

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)	5	PIMP (%)	100
M5-60 (mm)	19.700	Add Flow / Climate Change (%)	0
Ratio R	0.389	Minimum Backdrop Height (m)	1.000
Maximum Rainfall (mm/hr)	100	Maximum Backdrop Height (m)	0.000
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	0.581	4-8	0.283

Total Area Contributing (ha) = 0.864

Total Pipe Volume (m³) = 16.609

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	k (l/s)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	27.335	0.192	142.4	0.030	5.00	0.0	0.600	o	150	Pipe/Conduit	
S1.001	33.919	0.112	302.9	0.246	0.00	0.0	0.600	o	300	Pipe/Conduit	
S2.000	20.834	0.221	94.3	0.046	5.00	0.0	0.600	o	225	Pipe/Conduit	
S1.002	36.764	0.101	364.0	0.057	0.00	0.0	0.600	o	450	Pipe/Conduit	
S1.003	29.604	0.078	380.0	0.114	0.00	0.0	0.600	o	450	Pipe/Conduit	
S3.000	24.304	1.039	23.4	0.137	2.00	0.0	0.600	o	300	Pipe/Conduit	
S1.004	14.399	0.131	109.9	0.233	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)
S1.000	84.44	5.54	43.264	0.030	0.0	0.0	0.0	0.84	14.8	6.9
S1.001	80.49	6.17	42.922	0.276	0.0	0.0	0.0	0.90	63.5	60.2
S2.000	86.37	5.26	43.106	0.046	0.0	0.0	0.0	1.35	53.6	10.8
S1.002	77.22	6.75	42.660	0.380	0.0	0.0	0.0	1.06	168.5	79.5
S1.003	74.75	7.23	42.559	0.495	0.0	0.0	0.0	1.04	164.9	100.1
S3.000	100.00	2.12	43.520	0.137	0.0	0.0	0.0	3.26	230.8	37.1
S1.004	73.53	7.48	42.481	0.864	0.0	0.0	0.0	0.96	16.9«	172.1

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Lombard House 145 Great Charles Street Birmingham, B3 3LP	Knowsley Hub 50 Proposed Storm Drainage	
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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
S1.005	21.068	0.192	110.0	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)
S1.005	71.81	7.84	41.834	0.864	0.0	0.0	0.0	0.96	16.9«	172.1

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam., L*W (mm)	Pipe Out PN	Pipe Out Invert Level (m)	Pipe Out Diameter (mm)	Pipes In PN	Pipes In Invert Level (m)	Pipes In Diameter (mm)	Backdrop (mm)
SMH1	43.829	0.565	Open Manhole	1200	S1.000	43.264	150				
SMH2	44.737	1.815	Open Manhole	1200	S1.001	42.922	300	S1.000	43.072	150	
SMH3	44.531	1.425	Open Manhole	1200	S2.000	43.106	225				
SMH4	44.575	1.915	Open Manhole	1350	S1.002	42.660	450	S1.001	42.810	300	
								S2.000	42.885	225	
SMH5	44.934	2.375	Open Manhole	1350	S1.003	42.559	450	S1.002	42.559	450	
SMH6	44.945	1.425	Open Manhole	1200	S3.000	43.520	300				
SMH7	44.924	2.443	Open Manhole	1350	S1.004	42.481	150	S1.003	42.481	450	
								S3.000	42.481	300	
SMH8	44.370	2.536	Open Manhole	1200	S1.005	41.834	150	S1.004	42.350	150	516
SMH	43.920	2.278	Open Manhole	0		OUTFALL		S1.005	41.642	150	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SMH1	343306.488	397774.612	343306.488	397774.612	Required	
SMH2	343281.318	397785.273	343281.318	397785.273	Required	
SMH3	343247.296	397765.354	343247.296	397765.354	Required	
SMH4	343265.520	397755.257	343265.520	397755.257	Required	
SMH5	343294.922	397733.188	343294.922	397733.188	Required	
SMH6	343342.724	397708.299	343342.724	397708.299	Required	
SMH7	343320.890	397718.974	343320.890	397718.974	Required	
SMH8	343314.144	397706.253	343314.144	397706.253	Required	
SMH	343308.967	397685.831			No Entry	

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	150	SMH1	43.829	43.264	0.415	Open Manhole	1200
S1.001	o	300	SMH2	44.737	42.922	1.515	Open Manhole	1200
S2.000	o	225	SMH3	44.531	43.106	1.200	Open Manhole	1200
S1.002	o	450	SMH4	44.575	42.660	1.465	Open Manhole	1350
S1.003	o	450	SMH5	44.934	42.559	1.925	Open Manhole	1350
S3.000	o	300	SMH6	44.945	43.520	1.125	Open Manhole	1200
S1.004	o	150	SMH7	44.924	42.481	2.293	Open Manhole	1350
S1.005	o	150	SMH8	44.370	41.834	2.386	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	27.335	142.4	SMH2	44.737	43.072	1.515	Open Manhole	1200
S1.001	33.919	302.9	SMH4	44.575	42.810	1.465	Open Manhole	1350
S2.000	20.834	94.3	SMH4	44.575	42.885	1.465	Open Manhole	1350
S1.002	36.764	364.0	SMH5	44.934	42.559	1.925	Open Manhole	1350
S1.003	29.604	380.0	SMH7	44.924	42.481	1.993	Open Manhole	1350
S3.000	24.304	23.4	SMH7	44.924	42.481	2.143	Open Manhole	1350
S1.004	14.399	109.9	SMH8	44.370	42.350	1.870	Open Manhole	1200
S1.005	21.068	110.0	SMH	43.920	41.642	2.128	Open Manhole	0

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)
S1.005	SMH	43.920	41.642	0.000	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.840	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coefficient	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)	1880
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	16

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	Ratio R	0.389
Return Period (years)	100	Profile Type	Winter
Region England and Wales	Cv (Summer)		0.750
M5-60 (mm)	19.700	Cv (Winter)	0.840

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Synthetic Rainfall Details

Storm Duration (mins) 940

Online Controls for Storm

Hydro-Brake® Optimum Manhole: SMH7, DS/PN: S1.004, Volume (m³): 9.6

Unit Reference	MD-SHE-0088-4800-2200-4800
Design Head (m)	2.200
Design Flow (l/s)	4.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	88
Invert Level (m)	42.481
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)	2.200	4.8	Kick-Flo®	0.781	3.0
Flush-Flo™	0.383	3.7	Mean Flow over Head Range	-	3.7

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	2.7	0.800	3.0	2.000	4.6	4.000	6.4	7.000	8.3
0.200	3.5	1.000	3.3	2.200	4.8	4.500	6.7	7.500	8.5
0.300	3.7	1.200	3.6	2.400	5.0	5.000	7.1	8.000	8.8
0.400	3.7	1.400	3.9	2.600	5.2	5.500	7.4	8.500	9.1
0.500	3.7	1.600	4.1	3.000	5.5	6.000	7.7	9.000	9.3
0.600	3.6	1.800	4.4	3.500	6.0	6.500	8.0	9.500	9.6

Storage Structures for Storm

Cellular Storage Manhole: SMH4, DS/PN: S1.002

Invert Level (m) 42.660 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)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	435.0	0.0	0.800	435.0	0.0	0.801	0.0	0.0

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1 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	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 Online Controls	1	Number of Storage Structures	1
		Number of Time/Area Diagrams	0
		Number of Real Time Controls	0
Synthetic Rainfall Details			
Rainfall Model	FSR M5-60 (mm)	19.800 Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.391 Cv (Winter) 0.840
Margin for Flood Risk Warning (mm)			300.0
Analysis Timestep	2.5 Second Increment (Extended)		
DTS Status			ON
DVD Status			OFF
Inertia Status			OFF
Profile(s)		Summer and Winter	
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440		
Return Period(s) (years)		1, 30, 100	
Climate Change (%)		0, 30, 30	

			Water		Surcharged		Flooded		Maximum		Pipe	Status
PN	US/MH Name	Duration (mins)	US/CL (m)	Level (m)	Depth (m)	Volume (m³)	Maximum Vol (m³)	Velocity (m/s)	Flow (l/s)			
S1.000	SMH1	15	43.829	43.320	-0.094	0.000	0.057	0.7	4.1		OK	
S1.001	SMH2	15	44.737	43.083	-0.139	0.000	0.185	0.8	32.7		OK	
S2.000	SMH3	15	44.531	43.160	-0.171	0.000	0.055	0.9	6.3		OK	
S1.002	SMH4	240	44.575	42.866	-0.244	0.000	85.587	0.5	3.9		OK	
S1.003	SMH5	15	44.934	43.018	0.009	0.000	5.804	0.1	4.1	SURCHARGED		
S3.000	SMH6	15	44.945	43.590	-0.230	0.000	0.073	2.0	25.3		OK	
S1.004	SMH7	15	44.924	43.049	0.418	0.000	5.935	0.8	3.7	SURCHARGED		
S1.005	SMH8	120	44.370	41.883	-0.101	0.000	0.050	0.7	3.7		OK	

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30 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	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 Online Controls	1	Number of Storage Structures	1
		Number of Time/Area Diagrams	0
		Number of Real Time Controls	0
Synthetic Rainfall Details			
Rainfall Model	FSR M5-60 (mm)	19.800 Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.391 Cv (Winter) 0.840
Margin for Flood Risk Warning (mm)			300.0
Analysis Timestep	2.5 Second Increment (Extended)		
DTS Status			ON
DVD Status			OFF
Inertia Status			OFF
Profile(s)		Summer and Winter	
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440		
Return Period(s) (years)		1, 30, 100	
Climate Change (%)		0, 30, 30	

PN	US/MH Name	Duration (mins)	US/CL (m)	Water	Surcharged	Flooded	Maximum Vol (m³)	Maximum Velocity (m/s)	Pipe	Status
				Level (m)	Depth (m)	Volume (m³)			Flow (l/s)	
S1.000	SMH1	480	43.829	43.852	0.438	23.154	23.787	0.5	4.0	FLOOD
S1.001	SMH2	360	44.737	43.899	0.677	0.000	1.561	0.7	16.6	SURCHARGED
S2.000	SMH3	360	44.531	43.906	0.575	0.000	0.899	0.7	2.9	SURCHARGED
S1.002	SMH4	360	44.575	43.905	0.795	0.000	335.597	1.0	106.7	SURCHARGED
S1.003	SMH5	360	44.934	43.906	0.897	0.000	7.553	0.5	60.5	SURCHARGED
S3.000	SMH6	15	44.945	43.919	0.099	0.000	0.446	2.4	87.5	SURCHARGED
S1.004	SMH7	360	44.924	43.906	1.275	0.000	8.154	0.8	3.9	SURCHARGED
S1.005	SMH8	360	44.370	41.884	-0.100	0.000	0.051	0.8	3.9	OK

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	2.000
Hot Start Level (mm)	0	Inlet Coefficient	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 Online Controls	1	Number of Storage Structures	1
		Number of Time/Area Diagrams	0
		Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR M5-60 (mm) 19.800 Cv (Summer) 0.750
Region England and Wales	Ratio R 0.391 Cv (Winter) 0.840

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

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

				Water	Surcharged	Flooded			Maximum	Pipe		
PN	US/MH	Duration	US/CL	Level	Depth	Volume	Maximum	Velocity	Flow			
	Name	(mins)	(m)	(m)	(m)	(m³)	Vol (m³)	(m/s)	(l/s)	Status		
S1.000	SMH1	960	43.829	43.983	0.569	154.099	154.732	0.5	4.2	FLOOD		
S1.001	SMH2	240	44.737	44.550	1.328	0.000	2.298	0.8	29.5	FLOOD RISK		
S2.000	SMH3	240	44.531	44.546	1.215	15.656	17.252	0.8	13.0	FLOOD		
S1.002	SMH4	240	44.575	44.579	1.469	3.565	340.108	1.1	106.6	FLOOD		
S1.003	SMH5	240	44.934	44.624	1.615	0.000	8.581	0.5	60.5	SURCHARGED		
S3.000	SMH6	240	44.945	44.667	0.847	0.000	1.291	1.8	28.3	FLOOD RISK		
S1.004	SMH7	240	44.924	44.654	2.023	0.000	9.225	0.8	4.8	FLOOD RISK		
S1.005	SMH8	240	44.370	41.890	-0.094	0.000	0.058	0.8	4.8	OK		