PJCE

TECHNICAL NOTE

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Project: 27a West End Lane, London NW6 4QJ	Project No. L2216
Engineer: Vlad Myrsikov	Date: 11 May 2018
Title: SuDS Strategy for Planning	No. L2216-TN-001_Rev02

Planning Application Reference: 2016/5031/P

1 Introduction

Planning Condition 11 sets out the following requirements.

Prior to commencement of the development, full details of the sustainable drainage system shall be submitted to and approved in writing by the local planning authority. Such a system should be designed to accommodate all storms up to and including a 1:100 year storm with a 40% provision for climate change, such that flooding does not occur in any part of a building or in any utility plant susceptible to water, and shall demonstrate maximum run off rate of 5 l/s. Proposed measures shall include:

- Permeable paving (142m2)
- Green roofs (97 m2)
- Planters
- Attenuation tank (3.6m3)

Details shall include a lifetime maintenance plan and shall be thereafter retained and maintained in accordance with the approved details.

2 Surface Water Scheme

The primary requirements set-out in planning condition is to provide a surface water scheme, based on sustainable principles, with maximum discharge rate of 5.0l/s during 1-in-100 year storm, including for +40% climate change.

The existing site is approximately 300m2, covered by a mix of garage roofs and impermeable hard standing pavements, and is 100% impermeable. The site drains to a Thames Water unmapped public sewer that runs through the middle of the site.

Proposed scheme is enclosed in Appendix A and demonstrates site-wide drainage and SuDS elements that have been incorporated into the development. The appropriateness of SuDS measures was established based on non-statutory technical guidance CIRIA The SuDS Manual.

Although planning condition outlines suggestions regarding the type of SuDS to be implemented, such as Green roofs, permeable pavements and attenuation tank, the reality is that these are competing requirements and it is not practical to implement all of the proposed system for practical, access and maintenance reasons.

The following section describes the SuDS elements that have been accessed and fully implemented into the scheme.

Green Roofs
Extensive Green Roofs have been included within the development. Appendix A shown roof and associated Green Roofs. All water falling on the roofs drains down into Green Roof areas, as such, although approximate Green Roof area is 120m^2, for calculation purposes it can be treated as approximately 150m^2 which represents maximum possible for the development.

Permeable paving
Permeable paving has been included into the scheme to maximum possible extent – additional areas could not be included for practical reasons.

Some pavements drain to either permeable pavement or a different SuDS component, and as such could be considered as included within overall SuDS system. The overall proportion of paving that is considered permeable or draining to permeable areas or other SuDS is 93m^2.

Due to type of ground, all permeable pavements are Type C non-infiltrating type system.

Additional areas have been excluded for the following reasons:

- Utility corridors – Where utilities are placed, permeable pavements cannot be used. This is because in the future, when utilities are maintained, permeable pavement would be damaged, causing potential surface water issues and reduce permeable areas.
- Pavement in private gardens – It is not recommended to use permeable pavement in private garden areas as it would not be possible to enforce adequate maintenance or prevent homeowner changing permeable pavement to another type of pavement type in the future. As such it was decided to include regular pavement draining directly to sewer.
- Alternative SuDS – An impermeable paving area of 26m^2 (included in overall figure above) is draining to a small bioretention area, which is also a boundary planter. This provides maintenance advantage and biodiversity benefit.

Planters
Planters have been provided as shown on sketch in Appendix A. One of the planters has been changed from a raised planter to a bioretention area which provides additional sustainability benefits compared to a surface placed planter that could be removed in the future.

Attenuation Tank
Attenuation tank, in the form of permavoid crate system has been included within the development. The outflow is controlled by an orifice plate.

Detailed site-wide calculations, included in Appendix B, which include for green roofs, permeable pavements and unattenuated discharge, demonstrate that total water volume to be stored within Permavoid crates is only 1.7m^2.

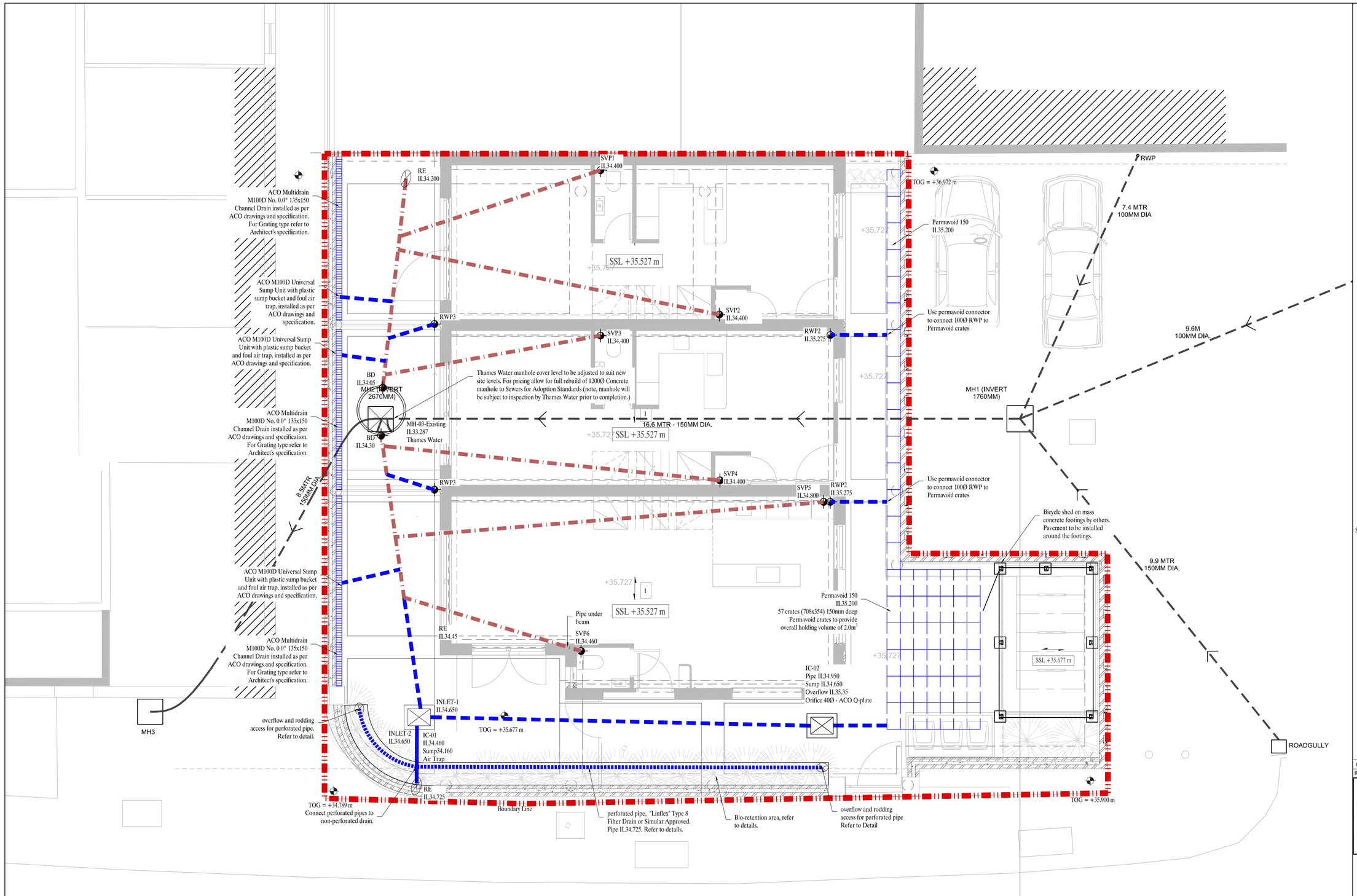
3 Modelling Results

Full Microdrainage calculation results have been included in the Appendix B. These demonstrate that during 1-in-100 year +40% Climate Change scenario the absolute peak discharge rate from the site is only **4.5 l/s**, which is compliant with planning requirements.

Maintenance requirements have been included in Appendix C, and cover outline maintenance for permeable pavements, Green Roofs, Bioretention planter and Orifice Plate and Permavoid attenuation crates.

Appendix A

- L2216-C-52-700 – Site Drainage Layout
- L2216-SK-C-002 – SuDS within the development



Proposed Ground Floor Plan

Scale 1:50

Notes:

1. All dimensions are in millimetres unless otherwise stated.
2. All levels are in metres unless otherwise stated.
3. This drawing should be read in conjunction with all relevant architects, structural engineers and m&e engineers drawings and specification.
4. For setting out of rainwater and foul water drain points refer to architects and M.E.P. drawings.
5. All above ground pipework to MEP specification and design. Refer to MEP package for information. When transitioning materials between above and below ground, use Flexseal flexible drain coupling or other suitable and equivalent coupling.
6. All stacks and rest bends are CAST IRON to BS EN 844.
7. All pipes below building slabs and external to building to be CLAY to BS EN 295
8. All stacks/svp/rwp are 100Ø U.N.O.
9. All pipes are 100Ø unless noted otherwise.
10. All pipes are minimum gradient 1:40 for foul drainage, U.N.O. and 1:60 for storm drainage U.N.O.
11. All drains are to be laid in a constant gradient between manhole chambers.
12. New connection onto existing sewer to be in accordance with Thames Water requirements. Contractor to submit application to Thames Water for permission to connect new building drainage to existing on-site manhole.
13. All buried concrete products and mortars are to contain class 2 sulphate resisting cement.

LEGEND:

- Existing drainage
- Foul water pipe
- Surface water pipe
- Site boundary
- Existing Thames Water Sewer
- Drainage channel
- Inspection Chamber (refer to details for type)
- RWP — RWP stack
- SVP / SS — Soil Vent pipe or Stub Stack
- RE — Rodding eye

TENDER ONLY
NOT FOR CONSTRUCTION

Rev.	Date	Drawn	Amendment
01	10.05.2018	JC	Issued for Tender

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OWNER

GARAGES TO THE SOUTH OF 27A
WEST END LANE, LONDON NW6 4QT

DRAINAGE LAYOUT
GROUND FLOOR PLAN

Status :	TENDER		
Scales :	1:100@A1		Date : Dec. 2017
Drawn :	DA	Engineer : VM	Checked : TF
Drawing No.	L2216-C-52-700		Revision 01

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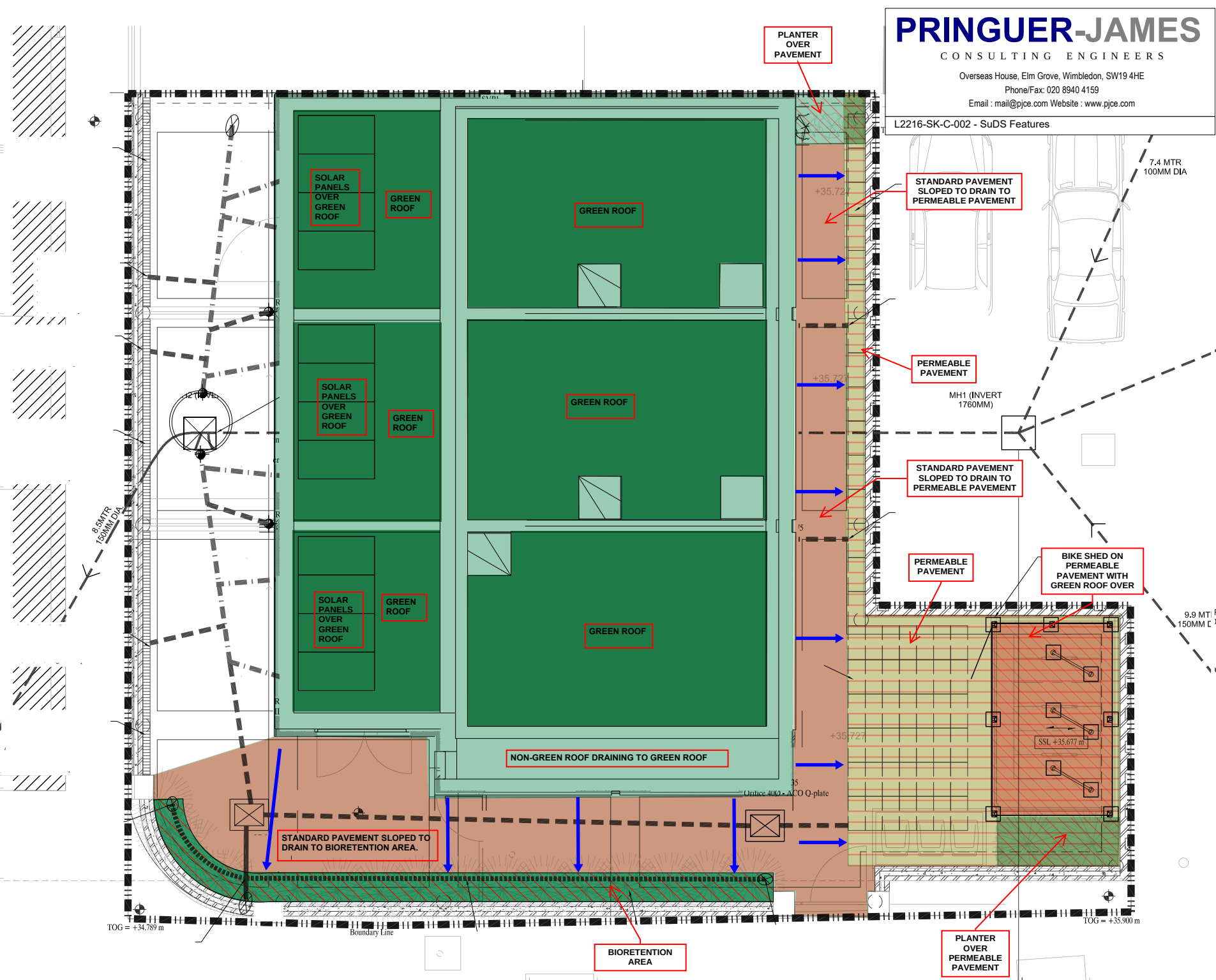
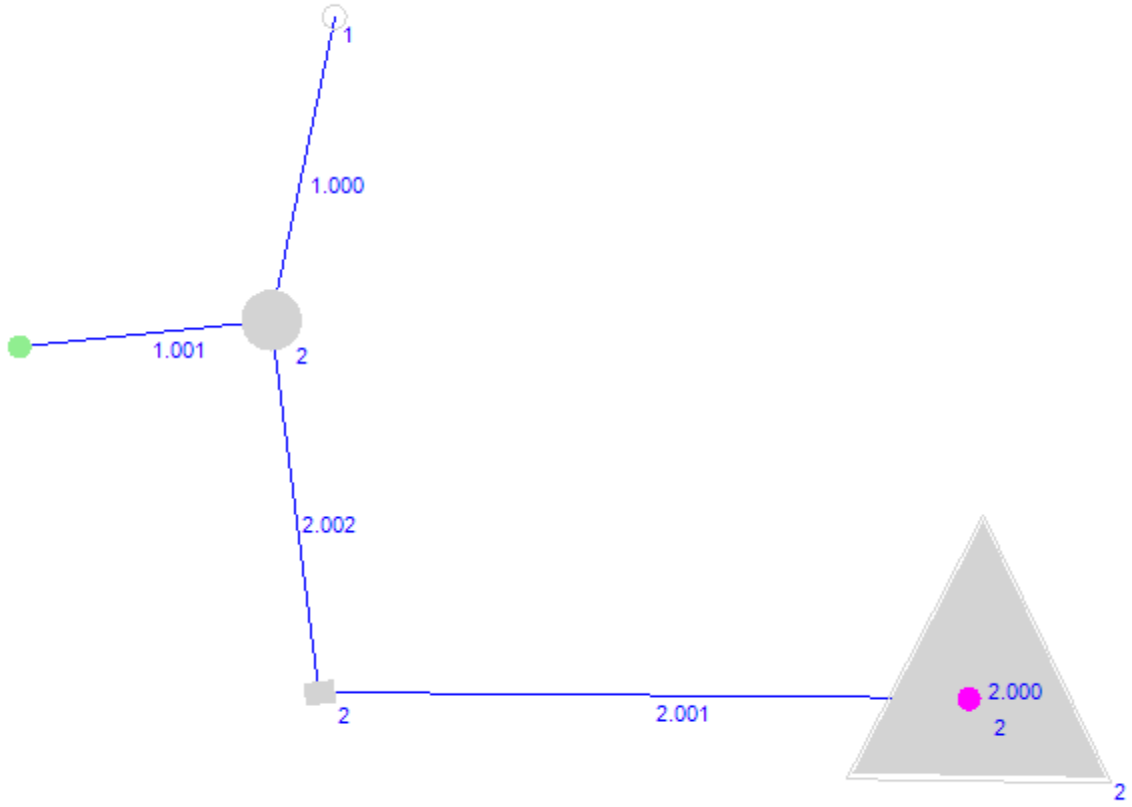
L2216-SK-C-002 - SuDS Features



Appendix B

Microdrainage calculations



STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	100	PIMP (%)	100
M5-60 (mm)	21.000	Add Flow / Climate Change (%)	40
Ratio R	0.436	Minimum Backdrop Height (m)	0.100
Maximum Rainfall (mm/hr)	214	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Inverts

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Foul Sewage per hectare (l/s)	0.000
Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	40.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Run Time (mins)	60
Manhole Headloss Coeff (Global)	0.500	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Storage Structures	1
Number of Online Controls	1	Number of Time/Area Diagrams	7
Number of Offline Controls	0		

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	21.000	Storm Duration (mins)	30
Ratio R	0.436		

Online Controls for Storm

Orifice Manhole: 2, DS/PN: 2.001, Volume (m^3): 0.2

Diameter (m) 0.040 Discharge Coefficient 0.600 Invert Level (m) 34.950

Storage Structures for Storm

Cellular Storage Manhole: 2, DS/PN: 2.000

Invert Level (m) 35.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	14.5	0.0	0.150	14.5	0.0

Time Area Diagram for Green Roof at Pipe Number 1.000 (Storm)

Area (m³) 10 Evaporation (mm/day) 3
Depression Storage (mm) 5 Decay Coefficient 0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000182	32	36	0.000037	64	68	0.000007	96	100	0.000001
4	8	0.000149	36	40	0.000030	68	72	0.000006	100	104	0.000001
8	12	0.000122	40	44	0.000025	72	76	0.000005	104	108	0.000001
12	16	0.000100	44	48	0.000020	76	80	0.000004	108	112	0.000001
16	20	0.000082	48	52	0.000016	80	84	0.000003	112	116	0.000001
20	24	0.000067	52	56	0.000013	84	88	0.000003	116	120	0.000001
24	28	0.000055	56	60	0.000011	88	92	0.000002			
28	32	0.000045	60	64	0.000009	92	96	0.000002			

Time Area Diagram at Pipe Number 1.000 for Storm

Total Area (ha) 0.002

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.001	4	8	0.001

Time Area Diagram for Green Roof at Pipe Number 2.000 (Storm)

Area (m³) 100 Evaporation (mm/day) 3
Depression Storage (mm) 5 Decay Coefficient 0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.001817	24	28	0.000547	48	52	0.000165	72	76	0.000050
4	8	0.001488	28	32	0.000448	52	56	0.000135	76	80	0.000041
8	12	0.001218	32	36	0.000367	56	60	0.000111	80	84	0.000033
12	16	0.000997	36	40	0.000300	60	64	0.000090	84	88	0.000027
16	20	0.000817	40	44	0.000246	64	68	0.000074	88	92	0.000022
20	24	0.000669	44	48	0.000201	68	72	0.000061	92	96	0.000018

Time Area Diagram for Green Roof at Pipe Number 2.000 (Storm)

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
96	100	0.000015	104	108	0.000010	112	116	0.000007			
100	104	0.000012	108	112	0.000008	116	120	0.000006			

Time Area Diagram at Pipe Number 2.000 for Storm

Total Area (ha) 0.006

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.002	4	8	0.002	8	12	0.002

Time Area Diagram for Green Roof at Pipe Number 2.002 (Storm)

Area (m³) 36 Evaporation (mm/day) 3
Depression Storage (mm) 30 Decay Coefficient 0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000654	32	36	0.000132	64	68	0.000027	96	100	0.000005
4	8	0.000536	36	40	0.000108	68	72	0.000022	100	104	0.000004
8	12	0.000439	40	44	0.000089	72	76	0.000018	104	108	0.000004
12	16	0.000359	44	48	0.000072	76	80	0.000015	108	112	0.000003
16	20	0.000294	48	52	0.000059	80	84	0.000012	112	116	0.000002
20	24	0.000241	52	56	0.000049	84	88	0.000010	116	120	0.000002
24	28	0.000197	56	60	0.000040	88	92	0.000008			
28	32	0.000161	60	64	0.000033	92	96	0.000007			

Time Area Diagram for Green Roof at Pipe Number 2.002 (Storm)

Area (m³) 36 Evaporation (mm/day) 3
Depression Storage (mm) 5 Decay Coefficient 0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000654	32	36	0.000132	64	68	0.000027	96	100	0.000005
4	8	0.000536	36	40	0.000108	68	72	0.000022	100	104	0.000004
8	12	0.000439	40	44	0.000089	72	76	0.000018	104	108	0.000004
12	16	0.000359	44	48	0.000072	76	80	0.000015	108	112	0.000003
16	20	0.000294	48	52	0.000059	80	84	0.000012	112	116	0.000002
20	24	0.000241	52	56	0.000049	84	88	0.000010	116	120	0.000002
24	28	0.000197	56	60	0.000040	88	92	0.000008			
28	32	0.000161	60	64	0.000033	92	96	0.000007			

Time Area Diagram at Pipe Number 2.002 for Storm

Total Area (ha) 0.003

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.001	4	8	0.001	8	12	0.001

Summary of Results for 30 minute 100 year Summer (Storm)

Margin for Flood Risk Warning (mm) 10.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

PN	US/MH Name	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status
1.000	1	34.220	-0.080	0.000	0.09		1.1	OK*
2.000	2	35.314	0.014	0.000	0.54		2.1	SURCHARGED*
2.001	2	35.320	0.270	0.000	0.16		1.9	SURCHARGED
2.002	2	34.437	-0.063	0.000	0.29		4.0	OK
1.001	2	33.915	-0.035	0.000	0.72		4.5	OK

Flows and Levels for Pipe 1.000 US/MH 1 (Storm)
30 minute 100 year Summer
Average Rainfall Intensity 69.314 mm/hr

Time (mins)	Upstream Level (m)	Downstream Level (m)	Surcharged Depth (m)	Total O/F (l/s)	Pipe Flow (l/s)
1	34.200	33.850	-0.100	0.0	0.0
2	34.200	33.850	-0.100	0.0	0.0
3	34.200	33.850	-0.100	0.0	0.0
4	34.200	33.850	-0.100	0.0	0.0
5	34.200	33.850	-0.100	0.0	0.0
6	34.200	33.850	-0.100	0.0	0.0
7	34.200	33.850	-0.100	0.0	0.0
8	34.200	33.850	-0.100	0.0	0.0
9	34.200	33.850	-0.100	0.0	0.0
10	34.206	33.850	-0.094	0.0	0.1
11	34.209	33.860	-0.091	0.0	0.2
12	34.211	33.864	-0.089	0.0	0.3
13	34.212	33.866	-0.088	0.0	0.4
14	34.213	33.869	-0.087	0.0	0.5
15	34.215	33.872	-0.085	0.0	0.7
16	34.217	33.875	-0.083	0.0	0.9
17	34.219	33.880	-0.081	0.0	1.0
18	34.220	33.887	-0.080	0.0	1.1
19	34.220	33.892	-0.080	0.0	1.1
20	34.220	33.896	-0.080	0.0	1.1
21	34.219	33.897	-0.081	0.0	1.1
22	34.218	33.896	-0.082	0.0	1.0
23	34.216	33.895	-0.084	0.0	0.9
24	34.214	33.894	-0.086	0.0	0.7
25	34.213	33.915	-0.087	0.0	0.6
26	34.212	33.912	-0.088	0.0	0.5
27	34.211	33.910	-0.089	0.0	0.4
28	34.211	33.908	-0.089	0.0	0.4
29	34.211	33.906	-0.089	0.0	0.3
30	34.210	33.905	-0.090	0.0	0.3
31	34.210	33.904	-0.090	0.0	0.3
32	34.209	33.903	-0.091	0.0	0.3
33	34.208	33.902	-0.092	0.0	0.2
34	34.207	33.900	-0.093	0.0	0.2
35	34.206	33.900	-0.094	0.0	0.2
36	34.205	33.899	-0.095	0.0	0.2
37	34.204	33.898	-0.096	0.0	0.1
38	34.204	33.897	-0.096	0.0	0.1
39	34.203	33.896	-0.097	0.0	0.1
40	34.203	33.895	-0.097	0.0	0.1
41	34.203	33.895	-0.097	0.0	0.1
42	34.203	33.894	-0.097	0.0	0.1
43	34.203	33.894	-0.097	0.0	0.1
44	34.203	33.893	-0.097	0.0	0.1
45	34.203	33.893	-0.097	0.0	0.1
46	34.202	33.893	-0.098	0.0	0.1
47	34.202	33.892	-0.098	0.0	0.1

Flows and Levels for Pipe 2.000 US/MH 2 (Storm)
30 minute 100 year Summer
Average Rainfall Intensity 69.314 mm/hr

Time (mins)	Upstream Level (m)	Downstream Level (m)	Surcharged Depth (m)	Total O/F (l/s)	Pipe Flow (l/s)
1	35.200	34.950	-0.100	0.0	0.0
2	35.200	34.950	-0.100	0.0	0.0
3	35.200	34.950	-0.100	0.0	0.0
4	35.200	34.950	-0.100	0.0	0.0
5	35.200	34.950	-0.100	0.0	0.0
6	35.200	34.950	-0.100	0.0	0.0
7	35.200	34.950	-0.100	0.0	0.0
8	35.200	34.950	-0.100	0.0	0.0
9	35.200	34.950	-0.100	0.0	0.0
10	35.200	34.950	-0.100	0.0	0.0
11	35.200	34.950	-0.100	0.0	0.0
12	35.200	34.950	-0.100	0.0	0.0
13	35.200	34.950	-0.100	0.0	0.0
14	35.200	34.950	-0.100	0.0	0.0
15	35.203	34.950	-0.097	0.0	0.0
16	35.217	34.968	-0.083	0.0	0.1
17	35.230	35.002	-0.070	0.0	0.4
18	35.242	35.055	-0.058	0.0	1.0
19	35.251	35.151	-0.049	0.0	1.6
20	35.259	35.262	-0.041	0.0	2.1
21	35.268	35.271	-0.032	0.0	1.8
22	35.276	35.267	-0.024	0.0	1.8
23	35.284	35.291	-0.016	0.0	2.0
24	35.292	35.280	-0.008	0.0	1.8
25	35.298	35.294	-0.002	0.0	2.0
26	35.304	35.308	0.004	0.0	1.9
27	35.308	35.295	0.008	0.0	1.9
28	35.311	35.318	0.011	0.0	2.1
29	35.313	35.302	0.013	0.0	1.8
30	35.313	35.309	0.013	0.0	2.0
31	35.314	35.317	0.014	0.0	2.0
32	35.313	35.300	0.013	0.0	1.9
33	35.312	35.320	0.012	0.0	2.0
34	35.311	35.301	0.011	0.0	1.8
35	35.309	35.305	0.009	0.0	2.0
36	35.307	35.311	0.007	0.0	1.9
37	35.304	35.291	0.004	0.0	1.8
38	35.301	35.309	0.001	0.0	2.0
39	35.299	35.288	-0.001	0.0	1.8
40	35.294	35.286	-0.006	0.0	1.9
41	35.291	35.296	-0.009	0.0	1.9
42	35.287	35.276	-0.013	0.0	1.8
43	35.283	35.290	-0.017	0.0	1.9
44	35.279	35.274	-0.021	0.0	1.8
45	35.274	35.269	-0.026	0.0	1.8
46	35.270	35.274	-0.030	0.0	1.8
47	35.266	35.255	-0.034	0.0	1.7

Flows and Levels for Pipe 2.001 US/MH 2 (Storm)
30 minute 100 year Summer
Average Rainfall Intensity 69.314 mm/hr

Time (mins)	Upstream Level (m)	Downstream Level (m)	Surcharged Depth (m)	Total O/F (l/s)	Pipe Flow (l/s)
1	34.950	34.400	-0.100	0.0	0.0
2	34.950	34.400	-0.100	0.0	0.0
3	34.950	34.400	-0.100	0.0	0.0
4	34.950	34.400	-0.100	0.0	0.0
5	34.950	34.400	-0.100	0.0	0.0
6	34.950	34.400	-0.100	0.0	0.0
7	34.950	34.400	-0.100	0.0	0.0
8	34.950	34.400	-0.100	0.0	0.0
9	34.950	34.400	-0.100	0.0	0.0
10	34.950	34.400	-0.100	0.0	0.0
11	34.950	34.400	-0.100	0.0	0.0
12	34.950	34.400	-0.100	0.0	0.0
13	34.950	34.400	-0.100	0.0	0.0
14	34.950	34.400	-0.100	0.0	0.0
15	34.950	34.400	-0.100	0.0	0.0
16	34.968	34.401	-0.082	0.0	0.0
17	35.002	34.412	-0.048	0.0	0.2
18	35.055	34.416	0.005	0.0	0.7
19	35.151	34.421	0.101	0.0	1.1
20	35.262	34.423	0.212	0.0	1.5
21	35.271	34.424	0.221	0.0	1.8
22	35.267	34.424	0.217	0.0	1.8
23	35.291	34.424	0.241	0.0	1.8
24	35.280	34.424	0.230	0.0	1.9
25	35.294	34.437	0.244	0.0	1.9
26	35.308	34.437	0.258	0.0	1.9
27	35.295	34.436	0.245	0.0	1.9
28	35.318	34.435	0.268	0.0	1.9
29	35.302	34.434	0.252	0.0	1.9
30	35.309	34.433	0.259	0.0	1.9
31	35.317	34.433	0.267	0.0	1.9
32	35.300	34.432	0.250	0.0	1.9
33	35.320	34.432	0.270	0.0	1.9
34	35.301	34.431	0.251	0.0	1.9
35	35.305	34.431	0.255	0.0	1.9
36	35.311	34.431	0.261	0.0	1.9
37	35.291	34.430	0.241	0.0	1.9
38	35.309	34.430	0.259	0.0	1.9
39	35.288	34.430	0.238	0.0	1.9
40	35.286	34.429	0.236	0.0	1.9
41	35.296	34.429	0.246	0.0	1.9
42	35.276	34.428	0.226	0.0	1.9
43	35.290	34.428	0.240	0.0	1.9
44	35.274	34.428	0.224	0.0	1.9
45	35.269	34.428	0.219	0.0	1.8
46	35.274	34.427	0.224	0.0	1.8
47	35.255	34.427	0.205	0.0	1.8

Flows and Levels for Pipe 2.002 US/MH 2 (Storm)
30 minute 100 year Summer
Average Rainfall Intensity 69.314 mm/hr

Time (mins)	Upstream Level (m)	Downstream Level (m)	Surcharged Depth (m)	Total O/F (l/s)	Pipe Flow (l/s)
1	34.400	33.850	-0.100	0.0	0.0
2	34.400	33.850	-0.100	0.0	0.0
3	34.400	33.850	-0.100	0.0	0.0
4	34.400	33.850	-0.100	0.0	0.0
5	34.400	33.850	-0.100	0.0	0.0
6	34.400	33.850	-0.100	0.0	0.0
7	34.400	33.850	-0.100	0.0	0.0
8	34.400	33.850	-0.100	0.0	0.0
9	34.400	33.850	-0.100	0.0	0.0
10	34.400	33.850	-0.100	0.0	0.0
11	34.400	33.860	-0.100	0.0	0.0
12	34.400	33.864	-0.100	0.0	0.0
13	34.400	33.866	-0.100	0.0	0.0
14	34.400	33.869	-0.100	0.0	0.0
15	34.400	33.872	-0.100	0.0	0.0
16	34.401	33.875	-0.099	0.0	0.0
17	34.412	33.880	-0.088	0.0	0.1
18	34.416	33.887	-0.084	0.0	0.6
19	34.421	33.892	-0.079	0.0	1.0
20	34.423	33.896	-0.077	0.0	1.4
21	34.424	33.897	-0.076	0.0	1.8
22	34.424	33.896	-0.076	0.0	1.8
23	34.424	33.895	-0.076	0.0	1.8
24	34.424	33.894	-0.076	0.0	1.9
25	34.437	33.915	-0.063	0.0	2.9
26	34.437	33.912	-0.063	0.0	4.0
27	34.436	33.910	-0.064	0.0	3.8
28	34.435	33.908	-0.065	0.0	3.7
29	34.434	33.906	-0.066	0.0	3.5
30	34.433	33.905	-0.067	0.0	3.4
31	34.433	33.904	-0.067	0.0	3.3
32	34.432	33.903	-0.068	0.0	3.2
33	34.432	33.902	-0.068	0.0	3.1
34	34.431	33.900	-0.069	0.0	3.0
35	34.431	33.900	-0.069	0.0	2.9
36	34.431	33.899	-0.069	0.0	2.9
37	34.430	33.898	-0.070	0.0	2.8
38	34.430	33.897	-0.070	0.0	2.7
39	34.430	33.896	-0.070	0.0	2.7
40	34.429	33.895	-0.071	0.0	2.6
41	34.429	33.895	-0.071	0.0	2.5
42	34.428	33.894	-0.072	0.0	2.5
43	34.428	33.894	-0.072	0.0	2.4
44	34.428	33.893	-0.072	0.0	2.4
45	34.428	33.893	-0.072	0.0	2.4
46	34.427	33.893	-0.073	0.0	2.3
47	34.427	33.892	-0.073	0.0	2.3

Flows and Levels for Pipe 1.001 US/MH 2 (Storm)
30 minute 100 year Summer
Average Rainfall Intensity 69.314 mm/hr

Time (mins)	Upstream Level (m)	Downstream Level (m)	Surcharged Depth (m)	Total O/F (l/s)	Pipe Flow (l/s)
1	33.850	33.777	-0.100	0.0	0.0
2	33.850	33.777	-0.100	0.0	0.0
3	33.850	33.777	-0.100	0.0	0.0
4	33.850	33.777	-0.100	0.0	0.0
5	33.850	33.777	-0.100	0.0	0.0
6	33.850	33.777	-0.100	0.0	0.0
7	33.850	33.777	-0.100	0.0	0.0
8	33.850	33.777	-0.100	0.0	0.0
9	33.850	33.777	-0.100	0.0	0.0
10	33.850	33.777	-0.100	0.0	0.0
11	33.860	33.777	-0.090	0.0	0.0
12	33.864	33.777	-0.086	0.0	0.2
13	33.866	33.777	-0.084	0.0	0.3
14	33.869	33.777	-0.081	0.0	0.4
15	33.872	33.777	-0.078	0.0	0.6
16	33.875	33.777	-0.075	0.0	0.8
17	33.880	33.777	-0.070	0.0	1.0
18	33.887	33.777	-0.063	0.0	1.4
19	33.892	33.777	-0.058	0.0	2.0
20	33.896	33.777	-0.054	0.0	2.4
21	33.897	33.777	-0.053	0.0	2.8
22	33.896	33.777	-0.054	0.0	2.8
23	33.895	33.777	-0.055	0.0	2.7
24	33.894	33.777	-0.056	0.0	2.6
25	33.915	33.777	-0.035	0.0	2.8
26	33.912	33.777	-0.038	0.0	4.5
27	33.910	33.777	-0.040	0.0	4.3
28	33.908	33.777	-0.042	0.0	4.1
29	33.906	33.777	-0.044	0.0	3.9
30	33.905	33.777	-0.045	0.0	3.8
31	33.904	33.777	-0.046	0.0	3.6
32	33.903	33.777	-0.047	0.0	3.5
33	33.902	33.777	-0.048	0.0	3.4
34	33.900	33.777	-0.050	0.0	3.3
35	33.900	33.777	-0.050	0.0	3.2
36	33.899	33.777	-0.051	0.0	3.1
37	33.898	33.777	-0.052	0.0	3.0
38	33.897	33.777	-0.053	0.0	2.9
39	33.896	33.777	-0.054	0.0	2.8
40	33.895	33.777	-0.055	0.0	2.7
41	33.895	33.777	-0.055	0.0	2.7
42	33.894	33.777	-0.056	0.0	2.6
43	33.894	33.777	-0.056	0.0	2.5
44	33.893	33.777	-0.057	0.0	2.5
45	33.893	33.777	-0.057	0.0	2.5
46	33.893	33.777	-0.057	0.0	2.4
47	33.892	33.777	-0.058	0.0	2.4

Appendix C

Maintenance Plan

- Green Roofs,
- Orifice Plate
- Permeable Pavements,
- Attenuation crates
- Bioretention Planter

Operation and maintenance requirements for Green Roofs

Maintenance Schedule	Required Action	Typical Frequency
Regular inspections	Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes and roof structure for proper operation, integrity of waterproofing and structural stability.	Annually and after severe storms
	Inspect soil substrate for evidence of erosion channels and identify any sediment source	Annually and after severe storms
	Inspect drain inlets to ensure unrestricted run-off from drainage layer to the conveyance or roof drain system	Annually and after severe storms
	Inspect underside of roof for evidence of leaking	Annually and after severe storms
Regular maintenance	Remove debris and litter to prevent clogging of inlet drains and interference with plant growth	Six monthly or as required
	During establishment (i.e. year one), replace dead plants as required	Monthly (but usually the responsibility of the manufacturer)
	Post establishment, replace dead plants as required (where >5% of coverage)	Annually (in autumn)
	Remove fallen leaves and debris from deciduous plant foliage	Six monthly or as required
	Remove nuisance and invasive vegetation, including weeds	Six monthly or as required
	Mow grasses, prune and manage other planting (if appropriate) as required – clipping should be removed and not allowed to accumulate	Six monthly or as required
Remedial action	If erosion channels are evident, these should be stabilised with extra soil substrate similar to the original material, and sources of erosion damage should be identified and controlled	As required
	If drain inlet has settled, cracked or moved, investigate and repair as appropriate	As required.

Operation and maintenance requirements for Orifice Plate flow-control

Maintenance Schedule	Required Action	Typical Frequency
Regular maintenance	No regular maintenance is required, except if fault is identified during routine inspection/monitoring	As required
Remedial action	Repair and/or replace orifice plate	As required
Monitoring	Inspection to check performance, condition of the system and to identify any faults	Every 3 to 6 months

Operation and maintenance requirements for Permeable 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.
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds and management of any weeds in the pavement or adjacent.	As required – once per year on less frequently used pavements
Remedial action	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50mm of the level of the paving	As required
	Rehabilitation of surface and upper structure by remedial sweeping	Every 10 to 15 years or as required (if infiltration performance reduced due to significant clogging)
Monitoring	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth – take remedial action if required.	Three-monthly, 48 hours after large storms in first six months.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually
	Monitor inspection chambers	Annually

Operation and maintenance requirements for Attenuation Tank (Permavoid units)

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
	Remove sediment from pre-treatment structures and/or internal forebays	Annually
	System inspection after heavy storms.	After every major storm.
Remedial actions	Repair/rehabilitate inlets, outlets, 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

Operation and maintenance requirements for bioretention systems.

Maintenance Schedule	Required Action	Typical Frequency
Regular Inspections	Inspect infiltration surface for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain (if appropriate) to determine if maintenance is necessary.	Quarterly
	Check operation of underdrains by inspection of flows after rain.	Annually
	Assess plants for disease infection, poor growth, invasive species etc and replace as necessary.	Quarterly
	Inspect inlets and outlets for blockage.	Quarterly
Regular Maintenance	Remove litter and surface debris and weeds	Quarterly (or more frequently for tidiness and aesthetic reasons)
	Replace any plants, to maintain planting density	As required
	Remove sediment, litter and debris build-up from around inlets or from forebays	Quarterly or biannually
Occasional Maintenance	Infill any holes or scour in the filter medium, improve erosion protection if required	As Required
	Repair minor accumulations of silt by racking away surface mulch, scarifying surface of medium and replacing mulch	As Required
Remedial actions	Remove and Replace filter medium and vegetation above	As required, but likely to be >20 years