

SuDS Maintenance and Management Plan

Land west of Arundel Road, Angmering

For

GD Group

Rev - P

Reference C1276

Date 4th March 2020

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1. Introduction

CGS Civils Ltd have been appointed to undertake a drainage design using sustainable techniques for a proposed development in Angmering, West Sussex.

The site will consist of the construction of 9 new dwellings. There will be individual driveways as well as visitor parking spaces located along the access road. Root protection zones border the eastern edge of the site. The site falls gradually to the south-west.

2. Sustainable Drainage Systems (SuDS)

The surface water management strategy has been developed using best practice Sustainable Drainage Systems (SuDS) techniques. Guidance on suitable techniques and methods has been obtained from the EA, and the SuDS manual (CIRIA C753).

The National Planning Policy Framework (NPPF) recognises that flood risk and other environmental damage can be managed by minimising changes in the volume and rate of surface runoff from development sites and recommends that priority is given to the use of Sustainable Drainage Systems (SuDS) in new development.

The overall philosophy of SuDS is to replicate, as closely as possible, the natural drainage process of a site prior to development to mitigate the adverse effect of storm water runoff on the environment. SuDS not only provide the ability to control surface water flows, but also improve water quality, amenity and bio-diversity within the development.

The Building Regulations Requirement H3 stipulates that rainwater from roofs and paved areas is carried away from the surface to discharge to one of the following, listed in order of priority:

- 1- Discharge into the ground
- 2- Discharge to a surface water body
- 3- Discharge to a surface water sewer

3. SuDS at Arundel Road

Geotechnical reports carried out on site confirm the sub-strata to be comprised of made ground followed by London Clay Formation which comprises of blue grey silty clay and finally Lambeth Group.

Soakage tests to the BRE 365 method were undertaken on site on August 2018. Testing undertaken proved the ground to be effectively impermeable.

Exploratory Hole	Groundwater Depth (m)		Depth of Borehole at time of test (m)	Stratum	Response Rate (m/sec)
	Start	Finish			
BH01 (within standpipe)	10.60	2.50	12.00	Lambeth Group	9.8×10^{-7}
BH02 (within standpipe)	4.70	4.47	11.50	Lambeth Group	3.6×10^{-8}
BH03 (within standpipe)	3.70	2.39	10.00	London Clay Formation / Lambeth group	9.6×10^{-6}

On 20th January 2020 another set of soakage tests to BRE 365 method were undertaken on site. This series of tests confirmed the ground to be effectively impermeable.

WS	Soakage Area Dimensions (m)	Depth (m)	Soil Description (Base of TP)	Infiltration Rate (m/sec)	Drainage Characteristics
TP01 test1	3.00 x 0.60	1.50	Light brown gravelly sandy CLAY. Sand is fine. Gravel is very occasional, angular of flint.	N/A	Practically Impermeable
TP02 test1	2.50 x 0.80	0.80	Light brown sandy CLAY. Sand is fine.	N/A	Practically Impermeable
TP03 test1	2.55 x 0.66	1.60	Light brown CLAY.	N/A	Practically Impermeable
TP04 test1	3.00 x 0.60	0.90	Light brown CLAY.	N/A	Practically Impermeable
TP05 test1	2.50 x 0.60	1.55	Light brown silty CLAY.	N/A	Practically Impermeable

Based on the above results and due to a lack of any watercourse or surface water sewer, the site will discharge all surface water into a nearby highway drain.

Greenfield runoff calculations have confirmed a QBar rate of 0.7l/s. We therefore propose restricted flows to a minimum of 1.0l/s which is the generally accepted minimum rate.

All driveways are to be constructed with a resin bound permeable surface that will be tanked with fin drains added to allow the water to enter into the main surface water drainage system. These areas will provide primary treatment of any pollutants whilst also providing a modest amount of storage.

The main SuDS feature itself will be in the form of a large cellular storage attenuation tank. Due to the high groundwater it has been necessary to have the tank manufacture design a system to counteract the effects of floatation. The calculations confirm that the tank passes therefore no anchoring or any additional work will be necessary.

Effects of Actions

Destabilising design vertical actions, $V_{d,dst}$ (= $V_{G,dst} \times U_{Gk}$)	2.73 kN/m ²	
Stabilising design vertical actions, $V_{d,stb}$ (= $V_{G,stb} \times W_{Gk}$)	13.89 kN/m ²	
Degree of utilization, Λ_{UPL} (= $V_{d,dst} / V_{d,stb}$)	20 %	< 100%; Passes Check

All SuDS features have been designed to cater for and contain the 1 in 100-year storm + 40%.

4. Managing SuDS

The SuDS have been designed for easy maintenance and comprise:

- Regular day-to-day care – litter collection, regular gardening to control vegetation growth and checking inlets where water enters the SuDS feature
- Occasional tasks – checking the SuDS feature and removing any silt that builds up in the SuDS feature
- Remedial work – repairing damage where necessary

The client will, within the first 6-12 months of construction, form a maintenance company within the structure of the current company and funded by the client to facilitate the maintenance of the drainage system and common areas as per the requirements and specifications within this document. Once the dwellings become occupied, the occupants will pay a fixed annual fee towards this to cover the costs of the maintenance as detailed below.

Should the maintenance company fail to carry out its duties then the maintenance company will be obliged to refund any costs to the occupants and a new company is to be appointed by a representative of the occupants to carry out the maintenance duties. This will be written into the contract.

Once design life has been met on the SuDS features then these will be repaired or replaced in part in accordance with the SuDS maintenance specification in Section 6 or fully replaced in accordance with the respective manufacturer's specifications.

5. Water Quality

The new SuDS Manual (Ciria C753, November 2015) introduces slightly different approach compared to the previous version for the water quality management of surface water. The Manual describes risks posed by the surface water runoff to the receiving environment as a function of:

- The pollution hazard at a particular site (i.e. the pollution source)
- The effectiveness of SuDS treatment components in reducing levels of pollutants to environmentally acceptable levels
- The sensitivity of the receiving environment

The EA website indicates that the site does not lie within a Source Protection Zone.

The recommended approaches for water quality risk management are given in the SuDS Manual Table 26.1.

Figure 7 Approaches to Water Quality Risk Management

TABLE 26.1 Approaches to water quality risk management			
Design method	Hazard characterisation	Risk reduction	
		For surface water	For groundwater
Simple index approach	Simple pollution hazard indices based on land use (eg Table 26.2 or equivalent)	Simple SuDS hazard mitigation indices (eg Table 26.3 or equivalent)	Simple SuDS hazard mitigation indices (eg Table 26.4 or equivalent)
Risk screening ¹	Factors characterising traffic density and extent of infiltration likely to occur (eg Table 26.5 or equivalent)	N/A	Factors characterising unsaturated soil depth and type, and predominant flow type through the soils (eg Table 26.5 or equivalent)
Detailed risk assessment	Site specific information used to define likely pollutants and their significance	More detailed, component specific performance information used to demonstrate that the proposed SuDS components reduce the hazard to acceptable levels	
Process-based treatment modelling	Time series rainfall used with generic pollution characteristics to determine statistical distributions of likely concentrations and loadings in the runoff	Models that represent the treatment processes in the proposed SuDS components give estimates of reductions in event mean discharge concentrations and total annual load reductions delivered by the system	

As per Table 26.1 Simple Index approach will be used as a design method for this site.

Table 26.2 will provide hazard classification of different land uses. The land uses for the surface water drainage for this site are;

- Residential Roofs
- Individual Property driveways
- Low traffic roads

To deliver adequate treatment, the selected SuDS components should have a total pollution mitigation index for each contaminant type that equals or exceeds the pollution hazard index for each contaminant type. Therefore, the following must be achieved for the surface running off the site.

Total SuDS mitigation index $\geq$ pollution hazard index

Pollution Hazard Indices are given for different land uses in Table 26.2 of the SuDS manual;

Figure 8 Pollution Hazard Indices for Different Land Use Classifications

TABLE 26.2 Pollution hazard indices for different land use classifications				
Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways ¹	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways ¹	High	0.8 ²	0.8 ²	0.9 ²

From Table 26.2 the following information is tabulated in Table 4

Table 4: Pollution hazard index and destination of runoff for the proposed site

Land Use	Destination of Runoff	Pollution Hazard Level	Total Suspended Solids	Metals	Hydrocarbons
Residential Roofs	Surface Waters	Very Low	0.2	0.2	0.05
Individual Driveways and low traffic roads	Surface Waters	Low	0.5	0.4	0.4

The SuDS mitigation index will be obtained from Table 26.4 (for surface water) of the SuDS manual.

Figure 9 Indicative SuDS Mitigation Indices for discharges to surface waters

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters				
Type of SuDS component	Mitigation indices¹			
	TSS	Metals	Hydrocarbons	
Filter strip	0.4	0.4	0.5	
Filter drain	0.4 ²	0.4	0.4	
Swale	0.5	0.6	0.6	
Bioretention system	0.8	0.8	0.8	
Permeable pavement	0.7	0.6	0.7	
Detention basin	0.5	0.5	0.6	
Pond ⁴	0.7 ³	0.7	0.5	
Wetland	0.8 ³	0.8	0.8	
Proprietary treatment systems ^{5,6}	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.			

SuDS mitigation index are tabulated in Table 5 as followed;

Runoff Source	Destination of Runoff	Mitigation Index Source	Mitigation Indices			
			Type of SuDS Component	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Individual Driveways	Surface Waters	Table 26.3 (for surface waters)	Permeable Pavement	0.7	0.6	0.7

Table 5: SuDS mitigation index

The above analysis demonstrates that the SuDS devices within the design will mitigate any pollution present within the surface water system.

6. SuDS Drainage Maintenance Specification

6.1. Permeable Paving

In order to maintain the functioning of the permeable paving, the following maintenance requirements should be adhered to:

TABLE 20.15 Operation and maintenance requirements for pervious pavements

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

6.2. Attenuation Tank

In order to maintain the functioning of the attenuation tanks, the following maintenance requirements should be adhered to:

TABLE 21.3 Operation and maintenance requirements for attenuation storage tanks

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

7. General Drainage Maintenance Specification

7.1. Inlet Structures and Inspection Chambers

- Inlet structures such as rain water downpipes, road gullies and channel drains should be free from obstruction at all times to allow free flow through the SuDS.
- Inspection Chambers and rodding eyes are used on bends or where pipes come together. They allow access and cleaning to the system if necessary.

Inlet Structures and Inspection Chambers	
Regular Maintenance	Frequency
Inlet Structures Inspect rainwater downpipes, channel drains and road gullies, removing obstructions and silt as necessary. Check that there is no physical damage. Strim vegetation 1m min surround to structures and keep area free from silt and debris	Monthly
Inspections Chambers and below ground control chambers Remove cover and inspect, ensuring that the water is flowing freely and that the exit route for water is unobstructed. Remove debris and silt. Undertake inspection after leaf fall in Autumn	Annually
Occasional Maintenance Check topsoil levels are 20mm above edges of chambers to avoid mower damage.	As necessary
Remedial Work Repair physical damage if necessary	As required

7.2. Below ground drainage pipes

- Below ground drainage pipes convey water to the SuDS system. They should always be free from obstruction to allow free flow.

Below Ground Drainage Pipes	
Regular Maintenance	Frequency
Inspect and identify any areas that are not operating correctly. If required take remedial action.	Monthly for 3 months then annually
Remove debris from the catchment surface (where it may cause risks to performance)	Monthly
Remove sediment from pre-treatment inlet structures and inspection chambers.	Annually or as required
Maintain vegetation to designed limits within the vicinity of below ground drainage pipes and tanks to avoid	Monthly or as required
Remedial Work	
Repair physical damage if necessary	As required
Monitoring	
Inspect all inlets, outlets and vents to ensure that they are in good conditions and operating as designed.	Annually
Survey inside of pipe runs for sediment build up and remove if necessary.	Every 5 years or as required

7.3. Hydro-Brake Flow Control Chamber

- See Appendix C

Appendix A

Drainage Strategy

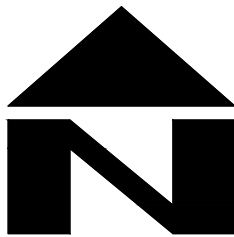
DESIGN SUBJECT TO THE APPROVAL OF:
PLANNING AUTHORITY
BUILDING CONTROL
SOUTHERN WATER
WEST SUSSEX COUNTY COUNCIL

DRAINAGE LEGEND (1:200)
PROPOSED FEATURES

- Storm water sewer/drain
- Fin Drain
- Rain water pipe
- Road Gully
- Storm water inspection chamber (3000)
- Storm water inspection chamber (4500)
- Storm water inspection chamber (6000)
- Storm water manhole
- Storm water vortex flow control chamber
- Geocellular Attenuation Tank
- Tanked porous pavements
- Foul water sewer/drain
- Soil stack (type TBC by architect/m&e engineer)
- Foul water access chamber (3000)
- Foul water inspection chamber (4500)
- Foul water manhole
- Finished floor level
- PIPE INFO - DIAMETER, LENGTH, GRADIENT, BEDDING TYPE
- ABBREVIATIONS
- CP - CATCHPIT
- MH - MANHOLE
- IC - INSPECTION CHAMBER
- AC - ACCESS CHAMBER
- RE - RISING EYE
- IL - INVERT LEVEL
- SL - SUMP LEVEL
- CL - COVER LEVEL
- BD IL 6.15 IL 3.50
- Backdrop
- High level IL
- Low level IL

STANDARD DRAINAGE NOTES

- DO NOT SCALE FROM THIS DRAWING. REFER TO FIGURED DIMENSIONS ONLY. THE CONTRACTOR SHOULD CHECK ALL DIMENSIONS ON SITE.
- ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS ARE IN METERS UNLESS NOTED OTHERWISE.
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ARCHITECT AND ENGINEERING DETAILS, DRAWINGS AND SPECIFICATIONS.
- ANY DISCREPANCIES SHOULD BE REPORTED TO THE ARCHITECT AND/OR ENGINEER IMMEDIATELY. SO THAT CLARIFICATION CAN BE SOUGHT PRIOR TO THE COMMENCEMENT OF WORKS.
- BEFORE COMMENCING CONSTRUCTION THE CONTRACTOR MUST CHECK THE INVERT LEVELS OF EXISTING SEWERS TO WHICH CONNECTIONS ARE MADE. IN ADDITION THE CONTRACTOR MUST LOCATE AND DETERMINE INVERT LEVELS OF THE EXISTING SPURS TO WHICH CONNECTIONS ARE PROPOSED. ANY DISCREPANCIES ARE TO BE NOTIFIED TO THE ENGINEER IMMEDIATELY, PRIOR TO CONSTRUCTION.
- ALL DRAINAGE WORKS SHOULD COMMENCE AT THE PROPOSED DOWNSTREAM CONNECTION POINT. THE WORKS CONTINUING UPSTREAM FOLLOWING CONFIRMATION OF THE TIE-IN INVERT LEVELS TO THE ENGINEER. CONNECTIONS TO MANHOLES OR LARGER SIZED PIPES ETC. SHOULD BE SOFFIT TO SOFFIT UNLESS OTHERWISE INSTRUCTED BY THE ENGINEER. IF THIS IS NOT POSSIBLE INFORM THE ENGINEER IMMEDIATELY.
- COVER LEVELS SHOWN ARE APPROXIMATE. COVERS AND FRAMES SHALL BE SET TO FINISHED GROUND LEVELS AND FALLS.
- ALL UN-REFERENCED PIPES ARE ASSUMED TO BE 100mm DIA
- ALL PIPES TO BE ADOPTED, OR CONNECTING TO ADOPTED SEWERS, TO BE VITRIFIED CLAY TO BS EN 295 AND BS65 (SWS ONLY), OR CONCRETE PIPES TO BE EN 1916 AND BS5911-PART 1.
- ROAD GULLY OUTLET PIPES ARE TO BE 150mm DIA. WITH CONCRETE SURROUND AND FLEXIBLE JOINTS. ALL GULLIES SHALL BE FITTED WITH GRADE D400 GRATINGS AND FRAMES TO BS EN124, UNLESS OTHERWISE STATED.
- ALL ADOPTABLE SEWERS SHALL BE CONSTRUCTED TO THE STANDARDS AND SPECIFICATION LAID DOWN DOWN IN 'SEWERS FOR ADOPTION' 6th EDITION, WITH A VIEW TO ADOPTION UPON COMPLETION OF WORKS.
- ALL PRIVATE DRAINAGE TO BE IN ACCORDANCE WITH THE BUILDING REGULATIONS APPROVED DOCUMENT PART-H AND TO THE SATISFACTION OF THE BUILDING CONTROL INSPECTOR.
- THE CONTRACTOR IS TO KEEP A RECORD OF ANY VARIATIONS MADE ON SITE, INCLUDING THE RELOCATION OF SEWERS OR DRAINS, SO THAT AN AS CONSTRUCTED DRAWING CAN BE PREPARED UPON COMPLETION OF THE PROJECT.
- STUB CONNECTIONS TO ADOPTABLE MANHOLES SHALL BE MADE FROM VITRIFIED CLAY AND CONSIST OF TWO ROCKER PIPES LAID AT THE SAME GRADIENT AS THE UP OR DOWNSTREAM PIPE.
- IF ANY SUB SOIL DRAINAGE SYSTEMS ARE UNCOVERED DURING THE WORKS CONTACT THE ENGINEER FOR INSTRUCTIONS. SUB SOIL DRAINS ARE TO BE DIVERTED AROUND NEW WORKS AND CONNECTED INTO THE SURFACE WATER.
- ALL EXISTING MANHOLE COVERS, GULLIES, ETC. ARE TO BE RAISED/LOWERED TO SUIT NEW LEVELS.



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AT1
Attenuation Tank using Polypropylene
Polypropylene units wrapped in
impermeable geomembrane
39x60x9m DTP
Total 177.84m³ storage for 1 in 100
year + 40% peak storm event
CL 20.350
TOTL 19.597
INC IL 19.297
BOTL 19.797
Min 500mm cover to units
Vent pipe to connect to S5 as per detail

S6
Hydro-Brake
Flow Control Chamber
Restricted to 0.0/s
CL 19.920
IL 19.796 (1000)
IL 18.671 (2250)
SL 18.439
12000 CP
Hydro-Brake Ref No.
CTL-SHE-0044-1000-1226-1000

SW Runoff

Drained site area = 0.2209ha

Cbar = 0.7%

Proposed discharge restricted to
rate of 1/s

Ex HWD MH

CL 18.65

IL 17.41

Existing manhole cover and frame
to be replaced with class D400
Ductile iron of the same size, and
bedded appropriately to the
satisfaction of Arun DC Engineer

New 1500 connection into WSCC

Highway Drain at Soffit level -
Subject to approval from WSCC
and Arun DC

FW Drainage layout downstream
of F11 subject to Southern Water
design under S98 Agreement

BD IL 18.620 IL 17.535

S10 CL 20.120 IL 17.535 4500 IC

F10 CL 19.800 IL 18.450 12000 MH

CL 18.02

SC

TP

T35

RNB

IL 17.80

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

TP

PRELIMINARY

P3	04.03.20	FULL DRAINAGE LAYOUT	LH	CS	CS
P2	17.02.20	UPDATED TO SUIT NEW SITEPLAN	LH	CS	CS
P1	07.01.20	CONNECTION TO HWD INDICATED	LH	CS	CS
P	16.01.20	PRELIMINARY ISSUE	LH	CS	CS
REV	DATE	DESCRIPTION	BY	CHK	APP

Consulting Civil Engineers

CLIENT

GD GROUP

ARCHITECT

CITYZEN

JOB TITLE

ARUNDEL ROAD ANGMERING

DRAWING TITLE

DRAINAGE LAYOUT

DRAWN	ENGINEER	CHECKED	APPROVED
LH	CS	CS	
DATE	NOVEMBER 2019	SCALE @ A1	1:200
JOB NO.	C1276	STATUS	P
DRAWING No.	100	REV.	P3

Appendix B

Surface Water Drainage Calculations

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	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.600
Ratio-R	0.300	Preferred Cover Depth (m)	1.200
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)
S1	0.000	5.00	22.350	450	506703.234	105430.121	0.600
S2	0.038	5.00	22.400	450	506713.315	105429.313	0.755
S3	0.034	5.00	21.850	450	506715.215	105392.830	1.259
S4	0.049	5.00	21.000	600	506713.332	105364.271	0.878
S5	0.051	5.00	20.450	1200	506717.901	105332.597	1.067
AT1	0.000		20.350	1	506737.402	105336.897	1.553
S6	0.036	5.00	19.920	1200	506740.994	105319.027	1.249
S7	0.000	5.00	20.300	450	506706.861	105321.009	0.556
S8	0.015	5.00	20.300	450	506717.726	105322.850	0.701
S9	0.000	5.00	19.700	450	506712.435	105306.423	0.598
S10	0.000		19.920	450	506746.620	105314.833	2.385

Links (Input)

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)
1.000	S1	S2	10.113	0.600	21.750	21.645	0.105	96.3	100	5.22	50.0
1.001	S2	S3	36.532	0.600	21.645	20.591	1.054	34.7	150	5.57	50.0
1.002	S3	S4	28.621	0.600	20.591	20.197	0.394	72.6	150	5.97	50.0
2.000	S4	S5	32.002	0.600	20.122	19.383	0.739	43.3	225	6.24	50.0
2.001	S5	AT1	19.969	0.600	19.383	19.297	0.086	232.2	225	6.63	50.0
2.002	AT1	S6	18.227	0.600	18.797	18.671	0.126	144.7	225	6.91	50.0
3.000	S9	S6	31.217	0.600	19.102	18.796	0.306	102.0	100	5.68	50.0
4.000	S7	S8	11.020	0.600	19.744	19.599	0.145	76.0	100	5.21	50.0
4.001	S8	S5	9.749	0.600	19.599	19.508	0.091	107.1	100	5.43	50.0
5.000	S6	S10	7.017	0.600	18.671	17.535	1.136	6.2	150	6.94	50.0

Simulation Settings

Rainfall Methodology	FSR	Winter CV	0.840
FSR Region	England and Wales	Analysis Speed	Normal
M5-60 (mm)	20.000	Skip Steady State	x
Ratio-R	0.300	Drain Down Time (mins)	240
Summer CV	0.750	Additional Storage (m³/ha)	20.0

Simulation Settings

Check Discharge Rate(s) x | Check Discharge Volume x

Storm Durations

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
30	0	0	0
100	40	0	0

Node S6 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	18.671	Product Number	CTL-SHE-0044-1000-1249-1000
Design Depth (m)	1.249	Min Outlet Diameter (m)	0.075
Design Flow (l/s)	1.0	Min Node Diameter (mm)	1200

Node AT1 Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	18.797
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	234.0	0.0	0.800	234.0	0.0	0.801	0.0	0.0

Node S1 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	21.750	Slope (1:X)	31.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)		Depth (m)	0.400
Safety Factor	2.0	Width (m)	8.600	Inf Depth (m)	
Porosity	0.30	Length (m)	6.000		

Node S3 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	20.591	Slope (1:X)	50.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	4	Depth (m)	0.400
Safety Factor	2.0	Width (m)	5.000	Inf Depth (m)	
Porosity	0.30	Length (m)	10.000		

Node S4 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	20.122	Slope (1:X)	30.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	4	Depth (m)	0.400
Safety Factor	2.0	Width (m)	5.000	Inf Depth (m)	
Porosity	0.30	Length (m)	5.000		

Node S5 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	19.383	Slope (1:X)	30.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	9	Depth (m)	0.400
Safety Factor	2.0	Width (m)	6.000	Inf Depth (m)	
Porosity	0.30	Length (m)	5.300		

Node S5 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	19.383	Slope (1:X)	30.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	8	Depth (m)	0.400
Safety Factor	2.0	Width (m)	6.000	Inf Depth (m)	
Porosity	0.30	Length (m)	7.000		

Node S8 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	19.599	Slope (1:X)	30.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)	90	Depth (m)	0.400
Safety Factor	2.0	Width (m)	8.000	Inf Depth (m)	
Porosity	0.30	Length (m)	7.000		

Node S6 Carpark Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Invert Level (m)	18.671	Slope (1:X)	30.0
Side Inf Coefficient (m/hr)	0.00000	Time to half empty (mins)		Depth (m)	0.400
Safety Factor	2.0	Width (m)	6.000	Inf Depth (m)	
Porosity	0.30	Length (m)	8.500		

Results for 30 year Critical Storm Duration. Lowest mass balance: 99.67%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S1	1	21.750	0.000	0.0	0.0000	0.0000	OK
15 minute winter	S2	10	21.710	0.065	11.9	0.0757	0.0000	OK
15 minute winter	S3	11	20.720	0.129	22.4	0.7202	0.0000	OK
15 minute winter	S4	11	20.226	0.104	35.0	0.3958	0.0000	OK
15 minute winter	S5	13	19.653	0.270	54.1	4.2464	0.0000	SURCHARGED
960 minute winter	AT1	930	19.218	0.421	4.9	93.5115	0.0000	SURCHARGED
960 minute winter	S6	930	19.218	0.547	1.1	4.9065	0.0000	SURCHARGED
15 minute summer	S7	1	19.744	0.000	0.0	0.0000	0.0000	OK
15 minute winter	S8	13	19.675	0.076	4.7	0.2593	0.0000	OK
960 minute winter	S9	930	19.218	0.116	0.0	0.0184	0.0000	SURCHARGED
15 minute summer	S10	1	17.535	0.000	0.7	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)
15 minute summer	S1	1.000	S2	0.0	0.000	0.000	0.0263	
15 minute winter	S2	1.001	S3	11.8	1.058	0.388	0.4233	
15 minute winter	S3	1.002	S4	20.5	1.313	0.984	0.4630	
15 minute winter	S4	2.000	S5	35.0	1.141	0.442	0.9234	
15 minute winter	S5	2.001	AT1	44.4	1.144	1.309	0.7304	
960 minute winter	AT1	2.002	S6	0.8	0.100	0.018	0.7249	
960 minute winter	S6	Hydro-Brake®	S10	0.7				45.6
15 minute summer	S7	4.000	S8	0.0	0.000	0.000	0.0298	
15 minute winter	S8	4.001	S5	4.3	0.741	0.746	0.0693	
960 minute winter	S9	3.000	S6	0.0	-0.008	-0.007	0.2443	

Results for 100 year +40% CC Critical Storm Duration. Lowest mass balance: 99.67%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S1	1	21.750	0.000	0.0	0.0000	0.0000	OK
15 minute winter	S2	10	21.738	0.093	21.6	0.1084	0.0000	OK
15 minute winter	S3	13	20.955	0.364	40.7	4.2301	0.0000	SURCHARGED
15 minute winter	S4	12	20.260	0.138	50.7	0.6275	0.0000	OK
15 minute winter	S5	12	19.891	0.508	79.1	7.6316	0.0000	SURCHARGED
1440 minute winter	AT1	1380	19.858	1.061	6.8	177.9512	0.0000	SURCHARGED
1440 minute winter	S6	1380	19.858	1.187	1.2	6.0003	0.0000	FLOOD RISK
1440 minute winter	S7	1380	19.858	0.114	0.0	0.0182	0.0000	SURCHARGED
1440 minute winter	S8	1380	19.858	0.259	0.5	2.5627	0.0000	SURCHARGED
960 minute winter	S9	885	19.700	0.598	0.1	0.1031	0.0000	FLOOD RISK
15 minute summer	S10	1	17.535	0.000	0.7	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)
15 minute summer	S1	1.000	S2	0.0	0.000	0.000	0.0375	
15 minute winter	S2	1.001	S3	21.4	1.326	0.705	0.5311	
15 minute winter	S3	1.002	S4	24.9	1.412	1.191	0.4955	
15 minute winter	S4	2.000	S5	49.2	1.383	0.621	1.0441	
15 minute winter	S5	2.001	AT1	65.8	1.656	1.940	0.7775	
1440 minute winter	AT1	2.002	S6	0.9	0.103	0.021	0.7249	
1440 minute winter	S6	Hydro-Brake®	S10	1.0				77.0
1440 minute winter	S7	4.000	S8	0.0	0.005	0.005	0.0862	
1440 minute winter	S8	4.001	S5	0.5	0.451	0.088	0.0763	
960 minute winter	S9	3.000	S6	-0.1	-0.018	-0.017	0.2443	

Appendix C

Hydro-Brake maintenance schedule

Hydro International Warranty, Maintenance and COSHH Statement

This statement covers all Hydro International Hydro-Brake Optimum®, Hydro-Brake® and S-Type Vortex Flow Control units (hereafter referred to as "Flow Control")

Defects Liability Period Warranty

The standard Hydro International warranty covers products for one year from date of purchase and will only be considered for those defects or faults reported directly to Hydro International in writing. Warranties will not be considered for defects or faults caused by accident, acts of vandalism or unauthorised repair/rectification. Please contact Hydro International for product specific details.

Maintenance

Normally, little maintenance is required as there are no moving parts within the Flow Control. Experience has shown that if blockages occur they do so at the intake, and the cause on such occasions has been due to a lack of attention to engineering detail such as approach velocities being too low, inadequate benching, or the use of units below the minimum recommended size. The Flow Control (where applicable) is fitted with a pivoting by-pass door, which allows the manhole chamber to be drained down should blockages occur. The smaller type conical units, below the minimum recommended size, are also supplied with rodding facilities or vortex suppressor pipes as standard.

Following installation of the Flow Control it is vitally important that any extraneous material i.e. Building materials are removed from the unit and the chamber. After the system is made live, and assuming that the chamber design is satisfactory, it is recommended that each unit be inspected monthly for three months and thereafter at six monthly intervals with hose down if required. If problems are experienced please do not hesitate to contact the company so that an investigation may be made.

All Flow Controls are typically manufactured from grade 304 Stainless Steel which has an estimated life span in excess of the design life of drainage systems.

COSHH

Flow Controls are manufactured from Stainless Steel, which is not regarded as hazardous to health and exhibits no chemical hazard when used under normal circumstances for the stated applications.

Manual Handling

The handling of Flow Controls should be in accordance with current legislation and regulations:

- The Health and Safety at Work Act 1972.
- The Management of Health and Safety at Work Regulations 1999.
- The Manual Handling Operations Regulations 1992.

All published and printed by the Health and Safety Executive.