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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)	1	PIMP (%)	100
M5-60 (mm)	20.000	Add Flow / Climate Change (%)	0
Ratio R	0.396	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)
0-4	0.109	4-8	0.015

Total Area Contributing (ha) = 0.124

Total Pipe Volume (m³) = 3.255

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
1.000	17.252	0.101	170.0	0.009	4.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	14.029	0.083	170.0	0.018	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.002	17.297	0.102	170.0	0.018	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.003	23.509	0.138	170.0	0.032	0.00	0.0	0.600	o	225	Pipe/Conduit	
2.000	8.100	0.048	170.0	0.015	4.00	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	4.29	43.850	0.009	0.0	0.0	0.0	1.00	39.8	1.2
1.001	50.00	4.52	43.749	0.027	0.0	0.0	0.0	1.00	39.8	3.7
1.002	50.00	4.81	43.666	0.045	0.0	0.0	0.0	1.00	39.8	6.1
1.003	50.00	5.20	43.564	0.077	0.0	0.0	0.0	1.00	39.8	10.4
2.000	50.00	4.14	43.500	0.015	0.0	0.0	0.0	1.00	39.8	2.0

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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
1.004	3.788	0.047	80.0	0.032	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)
1.004	50.00	5.26	43.426	0.124	0.0	0.0	0.0	1.12	19.9	16.8

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Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam., I*W (mm)	Pipe Out Invert Level (m) Diameter (mm)			Pipes In Invert Level (m) Diameter (mm)			Backdrop (mm)
1	44.750	0.900	Open Manhole	600	1.000	43.850	225				
2	44.750	1.001	Open Manhole	600	1.001	43.749	225	1.000	43.749	225	
3	44.745	1.079	Open Manhole	600	1.002	43.666	225	1.001	43.666	225	
4	44.665	1.101	Open Manhole	600	1.003	43.564	225	1.002	43.564	225	
5	44.750	1.250	Open Manhole	1200	2.000	43.500	225				
6	44.750	1.324	Open Manhole	1200	1.004	43.426	150	1.003	43.426	225	
								2.000	43.452	225	101
	44.625	1.246	Open Manhole	0		OUTFALL		1.004	43.379	150	

No coordinates have been specified, layout information cannot be produced.

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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., (mm)	L*W
1.000	o	225	1	44.750	43.850	0.675	Open Manhole		600
1.001	o	225	2	44.750	43.749	0.776	Open Manhole		600
1.002	o	225	3	44.745	43.666	0.854	Open Manhole		600
1.003	o	225	4	44.665	43.564	0.876	Open Manhole		600
2.000	o	225	5	44.750	43.500	1.025	Open Manhole		1200
1.004	o	150	6	44.750	43.426	1.174	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., (mm)	L*W
1.000	17.252	170.0	2	44.750	43.749	0.776	Open Manhole		600
1.001	14.029	170.0	3	44.745	43.666	0.854	Open Manhole		600
1.002	17.297	170.0	4	44.665	43.564	0.876	Open Manhole		600
1.003	23.509	170.0	6	44.750	43.426	1.099	Open Manhole		1200
2.000	8.100	170.0	6	44.750	43.452	1.073	Open Manhole		1200
1.004	3.788	80.0		44.625	43.379	1.096	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)
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1.004	44.625	43.379	0.000	0	0
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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	1
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

		Page 5																				
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Synthetic Rainfall Details <table><tr><td>Rainfall Model</td><td>FSR</td><td>Profile Type</td><td>Summer</td></tr><tr><td>Return Period (years)</td><td>1</td><td>Cv (Summer)</td><td>0.750</td></tr><tr><td>Region</td><td>England and Wales</td><td>Cv (Winter)</td><td>0.840</td></tr><tr><td>M5-60 (mm)</td><td>20.000</td><td>Storm Duration (mins)</td><td>30</td></tr><tr><td>Ratio R</td><td>0.396</td><td></td><td></td></tr></table>			Rainfall Model	FSR	Profile Type	Summer	Return Period (years)	1	Cv (Summer)	0.750	Region	England and Wales	Cv (Winter)	0.840	M5-60 (mm)	20.000	Storm Duration (mins)	30	Ratio R	0.396		
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Online Controls for Storm

Hydro-Brake® Optimum Manhole: 6, DS/PN: 1.004, Volume (m³): 2.7

Unit Reference	MD-SHE-0104-5000-1100-5000
Design Head (m)	1.100
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	104
Invert Level (m)	43.426
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	5.0
Flush-Flo™	0.323	5.0
Kick-Flo®	0.690	4.0
Mean Flow over Head Range	-	4.4

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	3.5	1.200	5.2	3.000	8.0	7.000	12.0
0.200	4.8	1.400	5.6	3.500	8.6	7.500	12.4
0.300	5.0	1.600	6.0	4.000	9.2	8.000	12.7
0.400	5.0	1.800	6.3	4.500	9.7	8.500	13.1
0.500	4.8	2.000	6.6	5.000	10.2	9.000	13.5
0.600	4.6	2.200	6.9	5.500	10.7	9.500	13.8
0.800	4.3	2.400	7.2	6.000	11.1		
1.000	4.8	2.600	7.5	6.500	11.5		

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<u>Storage Structures for Storm</u> <u>Cellular Storage Manhole: 4, DS/PN: 1.003</u> Invert Level (m) 43.564 Safety Factor 2.0 Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95 Infiltration Coefficient Side (m/hr) 0.00000 <table><tr><th>Depth (m)</th><th>Area (m²)</th><th>Inf. Area (m²)</th><th>Depth (m)</th><th>Area (m²)</th><th>Inf. Area (m²)</th></tr><tr><td>0.000</td><td>72.0</td><td>72.0</td><td>0.501</td><td>0.0</td><td>89.0</td></tr><tr><td>0.500</td><td>72.0</td><td>89.0</td><td></td><td></td><td></td></tr></table> <u>Volume Summary (Static)</u> Length Calculations based on True Length <table><tr><th>Pipe Number</th><th>USMH Name</th><th>Manhole Volume (m³)</th><th>Pipe Volume (m³)</th><th>Storage Structure Volume (m³)</th><th>Total Volume (m³)</th></tr><tr><td>1.000</td><td>1</td><td>0.254</td><td>0.662</td><td>0.000</td><td>0.917</td></tr><tr><td>1.001</td><td>2</td><td>0.283</td><td>0.534</td><td>0.000</td><td>0.817</td></tr><tr><td>1.002</td><td>3</td><td>0.305</td><td>0.664</td><td>0.000</td><td>0.969</td></tr><tr><td>1.003</td><td>4</td><td>0.311</td><td>0.899</td><td>34.223</td><td>35.433</td></tr><tr><td>2.000</td><td>5</td><td>1.414</td><td>0.274</td><td>0.000</td><td>1.688</td></tr><tr><td>1.004</td><td>6</td><td>1.497</td><td>0.056</td><td>0.000</td><td>1.554</td></tr><tr><td colspan="2">Total</td><td>4.065</td><td>3.090</td><td>34.223</td><td>41.377</td></tr></table>				Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	0.000	72.0	72.0	0.501	0.0	89.0	0.500	72.0	89.0				Pipe Number	USMH Name	Manhole Volume (m³)	Pipe Volume (m³)	Storage Structure Volume (m³)	Total Volume (m³)	1.000	1	0.254	0.662	0.000	0.917	1.001	2	0.283	0.534	0.000	0.817	1.002	3	0.305	0.664	0.000	0.969	1.003	4	0.311	0.899	34.223	35.433	2.000	5	1.414	0.274	0.000	1.688	1.004	6	1.497	0.056	0.000	1.554	Total		4.065	3.090	34.223	41.377
Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)																																																																
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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 Storage Structures	1
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	0.397
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	20.000	Cv (Winter)	0.840

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

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)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH		Storm	Return Period	Climate Change	First (X) Surchage	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water
	Name									Level (m)
1.000	1	15	Winter	1	+0%	100/60	Winter			43.878
1.001	2	15	Winter	1	+0%	100/30	Summer			43.796
1.002	3	15	Winter	1	+0%	100/15	Summer			43.726
1.003	4	30	Winter	1	+0%	30/60	Winter			43.624
2.000	5	30	Winter	1	+0%	30/15	Summer			43.612
1.004	6	30	Winter	1	+0%	1/15	Summer			43.612

PN	US/MH Name	Surcharged		Flooded	Flow / Overflow (l/s)	Half Drain	Pipe	Status	Level Exceeded
		Depth (m)	Volume (m³)	Flow		Time (mins)	Flow (l/s)		
1.000	1	-0.197	0.000	0.04			1.3	OK	
1.001	2	-0.177	0.000	0.10			3.4	OK	
1.002	3	-0.165	0.000	0.16			5.6	OK	
1.003	4	-0.166	0.000	0.09		19	3.3	OK	
2.000	5	-0.113	0.000	0.05			1.4	OK	
1.004	6	0.036	0.000	0.35			4.7	SURCHARGED	

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<u>30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm</u>								
<u>Simulation Criteria</u>								
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		1		
Number of Online Controls		1		Number of Time/Area Diagrams		0		
Number of Offline Controls		0		Number of Real Time Controls		0		
<u>Synthetic Rainfall Details</u>								
Rainfall Model		FSR		Ratio R		0.397		
Region England and Wales		Cv (Summer)		0.750				
M5-60 (mm)		20.000		Cv (Winter)		0.840		
Margin for Flood Risk Warning (mm)		300.0		DVD Status		ON		
Analysis Timestep		Fine Inertia		Status		ON		
DTS Status		OFF						
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)		1, 30, 100						
Climate Change (%)		0, 0, 40						
Water								
US/MH	Return	Climate	First (X)	First (Y)	First (Z)	Overflow	Level	
PN	Name	Storm	Period	Change	Surcharge	Flood	Overflow	Act.
1.000	1 15	Winter	30	+0%	100/60	Winter		43.896
1.001	2 15	Summer	30	+0%	100/30	Summer		43.830
1.002	3 60	Winter	30	+0%	100/15	Summer		43.799
1.003	4 60	Winter	30	+0%	30/60	Winter		43.795
2.000	5 15	Summer	30	+0%	30/15	Summer		43.833
1.004	6 15	Summer	30	+0%	1/15	Summer		43.825
Surcharged		Flooded		Half Drain		Pipe		
US/MH	Depth	Volume	Flow /	Overflow	Time	Flow	Level	
PN	Name	(m)	(m³)	Cap.	(l/s)	(mins)	(l/s)	Status
1.000	1	-0.179	0.000	0.09			3.3	OK
1.001	2	-0.144	0.000	0.28			9.8	OK
1.002	3	-0.092	0.000	0.22			7.9	OK
1.003	4	0.005	0.000	0.13		44	4.8	SURCHARGED
2.000	5	0.108	0.000	0.18			5.5	SURCHARGED
1.004	6	0.249	0.000	0.37			5.0	SURCHARGED

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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	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	1
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	0.397
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	20.000	Cv (Winter)	0.840

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

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)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH		Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
	Name									
1.000	1	60	Winter	100	+40%	100/60	Winter			44.663
1.001	2	60	Winter	100	+40%	100/30	Summer			44.662
1.002	3	60	Winter	100	+40%	100/15	Summer			44.660
1.003	4	60	Winter	100	+40%	30/60	Winter			44.656
2.000	5	60	Winter	100	+40%	30/15	Summer			44.649
1.004	6	60	Winter	100	+40%	1/15	Summer			44.649

PN	US/MH Name	Surcharged	Flooded	Flow / Cap.	Overflow (l/s)	Half Drain	Pipe	Status	Level Exceeded
		Depth (m)	Volume (m³)			Time (mins)	Flow (l/s)		
1.000	1	0.588	0.000	0.08			2.9	FLOOD	RISK
1.001	2	0.688	0.000	0.23			8.0	FLOOD	RISK
1.002	3	0.769	0.000	0.34			12.0	FLOOD	RISK
1.003	4	0.867	0.000	0.13		88	4.8	FLOOD	RISK
2.000	5	0.924	0.000	0.14			4.2	FLOOD	RISK
1.004	6	1.073	0.000	0.38			5.2	FLOOD	RISK