areas will not be taken in charge by Public Realm. SUDS measures are only accepted as an element of public open spaces where they are natural in form and integrate well into the open space landscape supporting a wider amenity and biodiversity function.**

Response – As outlined in AECOM's response to Part iii, AECOM have reviewed the potential systems that could have been proposed internally within the Phase 1 site and some have been found incompatible with the topography of the site and the nature of the proposed development, for the reasons outlined in AECOM's response to Part iii.

AECOM have maximised the use of ponds and swales to attenuate the upstream overland flow by introducing a tiered pond system such that cutting is minimised and storage is maximised. Given the nature of the development, it is not possible to implement this type of SUDS measures internally within the site.

An attenuation tank totalling a volume of 460m^3 is necessary to attenuation the surface runoff from the proposed development. This tank was proposed as part of a previous granted planning permission for the strategic housing development (SHD) and has a volume of 554.4 m^3. By implementing additional SUDS measures across the site, the tank volume has been reduced by 94.4m^3. Refer to Appendix D for details on the proposed tank.

The RFI Item No. 9 and response is detailed below.

9) **Roads.**

a) **The applicant shall submit a revised layout of not less than 1:200 scale, showing the amendments to the public road lining to facilitate turning into and out of the development. The works are to be undertaken by the applicant/developer and at their own expense.**

Response – Please refer to AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0002 showing the proposed road markings upgrade to all the turning into and out of the proposed development.

b) **The applicant is requested to submit a revised layout not less than 1:100 scale showing the car parking and pedestrian routes within the development. The number of parking spaces shall be limited to a ratio of 1.6 per 3-bedroom dwelling:**

   i. **The minimum width of footpaths shall be 1.8m wide to aid mobility impaired users.**

   ii. **Footpath layout shall provide adequate connectivity around the development and to footpaths on the main road.**

   Response – Please refer to AECOM drawing no. 60659192-ACM-01-00-DR-CE-10-0002 to 0006 showing the car parking and pedestrian routes within the development.

   To note all footpaths are 1.8m wide and footway access to the main Stoney Hill Road is via the only vehicular access point to the site. There is a homezone area, parallel to the access road on the north, however this is 3m higher than the existing Stoney Hill roadway levels therefore, a pedestrian access from this point is not achievable.

c) **The applicant shall submit a revised layout of not less than 1:200 scale, showing a main access road of 6.0m in width – if it is to become the main distributor road to residential zoned lands to the east of the development. Alternatively, the applicant may wish to display alternative access options via a masterplan of the adjoining lands.**

   Response – Please refer to Architectural drawing (P)020 which shows the future road connectivity between the proposed phase 1 development and the entire masterplan development.

   The current 5.5m wide access proposal is in accordance with the DMURS (Design Manual for Urban Roads and Streets) where the minimum width for Arterial/Link streets with low/moderate speed is 5.5/6.5m. Increasing the road width from 5.5m to 6.0m would encourage greater speeds and so it was deemed more appropriate to keep the internal road width at 5.5m.

Kind regards,

Jamie Cullen

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Appendix A – UKSuDS Greenfield Runoff Calculation Sheet

HR Wallingford
Working with water

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Jamie Cullen
Site name:	Stoney Hill
Site location:	Rathcoole

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

Site Details

Latitude:	53.27607° N
Longitude:	6.46818° W
Reference:	891046949
Date:	Feb 16 2023 09:22

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 3.3

Methodology

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

Soil characteristics	Default	Edited
SOIL type:	2	2
HOST class:	N/A	N/A
SPR/SPRHOST:	0.3	0.3

Hydrological characteristics	Default	Edited
SAAR (mm):	930	863
Hydrological region:	12	12
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 30 years:	2.13	2.13
Growth curve factor 100 years:	2.61	2.61
Growth curve factor 200 years:	2.86	2.86

Notes

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

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

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

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

(3) Is SPR/SPRHOST ≤ 0.3?

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

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):	8.39	7.68
1 in 1 year (l/s):	7.13	6.53
1 in 30 years (l/s):	17.86	16.37
1 in 100 year (l/s):	21.89	20.05
1 in 200 years (l/s):	23.98	21.97

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement , which can both be found at www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

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Appendix B – MicroDrainage Surface Water Network Calculations

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - Scotland and Ireland

Return Period (years)	5	PIMP (%)	100
M5-60 (mm)	21.300	Add Flow / Climate Change (%)	0
Ratio R	0.271	Minimum Backdrop Height (m)	0.000
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	0.000
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	11.403	0.114	100.0	0.017	4.00	0.0	0.600	o	225	Pipe/Conduit	
S1.001	53.008	0.530	100.0	0.091	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.002	15.945	0.725	22.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.003	12.416	0.062	200.3	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.004	4.025	0.310	13.0	0.007	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.005	13.876	0.069	201.1	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.000	10.385	0.104	99.9	0.028	4.00	0.0	0.600	o	225	Pipe/Conduit	
S2.001	10.385	0.104	99.9	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.002	9.356	0.094	99.5	0.028	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.003	6.060	0.061	99.3	0.038	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.004	8.370	0.084	99.6	0.044	0.00	0.0	0.600	o	225	Pipe/Conduit	
S2.005	11.223	0.321	35.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.006	2.775	0.350	7.9	0.007	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.007	18.721	0.094	199.2	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.008	15.129	0.598	25.3	0.005	0.00	0.0	0.600	o	225	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.000	50.00	4.15	136.847	0.017	0.0	0.0	0.0	1.31	52.0	2.3
S1.001	50.00	4.82	136.600	0.107	0.0	0.0	0.0	1.31	52.0	14.5
S1.002	50.00	4.92	135.400	0.107	0.0	0.0	0.0	2.80	111.4	14.5
S1.003	50.00	5.14	134.178	0.107	0.0	0.0	0.0	0.92	36.6	14.5
S1.004	50.00	5.16	134.116	0.114	0.0	0.0	0.0	3.65	145.2	15.4
S1.005	50.00	5.41	133.450	0.114	0.0	0.0	0.0	0.92	36.5	15.4
S2.000	50.00	4.13	135.750	0.028	0.0	0.0	0.0	1.31	52.0	3.9
S2.001	50.00	4.26	135.346	0.028	0.0	0.0	0.0	1.31	52.0	3.9
S2.002	50.00	4.38	134.942	0.057	0.0	0.0	0.0	1.31	52.1	7.7
S2.003	50.00	4.46	134.548	0.094	0.0	0.0	0.0	1.31	52.2	12.8
S2.004	50.00	4.57	134.312	0.138	0.0	0.0	0.0	1.31	52.1	18.7
S2.005	50.00	4.65	134.228	0.138	0.0	0.0	0.0	2.22	88.3	18.7
S1.006	50.00	5.42	133.381	0.260	0.0	0.0	0.0	4.68	185.9	35.2
S1.007	50.00	5.76	132.544	0.260	0.0	0.0	0.0	0.92	36.7	35.2
S1.008	50.00	5.86	132.450	0.265	0.0	0.0	0.0	2.61	103.9	35.9

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S3.000	10.304	0.103	100.0	0.002	4.00	0.0	0.600	o	225	Pipe/Conduit	
S3.001	9.210	0.092	100.1	0.006	0.00	0.0	0.600	o	225	Pipe/Conduit	
S3.002	9.210	0.092	100.1	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S3.003	7.158	0.358	20.0	0.001	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.009	14.399	0.050	288.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
S4.000	17.736	0.089	199.3	0.000	4.00	0.0	0.600	o	225	Pipe/Conduit	
S4.001	4.005	1.001	4.0	0.245	0.00	0.0	0.600	o	225	Pipe/Conduit	
S4.002	16.581	0.083	199.8	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.010	2.565	0.641	4.0	0.020	0.00	0.0	0.600	o	300	Pipe/Conduit	
S1.011	18.095	0.072	251.3	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
S1.012	1.083	0.011	100.0	0.012	0.00	0.0	0.600	o	375	Pipe/Conduit	
S1.013	5.071	0.135	37.6	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
S1.014	7.248	0.176	41.2	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
S1.015	10.631	0.356	29.9	0.021	0.00	0.0	0.600	o	375	Pipe/Conduit	
S5.000	8.211	0.082	100.1	0.008	4.00	0.0	0.600	o	225	Pipe/Conduit	
S5.001	2.061	0.103	20.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S5.002	22.541	0.225	100.2	0.016	0.00	0.0	0.600	o	225	Pipe/Conduit	
S5.003	11.270	0.113	99.7	0.009	0.00	0.0	0.600	o	225	Pipe/Conduit	
S5.004	11.270	0.113	99.7	0.009	0.00	0.0	0.600	o	225	Pipe/Conduit	
S5.005	3.250	0.102	31.9	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.016	56.935	0.284	200.5	0.108	0.00	0.0	0.600	o	375	Pipe/Conduit	
S1.017	8.513	0.022	386.9	0.005	0.00	0.0	0.600	o	375	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S3.000	50.00	4.13	133.955	0.002	0.0	0.0	0.0	1.31	52.0	0.2
S3.001	50.00	4.25	133.550	0.008	0.0	0.0	0.0	1.31	52.0	1.1
S3.002	50.00	4.37	133.158	0.008	0.0	0.0	0.0	1.31	52.0	1.1
S3.003	50.00	4.41	132.210	0.009	0.0	0.0	0.0	2.94	116.9	1.2
S1.009	50.00	6.12	131.777	0.274	0.0	0.0	0.0	0.92	65.1	37.1
S4.000	50.00	4.32	133.486	0.000	0.0	0.0	0.0	0.92	36.7	0.0
S4.001	50.00	4.33	133.397	0.245	0.0	0.0	0.0	6.59	261.9	33.2
S4.002	50.00	4.63	131.885	0.245	0.0	0.0	0.0	0.92	36.6	33.2
S1.010	50.00	6.12	131.727	0.539	0.0	0.0	0.0	7.91	559.3	73.0
S1.011	50.00	6.39	130.725	0.539	0.0	0.0	0.0	1.14	125.7	73.0
S1.012	50.00	6.40	130.653	0.551	0.0	0.0	0.0	1.81	200.1	74.6
S1.013	50.00	6.42	129.035	0.551	0.0	0.0	0.0	2.96	327.4	74.6
S1.014	50.00	6.47	128.900	0.551	0.0	0.0	0.0	2.83	312.6	74.6
S1.015	50.00	6.52	128.724	0.572	0.0	0.0	0.0	3.33	367.4	77.5
S5.000	50.00	4.10	132.512	0.008	0.0	0.0	0.0	1.31	52.0	1.1
S5.001	50.00	4.12	132.430	0.008	0.0	0.0	0.0	2.94	116.9	1.1
S5.002	50.00	4.40	131.277	0.025	0.0	0.0	0.0	1.31	51.9	3.3
S5.003	50.00	4.55	130.533	0.033	0.0	0.0	0.0	1.31	52.1	4.5
S5.004	50.00	4.69	129.902	0.043	0.0	0.0	0.0	1.31	52.1	5.8
S5.005	50.00	4.71	129.339	0.043	0.0	0.0	0.0	2.33	92.5	5.8
S1.016	50.00	7.26	128.368	0.723	0.0	0.0	0.0	1.28	140.9	97.8
S1.017	50.00	7.42	128.084	0.727	0.0	0.0	0.0	0.92	101.1	98.5

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S6.000	29.431	0.785	37.5	0.082	4.00	0.0	0.600	o	375	Pipe/Conduit	
S6.001	36.016	0.960	37.5	0.098	0.00	0.0	0.600	o	375	Pipe/Conduit	
S6.002	8.914	0.241	37.0	0.005	0.00	0.0	0.600	o	375	Pipe/Conduit	
S1.018	55.457	0.144	385.1	0.054	0.00	0.0	0.600	o	450	Pipe/Conduit	
S1.019	5.949	0.016	371.8	0.004	0.00	0.0	0.600	o	600	Pipe/Conduit	
S7.000	50.075	0.295	169.7	0.145	4.00	0.0	0.600	o	225	Pipe/Conduit	
S7.001	12.911	0.076	169.9	0.011	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.020	25.483	0.064	398.2	0.064	0.00	0.0	0.600	o	600	Pipe/Conduit	
S1.021	37.882	0.095	398.8	0.111	0.00	0.0	0.600	o	600	Pipe/Conduit	
S1.022	9.566	0.021	455.5	0.016	0.00	0.0	0.600	o	600	Pipe/Conduit	
S1.023	2.135	0.005	427.0	0.000	0.00	0.0	0.600	o	600	Pipe/Conduit	
S1.024	11.627	0.068	171.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.025	26.956	0.200	135.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.026	43.556	0.256	170.1	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.027	13.043	0.077	169.4	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.028	51.444	1.513	34.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.029	12.146	0.620	19.6	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.030	32.435	1.256	25.8	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.031	72.222	1.011	71.4	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
S1.032	22.321	0.149	150.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S6.000	50.00	4.17	135.025	0.082	0.0	0.0	0.0	2.97	327.7	11.1
S6.001	50.00	4.37	133.794	0.180	0.0	0.0	0.0	2.97	327.6	24.4
S6.002	50.00	4.42	132.715	0.185	0.0	0.0	0.0	2.99	329.9	25.1
S1.018	50.00	8.32	127.987	0.967	0.0	0.0	0.0	1.03	163.8	130.9
S1.019	50.00	8.40	127.693	0.971	0.0	0.0	0.0	1.26	355.4	131.5
S7.000	50.00	4.83	128.200	0.145	0.0	0.0	0.0	1.00	39.8	19.6
S7.001	50.00	5.05	127.905	0.156	0.0	0.0	0.0	1.00	39.8	21.1
S1.020	50.00	8.75	127.454	1.191	0.0	0.0	0.0	1.21	343.3	161.2
S1.021	50.00	9.27	127.390	1.302	0.0	0.0	0.0	1.21	343.0	176.3
S1.022	50.00	9.41	127.295	1.318	0.0	0.0	0.0	1.13	320.7	178.5
S1.023	50.00	9.44	127.274	1.318	0.0	0.0	0.0	1.17	331.4	178.5
S1.024	50.00	4.19	127.269	0.000	7.7	0.0	0.0	1.00	39.6	7.7
S1.025	50.00	4.59	127.201	0.000	7.7	0.0	0.0	1.12	44.7	7.7
S1.026	50.00	5.32	127.001	0.000	7.7	0.0	0.0	1.00	39.7	7.7
S1.027	50.00	5.54	126.745	0.000	7.7	0.0	0.0	1.00	39.8	7.7
S1.028	50.00	5.92	126.668	0.000	7.7	0.0	0.0	2.25	89.5	7.7
S1.029	50.00	5.99	125.155	0.000	7.7	0.0	0.0	2.97	118.1	7.7
S1.030	50.00	6.20	124.535	0.000	7.7	0.0	0.0	2.59	102.8	7.7
S1.031	50.00	6.97	123.279	0.000	7.7	0.0	0.0	1.55	61.6	7.7
S1.032	50.00	7.32	122.268	0.000	7.7	0.0	0.0	1.07	42.4	7.7

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	Pipe Out PN	Pipe Out Invert Level (m)	Pipe Out Diameter (mm)	Pipes In PN	Pipes In Invert Level (m)	Pipes In Diameter (mm)	Backdrop (mm)
S1	137.372	0.525	Open Manhole	1200	S1.000	136.847	225				
S2	137.241	0.641	Open Manhole	1200	S1.001	136.600	225	S1.000	136.733	225	133
S3	136.350	0.950	Open Manhole	1200	S1.002	135.400	225	S1.001	136.070	225	670
S4	135.000	0.822	Open Manhole	1200	S1.003	134.178	225	S1.002	134.675	225	497
SPond 1	134.941	0.825	Open Manhole	1200	S1.004	134.116	225	S1.003	134.116	225	
S6	134.206	0.756	Open Manhole	1200	S1.005	133.450	225	S1.004	133.806	225	356
S7	136.322	0.572	Open Manhole	1200	S2.000	135.750	225				
S8	135.902	0.556	Open Manhole	1200	S2.001	135.346	225	S2.000	135.646	225	300
S9	135.477	0.535	Open Manhole	1200	S2.002	134.942	225	S2.001	135.242	225	300
S10	135.141	0.593	Open Manhole	1200	S2.003	134.548	225	S2.002	134.848	225	300
S11	134.925	0.613	Open Manhole	1200	S2.004	134.312	225	S2.003	134.487	225	175
S12	134.601	0.373	Open Manhole	1200	S2.005	134.228	225	S2.004	134.228	225	
SPond 2	134.206	0.825	Open Manhole	1200	S1.006	133.381	225	S1.005	133.381	225	
								S2.005	133.907	225	526
S14	133.275	0.731	Open Manhole	1200	S1.007	132.544	225	S1.006	133.031	225	487
SPond 3	133.275	0.825	Open Manhole	1200	S1.008	132.450	225	S1.007	132.450	225	
S16	134.480	0.525	Open Manhole	1200	S3.000	133.955	225				
S17	134.091	0.541	Open Manhole	1200	S3.001	133.550	225	S3.000	133.852	225	302
S18	133.692	0.534	Open Manhole	1200	S3.002	133.158	225	S3.001	133.458	225	300
S19	133.313	1.103	Open Manhole	1200	S3.003	132.210	225	S3.002	133.066	225	856
S20	132.677	0.900	Open Manhole	1200	S1.009	131.777	300	S1.008	131.852	225	
								S3.003	131.852	225	
S21	134.238	0.752	Open Manhole	1200	S4.000	133.486	225				
SPond 4	134.222	0.825	Open Manhole	1200	S4.001	133.397	225	S4.000	133.397	225	
S23	132.637	0.752	Open Manhole	1200	S4.002	131.885	225	S4.001	132.396	225	511
SPond 5	132.627	0.900	Open Manhole	1200	S1.010	131.727	300	S1.009	131.727	300	
								S4.002	131.802	225	
S25	131.637	0.912	Open Manhole	1200	S1.011	130.725	375	S1.010	131.086	300	286
SPond 6	131.628	0.975	Open Manhole	1200	S1.012	130.653	375	S1.011	130.653	375	
S27	131.327	2.292	Open Manhole	1200	S1.013	129.035	375	S1.012	130.642	375	1607
S28	130.422	1.522	Open Manhole	1200	S1.014	128.900	375	S1.013	128.900	375	
S29	130.085	1.361	Open Manhole	1200	S1.015	128.724	375	S1.014	128.724	375	
S30	133.859	1.347	Open Manhole	1200	S5.000	132.512	225				
S31	133.405	0.975	Open Manhole	1200	S5.001	132.430	225	S5.000	132.430	225	
S32	133.290	2.013	Open Manhole	1200	S5.002	131.277	225	S5.001	132.327	225	1050
S33	132.027	1.494	Open Manhole	1200	S5.003	130.533	225	S5.002	131.052	225	519
S34	131.395	1.493	Open Manhole	1200	S5.004	129.902	225	S5.003	130.420	225	518
S35	130.764	1.425	Open Manhole	1200	S5.005	129.339	225	S5.004	129.789	225	450
S36	130.686	2.318	Open Manhole	1500	S1.016	128.368	375	S1.015	128.368	375	
								S5.005	129.237	225	719
S37	133.850	5.766	Open Manhole	1200	S1.017	128.084	375	S1.016	128.084	375	
S38	136.984	1.959	Open Manhole	1200	S6.000	135.025	375				
S39	135.799	2.005	Open Manhole	1200	S6.001	133.794	375	S6.000	134.240	375	446
S40	134.353	1.638	Open Manhole	1200	S6.002	132.715	375	S6.001	132.834	375	119
S41	133.938	5.951	Open Manhole	1200	S1.018	127.987	450	S1.017	128.062	375	
								S6.002	132.474	375	4412

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	Pipe Out PN	Pipe Out Invert Level (m)	Pipe Out Diameter (mm)	Pipes In PN	Pipes In Invert Level (m)	Pipes In Diameter (mm)	Backdrop (mm)
S42	132.266	4.573	Open Manhole	1200	S1.019	127.693	600	S1.018	127.843	450	
S43	129.661	1.461	Open Manhole	1500	S7.000	128.200	225				
S44	131.682	3.777	Open Manhole	1200	S7.001	127.905	225	S7.000	127.905	225	
S45	132.158	4.704	Open Manhole	1200	S1.020	127.454	600	S1.019	127.677	600	223
								S7.001	127.829	225	
S46	132.474	5.084	Open Manhole	1200	S1.021	127.390	600	S1.020	127.390	600	
S47	132.937	5.642	Open Manhole	1200	S1.022	127.295	600	S1.021	127.295	600	
S48	133.391	6.117	Open Manhole	1200	S1.023	127.274	600	S1.022	127.274	600	
S49	133.414	6.145	Open Manhole	1200	S1.024	127.269	225	S1.023	127.269	600	
S50	133.033	5.832	Open Manhole	1200	S1.025	127.201	225	S1.024	127.201	225	
S51	132.709	5.707	Open Manhole	1200	S1.026	127.001	225	S1.025	127.001	225	
S52	132.131	5.385	Open Manhole	1200	S1.027	126.745	225	S1.026	126.745	225	
S53	131.627	4.958	Open Manhole	1200	S1.028	126.668	225	S1.027	126.668	225	
S54	129.567	4.412	Open Manhole	1200	S1.029	125.155	225	S1.028	125.155	225	
S55	125.970	1.435	Open Manhole	1200	S1.030	124.535	225	S1.029	124.535	225	
S56	125.240	1.961	Open Manhole	1200	S1.031	123.279	225	S1.030	123.279	225	
S57	123.730	1.462	Open Manhole	1200	S1.032	122.268	225	S1.031	122.268	225	
SSurface	123.500	1.380	Open Manhole	0		OUTFALL		S1.032	122.120	225	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S1	702247.890	726170.970	702247.890	726170.970	Required	
S2	702236.541	726172.079	702236.541	726172.079	Required	
S3	702184.180	726180.331	702184.180	726180.331	Required	
S4	702168.733	726184.284	702168.733	726184.284	Required	
SPond 1	702156.382	726185.557	702156.382	726185.557	Required	
S6	702152.739	726187.269	702152.739	726187.269	Required	
S7	702178.629	726179.973	702178.629	726179.973	Required	
S8	702168.568	726177.402	702168.568	726177.402	Required	
S9	702158.507	726174.831	702158.507	726174.831	Required	

Manhole Schedules for Storm

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S10	702149.255	726176.217	702149.255	726176.217	Required	
S11	702143.757	726178.766	702143.757	726178.766	Required	
S12	702137.224	726183.998	702137.224	726183.998	Required	
SPond 2	702140.949	726194.585	702140.949	726194.585	Required	
S14	702138.442	726195.777	702138.442	726195.777	Required	
SPond 3	702122.764	726206.008	702122.764	726206.008	Required	
S16	702134.953	726185.861	702134.953	726185.861	Required	
S17	702127.631	726193.111	702127.631	726193.111	Required	
S18	702121.086	726199.592	702121.086	726199.592	Required	
S19	702114.541	726206.072	702114.541	726206.072	Required	
S20	702107.871	726208.671	702107.871	726208.671	Required	
S21	702115.555	726174.727	702115.555	726174.727	Required	
SPond 4	702105.108	726189.059	702105.108	726189.059	Required	
S23	702103.041	726192.489	702103.041	726192.489	Required	
SPond 5	702093.689	726206.181	702093.689	726206.181	Required	
S25	702091.237	726206.933	702091.237	726206.933	Required	
SPond 6	702078.147	726219.427	702078.147	726219.427	Required	
S27	702077.816	726220.458	702077.816	726220.458	Required	
S28	702076.267	726225.286	702076.267	726225.286	Required	

Manhole Schedules for Storm

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S29	702079.016	726231.992	702079.016	726231.992	Required	
S30	702139.924	726206.178	702139.924	726206.178	Required	
S31	702132.254	726209.109	702132.254	726209.109	Required	
S32	702130.328	726209.844	702130.328	726209.844	Required	
S33	702109.187	726217.663	702109.187	726217.663	Required	
S34	702098.616	726221.572	702098.616	726221.572	Required	
S35	702088.045	726225.481	702088.045	726225.481	Required	
S36	702089.079	726228.563	702089.079	726228.563	Required	
S37	702142.287	726208.301	702142.287	726208.301	Required	
S38	702217.456	726183.330	702217.456	726183.330	Required	
S39	702188.582	726189.028	702188.582	726189.028	Required	
S40	702154.827	726201.585	702154.827	726201.585	Required	
S41	702150.716	726209.495	702150.716	726209.495	Required	
S42	702170.511	726261.299	702170.511	726261.299	Required	
S43	702117.737	726289.840	702117.737	726289.840	Required	
S44	702164.723	726272.525	702164.723	726272.525	Required	
S45	702175.192	726264.969	702175.192	726264.969	Required	
S46	702199.431	726257.106	702199.431	726257.106	Required	
S47	702235.851	726246.683	702235.851	726246.683	Required	

Manhole Schedules for Storm

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
S48	702238.980	726237.643	702238.980	726237.643	Required	
S49	702241.115	726237.628	702241.115	726237.628	Required	
S50	702243.436	726249.021	702243.436	726249.021	Required	
S51	702217.191	726255.171	702217.191	726255.171	Required	
S52	702175.736	726268.536	702175.736	726268.536	Required	
S53	702164.723	726275.525	702164.723	726275.525	Required	
S54	702116.561	726293.606	702116.561	726293.606	Required	
S55	702109.548	726303.522	702109.548	726303.522	Required	
S56	702132.483	726326.457	702132.483	726326.457	Required	
S57	702190.131	726369.962	702190.131	726369.962	Required	
SSurface	702208.161	726383.122			No Entry	

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	User	-	30	0.056	0.017	0.017
1.001	User	-	30	0.302	0.091	0.091
1.002	-	-	100	0.000	0.000	0.000
1.003	-	-	100	0.000	0.000	0.000
1.004	User	-	30	0.023	0.007	0.007
1.005	-	-	100	0.000	0.000	0.000
2.000	User	-	30	0.095	0.028	0.028
2.001	-	-	100	0.000	0.000	0.000
2.002	User	-	30	0.095	0.028	0.028
2.003	User	-	30	0.125	0.038	0.038
2.004	User	-	30	0.147	0.044	0.044
2.005	-	-	100	0.000	0.000	0.000
1.006	User	-	30	0.025	0.007	0.007
1.007	-	-	100	0.000	0.000	0.000
1.008	User	-	30	0.017	0.005	0.005
3.000	User	-	30	0.006	0.002	0.002
3.001	User	-	30	0.021	0.006	0.006
3.002	-	-	100	0.000	0.000	0.000
3.003	User	-	30	0.003	0.001	0.001
1.009	-	-	100	0.000	0.000	0.000
4.000	-	-	100	0.000	0.000	0.000
4.001	User	-	30	0.817	0.245	0.245
4.002	-	-	100	0.000	0.000	0.000
1.010	User	-	30	0.066	0.020	0.020
1.011	-	-	100	0.000	0.000	0.000
1.012	User	-	30	0.041	0.012	0.012
1.013	-	-	100	0.000	0.000	0.000
1.014	-	-	100	0.000	0.000	0.000
1.015	User	-	100	0.021	0.021	0.021
5.000	User	-	100	0.008	0.008	0.008
5.001	-	-	100	0.000	0.000	0.000
5.002	User	-	100	0.016	0.016	0.016
5.003	User	-	100	0.009	0.009	0.009
5.004	User	-	100	0.009	0.009	0.009
5.005	-	-	100	0.000	0.000	0.000
1.016	User	-	100	0.108	0.108	0.108
1.017	User	-	100	0.005	0.005	0.005
6.000	User	-	100	0.036	0.036	0.036
	User	-	100	0.046	0.046	0.082
6.001	User	-	100	0.023	0.023	0.023
	User	-	100	0.074	0.074	0.098
6.002	User	-	100	0.005	0.005	0.005
1.018	User	-	100	0.054	0.054	0.054
1.019	User	-	100	0.004	0.004	0.004
7.000	User	-	100	0.042	0.042	0.042
	User	-	100	0.103	0.103	0.145
7.001	User	-	100	0.011	0.011	0.011
1.020	User	-	100	0.024	0.024	0.024
	User	-	100	0.040	0.040	0.064
1.021	User	-	100	0.035	0.035	0.035
	User	-	100	0.076	0.076	0.111
1.022	User	-	100	0.016	0.016	0.016
1.023	-	-	100	0.000	0.000	0.000
1.024	-	-	100	0.000	0.000	0.000
1.025	-	-	100	0.000	0.000	0.000
1.026	-	-	100	0.000	0.000	0.000
1.027	-	-	100	0.000	0.000	0.000
1.028	-	-	100	0.000	0.000	0.000
1.029	-	-	100	0.000	0.000	0.000
1.030	-	-	100	0.000	0.000	0.000
1.031	-	-	100	0.000	0.000	0.000
1.032	-	-	100	0.000	0.000	0.000

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
				Total	Total	Total
				2.604	1.318	1.318

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.032	SSurface	123.500	122.120	122.100	0	0

Online Controls for Storm

Weir Manhole: S2, DS/PN: S1.001, Volume (m³): 1.1

Discharge Coef 0.544 Width (m) 0.075 Invert Level (m) 137.050

Weir Manhole: SPond 1, DS/PN: S1.004, Volume (m³): 1.4

Discharge Coef 0.544 Width (m) 0.025 Invert Level (m) 134.716

Weir Manhole: S8, DS/PN: S2.001, Volume (m³): 1.0

Discharge Coef 0.544 Width (m) 0.075 Invert Level (m) 135.800

Weir Manhole: S9, DS/PN: S2.002, Volume (m³): 1.0

Discharge Coef 0.544 Width (m) 0.080 Invert Level (m) 135.300

Weir Manhole: S10, DS/PN: S2.003, Volume (m³): 1.0

Discharge Coef 0.544 Width (m) 0.125 Invert Level (m) 134.900

Weir Manhole: S11, DS/PN: S2.004, Volume (m³): 0.9

Discharge Coef 0.544 Width (m) 0.150 Invert Level (m) 134.650

Weir Manhole: SPond 2, DS/PN: S1.006, Volume (m³): 1.8

Discharge Coef 0.544 Width (m) 0.050 Invert Level (m) 133.981

Weir Manhole: SPond 3, DS/PN: S1.008, Volume (m³): 1.6

Discharge Coef 0.544 Width (m) 0.050 Invert Level (m) 133.050

Weir Manhole: S17, DS/PN: S3.001, Volume (m³): 1.0

Discharge Coef 0.544 Width (m) 0.040 Invert Level (m) 134.000

Weir Manhole: S18, DS/PN: S3.002, Volume (m³): 0.9

Discharge Coef 0.544 Width (m) 0.025 Invert Level (m) 133.600

Weir Manhole: SPond 4, DS/PN: S4.001, Volume (m³): 1.6

Discharge Coef 0.544 Width (m) 0.180 Invert Level (m) 133.947

Weir Manhole: SPond 5, DS/PN: S1.010, Volume (m³): 2.6

Discharge Coef 0.544 Width (m) 0.060 Invert Level (m) 132.327

Weir Manhole: SPond 6, DS/PN: S1.012, Volume (m³): 3.0

Discharge Coef 0.544 Width (m) 0.030 Invert Level (m) 131.253

Hydro-Brake® Optimum Manhole: S49, DS/PN: S1.024, Volume (m³): 7.2

Unit Reference MD-SHE-0114-7700-2000-7700
Design Head (m) 2.000

Hydro-Brake® Optimum Manhole: S49, DS/PN: S1.024, Volume (m³): 7.2

Design Flow (l/s)	7.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	114
Invert Level (m)	127.269
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.000	7.7	Kick-Flo®	1.021	5.6
Flush-Flo™	0.499	7.1	Mean Flow over Head Range	-	6.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.0	0.800	6.7	2.000	7.7	4.000	10.7	7.000	13.9
0.200	6.2	1.000	5.8	2.200	8.0	4.500	11.3	7.500	14.4
0.300	6.8	1.200	6.1	2.400	8.4	5.000	11.9	8.000	14.9
0.400	7.0	1.400	6.5	2.600	8.7	5.500	12.4	8.500	15.3
0.500	7.1	1.600	6.9	3.000	9.3	6.000	12.9	9.000	15.7
0.600	7.0	1.800	7.3	3.500	10.0	6.500	13.4	9.500	16.1

Storage Structures for Storm

Swale Manhole: S1, DS/PN: S1.000

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	10.8
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	136.847	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Swale Manhole: S2, DS/PN: S1.001

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	51.8
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	136.600	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Infiltration Basin Manhole: SPond 1, DS/PN: S1.004

Invert Level (m)	134.116	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00480	Porosity	1.00
Infiltration Coefficient Side (m/hr)	0.00480		

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	43.4	0.600	130.7	0.601	0.0

Swale Manhole: S7, DS/PN: S2.000

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	9.7
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	135.750	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Swale Manhole: S8, DS/PN: S2.001

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	9.3
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	135.346	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Swale Manhole: S9, DS/PN: S2.002

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Safety Factor	2.0
Infiltration Coefficient Side (m/hr)	0.00480	Porosity	1.00

Swale Manhole: S9, DS/PN: S2.002

Invert Level (m)	134.942	Slope (1:X)	100.0
Base Width (m)	0.5	Cap Volume Depth (m)	0.000
Length (m)	5.4	Cap Infiltration Depth (m)	0.000
Side Slope (1:X)	4.0	Include Swale Volume	Yes

Swale Manhole: S10, DS/PN: S2.003

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	4.8
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	134.548	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Swale Manhole: S11, DS/PN: S2.004

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	6.6
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	134.312	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Infiltration Basin Manhole: SPond 2, DS/PN: S1.006

Invert Level (m)	133.381	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00480	Porosity	1.00
Infiltration Coefficient Side (m/hr)	0.00480		

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	51.8	0.600	132.2	0.601	0.0

Infiltration Basin Manhole: SPond 3, DS/PN: S1.008

Invert Level (m)	132.375	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00480	Porosity	1.00
Infiltration Coefficient Side (m/hr)	0.00480		

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	7.1	0.600	87.1	0.601	0.0

Swale Manhole: S16, DS/PN: S3.000

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	10.6
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	133.955	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Swale Manhole: S17, DS/PN: S3.001

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Swale Manhole: S17, DS/PN: S3.001

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	7.6
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	133.550	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Swale Manhole: S18, DS/PN: S3.002

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00480	Length (m)	7.3
Infiltration Coefficient Side (m/hr)	0.00480	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	100.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	133.158	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

Infiltration Basin Manhole: SPond 4, DS/PN: S4.001

Invert Level (m)	133.397	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00480	Porosity	1.00
Infiltration Coefficient Side (m/hr)	0.00480		

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	100.6	0.600	204.0	0.601	0.0

Infiltration Basin Manhole: SPond 5, DS/PN: S1.010

Invert Level (m)	131.727	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00480	Porosity	1.00
Infiltration Coefficient Side (m/hr)	0.00480		

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	88.1	0.600	185.8	0.601	0.0

Infiltration Basin Manhole: SPond 6, DS/PN: S1.012

Invert Level (m)	130.653	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00480	Porosity	1.00
Infiltration Coefficient Side (m/hr)	0.00480		

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	88.1	0.600	185.8	0.601	0.0

Filter Drain Manhole: S30, DS/PN: S5.000

Infiltration Coefficient Base (m/hr)	0.00000	Pipe Diameter (m)	0.225
Infiltration Coefficient Side (m/hr)	0.00000	Pipe Depth above Invert (m)	0.225
Safety Factor	2.0	Number of Pipes	1
Porosity	0.30	Slope (1:X)	100.0
Invert Level (m)	132.450	Cap Volume Depth (m)	0.000
Trench Width (m)	0.5	Cap Infiltration Depth (m)	0.000
Trench Length (m)	8.2		

Filter Drain Manhole: S32, DS/PN: S5.002

Infiltration Coefficient Base (m/hr)	0.00000	Safety Factor	2.0
Infiltration Coefficient Side (m/hr)	0.00000	Porosity	0.30

Filter Drain Manhole: S32, DS/PN: S5.002

Invert Level (m)	131.450	Number of Pipes	1
Trench Width (m)	0.5	Slope (1:X)	100.0
Trench Length (m)	22.5	Cap Volume Depth (m)	0.000
Pipe Diameter (m)	0.225	Cap Infiltration Depth (m)	0.000
Pipe Depth above Invert (m)	0.225		

Filter Drain Manhole: S33, DS/PN: S5.003

Infiltration Coefficient Base (m/hr)	0.00000	Pipe Diameter (m)	0.225
Infiltration Coefficient Side (m/hr)	0.00000	Pipe Depth above Invert (m)	0.225
Safety Factor	2.0	Number of Pipes	1
Porosity	0.30	Slope (1:X)	100.0
Invert Level (m)	130.485	Cap Volume Depth (m)	0.000
Trench Width (m)	0.5	Cap Infiltration Depth (m)	0.000
Trench Length (m)	11.3		

Filter Drain Manhole: S34, DS/PN: S5.004

Infiltration Coefficient Base (m/hr)	0.00000	Pipe Diameter (m)	0.225
Infiltration Coefficient Side (m/hr)	0.00000	Pipe Depth above Invert (m)	0.225
Safety Factor	2.0	Number of Pipes	1
Porosity	0.30	Slope (1:X)	100.0
Invert Level (m)	129.685	Cap Volume Depth (m)	0.000
Trench Width (m)	0.5	Cap Infiltration Depth (m)	0.000
Trench Length (m)	11.3		

Porous Car Park Manhole: S38, DS/PN: S6.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	60.8
Max Percolation (l/s)	84.4	Slope (1:X)	26.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	136.484	Membrane Depth (mm)	0

Porous Car Park Manhole: S39, DS/PN: S6.001

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	36.0
Max Percolation (l/s)	50.0	Slope (1:X)	26.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	135.301	Membrane Depth (mm)	0

Porous Car Park Manhole: S40, DS/PN: S6.002

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	7.5
Max Percolation (l/s)	10.4	Slope (1:X)	26.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	133.853	Membrane Depth (mm)	0

Porous Car Park Manhole: S43, DS/PN: S7.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	102.6
Max Percolation (l/s)	142.5	Slope (1:X)	25.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	129.161	Membrane Depth (mm)	0

Porous Car Park Manhole: S44, DS/PN: S7.001

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	8.0
Max Percolation (l/s)	11.1	Slope (1:X)	25.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	131.182	Membrane Depth (mm)	0

Cellular Storage Manhole: S49, DS/PN: S1.024

Invert Level (m)	127.269	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00729	Porosity	0.60
Infiltration Coefficient Side (m/hr)	0.00729		

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	380.0	190.0	2.000	380.0	343.6	2.001	0.0	343.6

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 0.900 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 14 Number of Storage Structures 26 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 21.300 Cv (Summer) 1.000
Region Scotland and Ireland Ratio R 0.271 Cv (Winter) 1.000

Margin for Flood Risk Warning (mm) 100.0 DVD Status ON
Analysis Timestep Fine Inertia Status ON
DTS Status OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 20

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)
S1.000	S1	360 Summer	100	+20%	1/360 Summer				137.201	0.129	0.000
S1.001	S2	360 Summer	100	+20%	1/15 Summer				137.200	0.375	0.000
S1.002	S3	360 Summer	100	+20%					135.440	-0.185	0.000
S1.003	S4	960 Summer	100	+20%	1/2160 Summer				134.914	0.511	0.000
S1.004	SPond 1	960 Summer	100	+20%	1/1440 Summer				134.908	0.567	0.000
S1.005	S6	600 Summer	100	+20%	1/600 Summer				134.200	0.525	0.000
S2.000	S7	360 Summer	100	+20%					135.883	-0.092	0.000
S2.001	S8	360 Summer	100	+20%	1/30 Summer				135.880	0.309	0.000
S2.002	S9	60 Summer	100	+20%	1/15 Summer				135.436	0.269	0.000
S2.003	S10	60 Summer	100	+20%	1/15 Summer				135.083	0.310	0.000
S2.004	S11	60 Summer	100	+20%	1/15 Summer				134.875	0.338	0.000
S2.005	S12	60 Summer	100	+20%					134.321	-0.132	0.000
S1.006	SPond 2	720 Summer	100	+20%	1/360 Summer				134.202	0.596	0.000
S1.007	S14	1440 Summer	100	+20%	30/960 Summer				133.265	0.496	0.000
S1.008	SPond 3	1440 Summer	100	+20%	30/720 Summer				133.249	0.574	0.000
S3.000	S16	4320 Summer	100	+20%					134.019	-0.161	0.000
S3.001	S17	4320 Summer	100	+20%	1/480 Summer				134.019	0.244	0.000
S3.002	S18	5760 Summer	100	+20%					133.296	-0.087	0.000
S3.003	S19	1440 Summer	100	+20%	100/360 Summer				132.606	0.171	0.000
S1.009	S20	1440 Summer	100	+20%	1/5760 Summer				132.606	0.529	0.000
S4.000	S21	240 Summer	100	+20%	1/120 Summer				134.195	0.484	0.000
S4.001	SPond 4	240 Summer	100	+20%	1/60 Summer				134.195	0.573	0.000
S4.002	S23	1440 Summer	100	+20%	1/7200 Summer				132.612	0.502	0.000
S1.010	SPond 5	1440 Summer	100	+20%	1/4320 Summer				132.599	0.572	0.000
S1.011	S25	2160 Summer	100	+20%	30/4320 Summer				131.610	0.510	0.000
S1.012	SPond 6	2160 Summer	100	+20%	30/2880 Winter				131.604	0.576	0.000
S1.013	S27	2160 Summer	100	+20%					129.276	-0.134	0.000
S1.014	S28	2160 Summer	100	+20%					129.275	0.000	0.000
S1.015	S29	2160 Summer	100	+20%	100/600 Winter				129.271	0.172	0.000
S5.000	S30	15 Summer	100	+20%					132.567	-0.170	0.000
S5.001	S31	15 Summer	100	+20%					132.482	-0.173	0.000
S5.002	S32	15 Summer	100	+20%					131.367	-0.135	0.000
S5.003	S33	15 Summer	100	+20%					130.644	-0.114	0.000
S5.004	S34	15 Summer	100	+20%					130.032	-0.095	0.000

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
S1.000	S1	0.03		222	1.1	SURCHARGED	
S1.001	S2	0.15			7.4	FLOOD RISK	
S1.002	S3	0.07			7.4	OK	
S1.003	S4	0.18			5.8	FLOOD RISK	
S1.004	SPond 1	0.05			3.6	FLOOD RISK	
S1.005	S6	0.08			2.6	FLOOD RISK	
S2.000	S7	0.07		114	3.2	OK	
S2.001	S8	0.05			2.3	FLOOD RISK	
S2.002	S9	0.16			6.7	FLOOD RISK	
S2.003	S10	0.47			16.5	FLOOD RISK	
S2.004	S11	0.66		52	26.8	FLOOD RISK	
S2.005	S12	0.36			26.9	OK	
S1.006	SPond 2	0.10			8.6	FLOOD RISK	
S1.007	S14	0.21			6.9	FLOOD RISK	
S1.008	SPond 3	0.08			6.9	FLOOD RISK	
S3.000	S16	0.00		1704	0.0	OK	
S3.001	S17	0.00		4872	0.0	FLOOD RISK	
S3.002	S18	0.00		1512	0.0	OK	
S3.003	S19	0.00			0.1	SURCHARGED	
S1.009	S20	0.13			7.1	FLOOD RISK	
S4.000	S21	0.00			0.1	FLOOD RISK	
S4.001	SPond 4	0.24			33.8	FLOOD RISK	
S4.002	S23	0.37			12.2	FLOOD RISK	
S1.010	SPond 5	0.07			13.5	FLOOD RISK	
S1.011	S25	0.13			13.5	FLOOD RISK	
S1.012	SPond 6	0.11			9.9	FLOOD RISK	
S1.013	S27	0.07			9.9	OK	
S1.014	S28	0.06			9.9	OK	
S1.015	S29	0.04			10.2	SURCHARGED	
S5.000	S30	0.13		11	5.4	OK	
S5.001	S31	0.12			5.4	OK	
S5.002	S32	0.34		5	16.0	OK	
S5.003	S33	0.49		6	21.4	OK	
S5.004	S34	0.61			26.9	OK	

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)
S5.005	S35	15 Summer	100	+20%					129.467	-0.097	0.000
S1.016	S36	2160 Summer	100	+20%	100/15 Summer				129.270	0.527	0.000
S1.017	S37	2160 Summer	100	+20%	100/15 Summer				129.266	0.807	0.000
S6.000	S38	15 Summer	100	+20%					135.134	-0.266	0.000
S6.001	S39	15 Summer	100	+20%					133.958	-0.211	0.000
S6.002	S40	15 Summer	100	+20%					132.931	-0.159	0.000
S1.018	S41	2160 Summer	100	+20%	100/15 Summer				129.265	0.828	0.000
S1.019	S42	2160 Summer	100	+20%	30/360 Summer				129.262	0.969	0.000
S7.000	S43	15 Summer	100	+20%	30/15 Summer				129.432	1.007	0.000
S7.001	S44	2160 Summer	100	+20%	30/15 Summer				129.263	1.133	0.000
S1.020	S45	2160 Summer	100	+20%	30/60 Summer				129.261	1.207	0.000
S1.021	S46	2160 Summer	100	+20%	30/30 Summer				129.260	1.270	0.000
S1.022	S47	2160 Summer	100	+20%	30/60 Summer				129.258	1.363	0.000
S1.023	S48	2160 Summer	100	+20%	30/60 Summer				129.257	1.383	0.000
S1.024	S49	2160 Summer	100	+20%	1/30 Summer				129.257	1.763	0.000
S1.025	S50	2160 Summer	100	+20%					127.266	-0.160	0.000
S1.026	S51	2160 Summer	100	+20%					127.070	-0.157	0.000
S1.027	S52	2160 Summer	100	+20%					126.817	-0.153	0.000
S1.028	S53	2160 Summer	100	+20%					126.713	-0.180	0.000
S1.029	S54	2160 Summer	100	+20%					125.196	-0.184	0.000
S1.030	S55	2160 Summer	100	+20%					124.577	-0.183	0.000
S1.031	S56	2160 Summer	100	+20%					123.333	-0.172	0.000
S1.032	S57	2160 Summer	100	+20%					122.336	-0.157	0.000

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
S5.005	S35	0.60			27.1	OK	
S1.016	S36	0.10			12.9	SURCHARGED	
S1.017	S37	0.20			12.9	SURCHARGED	
S6.000	S38	0.19		4	53.6	OK	
S6.001	S39	0.40		5	117.4	OK	
S6.002	S40	0.63		5	120.7	OK	
S1.018	S41	0.12			17.6	SURCHARGED	
S1.019	S42	0.08			17.6	SURCHARGED	
S7.000	S43	1.78		3	67.8	SURCHARGED	
S7.001	S44	0.16		1056	5.7	SURCHARGED	
S1.020	S45	0.08			22.5	SURCHARGED	
S1.021	S46	0.09			26.6	SURCHARGED	
S1.022	S47	0.17			27.1	SURCHARGED	
S1.023	S48	0.12			27.0	SURCHARGED	
S1.024	S49	0.23		1032	7.7	SURCHARGED	
S1.025	S50	0.18			7.7	OK	
S1.026	S51	0.20			7.7	OK	
S1.027	S52	0.22			7.7	OK	
S1.028	S53	0.09			7.7	OK	
S1.029	S54	0.08			7.7	OK	
S1.030	S55	0.08			7.7	OK	
S1.031	S56	0.13			7.7	OK	
S1.032	S57	0.20			7.7	OK	

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Appendix C – Maintenance Checklist

continued from...

BOX B.1 An example SuDS specification

Tolerances

The sides slopes of the swale should have a longitudinal and transverse tolerance of 10 mm in 3 m to promote sheet flow from the drained surface down the slope to prevent erosion occurring.

Contractor design elements

The wet well pumping station at end of swale is to be designed by the contractor in accordance with WRc (2011) including chamber, inlet and outlet, pumps and controls. The pumps provided are to provide a capacity of at least 94 l/s with a duty and standby pump provided.

Provision is to be made in the pumping station to add lime dosing equipment at a later date if required.

The wet well should be designed so that it traps and prevents floating debris (sawdust and woodchip) from entering the pumps and a means of removing the debris provided.

B.8 MAINTENANCE PLAN AND CHECKLIST

B.8.1 Why is a Maintenance Plan needed?

The purpose of a Maintenance Plan is to ensure that all those involved in the maintenance and operation of the SuDS system understand its functionality and maintenance requirements in terms of supporting long-term performance to the design criteria to which it was designed.

A Maintenance Plan delivered as part of a drainage submission:

- confirms that the designer has taken maintenance into account within the design
- demonstrates the competence of the designer
- provides a guide to the adoption team as to what the maintenance requirements of the system are and how they can be met most efficiently
- provides a basis for costing long-term maintenance budgets (and commuted sums, if required)
- provides a working document for use on site
- details procedures for dealing with emergency spillages, vandalism etc; it should include the local environmental regulator telephone number, which should be called in case of spillages or other pollution incidents.

The Maintenance Plan for the drainage system should be designed in co-operation with the adopting organisation, and the information therein should be presented and discussed verbally with all those involved in inspecting and maintaining the drainage systems.

B.8.2 What should a Maintenance Plan include?

The SuDS Maintenance Plan should cover and clarify the following issues:

- a description of the site – concentrating on describing how the drainage system works in practice and what it is trying to achieve. This is likely to include flow routes, sub-catchments, SuDS components, flow control features and outfall arrangements. It should also explain the visual and biodiversity aspects of a scheme, as these can easily be compromised by inappropriate maintenance.
- a plan of the site that identifies runoff sub-catchments, SuDS components, critical water levels, control structures, flow routes (including exceedance routing) and outfalls

- a plan clearly showing the extent of the adopted area along with easements and rights of way for access to carry out maintenance. If other parties are responsible for different parts of a scheme, this should be clearly shown on the plan.
- the access that is required to each surface water management component for maintenance purposes and a plan for the safe and sustainable removal and disposal of waste periodically arising from the drainage system
- a review of the work to be undertaken, based on regular day-to-day maintenance, occasional tasks and remedial work. Details of the likely maintenance requirements for each SuDS element are provided in this Manual. Maintenance requirements for proprietary systems should be provided by the manufacturer or supplier.
- the maintenance specification – detailing the materials to be used and the standard of work required. A specification should describe how the work should be carried out and should contain clauses giving general instructions to the maintenance contractor.
- the maintenance schedule of work – itemising the tasks to be undertaken and the frequency at which they should be performed so that an acceptable long-term performance standard is secured. This schedule can then be priced and checked on site, and it can form the basis of an inspection log where appropriate. The schedule should be a living document because it may change, where inspections advise changes to the scheme maintenance requirements.
- contact sheet and any extra guidance notes – eg action plan for dealing with accidental spillages
- photographic records of the inspections. This can pick up long-term changes that might not be apparent on a single visit, especially where inspections are carried out by different members of staff.

Note: An example of a Maintenance Plan is available in Box B.2.

B.8.3 Maintenance inspection checklist

This checklist is a generic list that can be added to, or have items removed from it, to suit a particular site. The exact content of the checklist will depend on the combination of different SuDS components used in a scheme. Checklists should be selected based on the combination of elements in the drainage system to provide a bespoke inspection report.

The objective of this checklist is to:

- confirm that appropriate routine maintenance of the system is being undertaken
- confirm that the system is continuing to operate effectively
- identify any remedial works required
- provide a consistent record of the condition and performance of the system.

It is not a checklist of maintenance items, which is covered in Chapters 11 to 23 of this manual (Table B.24). It is a checklist to facilitate consistent inspection of the condition of the system. It can be used by any organisation responsible for the long-term maintenance of the SuDS system as a recording process, or by a subcontracted organisation as part of their client reporting procedures.

Inspections should comply with all relevant health and safety legislation (The Management of Health and Safety at Work Regulations 1999) including the development of risk assessments for working close to or in water.

Inspections should ideally be carried out monthly (and no less than three-monthly), at the same time as other routine maintenance activities.

TABLE B.24 Where to find information on maintenance activities and frequencies

Component	Ref (within this manual)
Green roofs	Section 12.12
Infiltration systems	Section 13.12
Proprietary systems	Section 14.12
Filter strips	Section 15.12
Filter drains	Section 16.12
Swales	Section 17.12
Bioretention systems	Section 18.12
Trees	Section 19.12
Pervious pavements	Section 20.14
Attenuation storage tanks	Section 21.13
Detention basins	Section 22.12
Ponds and wetlands	Section 23.12

TABLE B.25 SuDS maintenance inspection checklist

General information			
Site ID			
Site location and co-ordinates (GIS if appropriate)			
Elements forming the SuDS scheme		Approved drawing reference(s)	
Inspection frequency		Approved specification reference	
Type of development		Specific purpose of any parts of the scheme (eg biodiversity, wildlife and visual aspects)	

Inspection date								
	Details	Y/N	Action required	Date completed	Details	Y/N	Action required	Date Completed
General inspection items								
Is there any evidence of erosion, channelling, ponding (where not desirable) or other poor hydraulic performance?								
Is there any evidence of accidental spillages, oils, poor water quality, odours or nuisance insects?								
Have any health and safety risks been identified to either the public or maintenance operatives?								
Is there any deterioration in the surface of permeable or porous surfaces (eg rutting, spreading of blocks or signs of ponding water)?								
Silt/sediment accumulation								
Is there any sediment accumulation at inlets (or other defined accumulation zones such as the surface of filter drains or infiltration basins and within proprietary devices)? If yes, state depth (mm) and extent. Is removal required? If yes, state waste disposal requirements and confirm that all waste management requirements have been complied with (consult environmental regulator)								

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TABLE B.25 SuDS maintenance inspection checklist

Inspection date								
	Details	Y/N	Action required	Date completed	Details	Y/N	Action required	Date Completed
Is surface clogging visible (potentially problematic where water has to soak into the underlying construction or ground (eg underdrained swale or infiltration basin)?								
Does permeable or porous surfacing require sweeping to remove silt?								
System blockages and litter build-up								
Is there evidence of litter accumulation in the system? If yes, is this a blockage risk?								
Is there any evidence of any other clogging or blockage of outlets or drainage paths?								
Vegetation								
Is the vegetation condition satisfactory (density, weed growth, coverage etc)? (Check against approved planting regime.)								
Does any part of the system require weeding, pruning or mowing? (Check against maintenance frequency stated in approved design.)								
Is there any evidence of invasive species becoming established? If yes, state action required								
Infrastructure								
Are any check dams or weirs in good condition?								
Is there evidence of any accidental damage to the system (eg wheel ruts?)								
Is there any evidence of cross connections or other unauthorised inflows?								
Is there any evidence of tampering with the flow controls?								

continued...

continued from...

TABLE B.25 SuDS maintenance inspection checklist

Inspection date								
	Details	**Y/N**	**Action required**	**Date completed**	**Details**	**Y/N**	**Action required**	**Date Completed**
Are there any other matters that could affect the performance of the system in relation to the design objectives for hydraulic, water quality, biodiversity and visual aspects? (Specify.)								
Other observations								
Information appended (eg photos)								
Suitability of current maintenance regime								
Continue as current Increase maintenance Decrease maintenance								
Next inspection								
Proposed date for next inspection								

Some normally highly permeable soils and soft rocks (eg chalk) can have their permeability significantly reduced by "smearing" of the surface during excavation, especially by mechanical diggers. It is recommended that the exposed surface of the soil is manually cleaned of any smearing before the geotextile and granular fill surrounding any infiltration system are installed.

13.11.2 Infiltration basins

Where possible, construction of infiltration basins should take place after the site has been stabilised, in order to minimise the risk of premature system failure due to high sediment loadings in runoff from disturbed ground. If this is not possible, then initial excavation should be carried out to within 450 mm of the basin floor, and final excavation should be delayed until after site stabilisation. It is essential that infiltration basins should not be used to manage construction runoff and trap construction sediments.

Topsoil should not be laid in basins when the ground or the topsoil is saturated. This may be a constraint to the use of infiltration basins if the construction programme is particularly tight.

All excavation and levelling should be performed by equipment with tracks that exert very light pressures, to prevent compaction of the basin floor, which may reduce infiltration capacity. Before and after construction, other vehicular movements should be prevented.

The base of the basin should be carefully prepared to an even grade with no significant undulations. The surface soils within the basin should not be smeared or compacted during construction. After final grading, the basin floor should be tilled to a depth of 150 mm to provide a well-aerated, porous surface texture.

Backfilling against inlet and outlet structures needs to be controlled to minimise settlement and erosion. The topsoils used to finish the side slopes need to be suitably fertile, porous and of sufficient depth to ensure healthy vegetation growth.

Immediately following basin construction, the base and side slopes should be stabilised with a dense coverage of water-tolerant grass.

13.12 OPERATION AND MAINTENANCE REQUIREMENTS

Infiltration systems will require regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities along with likely machinery requirements and typical annual costs – within the Maintenance Plan. Different designs will have different operation and maintenance requirements, and this section gives some generic guidance for different system types.

13.12.1 Soakaways, trenches and blankets

The design of soakaways, infiltration trenches and blankets should include monitoring points where the water level in the system can be observed or measured. This can either be via an inspection well or inspection cover (where the attenuation storage space is a void). For larger installations the inspection access should provide a clear view of the infiltration surface (even if the storage zone is filled). For small, filled soakaways, a 50 mm perforated pipe is adequate.

The useful life and effective operation of an infiltration component is related to the frequency of maintenance and the risk of sediment being introduced into the system.

An easement should be considered where multiple properties discharge to a single soakaway, to ensure long-term access for maintenance purposes.

Table 13.1 provides guidance on the type of operational and maintenance requirements that may be appropriate for soakaways. The list of actions is not exhaustive and some actions may not always be required.

TABLE 13.1 Operation and maintenance requirements for soakaways

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Inspect for sediment and debris in pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings	Annually
	Cleaning of gutters and any filters on downpipes	Annually (or as required based on inspections)
	Trimming any roots that may be causing blockages	Annually (or as required)
Occasional maintenance	Remove sediment and debris from pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings	As required, based on inspections
Remedial actions	Reconstruct soakaway and/or replace or clean void fill, if performance deteriorates or failure occurs	As required
	Replacement of clogged geotextile (will require reconstruction of soakaway)	As required
Monitoring	Inspect silt traps and note rate of sediment accumulation	Monthly in the first year and then annually
	Check soakaway to ensure emptying is occurring	Annually

Maintenance will usually be carried out manually, although a suction tanker can be used for sediment/debris removal for large systems. If maintenance is not undertaken for long periods, deposits can become hard-packed and require considerable effort to remove.

Replacement of the aggregate or geocellular units will be necessary if the system becomes blocked with silt. Effective monitoring will give information on changes in infiltration rate and provide a warning of potential failure in the long term.

Roads and/or parking areas draining to infiltration components should be regularly swept to prevent silt being washed off the surface. This will minimise the need for maintenance.

Maintenance responsibility should be placed with an appropriate organisation, and maintenance schedules should be developed during the design phase.

► Generic health and safety guidance is presented in Chapter 36.

CDM 2015 requires designers to ensure that all maintenance risks have been identified and eliminated/reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

13.12.2 Infiltration basins

Regular inspection and maintenance is important for the effective operation of infiltration basins as designed. Maintenance responsibility for an infiltration basin and its surrounding area should be placed with a responsible organisation.

Regular mowing in and around infiltration basins is only required along maintenance access routes, amenity areas (eg footpaths), across embankments and across the main storage area. The remaining areas can be managed as "meadow" or other appropriate vegetation, unless additional management is required for landscaping purposes. Grass cutting may need to accommodate specific sward mixes and specialist seed or turf supplier recommendations. As described earlier in this chapter, deep-rooting vegetation can maintain infiltration rates and minimise the need for remedial maintenance. All vegetation management activities should take account of the need to maximise biosecurity and prevent the spread of invasive species.

Adequate access should be provided to the infiltration basin for inspection and maintenance, including for appropriate equipment and vehicles such as mowing equipment. Table 13.2 provides guidance on the type of operational and maintenance requirements that may be appropriate for infiltration basins. The list of actions is not exhaustive and some actions may not always be required.

TABLE 13.2 Operation and maintenance requirements for infiltration basins

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter, debris and trash	Monthly
	Cut grass – for landscaped areas and access routes	Monthly (during growing season) or as required
	Cut grass – meadow grass in and around basin	Half yearly: spring (before nesting season) and autumn
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
Occasional maintenance	Reseed areas of poor vegetation growth	Annually, or as required
	Prune and trim trees and remove cuttings	As required
	Remove sediment from pre-treatment system when 50% full	As required
Remedial actions	Repair erosion or other damage by reseeding or re-turfing	As required
	Realign the rip-rap	As required
	Repair or rehabilitate inlets, outlets and overflows	As required
	Rehabilitate infiltration surface using scarifying and spiking techniques if performance deteriorates	As required
	Relevel uneven surfaces and reinstate design levels	As required
Monitoring	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and pre-treatment systems for silt accumulation; establish appropriate silt removal frequencies	Half yearly
	Inspect infiltration surfaces for compaction and ponding	Monthly

Accumulated sediments on the surface of infiltration systems have been shown not to pose a hazard to human health, where people are using the basin as an open space (Scott Wilson, 2010). However, Scott Wilson (2010) shows that the accumulated material exceeded the total organic carbon (TOC) criteria for hazardous waste, and the accumulated sediment would require waste pre-treatment to lower the organic content before off-site disposal (other contaminant levels were well below hazardous waste criteria). Composting or windrowing might achieve this. Excavated sediment from infiltration basins or pre-treatment component that receive runoff from residential or standard road and roof areas are generally not toxic and can therefore be safely disposed of by either land application or off-site disposal. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Sediment testing may be required before sediment excavation, to determine its classification and appropriate disposal methods. For industrial site runoff, sediment testing will be essential. In the majority of cases, it will be acceptable to distribute the sediment on site if there is an appropriate safe and acceptable location to do so.

▶ Further information on waste management is provided in Chapter 33.

Maintenance Plans and schedules should be developed before maintenance contracts are commissioned. Specific maintenance needs of the basin should be monitored, and maintenance schedules adjusted to suit requirements.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

▶ Generic health and safety guidance is presented in Chapter 36.

Provided preventive maintenance measures are conscientiously undertaken, the need for corrective maintenance should rarely arise.

▶ Additional detail on the preparation of maintenance specifications and schedules of work is given in Chapter 32.

13.13 REFERENCES

BRE (1991) *Soakaway design,* BRE Digest 365, Building Research Establishment, Bracknell, UK (ISBN: 0-85125-502-7)

EMERSON, C H and TRAVER, R G (2008) "Multi-year and seasonal variation of infiltration from stormwater best management practices" *Journal of irrigation and drainage engineering,* vol 134, special issue *Urban Storm-Water Management*, American Society of Civil Engineers, Reston, VA, USA, pp 598–605

SCOTT WILSON (2010) *Fate of highway contaminants in the unsaturated zone, final synthesis report*, Highways Consultancy Group, Highways Agency, London, UK (unpublished)

SIRIWARDENE, N R, DELETIC, A and FLETCHER, T D (2007) "Clogging of stormwater gravel infiltration systems and filters: Insights from a laboratory study" *Water Research,* vol 41, 7, National Center for Biotechnology Information, US National Library of Medicine, MD, USA, pp1433–1440

Statutes

BS 7533-13:2009 *Pavement constructed with clay, natural stone or concrete pavers. Guide for the design of permeable pavements constructed with concrete paving blocks and flags, natural stone slabs and setts and clay pavers*

Construction (Design and Management) Regulations 2015

A construction phase health and safety plan is required under the Construction (Design and Management) Regulations (CDM) 2015. This should ensure that all construction risks have been identified, eliminated, reduced and/or controlled where appropriate.

Manufacturers should provide advice on whether the treatment systems need to be protected from construction phase runoff, and how this can best be achieved.

14.12 OPERATION AND MAINTENANCE REQUIREMENTS

14.12.1 General guidance

Proprietary treatment systems will require routine maintenance to ensure continuing operation to design performance standards. Because of the wide range of different designs and performance, all manufacturers should provide detailed specifications and frequencies for the required maintenance activities along with likely machinery requirements and typical annual costs for any given site. The treatment performance of proprietary systems is strongly dependent on maintenance, and robust management plans will be required to ensure that maintenance is carried out in the long term. There are examples where not undertaking maintenance has led to pollution, and the companies involved have been fined. The cost of maintenance would have been much less than the subsequent fine and clean-up costs. Different proprietary treatment devices will have different operation and maintenance requirements, but this section gives some generic guidance. Ease of access for maintenance and inspection is essential. In particular, access lids and covers should be kept as lightweight as practicable.

Many proprietary systems are beneath the ground, and malfunctioning is not easy to detect, and it is therefore often ignored unless alarms are provided or the system is designed to cause localised surface ponding if full. If systems lead to other surface features, early warning of maintenance being required may be easily observed at the inlet to the feature (which should be designed to prevent it entering the main part of the component). Preference should be given to systems or designs that give some easily observable indication that maintenance is required.

Lack of routine maintenance is more likely to cause poor outflow water quality than with other SuDS due to resuspension of solids and anaerobic conditions developing within the device. For example, anaerobic conditions can develop in deep sumps and catchpits that result in nutrients and metals being released from captured sediments. During the first few months after installation, subsurface treatment units should be visually inspected after rainfall events, and the amount of deposition measured to give the operator an idea of the expected rate of sediment and oil deposition. After this initial period, systems should be inspected every six months to verify the appropriate level of maintenance. During these inspections, the floating debris and any floating oils should normally be removed. This may be done using a van-mounted system, without the need for a large tanker. Silt should be removed when it reaches 75% of the capacity of the sump. In most situations, the units should be fully cleaned out at least annually. If there is a significant spill of oil (or other pollutant) the system should be cleaned immediately.

Hilliges *et al* (2013) recommends cleaning treatment channels out every six months, in spring and after the summer. This was based on observed silt build up for a busy road (AADT 57 000 vehicles per day) and this frequency could possibly be reduced in less trafficked areas. Experience with other channels in less trafficked areas shows silt removal may only be required every 10 years.

Proper disposal of oil, solids and floating debris removed from components must be ensured, and the environmental regulator should be approached for advice where there are any doubts concerning disposal options. A small portion of water will be removed along with the pollutants during the clean-out process, which should be considered when costing sediment disposal processes.

▶ Further guidance on waste management is given in Chapter 33.

Harmful vapours may develop in subsurface filtration or hydrodynamic separation units, as hydrocarbons may remain there for extended periods of time. Appropriate testing for harmful vapours and venting

TABLE 14.2 An example of operation and maintenance requirements for a proprietary treatment system

Maintenance schedule	Required action	Typical frequency
Routine maintenance	Remove litter and debris and inspect for sediment, oil and grease accumulation	Six monthly
	Change the filter media	As recommended by manufacturer
	Remove sediment, oil, grease and floatables	As necessary – indicated by system inspections or immediately following significant spill
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Six monthly
	Inspect filter media and establish appropriate replacement frequencies	Six monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first half year of operation, then every six months

should be undertaken whenever access for maintenance is required. Removal of oil, silt and other pollutants must be in accordance with the appropriate waste management legislation.

Maintenance responsibility for all systems should be placed with an appropriate organisation, and Maintenance Plans and schedules should be developed during the design phase.

▶ Further detail on the preparation of maintenance specifications and schedules of work is given in Chapter 32.

Table 14.2 provides guidance on the type of operation and maintenance schedule that may be appropriate for a proprietary treatment system. The list of actions is not exhaustive and some actions may not always be required.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

▶ Generic health and safety guidance is presented in Chapter 36.

14.12.2 Oil water separators

Specific requirements for oil/water separators are provided in PPG3 (EA/SEPA/EHSNI, 2006). The following items should be undertaken every six months as a minimum:

- check volume of sludge
- check thickness of light liquid
- check function of automatic closure device
- empty the separator, if required
- check the coalescing material and clean or change if necessary (class 1 only)
- check the function of the warning device (if fitted)

General inspection of the integrity of oil/water separators should occur at a maximum frequency of five years, and should cover the following:

- watertightness of system

- structural condition
- internal coatings
- in-built parts
- electrical devices and installations
- adjustment of automatic closure devices

It is usually a requirement that separators are filled with clean water before being put into operation and each time after emptying for maintenance. Failure to do so will cause the separator to malfunction until surface water builds up the required permanent water level in the facility. It is possible to fit an alarm to separators that will indicate when the collected oil volume is at a maximum, and this may be a regulatory requirement. The alarms should be placed in a location that is clearly visible to those responsible for maintenance of the system.

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16.11 CONSTRUCTION REQUIREMENTS

Filter drains should be protected before completion and stabilisation of the upstream development areas. They should not be used for drainage of construction sites, where untreated runoff is likely to contain large amounts of silt, debris and other pollutants, as this will cause rapid clogging of the systems.

All trench excavations should follow construction best practice and be supported, if required. No personnel should be allowed to enter an unsupported trench deeper than 1.2 m. Trench supports should be designed to guarantee the safety of those working in the trench. Support may also be needed for shallower trenches in weak ground.

Filter drain formations should be flat or to a shallow grade to reduce the risk of ponding and negative filter gradients. Geotextile and stone fill should be clean before construction. Backfill should be placed in 100–150 mm layers and lightly compacted as required.

All geotextiles should be wrapped and secured to prevent gravel or stone from clogging with sediments.

The drain-down time after a storm should be observed after completion or modification of the facility to confirm that the desired drain time has been obtained (BRE, 1991).

▶ Further detail on construction activities and the programming of construction activities is provided in Chapter 31.

A construction phase health and safety plan is required under the Construction (Design and Management) Regulations (CDM) 2015. This should ensure that all construction risks have been identified, eliminated, reduced and/or controlled where appropriate.

▶ Generic health and safety guidance is presented in Chapter 36.

16.12 OPERATION AND MAINTENANCE REQUIREMENTS

Filter drains will require regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities along with likely machinery requirements and typical annual costs – within the Maintenance Plan. The treatment performance of filter drains is dependent on maintenance, and robust management plans will be required to ensure that maintenance is carried out in the long term. Different designs will have different operation and maintenance requirements, but this section gives some generic guidance.

Regular inspection and maintenance is important for the effective operation of filter drains as designed. Maintenance responsibility for a filter drain should always be placed with an appropriate organisation. Adequate access should always be provided to the filter drain for inspection and maintenance. If filter drains are implemented within private property, owners should be educated on their routine maintenance needs, and should understand the long-term Maintenance Plan and any legally binding maintenance agreement.

Litter (including leaf litter) and debris removal should be undertaken as part of general landscape maintenance for the site and before any other SuDS management task. All litter should be removed from site.

Table 16.1 provides guidance on the type of operational and maintenance requirements that may be appropriate. The list of actions is not exhaustive and some actions may not always be required.

TABLE 16.1 Operation and maintenance requirements for filter drains

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter (including leaf litter) and debris from filter drain surface, access chambers and pre-treatment devices	Monthly (or as required)
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies	Six monthly
	Remove sediment from pre-treatment devices	Six monthly, or as required
Occasional maintenance	Remove or control tree roots where they are encroaching the sides of the filter drain, using recommended methods (eg NJUG, 2007 or BS 3998:2010)	As required
	At locations with high pollution loads, remove surface geotextile and replace, and wash or replace overlying filter medium	Five yearly, or as required
	Clear perforated pipework of blockages	As required

Sediments excavated from upstream pre-treatment devices that receive runoff from residential or standard road and roof areas are generally not toxic or hazardous material and can therefore be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate waste management protocols and compliance with legislation. Sediment testing may be required before sediment excavation to determine its classification and appropriate disposal methods. For industrial site runoff, sediment testing will be essential. In the majority of cases, it will be acceptable to distribute the sediment on site, if there is an appropriate safe and acceptable location to do so. Any damage due to sediment removal or erosion should be repaired and immediately reseeded or planted.

▶ Further detail on waste management is provided in Chapter 32.

Maintenance Plans and schedules should be developed during the design phase. Specific maintenance needs of the filter drain should be monitored and maintenance schedules adjusted to suit requirements.

▶ Further detail on the preparation of maintenance specifications and schedules of work is given in Chapter 32.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

▶ Generic health and safety guidance is presented in Chapter 36.

If sediment from construction work accumulates on a swale it should be cleared and the swale fully rehabilitated before the drainage system is adopted by the organisation carrying out the maintenance.

The swale should be planted at a time of year when successful plant establishment without irrigation is most likely (noting that temporary irrigation may still be required if the period is especially dry). Freshly seeded areas should be stabilised with appropriate temporary or permanent soil stabilisation methods, such as erosion control matting or blankets. If more than 30% of the planted area is bare after four weeks, reseeding or replanting should be considered to achieve 90% coverage.

Figure 17.16 Swale during construction showing coir matting used to protect soils from erosion before the establishment of vegetation, University of York (courtesy Arup)

▶ Further detail on construction activities and the programming of construction activities is provided in Chapter 31.

A construction phase health and safety plan is required under the Construction (Design and Management) Regulations (CDM) 2015. This should ensure that all construction risks have been identified, eliminated, reduced and/or controlled where appropriate.

▶ Generic health and safety guidance is provided in Chapter 36.

17.12 OPERATION AND MAINTENANCE REQUIREMENTS

Swales will require regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities along with likely machinery requirements and typical annual costs – within the Maintenance Plan. The treatment performance of swales is dependent on maintenance, and robust management plans will be required to ensure maintenance is carried out in the long term. Different designs will have different operation and maintenance requirements, but this section gives some generic guidance.

Maintenance of swales is relatively straightforward for landscape contractors, and typically there should only be a small amount of extra work (if any) required for a swale over and above what is necessary for standard public open space. Provided that landscape management is already required at site, swale maintenance should have marginal cost implications. However, regular inspection and maintenance are important for the effective operation of swales as designed. Maintenance responsibility for a swale should always be placed with an appropriate organisation. If swales are implemented within private property, owners should be educated on their routine maintenance needs, and should understand the long-term Maintenance Plan and any legally binding maintenance agreement.

Adequate access should be provided to all swale areas for inspection and maintenance, including for appropriate equipment and vehicles. Litter and debris removal should be undertaken as part of general landscape maintenance for the site and before any other SuDS management task. All litter should be removed from site.

The major maintenance requirement for dry swales is mowing. Mowing should ideally retain grass lengths of 75–150 mm across the main "treatment" surface, to assist in filtering pollutants and retaining sediments and to reduce the risk of flattening during runoff events. However, longer vegetation lengths, where appropriate, are not considered to pose a significant risk to functionality.

Grass clippings should be disposed of either off site or outside the area of the swale, to remove nutrients and pollutants. For wet swales, mowing of wetland vegetation is not required. However, harvesting of very dense vegetation may be desirable in the autumn after plant die-back, to prevent the discharge of excess organic material into receiving waters. All vegetation management activities should take account of the need to maximise biosecurity and prevent the spread of invasive species.

Figure 17.17 Grass cutting of roadside swale, Stirlingshire (courtesy Abertay University)

Occasionally sediment will need to be removed (eg once deposits exceed 25 mm in depth), although this can be minimised by ensuring that upstream areas are stabilised and by incorporating effective pre-treatment devices. Available evidence from monitoring studies indicates that small distributed infiltration practices such as swales do not contaminate underlying soils, even after more than 10 years of operation (TRCA, 2008). Sediments excavated from a swale that receives runoff from residential or standard road and roof areas are generally not toxic or hazardous material and can therefore be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Sediment testing may be required before sediment excavation to determine its classification and appropriate disposal methods. For runoff from busy streets with high vehicle traffic, sediment testing will be essential. Any damage due to sediment removal or erosion should be repaired and immediately reseeded or planted.

▶ Further detail on waste management is provided in Chapter 33.

Table 17.1 provides guidance on the type of operational and maintenance requirements that may be appropriate. The list of actions is not exhaustive and some actions may not always be required.

Maintenance Plans and schedules should be developed during the design phase. Specific maintenance needs of the swales should be monitored, and maintenance schedules adjusted to suit requirements.

▶ Further detail on the preparation of maintenance specifications and schedules of work is given in Chapter 32.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

▶ Generic health and safety guidance is provided in Chapter 36.

TABLE 17.1 Operation and maintenance requirements for swales

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Cut grass – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required or if bare soil is exposed over 10% or more of the swale treatment area
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standard practices	As required

bioretention areas should be protected from runoff by using silt fences or straw bales as recommended in Woods Ballard *et al* (2007).

In Australia there has been a significant issue with bioretention blinding, compaction and failure during the site construction phase. One approach to address this is to place the filter medium in the system and cover it with a temporary impermeable cover to collect all the silt and sediment that is washed into the depression during construction (ie the system is acting as a silt basin during construction). This impermeable layer and accumulated silt is removed once construction is completed and the system is planted. Relying on sediment fences and straw bales has not been found to be as effective as protecting the systems with a temporary cover.

To minimise the risk of premature system failure, the following points should be closely monitored during the construction of bioretention areas:

- Care should be taken not to over-compact the soils below the bioretention area, and particularly the filter and soil planting bed, as this will reduce infiltration capacities.
- To excavate a bioretention area, a backhoe excavator should be used, and construction plant should avoid running over the bioretention area. For smaller systems and rain gardens, hand excavation may be more suitable if access is limited.
- If mulch is required, it should be applied before planting. It should not be piled up around plants, as this will cause disease and encourage pests. It should be 50–75 mm thick and should be kept clear of plant stems by 50 mm to prevent excessive moisture around the stems.
- Care should be taken to ensure that geotextiles are not clogged or torn during construction.
- The filter medium should not be placed if it is saturated or if the ground below the system is saturated.

The filter medium should be tested to ensure that it meets the required criteria before placing (**Box 18.1**). It is important to establish the planting in the systems as quickly as possible. Watering, weeding and replanting will be required during the establishment period to ensure that greater than 90% of plants survive and give good cover.

The surface of the filter medium should be free of localised depressions so that water is distributed evenly across the surface and prevents localised ponding and clogging. The surface levels should be within a tolerance of ± 25 mm for smaller systems and ± 40 mm for systems with an area greater than 300 m². The thicknesses for the various layers should be constructed with a tolerance of + 25 mm (ie they should not be less than the design thickness). Levels around the edge of the system should be within ± 25 mm of design levels.

▶ Further detail on construction activities and the programming of construction activities is provided in **Chapter 31**.

A construction phase health and safety plan is required under the Construction (Design and Management) Regulations (CDM) 2015. This should ensure that all construction risks have been identified, eliminated, reduced and/or controlled where appropriate.

▶ Generic health and safety guidance is presented in **Chapter 36**.

18.12 OPERATION AND MAINTENANCE REQUIREMENTS

Dalrymple (2013) concluded that bioretention systems will typically require approximately 2.5 times more maintenance than typical landscape designs. Bioretention systems will require regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities along with likely machinery requirements and typical annual costs – within the Maintenance Plan. The treatment performance of bioretention systems is dependent on maintenance, and robust management plans will be required to

ensure that maintenance is carried out in the long term. Different designs will have different operation and maintenance requirements, but this section gives some generic guidance. Ease of access for maintenance and inspection is essential.

The main cause of failure of bioretention systems is clogging of the surface, which is easily visible. Underdrains and drainage layers are beneath the ground, and malfunctioning is not so easy to detect and therefore could potentially be ignored. However, the results of any malfunction are likely to cause surface ponding. The clogging of the surface or drainage layers can cause poor outflow water quality due to water bypassing the filter medium to the overflow more frequently than allowed for. During the first few months after installation, the system should be visually inspected after rainfall events, and the amount of deposition measured, to give the operator an idea of the expected rate of sediment deposition. After this initial period, systems should be inspected each quarter, to verify the appropriate level of maintenance.

▶ Further detail on waste management is provided in **Chapter 33**.

Adequate access should be provided for all bioretention areas for inspection and maintenance, including for the appropriate equipment and vehicles.

Litter picking should be frequent, as rubbish is detrimental to the visual appearance of bioretention systems. Frequent street sweeping in the catchment area will increase the time interval between cleaning out forebays or the filter surface and will reduce the loading of fine suspended solids that can potentially clog the filter medium.

All vegetation management activities should take account of the need to maximise biosecurity and prevent the spread of invasive species.

Maintenance responsibility for all systems should be placed with an appropriate organisation, and Maintenance Plans and schedules should be developed during the design phase. **Table 18.3** provides guidance on the type of operation and maintenance schedule that may be appropriate. The list of actions is not exhaustive and some actions may not always be required. The most intensive maintenance is required during the establishment period. Herbicides and pesticides (such as Roundup) and fertilizers should not be used on bioretention systems. This is because these pollutants will wash through the system quite easily.

Sediments excavated from pre-treatment devices that receive runoff from residential or standard road and roof areas are generally not toxic or hazardous material and can therefore be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Sediment testing may be required before sediment excavation, to determine its classification and appropriate disposal methods. For industrial site runoff, sediment testing will be essential. In the majority of cases, it will be acceptable to distribute the sediment on site, if there is an appropriate safe and acceptable location to do so. Proper disposal of sediment and debris removed must be ensured, and the environmental regulator should be approached for advice where there are any doubts concerning disposal options.

▶ Further detail on waste management is given in **Chapter 33**.

Specific maintenance needs of the bioretention area should be monitored, and maintenance schedules adjusted to suit requirements.

▶ Further detail on the preparation of maintenance specifications and schedules of work is given in **Chapter 32**.

In general, the maintenance for bioretention areas can often be undertaken as part of routine landscape maintenance.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

TABLE 18.3 Operation and maintenance requirements for bioretention systems

Maintenance schedule	Required action	Typical frequency
Regular inspections	Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain (if appropriate) 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 and surface debris and weeds	Quarterly (or more frequently for tidiness or aesthetic reasons)
	Replace any plants, to maintain planting density	As required
	Remove sediment, litter and debris build-up from around inlets or from forebays	Quarterly to biannually
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 above	As required but likely to be > 20 years

▶ Generic health and safety guidance is presented in **Chapter 36**.

20.14 OPERATION AND MAINTENANCE REQUIREMENTS

Regular inspection and maintenance is important for the effective operation of pervious pavements. Maintenance responsibility for a pervious pavement and its surrounding area should be placed with an appropriate responsible organisation. Before handing over the pavement to the client, it should be inspected for clogging, litter, weeds and water ponding, and all failures should be rectified. After handover, the pavement should be inspected regularly, preferably during and after heavy rainfall to check effective operation and to identify any areas of ponding.

Pervious pavements need to be regularly cleaned of silt and other sediments to preserve their infiltration capacity. Extensive experience suggests that sweeping once per year should be sufficient to maintain an acceptable infiltration rate on most sites. However, in some instances, more or less sweeping may be required and the frequency should be adjusted to suit site-specific circumstances and should be informed by inspection reports.

A brush and suction cleaner (which can be a lorry-mounted device or a smaller precinct sweeper) should be used for regular sweeping. Care should be taken in adjusting vacuuming equipment to avoid removal of jointing material. Any lost material should be replaced. It is also possible to clean the surface using lightweight rotating brush cleaners combined with power spraying using hot water, as shown in **Figure 20.30**. This is done every two years at the site shown.

If the surface has clogged then a more specialist sweeper with water jetting and oscillating and rotating brushes may be required, especially for porous asphalt surfaces, to restore the surface infiltration rate to an acceptable level. The specialist equipment should be adjusted so that it does not strip binder from the aggregate in the asphalt.

Figure 20.30 Deep cleaning a supermarket car park, Dundee (courtesy Abertay University)

The likely design life of grass reinforcement will be dictated by trafficking and is likely to be about 20 years if designed correctly. For concrete block permeable paving the design life should be no different from standard paving, assuming that an effective maintenance regime is in place to minimise risks of infiltration clogging. Porous asphalt will lose strength and begin to fatigue due to oxidation of the binder. This is likely to occur slightly faster in porous asphalt than normal asphalt, so the design life will be reduced slightly. Porous concrete should have a similar design life to a normal concrete slab.

The reconstruction of failed areas of concrete block pavement should be less costly and disruptive than the rehabilitation of continuous concrete or asphalt porous surfaces due to the reduced area that is likely to be affected. Materials removed from the voids or the layers below the surface may contain heavy metals and hydrocarbons and may need to be disposed of as controlled waste. Sediment testing should be carried out before disposal to confirm its classification and appropriate disposal methods.

▶ Guidance on waste management is provided in **Chapter 33**.

Table 20.15 provides guidance on the type of operational and maintenance requirements that may be appropriate. The list of actions is not exhaustive and some actions may not always be required.

Maintenance Plans and schedules should be prepared during the design phase. Specific maintenance needs of the pervious pavement should be monitored, and maintenance schedules adjusted to suit requirements.

▶ Further detail on the preparation of maintenance specifications and schedules of work is given in **Chapter 32**.

TABLE 20.15 Operation and maintenance requirements for pervious pavements

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds or management using glyphospate applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements
Remedial Actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving	As required
	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 material	As required
	Rehabilitation of surface and upper substructure by remedial sweeping	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging)
Monitoring	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth – if required, take remedial action	Three-monthly, 48 h after large storms in first six months
	Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually
	Monitor inspection chambers	Annually

Many of the specific maintenance activities for pervious pavements can be undertaken as part of a general site cleaning contract (many car parks or roads are swept to remove litter and for visual reasons to keep them tidy) and therefore, if litter management is already required at site, this should have marginal cost implications.

Generally, pervious pavements require less frequent gritting in winter to prevent ice formation. There is also less risk of ice formation after snow melt, as the melt water drains directly into the underlying sub-base and does not have chance to refreeze. A slight frost may occur more frequently on the surface of pervious pavements compared to adjacent impermeable surfaces, but this is only likely to last for a few hours. It does not happen in all installations and, if necessary, this can be dealt with by application of salt. It is not likely to pose a hazard to vehicle movements.

▶ Generic health and safety guidance is presented in **Chapter 36**.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

Heavy vibrating rollers are definitely not recommended around plastic pipes or tanks due to the high pressures that they can generate. Thin layers with smaller plant are recommended. DfT (2009) should be referred to for guidance for plant and methods for achieving compaction. The manufacturers' recommendations usually limit plant size above geocellular units to no more than 2300 kg/m width. However, the loading resulting from this will still need to be checked in the design. If such plant is to be used adjacent to the units, the resulting compaction pressures need to be checked.

Any arch or flexible pipe structures depend on the even resistance provided from soil or aggregate on both sides of the arch/pipe for their structural capacity. Even slight differences in the level of filling on each side of the arch/pipe as it progresses could potentially cause uneven deflections and increase the stress within the structure above design values. Close supervision during backfilling is therefore vital. The backfill around geocellular tanks should also be brought up evenly around all sides.

Bedding directly below a concrete pipe should have minimal compaction. The fill at the side of the pipe should be well compacted to a level 300 mm above the crown of the pipe. Only light compaction should be applied to the backfill directly over the crown of the pipe to a point 300 mm above it. With reasonable workmanship and supervision, the bedding factors used in the design should be relatively conservative.

21.12.6 Wrapping

All storage tanks should be watertight in accordance with the relevant standards. Geocellular and similar structures using geomembranes to hold water should be sealed in accordance with waterproofing standards (ie welded joints rather than adhesive taped) and the integrity of the seal checked on site through the use of non-destructive testing, to ensure that it is leak-proof. Advice on appropriate integrity and seam tests for geomembranes, that could be adapted for testing membranes around storage tanks, is provided in Mallett *et al* (2014). Care needs to be taken during installation to protect against damage of both the tank structure and the geotextile and the geomembrane wrapping. Follow-on trades can also cause damage and put the integrity and performance of the structure at risk.

21.13 OPERATION AND MAINTENANCE REQUIREMENTS

Regular inspection and maintenance is required to ensure the effective long-term operation of below-ground storage systems. Maintenance responsibility for systems should be placed with a responsible organisation. **Table 21.3** provides guidance on the type of operational and maintenance requirements that may be appropriate. The list of actions is not exhaustive and some actions may not always be required.

Maintenance Plans and schedules should be developed during the design phase, and will be specific to the type of tank that is adopted. Specific maintenance needs of the system should be monitored, and maintenance schedules adjusted to suit requirements. Further detail on the preparation of maintenance specifications and schedules of work is given in **Chapter 32**.

CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

- Generic health and safety guidance is provided in **Chapter 36**.

TABLE 21.3 Operation and maintenance requirements for attenuation storage tanks

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary.	Annually
	Remove sediment from pre-treatment structures and/or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required

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Figure 22.6 Examples of detention basins with easy access for maintenance (courtesy Peterborough City Council and Kent County Council)

22.11 CONSTRUCTION REQUIREMENTS

The bottom and side slopes of the basin should be carefully prepared to ensure that they are structurally sound and the grading should be uniform and smooth to the correct slope so that water does not pond in depressions and to minimise the risk of channelling and erosion through preferential flow paths. Checks should be made that any embankment structures meet their design criteria. The preparation should also ensure that the basin will satisfactorily manage design flows without significant erosion damage.

Backfilling against inlet and outlet structures needs to be controlled so as to minimise settlement and erosion. The soils used to finish the side slopes need to be suitably fertile, porous and of sufficient depth to ensure healthy vegetation growth. If an impermeable liner is used, care should be taken to ensure that it is not damaged during construction.

During the SuDS establishment phase, runoff from bare soils should be minimised. For example:

- vegetation on slopes should be rapidly established
- base-of-slope trenches should be introduced to retain the inevitable runoff of sediments
- construction should be timed to avoid autumn and winter when high runoff rates are to be expected.

Detention basins may be used to manage construction runoff and trap construction sediments, provided they are fully rehabilitated to original design formation levels before handover.

Further detail on construction activities and the programming of construction activities is provided in Chapter 31. Generic health and safety guidance is provided in Chapter 36. A construction phase health and safety plan is required under the Construction (Design and Management) Regulations (CDM) 2015. This should ensure that all construction risks have been identified, eliminated, reduced and/or controlled where appropriate.

22.12 OPERATION AND MAINTENANCE REQUIREMENTS

Detention basins will require ongoing regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities along with likely machinery requirements and typical annual costs – within the Maintenance Plan. The treatment performance of bioretention systems is dependent on maintenance, and robust management plans will be required to ensure maintenance is carried out in the long term. Different designs will have different operation and maintenance requirements, but this section gives some generic guidance.

Maintenance of detention basins is relatively straightforward for landscape contractors, and typically there should only be a small amount of extra work (if any) required for a SuDS detention basin over and above what is necessary for standard public open space.

Maintenance responsibility for a basin should always be placed with an appropriate organisation. Adequate access should be provided to all detention basin areas for inspection and maintenance, including for appropriate equipment and vehicles. Litter and debris removal should be undertaken as part of general landscape maintenance for the site and before any other SuDS management task. All litter should be removed from site.

The major maintenance requirement for detention basins is usually mowing. Regular mowing in and around detention basins is only required along maintenance access routes, amenity areas (eg footpaths), across any embankment and across the main storage area. The remaining areas can be managed as "meadow", unless additional management is required for landscape/amenity/recreational or aesthetic reasons.

Mowing should ideally retain grass lengths of 75–150 mm across the main "treatment" surface to assist in filtering pollutants and retaining sediments and to reduce the risk of flattening during runoff events. Longer lengths of vegetation may be appropriate, depending on the functionality of the component, and its associated design criteria and are not considered to pose a significant risk to functionality.

Shorter lengths may be required when recreational facilities form part of the basin, but in this case the basin will be dealing with exceedance flows only and not treatment.

Grass clippings should be disposed of off-site or outside the detention basin area to remove nutrients and pollutants. Where a detention basin has a small permanent pool at the outlet, its submerged and emergent aquatic vegetation should be managed as for ponds or wetlands. Plant management, to achieve the desired habitat effect, should be clearly specified in a maintenance schedule. All vegetation management activities should take account of the need to maximise biosecurity and prevent the spread of invasive species.

Occasionally sediment will need to be removed (eg once deposits exceed 25 mm in depth). Sediments excavated from a detention basin that receives runoff from residential or standard road and roof areas are generally not toxic or hazardous and can therefore be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Sediment testing may be required before sediment excavation to determine its classification and appropriate disposal methods. For runoff from busy streets with high vehicle traffic, sediment testing will be essential. In the majority of cases, it will be acceptable to distribute the sediment on-site if there is an appropriate safe and acceptable location to do so. Further detail on waste management is provided in Chapter 32. Any damage due to sediment removal or erosion and scour resulting from major events should be repaired and immediately reseeded or planted.

Table 22.1 provides guidance on the type of operational and maintenance requirements that may be appropriate. The list of actions is not exhaustive and some actions may not always be required.

Maintenance Plans and schedules should be developed during the design phase. Specific maintenance needs of the detention basins should be monitored, and maintenance schedules adjusted to suit requirements. Further detail on the preparation of maintenance specifications and schedules of work is given in Chapter 32.

Generic health and safety guidance is provided in Chapter 36. CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

Many of the specific maintenance activities for detention basins can be undertaken as part of a general landscape management contract and therefore, if landscape management is already required at site, should have marginal cost implications. If basins are implemented within private property, owners should be educated on their routine maintenance needs, and should understand the long-term Maintenance Plan and any legally binding maintenance agreement.

TABLE 22.1 Operation and maintenance requirements for detention basins

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly
	Cut grass – for spillways and access routes	Monthly (during growing season), or as required
	Cut grass – meadow grass in and around basin	Half yearly (spring – before nesting season, and autumn)
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
	Inspect inlets, outlets and overflows for blockages, and clear if required.	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies.	Monthly (for first year), then annually or as required
	Check any penstocks and other mechanical devices	Annually
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from inlets, outlet and forebay	Annually (or as required)
	Manage wetland plants in outlet pool – where provided	Annually (as set out in Chapter 23)
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every 2 years, or as required
	Remove sediment from inlets, outlets, forebay and main basin when required	Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided)
Remedial actions	Repair erosion or other damage by reseeding or re-turfing	As required
	Realignment of rip-rap	As required
	Repair/rehabilitation of inlets, outlets and overflows	As required
	Relevel uneven surfaces and reinstate design levels	As required

22.13 REFERENCE

KENNARD, M F, HOSKINS, C G and FLETCHER, M (1996) *Small embankment reservoirs*, R161, CIRIA, London, UK (ISBN: 978-0-86017-461-5). Go to: **www.ciria.org**

Statutes

Reservoir Act 1975 (c.23)

Health and Safety at Work (etc) Act 1974 (c.37)

Building Act 1984 (c.55)

Flood and Water Management Act 2010 (c.29)

Construction (Design and Management) Regulations (CDM) 2015

23.11 CONSTRUCTION REQUIREMENTS

The bottom and side slopes of the pond, including any benches, should be carefully prepared to ensure that they are structurally sound. Any embankments should be checked to ensure that they meet their design criteria. The preparation should also ensure that the basin will satisfactorily retain the surface water runoff without significant erosion damage.

Backfilling against inlet and outlet structures needs to be controlled so as to minimise settlement and erosion. The soils used to finish the side slopes of the pond above the retained level need to be suitably fertile, porous and of sufficient depth to ensure healthy vegetation growth. If an impermeable liner is used, care should be taken to ensure that it is not damaged during construction.

There are various materials available to help prevent erosion while allowing plants to establish (Section 29.4.3). Ideally, planting would be planned over a number of years so that the rate of establishment can be monitored and densities adjusted accordingly.

Ponds can only be used to manage construction runoff where there is provision made for their complete rehabilitation to original design formation levels before handover. Planting schemes should be delayed until full rehabilitation has been undertaken.

Further detail on construction activities and the programming of construction activities is provided in Chapter 31. Generic health and safety guidance is provided in Chapter 36. A construction phase health and safety plan is required under CDM 2015. This should ensure that all construction risks have been identified, eliminated, reduced and/or controlled where appropriate.

23.12 OPERATION AND MAINTENANCE REQUIREMENTS

Ponds and wetlands will require regular maintenance to ensure continuing operation to design performance standards, and all designers should provide detailed specifications and frequencies for the required maintenance activities, along with likely machinery requirements and typical annual costs – within the Maintenance Plan. The treatment performance of ponds and wetlands is dependent on maintenance, and robust management plans will be required to ensure maintenance is carried out in the long term. Different designs will have different operation and maintenance requirements, but this section gives some generic guidance.

Maintenance of ponds is relatively straightforward for landscape contractors, and typically there should only be a small amount of extra work required for a SuDS pond or wetland feature over and above what is necessary for standard public open space.

Regular inspection and maintenance is important for the effective operation of ponds as designed. Maintenance responsibility for a pond and its surrounding area should always be placed with a responsible organisation. Litter and debris removal should be undertaken as part of general landscape maintenance for the site and before any other SuDS management task. All litter should be removed from site.

Any invasive maintenance work such as silt or vegetation removal is only required intermittently, but it should be planned to be sympathetic to the requirements of wildlife in a pond. Care should be taken to avoid disturbance to nesting birds during the breeding season and habitats of target species (eg great crested newt and water voles) at critical times. The window for carrying out maintenance to achieve this is usually towards the end of the growing season (typically September/October), although this will vary with species). Invasive silt and vegetation removal should only be carried out to limited areas at any one time (25–30% of the pond area on one occasion each year to minimise the impact on biodiversity. Plant management, to achieve particular desired habitat effects, should be clearly specified in a maintenance schedule.

Site vegetation should be trimmed as necessary to keep the pond free of leaves and to maintain the aesthetic appearance of the site. Slope areas that have become bare should be re-vegetated and any eroded areas should be regraded before replanting.

Maintenance access (or "easement") should be provided to the pond from a public or private road. An assessment should be made at the planning stage regarding the maintenance and associated access requirements. Ideally, access should be at least 3.5 m wide, have a maximum cross fall of 1 in 7, and be sufficiently robust to withstand maintenance equipment and vehicles. However, temporary access routes for infrequent operations could be considered where permanent routes are not appropriate. The access should extend to any forebay, safety and aquatic benches, inlet and outlet infrastructure. Consideration should be given as to whether maintenance vehicles will need to turn around. Wherever possible SuDS ponds and wetlands should be designed so that special machinery is not required to undertake maintenance.

Table 23.1 provides guidance on the type of operational and maintenance requirements that may be appropriate. The list of actions is not exhaustive and some actions may not always be required. Consideration should be given to the need to control risks to biosecurity during maintenance operations and guidance is provided in Chapter 29.

Sediments excavated from ponds or forebays that receive runoff from residential or standard road and roof areas should be safely disposed of in accordance with current waste management legislation. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Chemical testing of the sediment may be required, before sediment excavation, to determine its classification and appropriate disposal methods. For industrial site runoff, sediment testing will be essential. In the majority of cases on low-risk sites with source control and a Management Train, it will be acceptable to distribute the sediment on site, if there is an appropriate safe and acceptable location to do so. Further detail on waste management is provided in Chapter 33. If ponds are to be drawn down, care should be taken to prevent downstream discharge of sediments and anoxic water. The environmental regulator should be notified before such activities.

New ponds may become rapidly dominated by invasive native plants, particularly common bulrush (Typha latifolia). As it is not desirable for all new ponds to be bulrush dominated, it should be ensured that in the first five years, while vegetation is establishing, certain plant growth is controlled. After this time, ponds can usually be allowed to develop naturally recognising that, unless the margins are occasionally managed, they are likely to become dominated by trees and shrubs.

Eutrophication of SuDS ponds can occur during the summer months. This is best alleviated by controlling the nutrient source or providing a continuous baseflow to the pond. Unless eutrophication is severe, aeration can be used as a stop-gap measure to save aquatic animal species and reduce risks to receiving waters. However, the addition of barley straw bales, dredging or rendering the nutrients inactive by chemical means can also be successful.

Maintenance Plans and schedules should be developed during the design phase. Specific maintenance needs of the pond should be monitored, and maintenance schedules adjusted to suit requirements. Further detail on the preparation of maintenance specifications and schedules of work is given in Chapter 32.

Generic health and safety guidance is provided in Chapter 36. CDM 2015 requires designers to ensure that all maintenance risks have been identified, eliminated, reduced and/or controlled where appropriate. This information will be required as part of the health and safety file.

TABLE 23.1 Operation and maintenance requirements for ponds and wetlands

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut the meadow grass	Half yearly (spring, before nesting season, and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Inspect inlets, outlets, banksides, structures, pipework etc for evidence of blockage and/or physical damage	Monthly
	Inspect water body for signs of poor water quality	Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options	Half yearly
	Check any mechanical devices, eg penstocks	Half yearly
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1 m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1 m above water level	Annually
	Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay.	Every 1–5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays.	Every 5 years, or as required
Occasional maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant, where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realign rip-rap or repair other damage	As required
	Repair / rehabilitate inlets, outlets and overflows.	As required

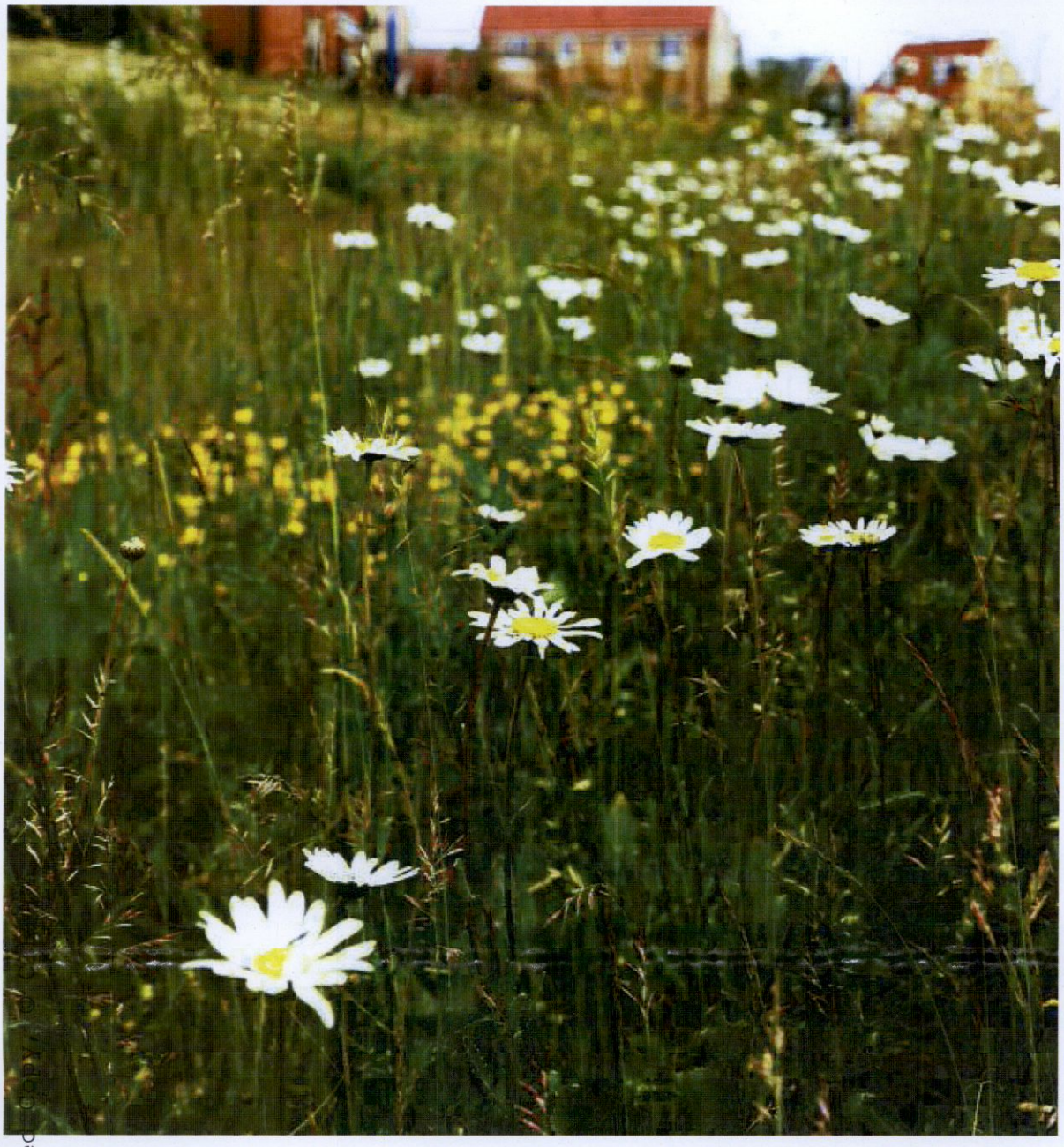

Image courtesy Simon Bunn

32 OPERATION AND MAINTENANCE

Contents

Chapter 32

Operation and maintenance

This chapter discusses general good practice for operation and maintenance activities, and the types of documents that can be developed to define the requirements at a particular site.

- *Specific maintenance requirements for each type of SuDS component are listed in detail towards the end of each of the SuDS component chapters (Chapters 11–23).*
- *Chapter 29 provides further detail on landscape design (including planting) for ease of maintenance.*
- *Chapter 33 provides guidance on waste management, including waste resulting from maintenance.*

32.1 INTRODUCTION

Many SuDS components are visible on the surface, form part of the overall site landscape and include a range of habitats. Depending on the design, maintenance regimes need to take account of the wider landscape context of amenity and biodiversity, as well as drainage requirements. The maintenance activities required to deliver the desired amenity, for example, may exceed those required to deliver the designed water quantity and water quality performance. In such cases, this needs to be recognised by those responsible for delivering and maintaining that functionality. Where SuDS components are hard surfaces or below ground, the maintenance will generally be based on engineering requirements.

For the purpose of this manual, maintenance refers to:

- inspections required to identify performance issues and plan appropriate maintenance needs
- operation and maintenance of the drainage system
- landscape management
- waste management associated with contaminated silt and other waste materials resulting from maintenance.

All maintenance will need to take the protection of habitats and associated ecology into account (Chapter 6). Maintenance regimes should be regularly assessed (eg once per year) to make sure that the approach is still meeting the drainage, landscape and any other objectives. This may result in changes to the maintenance of a feature or area. For example, more frequent vegetation management may be identified where vegetation growth is obstructing highway sight lines.

The function of the surface water management system should be understood by those responsible for maintenance, regardless of whether individual components are below ground or on the surface. When problems occur in vegetated components on the surface, they may be obvious and can be remedied using standard landscape or engineering practices. However, this is not always the case – particularly with more complex systems such as bioretention systems and pervious surfaces. If any system (whether above or below ground) is properly designed, monitored and maintained, performance deterioration can usually be minimised.

Ease of maintenance and access is therefore a necessary and important consideration of SuDS design (not least as part of CDM requirements to ensure that maintenance can be undertaken safely). Sufficient thought should be given to the likely required maintenance over the design life of the SuDS and its funding during the feasibility and planning stages of a scheme (Chapter 35). In particular, the following requirements should be given full consideration:

- maintenance access – ensuring appropriate and permanent access to all points in the system where future maintenance may be required
- forebays and/or appropriate pre-treatment systems to help trap sediment
- appropriate provision for temporary drainage, if required, during sediment management or other maintenance activities
- the availability of storage and disposal areas for green waste, such as grass cuttings and organic sediments.

Appropriate legal agreements between adoption and maintenance organisations that define maintenance responsibilities are presented in Shaffer *et al* (2004). Maintenance Plans will often be required as a condition of planning for the site. For example, many buildings are required to achieve a high BREEAM rating and a landscape management plan (LMP) is a mandatory requirement to achieve this. Planning authorities will include this in a planning condition.

The LMP can also form a useful tool for public or client engagement with SuDS and help them to understand the wider benefits of the system. They can include the provision for ecological re-survey, tree inspection and works and information about how the system delivers multiple benefits.

32.2 OPERATION AND MAINTENANCE MANUAL

Those responsible for SuDS within a development (owner, tenant, local authority, water company etc) should ideally be provided with an operation and maintenance manual by the designer. This could be part of the documentation provided under CDM (part of the health and safety file).

If the user of the system is not responsible for maintenance, then it is important to ensure that they know when the SuDS is not functioning correctly and who to contact if an issue arises, such as a blockage at a SuDS pond seen by a householder on a housing estate or a tenant on an industrial estate.

The operation and maintenance manual should be succinct and easy to use and should include the following:

- location of all SuDS components on the site
- brief summary of the design intent, how the SuDS components work, their purpose and potential performance risks
- depth of silt that will trigger requirement for removal
- visual indicators that will trigger maintenance
- depth of oil in separators etc that will trigger removal
- maintenance requirements (ie the Maintenance Plan) and a maintenance record pro forma
- explanation of the objectives of the maintenance proposed and potential implications of not meeting those objectives (it may be useful to split this into planted and hard elements, for clarity)
- identification of areas where certain activities are prohibited (eg stockpiling materials on pervious surfaces)
- an action plan for dealing with accidental spillages of pollutants

- advice on what to do if alterations are to be made to a development or if service companies need to undertake excavations or other similar works that could affect the SuDS
- details of whom to contact in the event that pollution is seen in the system or if it is not working correctly.

The operation and maintenance manual should also include brief details of the design concepts and performance criteria for the scheme and how the owner or operator should ensure that any works undertaken on a development do not compromise this. For example, householders should be made aware that surface water drainage is connected to soakaways, and be given full details and maintenance obligations for any rainwater harvesting systems in the property. This education is part of the wider community engagement process that is vital to the successful uptake of SuDS (Chapter 34). The operation and maintenance manual may also include the LMP.

It is important on industrial estates to clearly identify to everyone which areas drain to SuDS and which to foul sewer. For example, gullies and manhole covers could be colour coded or marked. Owner and tenants should be made aware of what is allowed to drain to the SuDS. Similarly, it is a good idea to use interpretation boards, for example at a pond on a housing estate, to increase householders' awareness of the purpose and benefits of the SuDS and to encourage them not to put polluting substances down the surface water drainage system (Chapter 27).

32.3 LEVEL OF OPERATION AND MAINTENANCE

There are many factors that will influence the type and frequency of maintenance required for a SuDS component or scheme at any particular site, including:

- the type of SuDS components
- the size of the contributing catchment in relation to the area of the SuDS components (this will affect the likely sediment loading rates and potential for erosion etc)
- the land use associated with the contributing catchment (this will affect the likely build-up of contamination)
- the level of continuing construction within the contributing catchment
- the SuDS planting scheme
- the habitat types that have been created as part of the scheme and how they are anticipated to evolve into a mature landscape
- the amenity and visual requirements of the area.

The demands on the SuDS component or scheme to perform a particular aesthetic function may be a key driver, with high frequencies of grass cutting and/or other vegetation management often being required for appearance and amenity value rather than for functional reasons. Specific habitats may dictate the time of year that is suitable for particular activities to be undertaken (eg reed cutting), and/or the extent of the system that should be subject to certain activities at any one time (eg sediment removal). Plants and trees tend to require different periodic management techniques as they mature. This is particularly relevant to coppice areas and woodland, or indeed shrub and herbaceous planting, some of which may require renewal after 10 years or so, depending on the planting and its purpose.

The maintenance regime of a site also needs to consider the response to extreme pollution events. A response action plan should be developed and communicated to all those involved in the operation of a site, so that if a spillage occurs it can be prevented from causing pollution to receiving waters.

It is recommended that SuDS are not handed over to those responsible for maintenance until upstream construction has ceased, the contributing catchment has stabilised, and any necessary rehabilitation of downstream components has been undertaken by the developer/contractor. However, if maintenance agreements have to be put in place in advance of this time, and the level of construction activity in the

contributing catchment is still high, maintenance specifications should be prepared that take account of high sediment accumulation rates and the increased risks of potential spillages.

32.4 OPERATION AND MAINTENANCE ACTIVITY CATEGORIES

Maintenance activities can be broadly defined as:

1 regular maintenance (including inspections) – Section 32.6
2 occasional maintenance – Section 32.7
3 remedial maintenance – Section 32.8.

There may also be initial one-off requirements sometimes referred to as "establishment maintenance", particularly for planting (eg weeding and watering). Regular maintenance consists of basic tasks carried out to a frequent and predictable schedule, including inspections/monitoring, silt or oil removal if required more frequently than once per year, vegetation management, sweeping of surfaces and litter and debris removal.

Occasional maintenance comprises tasks that are likely to be required periodically, but on a much less frequent and predictable basis than the regular tasks (eg sediment removal or filter replacement). Table 32.1 summarises the likely maintenance activities required for each SuDS component, and guidance on specific maintenance activities is given in the following sections.

Remedial maintenance describes the intermittent tasks that may be required to rectify faults associated with the system, although the likelihood of faults can be minimised by good design, construction and regular maintenance activities. Where remedial work is found to be necessary, it is likely to be due to site-specific characteristics or unforeseen events, and so timings are difficult to predict. Remedial maintenance can comprise activities such as:

- inlet and outlet repairs
- erosion repairs
- reinstatement or realignment of edgings, barriers, rip-rap or other erosion control
- infiltration surface rehabilitation
- replacement of blocked filter materials/fabrics
- construction stage sediment removal (although this activity should have been undertaken before the start of the maintenance contract)
- system rehabilitation immediately following a pollution event.

It is important to note that these remedial activities will not be required for all systems, but for the purpose of estimating whole life maintenance costs, a contingency sum of 15–20% should be added to the annual regular and occasional maintenance costs to cover the risk of these activities being required.

TABLE 32.1 Typical key SuDS components operation and maintenance activities (for full specifications, see Chapters 11–23)

Operation and maintenance activity	SuDS component												
	Pond	Wetland	Detention basin	Infiltration basin	Soakaway	Infiltration trench	Filter drain	Modular storage	Pervious pavement	Swale/bioretention/ trees	Filter strip	Green roofs	Proprietary treatment systems
Regular maintenance													
Inspection	■	■	■	■	■	■	■	■	■	■	■	■	■
Litter and debris removal	■	■	■	■	□	■	■	□	■	■	■		□
Grass cutting	■	■	■	■	□	■	■	□	□	■	■		
Weed and invasive plant control	□	□	□	□		□	□		□		□	■	
Shrub management (including pruning)	□	□	□	□					□	□	□		
Shoreline vegetation management	■	■	□										
Aquatic vegetation management	■	■	□										
Occasional maintenance													
Sediment management[1]	■	■	■	■	■	■	■	■	■	■	■		■
Vegetation replacement	□	□	□	□						□	□	■	
Vacuum sweeping and brushing									■				
Remedial maintenance													
Structure rehabilitation /repair	□	□	□	□	□	□	□	□	□	□	□	□	
Infiltration surface reconditioning				□	□	□	□		□	□	□		

Key

■ will be required

□ may be required

Notes

1 Sediment should be collected and managed in pre-treatment systems, upstream of the main device.

32.5 HEALTH AND SAFETY

To comply with the Construction (Design and Management) Regulations (CDM) 2015, designers must assess all foreseeable risks during construction and maintenance and the design must minimise them by the following (in order of preference):

- avoid
- reduce
- identify and mitigate residual risks.

Designers must also make contractors and others aware of risks, in the health and safety file, which is a record of the key health and safety risks that will need to be managed during future maintenance work. For example, the file for a SuDS pond should contain information on the collection of hazardous compounds in the sediment, so that maintenance contractors are aware of it and can take appropriate

precautions. During construction, the residual risks must be identified and an action plan developed to deal with them safely (the health and safety plan and site rules).

All those responsible for maintenance should take appropriate health and safety precautions for all activities (including lone working, if relevant), and risk assessments should always be undertaken. Guidance on generic health and safety principles is provided in Chapter 36.

32.6 REGULAR MAINTENANCE

32.6.1 Inspections and reporting

An initial pre-handover inspection of the scheme is required, to ensure that it has been constructed as designed (Chapter 31).

Regular inspections of SuDS will then:

1 help determine optimum future maintenance activities

2 help establish ongoing hydraulic, water quality, amenity and biodiversity performance of the system

3 allow identification of potential performance failures, such as blockage, reduced infiltration and poor water quality resulting from lack of maintenance.

Maintenance of SuDS is carried out by a range of people, which can include school caretakers, highway authorities, facilities management companies and landscape contractors. Pervious surfaces and proprietary systems will most likely be managed by people familiar with highway or drainage maintenance. Landscaped systems will be managed by the landscape contractor, although connecting pipework may be managed by others.

Where the maintenance of a system is carried out by those responsible for the wider landscaped area, the inspections can generally be undertaken during routine site visits (eg for grass cutting, leaf collection and/or litter collection) for little extra cost, although there may need to be dedicated visits during some winter months.

The staff doing the landscape maintenance should have appropriate experience of SuDS maintenance and should be capable of keeping sufficiently detailed records of any inspections. If staff do not have appropriate experience, then specific inspection visits will be necessary.

Those with overall responsibility for the drainage system may not be responsible for maintenance of the wider landscape and in those circumstances specific inspection visits may also be required at a suitable interval.

Specific visits will also be required if the system includes proprietary treatment systems (Chapter 14).

Whichever arrangements are made, the inspections should be recorded, and the records saved for future reference (Section 32.10 and Appendix B).

During the first year of operation of all types of SuDS, inspections should usually be carried out at least monthly (and after significant storm events) to ensure that the system is functioning as designed and that no damage is evident.

Typical routine inspection questions that will indicate when occasional or remedial maintenance activities are required for any type of system include:

- Are inlets or outlets blocked?
- Does any part of the system appear to be leaking (especially ponds and wetlands)?
- Is the vegetation healthy?

- Is there evidence of poor water quality (eg algae, oils, milky froth, odour, unusual colourings)?
- Is there evidence of sediment build-up beyond the designer's stated limits?
- Is there visual evidence of oil accumulation?
- Is there evidence of ponding above an infiltration surface?
- Is there any evidence of structural damage that requires repair?
- Are there areas of erosion or channelling over vegetated surfaces?
- Is there any visual evidence of regular or unplanned over-topping of banks?

For large sites, it is recommended that an annual maintenance report and record should be prepared by the maintenance contractor, which should be retained with the operation and maintenance manual (Section 32.2). The report should provide the following information:

- observations resulting from inspections
- measured sediment depths (where appropriate)
- monitoring results, if flow or water quality monitoring is undertaken
- confirmation that any penstocks or valves are free and working correctly
- maintenance and operation activities undertaken during the year
- recommendations for inspection and maintenance programme for the following year.

As with any paved area, safety inspections of pervious surfaces will be necessary for tripping hazards. If pervious surfaces are to be used in a shopping centre car park or high footfall area, these should be inspected monthly as a minimum, and repairs made as necessary through the lifetime of the surface. This would apply to any type of surface. Guidance is provided by the Road Liaison Group (2005).

32.6.2 Litter and debris removal

Litter and debris removal is an integral part of SuDS maintenance for surface features, in order to reduce the risks of inlet and outlet blockages, to retain amenity value and to minimise pollution risks. High litter removal frequencies may be required where aesthetics are a major driver, for example on residential sites or at high profile commercial or retail parks. Litter removal is less of an issue for engineered or underground systems, such as pervious surfaces, filter drains and proprietary systems and will normally form part of routine open space maintenance.

32.6.3 Grass cutting

It is recommended that the grass cutting regime around SuDS components is carefully specified to maximise the performance of the SuDS and meet visual requirements. In general, allowing grass to grow tends to enhance water quality performance. Short grass around a wet system, such as a pond or wetland, provides an ideal habitat for nuisance wildlife species such as geese, but allowing the grass to grow is an effective means of discouraging them. Grass around wet pond or wetland systems should not be cut to the edge of the permanent water in order to deter large birds and to reduce the risks of nutrients associated with grass cuttings falling into the water.

Figure 32.1 Grass cuttings

Grass cutting is an activity primarily undertaken to enhance the perceived aesthetics of the

facility. The frequency of cutting will tend to depend on surrounding land uses, and public requirements. Grass cutting should be done as infrequently as possible, recognising the aesthetic preferences of local residents and other landscape management activities required at the site. Visibility around highways also needs to be considered. Grass around inlet and outlet infrastructure should be strimmed closely to reduce risks to system performance. If a manicured, parkland effect is required, then cutting will need to be undertaken more regularly than for meadow type grass areas, the latter aiming to maximise habitat and biodiversity potential. The impact of grass cutting on soil compaction should also be considered. The landscape management plan will usually identify the mowing regimes required in different areas or zones.

Guidance on designing a site to ease maintenance, such as limiting the slope of grassed areas, is provided in Chapter 29.

In the past there have been recommendations that keeping grass short in filter strips and swales prevents the grass lodging over (ie being pushed over and flattened by the flow of water) and improves pollution removal. However, the risk of pollution removal being compromised is now considered to be minimal and there is no reason for a blanket requirement to keep grass short in all swales and filter strips.

32.6.4 Weed and invasive plant control

Weeds are generally defined as vegetation types that are unwanted in a particular area. For SuDS, weeds can include:

- alien or invasive species (ie plants that are particularly aggressive, non-native species), the spread of which is generally undesirable
- plants that negatively affect the technical performance or amenity/biodiversity value of the system.

In some places, weeding has to be done by hand to prevent the destruction of surrounding vegetation (hand weeding should generally only be required during the first year, during plant establishment). However, mowing can be an effective weed management measure for grassed areas. Where the use of herbicides and pesticides is permitted (Chapter 29), this should be limited, where possible, to the establishment period, as the benefits of rapid sward/plant cover development are likely to outweigh any potential resulting water quality deterioration. The use of fertilisers should also be limited or prohibited, to minimise nutrient loadings, which are damaging to water bodies.

Specific advice on weed control for green roofs, filter drains and pervious pavements is provided in Chapters 12, 16 and 20 respectively.

32.6.5 Shrub management

Shrubs may be densely planted and may mature very rapidly over the first year. They are likely to require weeding at the base, especially during the first year or two, to ensure that they get enough water, and mulching to retain water in the soils where possible. Bark mulch around shrubs should not be used, as it floats and clogs outlets. Pruning shrubs can result in a denser structure and better lateral growth, which may be desirable in SuDS.

32.6.6 Aquatic and shoreline vegetation management

Aquatic plant aftercare in the first 1–3 years may be required to ensure establishment of planted vegetation and to control nuisance weeds and invasive plants. Once it is established, the build-up of dead vegetation from previous seasons should be removed at convenient intervals (eg every 3 years and at the end of landscape contract periods) in order to reduce organic silt accumulation. Emergent vegetation may need to be harvested every 2–10 years in order to maintain flood attenuation volumes, optimise water quality treatment potential and ensure fresh growth. Where the density of vegetation is high, annual removal may be required. Care should be taken to avoid disturbance to nesting birds during the breeding season and habitats of target species (eg great crested newt and water voles) at critical times. The window for carrying out maintenance to achieve this is towards the end of the growing season (typically September and October, but this will vary with species). As vegetation matures, plant height may need

to be reviewed with respect to any health and safety framework or strategy such as if it blocks necessary sightlines to an open water feature.

Where emergent vegetation is managed, up to 25% can be removed by cutting at 100 mm above soil level using shearing action machinery. Up to 25% of submerged vegetation can be cut and raked out at any one time, using approved rakes, grabs or other techniques, depending on whether clay or waterproof membranes are present. Aquatic vegetation arisings should be stacked close to the water's edge for 48 hours to de-water it and allow wildlife to return to the SuDS feature. They should then be removed to wildlife piles, compost heaps or off site before decomposition, rotting or damage to existing vegetation can occur.

Algae removal may be undertaken for aesthetic purposes during the first 3–5 years of a pond/wetland's life. The growth of algae, which is considered by some to be visually intrusive, is encouraged by nutrients introduced into the water body. This situation should settle down once upstream construction activities are complete.

32.6.7 Sweeping pervious surfaces

Pervious surfaces need to be regularly cleaned of silt and other sediments to preserve their infiltration capacity. Typically this will be required no more than once per year and often less, where inspections indicate that it is not required. Refer to Chapter 20 for details of this process.

32.6.8 Oil removal and cleaning or replacing filters in proprietary systems

Oil removal from proprietary treatment systems should be undertaken at intervals recommended by the manufacturer. This will depend on the catchment characteristics. On small sites with a low pollution hazard, small amounts of oil may be removed by skimming, using small van-mounted equipment. This is relatively inexpensive. Those serving larger, more heavily polluted catchments may require tankers to remove the accumulated oil.

Where proprietary systems use filters, they should be replaced or cleaned at the intervals recommended by the manufacturer. For example, the coalescing filters in an oil separator can require cleaning every 6 months if the runoff from the catchment has a high oil load (eg from a heavily used road).

32.7 OCCASIONAL MAINTENANCE

32.7.1 Sediment removal

To ensure the long-term performance of SuDS, the sediment that accumulates in treatment components should be removed periodically (whether landscaped or proprietary systems). The required frequency of sediment removal is dependent on many factors including:

- design of upstream drainage system
- type of system
- design silt storage volume
- size of upstream catchment in relation to surface area of SuDS component
- characteristics of upstream catchment area (eg land use, level of imperviousness, upstream construction activities, erosion control management and effectiveness of upstream pre-treatment).

Figure 32.2 De-silting (courtesy Bedford Group of Drainage Boards)

Sediment accumulation will typically be rapid for the entire construction period (including during the period of building, turfing and landscaping of all upstream development plots). Once a catchment is completely developed and all vegetation is well-established, sediment mobility (erosion) and accumulation is likely to drop significantly.

Detailed information on waste management (in particular with respect to sediment removal) is provided in Chapter 33.

For most small features, sediment can be removed either by hand or using small excavators. For any system that has a waterproof liner, the method of sediment removal should be chosen so there is minimal risk of damaging the liner.

For proprietary treatment systems, a suction tanker will be needed to remove the sediment. The size of tanker will depend on the scale of the proprietary system and its location. For small catchments using treatment channels, silt accumulation in the channel can often be removed with hand tools or a small suction tanker.

General sediment removal considerations

Sediment removal from SuDS systems should always be carried out such that no damage is caused to the SuDS, and impacts on ecological systems and aesthetic appearance are minimised. The appropriate method of sediment removal at a particular site will depend on the size of the SuDS component, the access, whether the sediments are submerged or lying on dry ground, the sediment properties, the design characteristics of the SuDS component, visual requirements and wildlife concerns and sediment depths.

For small source-control SuDS components where sediment volumes are likely to be small, it is usually appropriate to remove sediment using hand tools and appropriate protective equipment. Where components and associated sediment volumes are larger, or where the sediment has accumulated in a permanent water body, then mechanical equipment may be required.

In particular, it is recommended to do the following:

1 Establish how the structure is lined and avoid damage to clay puddle layers or waterproof membranes.
2 Undertake work between September and March to minimise impacts on receiving water bodies (high suspended solids can cause reduced dissolved oxygen levels, which causes particular problems during elevated summer temperatures). Where required, works may be restricted to September and October, in order to protect breeding or hibernating wildlife.
3 Where machinery or pumping is to be used, agree the sediment removal and management plan in advance with the environmental regulator.
4 Where machinery is used to excavate sediment, undertake the operation in dry weather when the surrounding ground is firm, and ideally operate from a hard surface.
5 Use machinery with an extending arm to avoid contact with edges, banks and other features within a minimum distance of 1 m from the edge. Use a bucket without teeth to avoid puncturing clay layers or waterproof membranes.
6 Secure consent for any de-watering operations with the environmental regulator, if required.

Specific requirements of different SuDS components are presented in subsequent sections. Individual SuDS component chapters should be referenced for further details.

Sediment removal from retention ponds

Ponds and wetlands may eventually accumulate sufficient sediment to impact on the storage capacity of the permanent pool. This loss of capacity can affect both the appearance and the pollution removal efficiency of the pond. The rate at which this occurs will depend on allowances made during storage

capacity design. The loss in storage will occur more rapidly if the pond receives additional sediment input during the construction phase. The accumulation of sediment should be monitored and where it is significant and/or if the quality in the pond begins to deteriorate, sediment characterisation should be undertaken to establish the need and options for its removal.

Figure 32.3 Floating excavator working in small pond (courtesy Land & Water)

The following issues should be considered:

1 Regular partial sediment removal is most effective, but may not be economic. However, where possible, sediment should not be removed from more than 50% of the pond or wetland area at any one time.
2 Appropriate bankside working areas should be selected, and wetland and bankside habitats protected.
3 Sufficient vegetation should be retained to ensure rapid re-colonisation of damaged areas.
4 Ideally, sediment removal should remove only accumulated inorganic and organic sediment, but not wetland subsoil or topsoil layers. In practice, this can be difficult to achieve.

Specialist contractors should generally undertake sediment removal from ponds or wetlands. The types of machines capable of removing sediment from a pond will vary. It may be possible to drain the pond and employ a mini excavator or excavator with swamp tracks to excavate sediments from within the feature, or else an excavator may have to be deployed from the bank. Standard hydraulic excavators have limited reach, but are normally sufficient to deal with removal from small features within sites. For large ponds, a long-reach excavator may be required that can reach up to 25 m.

A further option that may occasionally be necessary is to use machinery on floating pontoons and/or barges. Figure 32.2 shows a floating excavator working in water.

For safety reasons excavators cannot operate close to overhead power lines and they need a clear area to swing their bucket and dump spoil. This should be taken into account when assessing the access required for maintenance (eg if a pond is surrounded by trees or buildings).

If de-watering of ponds in advance of sediment extraction is feasible at a site, and assuming that the water body can be left drained for a reasonable period of time (ie a few weeks), then this can considerably reduce the volume of material to be extracted and that will require disposal, and will often allow some biodegradation of organic material.

De-watering can be undertaken by:

1 draining down the pond using the penstock or outlet valve (if included within the design)
2 pumping out the pond.

Both options require consideration of the environmental impact of the de-watering, especially with respect to downstream receiving waters, which could be a sewer, watercourse or other water body. In some cases, water pumped from ponds or settlement channels has to be tankered off site. Discharge to a watercourse or body is likely to require discharge consent from the environmental regulator. Consent from the sewerage undertaker will be required if the discharge is to a sewer, and large-scale de-watering may also require planning permission. Testing of the system water quality (for COD, BOD, suspended solids and metals – in consultation with the environmental regulator) may be required to demonstrate the likely risks to the local environment and this can be undertaken together with the sediment sampling.

The water may contain high concentrations of suspended solids that are either already in suspension or become entrained as a result of the pumping process. Adequate sediment control should therefore be provided before the pumped water is discharged. Once the pumped water is running clear then the sediment control devices may be bypassed as long as sediment is not reintroduced into the system. Appropriate sediment control systems include:

- temporary traps formed by constructing an earth embankment with a gravel filled outlet across a swale
- sediment basins (this can include the use of floodable fields)
- sumps (either constructed or mobile proprietary units)
- geotextile filters.

A dump truck with a watertight tailgate is likely to be required to remove the sediment from the site.

Sediment removal from detention basins

Dry basins accumulate sediment with time that will gradually reduce the storage capacity available and can in some cases also reduce sediment trapping efficiency. Also, sediment may tend to accumulate around the control device, which increases the risk that either the orifice may become clogged or that sediment may become re-entrained into the outflow. Where basins are amenity features, sediment accumulation is likely to be unsightly and reduce the amenity value of the component. Sediment accumulation should be monitored as part of the inspection regime for the surface water management system and appropriate frequencies determined for removal and disposal. Small volumes of sediment can usually be removed by landscape contractors using hand tools. Sediment excavation using front-end loaders or backhoes is simple, if appropriate access is available for the equipment. Sediment removal will usually damage the vegetation, and re-establishment may be required.

Sediment removal from filter strips and swales

Sediment accumulation should be monitored as part of the inspection regime for the surface water management system and appropriate frequencies determined for removal and disposal. Filter strips and swales will only accumulate very small volumes of sediment which can be removed by landscape contractors using hand tools at appropriate frequencies depending on the impact of the accumulation on the performance of the component in terms of hydraulics (eg sheet flow characteristics), water quality (eg vegetation cover) and amenity (eg visual).

Sediment removal from infiltration basins

Infiltration basins should always have source control, a pre-treatment or other sediment trapping system upstream. Even with low sediment loads, the system performance can still become significantly impaired in a relatively short space of time. The sediment deposits reduce the storage capacity and may also clog the surface soils. Dense vegetation can minimise the risk of surface clogging (Chapter 13, Section 13.12).

Methods of removing sediment from infiltration basins are different from detention basins. Removal should not start until the basin has dried out, at which point the top layer should then be removed using lightweight equipment, with care being taken not to unduly compact the basin surface. The remaining soil can then be scarified or tilled to restore the surface infiltration capacity (see Chapter 13 for detail of these methods). Vegetated areas disturbed during sediment removal should be replanted or re-sown immediately to reduce the risk of erosion. Suitable erosion control should also be provided.

Sediment removal from proprietary systems

Proprietary systems should be cleaned out regularly to prevent re-entry of any residuals or pollutants into the downstream system. The frequency will depend on the site-specific pollutant load, but most suppliers/manufacturers recommend that cleaning operations should take place every 6 months. They can be cleaned by vacuum pumping which transfers a slurry of water and sediment to a tanker, or by adding chemicals to help solidify the residuals, which can then be removed using appropriate methods.

Maintenance of pervious pavement systems involves removing sediment from the pavement surface using vacuum sweeping. It is recommended that the pavement be vacuum swept once a year, and the collected sediments will require appropriate handling and disposal.

Sediment removal from filter drains

Filter drains will require occasional removal of the gravel infill which can be either cleaned and reused, or new material used as a replacement. The geotextile surrounds to the trench and to pipes may also require replacement at this time.

Small lengths would probably be cleaned using a small excavator to remove the material and replace it with clean. There are specialist companies that can clean long lengths of linear filter drain (eg alongside roads) using specialist machinery. The machinery can easily deal with single size material of 40 mm and Type B filter material (Chapter 30). It may require adapting, or the settings changed to deal with other infill materials. The machinery lifts the filter material from the trench, segregates and cleans it and then returns it to the trench. Typically the machines will clean the gravel to depths of 300 mm or exceptionally 600 mm.

Disposal of silt and debris that is removed is achieved via a belt which can discharge to a truck running alongside, or it can be deposited well back on the verge if permitted. The amount of spoil is usually in the order of 5–10 tonnes for every 100 m of drain cleaned to 300 mm depth.

32.7.2 Vegetation and plant replacement

Some replacement of plants may be required in the first 12 months after installation (ie the defects liability/rectification period), possibly after storm events. Dead or damaged plants should be removed and replaced, to restore the prescribed number of living plants per m^2. The responsibility for doing this should be made clear in the construction contract.

Inspection programmes should identify areas of filtration, or infiltration surfaces where vegetation growth is poor and likely to cause a reduced level of system performance. Such areas can then be rehabilitated, and plant growth repaired.

32.8 REMEDIAL MAINTENANCE

32.8.1 Structure rehabilitation and repair

The need for component rehabilitation (eg to remove clogged filters, geotextiles and gravels) will typically be 10–25 years, depending on the component design and factors such as the type of catchment and sediment load. The SuDS design should allow for vehicle access to undertake this work and consider how to implement such overhauls without causing major disruption to the functionality of the drainage system. For example, if geotextiles are used at a high level within a pervious surface, then reconstruction of the surface and bedding layer is all that is required if they become clogged, rather than reconstruction of the whole pavement depth.

Some form of rehabilitation is likely to be required at some point where component functionality relies on filtration through soils or aggregates. However, for many SuDS components, routine maintenance is sufficient.

Rehabilitation activities for each SuDS component are described in the individual component chapters. The requirements should be identified in the operation and maintenance manual.

32.8.2 Infiltration surface rehabilitation

Inspections should look for signs of infiltration surfaces becoming clogged, such as if water is standing for long periods on the surface or if it is flowing via an overflow channel and bypassing the basin. In the event that grassed surface permeability is unacceptably reduced, there are a number of landscape techniques that can be used to open the surface to encourage infiltration. Such activities are likely to be required in

circumstances where silt has not been effectively managed upstream, or the infiltration surface has been compacted by foot traffic (eg if a basin is also used as a recreational area).

Scarifying to remove "thatch"

Thatch is a tightly intermingled organic layer of dead and living shoots, stems and roots, developing between the zone of green vegetation and the soil surface. Scarifying with tractor-drawn or self-propelled equipment to a depth of at least 50 mm breaks up silt deposits, removes dead grass and other organic matter and relieves compaction of the soil surface.

Spiking or tining the soil, using aerating equipment to encourage water percolation

This is particularly effective where a hollow tine machine is used, and sand is dressed in, and is best undertaken when the soil is moist (note: the removal and disposal of the dried cores will be necessary). Spiking or tining with tractor-drawn or self-propelled equipment penetrates and perforates soil layers to a depth of at least 100 mm (at 100 mm centres) and allows the entry of air, water, nutrients and top dressing materials.

Air pressure treatment

If the infiltration capacity has reduced due to compaction, it may be possible to rehabilitate it using air pressure treatment. This process breaks up subsoil layers by driving probes into the ground. The probe is connected to a high pressure gas source (typically nitrogen bottles) and a high pressure stream of gas is quickly introduced into the soil. This causes the soil to rupture both vertically and horizontally.

As a last resort, it may be necessary to remove and replace the grass and topsoil by:

- removing accumulated silt and (subject to a toxicity test) applying to land or dispose off site
- removing damaged turf, which should be composted or disposed off site
- cultivating remaining topsoil to required levels
- re-turfing (using turf of a quality and appearance to match existing) or reseeding (to Clause 12.6 of BS 7370-3:1991) using seed to match existing turf) area to required levels. It may be necessary to supply and fix erosion protection to protect seeded soil. The placing or grading of turf and seeded areas should be undertaken carefully to ensure that final design levels are achieved. Watering will be required to promote successful germination and/or establishment.

32.9 FREQUENCY OF MAINTENANCE TASKS

Landscape maintenance contract periods are usually of 1–3 years in duration. The 3-year cycle is increasingly common to ensure continuity and commitment to long-term landscape care. The frequency of regular landscape maintenance tasks in a contract period can range from daily to once in the contract period. In practice, most site tasks are based on monthly or fortnightly site visits, except where grass or weed growth requires a higher frequency of work. In many cases, a performance specification is used with terms such as "beds shall be maintained weed-free" or "grass shall be cut to a height of 50 mm with a minimum height of 35 mm and a maximum height of 100 mm" to obtain the required standards.

Frequency can be specified within the schedule to include occasional items, such as "'meadow grass' – cut twice annually in July and September to a height of 75–100 mm (or to supplier's recommendations), all arisings raked off and removed to wildlife features, compost facility or other recycling facility", which provides flexibility for work that is not critical to the management of the site.

Maintenance tasks that suit a performance approach commonly include plant growth, grass cutting, pruning and tree maintenance. However, work tasks, such as sweeping paths, regular litter collection and cleaning road surfaces, will require work at an agreed frequency, with more specific timings such as weekly, monthly or annually. Where the frequency and timing of tasks is critical, a mixture of performance and frequency specification is necessary to provide effective maintenance.

SuDS maintenance generally tends towards a frequency requirement to ensure a predictable standard of care, which can be recorded on site and provides a reasonable basis for pricing work. A convenient frequency for many tasks is at a monthly inspection, as this is the usual minimum site attendance required in a landscape specification. The monthly frequency should provide for an inspection of all SuDS components and for the checking of all inlets and outlets. The inspection should be carried out by someone familiar with the operation of the specific SuDS components, and it should be recorded.

However, certain SuDS maintenance tasks fall outside this monthly cycle and need to be accommodated in the contract. The most obvious are:

- wetland vegetation maintenance
- silt management
- filter replacement in proprietary systems
- sweeping of pervious surfaces (unless loose, gravel surfaces).

There are other tasks associated with ensuring the long-term performance of the systems that may be more difficult to predict, and may even fall outside any contract period. It may, therefore, be more appropriate to review requirements, for example, for system rehabilitation at interim periods, when contracts are falling due for renewal.

The vast majority of well-designed SuDS, whether "hard" or "soft", do not seem to suffer from problems with excessive and rapid silt accumulation, if they apply the key concepts of the SuDS philosophy: source control with a correctly designed Management Train. The frequency of sediment removal will increase as the area of the catchment increases in relation to the surface area of the SuDS where sediment accumulates (whether this is within a proprietary system or a landscape feature).

32.10 APPLYING THE PRINCIPLES OF LANDSCAPE MANAGEMENT

Typical landscape management documentation and its potential application to SuDS is summarised in the following subsections.

32.10.1 Management plan

This document should include a clear statement of design intent and an explanation of each of the SuDS components and the benefits being delivered by the SuDS for the site. The document should describe the management objectives for the site over time, and the management strategies that should be employed to realise these objectives and reconcile any potential conflicts that may arise.

Where the drainage system has an impact on the wildlife value or public use of a site, the document should explain any habitat enhancement goals, health and safety issues and long-term management implications.

For SuDS, the management plan should include a Maintenance Plan, which will be required so that maintenance aspirations can be costed, in order to secure their long-term financing. The Maintenance Plan can also establish changes in maintenance regimes that may be required to match changes in objectives such as the need to adapt operation and maintenance practices to accommodate specific wildlife habitats that may develop.

Sites with special wildlife or amenity interest may require detailed management plans that monitor habitat development, infrastructure changes or damage to sites, and ensure rapid responses to such changes, should they occur. In these cases the management plan should be prepared in collaboration with an ecologist. Ecological supervision may be required for certain works.

It is common for smaller commercial, industrial and housing sites to have a simple maintenance statement. In this case, a single page explaining the site management (including the SuDS) would be useful for all parties involved in the care of the development.

An important part of a management plan is an annual and 3–5 yearly review of the Maintenance Plan (when maintenance contracts are typically renewed). This should apply to all types of SuDS, but is particularly important for the soft landscape element, as plants and trees require different periodic management techniques as they develop. The review should involve those responsible for the maintenance and those undertaking the work.

The management plan should be a living document that is reviewed periodically with reference to changes on site, as well as changes to adjacent sites that might impact the site.

Further guidance and an example of a Maintenance Plan (in the form of a checklist) is provided in Appendix B.

32.10.2 Conditions of Contract

Appropriate conditions of contract will be required. Advice can be sought from the Landscape Institute which publishes specific landscape maintenance contracts. Guidance is also provided in Shaffer *et al* (2004).

32.10.3 Specification

The specification details the materials to be used and the standard of work required.

A specification, usually preceded by preliminaries, details how work shall be carried out, and contains clauses that give general instructions to the contractor. It will normally be accompanied by a schedule of work (Section 32.10.4). Specific SuDS maintenance clauses may be included in a general specification or as a separate "SuDS maintenance specification" section either within or referenced by the management plan (Section 32.10.1).

32.10.4 Schedule of work

The schedule of work itemises the tasks to be undertaken and the frequency at which they will be performed.

The tasks required to maintain the site and the frequency necessary to achieve an acceptable standard should be set out in the schedule of work.

This document (and Section 32.10.3) will often form the basis of a pricing framework, and can also act as a checklist to ensure that the work has been carried out satisfactorily.

For further information on the development of appropriate schedules, see HR Wallingford (2004).

32.10.5 Maintenance record

It is vital that a record is kept of the inspections and maintenance work that has been carried out. This allows the response of the system to different maintenance regimes to be assessed in future, and also provides protection against legal claims should the capacity of the system be exceeded during a rainfall event and flooding occurs elsewhere as a result.

32.11 REFERENCES

HR WALLINGFORD (2004) *The operation and maintenance of sustainable drainage systems (and associated costs)*, SR 626, HR Wallingford, UK. Go to: **http://tinyurl.com/lcot2g6**

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SHAFFER, P, ELLIOTT, C, REED, J, HOLMES, J and WARD, M (2004) *Model agreements for sustainable water management systems. Model agreements for SuDS*, C625, CIRIA, London, UK (ISBN: 978-0-86017-625-1). Go to: **www.ciria.org**

STATUTES

British Standards

BS 7370-3:1991 *Grounds maintenance. Recommendations for maintenance of amenity and functional turf (other than sports turf)*

Regulations

Construction (design and Management) Regulations (CDM) 2015

Image courtesy Illman Young

33 WASTE MANAGEMENT

Contents

Chapter 33

Waste management

This chapter discusses the principles of good practice for the management of waste resulting from maintenance of SuDS.

33.1 INTRODUCTION

SuDS remove pollutants from runoff, thereby minimising the impacts on receiving water quality. A key part of this process is sediment management. Sediment accumulates in SuDS for two main reasons:

- surface water runoff brings debris and silt loadings from hard surfaces
- green areas and vegetated systems generate organic waste, due to plant growth and die-off.

If sediment is not removed from the drainage system at appropriate frequencies, there is a risk that the following problems could develop:

1 SuDS components can become sources of pollutants as the inorganic and organic sediments that accumulate on their base become resuspended during storm events.
2 Storage capacity may be reduced.
3 The risk of inlets and outlets blocking may increase.
4 Amenity and aesthetic value could decrease because of odours and vectors (organisms that carry disease-causing microorganisms from one host to another).

To prevent these problems, SuDS (and their pre-treatment structures, if present) should be periodically inspected, the level of sediment (and other waste) accumulation should be monitored and the systems cleaned when appropriate. Sediment and vegetation that is grown in components where contaminant loadings are high may contain a variety of pollutants, and proper handling and disposal of these materials is essential.

Materials such as sediment, vegetation, contaminated geotextiles and other structural material arising from the maintenance of SuDS may be classified as "controlled wastes" and where this is the case, their removal and disposal must always be in accordance with the latest regulations and legislation. This chapter refers to legislation that is current at the time of writing (2015), but may be amended over time. It is, therefore, the responsibility of the SuDS operator to keep abreast of the latest information and requirements. The environmental regulator should be contacted to confirm the required protocols for the proper handling of any sediment or other waste at a particular site.

33.2 WASTE MANAGEMENT REQUIREMENTS

33.2.1 General

There are usually three types of waste arising from regular SuDS maintenance: litter, green waste (vegetation) and sediment. Litter should be disposed of as for any open space. Green waste management is described in Section 33.2.2 and sediment management is described in Section 33.2.3.

Directive 2008/98/EC (the Waste Framework Directive) requires all member states to take the necessary measures to ensure that waste is recovered or disposed of

without endangering human health or causing harm to the environment. This includes requirements for permitting, registration and inspection of waste disposal facilities and operations.

UK waste legislation is derived predominantly from European Union (EU) laws and transposed into UK law via various statutory instruments specific to England and Wales, Scotland or Northern Ireland. The current regulatory constraints and obligations for waste management and disposal should be established through consultation with the environmental regulator.

The guidance on complying with the latest regulations is summarised on the following websites:

- England and Wales: **https://www.gov.uk/waste-legislation-and-regulations**
- Scotland: **www.sepa.org.uk/waste.aspx**
- Northern Ireland: **www.doeni.gov.uk/waste**

Where waste is removed from site, it will be subject to the relevant waste management legislation for the country. In brief, this generally means that those responsible for generating waste must:

1 adequately characterise and describe the waste to allow for its safe disposal
2 only allow the waste to be removed and transported by those who are licensed to do so
3 ensure that it is disposed at a suitably licensed waste disposal or treatment facility.

The producer of the waste will be required to undertake analysis of the waste, including the CEN leaching test, so as to properly characterise the waste as hazardous, non-hazardous or inert, to assign a classification in accordance with the European List of Wastes (EC, 2000) and to provide a full description for the receiving landfill. There is a further requirement to pre-treat hazardous waste for volume reduction, to make it non-reactive and to improve its physical stability. A landfill can only accept waste provided that the appropriate waste acceptance criteria are met. More information is available from the WRAP website: **www.wrap.org.uk**

If wastes arising from the maintenance of SuDS are to be disposed of through beneficial reuse, the proposed activity will need to meet the requirements of an appropriate exemption and, having done so, be registered. The exemption registration process requires a burden of proof in demonstrating that the conditions of the particular exemption are met and that the activity is unlikely to cause pollution of the environment or harm to human health.

Waste disposal options that may be possible include the following:

- Non-contaminated sediments or sediments with low levels of contamination arising from SuDS could possibly be placed on the land surrounding the SuDS (without planning permission), provided that (1) the disposal area is within the operational land of the SuDS owner (2) the land is not used for agriculture and (3) it can be demonstrated that the deposit results in an ecological improvement to the land. See EA position statement requirements (**Section 33.3**).
- Green waste may be composted on site under an appropriate exemption. Alternatively, green wastes may be collected by a commercial operator for processing into compost at their own site.
- If SuDS could be excavated in the dry, then recovered sediments could be beneficially reused as "building material", for example to raise banks or for other landscaping. However, if wet excavation occurs, the material can only be used in land drainage works.
- Direct dredging of the sediments to the surrounding banks may be possible if there is demonstrable benefit to agriculture or ecology.

The waste disposal route and proposals should always be confirmed with the environmental regulator before sediment or green waste is removed from the site or applied onto land within it.

In some landscape features with specific habitats, sediment removal operations may require adequate method statements that are prepared in liaison with an ecologist. The method statement should take

account of the time of year, sequence of operations on site and disposal of waste. In some places, waste material may need to be retained on site for a period of time to manage movement and relocation of invertebrates. Adequate time and resources may also have to be allocated, to transplant vegetation in sensitive zones.

33.2.2 Green waste management

The relevant waste management regulations must be followed when removing and disposing of green waste. Where green waste is cut from areas subject to low levels of contaminants, it may be possible to compost and reuse it.

Larger corporate sites or public open spaces and communal residential land with dedicated management facilities may incorporate composting facilities of a suitable scale using contained structures/bins (with ventilation) or open bays. For efficient compost management, at least two or three bins/bays are required, and the compost needs to be mixed/turned by suitable machinery (eg JCB bucket) at a regular frequency (see below).

A compost facility allows all green waste, particularly grass cuttings and prunings, to be recycled and to provide compost for mulching ornamental plant beds. The following process should be followed for composting:

- shred all arisings from site
- combine all arisings in active compost bin with grass cuttings not exceeding 70%
- turn and mix active compost when bin is > 50% full, at weekly intervals for at least 4 weeks
- turn and mix full bin every 28 days until used
- combine adjacent compost bins/bays when contents are settled to 50% volume reduction
- use compost after 3–4 months.

Where there is no facility for composting on site, green waste can be removed to an off-site dedicated composting facility where the material is used to make compost to PAS 100:2011 or to the Compost Quality Protocol by EA (2012). Any third-party sites need to be appropriately permitted.

Some prunings (supplemented with occasional grass and other non-woody cuttings during the summer) can be used to create or enhance hibernaculae or other facilities on the development site, where this is part of the landscape or biodiversity strategy. Such facilities can provide refuges, hibernation shelter, food and egg laying sites for a large number of animals (commonly known as wildlife piles) (RSPB, 2015).

33.2.3 Sediment management

Silt/sediment collected from a SuDS component will often contain low levels of metals, hydrocarbons and other pollutants.

Any sediment removed from SuDS must meet the requirements of relevant waste management legislation.

The Environment Agency has adopted a risk-based approach in relation to removal of sediment from SuDS in England and Wales (EA, 2011), but at the time of writing there is no comparable SuDS-specific approach in Scotland or Northern Ireland.

The approach within the position statement can be summarised as follows:

1 Evaluate whether the silt/sediment collected in the system is likely to have a high risk of being defined as "hazardous waste". This will mainly be based on the land use within the catchment (eg industrial or heavy vehicle management areas or end-of-pipe ponds without source control; basins etc without source control).

2 If this is the case, then proceed to "hazardous waste" disposal. This will require chemical analysis of the silt and compliance with all relevant legislation and guidance.

3 Where there is low risk of pollution (eg housing, schools, commercial sites with source control) then a "sustainable" approach to waste management should be agreed with the environmental regulator. This may require confirmation of the levels of contaminants but, provided that they are below acceptable limits, should allow removal and land application to suitable vegetated surfaces outside the SuDS design profile but still close by (eg within 20 m of the SuDS component). For any adverse silt accumulation in wetlands and ponds (this should be very low if effective source control/pre-treatment is in place), the material should be removed, allowed to de-water by the side of the SuDS component for 24–48 hours and then land applied in a similar manner. These activities will need consideration of the potential impacts to amenity (particularly aesthetic) and biodiversity performance, and specific constraints (eg relating to protected species and specific habitats, Chapter 32).

If land application is not appropriate for low-risk sites, the sediment will have to be disposed off site. If material is removed off site, the site owner and those carrying out the work must comply with the required legislation (Section 33.2.1).

The waste disposal route and proposals should be confirmed with the environmental regulator before silt is removed from site.

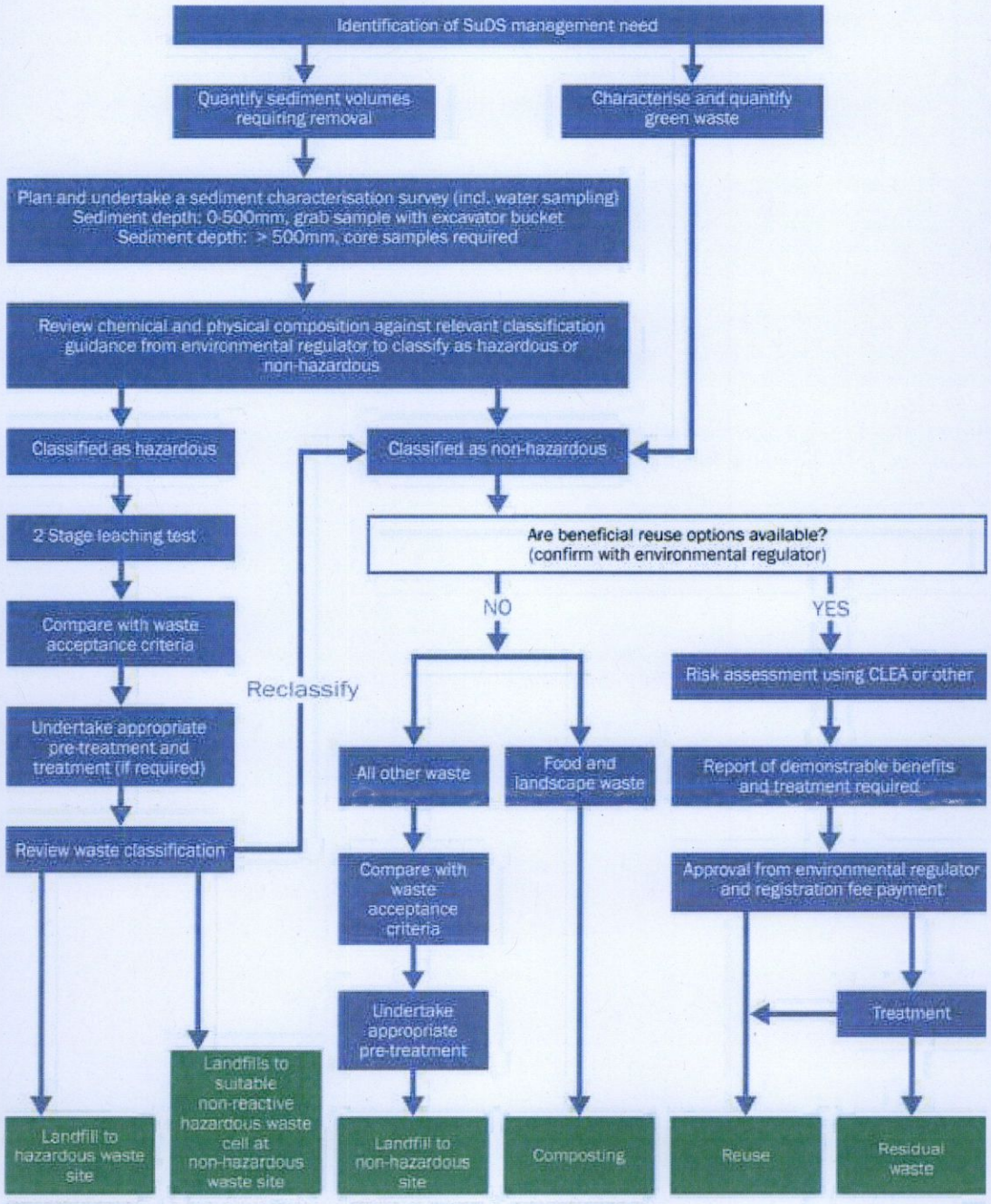
33.3 SEDIMENT CHARACTERISATION AND DISPOSAL

Sediments in surface water runoff have properties that are site specific, and it is extremely difficult to give "typical" sediment characteristics. The surface layer (approximately the top 5 cm) is likely to be high in organic matter, have a high water content, and a low density.

Testing for the presence, concentration and toxicity of metals in both the UK and the USA has indicated that extracted sediments tend to be non-hazardous to human health as defined by current standards (environmental quality standards). Nutrient concentrations in pond sediments are generally significantly lower than nutrient concentrations found in combined sewer overflows. Currently, there are few datasets available on the presence of total petrohydrocarbon (TPH) and polyaromatic hydrocarbon (PAH) concentrations in sediments. Urban surface water sediments may also contain bacteria and viruses, including faecal streptococcus and faecal coliform from animal and human wastes – particularly where there are foul sewer misconnections in the catchment.

Surface water runoff may also contain traces of fertilisers, herbicides and household substances such as paints and cleaning materials, which may contain substances that are potentially hazardous.

Sediment disposal options will depend largely on the concentrations of the pollutants in the sediment. The decision-making process is summarised in Figure 33.1. This flowchart applies to sites where the EA position statement (the deposit and de-watering of non-hazardous sites from SuDS on land) does not apply. The EA (2011) position statement allows the land application of sediment from SuDS in low-risk sites (to an area outside the design profile of the SuDS).



Note: The flow chart applies to sites where the EA position statement does not apply

Figure 33.1 Sediment categorisation and associated disposal options (from Kellagher *et al*, 2006)

33.4 REFERENCES

EA (2011) *Regulatory Position Statement. The deposit and de-watering of non-hazardous silts from sustainable drainage systems (SUDS) on land*, MWRP RPS 055, Version 2.0, Environment Agency, Bristol, UK. Go to: **http://tinyurl.com/p4478yo**

EA (2012) *Quality Protocol. Compost. End of waste criteria for the production and use of quality compost from source-segregated biodegradable waste*, Environment Agency, London, UK . Go to: **http://tinyurl.com/p958bql**

EC (2000) *List of Waste*, web page, European Commission, Brussels. Go to: **http://tinyurl.com/oaprqj6**

KELLAGHER, R, WOODS BALLARD, B and BARNFORD, S (2006) *SUDS – Increased liability for the water industry – Phase 2*, UK Water Industry Research (UKWIR), London, UK (ISBN: 1-84057-417-8). Go to: **http://tinyurl.com/pxrtu9h**

RSPB (2015) *Building a hibernacoulum*, web page, Royal Society for the Protection of Birds, Bedfordshire, UK. Go to: **http://tinyurl.com/qfljcx9**

STATUTES

Directives

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance) (Waste Framework Directive)

Standards

BSI PAS 100:2011 *Compost specification*

AECOM

Appendix D – Attenuation Tank Details

PROJECT INFORMATION	
ENGINEERED PRODUCT MANAGER	
ADS SALES REP	
PROJECT NO.	

Advanced Drainage Systems, Inc.

SiteAssist™
FOR STORMTECH
INSTALLATION INSTRUCTIONS
VISIT OUR APP

STONEY HILL TANK

RATHCOOLE, EUROPE, EUROPE

MC-3500 STORMTECH CHAMBER SPECIFICATIONS

1. CHAMBERS SHALL BE STORMTECH MC-3500.
2. CHAMBERS SHALL BE ARCH-SHAPED AND SHALL BE MANUFACTURED FROM VIRGIN, IMPACT-MODIFIED POLYPROPYLENE COPOLYMERS.
3. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS" CHAMBER CLASSIFICATION 45x76 DESIGNATION SS.
4. CHAMBER ROWS SHALL PROVIDE CONTINUOUS, UNOBSTRUCTED INTERNAL SPACE WITH NO INTERNAL SUPPORTS THAT WOULD IMPEDE FLOW OR LIMIT ACCESS FOR INSPECTION.
5. THE STRUCTURAL DESIGN OF THE CHAMBERS, THE STRUCTURAL BACKFILL, AND THE INSTALLATION REQUIREMENTS SHALL ENSURE THAT THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, SECTION 12.12, ARE MET FOR: 1) LONG-DURATION DEAD LOADS, AND 2) SHORT-DURATION LIVE LOADS, BASED ON THE AASHTO DESIGN TRUCK WITH CONSIDERATION FOR IMPACT AND MULTIPLE VEHICLE PRESENCES.
6. CHAMBERS SHALL BE DESIGNED, TESTED, AND ALLOWABLE LOAD CONFIGURATIONS DETERMINED IN ACCORDANCE WITH ASTM F2787, "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS". LOAD CONFIGURATIONS SHALL INCLUDE: 1) INSTANTANEOUS (<1 MIN) AASHTO DESIGN TRUCK LIVE LOAD ON MINIMUM COVER, 2) MAXIMUM PERMANENT (75-YR) COVER LOAD, AND 3) ALLOWABLE COVER WITH PARKED (1-WEEK) AASHTO DESIGN TRUCK.
7. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 3".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 450 LBS/FT/%. THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418. AND, b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLOURS.
8. ONLY CHAMBERS THAT ARE APPROVED BY THE SITE DESIGN ENGINEER WILL BE ALLOWED. UPON REQUEST BY THE SITE DESIGN ENGINEER OR OWNER, THE CHAMBER MANUFACTURER SHALL SUBMIT A STRUCTURAL EVALUATION FOR APPROVAL BEFORE DELIVERING CHAMBERS TO THE PROJECT SITE AS FOLLOWS:
   - THE STRUCTURAL EVALUATION SHALL BE SEALED BY A REGISTERED PROFESSIONAL ENGINEER.
   - THE STRUCTURAL EVALUATION SHALL DEMONSTRATE THAT THE SAFETY FACTORS ARE GREATER THAN OR EQUAL TO 1.95 FOR DEAD LOAD AND 1.75 FOR LIVE LOAD, THE MINIMUM REQUIRED BY ASTM F2787 AND BY SECTIONS 3 AND 12.12 OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR THERMOPLASTIC PIPE.
   - THE TEST DERIVED CREEP MODULUS AS SPECIFIED IN ASTM F2418 SHALL BE USED FOR PERMANENT DEAD LOAD DESIGN EXCEPT THAT IT SHALL BE THE 75-YEAR MODULUS USED FOR DESIGN.
9. CHAMBERS AND END CAPS SHALL BE PRODUCED AT AN ISO 9001 CERTIFIED MANUFACTURING FACILITY.

IMPORTANT - NOTES FOR THE BIDDING AND INSTALLATION OF MC-3500 CHAMBER SYSTEM

1. STORMTECH MC-3500 CHAMBERS SHALL NOT BE INSTALLED UNTIL THE MANUFACTURER'S REPRESENTATIVE HAS COMPLETED A PRE-CONSTRUCTION MEETING WITH THE INSTALLERS.
2. STORMTECH MC-3500 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH MC-3500/MC-4500 CONSTRUCTION GUIDE".
3. CHAMBERS ARE NOT TO BE BACKFILLED WITH A DOZER OR AN EXCAVATOR SITUATED OVER THE CHAMBERS. STORMTECH RECOMMENDS 3 BACKFILL METHODS:
   - STONESHOOTER LOCATED OFF THE CHAMBER BED.
   - BACKFILL AS ROWS ARE BUILT USING AN EXCAVATOR ON THE FOUNDATION STONE OR SUB-GRADE.
   - BACKFILL FROM OUTSIDE THE EXCAVATION USING A LONG BOOM HOE OR EXCAVATOR.
4. THE FOUNDATION STONE SHALL BE LEVELED AND COMPACTED PRIOR TO PLACING CHAMBERS.
5. JOINTS BETWEEN CHAMBERS SHALL BE PROPERLY SEATED PRIOR TO PLACING STONE.
6. MAINTAIN MINIMUM - 6" (150 mm) SPACING BETWEEN THE CHAMBER ROWS.
7. INLET AND OUTLET MANIFOLDS MUST BE INSERTED A MINIMUM OF 12" (300 mm) INTO CHAMBER END CAPS.
8. EMBEDMENT STONE SURROUNDING CHAMBERS MUST BE A CLEAN, CRUSHED, ANGULAR STONE WELL GRADED BETWEEN ¾" AND 2" (20-50 mm).
9. STONE MUST BE PLACED ON THE TOP CENTER OF THE CHAMBER TO ANCHOR THE CHAMBERS IN PLACE AND PRESERVE ROW SPACING.
10. THE CONTRACTOR MUST REPORT ANY DISCREPANCIES WITH CHAMBER FOUNDATION MATERIALS BEARING CAPACITIES TO THE SITE DESIGN ENGINEER.
11. ADS RECOMMENDS THE USE OF "FLEXSTORM CATCH IT" INSERTS DURING CONSTRUCTION FOR ALL INLETS TO PROTECT THE SUB-SURFACE STORMWATER MANAGEMENT SYSTEM FROM CONSTRUCTION SITE RUNOFF.

NOTES FOR CONSTRUCTION EQUIPMENT

1. STORMTECH MC-3500 CHAMBERS SHALL BE INSTALLED IN ACCORDANCE WITH THE "STORMTECH MC-3500/MC-4500 CONSTRUCTION GUIDE".
2. THE USE OF EQUIPMENT OVER MC-3500 CHAMBERS IS LIMITED:
   - NO EQUIPMENT IS ALLOWED ON BARE CHAMBERS.
   - NO RUBBER TIRED LOADER, DUMP TRUCK, OR EXCAVATORS ARE ALLOWED UNTIL PROPER FILL DEPTHS ARE REACHED IN ACCORDANCE WITH THE "STORMTECH MC-3500/MC-4500 CONSTRUCTION GUIDE".
   - WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT CAN BE FOUND IN THE "STORMTECH MC-3500/MC-4500 CONSTRUCTION GUIDE".
3. FULL 36" (900 mm) OF STABILISED COVER MATERIALS OVER THE CHAMBERS IS REQUIRED FOR DUMP TRUCK TRAVEL OR DUMPING.

USE OF A DOZER TO PUSH EMBEDMENT STONE BETWEEN THE ROWS OF CHAMBERS MAY CAUSE DAMAGE TO CHAMBERS AND IS NOT AN ACCEPTABLE BACKFILL METHOD. ANY CHAMBERS DAMAGED BY USING THE "DUMP AND PUSH" METHOD ARE NOT COVERED UNDER THE STORMTECH STANDARD WARRANTY.

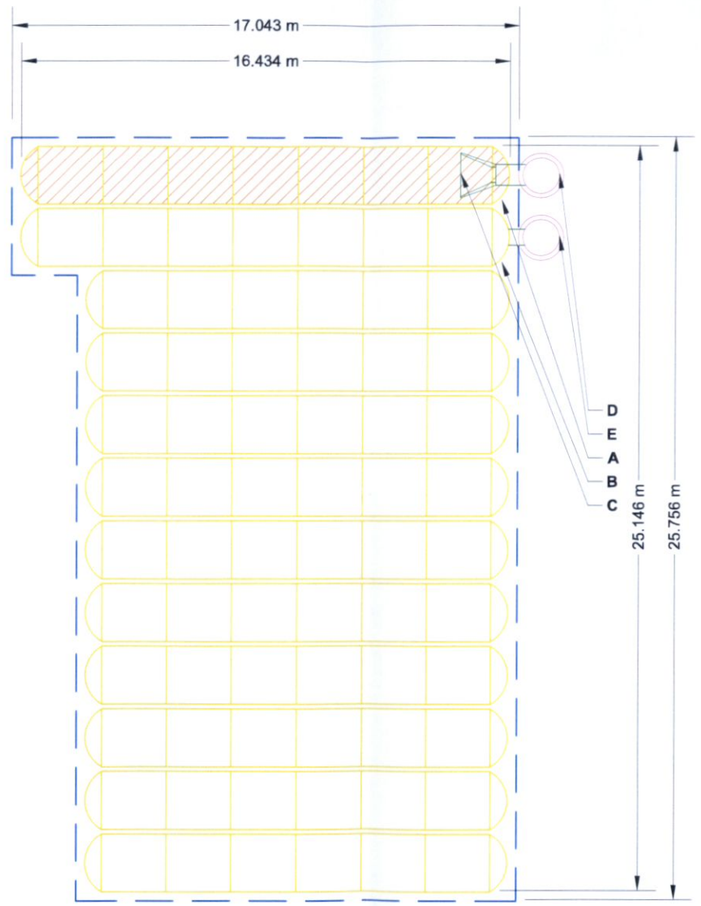
CONTACT STORMTECH AT 1-888-892-2694 WITH ANY QUESTIONS ON INSTALLATION REQUIREMENTS OR WEIGHT LIMITS FOR CONSTRUCTION EQUIPMENT.

ISOLATOR ROW PLUS COMPONENTS SHOWN ON THIS DESIGN MAY NOT BE AVAILABLE IN THE SPECIFIED PROJECT REGION. PLEASE CONTACT YOUR LOCAL ADS REPRESENTATIVE OR E-MAIL ADSINTERNATIONAL@ADS-PIPE.COM FOR FURTHER INFORMATION

PROPOSED LAYOUT		PROPOSED ELEVATIONS	
74	STORMTECH MC-3500 CHAMBERS	MAXIMUM ALLOWABLE GRADE (TOP OF PAVEMENT/UNPAVED):	131.250
24	STORMTECH MC-3500 END CAPS	MINIMUM ALLOWABLE GRADE (UNPAVED WITH TRAFFIC):	129.422
460	STONE ABOVE (mm)	TOP OF STONE:	129.272
400	STONE BELOW (mm)	MINIMUM ALLOWABLE GRADE (UNPAVED NO TRAFFIC):	129.269
40	STONE VOID	MINIMUM ALLOWABLE GRADE (TOP OF RIGID CONCRETE PAVEMENT):	129.269
459.7	INSTALLED SYSTEM VOLUME (m^3) (PERIMETER STONE INCLUDED) (COVER STONE INCLUDED) (BASE STONE INCLUDED)	MINIMUM ALLOWABLE GRADE (BASE OF FLEXIBLE PAVEMENT):	129.269
		TOP OF MC-3500 CHAMBER:	128.812
		600 mm ISOLATOR ROW PLUS INVERT:	127.721
		450 mm BOTTOM CONNECTION INVERT:	127.714
392.9	SYSTEM AREA (m^2)	BOTTOM OF MC-3500 CHAMBER:	127.669
85.6	SYSTEM PERIMETER (m)	BOTTOM OF STONE:	127.269

*INVERT ABOVE BASE OF CHAMBER

PART TYPE	ITEM ON LAYOUT	DESCRIPTION	INVERT*	MAX FLOW
PREFABRICATED END CAP	A	600 mm BOTTOM CORED END CAP, PART#: MC3500IEPP24BC / TYP OF ALL 600 mm BOTTOM CONNECTIONS AND ISOLATOR PLUS ROWS	52 mm	
PREFABRICATED END CAP	B	450 mm BOTTOM CORED END CAP, PART#: MC3500IEPP18BC / TYP OF ALL 450 mm BOTTOM CONNECTIONS	45 mm	
FLAMP	C	INSTALL FLAMP ON 600 mm ACCESS PIPE / PART#: MC350024RAMP		
CONCRETE STRUCTURE	D	(DESIGN BY ENGINEER / PROVIDED BY OTHERS)		
CONCRETE STRUCTURE	E	OCS (DESIGN BY ENGINEER / PROVIDED BY OTHERS)		113 L/s OUT



ISOLATOR ROW PLUS (SEE DETAIL)

NO WOVEN GEOTEXTILE

BED LIMITS

NOTES

- MANIFOLD SIZE TO BE DETERMINED BY SITE DESIGN ENGINEER. SEE TECH NOTE #6.32 FOR MANIFOLD SIZING GUIDANCE.
- DUE TO THE ADAPTATION OF THIS CHAMBER SYSTEM TO SPECIFIC SITE AND DESIGN CONSTRAINTS, IT MAY BE NECESSARY TO CUT AND COUPLE ADDITIONAL PIPE TO STANDARD MANIFOLD COMPONENTS IN THE FIELD.
- THE SITE DESIGN ENGINEER MUST REVIEW ELEVATIONS AND IF NECESSARY ADJUST GRADING TO ENSURE THE CHAMBER COVER REQUIREMENTS ARE MET.
- THIS CHAMBER SYSTEM WAS DESIGNED WITHOUT SITE-SPECIFIC INFORMATION ON SOIL CONDITIONS OR BEARING CAPACITY. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR DETERMINING THE SUITABILITY OF THE SOIL AND PROVIDING THE BEARING CAPACITY OF THE INSITU SOILS. THE BASE STONE DEPTH MAY BE INCREASED OR DECREASED ONCE THIS INFORMATION IS PROVIDED.
- **NOT FOR CONSTRUCTION:** THIS LAYOUT IS FOR DIMENSIONAL PURPOSES ONLY TO PROVE CONCEPT & THE REQUIRED STORAGE VOLUME CAN BE ACHIEVED ON SITE.

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RATHCOOLE, EUROPE, EUROPE
DATE: | PROJECT #: | DRAWN: JC | CHECKED: N/A

DESCRIPTION	DRW	CHK	DATE

THIS DRAWING HAS BEEN PREPARED BASED ON INFORMATION PROVIDED TO ADS UNDER THE DIRECTION OF THE SITE DESIGN ENGINEER OR OTHER PROJECT REPRESENTATIVE. THE SITE DESIGN ENGINEER SHALL REVIEW THIS DRAWING PRIOR TO CONSTRUCTION. IT IS THE ULTIMATE RESPONSIBILITY OF THE SITE DESIGN ENGINEER TO ENSURE THAT THE OVERALL SITE DESIGN MEETS ALL APPLICABLE REQUIREMENTS.

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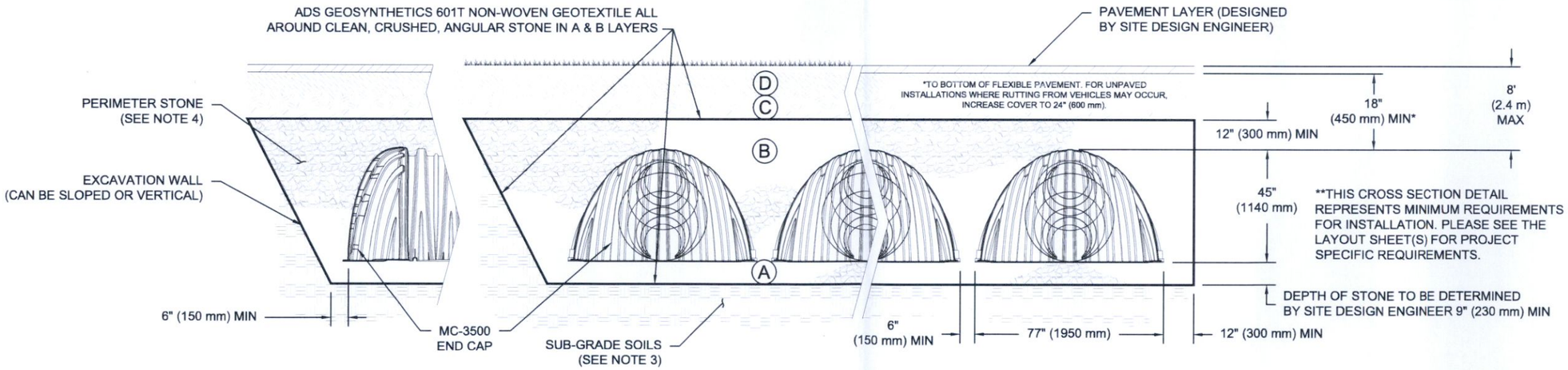
ACCEPTABLE FILL MATERIALS: STORMTECH MC-3500 CHAMBER SYSTEMS

	MATERIAL LOCATION	DESCRIPTION	AASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	**FINAL FILL:** FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUB-BASE MAY BE PART OF THE 'D' LAYER.	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUB-GRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	**INITIAL FILL:** FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 24" (600 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUB-BASE MAY BE A PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUB-BASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	AASHTO M145[1] A-1, A-2-4, A-3 OR AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 24" (600 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 12" (300 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS.
B	**EMBEDMENT STONE:** FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 4	NO COMPACTION REQUIRED.
A	**FOUNDATION STONE:** FILL BELOW CHAMBERS FROM THE SUB-GRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 4	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE.[2,3]

PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 9" (230 mm) (MAX) LIFTS USING TWO FULL COVERAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.
4. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUB-BASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.



NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS" CHAMBER CLASSIFICATION 45x76 DESIGNATION SS.
2. MC-3500 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
3. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUB-GRADE SOILS, AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS.
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 3".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT SHALL BE GREATER THAN OR EQUAL TO 450 LBS/FT/%. THE ASC IS DEFINED IN SECTION 6.2.8 OF ASTM F2418. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23°, AND C) CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLOURS.

STONEY HILL TANK
RATHCOOLE, EUROPE, EUROPE
DATE: DRAWN: JC CHECKED: N/A
PROJECT #:
DESCRIPTION
DATE DRW CHK

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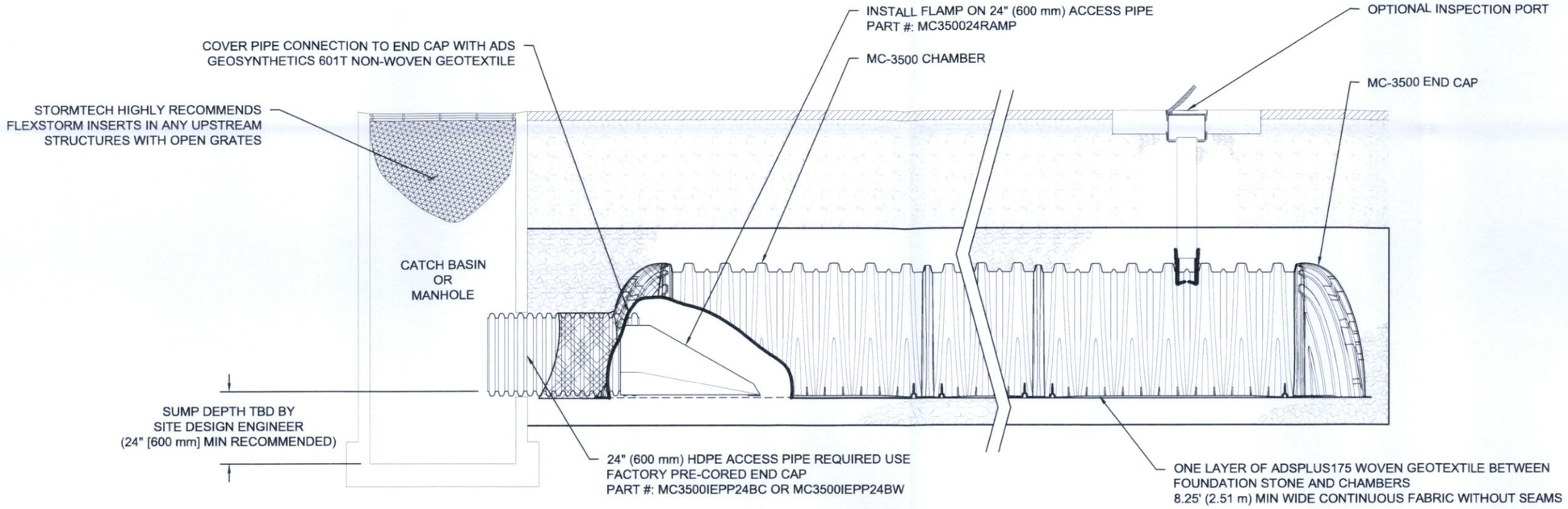


MC-3500 ISOLATOR ROW PLUS DETAIL
NTS

ISOLATOR ROW PLUS COMPONENTS SHOWN ON THIS DESIGN MAY NOT BE AVAILABLE IN THE SPECIFIED PROJECT REGION. PLEASE CONTACT YOUR LOCAL ADS REPRESENTATIVE OR E-MAIL ADSINTERNATIONAL@ADS-PIPE.COM FOR FURTHER INFORMATION

INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS FOR SEDIMENT
- A. INSPECTION PORTS (IF PRESENT)
  - A.1. REMOVE/OPEN LID ON NYLOPLAST INLINE DRAIN
  - A.2. REMOVE AND CLEAN FLEXSTORM FILTER IF INSTALLED
  - A.3. USING A FLASHLIGHT AND STADIA ROD, MEASURE DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
  - A.4. LOWER A CAMERA INTO ISOLATOR ROW PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- B. ALL ISOLATOR PLUS ROWS
  - B.1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2. USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS THROUGH OUTLET PIPE
    - i) MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
    - ii) FOLLOW OSHA REGULATIONS FOR CONFINED SPACE ENTRY IF ENTERING MANHOLE
  - B.3. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

STEP 2) CLEAN OUT ISOLATOR ROW PLUS USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45" (1.1 m) OR MORE IS PREFERRED
- B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
- C. VACUUM STRUCTURE SUMP AS REQUIRED

STEP 3) REPLACE ALL COVERS, GRATES, FILTERS, AND LIDS; RECORD OBSERVATIONS AND ACTIONS.

STEP 4) INSPECT AND CLEAN BASINS AND MANHOLES UPSTREAM OF THE STORMTECH SYSTEM.

NOTES

1. INSPECT EVERY 6 MONTHS DURING THE FIRST YEAR OF OPERATION. ADJUST THE INSPECTION INTERVAL BASED ON PREVIOUS OBSERVATIONS OF SEDIMENT ACCUMULATION AND HIGH-WATER ELEVATIONS.
2. CONDUCT JETTING AND VACTORING ANNUALLY OR WHEN INSPECTION SHOWS THAT MAINTENANCE IS NECESSARY.

STONEY HILL TANK
RATHCOOLE, EUROPE, EUROPE
DATE: DRAWN: JC CHECKED: N/A
PROJECT #:

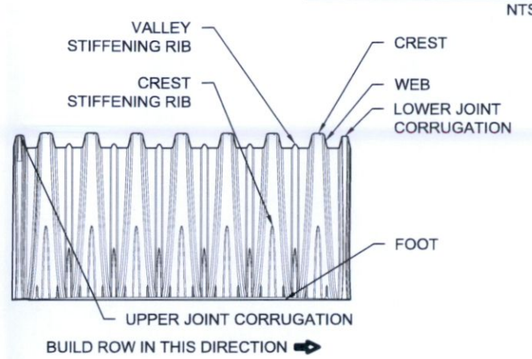
DATE	DRW	CHK	DESCRIPTION

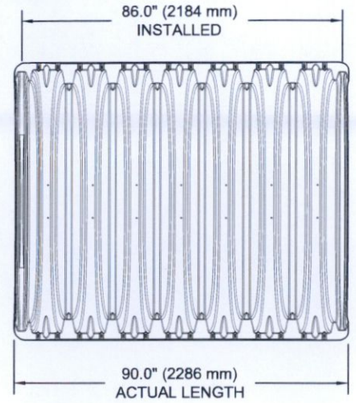
StormTech®
Chamber System
888-892-2694 | WWW.STORMTECH.COM

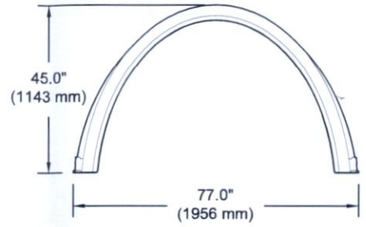
4640 TRUEMAN BLVD
HILLIARD, OH 43026
1-800-733-7473

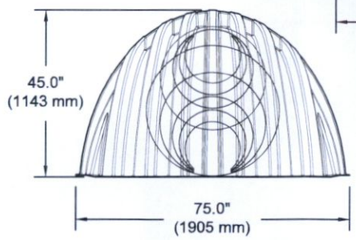
MC-3500 TECHNICAL SPECIFICATION

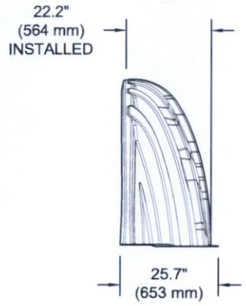
NTS











NOMINAL CHAMBER SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	77.0" X 45.0" X 86.0"	(1956 mm X 1143 mm X 2184 mm)
CHAMBER STORAGE	109.9 CUBIC FEET	(3.11 m³)
MINIMUM INSTALLED STORAGE*	175.0 CUBIC FEET	(4.96 m³)
WEIGHT	134 lbs.	(60.8 kg)

NOMINAL END CAP SPECIFICATIONS

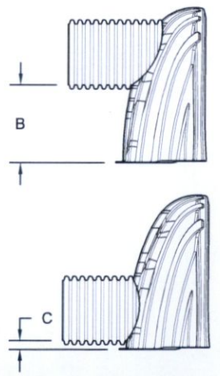
SIZE (W X H X INSTALLED LENGTH)	75.0" X 45.0" X 22.2"	(1905 mm X 1143 mm X 564 mm)
END CAP STORAGE	14.9 CUBIC FEET	(0.42 m³)
MINIMUM INSTALLED STORAGE*	45.1 CUBIC FEET	(1.28 m³)
WEIGHT	49 lbs.	(22.2 kg)

*ASSUMES 12" (305 mm) STONE ABOVE, 9" (229 mm) STONE FOUNDATION, 6" SPACING BETWEEN CHAMBERS, 6" (152 mm) STONE PERIMETER IN FRONT OF END CAPS AND 40% STONE POROSITY

STUBS AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
STUBS AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
END CAPS WITH A WELDED CROWN PLATE END WITH "C"
END CAPS WITH A PREFABRICATED WELDED STUB END WITH "W"

PART #	STUB	B	C
MC3500IEPP06T	6" (150 mm)	33.21" (844 mm)	---
MC3500IEPP06B		---	0.66" (17 mm)
MC3500IEPP08T	8" (200 mm)	31.16" (791 mm)	---
MC3500IEPP08B		---	0.81" (21 mm)
MC3500IEPP10T	10" (250 mm)	29.04" (738 mm)	---
MC3500IEPP10B		---	0.93" (24 mm)
MC3500IEPP12T	12" (300 mm)	26.36" (670 mm)	---
MC3500IEPP12B		---	1.35" (34 mm)
MC3500IEPP15T	15" (375 mm)	23.39" (594 mm)	---
MC3500IEPP15B		---	1.50" (38 mm)
MC3500IEPP18TC	18" (450 mm)	20.03" (509 mm)	---
MC3500IEPP18TW			
MC3500IEPP18BC		---	1.77" (45 mm)
MC3500IEPP18BW			
MC3500IEPP24TC	24" (600 mm)	14.48" (368 mm)	---
MC3500IEPP24TW			
MC3500IEPP24BC		---	2.06" (52 mm)
MC3500IEPP24BW			
MC3500IEPP30BC	30" (750 mm)	---	2.75" (70 mm)

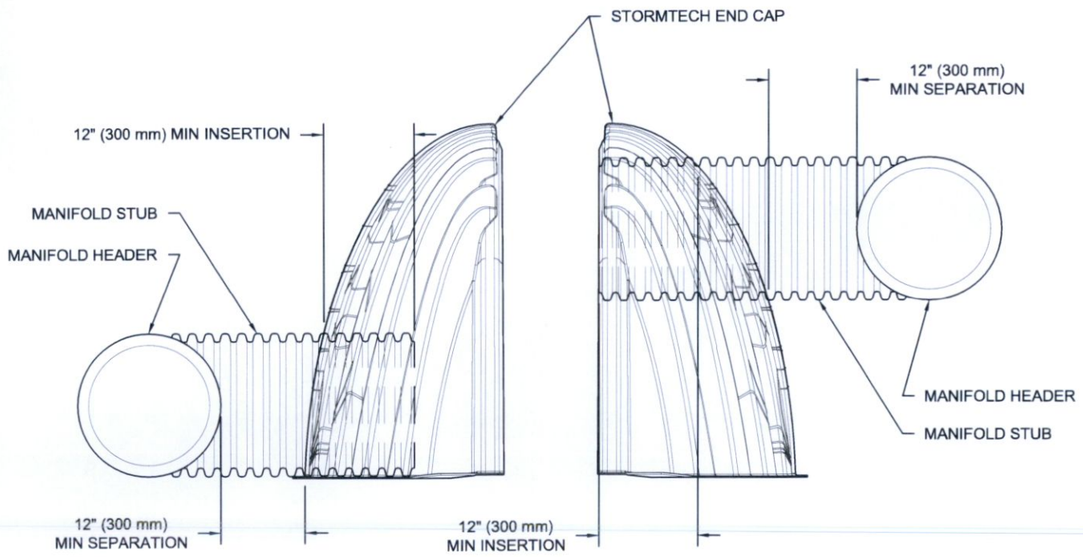
NOTE: ALL DIMENSIONS ARE NOMINAL



CUSTOM PRECORED INVERTS ARE AVAILABLE UPON REQUEST. INVENTORIED MANIFOLDS INCLUDE 12-24" (300-600 mm) SIZE ON SIZE AND 15-48" (375-1200 mm) ECCENTRIC MANIFOLDS. CUSTOM INVERT LOCATIONS ON THE MC-3500 END CAP CUT IN THE FIELD ARE NOT RECOMMENDED FOR PIPE SIZES GREATER THAN 10" (250 mm). THE INVERT LOCATION IN COLUMN 'B' ARE THE HIGHEST POSSIBLE FOR THE PIPE SIZE.

MC-SERIES END CAP INSERTION DETAIL

NTS



NOTE: MANIFOLD STUB MUST BE LAID HORIZONTAL FOR A PROPER FIT IN END CAP OPENING.

STONEY HILL TANK
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