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)	2	PIMP (%)	100
M5-60 (mm)	20.000	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)
0-4	0.066	4-8	0.034

Total Area Contributing (ha) = 0.100

Total Pipe Volume (m³) = 4.235

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	32.569	0.400	81.4	0.030	5.00	0.0	0.600	o	150	Pipe/Conduit	
1.001	25.033	0.150	166.9	0.030	0.00	0.0	0.600	o	225	Pipe/Conduit	
2.000	37.075	0.350	105.9	0.020	5.00	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	5.49	44.900	0.030	0.0	0.0	0.0	1.11	19.7	4.1
1.001	50.00	5.90	44.500	0.060	0.0	0.0	0.0	1.01	40.1	8.1
2.000	50.00	5.49	44.700	0.020	0.0	0.0	0.0	1.27	50.5	2.7

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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)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.002	20.878	0.100	208.8	0.020	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.003	20.340	0.590	34.5	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)
1.002	50.00	6.29	44.350	0.100	0.0	0.0	0.0	0.90	35.8	13.5
1.003	50.00	6.48	44.250	0.100	0.0	0.0	0.0	1.72	30.4	13.5

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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
1.000	S6	150	0.450	0.650	Unclassified	1200	0	0.650	Unclassified
1.001	S7	225	0.375	0.975	Unclassified	1200	0	0.375	Unclassified
2.000	S9	225	0.775	0.975	Unclassified	1200	0	0.775	Unclassified
1.002	S8	225	0.725	0.975	Unclassified	1200	0	0.975	Unclassified
1.003	HB	150	0.800	1.290	Unclassified	1200	0	0.800	Unclassified

Surcharged Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.003	Ditch	45.100	43.660	43.660	0	0

Datum (m) 0.000 Offset (mins) 0

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
5	44.900	125	44.900	245	44.900	365	44.900	485	44.900	605	44.900
10	44.900	130	44.900	250	44.900	370	44.900	490	44.900	610	44.900
15	44.900	135	44.900	255	44.900	375	44.900	495	44.900	615	44.900
20	44.900	140	44.900	260	44.900	380	44.900	500	44.900	620	44.900
25	44.900	145	44.900	265	44.900	385	44.900	505	44.900	625	44.900
30	44.900	150	44.900	270	44.900	390	44.900	510	44.900	630	44.900
35	44.900	155	44.900	275	44.900	395	44.900	515	44.900	635	44.900
40	44.900	160	44.900	280	44.900	400	44.900	520	44.900	640	44.900
45	44.900	165	44.900	285	44.900	405	44.900	525	44.900	645	44.900
50	44.900	170	44.900	290	44.900	410	44.900	530	44.900	650	44.900
55	44.900	175	44.900	295	44.900	415	44.900	535	44.900	655	44.900
60	44.900	180	44.900	300	44.900	420	44.900	540	44.900	660	44.900
65	44.900	185	44.900	305	44.900	425	44.900	545	44.900	665	44.900
70	44.900	190	44.900	310	44.900	430	44.900	550	44.900	670	44.900
75	44.900	195	44.900	315	44.900	435	44.900	555	44.900	675	44.900
80	44.900	200	44.900	320	44.900	440	44.900	560	44.900	680	44.900
85	44.900	205	44.900	325	44.900	445	44.900	565	44.900	685	44.900
90	44.900	210	44.900	330	44.900	450	44.900	570	44.900	690	44.900
95	44.900	215	44.900	335	44.900	455	44.900	575	44.900	695	44.900
100	44.900	220	44.900	340	44.900	460	44.900	580	44.900	700	44.900
105	44.900	225	44.900	345	44.900	465	44.900	585	44.900	705	44.900
110	44.900	230	44.900	350	44.900	470	44.900	590	44.900	710	44.900
115	44.900	235	44.900	355	44.900	475	44.900	595	44.900	715	44.900
120	44.900	240	44.900	360	44.900	480	44.900	600	44.900	720	44.900

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Surcharged Outfall Details for Storm

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
725	44.900	950	44.900	1175	44.900	1400	44.900	1625	44.900	1850	44.900
730	44.900	955	44.900	1180	44.900	1405	44.900	1630	44.900	1855	44.900
735	44.900	960	44.900	1185	44.900	1410	44.900	1635	44.900	1860	44.900
740	44.900	965	44.900	1190	44.900	1415	44.900	1640	44.900	1865	44.900
745	44.900	970	44.900	1195	44.900	1420	44.900	1645	44.900	1870	44.900
750	44.900	975	44.900	1200	44.900	1425	44.900	1650	44.900	1875	44.900
755	44.900	980	44.900	1205	44.900	1430	44.900	1655	44.900	1880	44.900
760	44.900	985	44.900	1210	44.900	1435	44.900	1660	44.900	1885	44.900
765	44.900	990	44.900	1215	44.900	1440	44.900	1665	44.900	1890	44.900
770	44.900	995	44.900	1220	44.900	1445	44.900	1670	44.900	1895	44.900
775	44.900	1000	44.900	1225	44.900	1450	44.900	1675	44.900	1900	44.900
780	44.900	1005	44.900	1230	44.900	1455	44.900	1680	44.900	1905	44.900
785	44.900	1010	44.900	1235	44.900	1460	44.900	1685	44.900	1910	44.900
790	44.900	1015	44.900	1240	44.900	1465	44.900	1690	44.900	1915	44.900
795	44.900	1020	44.900	1245	44.900	1470	44.900	1695	44.900	1920	44.900
800	44.900	1025	44.900	1250	44.900	1475	44.900	1700	44.900	1925	44.900
805	44.900	1030	44.900	1255	44.900	1480	44.900	1705	44.900	1930	44.900
810	44.900	1035	44.900	1260	44.900	1485	44.900	1710	44.900	1935	44.900
815	44.900	1040	44.900	1265	44.900	1490	44.900	1715	44.900	1940	44.900
820	44.900	1045	44.900	1270	44.900	1495	44.900	1720	44.900	1945	44.900
825	44.900	1050	44.900	1275	44.900	1500	44.900	1725	44.900	1950	44.900
830	44.900	1055	44.900	1280	44.900	1505	44.900	1730	44.900	1955	44.900
835	44.900	1060	44.900	1285	44.900	1510	44.900	1735	44.900	1960	44.900
840	44.900	1065	44.900	1290	44.900	1515	44.900	1740	44.900	1965	44.900
845	44.900	1070	44.900	1295	44.900	1520	44.900	1745	44.900	1970	44.900
850	44.900	1075	44.900	1300	44.900	1525	44.900	1750	44.900	1975	44.900
855	44.900	1080	44.900	1305	44.900	1530	44.900	1755	44.900	1980	44.900
860	44.900	1085	44.900	1310	44.900	1535	44.900	1760	44.900	1985	44.900
865	44.900	1090	44.900	1315	44.900	1540	44.900	1765	44.900	1990	44.900
870	44.900	1095	44.900	1320	44.900	1545	44.900	1770	44.900	1995	44.900
875	44.900	1100	44.900	1325	44.900	1550	44.900	1775	44.900	2000	44.900
880	44.900	1105	44.900	1330	44.900	1555	44.900	1780	44.900	2005	44.900
885	44.900	1110	44.900	1335	44.900	1560	44.900	1785	44.900	2010	44.900
890	44.900	1115	44.900	1340	44.900	1565	44.900	1790	44.900	2015	44.900
895	44.900	1120	44.900	1345	44.900	1570	44.900	1795	44.900	2020	44.900
900	44.900	1125	44.900	1350	44.900	1575	44.900	1800	44.900	2025	44.900
905	44.900	1130	44.900	1355	44.900	1580	44.900	1805	44.900	2030	44.900
910	44.900	1135	44.900	1360	44.900	1585	44.900	1810	44.900	2035	44.900
915	44.900	1140	44.900	1365	44.900	1590	44.900	1815	44.900	2040	44.900
920	44.900	1145	44.900	1370	44.900	1595	44.900	1820	44.900	2045	44.900
925	44.900	1150	44.900	1375	44.900	1600	44.900	1825	44.900	2050	44.900
930	44.900	1155	44.900	1380	44.900	1605	44.900	1830	44.900	2055	44.900
935	44.900	1160	44.900	1385	44.900	1610	44.900	1835	44.900	2060	44.900
940	44.900	1165	44.900	1390	44.900	1615	44.900	1840	44.900	2065	44.900
945	44.900	1170	44.900	1395	44.900	1620	44.900	1845	44.900	2070	44.900

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Surcharged Outfall Details for Storm

Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)	Time (mins)	Depth (m)
2075	44.900	2230	44.900	2385	44.900	2540	44.900	2695	44.900	2850	44.900
2080	44.900	2235	44.900	2390	44.900	2545	44.900	2700	44.900	2855	44.900
2085	44.900	2240	44.900	2395	44.900	2550	44.900	2705	44.900	2860	44.900
2090	44.900	2245	44.900	2400	44.900	2555	44.900	2710	44.900	2865	44.900
2095	44.900	2250	44.900	2405	44.900	2560	44.900	2715	44.900	2870	44.900
2100	44.900	2255	44.900	2410	44.900	2565	44.900	2720	44.900	2875	44.900
2105	44.900	2260	44.900	2415	44.900	2570	44.900	2725	44.900	2880	44.900
2110	44.900	2265	44.900	2420	44.900	2575	44.900	2730	44.900	2885	44.900
2115	44.900	2270	44.900	2425	44.900	2580	44.900	2735	44.900	2890	44.900
2120	44.900	2275	44.900	2430	44.900	2585	44.900	2740	44.900	2895	44.900
2125	44.900	2280	44.900	2435	44.900	2590	44.900	2745	44.900	2900	44.900
2130	44.900	2285	44.900	2440	44.900	2595	44.900	2750	44.900	2905	44.900
2135	44.900	2290	44.900	2445	44.900	2600	44.900	2755	44.900	2910	44.900
2140	44.900	2295	44.900	2450	44.900	2605	44.900	2760	44.900	2915	44.900
2145	44.900	2300	44.900	2455	44.900	2610	44.900	2765	44.900	2920	44.900
2150	44.900	2305	44.900	2460	44.900	2615	44.900	2770	44.900	2925	44.900
2155	44.900	2310	44.900	2465	44.900	2620	44.900	2775	44.900	2930	44.900
2160	44.900	2315	44.900	2470	44.900	2625	44.900	2780	44.900	2935	44.900
2165	44.900	2320	44.900	2475	44.900	2630	44.900	2785	44.900	2940	44.900
2170	44.900	2325	44.900	2480	44.900	2635	44.900	2790	44.900	2945	44.900
2175	44.900	2330	44.900	2485	44.900	2640	44.900	2795	44.900	2950	44.900
2180	44.900	2335	44.900	2490	44.900	2645	44.900	2800	44.900	2955	44.900
2185	44.900	2340	44.900	2495	44.900	2650	44.900	2805	44.900	2960	44.900
2190	44.900	2345	44.900	2500	44.900	2655	44.900	2810	44.900	2965	44.900
2195	44.900	2350	44.900	2505	44.900	2660	44.900	2815	44.900	2970	44.900
2200	44.900	2355	44.900	2510	44.900	2665	44.900	2820	44.900	2975	44.900
2205	44.900	2360	44.900	2515	44.900	2670	44.900	2825	44.900	2980	44.900
2210	44.900	2365	44.900	2520	44.900	2675	44.900	2830	44.900	2985	44.900
2215	44.900	2370	44.900	2525	44.900	2680	44.900	2835	44.900	2990	44.900
2220	44.900	2375	44.900	2530	44.900	2685	44.900	2840	44.900	2995	44.900
2225	44.900	2380	44.900	2535	44.900	2690	44.900	2845	44.900	3000	44.900

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 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

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Simulation Criteria for Storm

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	0.350		

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: HB, DS/PN: 1.003, Volume (m³): 1.9

Unit Reference	MD-SHE-0052-1000-0580-1000
Design Head (m)	0.580
Design Flow (l/s)	1.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	52
Invert Level (m)	44.250
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)	0.580	1.0	Kick-Flo®	0.378	0.8
Flush-Flo™	0.178	1.0	Mean Flow over Head Range	-	0.9

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	0.9	1.200	1.4	3.000	2.1	7.000	3.1
0.200	1.0	1.400	1.5	3.500	2.3	7.500	3.2
0.300	1.0	1.600	1.6	4.000	2.4	8.000	3.3
0.400	0.8	1.800	1.7	4.500	2.5	8.500	3.4
0.500	0.9	2.000	1.7	5.000	2.7	9.000	3.5
0.600	1.0	2.200	1.8	5.500	2.8	9.500	3.6
0.800	1.2	2.400	1.9	6.000	2.9		
1.000	1.3	2.600	2.0	6.500	3.0		

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Storage Structures for Storm

Tank or Pond Manhole: HB, DS/PN: 1.003

Invert Level (m) 44.375

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	290.0	0.825	690.0

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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 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 0.350
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 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) 100
Climate Change (%) 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.000	S6	15 Winter	100	+40%	100/15 Summer				45.119
1.001	S7	15 Winter	100	+40%	100/15 Summer				44.831
2.000	S9	15 Winter	100	+40%					44.776
1.002	S8	15 Winter	100	+40%	100/15 Summer				44.723
1.003	HB	2880 Winter	100	+40%	100/15 Summer				44.708

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	S6	0.069	0.000	0.84			15.9	SURCHARGED	
1.001	S7	0.106	0.000	0.83			30.8	FLOOD RISK	
2.000	S9	-0.149	0.000	0.24			11.6	OK	
1.002	S8	0.148	0.000	1.59			51.7	SURCHARGED	
1.003	HB	0.308	0.000	0.03			1.0	SURCHARGED	

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