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)	50	PIMP (%)	100
M5-60 (mm)	20.000	Add Flow / Climate Change (%)	0
Ratio R	0.400	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	100	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 Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.843	4-8	0.533

Total Area Contributing (ha) = 1.376

Total Pipe Volume (m³) = 615.347

Network Design Table for Storm

« - Indicates pipe capacity < flow

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	18.120	0.045	402.7	0.150	1.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.001	12.821	0.032	400.7	0.000	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.002	13.746	0.034	404.3	0.077	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.003	28.674	0.173	165.6	0.096	0.00	0.0	0.600	o	1350	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.000	100.00	1.15	97.400	0.150	0.0	0.0	0.0	2.00	2859.8	40.6
S1.001	100.00	1.26	97.355	0.150	0.0	0.0	0.0	2.00	2867.0	40.6
S1.002	100.00	1.37	97.323	0.227	0.0	0.0	0.0	1.99	2854.0	61.5
S1.003	100.00	1.53	97.289	0.323	0.0	0.0	0.0	3.12	4469.0	87.5

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Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S2.000	9.879	0.020	493.9	0.030	1.00	0.0	0.600	o	1350	Pipe/Conduit	
S3.000	6.974	0.014	498.2	0.030	1.00	0.0	0.600	o	1350	Pipe/Conduit	
S2.001	5.891	0.012	500.0	0.000	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S2.002	11.069	0.022	500.0	0.035	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S2.003	13.090	0.126	103.7	0.049	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.004	22.393	0.056	400.0	0.017	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.005	21.762	0.054	400.0	0.094	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.006	22.960	0.102	225.0	0.000	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S4.000	24.662	0.123	200.0	0.037	1.00	0.0	0.600	o	1350	Pipe/Conduit	
S4.001	10.751	0.027	398.2	0.047	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S4.002	11.002	0.028	392.9	0.049	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S4.003	29.418	0.059	500.0	0.051	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S4.004	19.124	0.038	500.0	0.078	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.007	22.228	0.030	750.0	0.054	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.008	36.136	0.048	750.0	0.089	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.009	52.323	0.070	750.0	0.139	0.00	0.0	0.600	o	1350	Pipe/Conduit	
S1.010	10.528	0.035	300.0	0.256	0.00	0.0	0.600	o	375	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S2.000	100.00	1.09	97.463	0.030	0.0	0.0	0.0	1.80	2580.3	8.1
S3.000	100.00	1.06	97.290	0.030	0.0	0.0	0.0	1.79	2569.3	8.1
S2.001	100.00	1.15	97.276	0.060	0.0	0.0	0.0	1.79	2564.5	16.2
S2.002	100.00	1.25	97.264	0.095	0.0	0.0	0.0	1.79	2564.5	25.7
S2.003	100.00	1.30	97.242	0.144	0.0	0.0	0.0	3.95	5652.0	39.0
S1.004	100.00	1.71	97.116	0.484	0.0	0.0	0.0	2.00	2869.3	131.0
S1.005	100.00	1.89	97.060	0.578	0.0	0.0	0.0	2.00	2869.4	156.6
S1.006	100.00	2.04	97.006	0.578	0.0	0.0	0.0	2.68	3831.9	156.6
S4.000	100.00	1.14	97.300	0.037	0.0	0.0	0.0	2.84	4065.4	9.9
S4.001	100.00	1.23	97.177	0.083	0.0	0.0	0.0	2.01	2875.9	22.5
S4.002	100.00	1.32	97.150	0.132	0.0	0.0	0.0	2.02	2895.2	35.8
S4.003	100.00	1.60	97.122	0.183	0.0	0.0	0.0	1.79	2564.5	49.6
S4.004	100.00	1.78	97.124	0.261	0.0	0.0	0.0	1.79	2564.5	70.6
S1.007	100.00	2.29	96.903	0.893	0.0	0.0	0.0	1.46	2090.6	241.8
S1.008	100.00	2.70	96.874	0.981	0.0	0.0	0.0	1.46	2090.6	265.8
S1.009	100.00	3.30	96.826	1.120	0.0	0.0	0.0	1.46	2090.6	303.3
S1.010	100.00	3.47	96.756	1.376	0.0	0.0	0.0	1.04	115.0«	372.6

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Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.011	13.272	0.087	152.6	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
S1.012	45.429	0.227	200.1	0.000	0.00	0.0	0.600	o	1200	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.011	100.00	3.74	95.720	1.376	0.0	0.0	0.0	0.81	14.3«	372.6
S1.012	100.00	4.03	94.583	1.376	0.0	0.0	0.0	2.64	2987.0	372.6

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.012	SEX UU3	99.420	94.356	0.000	0	0

Simulation Criteria for Storm

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 Storage Structures	0
Number of Online Controls	1	Number of Time/Area Diagrams	0
Number of Offline Controls	0	Number of Real Time 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)	20.000	Storm Duration (mins)	30
Ratio R	0.400		

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: SW9, DS/PN: S1.010, Volume (m³): 85.1

Unit Reference	MD-SHE-0156-1540-2400-1540
Design Head (m)	2.400
Design Flow (l/s)	15.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	156
Invert Level (m)	96.756
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.400	15.4
Flush-Flo™	0.681	15.2
Kick-Flo®	1.399	11.9
Mean Flow over Head Range	-	13.3

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)
0.100	5.6	1.200	13.8	3.000	17.1	7.000	25.7
0.200	12.0	1.400	12.0	3.500	18.4	7.500	26.5
0.300	13.6	1.600	12.7	4.000	19.6	8.000	27.4
0.400	14.4	1.800	13.4	4.500	20.8	8.500	28.2
0.500	14.9	2.000	14.1	5.000	21.8	9.000	29.0
0.600	15.1	2.200	14.8	5.500	22.9	9.500	29.8
0.800	15.1	2.400	15.4	6.000	23.8		
1.000	14.7	2.600	16.0	6.500	24.8		

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

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

Synthetic Rainfall Details

Rainfall Model		FSR	Ratio R 0.355
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	18.000	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	ON
DVD Status	ON
Inertia Status	ON

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years)	2, 30, 100
Climate Change (%)	0, 0, 45

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
S1.000	SW17a	360 Winter	100	+45%	100/120 Winter				99.136
S1.001	SW17	360 Winter	100	+45%	100/120 Winter				99.135
S1.002	SW1	360 Winter	100	+45%	100/120 Winter				99.134
S1.003	SW2	360 Winter	100	+45%	100/120 Winter				99.133
S2.000	SW10a	360 Winter	100	+45%	100/180 Winter				99.134
S3.000	SW10c	360 Winter	100	+45%	100/120 Winter				99.134
S2.001	SW10b	360 Winter	100	+45%	100/120 Winter				99.133
S2.002	SW10	360 Winter	100	+45%	100/120 Winter				99.132
S2.003	SW11	360 Winter	100	+45%	100/120 Winter				99.132
S1.004	SW3	360 Winter	100	+45%	100/120 Winter				99.135
S1.005	SW4	360 Winter	100	+45%	100/120 Winter				99.161
S1.006	SW5	360 Winter	100	+45%	100/120 Winter				99.179
S4.000	SW12	360 Winter	100	+45%	100/120 Winter				99.167
S4.001	SW13	360 Winter	100	+45%	100/120 Winter				99.166
S4.002	SW14	360 Winter	100	+45%	100/120 Winter				99.167
S4.003	SW15	360 Winter	100	+45%	100/120 Winter				99.170
S4.004	SW16	360 Winter	100	+45%	100/120 Winter				99.179
S1.007	SW6	360 Winter	100	+45%	100/60 Winter				99.189

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

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
S1.000	SW17a	0.386	0.000	0.01			19.5	SURCHARGED	
S1.001	SW17	0.430	0.000	0.04			43.3	SURCHARGED	
S1.002	SW1	0.461	0.000	0.05			66.6	SURCHARGED	
S1.003	SW2	0.494	0.000	0.03			81.3	SURCHARGED	
S2.000	SW10a	0.321	0.000	0.02			15.0	SURCHARGED	
S3.000	SW10c	0.494	0.000	0.01			15.0	SURCHARGED	
S2.001	SW10b	0.507	0.000	0.04			49.3	SURCHARGED	
S2.002	SW10	0.518	0.000	0.07			62.1	SURCHARGED	
S2.003	SW11	0.540	0.000	0.03			78.1	SURCHARGED	
S1.004	SW3	0.669	0.000	0.13			212.9	SURCHARGED	
S1.005	SW4	0.751	0.000	0.15			249.4	SURCHARGED	
S1.006	SW5	0.823	0.000	0.12			282.0	SURCHARGED	
S4.000	SW12	0.517	0.000	0.01			23.3	SURCHARGED	
S4.001	SW13	0.639	0.000	0.04			47.9	SURCHARGED	
S4.002	SW14	0.667	0.000	0.08			88.9	SURCHARGED	
S4.003	SW15	0.698	0.000	0.08			126.8	SURCHARGED	
S4.004	SW16	0.705	0.000	0.17			212.3	SURCHARGED	
S1.007	SW6	0.935	0.000	0.42			399.4	SURCHARGED	

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

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.
S1.008	SW7	360 Winter	100	+45%	100/60 Winter			
S1.009	SW8	360 Winter	100	+45%	100/60 Winter			
S1.010	SW9	240 Winter	100	+45%	2/15 Summer	100/180 Winter		
S1.011	SEX UU 1	360 Winter	100	+45%	2/15 Summer			
S1.012	SEX UU 2	360 Winter	100	+45%				

PN	US/MH Name	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
S1.008	SW7	99.207	0.983	0.000	0.21			292.2	SURCHARGED
S1.009	SW8	99.218	1.042	0.000	0.09			143.0	SURCHARGED
S1.010	SW9	99.214	2.083	2.038	0.18			15.5	FLOOD
S1.011	SEX UU 1	95.898	0.028	0.000	1.18			15.5	SURCHARGED
S1.012	SEX UU 2	94.628	-1.155	0.000	0.01			15.3	OK

PN	US/MH Name	Level Exceeded
S1.008	SW7	
S1.009	SW8	
S1.010	SW9	4
S1.011	SEX UU 1	
S1.012	SEX UU 2	

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