KAVANAGH BURKE
CONSULTING ENGINEERS

# Drainage Design Report

*for*

## Warehouse Development

*at*

## Magna Avenue and Magna Drive,
## Citywest,
## Dublin 24.

| | |
|---|---|
| Job No: | D1720 |
| Client: | Rockface Developments Ltd. |
| Date: | 9th June 2022 |
| Local Authority: | South Dublin County Council |
| Revision: | Planning Additional Information PL2 |

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# Introduction.

Rockface Developments Limited intends to apply for permission for development at this 3.03 Ha site at Magna Avenue and Magna Drive, Citywest, Dublin 24. The lands are bounded to the south by Magna Avenue, to the north and west by Magna Drive, and to the east by development within Manga Business Park. The building will have a maximum height of 16.5 m with a gross floor area of 13,604 sq. m including a warehouse area (12,568 sq. m), staff facilities (498 sq. m) and ancillary office (538 sq. m).

The development will also include: a vehicular and pedestrian entrance to the site from Magna Avenue, a separate HGV entrance from Magna Drive; 67 No. ancillary car parking spaces; covered bicycle parking; HGV Parking and yards; level access goods doors; dock levellers; access gates; signage; hard and soft landscaping; lighting; boundary treatments; ESB substation; sprinkler tank and pump house; and all associated site development works above and below ground.

The site will be serviced primarily through connection to the existing services in the area.

The provision of the new on-site foul sewer, surface water & watermain are described as follows with calculations appended.

## Surface Water:

*SuDS Management Plan:*

Due to the industrial nature of the proposed development, the yard surfacing for HGV access and marshalling is concrete. An area of porous asphalt is provided to the car park area where traffic loads are light, and for the same purpose grasscrete surfacing is provided for parking spaced and for the fire tender access road. In addition, a green roof is proposed for the ancillary office.

Runoff from the hardstanding areas will be collected by trapped road gullies and rainwater goods throughout the development and directed to the on-site surface water attenuation facilities. These facilities are designed to attenuate 1 in 30-year storm event of any duration; therefore, no flooding will occur on site for any duration events up to 30-year return period as per "Greater Dublin Strategic Drainage Study" (GDSDS) requirements. In addition to providing attenuation volume, temporary flood storage is check and provided where needed (as an integrated part of the attenuation system) for 100-year return events as per GDSDS requirements.

The restricted discharge from site will be limited by proprietaries flow control devices. The maximum allowable discharge is limited to calculated flow (see calculations in the succeeding chapters) not exceeding Greenfield runoff rate, QBAR (as per criterion 4.3 "River Flood Protection" chapter 6.3.4 of GDSDS). All flows and runoffs for storm water network design and attenuation sizing are calculated incorporating 20% climate change factor for all rainfall intensities as per chapter 6.3.2.4 of GDSDS table 6.2 "Climate Change Factors". In addition, a computer analysis in the storm network modelling software was performed to confirm the sizing of the pipe network and attenuation storages for 1 in 100-year storms of all durations. This analysis includes a specific model of vortex flow control device with discharge of the calculated QBAR and 20% Climate Change Factor. The analysis indicated no on-site flooding (meaning that both the network and all proposed attenuation storage have sufficient capacities).

*Treatment Train:*

The treatment train approach was applied to both the storm water network and the attenuation design to ensure that both run-off quality and quantity are appropriately addressed. An array of techniques was used to fulfil requirements of each element of the treatment train:

- ✓ Pollution prevention:
  To prevent chemicals and other pollutants from contaminating the rainfall runoff, a maintenance regime for the proposed development will be established. A proprietary silt trap and petrol interceptor will be provided on the surface water drainage network to intercept debris, silts and hydrocarbons and prevent them from entering the attenuation systems and from being discharged to the soil or receiving watercourse.

- ✓ Source control:
  To detain and infiltrate the runoff as close as possible to the point of origin, we have included for the following:

  + Permeable paving / Grasscrete will provide infiltration of the surface water, promoting water disposal at source and limiting the discharge to the SW network.

  + Infiltration via tree pits will also give permeation at the car parking area, as per landscaping details.

  + Green roof will provide an initial storage capacity that will not be discharged into the surface water network, it will retain and bind pollutants.

- ✓ Site control:
  The inclusion of SUDs devices around the site will provide a means for run-off to infiltrate into the ground across some parts of the it. This approach will inevitability reduce the quantity of water that discharges from the site.

- ✓ Regional Control:
  To mimic the behaviour of the green field site and protect the receiving watercourse, the attenuation systems are designed to cater for all durations of rainfall up to 30-year return period with 20% climate change factor applied. These attenuation systems have also been designed to cater for 1 in 100-year storms of all durations exceeding the requirements of Greater Dublin Strategic Drainage Study (GDSDS).

*Attenuation Systems:*

There are three separate proposed attenuation facilities: two underground "StormTech" storage tanks or equivalents, and a detention basin. These three systems work parallel, this means that each collects run-off from a specific predetermined independent sub-catchment. This design is proposed to achieve maximum efficiency of hardstanding area use, reducing it as minimum as possible without compromising the operational needs of the warehouse project.

The "StormTech" system consists of thermoplastic arches backfilled in specified stone and wrapped in a pervious geotextile. Prior to entering the system, the surface water runoff will pass through a proprietary silt trap and petrol interceptor to ensure debris, silt particles and hydrocarbons are removed. Subsequently the surface runoff enters these attenuation facilities through an "isolator row" whereby a row of void forming thermoplastic arches are wrapped in a pervious geotextile which provides a second level of suspended solid removal prior to the water entering the greater attenuation area.

These water quality control measures can be cleaned out by suction hose/tanker if required from standard maintenance inspections. In the case of the isolator row, the chamber is backwashed with a proprietary power jet wash and its water removed by suction hose/tanker. Water quantity control is provided downstream of the attenuation facilities by flow control devices. The proposed vortex style flow control devices of discharge rate will be installed on the outfall from the last surface water manhole.

The proposed detention basin will cater run-off from half of the warehouse roof. This attenuation system increases the non-hardstanding area of the proposed development and provides a 64 $m^3$ interception volume at its most profound part; to allow this, bed level is set 20 mm lower than the outlet and inlet invert levels. Before entering the detention basin, the surface water run-off will pass through a proprietary silt trap to ensure debris and silt particles are removed; because no HGV concrete yard run-off will be catered, there is no need to intercept hydrocarbons and thus petrol interceptor is not provided here. A Maintenance Plan will be implemented to ensure the proper functioning and will include:

- Cleaning of litter and debris.
- Inlet and outlet structural integrity check.
- Removal of sediment accumulation.
- Re-establish of permanent vegetation on eroded areas.

The discharge from sites, i.e. the restricted flow from the flow control devices will ultimately discharge to an existing surface water manhole located to the northern site's boundary at the public footpaths adjacent to Magna Drive, as shown at the accompanying drawing reference *D1720 D3 Drainage and Watermain Layout PL2*.

The details of the surface water attenuation systems including interceptors, flow restrictions, volume and pipe designs are attached in this Drainage Design Report and on the accompanying Drainage details layout (drawing reference *D1720 D3 Drainage and Watermain Layout PL2*) for review by the Local Authority.

*Proposed SuDS elements to improve the quality and reduce run-off:*

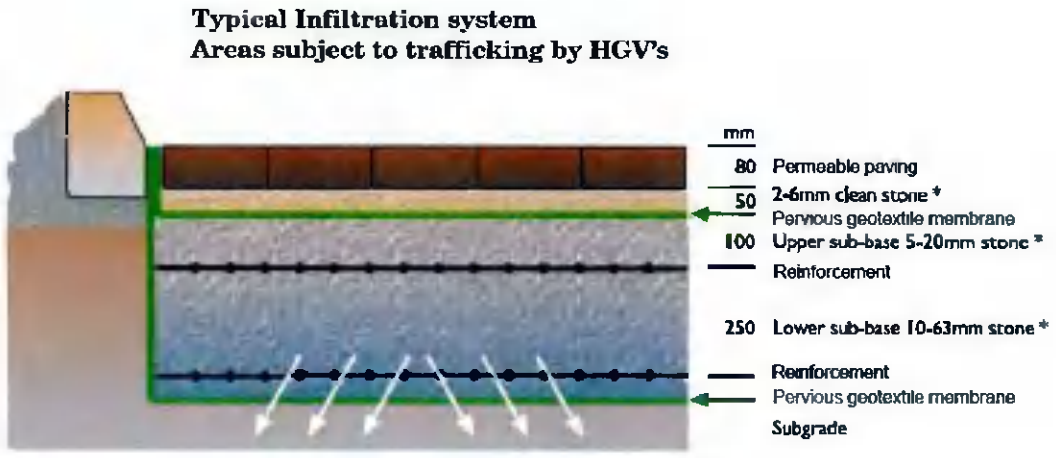
In considering the above surface water management solution, we considered all SuDS devices and given the industrial nature of the proposed operations on this site, the above solution of underground surface water attenuation plus a detention basin was decided on. In summary, a range of measures have been incorporated into the development to couple the attenuation systems as follows:

- Tree Pits (at the car parking area for source control as per landscaping details).
- Trapped Road Gullies (to collect run-off from all type of paved surfaces).
- Permeable paving (to the access road to the carparking).
- Grasscrete paving (to the car parking bays and to the fire tender access).
- Green roof (to the ancillary office roof).
- Restricted discharge (to the outlets of all attenuation systems for regional control).
- Silt trap and petrol interceptor (to the inlets of all attenuation systems for pollution prevention).

*Permeable paving.*

Proposed pervious paving will allow for infiltration of the storm water runoff from it into the underlying stone and soil. This system not only reduces the quantity of runoff, but it also has a positive impact on water quality. Due to the shallow nature of the underlying build-up, permeable paving can be utilised even on sites with high ground water levels where other deeper infiltration devices would not work.

Picture 1 – Pervious paving schematic cross section




*Green Roof.*

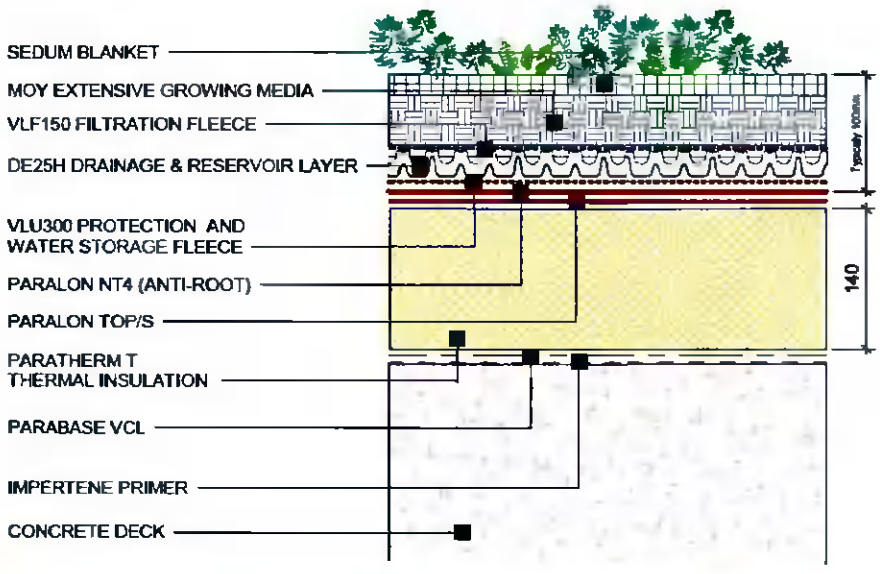
Sustainable drainage studies indicate that Green Roofs reduce annual run-off from roofs by at least 50%, and more usually by 60-70%. Moreover, the rate of release following heavy rainfall will be slower thus assisting with issues relating to storm surges.

Proposed sedum blanket type roof thickness varies form 25 – 45mm and it is installed on 50mm multilayer roof substrate composed of mineral bulk mixture with a proportion of mineral and organic matter. Maximum water capacity of the roof substrate layer is ≥35%.

Max Water Storage Capacity in the substrate of these equal: 360 $m^2$ x 50 mm x 35% = 63 $m^3$

It is proposed to use the green roof for interception storage for 5mm and smaller rainfall events. Max water capacity of the substrate will add to the provided at the bottom of the detention basin to reach the required interception storage.

Picture 2 – Moy Materials Green Roof System Build-up (Concrete Deck).



*Proposed Water Strategy:*

The proposed surface water management solution for the subject site provides both runoff quality and quantity control. Quality control is provided by ensuring all surface water runoff is dealt with on site as described earlier in this document, with reference to the specified "StormTech" attenuation systems with in-built "isolator row", proprietary silt traps & petrol interceptors. Quantity control is also provided through the surface water attenuation system coupled with the downstream flow control device. This system of surface water management has been put in place throughout the more recent developments of South Dublin area where many individual sites have been developed in a similar nature.

In summary, the following figures synopsise the surface water attenuation calculations:

| | |
|---|---|
| SITE AREA | 30,340 m² (3.03 Ha) |
| SAAR | 839 |
| SOIL VALUE | 0.3 |

| STRUCTURE TYPE | RUNOFF COEFFICIENTS | AREA (ha) |
|---|---|---|
| Impermeable Areas *(Buildings; Concrete Yard/Road; Pathways; Permeable paving)* | 1.0 | 2.31 |
| Landscaping | 0.3 | 0.72 |
| TOTAL | - | 3.03 |

Details of the surface water attenuation system including interceptors, flow restrictions, volume and pipe designs are included in this Drainage Design Report and on the accompanying Drainage Layout (drawing reference *D1720 D3 Drainage & Watermain Layout PL2*) for review by the Local Authority.

**Foul Sewer:**

A new foul sewer has been designed to collect discharge from the proposed development and discharge to the existing foul sewer network at Magna Drive. This proposed network collects the sewage on site from the proposed unit and ancillary office/staff facilities. Connection to the existing foul sewer network is proposed to the eastern site boundary at the existing foul sewer manhole at the footpaths of Magna Drive.

The peak foul sewer discharge rate is based on the discharge unit method of drainage design for calculating maximum sewage and wastewater flows. The proposed ancillary offices and warehouse toilet facilities are the source of wastewater for overall development.

As per the requirements of the Irish Water Code of Practice, minimum velocities of 0.75 m/s are met for the proposed gradients and contributing discharge unit numbers (refer to discharge unit calculation sheet for details). The proposed foul sewer including manholes and service connections will be constructed in compliance with design standards set out by Irish Water in the IW Code of Practice for Wastewater Infrastructure and Wastewater Infrastructure Standard Details.

The method of calculating the total discharge units from the development is carried out in accordance with BS EN 752-4:1998 "Drain and sewer systems outside buildings", refer to insert below for the relative tabulated extract.

**Table C.1 — Typical frequency factors ($k_{DU}$)**

| Type of building | $k_{DU}$ |
|---|---|
| Dwelling, guesthouse, office (intermittent use) | 0,5 |
| Hospital, school, restaurant, hotel (frequent use) | 0,7 |
| Toilets and/or shower open to the public (congested use) | 1,0 |
| Laboratory buildings (special use) | 1,2 |

**Table C.2 — Typical values of discharge units (*DU*)**

| Type of appliance | *DU* |
|---|---|
| Washbasin, shower | 0,3 to 0,6 |
| Urinal | 0,3 to 0,8 |
| Bath, kitchen sink | 0,8 to 1,3 |
| Dishwasher | 0,2 to 0,8 |
| Household washing machine | 0,5 to 0,8 |
| Commercial washing machine | 1,0 to 1,5 |
| WCs (4,0 l to 9,0 l cistern) | 1,2 to 2,5 |
| Floor drains (DN 50 to DN 100) | 0,6 to 2,0 |
| The discharge unit will depend on the type of drainage system inside the building and the size of the appliance. Where no specific information is available, the higher value should be used. | |

All proposed calculations of discharge units, flows and pipe designs are included further in this Drainage Design Report for the review of the Local Authority.

## Watermain:

The watermain proposed to serve the development will form a metered connection from the existing 150mm watermain on site, at Manga Avenue, the exact connection locations shown on accompanying drawing reference *D1720 D3 Drainage and Watermain Layout PL2*.

A new 150mm dia. HDPE watermain within the site will be provided with adequate sluice valves, water meter & fire hydrants to provide water supply and for firefighting purposes. Hydrants will not be placed within 6m of a building or structure and at a maximum 46m from proposed buildings.

All associated details including watermain pipe material will be in accordance with the current Irish Water guidelines. Guidelines set out in the Irish Water Publications IW-CDS_5020-1 & IW-CDS-5030-1 have been consulted and adopted within the design of the proposed drainage & watermain networks. Refer to enclosed Drainage & Watermain drawing reference *D1720 D3 Drainage and Watermain Layout PL2*.

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# Surface Water Attenuation Design

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# Surface Water Attenuation Calculation

## 1) Areas for Attenuation Calculation

| | |
|---|---|
| Site Area of development: | 30,340 m² (3.03 Ha) |
| Overall landscaping: | 7,222 m² |
| Contributing Landscaping: | 7,222 m² |
| Impermeable Areas (roof, concrete yard): | 23,118 m² |

## 2) Interception Storage

Calculate runoff from 5mm of rainfall on developed area.

For this calculation only hardstanding areas are assumed to provide 80% runoff, and non-hardstanding areas are assumed to provide 30% runoff.

The equivalent volume of Interception Storage should be provided on site as no discharge from site should occur for this initial 5mm depth of rainfall. The Interception Storage on this subject site will be provided through the base of attenuation tank.

| | |
|---|---|
| Design Impermeable Areas: | 23,118 m² x 1.00 = 23,118 m² |
| Total volume for 5mm rainfall: | 5mm x 23,118 m² = **116 m³** |

Therefore, a minimum Interception Storage volume of 116 m³ should be provided. This will prevent discharge from site during rainfall events of up to 5mm rainfall.

## 3) Greenfield Runoff Rate – QBAR, (mean annual flood flow):

*3.1) Site QBAR*

$Q_{BARrural}$ (m³/sec) = 0.00108 x $AREA^{0.89}$ x $SAAR^{1.17}$ x $SOIL^{2.17}$

SAAR (E 305630, N 226640): 839 mm (*as per Met Eireann data*)

Soil Index:
S1 (very low runoff)
S2
S3 (moderate runoff)
S4
S5 (very high runoff)

Soil = $0.1(Soil_1) + 0.3(Soil_2) + 0.37(Soil_3) + 0.47(Soil_4) + 0.53(Soil_5)$

As the site is relatively small in catchment terms the soil class will be 100% Soil2 as per online Wallingford

Procedure Greenfield runoff estimation tool on www.uksuds.com (see Appendix to Surface Water Design for the HR Wallingford Greenfield runoff rate estimation report).

Soil Class: $Soil_2$
Runoff Potential: Low
Soil Value: 0.3

$Q_{BAR}$:

As the site area is less than 50 hectares, QBAR for 50 hectares is firstly calculated:

$Q_{BAR}$ ($m^3$/sec) = 0.00108 x $AREA^{0.89}$ x $SAAR^{1.17}$ x $SOIL^{2.17}$ =
0.00108 x $(0.5)^{0.89}$ x $(839)^{1.17}$ x $(0.3)^{2.17}$ =
112.6 l/sec =
2.25 l/sec/ha

$Q_{BAR}$ for the subject site area:

2.25 l/sec/ha x 3.03ha =
**$Q_{BAR}$ = 6.83 l/sec**

According to GDSDS chapter 6.3.1.4 if the separate long-term storage cannot be provided and temporary flood storage forms part of the single attenuation system, all the runoff from the site should be discharged at either a rate of 2.0 l/s/ha or the average annual peak flow rate $Q_{BAR}$, whichever is greater:

2 l/sec/ha x 3.02 ha = 6.04 l/sec.

Therefore, allowable discharge ($Q_{BAR}$) will be set at **6.83 l/sec.**

*3.2) $QBAR_i$ for each sub-catchment*

The proposed surface drainage network is separated into three independent catchments, each one with its own individual attenuation system and flow control device. Thus, individual values for $QBAR_i$ are calculated for the purpose of designing the attenuation systems and flow control devices. The sum of these $QBAR_i$ must be equal or lesser to the site QBAR.

| Catchment | Proposed Attenuation System | Contributing Area | $QBAR_i$ |
|---|---|---|---|
| 1 | Stormtech underground tank | 7,715 $m^2$ (0.722 Ha) | 1.74 l/s |
| 2 | Stormtech underground tank | 8,088 $m^2$ (0.809 Ha) | 1.82 l/s |
| 3 | Retention basin | 6,361 $m^2$ (0.636 Ha) | 1.43 l/s |

$\sum Q_{BARi}$ shall be equal or lesser to the site $Q_{BAR}$:

1.74 l/sec + 1.82 l/sec + 1.43 l/sec =
**$\sum Q_{BARi}$ = 4.99 l/sec** <= 6.83 l/sec

## 4) Attenuation Storage Volume

100% of hardstand areas are assumed to contribute.

Permeable paving taken as impervious surfacing for attenuation storage calculations to allow for long term paving infiltration rate reduction.

Met Eireann's Rainfall depths for the 30-year storm event have been used. The rainfall depth used includes a 20% allowance for climate change.

*4.1) No. 1 Stormtech Attenuation Tank*

Equivalent Runoff Area: 100% x 7,715 $m^2$ =7,715 $m^2$

| *A* **Duration** | *B* **Runoff Area** ($m^2$) | *C* **Total Rainfall Depth** (mm) | *D* **Revised Depth for 20% CC** (mm) C x 1.2 | *E* **Total Surface Water** ($m^3$) B x D | *F* **Total Permitted Discharge** ($m^3$) $Q_{BAR1}$ x A ($Q_{BAR1}$=1.74 l/sec) | *G* **Storage Volume Required** ($m^3$) E - F |
|---|---|---|---|---|---|---|
| 15 min | 7715 | 18.5 | 22.2 | 172 | 1 | 171 |
| 30 min | 7715 | 24.3 | 29.2 | 225 | 3 | 222 |
| 1 hour | 7715 | 32.0 | 38.4 | 297 | 6 | 291 |
| 2 hours | 7715 | 42.2 | 50.6 | 391 | 12 | 379 |
| 4 hours | 7715 | 55.6 | 66.7 | 515 | 25 | 490 |
| 6 hours | 7715 | 65.3 | 78.4 | 605 | 37 | 568 |
| 9 hours | 7715 | 76.8 | 92.2 | 712 | 56 | 656 |
| 12 hours | 7715 | 86.2 | 103.4 | 799 | 75 | 724 |
| 18 hours | 7715 | 101.3 | 121.6 | 938 | 112 | 826 |
| 1 day | 7715 | 113.7 | 136.4 | 1053 | 150 | 903 |
| 2 days | 7715 | 127.6 | 153.1 | 1182 | 300 | 882 |
| 3 days | 7715 | 139.1 | 166.9 | 1288 | 451 | 837 |

**Critical Attenuation Volume for No. 1 Stormech Tank = 903 $m^3$**

*4.2) No. 2 Stormtech Attenuation Tank*

Equivalent Runoff Area: 100% x 8,088 $m^2$ = 8,088 $m^2$

| A<br>Duration | B<br>Runoff Area<br>($m^2$) | C<br>Total Rainfall Depth<br>(mm) | D<br>Revised Depth for 20% CC<br>(mm)<br>C x 1.2 | E<br>Total Surface Water<br>($m^3$)<br>B x D | F<br>Total Permitted Discharge<br>($m^3$) $Q_{BAR}$ x A<br>($Q_{BAR}$=1.82 l/sec) | G<br>Storage Volume Required<br>($m^3$)<br>E - F |
|---|---|---|---|---|---|---|
| 15 min | 8088 | 18.5 | 22.2 | 180 | 1 | 179 |
| 30 min | 8088 | 24.3 | 29.2 | 236 | 3 | 233 |
| 1 hour | 8088 | 32.0 | 38.4 | 311 | 6 | 305 |
| 2 hours | 8088 | 42.2 | 50.6 | 410 | 13 | 397 |
| 4 hours | 8088 | 55.6 | 66.7 | 540 | 26 | 514 |
| 6 hours | 8088 | 65.3 | 78.4 | 634 | 39 | 595 |
| 9 hours | 8088 | 76.8 | 92.2 | 746 | 58 | 688 |
| 12 hours | 8088 | 86.2 | 103.4 | 837 | 78 | 759 |
| 18 hours | 8088 | 101.3 | 121.6 | 984 | 117 | 867 |
| 1 day | 8088 | 113.7 | 136.4 | 1104 | 157 | 947 |
| 2 days | 8088 | 127.6 | 153.1 | 1239 | 314 | 925 |
| 3 days | 8088 | 139.1 | 166.9 | 1351 | 471 | 880 |

**Critical Attenuation Volume for No. 2 Stormech Tank = 947 $m^3$**

*4.3) Retention Basin*

Equivalent Runoff Area: 100% x 6,361 $m^2$ = 6,361 $m^2$

| A<br>Duration | B<br>Runoff Area<br>($m^2$) | C<br>Total Rainfall Depth<br>(mm) | D<br>Revised Depth for 20% CC<br>(mm)<br>C x 1.2 | E<br>Total Surface Water<br>($m^3$)<br>B x D | F<br>Total Permitted Discharge<br>($m^3$) $Q_{BAR}$ x A<br>($Q_{BAR}$=1.43 l/sec) | G<br>Storage Volume Required<br>($m^3$)<br>E - F |
|---|---|---|---|---|---|---|
| 15 min | 6361 | 18.5 | 22.2 | 142 | 1 | 141 |
| 30 min | 6361 | 24.3 | 29.2 | 186 | 3 | 183 |
| 1 hour | 6361 | 32.0 | 38.4 | 245 | 6 | 239 |
| 2 hours | 6361 | 42.2 | 50.6 | 323 | 13 | 310 |
| 4 hours | 6361 | 55.6 | 66.7 | 425 | 26 | 399 |
| 6 hours | 6361 | 65.3 | 78.4 | 499 | 39 | 460 |
| 9 hours | 6361 | 76.8 | 92.2 | 587 | 58 | 529 |
| 12 hours | 6361 | 86.2 | 103.4 | 658 | 78 | 580 |
| 18 hours | 6361 | 101.3 | 121.6 | 774 | 117 | 657 |
| 1 day | 6361 | 113.7 | 136.4 | 868 | 157 | 711 |
| 2 days | 6361 | 127.6 | 153.1 | 974 | 314 | 660 |
| 3 days | 6361 | 139.1 | 166.9 | 1062 | 471 | 591 |

**Critical Attenuation Volume for Retention Basin = 711 m³**

*4.4) Software Design*

All calculated attenuation storage volumes were analysed in the storm water network modelling software using the site-specific vortex type flow control device and there was no indication of flood or ponding for any storm duration for 1 in 30-year return period including 20% CCF therefore calculated volume of attenuation tank is sufficient.

The detailed results of this analysis are enclosed in this report at Surface Water Network Design.

## 5) Temporary Flood Storage

In addition to the previous calculations for interception & attenuation storage, the temporary flood storage must be calculated.
For long term storage the GDSDS runoff model assumptions:

100% of hardstand areas are assumed to contribute.
Soil SPR Value – 0.3, therefore 30% of non-hardstand areas assumed to contribute.
Equivalent Runoff Area: 100% x 23,118 m² + 30% x 7,222 m² =
= 23,118 m² + 2,167 m² =
= **25,285 m²**

The 6-hour duration, 100-year return period must be checked to assess the **temporary flood storage** required for the site.

100-year 6-hour event, rainfall depth: 91.4 mm
Factor up by 10% for climate change: 100.5 mm

| | | | |
|---|---|---|---|
| Total Volume of Runoff: | 100.5mm x 25,285 m² | = | 2,311 m³ |
| Deduct discharge at $Q_{BAR}$ for 6hrs: | 6.83 l/sec x 6 hrs | = | 148 m³ |
| Storage volume required: | 2,311 m³ – 148 m³ | = | 2,164 m³ |
| Deduct Interception Storage: | 116 m³ | | |
| Deduct Attenuation Storage: | (903 m³ + 947 m³ + 711 m³) | = | 2,561 m³ |
| Temporary Flood Storage required: | 2,164 m³ – 116 m³ – 2,561 m³ | < | 0 m³ |

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The calculated attenuation volume was analysed in a storm water network modelling software using the site-specific vortex type flow control device and there was no indication of flood or ponding for any storm duration for 1 in 100 year storms with 20% CCF and there is no flooding or ponding during the analysis.

The detailed results of this analysis are enclosed in this report at Surface Water Network Design.

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*In summary:*

**INTERCEPTION STORAGE: 116 m³** to be provided in the green roof and at the base to the retention basin.

Proposed sedum blanket type roof thickness varies form 25 – 45mm and it is installed on 50mm multilayer roof substrate composed of mineral bulk mixture with a proportion of mineral and organic matter. Maximum water capacity of the roof substrate layer is ≥ 35%.

- Green Roof max water storage capacity in the substrate: 360 m² x 50 mm x 35% = 63 m³

The bed level of the Retention Basin is set at +119.50 m, while inlet and outlet invert levels are proposed at +119.70, therefore the first 20 mm depth of the retention basin are intended for interception storage purposes only.

- Volume provided for 20 mm depth in the retention basin: 64 m³

**Interception storage volume provided: 127 m³**.

**TOTAL ATTENUATION VOLUME: 2,561 m³** to be provided within the attenuation systems on site.

**NO 1 STORMTECH VOLUME REQUIRED: 903 m³**

**NO 1 STORMTECH VOLUME PROVIDED: 808 m³**

(Refer to StormTech Cumulative Storages spreadsheet Tank 1 below)

Note: volume provided is less than volume required. However, the attenuation volumes check done with the computer analysis software demonstrate that the proposed volume is sufficient.

**NO 2 STORMTECH VOLUME REQUIRED: 947 m³**

**NO 2 STORMTECH VOLUME PROVIDED: 954 m³**

(Refer to StormTech Cumulative Storages spreadsheet Tank 2 below)

**RETENTION BASIN VOLUME REQUIRED: 711 m³**

**RETENTION BASIN VOLUME PROVIDED: 743 m³**

(Refer to Retention Basin cumulative table below)

**TEMPORARY FLOOD STORAGE: 0 m³**

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Storm Water Network analysis and Attenuation Volumes checks were performed using a computer hydraulic analysis software. The analysis did not highlight any ponding for any storm durations up to 1:100y return therefore the network and attenuation capacity calculated above are satisfactory.

The results of the analysis are included in this report.

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**Project:** D1720

| | | |
|---|---|---|
| Chamber Model - | MC-3500 | |
| Units - | Metric | Click Here for Imperial |
| Number of Chambers - | 150 | |
| Number of End Caps - | 14 | |
| Voids in the stone (porosity) - | 43 | % |
| Base of Stone Elevation - | 118.18 | m |
| Amount of Stone Above Chambers - | 305 | mm |
| Amount of Stone Below Chambers - | 230 | mm |
| Area of system - | 747 | sq.meters |

Include Perimeter Stone in Calculations

Min. Area - 737.943 sq.meters

## StormTech MC-3500 Cumulative Storage Volumes

| Height of System (mm) | Incremental Single Chamber (cubic meters) | Incremental Single End Cap (cubic meters) | Incremental Chambers (cubic meters) | Incremental End Cap (cubic meters) | Incremental Stone (cubic meters) | Incremental Chamber, End Cap and Stone (cubic meters) | Cumulative System (cubic meters) | Elevation (meters) |
|---|---|---|---|---|---|---|---|---|
| 1676 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 807.93 | 119.86 |
| 1651 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 799.78 | 119.83 |
| 1626 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 791.63 | 119.81 |
| 1600 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 783.47 | 119.78 |
| 1575 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 775.32 | 119.75 |
| 1549 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 767.16 | 119.73 |
| 1524 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 759.01 | 119.70 |
| 1499 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 750.85 | 119.68 |
| 1473 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 742.70 | 119.65 |
| 1448 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 734.54 | 119.63 |
| 1422 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 726.39 | 119.60 |
| 1397 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 718.23 | 119.58 |
| 1372 | 0.00 | 0.00 | 0.25 | 0.00 | 8.049 | 8.30 | 710.08 | 119.55 |
| 1346 | 0.01 | 0.00 | 0.82 | 0.00 | 7.798 | 8.63 | 701.78 | 119.53 |
| 1321 | 0.01 | 0.00 | 1.25 | 0.00 | 7.616 | 8.87 | 693.16 | 119.50 |
| 1295 | 0.01 | 0.00 | 1.71 | 0.01 | 7.414 | 9.14 | 684.29 | 119.48 |
| 1270 | 0.02 | 0.00 | 2.92 | 0.02 | 6.893 | 9.83 | 675.15 | 119.45 |
| 1245 | 0.03 | 0.00 | 4.37 | 0.02 | 6.268 | 10.66 | 665.32 | 119.42 |
| 1219 | 0.04 | 0.00 | 5.31 | 0.03 | 5.860 | 11.20 | 654.67 | 119.40 |
| 1194 | 0.04 | 0.00 | 6.04 | 0.04 | 5.542 | 11.62 | 643.47 | 119.37 |
| 1168 | 0.04 | 0.00 | 6.68 | 0.04 | 5.264 | 11.99 | 631.85 | 119.35 |
| 1143 | 0.05 | 0.00 | 7.25 | 0.05 | 5.016 | 12.31 | 619.87 | 119.32 |
| 1118 | 0.05 | 0.00 | 7.77 | 0.06 | 4.791 | 12.61 | 607.55 | 119.30 |
| 1092 | 0.05 | 0.00 | 8.23 | 0.06 | 4.588 | 12.88 | 594.94 | 119.27 |
| 1067 | 0.06 | 0.01 | 8.67 | 0.07 | 4.396 | 13.14 | 582.06 | 119.25 |
| 1041 | 0.06 | 0.01 | 9.07 | 0.08 | 4.222 | 13.37 | 568.92 | 119.22 |
| 1016 | 0.06 | 0.01 | 9.45 | 0.08 | 4.056 | 13.59 | 555.55 | 119.20 |
| 991 | 0.07 | 0.01 | 9.80 | 0.10 | 3.900 | 13.79 | 541.97 | 119.17 |
| 965 | 0.07 | 0.01 | 10.13 | 0.10 | 3.755 | 13.99 | 528.17 | 119.15 |
| 940 | 0.07 | 0.01 | 10.45 | 0.11 | 3.617 | 14.17 | 514.19 | 119.12 |
| 914 | 0.07 | 0.01 | 10.74 | 0.11 | 3.488 | 14.34 | 500.02 | 119.09 |
| 889 | 0.07 | 0.01 | 11.02 | 0.13 | 3.363 | 14.51 | 485.67 | 119.07 |
| 864 | 0.08 | 0.01 | 11.28 | 0.13 | 3.247 | 14.66 | 471.17 | 119.04 |
| 838 | 0.08 | 0.01 | 11.53 | 0.14 | 3.136 | 14.81 | 456.51 | 119.02 |
| 813 | 0.08 | 0.01 | 11.77 | 0.15 | 3.030 | 14.95 | 441.70 | 118.99 |
| 787 | 0.08 | 0.01 | 12.00 | 0.15 | 2.929 | 15.08 | 426.75 | 118.97 |
| 762 | 0.08 | 0.01 | 12.21 | 0.16 | 2.833 | 15.21 | 411.67 | 118.94 |
| 737 | 0.08 | 0.01 | 12.42 | 0.17 | 2.741 | 15.33 | 396.46 | 118.92 |
| 711 | 0.08 | 0.01 | 12.61 | 0.18 | 2.654 | 15.45 | 381.13 | 118.89 |
| 686 | 0.09 | 0.01 | 12.80 | 0.18 | 2.574 | 15.55 | 365.68 | 118.87 |
| 660 | 0.09 | 0.01 | 12.97 | 0.19 | 2.496 | 15.66 | 350.13 | 118.84 |
| 635 | 0.09 | 0.01 | 13.14 | 0.19 | 2.420 | 15.76 | 334.48 | 118.82 |
| 610 | 0.09 | 0.01 | 13.30 | 0.20 | 2.350 | 15.85 | 318.72 | 118.79 |
| 584 | 0.09 | 0.01 | 13.45 | 0.21 | 2.284 | 15.94 | 302.87 | 118.76 |
| 559 | 0.09 | 0.02 | 13.59 | 0.21 | 2.219 | 16.02 | 286.93 | 118.74 |
| 533 | 0.09 | 0.02 | 13.72 | 0.21 | 2.161 | 16.10 | 270.91 | 118.71 |
| 508 | 0.09 | 0.02 | 13.85 | 0.22 | 2.102 | 16.18 | 254.81 | 118.69 |
| 483 | 0.09 | 0.02 | 13.98 | 0.23 | 2.048 | 16.25 | 238.63 | 118.66 |
| 457 | 0.09 | 0.02 | 14.09 | 0.23 | 1.996 | 16.32 | 222.38 | 118.64 |
| 432 | 0.09 | 0.02 | 14.20 | 0.23 | 1.948 | 16.38 | 206.07 | 118.61 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 406 | 0.10 | 0.02 | 14.31 | 0.24 | 1.900 | 16.45 | 189.68 | 118.59 |
| 381 | 0.10 | 0.02 | 14.41 | 0.24 | 1.856 | 16.50 | 173.24 | 118.56 |
| 356 | 0.10 | 0.02 | 14.50 | 0.24 | 1.814 | 16.56 | 156.73 | 118.54 |
| 330 | 0.10 | 0.02 | 14.60 | 0.24 | 1.773 | 16.61 | 140.17 | 118.51 |
| 305 | 0.10 | 0.02 | 14.69 | 0.25 | 1.734 | 16.67 | 123.56 | 118.48 |
| 279 | 0.10 | 0.02 | 14.78 | 0.25 | 1.694 | 16.72 | 106.89 | 118.46 |
| 254 | 0.10 | 0.02 | 14.89 | 0.25 | 1.645 | 16.78 | 90.17 | 118.43 |
| 229 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 73.39 | 118.41 |
| 203 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 65.24 | 118.38 |
| 178 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 57.08 | 118.36 |
| 152 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 48.93 | 118.33 |
| 127 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 40.77 | 118.31 |
| 102 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 32.62 | 118.28 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 24.46 | 118.26 |
| 51 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 16.31 | 118.23 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 8.155 | 8.15 | 8.15 | 118.21 |

**Project:** D1720

| | | |
|---|---|---|
| Chamber Model - | MC-3500 | |
| Units - | Metric | Click Here for Imperial |
| Number of Chambers - | 176 | |
| Number of End Caps - | 14 | |
| Voids in the stone (porosity) - | 43 | % |
| Base of Stone Elevation - | 118.22 | m |
| Amount of Stone Above Chambers - | 305 | mm |
| Amount of Stone Below Chambers - | 230 | mm |
| Area of system - | 885 | sq.meters |

Include Perimeter Stone in Calculations

Min. Area - 862.004 sq.meters

## StormTech MC-3500 Cumulative Storage Volumes

| Height of System (mm) | Incremental Single Chamber (cubic meters) | Incremental Single End Cap (cubic meters) | Incremental Chambers (cubic meters) | Incremental End Cap (cubic meters) | Incremental Stone (cubic meters) | Incremental Chamber, End Cap and Stone (cubic meters) | Cumulative System (cubic meters) | Elevation (meters) |
|---|---|---|---|---|---|---|---|---|
| 1676 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 953.50 | 119.90 |
| 1651 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 943.84 | 119.87 |
| 1626 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 934.18 | 119.85 |
| 1600 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 924.52 | 119.82 |
| 1575 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 914.86 | 119.79 |
| 1549 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 905.20 | 119.77 |
| 1524 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 895.54 | 119.74 |
| 1499 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 885.87 | 119.72 |
| 1473 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 876.21 | 119.69 |
| 1448 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 866.55 | 119.67 |
| 1422 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 856.89 | 119.64 |
| 1397 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 847.23 | 119.62 |
| 1372 | 0.00 | 0.00 | 0.29 | 0.00 | 9.537 | 9.83 | 837.57 | 119.59 |
| 1346 | 0.01 | 0.00 | 0.97 | 0.00 | 9.243 | 10.21 | 827.74 | 119.57 |
| 1321 | 0.01 | 0.00 | 1.47 | 0.00 | 9.029 | 10.50 | 817.53 | 119.54 |
| 1295 | 0.01 | 0.00 | 2.01 | 0.01 | 8.793 | 10.81 | 807.03 | 119.52 |
| 1270 | 0.02 | 0.00 | 3.42 | 0.02 | 8.182 | 11.62 | 796.22 | 119.49 |
| 1245 | 0.03 | 0.00 | 5.12 | 0.02 | 7.449 | 12.59 | 784.59 | 119.46 |
| 1219 | 0.04 | 0.00 | 6.23 | 0.03 | 6.971 | 13.23 | 772.00 | 119.44 |
| 1194 | 0.04 | 0.00 | 7.09 | 0.04 | 6.598 | 13.72 | 758.77 | 119.41 |
| 1168 | 0.04 | 0.00 | 7.84 | 0.04 | 6.273 | 14.15 | 745.05 | 119.39 |
| 1143 | 0.05 | 0.00 | 8.51 | 0.05 | 5.982 | 14.54 | 730.90 | 119.36 |
| 1118 | 0.05 | 0.00 | 9.11 | 0.06 | 5.719 | 14.89 | 716.36 | 119.34 |
| 1092 | 0.05 | 0.00 | 9.66 | 0.06 | 5.481 | 15.20 | 701.48 | 119.31 |
| 1067 | 0.06 | 0.01 | 10.17 | 0.07 | 5.257 | 15.50 | 686.27 | 119.29 |
| 1041 | 0.06 | 0.01 | 10.64 | 0.08 | 5.052 | 15.77 | 670.77 | 119.26 |
| 1016 | 0.06 | 0.01 | 11.09 | 0.08 | 4.859 | 16.03 | 655.00 | 119.24 |
| 991 | 0.07 | 0.01 | 11.50 | 0.10 | 4.677 | 16.27 | 638.98 | 119.21 |
| 965 | 0.07 | 0.01 | 11.89 | 0.10 | 4.506 | 16.49 | 622.71 | 119.19 |
| 940 | 0.07 | 0.01 | 12.26 | 0.11 | 4.345 | 16.71 | 606.21 | 119.16 |
| 914 | 0.07 | 0.01 | 12.60 | 0.11 | 4.194 | 16.91 | 589.51 | 119.13 |
| 889 | 0.07 | 0.01 | 12.93 | 0.13 | 4.048 | 17.10 | 572.60 | 119.11 |
| 864 | 0.08 | 0.01 | 13.24 | 0.13 | 3.913 | 17.28 | 555.50 | 119.08 |
| 838 | 0.08 | 0.01 | 13.53 | 0.14 | 3.783 | 17.45 | 538.21 | 119.06 |
| 813 | 0.08 | 0.01 | 13.81 | 0.15 | 3.659 | 17.62 | 520.76 | 119.03 |
| 787 | 0.08 | 0.01 | 14.08 | 0.15 | 3.541 | 17.77 | 503.14 | 119.01 |
| 762 | 0.08 | 0.01 | 14.33 | 0.16 | 3.429 | 17.92 | 485.37 | 118.98 |
| 737 | 0.08 | 0.01 | 14.57 | 0.17 | 3.321 | 18.07 | 467.45 | 118.96 |
| 711 | 0.08 | 0.01 | 14.80 | 0.18 | 3.220 | 18.20 | 449.38 | 118.93 |
| 686 | 0.09 | 0.01 | 15.01 | 0.18 | 3.127 | 18.32 | 431.18 | 118.91 |
| 660 | 0.09 | 0.01 | 15.22 | 0.19 | 3.036 | 18.44 | 412.86 | 118.88 |
| 635 | 0.09 | 0.01 | 15.42 | 0.19 | 2.946 | 18.56 | 394.42 | 118.86 |
| 610 | 0.09 | 0.01 | 15.60 | 0.20 | 2.865 | 18.67 | 375.86 | 118.83 |
| 584 | 0.09 | 0.01 | 15.78 | 0.21 | 2.788 | 18.77 | 357.19 | 118.80 |
| 559 | 0.09 | 0.02 | 15.95 | 0.21 | 2.713 | 18.87 | 338.42 | 118.78 |
| 533 | 0.09 | 0.02 | 16.10 | 0.21 | 2.645 | 18.96 | 319.54 | 118.75 |
| 508 | 0.09 | 0.02 | 16.25 | 0.22 | 2.576 | 19.05 | 300.58 | 118.73 |
| 483 | 0.09 | 0.02 | 16.40 | 0.23 | 2.513 | 19.14 | 281.53 | 118.70 |
| 457 | 0.09 | 0.02 | 16.54 | 0.23 | 2.452 | 19.22 | 262.39 | 118.68 |
| 432 | 0.09 | 0.02 | 16.67 | 0.23 | 2.396 | 19.29 | 243.17 | 118.65 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 406 | 0.10 | 0.02 | 16.79 | 0.24 | 2.340 | 19.37 | 223.88 | 118.63 |
| 381 | 0.10 | 0.02 | 16.91 | 0.24 | 2.289 | 19.43 | 204.52 | 118.60 |
| 356 | 0.10 | 0.02 | 17.02 | 0.24 | 2.240 | 19.50 | 185.08 | 118.58 |
| 330 | 0.10 | 0.02 | 17.13 | 0.24 | 2.191 | 19.56 | 165.58 | 118.55 |
| 305 | 0.10 | 0.02 | 17.23 | 0.25 | 2.145 | 19.62 | 146.02 | 118.52 |
| 279 | 0.10 | 0.02 | 17.34 | 0.25 | 2.099 | 19.69 | 126.40 | 118.50 |
| 254 | 0.10 | 0.02 | 17.47 | 0.25 | 2.042 | 19.76 | 106.71 | 118.47 |
| 229 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 86.95 | 118.45 |
| 203 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 77.29 | 118.42 |
| 178 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 67.63 | 118.40 |
| 152 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 57.97 | 118.37 |
| 127 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 48.31 | 118.35 |
| 102 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 38.64 | 118.32 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 28.98 | 118.30 |
| 51 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 19.32 | 118.27 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 9.661 | 9.66 | 9.66 | 118.25 |

DETENTION BASIN

Project: D1720

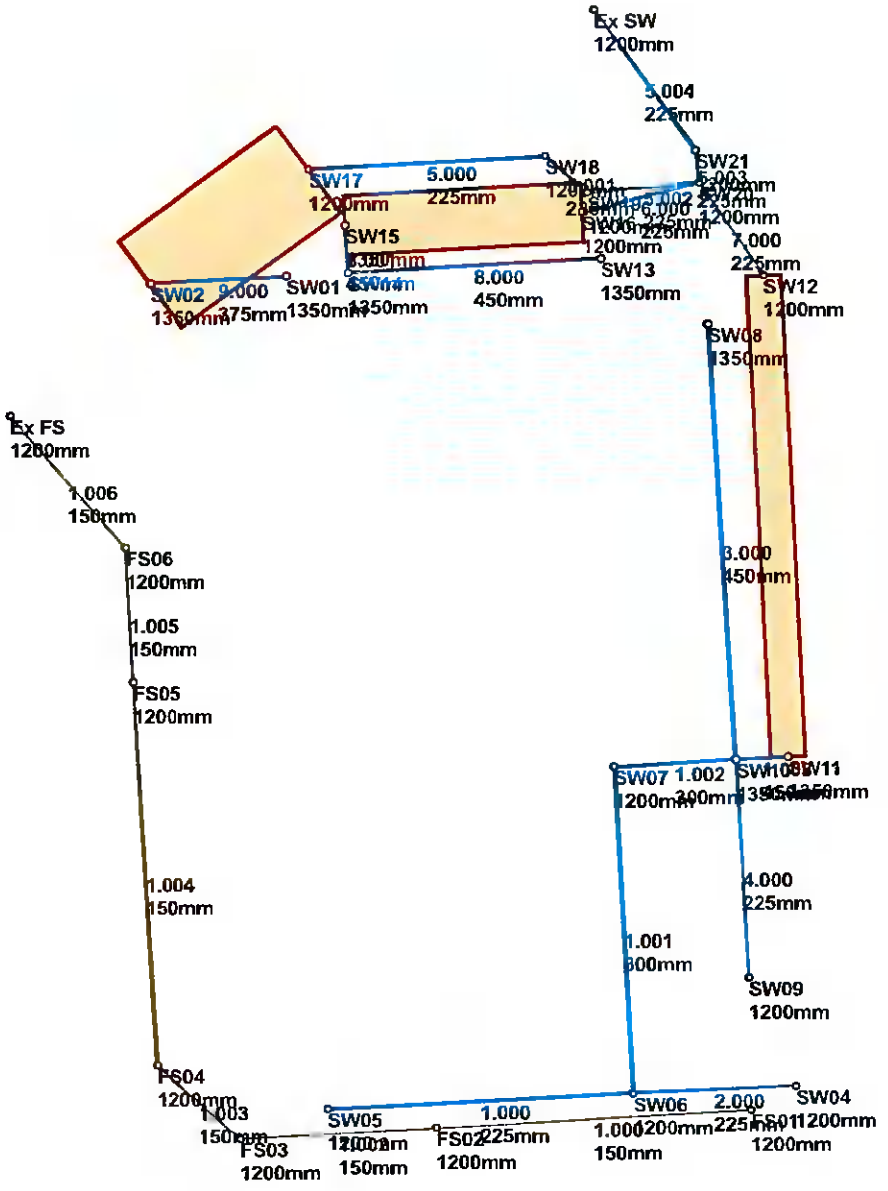
DETENTION BASIN CUMULATIVE STORAGE VOLUME

| Level (m) | Height (m) | Area ($m^2$) | Volume ($m^3$) | Cumulative Volume ($m^3$) |
|---|---|---|---|---|
| **119.50** | 0.00 | 299 | 0 | 0 |
| **119.70** | 0.20 | **349** | 64 | 64 |
| 120.00 | 0.50 | 423 | 178 | 242 |
| 120.50 | 1.00 | 562 | 246 | 488 |
| **120.96** | 1.46 | **703** | 290 | 778 |
| 121.00 | 1.50 | 715 | 319 | 807 |

KAVANAGH BURKE
CONSULTING ENGINEERS

# Surface Water Network Design

| KAVANAGH BURKE CONSULTING ENGINEERS | Kavanagh Burke Ltd<br>Unit F3 Calmount Park<br>Ballymount<br>Dublin 12 | File: D1720 SW & FSI Drainage PL2.pfd<br>Network: Storm Network<br>Pablo M Bussi<br>07/06/2022 | Page 1 |
|---|---|---|---|



## Design Settings

| | | | |
|---|---|---|---|
| Rainfall Methodology | FSR | Maximum Time of Concentration (mins) | 30.00 |
| Return Period (years) | 2 | Maximum Rainfall (mm/hr) | 50.0 |
| Additional Flow (%) | 0 | Minimum Velocity (m/s) | 1.00 |
| FSR Region | Scotland and Ireland | Connection Type | Level Soffits |
| M5-60 (mm) | 18.400 | Minimum Backdrop Height (m) | 0.200 |
| Ratio-R | 0.234 | Preferred Cover Depth (m) | 0.700 |
| CV | 0.750 | Include Intermediate Ground | ✓ |
| Time of Entry (mins) | 5.00 | Enforce best practice design rules | ✓ |

## Nodes

| Name | Area (ha) | T of E (mins) | Cover Level (m) | Diameter (mm) | Easting (m) | Northing (m) | Depth (m) |
|---|---|---|---|---|---|---|---|
| SW01 | 0.636 | 5.00 | 121.250 | 1350 | 705532.877 | 726737.648 | 1.450 |
| SW02 | | | 121.250 | 1350 | 705507.916 | 726736.265 | 1.550 |
| SW04 | 0.095 | 5.00 | 123.700 | 1200 | 705625.940 | 726586.958 | 1.500 |
| SW05 | 0.178 | 5.00 | 122.500 | 1200 | 705540.040 | 726582.809 | 1.900 |
| SW06 | | | 122.300 | 1200 | 705596.131 | 726585.596 | 2.125 |
| SW07 | | | 122.800 | 1200 | 705592.781 | 726646.340 | 3.025 |
| SW08 | 0.459 | 5.00 | 120.500 | 1350 | 705610.171 | 726728.546 | 1.500 |
| SW09 | 0.077 | 5.00 | 122.850 | 1200 | 705617.416 | 726607.086 | 1.350 |
| SW10 | | | 122.350 | 1350 | 705615.156 | 726647.619 | 3.550 |
| SW11 | | | 122.320 | 1350 | 705624.655 | 726648.124 | 4.033 |
| SW12 | | 5.00 | 120.400 | 1200 | 705620.347 | 726737.667 | 2.200 |
| SW13 | 0.772 | 5.00 | 119.950 | 1350 | 705590.520 | 726740.778 | 1.300 |
| SW14 | | | 120.980 | 1350 | 705544.112 | 726738.204 | 2.480 |
| SW15 | | | 120.980 | 1350 | 705543.616 | 726747.100 | 2.760 |
| SW16 | | 5.00 | 120.000 | 1200 | 705587.067 | 726749.486 | 1.820 |
| SW17 | | 5.00 | 121.100 | 1200 | 705536.987 | 726757.505 | 1.400 |
| SW18 | | | 120.150 | 1200 | 705580.330 | 726759.909 | 0.925 |
| SW19 | | | 120.000 | 1200 | 705588.038 | 726753.105 | 0.925 |
| SW20 | 0.101 | 5.00 | 119.250 | 1200 | 705608.573 | 726754.925 | 1.155 |
| SW21 | | | 119.050 | 1200 | 705607.945 | 726760.948 | 0.980 |
| Ex SW | | | 119.260 | 1200 | 705589.394 | 726787.049 | 1.330 |

## Links

| Name | US Node | DS Node | Length (m) | ks (mm) / n | US IL (m) | DS IL (m) | Fall (m) | Slope (1:X) | Dia (mm) | T of C (mins) | Rain (mm/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.003 | SW20 | SW21 | 6.056 | 0.600 | 118.095 | 118.070 | 0.025 | 242.2 | 225 | 5.90 | 48.0 |
| 6.000 | SW16 | SW20 | 22.183 | 0.600 | 118.180 | 118.095 | 0.085 | 261.0 | 225 | 5.46 | 49.4 |
| 5.004 | SW21 | Ex SW | 32.022 | 0.600 | 118.070 | 117.930 | 0.140 | 228.7 | 225 | 6.52 | 46.2 |
| 8.000 | SW13 | SW14 | 46.479 | 0.600 | 118.650 | 118.500 | 0.150 | 309.9 | 450 | 5.67 | 48.7 |
| 8.001 | SW14 | SW15 | 8.910 | 0.600 | 118.500 | 118.350 | 0.150 | 59.4 | 450 | 5.73 | 48.5 |

| Name | US Node | DS Node | Cap (l/s) | Flow (l/s) | US Depth (m) | DS Depth (m) | Maximum Depth (m) | Σ Area (ha) | Σ Add Inflow (l/s) | Pro Velocity (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.003 | SW20 | SW21 | 33.2 | 13.1 | 0.930 | 0.755 | 0.930 | 0.101 | 0.0 | 0.787 |
| 6.000 | SW16 | SW20 | 32.0 | 0.0 | 1.595 | 0.930 | 1.595 | 0.000 | 0.0 | 0.000 |
| 5.004 | SW21 | Ex SW | 34.2 | 12.7 | 0.755 | 1.105 | 1.105 | 0.101 | 0.0 | 0.796 |
| 8.000 | SW13 | SW14 | 182.8 | 101.8 | 0.850 | 2.030 | 2.030 | 0.772 | 0.0 | 1.179 |
| 8.001 | SW14 | SW15 | 420.1 | 101.5 | 2.030 | 2.180 | 2.180 | 0.772 | 0.0 | 2.191 |

## Links

| Name | US Node | DS Node | Length (m) | ks (mm) / n | US IL (m) | DS IL (m) | Fall (m) | Slope (1:X) | Dia (mm) | T of C (mins) | Rain (mm/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.000 | SW08 | SW10 | 81.080 | 0.600 | 119.000 | 118.800 | 0.200 | 405.4 | 450 | 6.35 | 46.7 |
| 1.003 | SW10 | SW11 | 9.512 | 0.600 | 118.800 | 118.650 | 0.150 | 63.4 | 450 | 7.06 | 44.8 |
| 7.000 | SW12 | SW20 | 20.892 | 0.600 | 118.200 | 118.095 | 0.105 | 199.0 | 225 | 5.38 | 49.6 |
| 4.000 | SW09 | SW10 | 40.596 | 0.600 | 121.500 | 121.100 | 0.400 | 101.5 | 225 | 5.52 | 49.2 |
| 1.001 | SW06 | SW07 | 60.836 | 0.600 | 120.175 | 119.775 | 0.400 | 152.1 | 300 | 6.71 | 45.7 |
| 1.002 | SW07 | SW10 | 22.412 | 0.600 | 119.775 | 119.625 | 0.150 | 149.4 | 300 | 7.00 | 45.0 |
| 1.000 | SW05 | SW06 | 56.160 | 0.600 | 120.600 | 120.250 | 0.350 | 160.5 | 225 | 5.91 | 48.0 |
| 2.000 | SW04 | SW06 | 29.840 | 0.600 | 122.200 | 120.750 | 1.450 | 20.6 | 225 | 5.17 | 50.0 |
| 9.000 | SW01 | SW02 | 24.999 | 0.600 | 119.800 | 119.700 | 0.100 | 250.0 | 375 | 5.37 | 49.7 |
| 5.000 | SW17 | SW18 | 43.410 | 0.600 | 119.700 | 119.225 | 0.475 | 91.4 | 225 | 5.53 | 49.1 |
| 5.001 | SW18 | SW19 | 10.281 | 0.600 | 119.225 | 119.075 | 0.150 | 68.5 | 225 | 5.64 | 48.8 |
| 5.002 | SW19 | SW20 | 20.615 | 0.600 | 119.075 | 118.325 | 0.750 | 27.5 | 225 | 5.77 | 48.4 |

| Name | US Node | DS Node | Cap (l/s) | Flow (l/s) | US Depth (m) | DS Depth (m) | Maximum Depth (m) | Σ Area (ha) | Σ Add Inflow (l/s) | Pro Velocity (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.000 | SW08 | SW10 | 159.6 | 58.1 | 1.050 | 3.100 | 3.100 | 0.459 | 0.0 | 0.927 |
| 1.003 | SW10 | SW11 | 406.5 | 98.2 | 3.100 | 3.220 | 3.220 | 0.809 | 0.0 | 2.120 |
| 7.000 | SW12 | SW20 | 36.7 | 0.0 | 1.975 | 0.930 | 1.975 | 0.000 | 0.0 | 0.000 |
| 4.000 | SW09 | SW10 | 51.6 | 10.3 | 1.125 | 1.025 | 1.125 | 0.077 | 0.0 | 1.019 |
| 1.001 | SW06 | SW07 | 89.9 | 33.8 | 1.825 | 2.725 | 2.725 | 0.273 | 0.0 | 1.185 |
| 1.002 | SW07 | SW10 | 90.7 | 33.3 | 2.725 | 2.425 | 2.725 | 0.273 | 0.0 | 1.188 |
| 1.000 | SW05 | SW06 | 40.9 | 23.1 | 1.675 | 1.825 | 1.825 | 0.178 | 0.0 | 1.059 |
| 2.000 | SW04 | SW06 | 115.2 | 12.9 | 1.275 | 1.325 | 1.325 | 0.095 | 0.0 | 1.930 |
| 9.000 | SW01 | SW02 | 126.0 | 85.6 | 1.075 | 1.175 | 1.175 | 0.636 | 0.0 | 1.224 |
| 5.000 | SW17 | SW18 | 54.4 | 0.0 | 1.175 | 0.700 | 1.175 | 0.000 | 0.0 | 0.000 |
| 5.001 | SW18 | SW19 | 62.9 | 0.0 | 0.700 | 0.700 | 0.700 | 0.000 | 0.0 | 0.000 |
| 5.002 | SW19 | SW20 | 99.6 | 0.0 | 0.700 | 0.700 | 0.700 | 0.000 | 0.0 | 0.000 |

## Simulation Settings

| | | | |
|---|---|---|---|
| Rainfall Methodology | FSR | Analysis Speed | Normal |
| FSR Region | Scotland and Ireland | Skip Steady State | x |
| M5-60 (mm) | 18.400 | Drain Down Time (mins) | 240 |
| Ratio-R | 0.234 | Additional Storage (m³/ha) | 20.0 |
| Summer CV | 0.750 | Check Discharge Rate(s) | x |
| Winter CV | 0.840 | Check Discharge Volume | x |

**Storm Durations**

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

| Return Period (years) | Climate Change (CC %) | Additional Area (A %) | Additional Flow (Q %) |
|---|---|---|---|
| 30 | 20 | 0 | 0 |
| 100 | 20 | 0 | 0 |

## Node SW16 Online Hydro-Brake® Control

| | | | |
|---|---|---|---|
| Flap Valve | x | Objective | (HE) Minimise upstream storage |
| Replaces Downstream Link | ✓ | Sump Available | ✓ |
| Invert Level (m) | 118.180 | Product Number | CTL-SHE-0056-1800-1676-1800 |
| Design Depth (m) | 1.676 | Min Outlet Diameter (m) | 0.075 |
| Design Flow (l/s) | 1.8 | Min Node Diameter (mm) | 1200 |

## Node SW12 Online Hydro-Brake® Control

| | | | |
|---|---|---|---|
| Flap Valve | x | Objective | (HE) Minimise upstream storage |
| Replaces Downstream Link | ✓ | Sump Available | ✓ |
| Invert Level (m) | 118.200 | Product Number | CTL-SHE-0056-1800-1676-1800 |
| Design Depth (m) | 1.676 | Min Outlet Diameter (m) | 0.075 |
| Design Flow (l/s) | 1.8 | Min Node Diameter (mm) | 1200 |

## Node SW17 Online Hydro-Brake® Control

| | | | |
|---|---|---|---|
| Flap Valve | x | Objective | (HE) Minimise upstream storage |
| Replaces Downstream Link | ✓ | Sump Available | ✓ |
| Invert Level (m) | 119.700 | Product Number | CTL-SHE-0052-1400-1300-1400 |
| Design Depth (m) | 1.300 | Min Outlet Diameter (m) | 0.075 |
| Design Flow (l/s) | 1.4 | Min Node Diameter (mm) | 1200 |

## Node SW16 Flow through Pond Storage Structure

| | | | | | |
|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 1.00 | Main Channel Length (m) | 40.000 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 118.180 | Main Channel Slope (1:X) | 1000.0 |
| Safety Factor | 2.0 | Time to half empty (mins) | | Main Channel n | 0.016 |

**Inlets**

SW15

| Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) |
|---|---|---|---|---|---|---|---|---|
| 0.000 | 482.1 | 0.0 | 1.676 | 482.1 | 0.0 | 1.677 | 0.0 | 0.0 |

## Node SW12 Flow through Pond Storage Structure

| | | | | | |
|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 1.00 | Main Channel Length (m) | 87.400 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 118.200 | Main Channel Slope (1:X) | 1000.0 |
| Safety Factor | 2.0 | Time to half empty (mins) | | Main Channel n | 0.016 |

**Inlets**

SW11

| Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) | Depth (m) | Area (m²) | Inf Area (m²) |
|---|---|---|---|---|---|---|---|---|
| 0.000 | 568.9 | 0.0 | 1.676 | 568.9 | 0.0 | 1.677 | 0.0 | 0.0 |

## Node SW17 Flow through Pond Storage Structure

| | | | | | |
|---|---|---|---|---|---|
| Base Inf Coefficient (m/hr) | 0.00000 | Porosity | 1.00 | Main Channel Length (m) | 35.000 |
| Side Inf Coefficient (m/hr) | 0.00000 | Invert Level (m) | 119.700 | Main Channel Slope (1:X) | 1000.0 |
| Safety Factor | 2.0 | Time to half empty (mins) | | Main Channel n | 0.030 |

**Inlets**

SW02

| Depth (m) | Area ($m^2$) | Inf Area ($m^2$) | Depth (m) | Area ($m^2$) | Inf Area ($m^2$) | Depth (m) | Area ($m^2$) | Inf Area ($m^2$) | Depth (m) | Area ($m^2$) | Inf Area ($m^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 349.0 | 0.0 | 0.300 | 423.0 | 0.0 | 0.800 | 562.0 | 0.0 | 1.300 | 715.0 | 0.0 |

**Rainfall**

| Event | Peak Intensity (mm/hr) | Average Intensity (mm/hr) | Event | Peak Intensity (mm/hr) | Average Intensity (mm/hr) |
|---|---|---|---|---|---|
| 30 year +20% CC 15 minute summer | 250.292 | 70.824 | 100 year +20% CC 15 minute summer | 325.056 | 91.980 |
| 30 year +20% CC 15 minute winter | 175.644 | 70.824 | 100 year +20% CC 15 minute winter | 228.110 | 91.980 |
| 30 year +20% CC 30 minute summer | 175.868 | 49.765 | 100 year +20% CC 30 minute summer | 229.536 | 64.951 |
| 30 year +20% CC 30 minute winter | 123.416 | 49.765 | 100 year +20% CC 30 minute winter | 161.078 | 64.951 |
| 30 year +20% CC 60 minute summer | 125.709 | 33.221 | 100 year +20% CC 60 minute summer | 162.824 | 43.030 |
| 30 year +20% CC 60 minute winter | 83.518 | 33.221 | 100 year +20% CC 60 minute winter | 108.177 | 43.030 |
| 30 year +20% CC 120 minute summer | 81.999 | 21.670 | 100 year +20% CC 120 minute summer | 105.052 | 27.762 |
| 30 year +20% CC 120 minute winter | 54.478 | 21.670 | 100 year +20% CC 120 minute winter | 69.794 | 27.762 |
| 30 year +20% CC 180 minute summer | 65.175 | 16.772 | 100 year +20% CC 180 minute summer | 82.888 | 21.330 |
| 30 year +20% CC 180 minute winter | 42.366 | 16.772 | 100 year +20% CC 180 minute winter | 53.880 | 21.330 |
| 30 year +20% CC 240 minute summer | 52.805 | 13.955 | 100 year +20% CC 240 minute summer | 66.778 | 17.647 |
| 30 year +20% CC 240 minute winter | 35.082 | 13.955 | 100 year +20% CC 240 minute winter | 44.365 | 17.647 |
| 30 year +20% CC 360 minute summer | 41.767 | 10.748 | 100 year +20% CC 360 minute summer | 52.380 | 13.479 |
| 30 year +20% CC 360 minute winter | 27.150 | 10.748 | 100 year +20% CC 360 minute winter | 34.049 | 13.479 |
| 30 year +20% CC 480 minute summer | 33.760 | 8.922 | 100 year +20% CC 480 minute summer | 42.083 | 11.121 |
| 30 year +20% CC 480 minute winter | 22.430 | 8.922 | 100 year +20% CC 480 minute winter | 27.959 | 11.121 |
| 30 year +20% CC 600 minute summer | 28.222 | 7.719 | 100 year +20% CC 600 minute summer | 35.013 | 9.577 |
| 30 year +20% CC 600 minute winter | 19.283 | 7.719 | 100 year +20% CC 600 minute winter | 23.923 | 9.577 |
| 30 year +20% CC 720 minute summer | 25.587 | 6.858 | 100 year +20% CC 720 minute summer | 31.623 | 8.475 |
| 30 year +20% CC 720 minute winter | 17.196 | 6.858 | 100 year +20% CC 720 minute winter | 21.252 | 8.475 |
| 30 year +20% CC 960 minute summer | 21.600 | 5.688 | 100 year +20% CC 960 minute summer | 26.533 | 6.987 |
| 30 year +20% CC 960 minute winter | 14.308 | 5.688 | 100 year +20% CC 960 minute winter | 17.576 | 6.987 |
| 30 year +20% CC 1440 minute summer | 16.283 | 4.364 | 100 year +20% CC 1440 minute summer | 19.821 | 5.312 |
| 30 year +20% CC 1440 minute winter | 10.943 | 4.364 | 100 year +20% CC 1440 minute winter | 13.321 | 5.312 |
| 30 year +20% CC 2160 minute summer | 12.100 | 3.344 | 100 year +20% CC 2160 minute summer | 14.585 | 4.031 |
| 30 year +20% CC 2160 minute winter | 8.337 | 3.344 | 100 year +20% CC 2160 minute winter | 10.049 | 4.031 |
| 30 year +20% CC 2880 minute summer | 10.323 | 2.767 | 100 year +20% CC 2880 minute summer | 12.352 | 3.311 |
| 30 year +20% CC 2880 minute winter | 6.937 | 2.767 | 100 year +20% CC 2880 minute winter | 8.301 | 3.311 |
| 30 year +20% CC 4320 minute summer | 8.097 | 2.117 | 100 year +20% CC 4320 minute summer | 9.588 | 2.507 |
| 30 year +20% CC 4320 minute winter | 5.332 | 2.117 | 100 year +20% CC 4320 minute winter | 6.314 | 2.507 |
| 30 year +20% CC 5760 minute summer | 6.840 | 1.751 | 100 year +20% CC 5760 minute summer | 8.039 | 2.058 |
| 30 year +20% CC 5760 minute winter | 4.427 | 1.751 | 100 year +20% CC 5760 minute winter | 5.203 | 2.058 |
| 30 year +20% CC 7200 minute summer | 5.925 | 1.512 | 100 year +20% CC 7200 minute summer | 6.926 | 1.767 |
| 30 year +20% CC 7200 minute winter | 3.824 | 1.512 | 100 year +20% CC 7200 minute winter | 4.470 | 1.767 |

**Results for 30 year +20% CC Critical Storm Duration. Lowest mass balance: 99.88%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 5760 minute winter | SW01 | 4560 | 120.812 | 1.012 | 6.6 | 10.3264 | 0.0000 | SURCHARGED |
| 5760 minute winter | SW02 | 4560 | 120.812 | 1.112 | 6.5 | 1.5912 | 0.0000 | OK |
| 15 minute winter | SW04 | 10 | 122.281 | 0.081 | 30.6 | 0.1945 | 0.0000 | OK |
| 15 minute winter | SW05 | 11 | 120.984 | 0.384 | 57.4 | 1.1547 | 0.0000 | SURCHARGED |
| 15 minute winter | SW06 | 11 | 120.405 | 0.230 | 80.5 | 0.2601 | 0.0000 | OK |
| 15 minute winter | SW07 | 12 | 120.013 | 0.238 | 80.4 | 0.2693 | 0.0000 | OK |
| 7200 minute winter | SW08 | 5580 | 119.487 | 0.487 | 4.1 | 3.6792 | 0.0000 | SURCHARGED |
| 15 minute winter | SW09 | 10 | 121.611 | 0.111 | 24.8 | 0.2524 | 0.0000 | OK |
| 7200 minute winter | SW10 | 5580 | 119.487 | 0.687 | 25.0 | 0.9835 | 0.0000 | SURCHARGED |
| 7200 minute winter | SW11 | 5580 | 119.488 | 1.200 | 74.1 | 1.7176 | 0.0000 | OK |
| 7200 minute winter | SW12 | 5520 | 119.487 | 1.287 | 26.1 | 1.4559 | 0.0000 | SURCHARGED |
| 7200 minute winter | SW13 | 5460 | 119.552 | 0.902 | 6.9 | 12.0024 | 0.0000 | SURCHARGED |
| 7200 minute winter | SW14 | 5460 | 119.552 | 1.052 | 8.2 | 1.5052 | 0.0000 | SURCHARGED |
| 7200 minute winter | SW15 | 5460 | 119.552 | 1.332 | 15.4 | 1.9059 | 0.0000 | OK |
| 7200 minute winter | SW16 | 5460 | 119.552 | 1.372 | 23.0 | 1.5516 | 0.0000 | SURCHARGED |
| 5760 minute winter | SW17 | 4560 | 120.812 | 1.112 | 3.8 | 1.2577 | 0.0000 | FLOOD RISK |
| 5760 minute winter | SW18 | 4560 | 119.249 | 0.024 | 1.3 | 0.0268 | 0.0000 | OK |
| 5760 minute winter | SW19 | 4560 | 119.093 | 0.018 | 1.3 | 0.0206 | 0.0000 | OK |
| 15 minute winter | SW20 | 11 | 118.297 | 0.201 | 33.3 | 0.5802 | 0.0000 | OK |
| 15 minute winter | SW21 | 11 | 118.250 | 0.180 | 31.7 | 0.2037 | 0.0000 | OK |
| 15 minute winter | Ex SW | 11 | 118.080 | 0.150 | 31.9 | 0.0000 | 0.0000 | OK |

| Link Event (Upstream Depth) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 5760 minute winter | SW01 | 9.000 | SW02 | 6.5 | 0.221 | 0.052 | 2.7573 | |
| 5760 minute winter | SW02 | Flow through pond | SW17 | 3.8 | 0.009 | 0.000 | 541.0786 | |
| 15 minute winter | SW04 | 2.000 | SW06 | 30.2 | 2.404 | 0.262 | 0.3751 | |
| 15 minute winter | SW05 | 1.000 | SW06 | 51.3 | 1.303 | 1.254 | 2.1136 | |
| 15 minute winter | SW06 | 1.001 | SW07 | 80.4 | 1.375 | 0.894 | 3.5576 | |
| 15 minute winter | SW07 | 1.002 | SW10 | 79.7 | 1.398 | 0.878 | 1.2750 | |
| 7200 minute winter | SW08 | 3.000 | SW10 | 4.1 | 0.469 | 0.026 | 12.8466 | |
| 15 minute winter | SW09 | 4.000 | SW10 | 24.0 | 1.266 | 0.466 | 0.7731 | |
| 7200 minute winter | SW10 | 1.003 | SW11 | -17.8 | 0.928 | -0.044 | 1.5071 | |
| 7200 minute winter | SW11 | Flow through pond | SW12 | -74.1 | -0.016 | -0.005 | 707.8126 | |
| 7200 minute winter | SW12 | Hydro-Brake® | SW20 | 1.6 | | | | |
| 7200 minute winter | SW13 | 8.000 | SW14 | 7.2 | 0.627 | 0.039 | 7.3643 | |
| 7200 minute winter | SW14 | 8.001 | SW15 | 15.4 | 0.785 | 0.037 | 1.4117 | |
| 7200 minute winter | SW15 | Flow through pond | SW16 | 23.0 | 0.010 | 0.001 | 651.7279 | |
| 7200 minute winter | SW16 | Hydro-Brake® | SW20 | 1.6 | | | | |
| 5760 minute winter | SW17 | Hydro-Brake® | SW18 | 1.3 | | | | |
| 5760 minute winter | SW18 | 5.001 | SW19 | 1.3 | 0.709 | 0.021 | 0.0191 | |
| 5760 minute winter | SW19 | 5.002 | SW20 | 1.3 | 0.873 | 0.013 | 0.0309 | |
| 15 minute winter | SW20 | 5.003 | SW21 | 31.7 | 0.897 | 0.955 | 0.2168 | |
| 15 minute winter | SW21 | 5.004 | Ex SW | 31.9 | 1.023 | 0.932 | 0.9944 | 67.9 |

**Results for 100 year +20% CC Critical Storm Duration. Lowest mass balance: 99.88%**

| Node Event | US Node | Peak (mins) | Level (m) | Depth (m) | Inflow (l/s) | Node Vol (m³) | Flood (m³) | Status |
|---|---|---|---|---|---|---|---|---|
| 5760 minute winter | SW01 | 4680 | 120.998 | 1.198 | 7.7 | 12.2248 | 0.0000 | FLOOD RISK |
| 5760 minute winter | SW02 | 4680 | 120.998 | 1.298 | 7.6 | 1.8575 | 0.0000 | OK |
| 15 minute winter | SW04 | 10 | 122.294 | 0.094 | 39.8 | 0.2255 | 0.0000 | OK |
| 15 minute winter | SW05 | 12 | 121.512 | 0.912 | 74.4 | 2.7394 | 0.0000 | SURCHARGED |
| 15 minute winter | SW06 | 12 | 120.600 | 0.424 | 98.5 | 0.4801 | 0.0000 | SURCHARGED |
| 15 minute winter | SW07 | 12 | 120.090 | 0.315 | 97.7 | 0.3567 | 0.0000 | SURCHARGED |
| 5760 minute winter | SW08 | 5340 | 119.769 | 0.769 | 5.6 | 5.8090 | 0.0000 | SURCHARGED |
| 15 minute winter | SW09 | 10 | 121.631 | 0.131 | 32.2 | 0.2972 | 0.0000 | OK |
| 5760 minute winter | SW10 | 5280 | 119.769 | 0.969 | 28.2 | 1.3871 | 0.0000 | SURCHARGED |
| 5760 minute winter | SW11 | 5280 | 119.770 | 1.482 | 66.3 | 2.1212 | 0.0000 | OK |
| 5760 minute winter | SW12 | 5340 | 119.769 | 1.569 | 103.7 | 1.7749 | 0.0000 | SURCHARGED |
| 7200 minute winter | SW13 | 5520 | 119.860 | 1.210 | 8.1 | 16.1084 | 0.0000 | FLOOD RISK |
| 7200 minute winter | SW14 | 5520 | 119.861 | 1.360 | 14.6 | 1.9468 | 0.0000 | SURCHARGED |
| 7200 minute winter | SW15 | 5520 | 119.860 | 1.640 | 24.8 | 2.3475 | 0.0000 | OK |
| 7200 minute winter | SW16 | 5520 | 119.860 | 1.680 | 26.1 | 1.9005 | 0.0000 | FLOOD RISK |
| 5760 minute winter | SW17 | 4680 | 120.998 | 1.298 | 4.4 | 1.4681 | 0.0000 | FLOOD RISK |
| 5760 minute winter | SW18 | 4680 | 119.250 | 0.024 | 1.4 | 0.0277 | 0.0000 | OK |
| 5760 minute winter | SW19 | 4680 | 119.094 | 0.019 | 1.4 | 0.0213 | 0.0000 | OK |
| 15 minute winter | SW20 | 11 | 118.373 | 0.278 | 43.3 | 0.8001 | 0.0000 | SURCHARGED |
| 15 minute winter | SW21 | 11 | 118.311 | 0.241 | 39.7 | 0.2723 | 0.0000 | SURCHARGED |
| 15 minute winter | Ex SW | 11 | 118.097 | 0.167 | 39.6 | 0.0000 | 0.0000 | OK |

| Link Event (Upstream Depth) | US Node | Link | DS Node | Outflow (l/s) | Velocity (m/s) | Flow/Cap | Link Vol (m³) | Discharge Vol (m³) |
|---|---|---|---|---|---|---|---|---|
| 5760 minute winter | SW01 | 9.000 | SW02 | 7.6 | 0.229 | 0.060 | 2.7573 | |
| 5760 minute winter | SW02 | Flow through pond | SW17 | 4.4 | 0.009 | 0.000 | 667.6387 | |
| 15 minute winter | SW04 | 2.000 | SW06 | 39.3 | 2.573 | 0.341 | 0.4559 | |
| 15 minute winter | SW05 | 1.000 | SW06 | 62.4 | 1.570 | 1.526 | 2.2335 | |
| 15 minute winter | SW06 | 1.001 | SW07 | 97.7 | 1.397 | 1.086 | 4.2840 | |
| 15 minute winter | SW07 | 1.002 | SW10 | 97.0 | 1.424 | 1.069 | 1.4710 | |
| 5760 minute winter | SW08 | 3.000 | SW10 | 6.0 | 0.506 | 0.037 | 12.8466 | |
| 15 minute winter | SW09 | 4.000 | SW10 | 31.2 | 1.346 | 0.604 | 0.9449 | |
| 5760 minute winter | SW10 | 1.003 | SW11 | 33.8 | 0.981 | 0.083 | 1.5071 | |
| 5760 minute winter | SW11 | Flow through pond | SW12 | 103.7 | 0.022 | 0.007 | 868.2910 | |
| 5760 minute winter | SW12 | Hydro-Brake® | SW20 | 1.8 | | | | |
| 7200 minute winter | SW13 | 8.000 | SW14 | 7.9 | 0.631 | 0.043 | 7.3643 | |
| 7200 minute winter | SW14 | 8.001 | SW15 | 24.8 | 0.785 | 0.059 | 1.4117 | |
| 7200 minute winter | SW15 | Flow through pond | SW16 | 26.1 | 0.010 | 0.001 | 798.7513 | |
| 7200 minute winter | SW16 | Hydro-Brake® | SW20 | 1.8 | | | | |
| 5760 minute winter | SW17 | Hydro-Brake® | SW18 | 1.4 | | | | |
| 5760 minute winter | SW18 | 5.001 | SW19 | 1.4 | 0.722 | 0.022 | 0.0200 | |
| 5760 minute winter | SW19 | 5.002 | SW20 | 1.4 | 0.893 | 0.014 | 0.0324 | |
| 15 minute winter | SW20 | 5.003 | SW21 | 39.7 | 0.999 | 1.196 | 0.2409 | |
| 15 minute winter | SW21 | 5.004 | Ex SW | 39.6 | 1.053 | 1.158 | 1.1425 | 71.8 |

KAVANAGH BURKE
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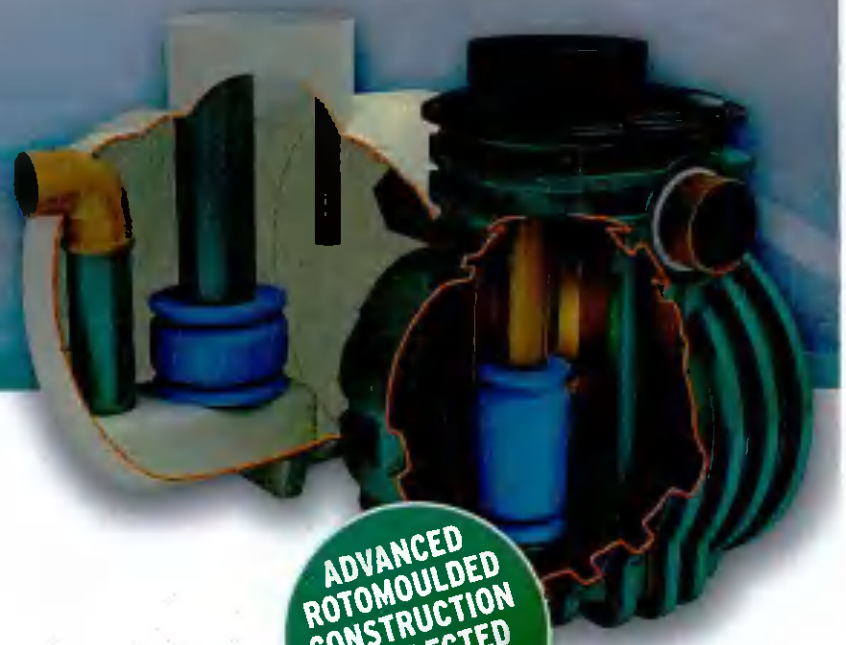
# Appendix to Surface Water Design

- Rainfall table for subject's site
- HR Wallingford Greenfield runoff rate estimation report
- Specification/Product Information for:
  - Separators
  - Silt Trap
  - Flow Control Device
- StormTech Chamber Information Sheets: SC-740™ & MC-3500™

Kingspan Klargester

# SEPARATORS

A RANGE OF FUEL/OIL SEPARATORS FOR PEACE OF MIND



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# Separators

## A RANGE OF FUEL/OIL SEPARATORS FOR PEACE OF MIND

Surface water drains normally discharge to a watercourse or indirectly into underground waters (groundwater) via a soakaway. Contamination of surface water by oil, chemicals or suspended solids can cause these discharges to have a serious impact on the receiving water.

**The Environment Regulators, Environment Agency, England and Wales, SEPA, Scottish Environmental Protection Agency in Scotland and Department of Environment & Heritage in Northern Ireland, have published guidance on surface water disposal, which offers a range of means of dealing with pollution both at source and at the point of discharge from site (so called 'end of pipe' treatment). These techniques are known as 'Sustainable Drainage Systems' (SuDS).**

Where run-off is draining from relatively low risk areas such as car-parks and non-operational areas, a source control approach, such as permeable surfaces or infiltration trenches, may offer a suitable means of treatment, removing the need for a separator.

Oil separators are installed on surface water drainage systems to protect receiving waters from pollution by oil, which may be present due to minor leaks from vehicles and plant, from accidental spillage.

Effluent from industrial processes and vehicle washing should normally be discharged to the foul sewer (subject to the approval of the sewerage undertaker) for further treatment at a municipal treatment works.

### SEPARATOR STANDARDS AND TYPES

A British (and European) standard (EN 858-1 and 858-2) for the design and use of prefabricated oil separators has been adopted. New prefabricated separators should comply with the standard.

### SEPARATOR CLASSES

The standard refers to two 'classes' of separator, based on performance under standard test conditions.

### CLASS I

Designed to achieve a concentration of less than 5mg/l of oil under standard test conditions, should be used when the separator is required to remove very small oil droplets.

### CLASS II

Designed to achieve a concentration of less than 100mg/l oil under standard test conditions and are suitable for dealing with discharges where a lower quality requirement applies (for example where the effluent passes to foul sewer).

Both classes can be produced as full retention or bypass separators. The oil concentration limits of 5 mg/l and 100 mg/l are only applicable under standard test conditions. It should not be expected that separators will comply with these limits when operating under field conditions.

### FULL RETENTION SEPARATORS

Full retention separators treat the full flow that can be delivered by the drainage system, which is normally equivalent to the flow generated by a rainfall intensity of 65mm/hr.

On large sites, some short term flooding may be an acceptable means of limiting the flow rate and hence the size of full retention systems.



### BYPASS SEPARATORS

Bypass separators fully treat all flows generated by rainfall rates of up to 6.5mm/hr. This covers over 99% of all rainfall events. Flows above this rate are allowed to bypass the separator. These separators are used when it is considered an acceptable risk not to provide full treatment for high flows, for example where the risk of a large spillage and heavy rainfall occurring at the same time is small.

### FORECOURT SEPARATORS

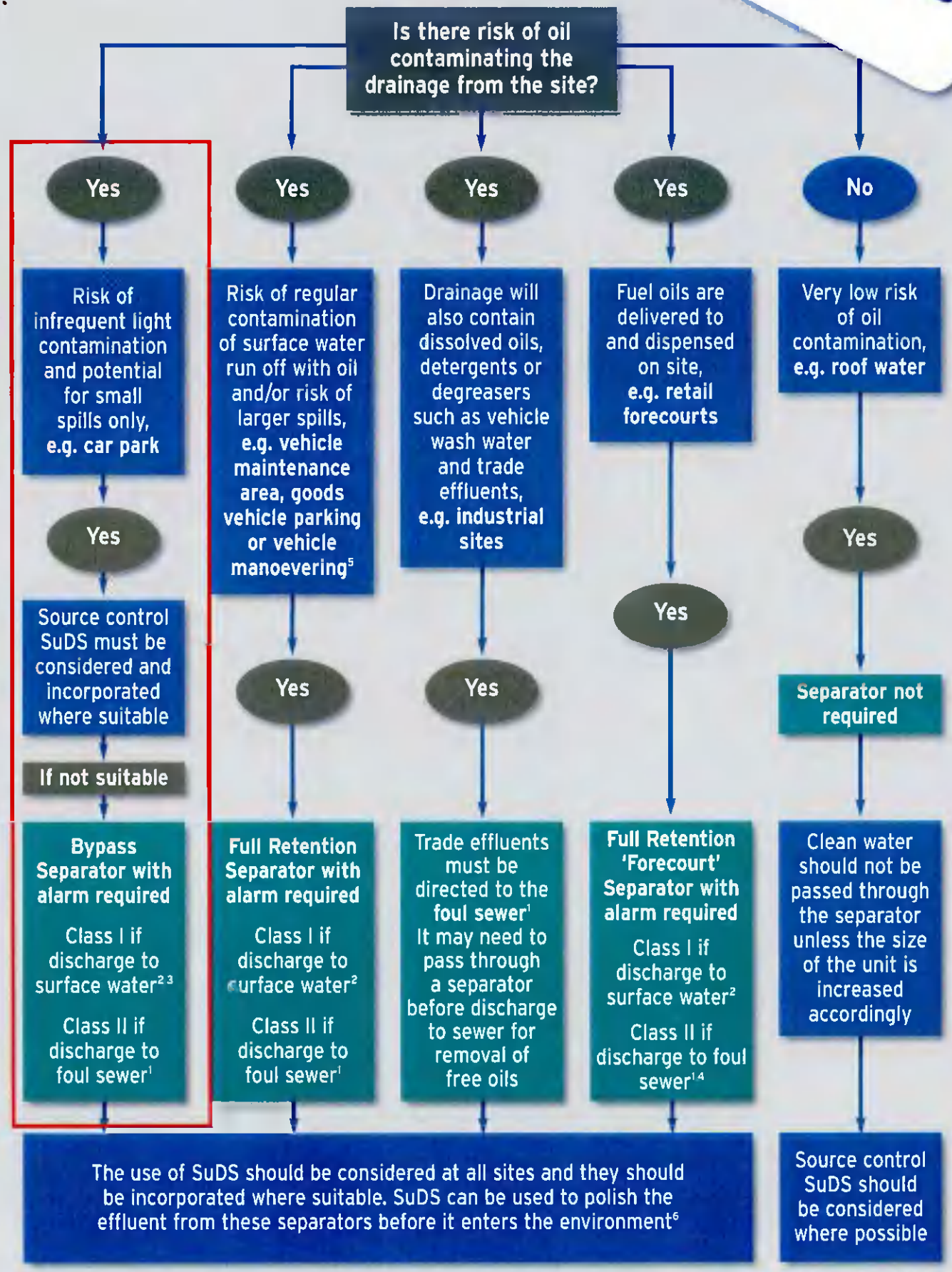
Forecourt separators are full retention separators specified to retain on site the maximum spillage likely to occur on a petrol filling station. They are required for both safety and environmental reasons and will treat spillages occurring during vehicle refuelling and road tanker delivery. The size of the separator is increased in order to retain the possible loss of the contents of one compartment of a road tanker, which may be up to 7,600 litres.

### SELECTING THE RIGHT SEPARATOR

The chart on the following page gives guidance to aid selection of the appropriate type of fuel/oil separator for use in surface water drainage systems which discharge into rivers and soakaways.

For further detailed information, please consult the Environment Agency Pollution Prevention Guideline 03 (PPG 3) 'Use and design of oil separators in surface water drainage systems' available from their website.

Klargester has a specialist team who provide technical assistance in selecting the appropriate separator for your application.




1 *You must seek prior permission from your local sewer provider before you decide which separator to install and before you make any discharge.*
2 *You must seek prior permission from the relevant environmental body before you decide which separator to install.*
3 *In this case, if it is considered that there is a low risk of pollution a source control SuDS scheme may be appropriate.*
4 *In certain circumstances, the sewer provider may require a Class 1 separator for discharges to sewer to prevent explosive atmospheres from being generated.*
5 *Drainage from higher risk areas such as vehicle maintenance yards and goods vehicle parking areas should be connected to foul sewer in preference to surface water.*
6 *In certain circumstances, a separator may be one of the devices used in the SuDS scheme. Ask us for advice.*

# Bypass NSB RANGE

## APPLICATION

Bypass separators are used when it is considered an acceptable risk not to provide full treatment, for very high flows, and are used, for example, where the risk of a large spillage and heavy rainfall occurring at the same time is small, e.g.

- Surface car parks.
- Roadways.
- Lightly contaminated commercial areas.

## PERFORMANCE

Klargester were one of the first UK manufacturers to have separators tested to EN 858-1. Klargester have now added the NSB bypass range to their portfolio of certified and tested models. The NSB number denotes the maximum flow at which the separator treats liquids. The British Standards Institute (BSI) tested the required range of Klargester full retention separators and certified their performance in relation to their flow and process performance assessing the effluent qualities to the requirements of EN 858-1. Klargester bypass separator designs follow the parameters determined during the testing of the required range of bypass separators.

Each bypass separator design includes the necessary volume requirements for:

- Oil separation capacity.
- Silt storage capacity.
- Oil storage volume.
- Coalescer.

The unit is designed to treat 10% of peak flow. The calculated drainage areas served by each separator are indicated according to the formula given by PPG3 NSB = 0.0018A(m2). Flows generated by higher rainfall rates will pass through part of the separator and bypass the main separation chamber.

Class I separators are designed to achieve a concentration of 5mg/litre of oil under standard test conditions.

Class II separators are designed to achieve a concentration of 100mg/litre of oil under standard test conditions.

Advanced rotomoulded construction on selected models
- Compact and robust
- Require less back fill
- Tough, lightweight and easy to handle

## FEATURES

- Light and easy to install.
- Class I and Class II designs.
- Inclusive of silt storage volume.
- Fitted inlet/outlet connectors.
- Vent points within necks.
- Oil alarm system available (required by EN 858-1 and PPG3).
- Extension access shafts for deep inverts.
- Maintenance from ground level.
- GRP or rotomoulded construction (subject to model).

To specify a nominal size bypass separator, the following information is needed:-

- The calculated flow rate for the drainage area served. Our designs are based on the assumption that any interconnecting pipework fitted elsewhere on site does not impede flow into or out of the separator and that the flow is not pumped .
- The required discharge standard. This will decide whether a Class I or Class II unit is required.
- The drain invert inlet depth.
- Pipework type, size and orientation.

## SIZES AND SPECIFICATIONS

| UNIT NOMINAL SIZE | FLOW (l/s) | PEAK FLOW RATE (l/s) | DRAINAGE AREA (m²) | STORAGE CAPACITY (litres) SILT | OIL | UNIT LENGTH (mm) | UNIT DIA. (mm) | ACCESS SHAFT DIA. (mm) | BASE TO INLET INVERT (mm) | BASE TO OUTLET INVERT | STANDARD FALL ACROSS (mm) | MIN. INLET INVERT (mm) | STANDARD PIPEWORK DIA. (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NSBP003 | 3 | 30 | 1670 | 300 | 45 | 1700 | 1350 | 600 | 1420 | 1320 | 100 | 500 | 160 |
| NSBP004 | 4.5 | 45 | 2500 | 450 | 60 | 1700 | 1350 | 600 | 1420 | 1320 | 100 | 500 | 160 |
| NSBP006 | 6 | 60 | 3335 | 600 | 90 | 1700 | 1350 | 600 | 1420 | 1320 | 100 | 500 | 160 |
| NSBE010 | 10 | 100 | 5560 | 1000 | 150 | 2069 | 1220 | 750 | 1450 | 1350 | 100 | 700 | 315 |
| NSBE015 | 15 | 150 | 8335 | 1500 | 225 | 2947 | 1220 | 750 | 1450 | 1350 | 100 | 700 | 315 |
| NSBE020 | 20 | 200 | 11111 | 2000 | 300 | 3893 | 1220 | 750 | 1450 | 1350 | 100 | 700 | 375 |
| NSBE025 | 25 | 250 | 13890 | 2500 | 375 | 3575 | 1420 | 750 | 1680 | 1580 | 100 | 700 | 375 |
| NSBE030 | 30 | 300 | 16670 | 3000 | 450 | 4265 | 1420 | 750 | 1680 | 1580 | 100 | 700 | 450 |
| NSBE040 | 40 | 400 | 22222 | 4000 | 600 | 3230 | 1920 | 600 | 2185 | 2035 | 150 | 1000 | 500 |
| NSBE050 | 50 | 500 | 27778 | 5000 | 750 | 3960 | 1920 | 600 | 2185 | 2035 | 150 | 1000 | 600 |
| NSBE075 | 75 | 750 | 41667 | 7500 | 1125 | 5841 | 1920 | 600 | 2235 | 2035 | 200 | 950 | 675 |
| NSBE100 | 100 | 1000 | 55556 | 10000 | 1500 | 7661 | 1920 | 600 | 2235 | 2035 | 200 | 950 | 750 |
| NSBE125 | 125 | 1250 | 69444 | 12500 | 1875 | 9548 | 1920 | 600 | 2235 | 2035 | 200 | 950 | 750 |

*Rotomoulded chamber construction* *GRP chamber construction* ** Some units have more than one access shaft – diameter of largest shown.*

# Full Retention NSF RANGE

## APPLICATION

Full retention separators are used in high risk spillage areas such as:

- Fuel distribution depots.
- Vehicle workshops.
- Scrap Yards

## PERFORMANCE

Klargester were the first UK manufacturer to have the required range (3-30 l/sec) certified to EN 858-1 in the UK. The NSF number denotes the flow at which the separator operates.

The British Standards Institute (BSI) have witnessed the performance tests of the required range of separators and have certified their performance, in relation to their flow and process performance to ensure that they met the effluent quality requirements of EN 858-1. Larger separator designs have been determined using the formulas extrapolated from the test range.

Each full retention separator design includes the necessary volume requirements for:

- Oil separation capacity.
- Silt storage capacity.
- Automatic closure device.
- Oil storage volume.
- Coalescer (Class I units only).

Klargester full retention separators treat the whole of the specified flow.

## FEATURES

- Light and easy to install.
- Class I and Class II designs.
- 3-30 l/sec range independently tested and performance sampled, certified by the BSI.
- Inclusive of silt storage volume.
- Fitted inlet/outlet connectors.


- Oil alarm system available.
- Vent points within necks.
- Extension access shafts for deep inverts.
- Maintenance from ground level.
- GRP or rotomoulded construction (subject to model).

To specify a nominal size full retention separator, the following information is needed:-

- The calculated flow rate for the drainage area served. Our designs are based on the assumption that any interconnecting pipework fitted elsewhere on site does not impede flow into or out of the separator and that the influent is not pumped.
- The required discharge standard. This will decide whether a Class I or Class II unit is required.
- The drain invert inlet depth.
- Pipework type, size and orientation.

### SIZES AND SPECIFICATIONS

| UNIT NOMINAL SIZE | FLOW (l/s) | DRAINAGE AREA (m²) PPG-3 (0.018) | STORAGE CAPACITY (litres) SILT | OIL | UNIT LENGTH (mm) | UNIT DIA. (mm) | BASE TO INLET INVERT (mm) | BASE TO OUTLET INVERT | MIN. INLET INLET (mm) | STANDARD PIPEWORK DIA. (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| NSFP003 | 3 | 170 | 300 | 30 | 1700 | 1350 | 1420 | 1345 | 500 | 160 |
| NSFP006 | 6 | 335 | 600 | 60 | 1700 | 1350 | 1420 | 1345 | 500 | 160 |
| NSFA010 | 10 | 555 | 1000 | 100 | 2610 | 1225 | 1050 | 1000 | 500 | 200 |
| NSFA015 | 15 | 835 | 1500 | 150 | 3910 | 1225 | 1050 | 1000 | 500 | 200 |
| NSFA020 | 20 | 1115 | 2000 | 200 | 3200 | 2010 | 1810 | 1760 | 1000 | 315 |
| NSFA030 | 30 | 1670 | 3000 | 300 | 3915 | 2010 | 1810 | 1760 | 1000 | 315 |
| NSFA040 | 40 | 2225 | 4000 | 400 | 4640 | 2010 | 1810 | 1760 | 1000 | 315 |
| NSFA050 | 50 | 2780 | 5000 | 500 | 5425 | 2010 | 1810 | 1760 | 1000 | 315 |
| NSFA065 | 65 | 3610 | 6500 | 650 | 6850 | 2010 | 1810 | 1760 | 1000 | 315 |
| NSFA080 | 80 | 4445 | 8000 | 800 | 5744 | 2820 | 2500 | 2450 | 1000 | 300 |
| NSFA100 | 100 | 5560 | 10000 | 1000 | 6200 | 2820 | 2500 | 2450 | 1000 | 400 |
| NSFA125 | 125 | 6945 | 12500 | 1250 | 7365 | 2820 | 2500 | 2450 | 1000 | 450 |
| NSFA150 | 150 | 8335 | 15000 | 1500 | 8675 | 2820 | 2550 | 2450 | 1000 | 525 |
| NSFA175 | 175 | 9725 | 17500 | 1750 | 9975 | 2820 | 2550 | 2450 | 1000 | 525 |
| NSFA200 | 200 | 11110 | 20000 | 2000 | 11280 | 2820 | 2550 | 2450 | 1000 | 600 |

*Rotomoulded chamber construction* *GRP chamber construction*

## PROFESSIONAL INSTALLERS

**Klargester Accredited Installers**
Experience shows that correct installation is a prerequisite for the long-lasting and successful operation of any wastewater treatment product. This is why using an installer with the experience and expertise to install your product is highly recommended.

Services include :

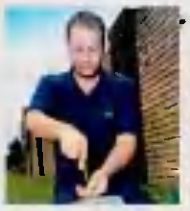
- Site survey to establish ground conditions and soil types
- Advice on system design and product selection
- Assistance on gaining environmental consents and building approvals
- Tank and drainage system installation
- Connection to discharge point and electrical networks
- Waste emptying and disposal

Discover more about the Accredited Installers and locate your local expert online.

**www.klargester.com/installers**

Kingspan Klargester Accredited Installer

## CARE & MAINTENANCE



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Kingspan Klargester

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- **BIODISC®, BIOTEC™ & ENVIROSAFE**
  HIGH PERFORMANCE SEWAGE TREATMENT SYSTEMS
- **HILLMASTER** PACKAGE PUMP STATIONS
- **PUMPSTOR24** PUMPING SYSTEMS
- STORMWATER ATTENUATION SYSTEMS
- OIL/WATER SEPARATORS
- BELOW GROUND STORAGE TANKS
- GREASE & SILT TRAPS

Kingspan Water

## NEW BUILD & RETROFIT SOLUTIONS

- BELOW GROUND RAINWATER HARVESTING SYSTEMS
- ABOVE GROUND RAINWATER HARVESTING SYSTEMS


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Certificate No. FM 563603 Certificate No. OHS 563504




Issue No. 20: August 2014

CDS TECHNOLOGIES

Specialists in Wastewater Treatment & Stormwater Management

# Surface Water Treatment SUDs Protector

**The CDS Non Blocking screening technology is an innovative method of liquid / solid separation for Surface Water, Combined Sewer Overflows (CSO) and Foul Sewage Systems.**

- ***SurfSep*** for Surface Water applications
- ***OverSep*** for Combined Sewer Overflow applications.

The technology accomplishes high efficiency separation of settleable particulate matter and capture of floatable material.

A unique feature of the CDS Technology is it's compact design. Both the *SurfSep* and *OverSep* are available as packaged systems, which can either be installed inside pre-cast concrete chamber rings, or complete BBA Approved Polyethylene Chambers unit.

**Applications**

- Storm-water Treatment
- Combined Sewer Overflow Treatment
- Parking Area Run-Off Treatment
- Vehicle Service Yard Areas
- Pre-treatment for Wetlands, Ponds and Swales
- Rainwater Harvesting
- Pre-treatment for Oil Separators
- Pre-treatment for media and Ground In-filtration Systems

# Rapid installation

## Primary features

- **Effective**: Capturing more than 95% of solid pollutants.
- **Non-Blocking**: Unique design takes advantage of indirect filtration and properly proportioned hydraulic forces that virtually makes the unit unblockable.
- **Non-Mechanical**. The unit has no moving parts and requires no mechanical devices to support the solid separation function
- **Low Maintenance Costs**. The system has no moving parts and is fabricated of durable materials.
- **Compact & Flexible**. Design and size flexibility enables the use of various configurations
- **High Flow Effectiveness**: The technology remains highly effective across a broad spectrum of flow ranges.
- **Assured Pollutant Capture**: All materials captured are retained during high flow conditions.
- **Safe & Easy Pollutant Removal**: Extraction methods allow safe and easy removal of pollutants without manual handling.

## Surface Water System

### Hydraulic Analysis

In storm water applications, an analysis of the catchment in terms of its size, topography and land use will provide information for determining flow to be expected for various return periods.

The *SurfSep* is designed for the flow that mobilizes the gross pollutants within the catchment. Since there are variations in catchment response due to region, land use and topography, it is recommended that the selection of flow to be treated will be for return periods of between 3 months and 1 year.

### Balancing the cost to the operator against the benefits to the environment

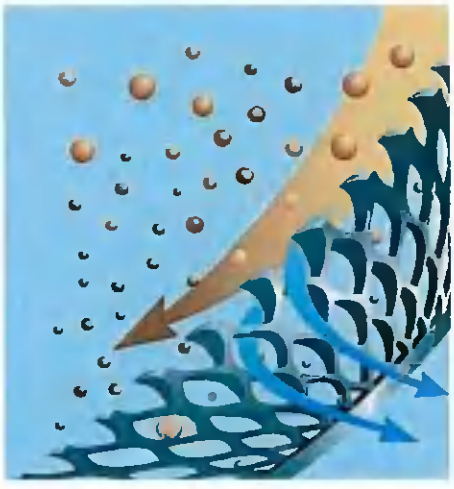
Field evaluations to determine pollutant mobilization have found that the vast majority of pollutants are mobilized in flows that are well below the design capacity for the conveyance facility - typically known as the 'first flush'.

Therefore it is typical not to design the *SurfSep* models to process the conveyance system's maximum flow in order to achieve a very high level of pollutant removal.

The added value benefit to the operator is reduced civil costs without compromising the benefits to the environment.

### How it works

Water and pollutants enter the system and are introduced tangentially inside the separation chamber forming a circular flow motion. Floatables and suspended solids are diverted to the slow moving centre of the flow. Negatively buoyant solids settle out to an undisturbed sump chamber below, while the water passes countercurrently through the separation screen. Floatables remain at the water surface and retained within the screen.



# Surface Water Treatment Systems

## Hydraulic Design

Every application requires a detailed hydraulic analysis to ensure the final installation will perform to effect optimum solids separation without blocking the screen.

After the design flow has been determined, the appropriate standard model can be selected. A selection table is provided on page 7.

## The Ultimate SUDs Protector

There a four principal areas of proprietary SUDs technology;

• Infiltration • Flow Control • Storage/attenuation • Treatment

*SurfSeps*, although a common form of treatment are unique. When installed upstream of any proprietary SUDs technology, the *SurfSep* protects the receiving SUDs from fine solids and debris that would otherwise accumulate over time rendering the SUDs non-operational, as the worst case.

*SurfSeps* have been successfully installed in front of;

- Soakaways
- Infiltration Trenches
- Filters
- Wetlands
- Ponds and Water Features
- Detention and Retention Systems
- Oil Separators
- Create storage storage systems

to remove fine solids and debris that would otherwise accumulate over time reducing the down stream effectiveness of downstream SUDs assets.

Various independent field trials have shown that the *SurfSep* can remove high levels of Phosphates, Heavy Metals and PolyAramatic Hydrocarbons (PAH's) from the flow.

## Infiltration

*SurfSeps* have been successfully installed in front of ground Infiltration systems to remove grit, fine solids and debris which accumulates in and around the SUDs causing visual degradation in the short term and accumulation of silt and grits leading to reduced volume in the long term.

Studies have also shown that Heavy metals & PAH's accumulate within the SUDs over time before being released back to the environment resulting in elevated concentrations.

## Detention & Retention Systems

*SurfSeps* have been successfully installed in front of collection and attenuation SUDs to remove grit, fine solids and debris which accumulates in the SUDs leading to potential blockage of flow regulators resulting in increased Occupational Health & Safety risk during the treatment of blockages and during the periodic cleaning operations.

## Applications

- Rainwater Harvesting
- Road run off
- New Developments
- Motorways
- A / B Roads
- Local Roads
- Residential
- Industrial
- Commercial

## Purpose

Removal of plastics, oil, grit, fine solids, organic and inorganic debris, from point source pollution.

# Flow Control Systems

## Flow Control

Flow control is often required to reduce flooding of downstream sewer networks or receiving water courses. There are a number of ways to achieve this. The Hydroslide - Float controlled. constant flow regulator, as detailed below is ideally suited to the providing an efficient and reliable means of flow control.

There are four types of standard Hydroslide flow regulators as pictured.

1) Mini
2) HydroLimiter
3) VS - Vertical Standard
4) Combi - self flushing, can be mounted on the dry or wet side of the flow chamber.

Most applications can be dealt with using any of the four models to suit the flow. An accuracy of +/-5% is achievable.





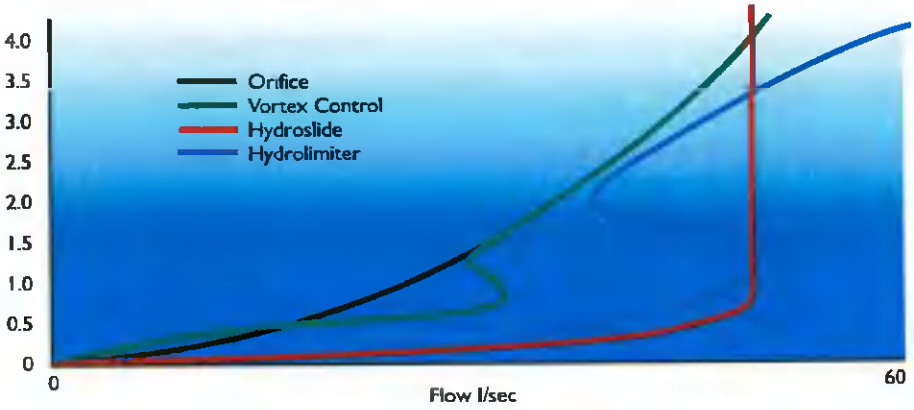

*Typical SurfSep installation*

## Flow Control Technical Design

The Hydroslide regulator does not affect the flow until the flow is approaching the set discharge limit, this allows all flow (the first flush) to be discharged to the sewer. Because the flow to the sewer can be optimised at it's maximum permitted capacity the attentuation/storage capacity can be reduced over other methods of flow control, thus giving cost savings in storage provision. This is best explained by looking at a single storm event and comparing the 3 flow regulation processes as was done independantly by WRc in the report titled 'REDUCING THE COST OF STORMWATER STORAGE', Report No. PT1052, March 1995. The chart below represents 50 l/s control and up to 4m of head. The area difference between the curves being the detention volume saving.

**Typically the volume saving when using a Hydroslide regulator is between 7% to 40%**

**Representation of flow through an orifice**



# Operation & Performance

### Performance Criteria

Note: Screen apertures of 4.8 mm , 2.4 mm and 1.2 mm are available.

The 4.8 and 2.4 mm screens are generally used for Surface Water applications, with foul applications using either 2.4 or 1.2 mm aperture units.

### Typical 1.2 mm aperture Performance

- shall remove all solids with a single dimension greater than 1.2 mm and positively contain those solids until the unit is cleaned.
- shall remove and positively contain 100 percent of all neutrally buoyant particles with a single dimension greater than 1.2 mm for all flow conditions to design capacity.
- shall remove and positively contain 100 percent of all floating trash and debris with a single dimension greater than 1.2 mm for all flow conditions to the design capacity.
- shall remove a minimum of 50 percent of oil and grease (as defined as the floating portion of total hexane extractable materials) for all flow conditions to the design capacity, without the addition of absorbents.
- shall provide the following minimum particle removal efficiencies (based on a specific gravity of 2.65):

a) 100 percent of all particles greater than 1100 microns.

b) 95 percent of all particles greater than 550 microns.

c) 90 percent of all particles greater than 367 microns.

d) 20 percent of all particles greater than 200 microns.

### Maintenance

*SurfSep* maintenance can be site and drainage area specific. The installation should be inspected periodically to assure its condition to handle anticipated runoff. If pollutant loadings are known, then a preventive maintenance schedule can be developed based on runoff volumes processed.

Since this is seldom the case we recommend;

### New Installations

Check the condition of the installation after the first few events. This includes a visual inspection to ascertain that the unit is operating correctly and measuring the amount of deposition that has occurred in the unit. This may be achieved using a 'Dip Stick'.

### Ongoing Operation

For the first 12 months the installations sump full volume should be inspected monthly and recorded. When the inspection indicates that the sump full volume is approaching the top of the sump (base of screen) a cleanout should be undertaken.

### Cleaning Methods

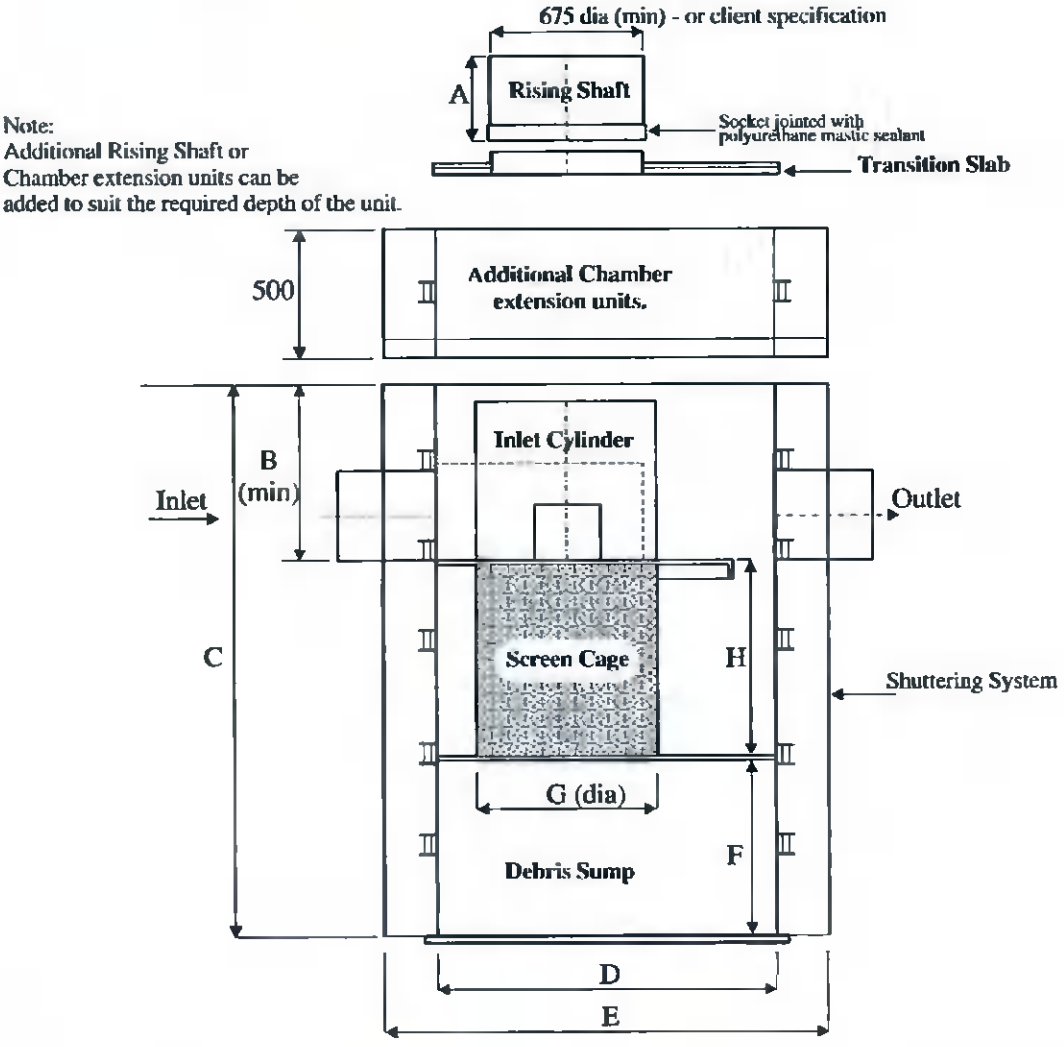
- Eduction (Suction)
- Basket Removal
- Mechanical Grab

### Maintenance Cycle

Minimum once per year. Depending on the pollutant load it may be necessary to maintain the installation more frequently.

The operator shall be able to devise the most efficient maintenance schedule for any particular installation over a 12 month operating cycle.

# *SurfSep* Dimensions




***SurfSep* Dimensions (mm)**

| | SWI0404 | SW0604 | SW0606 | SW0804 | SW0806 | SW0808 | SWI010 | SWI012 | SWI015 |
|---|---|---|---|---|---|---|---|---|---|
| A | 370 | 370 | 370 | 370 | 370 | 370 | 500 | 500 | 500 |
| B | 444 | 815 | 615 | 810 | 830 | 810 | 800 | 800 | 830 |
| C | 1250 | 1985 | 1985 | 2080 | 2300 | 2480 | 2800 | 3000 | 3330 |
| D | 800 | 1200 | 1200 | 1500 | 1500 | 1500 | 2000 | 2000 | 2000 |
| E | 1112 | 1665 | 1665 | 1966 | 1966 | 1966 | 2475 | 2475 | 2475 |
| F | 400 | 700 | 700 | 700 | 700 | 800 | 1000 | 1000 | 1000 |
| G (dia) | 400 | 600 | 600 | 800 | 800 | 800 | 1000 | 1000 | 1000 |
| H | 400 | 400 | 600 | 400 | 600 | 800 | 1000 | 1200 | 1500 |

# Selection Table - *SurfSep*

| Model Reference | Hydraulic Peak Flow Rate l/s | Drainage Area - Impermeable $m^2$ | Chamber Diameter (mm) | Internal Pipe Diameter (mm) |
|---|---|---|---|---|
| SWI 0404 | 30 | 2,000 | 900 | 150 / 225 |
| SWI 0604 | 70 | 5,000 | 1200 | 225 |
| SWI 0606 / 01 | 140 | 10,000 | 1200 | 225 - 375 |
| SWI 0606 / 02 | 200 | 15,000 | 1200 | 225 - 375 |
| SWI 0804 | 275 | 20,000 | 1500 | 300 |
| SWI 0806 | 350 | 25,000 | 1500 | 450 |
| SWI 0808 | 400 | 30,000 | 1500 | 450 |
| SWI 1010 | 480 | 35,000 | 2000 | 450 |
| SWI 1012 | 550 | 40,000 | 2000 | 450 / 750 |
| SWI 1015 | 700 | 50,000 | 2000 | 450 / 750 |

* Proposed Peak Flow Rate for each model calculated using Rational Lloyd Davies with a rainfall intensity of 50mm/hr. For greater flows - special design / construction required.

### In-Line *SurfSep* Units (SWI)

These units are used with in the drainage system in-line and are supplied as BBA Approved complete Polyethylene Chamber units from the selection table above.

### Off-Line *SurfSep* Units (SWO)

These can be designed either using pre-cast concrete or specially designed Polyethylene chambers.

### Model Designation

*SurfSep* models are firstly identified by the letters SW for Surface Water followed by a letter (**I** or **O**) representing the configuration (**I**nline or **O**ffline).

A four digit number representing the screen diameter and screen height then follows to give the standard model designation for a *SurfSep* screen for installation into standard commercially available pre-fabricated manhole chambers i.e SWI 0806. Example: SWI 0806 designates Surface Water Inline with a separation screen dia 0.8 m and screen height of 0.6m.

# Surface Water Treatment

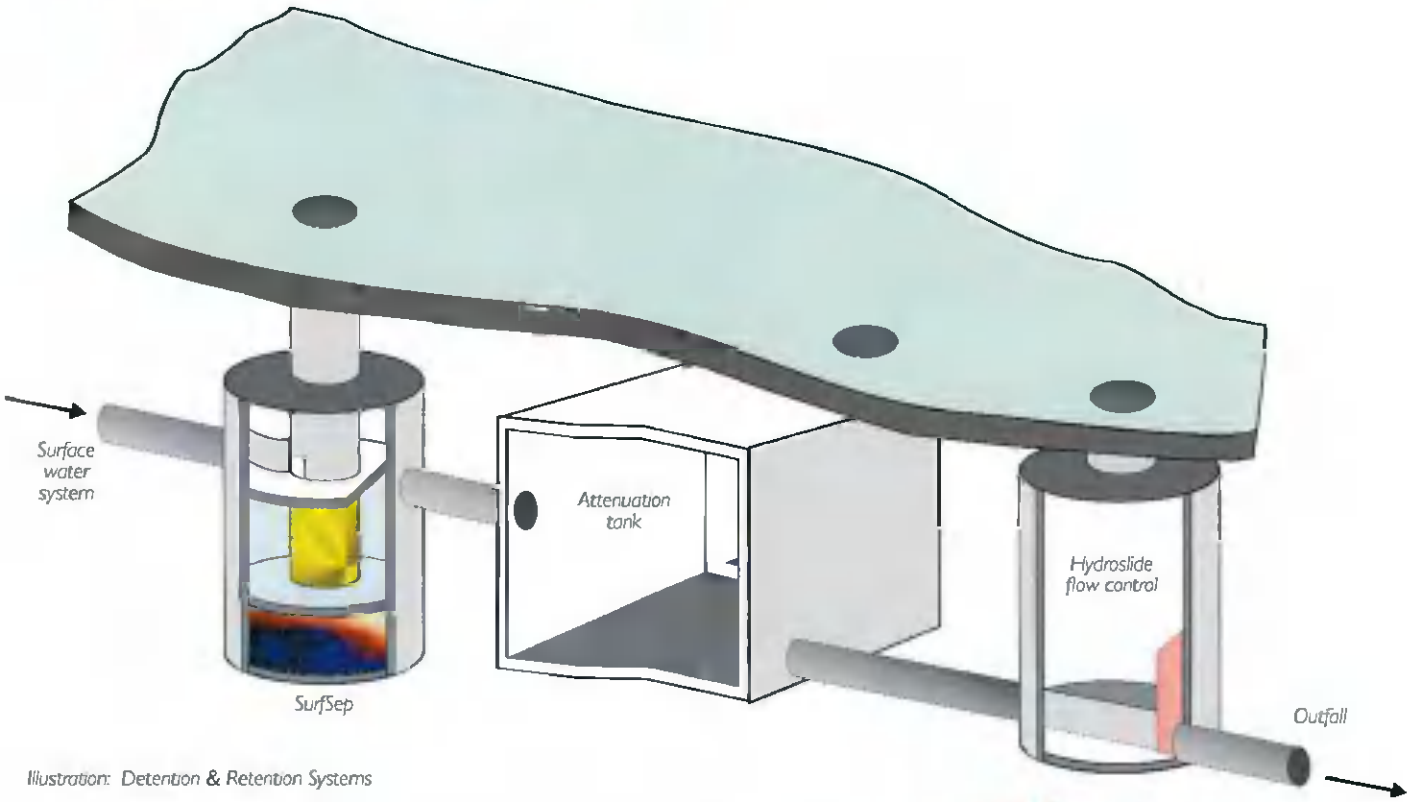



*Illustration: Detention & Retention Systems*

*SurfSeps* unit installed in front of attenuation tank / cellular storage system, to remove grit, fine sediments and floating debris which can accumulate within surface water systems. Hydroslide flow control regulating the discharge to the outfall. The Hydroslide can be supplied for installation in an insitu constructed chamber, or as a complete unit housed within a pre-fabricated polyethylene manhole chamber.

BBA BRITISH BOARD OF AGREEMENT

* BBA - THIS CERTIFICATE RELATES TO PIPEX UNIVERSAL MANHOLES AND ACCESS CHAMBERS, WHICH ARE MANUFACTURED FROM WELDED POLYPROPYLENE This Certificate covers the use of the manholes and chambers for drain and sewer applications where they are used for maintenance to depths of 6 mtrs.

## Approved Suppliers

If you would like more information please contact:

*CDS Technologies is a multi disciplined, international, company offering a comprehensive product range of; wastewater treatment technologies and processes, and stormwater management solutions for attenuation, infiltration, flow control and overflow treatment. CDS have an established network of Distributors and Representatives. Further information can be found on our website www.cdstech.com.au*

*Alternatively please contact our approved supplier detailed left.*

 Issue 1001/100206

# Hydro-Brake® Flow Control

*Modelling Guide*

## Unit Selection Design Guide

### Overview

Hydro-Brake® Flow Controls restrict the flow in surface/storm water or foul/combined sewer systems by inducing a vortex flow pattern in the water passing through the device, having the effect of increasing back-pressure.

Their 'hydrodynamic' rather than 'physical restriction' based operation provides flow regulation whilst maintaining larger clearances than most other types of flow control, making them less susceptible to blockage. Their unique "S"-shaped head-flow characteristic also enables them to pass greater flows at lower heads, which can enable more efficient use of upstream storage facilities.

This document provides guidance relating to the selection and use of Hydro-Brake® Flow Controls for use in surface/storm water and foul/combined sewer systems.

The information provided here is intended for the purposes of general guidance only - individual application requirements may differ. If in doubt, or to enquire about new product additions, please contact HRD Technologies Ltd.

**STH Range of Hydro-Brake® Flow Controls**

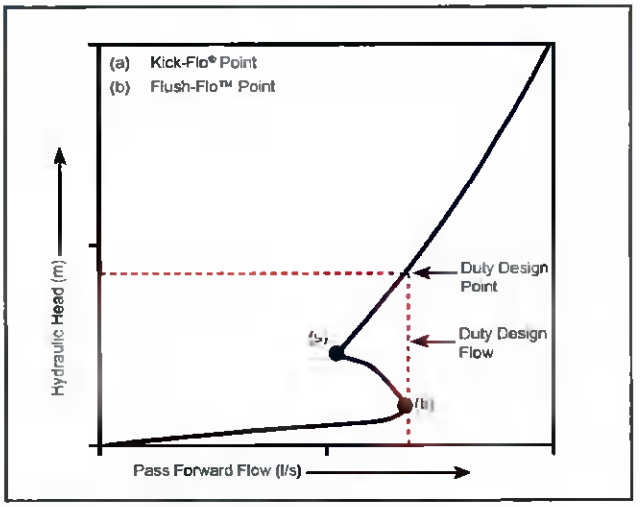
BBA APPROVAL INSPECTION TESTING CERTIFICATION
CERTIFICATE No 08/4599

See back cover for details.

### Hydraulic Characteristics and Specification

Hydro-Brake® Flow Controls should be selected such that the duty/design flow is not exceeded at any point on the head-flow curve, see illustration right. If this is not achievable using the initially selected unit, it may be appropriate to select an alternative option (see selection guidance overleaf).

While the primary aim of a flow control is to provide a particular flow rate at a given upstream head (giving a design/duty point), it is important to note that secondary opportunities, such as potential for optimised storage use, derive from consideration of the full hydraulic characteristic. It is therefore important to ensure that the same flow control, or one confirmed to provide equivalent hydraulic performance, is implemented in any final installation.




Typical Hydro-Brake® Head Versus Flow Characteristics

To ensure correct implementation a multiple design-point specification, defining the main hydraulic features of the selected flow control, can be provided by HRD Technologies Ltd. This should include at least the following information:

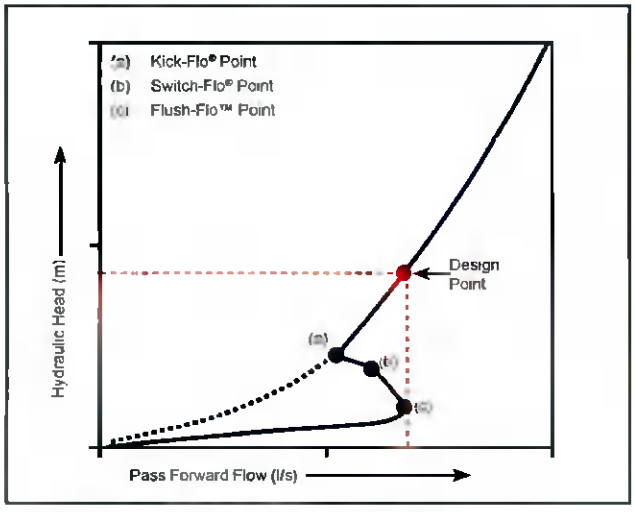
- outlet size and model of Hydro-Brake® Flow Control
- definition of the duty/design point (head and flow)
- definition of the Flush-Flo™ point (head and flow)
- definition of the Kick-Flo® point (head and flow)

To ensure that a drainage system performs as designed, it is strongly recommended that this information is reproduced on any technical specifications.

# STH Type Hydro-Brake® Flow Control with BBA Approval

## Now included in WinDes® W.12.6!

The new STH type Hydro-Brake® Flow Control range has a unique head / discharge performance curve which introduces a very important feature - the Switch-Flo® Point. This point illustrates the unique performance feature of the STH range which can lead to further savings in upstream storage, whilst also enabling increased inlet / outlet size to further reduce the risk of blockage.




Typical STH Head Versus Flow Characteristics

**Kick-Flo® (a)** - the point at which the vortex has initiated and at which the curve begins to return back to follow the orifice curve and reach the same design point or desired head / flow condition.

**NEW Switch-Flo® (b)** - marks the transition between the Kick-Flo® and Flush-Flo™, from vortex initiation to stabilisation. This point adds a new layer of resolution to the Hydro-Brake® curve that has implications to upstream storage savings.

**Flush-Flo™ (c)** - the point at which the vortex begins to initiate and have a throttling effect. This point on the Hydro-Brake® curve is usually much nearer to the maximum design flow (Design Point), than other vortex flow controls leading to more water passing through the unit during the earlier stages of a storm, thus reducing the amount of water that needs to be stored upstream.

BBA APPROVAL INSPECTION TESTING CERTIFICATION
CERTIFICATE No 08/4599

STH Range of
Hydro-Brake® Flow Controls

The STH Hydro-Brake® Flow Control is the only vortex flow control available today that has been given the prestigious BBA Approval Certificate. The BBA assessment procedure entails rigorous assessment of production and manufacturing standards, and confirms that the hydraulic performance of the Hydro-Brake® Flow Control matches the data given to designers by HRD Technologies with their head / discharge curves.

A worked example showing the steps to model a Hydro-Brake® Flow Control and associated Stormcell® Storage System within Micro Drainage WinDes® is available on our website:

**www.hrdtec.com**

### Take a Look at Our New Stormwater Web Resource

Engineering Nature's Way™

**www.engineeringnaturesway.co.uk**

Engineering Nature's Way is a brand new resource for people working with Sustainable Drainage and flood management in the UK.

The site provides an opportunity to share news, opinion, information and best practice for people working in local and central Government; developers, consulting engineers and contractors. Do you have something to share? We would be delighted to receive your contributions.

*turning water around ...®*



HRD Technologies Ltd

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*HRD Technologies Ltd is a subsidiary of Hydro International plc*

# STORMTECH MC-3500 CHAMBER

Designed to meet the most stringent industry performance standards for superior structural integrity while providing designers with a cost-effective method to save valuable land and protect water resources. The StormTech system is designed primarily to be used under parking lots, thus maximizing land usage for private (commercial) and public applications. StormTech chambers can also be used in conjunction with Green Infrastructure, thus enhancing the performance and extending the service life of these practices.

### STORMTECH MC-3500 CHAMBER
(not to scale)

**Nominal Chamber Specifications**

**Size (L x W x H)**
90" x 77" x 45"
2,286 mm x 1,956 mm x 1,143 mm

**Chamber Storage**
109.9 ft³ (3.11 m³)

**Min. Installed Storage***
175.0 ft³ (4.96 m³)

**Weight**
134 lbs (60.8 kg)

**Shipping**
15 chambers/pallet
7 end caps/pallet
7 pallets/truck

*Assumes a minimum of 12" (300 mm) of stone above, 9" (230 mm) of stone below chambers, 6" (150 mm) of stone between chambers/end caps and 40% stone porosity.

### STORMTECH MC-3500 END CAP
(not to scale)

**Nominal End Cap Specifications**

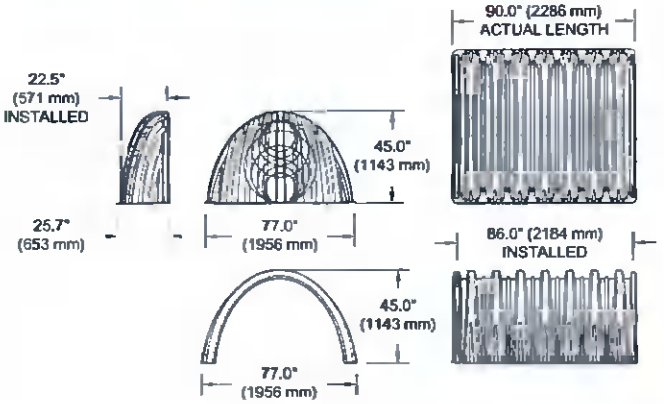
**Size (L x W x H)**
26.5" x 71" x 45.1"
673 mm x 1,803 mm x 1,145 mm

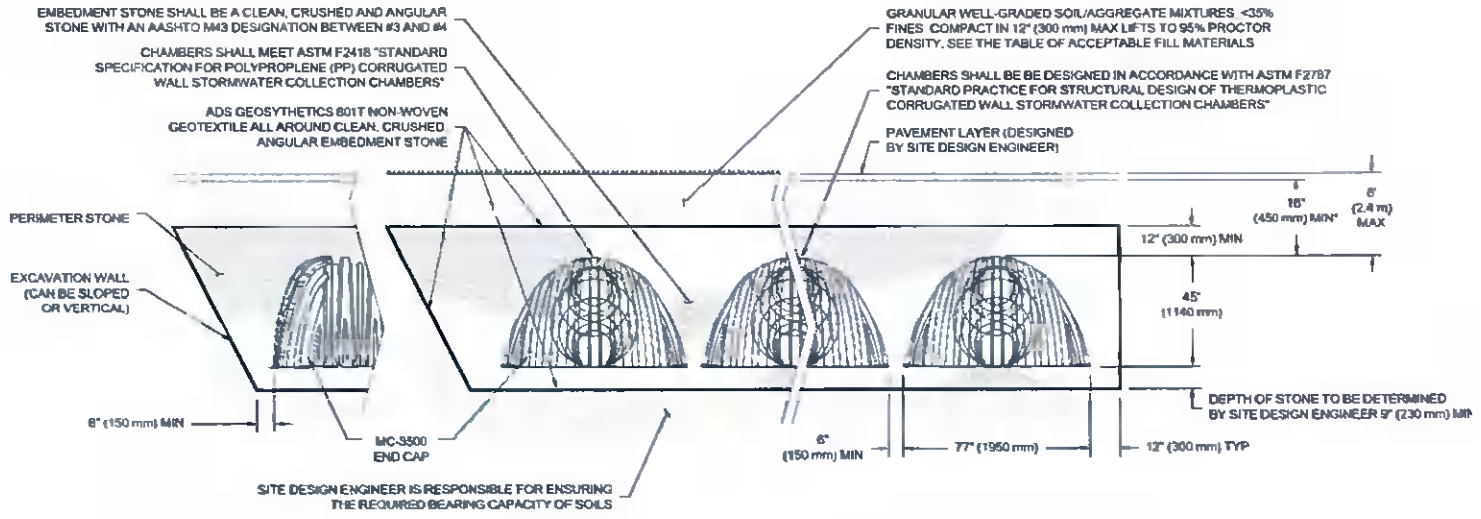
**End Cap Storage**
14.9 ft³ (0.42 m³)

**Min. Installed Storage***
45.1ft³ (1.28 m³)

**Weight**
49 lbs (22.2 kg)

*Assumes a minimum of 12" (300 mm) of stone above, 9" (230 mm) of stone below, 6" (150 mm) of stone perimeter, 6" (150 mm) of stone between chambers/end caps and 40% stone porosity.




*MINIMUM COVER TO BOTTOM OF FLEXIBLE PAVEMENT. FOR UNPAVED INSTALLATIONS WHERE RUTTING FROM VEHICLES MAY OCCUR, INCREASE COVER TO 24" (600 mm).

# MC-3500 CHAMBER SPECIFICATION

## STORAGE VOLUME PER CHAMBER FT³ (M³)

| | Bare Chamber Storage ft³ (m³) | Chamber and Stone Foundation Depth in. (mm) | | | |
|---|---|---|---|---|---|
| | | 9" (230 mm) | 12" (300 mm) | 15" (375 mm) | 18" (450 mm) |
| MC-3500 Chamber | 109.9 (3.11) | 175.0 (4.96) | 179.9 (5.09) | 184.9 (5.24) | 189.9 (5.38) |
| MC-3500 End Cap | 14.9 (.42) | 45.1 (1.28) | 46.6 (1.32) | 48.3 (1.37) | 49.9 (1.41) |

**Note:** Assumes 6" (150 mm) row spacing, 40% stone porosity, 12" (300 mm) stone above and includes the bare chamber/end cap volume.

## AMOUNT OF STONE PER CHAMBER

| ENGLISH TONS (yds³) | Stone Foundation Depth | | | |
|---|---|---|---|---|
| | 9" | 12" | 15" | 18" |
| MC-3500 Chamber | 8.5 (6.0) | 9.1 (6.5) | 9.7 (6.9) | 10.4 (7.4) |
| MC-3500 End Cap | 3.9 (2.8) | 4.1 (2.9) | 4.3 (3.1) | 4.5 (3.2) |
| **METRIC KILOGRAMS (m³)** | **230 mm** | **300 mm** | **375 mm** | **450 mm** |
| MC-3500 Chamber | 7711 (4.6) | 8255 (5.0) | 8800 (5.3) | 9435 (5.7) |
| MC-3500 End Cap | 3538 (2.1) | 3719 (2.2) | 3901 (2.4) | 4082 (2.5) |

**Note:** Assumes 12" (300 mm) of stone above and 6" (150 mm) row spacing and 6" (150 mm) of perimeter stone in front of end caps.

## VOLUME EXCAVATION PER CHAMBER YD³ (M³)

| | Stone Foundation Depth | | | |
|---|---|---|---|---|
| | 9" (230 mm) | 12" (300 mm) | 15" (375mm) | 18" (450 mm) |
| MC-3500 Chamber | 11.9 (9.1) | 12.4 (9.5) | 12.8(9.8) | 13.3 (10.2) |
| MC-3500 End Cap | 4.0 (3.1) | 4.1 (3.2) | 4.3 (3.3) | 4.4 (3.4) |

**Note:** Assumes 6" (150 mm) of separation between chamber rows and 24" (600 mm) of cover. The volume of excavation will vary as depth of cover increases.


**Working on a project?**
**Visit us at www.stormtech.com**
**and utilize the StormTech Design Tool**

**For more information on the StormTech MC-3500 Chamber and other ADS products, please contact our Customer Service Representatives at 1-800-821-6710**

THE MOST ADVANCED NAME IN WATER MANAGEMENT SOLUTIONS®



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1-800-821-6710 www.ads-pipe.com

KAVANAGH BURKE
CONSULTING ENGINEERS

# Discharge Units Calculation

KAVANAGH BURKE
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## INPUT FOR FOUL SEWER NETWORK DESIGN

**Client:** ROCKFACE DEVELOPMENTS LTD
**Project:** WAREHOUSE DEVELOPMENT AT MAGNA ROAD,
CITYWEST BUSINESS CAMPUS,
DUBLIN 24

**Project Ref:** **D1720 PL2 - OFFICE BLOCK & WAREHOUSE TOILET BLOCK**

| Floors | Type of Applience | Discharge Unit per Applience | No of Applie. | Discharge Units |
|---|---|---|---|---|
| **OFFICE/STAFF FACILITIES** | | | | |
| ***GROUND FLOOR PLAN:*** | WB | 0.6 | 11 | 6.6 |
| | WC | 2.5 | 8 | 20.0 |
| | URINAL | 0.8 | 3 | 2.4 |
| | SINK | 1.3 | 1 | 1.3 |
| | DISHWASHER | 0.8 | 1 | 0.8 |
| | SHOWER | 0.6 | 2 | 1.2 |
| | ***TOTAL:*** | | | ***32.3*** |
| ***FIRST FLOOR PLAN:*** | WB | 0.6 | 4 | 2.4 |
| | WC | 2.5 | 4 | 10.0 |
| | URINAL | 0.8 | 1 | 0.8 |
| | SINK | 1.3 | 1 | 1.3 |
| | DISHWASHER | 0.8 | 1 | 0.8 |
| | ***TOTAL:*** | | | ***15.3*** |
| ***SECOND FLOOR PLAN:*** | WB | 0.6 | 4 | 2.4 |
| | WC | 2.5 | 4 | 10.0 |
| | URINAL | 0.8 | 1 | 0.8 |
| | SINK | 1.3 | 1 | 1.3 |
| | DISHWASHER | 0.8 | 1 | 0.8 |
| | ***TOTAL:*** | | | ***15.3*** |
| ***TOTAL NO OF DICHARGE UNITS FOR OFFICE BLOCK 2:*** | | | | ***63*** |
| *Q (l/sec) =* | | | | *5.55* |
| **WAREHOUSE TOILET BLOCK** | | | | |
| ***GROUND FLOOR PLAN:*** | WB | 0.6 | 10 | 6.0 |
| | WC | 2.5 | 6 | 15.0 |
| | URINAL | 0.8 | 5 | 4.0 |
| ***TOTAL NO OF DICHARGE UNITS FOR 1 NO WAREHOUSE TOILET BLOCK:*** | | | | ***25*** |
| *Q (l/sec) =* | | | | *3.50* |

*NOTE:*
*Discharge units calculated as per Table C.2. Typical values of discharge units of BS EN 752-4.*
*Typical frequency factors are taken from Table C.1. ($k_{DU}$=0.7)*
*Design flow rate is given by the equation: $Q = kDU\sqrt{\Sigma DU}$*

KAVANAGH BURKE
CONSULTING ENGINEERS

# Foul Sewer Network Design

## Design Settings

| | | | |
|---|---|---|---|
| Frequency of use (kDU) | 0.70 | Minimum Velocity (m/s) | 0.75 |
| Flow per dwelling per day (l/day) | 2700 | Connection Type | Level Soffits |
| Domestic Flow (l/s/ha) | 0.0 | Minimum Backdrop Height (m) | 0.200 |
| Industrial Flow (l/s/ha) | 0.0 | Preferred Cover Depth (m) | 0.700 |
| Additional Flow (%) | 0 | Include Intermediate Ground | ✓ |

## Nodes

| Name | Units | Cover Level (m) | Manhole Type | Easting (m) | Northing (m) | Depth (m) |
|---|---|---|---|---|---|---|
| FS01 | 35.0 | 123.850 | Adoptable | 705617.736 | 726582.545 | 0.850 |
| FS02 | | 122.650 | Adoptable | 705559.981 | 726579.263 | 0.850 |
| FS03 | | 122.600 | Adoptable | 705524.050 | 726577.280 | 1.040 |
| FS04 | | 122.600 | Adoptable | 705508.812 | 726591.007 | 1.177 |
| FS05 | 16.0 | 122.600 | Adoptable | 705504.524 | 726662.162 | 1.653 |
| FS06 | | 122.600 | Adoptable | 705503.146 | 726687.176 | 1.821 |
| Ex FS | | 122.200 | Adoptable | 705481.760 | 726711.753 | 1.630 |

## Links

| Name | US Node | DS Node | Length (m) | ks (mm) / n | US IL (m) | DS IL (m) | Fall (m) | Slope (1:X) | Dia (mm) |
|---|---|---|---|---|---|---|---|---|---|
| 1.000 | FS01 | FS02 | 57.848 | 1.500 | 123.000 | 121.800 | 1.200 | 48.2 | 150 |
| 1.002 | FS02 | FS03 | 35.986 | 1.500 | 121.800 | 121.560 | 0.240 | 149.9 | 150 |
| 1.003 | FS03 | FS04 | 20.509 | 1.500 | 121.560 | 121.423 | 0.137 | 149.7 | 150 |
| 1.004 | FS04 | FS05 | 71.284 | 1.500 | 121.423 | 120.947 | 0.476 | 149.8 | 150 |
| 1.005 | FS05 | FS06 | 25.052 | 1.500 | 120.947 | 120.779 | 0.168 | 149.1 | 150 |
| 1.006 | FS06 | Ex FS | 32.579 | 1.500 | 120.779 | 120.570 | 0.209 | 155.9 | 150 |

| Name | US Node | DS Node | Cap (l/s) | Flow (l/s) | US Depth (m) | DS Depth (m) | Maximum Depth (m) | Σ Area (ha) | Σ Units (ha) | Σ Add Inflow (ha) | Pro Velocity (m/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.000 | FS01 | FS02 | 22.3 | 4.1 | 0.700 | 0.700 | 0.700 | 0.000 | 35.0 | 0.0 | 0.960 |
| 1.002 | FS02 | FS03 | 12.6 | 4.1 | 0.700 | 0.890 | 0.890 | 0.000 | 35.0 | 0.0 | 0.641 |
| 1.003 | FS03 | FS04 | 12.6 | 4.1 | 0.890 | 1.027 | 1.027 | 0.000 | 35.0 | 0.0 | 0.638 |
| 1.004 | FS04 | FS05 | 12.6 | 4.1 | 1.027 | 1.503 | 1.503 | 0.000 | 35.0 | 0.0 | 0.638 |
| 1.005 | FS05 | FS06 | 12.7 | 5.0 | 1.503 | 1.671 | 1.671 | 0.000 | 51.0 | 0.0 | 0.673 |
| 1.006 | FS06 | Ex FS | 12.4 | 5.0 | 1.671 | 1.480 | 1.671 | 0.000 | 51.0 | 0.0 | 0.663 |