STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Surface Network 1

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	2	PIMP (%)	100
M5-60 (mm)	20.400	Add Flow / Climate Change (%)	0
Ratio R	0.350	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	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 Soffits

Time Area Diagram for Surface Network 1

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.202	4-8	0.180

Total Area Contributing (ha) = 0.383

Total Pipe Volume (m³) = 14.409

Network Design Table for Surface Network 1

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.000	8.990	0.599	15.0	0.087	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	11.438	0.763	15.0	0.019	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.002	14.636	0.976	15.0	0.036	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.003	11.003	0.331	33.2	0.033	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.004	30.198	0.134	225.0	0.036	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.005	5.629	0.025	225.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
2.000	17.529	0.240	73.0	0.068	5.00	0.0	0.600	o	225	Pipe/Conduit	
2.001	31.335	2.180	14.4	0.099	0.00	0.0	0.600	o	225	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	5.04	74.449	0.087	0.0	0.0	0.0	3.40	135.0	11.7
1.001	50.00	5.10	73.849	0.106	0.0	0.0	0.0	3.40	135.0	14.3
1.002	50.00	5.17	73.087	0.142	0.0	0.0	0.0	3.40	135.0	19.3
1.003	50.00	5.25	72.111	0.175	0.0	0.0	0.0	2.28	90.5	23.7
1.004	50.00	5.73	71.659	0.211	0.0	0.0	0.0	1.04	73.8	28.6
1.005	50.00	5.82	71.525	0.211	0.0	0.0	0.0	1.04	73.8	28.6
2.000	50.00	5.19	74.870	0.068	0.0	0.0	0.0	1.53	60.9	9.2
2.001	50.00	5.34	74.630	0.167	0.0	0.0	0.0	3.47	138.0	22.6

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Network Design Table for Surface Network 1

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
2.002	13.929	0.885	15.7	0.004	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.006	23.191	0.103	225.2	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	
1.007	19.955	0.089	224.2	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.008	29.224	0.130	225.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.009	5.430	0.018	300.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
2.002	50.00	5.41	72.450	0.171	0.0	0.0	0.0	3.32	131.8	23.2
1.006	50.00	6.11	71.500	0.383	0.0	0.0	0.0	1.35	214.8	51.8
1.007	50.00	6.43	71.397	0.383	0.0	0.0	0.0	1.05	73.9	51.8
1.008	50.00	6.90	71.308	0.383	0.0	0.0	0.0	1.04	73.8	51.8
1.009	50.00	7.00	71.178	0.383	0.0	0.0	0.0	0.90	63.8	51.8

Free Flowing Outfall Details for Surface Network 1

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.009	S17	72.214	71.160	0.000	1350	0

Simulation Criteria for Surface Network 1

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

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

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	2	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.400	Storm Duration (mins)	30
Ratio R	0.350		

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Online Controls for Surface Network 1

Complex Manhole: S18, DS/PN: 1.007, Volume (m³): 10.0

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0077-2400-0800-2400
Design Head (m)	0.800
Design Flow (l/s)	2.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	77
Invert Level (m)	71.397
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	2.4	Kick-Flo®	0.511	2.0
Flush-Flo™	0.240	2.4	Mean Flow over Head Range	-	2.1

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.1	0.800	2.4	2.000	3.7	4.000	5.0	7.000	6.6
0.200	2.4	1.000	2.7	2.200	3.8	4.500	5.3	7.500	6.8
0.300	2.4	1.200	2.9	2.400	4.0	5.000	5.6	8.000	7.0
0.400	2.3	1.400	3.1	2.600	4.1	5.500	5.9	8.500	7.2
0.500	2.0	1.600	3.3	3.000	4.4	6.000	6.1	9.000	7.4
0.600	2.1	1.800	3.5	3.500	4.7	6.500	6.3	9.500	7.6

Hydro-Brake® Optimum

Unit Reference	MD-SHE-0061-1500-0800-1500
Design Head (m)	0.800
Design Flow (l/s)	1.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	61
Invert Level (m)	71.697
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	1.5	Kick-Flo®	0.507	1.2
Flush-Flo™	0.248	1.5	Mean Flow over Head Range	-	1.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum

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Hydro-Brake® Optimum

as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.3	0.800	1.5	2.000	2.3	4.000	3.1	7.000	4.1
0.200	1.5	1.000	1.7	2.200	2.4	4.500	3.3	7.500	4.2
0.300	1.5	1.200	1.8	2.400	2.5	5.000	3.5	8.000	4.3
0.400	1.4	1.400	1.9	2.600	2.6	5.500	3.6	8.500	4.5
0.500	1.2	1.600	2.1	3.000	2.7	6.000	3.8	9.000	4.6
0.600	1.3	1.800	2.2	3.500	2.9	6.500	3.9	9.500	4.7

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Storage Structures for Surface Network 1

Tank or Pond Manhole: S18, DS/PN: 1.007

Invert Level (m) 71.397

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	270.0	0.800	270.0	0.801	0.0

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1 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Surface Network 1

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

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

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 20.000 Cv (Summer) 0.750
Region England and Wales Ratio R 0.400 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)
1.000	S1	15 Winter	1	+0%					74.498	-0.175	0.000
1.001	S2	15 Winter	1	+0%					73.902	-0.172	0.000
1.002	S3	15 Winter	1	+0%	100/15 Winter				73.147	-0.165	0.000
1.003	S4	15 Winter	1	+0%	100/15 Winter				72.195	-0.141	0.000
1.004	S6	15 Winter	1	+0%	30/15 Winter				71.790	-0.169	0.000
1.005	S9	15 Winter	1	+0%	30/15 Winter				71.679	-0.146	0.000
2.000	S10	15 Winter	1	+0%					74.933	-0.162	0.000
2.001	S11	15 Winter	1	+0%					74.691	-0.164	0.000
2.002	S12	15 Winter	1	+0%	100/15 Winter				72.516	-0.159	0.000
1.006	S13	15 Winter	1	+0%	100/15 Winter				71.657	-0.293	0.000
1.007	S18	360 Winter	1	+0%	30/60 Winter				71.556	-0.141	0.000
1.008	S15	360 Winter	1	+0%					71.344	-0.264	0.000
1.009	S16	360 Winter	1	+0%					71.221	-0.257	0.000

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Level Status	Exceeded
1.000	S1	0.11			12.1	OK	
1.001	S2	0.12			14.2	OK	
1.002	S3	0.16			18.4	OK	
1.003	S4	0.29			22.5	OK	
1.004	S6	0.39			26.5	OK	
1.005	S9	0.52			26.3	OK	
2.000	S10	0.17			9.4	OK	
2.001	S11	0.16			21.0	OK	

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1 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Surface Network 1

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
2.002	S12	0.19			21.6	OK	
1.006	S13	0.26			47.0	OK	
1.007	S18	0.04			2.3	OK	
1.008	S15	0.03			2.3	OK	
1.009	S16	0.05			2.3	OK	

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30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Surface Network 1

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

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

Synthetic Rainfall Details

Rainfall Model		FSR M5-60 (mm)	20.000 Cv (Summer) 0.750
Region	England and Wales	Ratio R	0.400 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)
1.000	S1	15 Winter	30	+0%					74.528	-0.145	0.000
1.001	S2	15 Winter	30	+0%					73.937	-0.137	0.000
1.002	S3	15 Winter	30	+0%	100/15 Winter				73.189	-0.123	0.000
1.003	S4	15 Winter	30	+0%	100/15 Winter				72.266	-0.069	0.000
1.004	S6	15 Winter	30	+0%	30/15 Winter				72.027	0.068	0.000
1.005	S9	15 Winter	30	+0%	30/15 Winter				71.871	0.047	0.000
2.000	S10	15 Winter	30	+0%					74.973	-0.122	0.000
2.001	S11	15 Winter	30	+0%					74.738	-0.117	0.000
2.002	S12	15 Winter	30	+0%	100/15 Winter				72.567	-0.108	0.000
1.006	S13	240 Winter	30	+0%	100/15 Winter				71.786	-0.164	0.000
1.007	S18	240 Winter	30	+0%	30/60 Winter				71.784	0.087	0.000
1.008	S15	240 Winter	30	+0%					71.352	-0.256	0.000
1.009	S16	240 Winter	30	+0%					71.234	-0.245	0.000

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	S1	0.27			29.6	OK	
1.001	S2	0.32			36.3	OK	
1.002	S3	0.42			49.3	OK	
1.003	S4	0.80			61.0	OK	
1.004	S6	1.06			71.3	SURCHARGED	
1.005	S9	1.40			70.5	SURCHARGED	
2.000	S10	0.43			23.2	OK	
2.001	S11	0.46			59.2	OK	

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30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Surface Network 1

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
2.002	S12	0.53			60.5	OK	
1.006	S13	0.14			24.2	OK	
1.007	S18	0.06			3.6	SURCHARGED	
1.008	S15	0.05			3.6	OK	
1.009	S16	0.08			3.6	OK	

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100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Surface Network 1

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

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

Synthetic Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	20.000
Region	England and Wales	Ratio R	0.400
Cv (Summer)	0.750		
Cv (Winter)	0.840		

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s)	Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)
1.000	S1	15 Winter	100	+40%					74.561	-0.113	0.000
1.001	S2	15 Winter	100	+40%					73.973	-0.101	0.000
1.002	S3	15 Winter	100	+40%	100/15 Winter				73.651	0.340	0.000
1.003	S4	15 Winter	100	+40%	100/15 Winter				73.189	0.853	0.000
1.004	S6	15 Winter	100	+40%	30/15 Winter				72.625	0.666	0.000
1.005	S9	15 Winter	100	+40%	30/15 Winter				72.201	0.376	0.000
2.000	S10	15 Winter	100	+40%					75.021	-0.074	0.000
2.001	S11	15 Winter	100	+40%					74.789	-0.066	0.000
2.002	S12	15 Winter	100	+40%	100/15 Winter				72.792	0.117	0.000
1.006	S13	360 Winter	100	+40%	100/15 Winter				72.187	0.237	0.000
1.007	S18	360 Winter	100	+40%	30/60 Winter				72.185	0.488	0.000
1.008	S15	960 Winter	100	+40%					71.353	-0.255	0.000
1.009	S16	360 Winter	100	+40%					71.235	-0.243	0.000

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	S1	0.49			53.8	OK	
1.001	S2	0.58			66.0	OK	
1.002	S3	0.70			82.6	SURCHARGED	
1.003	S4	1.29			98.4	FLOOD RISK	
1.004	S6	1.74			116.9	FLOOD RISK	
1.005	S9	2.33			117.7	SURCHARGED	
2.000	S10	0.77			42.1	OK	
2.001	S11	0.83			107.6	OK	

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100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Surface Network 1

PN	US/MH Name	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
2.002	S12	0.94			107.4	SURCHARGED	
1.006	S13	0.18			31.6	SURCHARGED	
1.007	S18	0.06			3.7	SURCHARGED	
1.008	S15	0.06			3.7	OK	
1.009	S16	0.08			3.7	OK	

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