STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes Pipesize Manhole Sizes Manholes

FSR Rainfall Model - England and Wales

Return Period (years)	30	PIMP (%)	100
M5-60 (mm)	18.400	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 Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.091	4-8	0.092	8-12	0.000

Total Area Contributing (ha) = 0.183

Total Pipe Volume (m³) = 110.200

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)	n	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	28.200	0.900	31.3	0.002	5.00	0.0	0.600		o	100	Pipe/Conduit	
S1.001	6.700	0.100	67.0	0.012	0.00	0.0	0.600		o	100	Pipe/Conduit	
S1.002	34.500	0.625	55.2	0.030	0.00	0.0	0.600		o	100	Pipe/Conduit	
S2.000	16.300	0.200	81.5	0.007	5.00	0.0	0.600		o	100	Pipe/Conduit	
S2.001	15.000	0.245	61.2	0.022	0.00	0.0	0.600		o	100	Pipe/Conduit	
S3.000	11.500	0.120	95.8	0.005	5.00	0.0	0.600		o	100	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	50.00	5.34	15.750	0.002	0.0	0.0	0.0	1.38	10.9	0.3
S1.001	50.00	5.46	14.850	0.014	0.0	0.0	0.0	0.94	7.4	1.9
S1.002	50.00	6.01	14.750	0.044	0.0	0.0	0.0	1.04	8.2	6.0
S2.000	50.00	5.32	15.300	0.007	0.0	0.0	0.0	0.85	6.7	0.9
S2.001	50.00	5.57	15.100	0.029	0.0	0.0	0.0	0.99	7.7	3.9
S3.000	50.00	5.24	14.975	0.005	0.0	0.0	0.0	0.79	6.2	0.7

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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)	n	HYD SECT	DIA (mm)	Section Type	Auto Design
S2.002	14.900	0.730	20.4	0.030	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.003	3.400	0.050	68.0	0.000	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.004	6.000	0.050	120.0	0.000	0.00	0.0		0.060	→|*|		Bio-Retention Area	
S1.005	4.700	0.035	134.3	0.000	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.006	13.100	0.115	113.9	0.010	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.007	3.600	0.150	24.0	0.010	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.008	16.200	0.175	92.6	0.015	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.009	31.000	0.100	310.0	0.040	0.00	0.0		0.050	→[↓]		Cellular Storage	
S1.010	3.500	0.025	140.0	0.000	0.00	0.0	0.600		o	150	Pipe/Conduit	
S1.011	8.900	0.075	118.7	0.000	0.00	0.0	0.600		o	150	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)
S2.002	50.00	5.68	14.805	0.064	0.0	0.0	0.0	2.24	39.6	8.7
S1.003	50.00	6.06	14.075	0.108	0.0	0.0	0.0	1.22	21.6	14.6
S1.004	50.00	6.17	14.000	0.108	0.0	0.0	0.0	0.88	3373.7	14.6
S1.005	50.00	5.09	13.725	0.000	15.0	0.0	0.0	0.87	15.3	15.0
S1.006	50.00	5.32	13.690	0.010	15.0	0.0	0.0	0.94	16.6	16.4
S1.007	50.00	5.35	13.575	0.020	15.0	0.0	0.0	2.06	36.5	17.7
S1.008	50.00	5.61	13.425	0.035	15.0	0.0	0.0	1.04	18.5«	19.7
S1.009	50.00	6.60	13.100	0.075	15.0	0.0	0.0	0.52	1383.4	25.2
S1.010	50.00	5.07	13.000	0.000	5.0	0.0	0.0	0.85	15.0	5.0
S1.011	50.00	5.23	12.975	0.000	5.0	0.0	0.0	0.92	16.3	5.0

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PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	o		SCP	16.350	15.750	0.500	Open Manhole	600
S1.001	o	100	SSW01	15.609	14.850	0.659	Open Manhole	600
S1.002	o	100	SSW02	15.468	14.750	0.618	Open Manhole	600
S2.000	o	100	SAC	15.900	15.300	0.500	Open Manhole	600
S2.001	o	100	SSW03	15.927	15.100	0.727	Open Manhole	600
S3.000	o	100	SCP	15.577	14.975	0.502	Open Manhole	600
S2.002	o	150	SSW04	15.464	14.805	0.509	Open Manhole	600
S1.003	o	150	SSW05	15.031	14.075	0.806	Open Manhole	600
S1.004	→|⁂|		SBIORETENTION	15.000	14.000	0.000	Open Manhole	600
S1.005	o	150	SHW02	15.000	13.725	1.125	Junction	
S1.006	o	150	SSW06	15.060	13.690	1.220	Open Manhole	600
S1.007	o	150	SSW07	14.718	13.575	0.993	Open Manhole	600
S1.008	o	150	SSW08	14.715	13.425	1.140	Open Manhole	600
S1.009	→[↓]		SCELLULAR	14.400	13.100	0.499	Open Manhole	600
S1.010	o	150	SOUT	14.400	13.000	1.250	Open Manhole	600
S1.011	o	150	SSW09	14.522	12.975	1.397	Open Manhole	1200

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
S1.000	28.200	31.3	SSW01	15.609	14.850	0.659	Open Manhole	600
S1.001	6.700	67.0	SSW02	15.468	14.750	0.618	Open Manhole	600
S1.002	34.500	55.2	SSW05	15.031	14.125	0.806	Open Manhole	600
S2.000	16.300	81.5	SSW03	15.927	15.100	0.727	Open Manhole	600
S2.001	15.000	61.2	SSW04	15.464	14.855	0.509	Open Manhole	600
S3.000	11.500	95.8	SSW04	15.464	14.855	0.509	Open Manhole	600
S2.002	14.900	20.4	SSW05	15.031	14.075	0.806	Open Manhole	600
S1.003	3.400	68.0	SBIORETENTION	15.000	14.025	0.825	Open Manhole	600
S1.004	6.000	120.0	SHW02	15.000	13.950	0.050	Junction	
S1.005	4.700	134.3	SSW06	15.060	13.690	1.220	Open Manhole	600
S1.006	13.100	113.9	SSW07	14.718	13.575	0.993	Open Manhole	600
S1.007	3.600	24.0	SSW08	14.715	13.425	1.140	Open Manhole	600
S1.008	16.200	92.6	SCELLULAR	14.400	13.250	1.000	Open Manhole	600
S1.009	31.000	310.0	SOUT	14.400	13.000	0.599	Open Manhole	600
S1.010	3.500	140.0	SSW09	14.522	12.975	1.397	Open Manhole	1200
S1.011	8.900	118.7	SSW10	14.300	12.900	1.250	Open Manhole	0

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Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	-	-	100	0.002	0.002	0.002
1.001	-	-	100	0.012	0.012	0.012
1.002	-	-	100	0.030	0.030	0.030
2.000	-	-	100	0.007	0.007	0.007
2.001	-	-	100	0.022	0.022	0.022
3.000	-	-	100	0.005	0.005	0.005
2.002	-	-	100	0.030	0.030	0.030
1.003	-	-	100	0.000	0.000	0.000
1.004	-	-	100	0.000	0.000	0.000
1.005	-	-	100	0.000	0.000	0.000
1.006	-	-	100	0.010	0.010	0.010
1.007	-	-	100	0.010	0.010	0.010
1.008	-	-	100	0.015	0.015	0.015
1.009	-	-	100	0.040	0.040	0.040
1.010	-	-	100	0.000	0.000	0.000
1.011	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				0.183	0.183	0.183

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Network Classifications for Storm

PN	USMH Name	Pipe Dia (mm)	Min Cover Depth (m)	Max Cover Depth (m)	Pipe Type	MH Dia (mm)	MH Width (mm)	MH Ring Depth (m)	MH Type
S1.000	SCP	100	0.500	0.659	Unclassified	600	0	0.500	Unclassified
S1.001	SSW01	100	0.618	0.659	Unclassified	600	0	0.659	Unclassified
S1.002	SSW02	100	0.618	0.806	Unclassified	600	0	0.618	Unclassified
S2.000	SAC	100	0.500	0.727	Unclassified	600	0	0.500	Unclassified
S2.001	SSW03	100	0.509	0.727	Unclassified	600	0	0.727	Unclassified
S3.000	SCP	100	0.502	0.509	Unclassified	600	0	0.502	Unclassified
S2.002	SSW04	150	0.509	0.806	Unclassified	600	0	0.509	Unclassified
S1.003	SSW05	150	0.806	0.825	Unclassified	600	0	0.806	Unclassified
S1.004	SBIORETENTION				Bio-Retention Area	600	0	0.000	Unclassified
S1.005	SHW02	150	1.125	1.220	Unclassified				Junction
S1.006	SSW06	150	0.993	1.220	Unclassified	600	0	1.220	Unclassified
S1.007	SSW07	150	0.993	1.140	Unclassified	600	0	0.993	Unclassified
S1.008	SSW08	150	1.000	1.140	Unclassified	600	0	1.140	Unclassified
S1.009	SCELLULAR				Cellular Storage	600	0	0.499	Unclassified
S1.010	SOUT	150	1.250	1.397	Unclassified	600	0	1.250	Unclassified
S1.011	SSW09	150	1.250	1.397	Unclassified	1200	0	1.397	Unclassified

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)
S1.011	SSW10	14.300	12.900	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	0.000
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 6 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.400	Storm Duration (mins)	30
Ratio R	0.350		

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: SSW09, DS/PN: S1.011, Volume (m³): 1.8

Unit Reference	MD-SHE-0082-3000-1000-3000
Design Head (m)	1.000
Design Flow (l/s)	3.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	82
Invert Level (m)	12.975
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)	1.000	3.0	Kick-Flo®	0.623	2.4
Flush-Flo™	0.297	3.0	Mean Flow over Head Range	-	2.6

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	2.4	1.200	3.3	3.000	5.0	7.000	7.4
0.200	2.9	1.400	3.5	3.500	5.4	7.500	7.7
0.300	3.0	1.600	3.7	4.000	5.7	8.000	7.9
0.400	2.9	1.800	3.9	4.500	6.0	8.500	8.2
0.500	2.8	2.000	4.1	5.000	6.3	9.000	8.4
0.600	2.5	2.200	4.3	5.500	6.6	9.500	8.6
0.800	2.7	2.400	4.5	6.000	6.9		
1.000	3.0	2.600	4.7	6.500	7.2		

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Storage Structures for Storm

Porous Car Park Manhole: SCP, DS/PN: S1.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	13.9	Slope (1:X)	150.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	16.200	Membrane Depth (mm)	0

Porous Car Park Manhole: SSW02, DS/PN: S1.002

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	18.0
Max Percolation (l/s)	25.0	Slope (1:X)	150.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	15.000	Membrane Depth (mm)	0

Porous Car Park Manhole: SCP, DS/PN: S3.000

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	13.9	Slope (1:X)	150.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	15.150	Membrane Depth (mm)	0

Bio-Retention Area Pipe: S1.004

Manning's N	0.060	Infiltration Coefficient Base (m/hr)	0.00000
Invert Level (m)	14.000	Infiltration Coefficient Side (m/hr)	0.00000
Porosity	1.00	Safety Factor	2.0

Depth (m)	Area (m²)	Perimeter (m)	Depth (m)	Area (m²)	Perimeter (m)
0.000	2.0	6.800	1.000	51.0	25.800
0.500	19.6	16.400			

Porous Car Park Manhole: SCELLULAR, DS/PN: S1.009

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	50.0
Max Percolation (l/s)	69.4	Slope (1:X)	150.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	14.000	Membrane Depth (mm)	0

Cellular Storage Pipe: S1.009

Manning's N	0.050	Infiltration Coefficient Side (m/hr)	0.00000
Invert Level (m)	13.100	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000	Porosity	0.95

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Cellular Storage Pipe: S1.009

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	108.5	0.0	0.801	0.0	0.0
0.800	108.5	0.0			

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100 year Return Period 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	0.000
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 6 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	M5-60 (mm)	18.400
Region	England and Wales	Ratio R	0.350
Cv (Summer)	0.750		
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, 240, 360, 480, 960, 1440
Return Period(s) (years)	100
Climate Change (%)	45

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.
S1.000	SCP	15 Summer	100	+45%				
S1.001	SSW01	15 Winter	100	+45%	100/15 Summer			
S1.002	SSW02	30 Winter	100	+45%	100/15 Summer			
S2.000	SAC	15 Winter	100	+45%	100/15 Summer	100/15 Summer		
S2.001	SSW03	15 Winter	100	+45%	100/15 Summer			
S3.000	SCP	15 Winter	100	+45%	100/15 Summer			
S2.002	SSW04	15 Winter	100	+45%	100/15 Summer			
S1.003	SSW05	15 Winter	100	+45%	100/15 Summer			
S1.004	SBIORETENTION	30 Winter	100	+45%				
S1.005	SHW02	30 Winter	100	+45%	100/15 Summer			
S1.006	SSW06	30 Winter	100	+45%	100/15 Summer			
S1.007	SSW07	15 Winter	100	+45%	100/15 Summer			
S1.008	SSW08	240 Winter	100	+45%	100/15 Summer			
S1.009	SCELLULAR	240 Winter	100	+45%	100/120 Winter			
S1.010	SOUT	240 Winter	100	+45%	100/15 Summer			
S1.011	SSW09	240 Winter	100	+45%	100/15 Summer			

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	Level Exceeded
S1.000	SCP	15.772	-0.078	0.000	0.09		5	0.9	OK	
S1.001	SSW01	15.312	0.362	0.000	1.07			7.1	FLOOD RISK	
S1.002	SSW02	15.245	0.395	0.000	1.18		11	9.4	FLOOD RISK	
S2.000	SAC	15.900	0.500	0.468	1.02			6.6	FLOOD	3

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

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	Level Exceeded
S2.001	SSW03	15.920	0.720	0.000	1.76			13.0	FLOOD RISK	
S3.000	SCP	15.198	0.123	0.000	0.76		3	4.4	SURCHARGED	
S2.002	SSW04	15.204	0.249	0.000	0.82			30.0	FLOOD RISK	
S1.003	SSW05	14.776	0.551	0.000	2.52			35.3	FLOOD RISK	
S1.004	SBIORETENTION	14.569	-0.431	0.000	0.01		13	32.3	OK	
S1.005	SHW02	14.566	0.691	0.000	2.08			24.3	SURCHARGED*	
S1.006	SSW06	14.431	0.591	0.000	1.69			25.6	SURCHARGED	
S1.007	SSW07	14.184	0.459	0.000	1.11			27.0	SURCHARGED	
S1.008	SSW08	14.148	0.573	0.000	0.97			16.6	SURCHARGED	
S1.009	SCELLULAR	14.147	0.246	0.000	0.01		15	12.0	FLOOD RISK	
S1.010	SOUT	14.152	1.002	0.000	0.53			5.7	FLOOD RISK	
S1.011	SSW09	14.161	1.036	0.000	0.22			3.2	SURCHARGED	

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