


Woods Hardwick		Page 1
15-17 Goldington Road Bedford Bedfordshire MK40 3NH		
Date 19/11/2020 16:45	Designed by a.tew	
File SW PH9 Existing 19.03.19...	Checked by	
XP Solutions	Network 2014.1.1	

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm





Pipe Sizes STANDARD Manhole Sizes STANDARD

FEH Rainfall Model

Return Period (years)	2
Site Location GB 450500 225250 SP 50500 25250	
C (1km)	-0.023
D1 (1km)	0.328
D2 (1km)	0.309
D3 (1km)	0.264
E (1km)	0.292
F (1km)	2.461
Maximum Rainfall (mm/hr)	0
Maximum Time of Concentration (mins)	30
Foul Sewage (l/s/ha)	0.000
Volumetric Runoff Coeff.	0.750
Add Flow / Climate Change (%)	0
Minimum Backdrop Height (m)	0.000
Maximum Backdrop Height (m)	0.000
Min Design Depth for Optimisation (m)	1.200
Min Vel for Auto Design only (m/s)	1.00
Min Slope for Optimisation (1:X)	500


Designed with Level Inverts

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)	Auto Design
1.000	9.050	0.650	13.9	0.026	5.00	0.0	0.600	\	-1	
1.001	9.000	0.500	18.0	0.016	0.00	0.0	0.600	\	-1	
1.002	7.527	0.250	30.1	0.024	0.00	0.0	0.600	\	-1	
1.003	12.654	0.287	44.1	0.000	0.00	0.0	0.600	o	150	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	E I.Area (ha)	E Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	0.00	5.01	123.850	0.026	0.0	0.0	0.0	14.05	50669.7	0.0
1.001	0.00	5.02	123.200	0.042	0.0	0.0	0.0	12.36	44557.7	0.0
1.002	0.00	5.04	122.700	0.066	0.0	0.0	0.0	9.55	34441.1	0.0
1.003	0.00	5.17	122.450	0.066	0.0	0.0	0.0	1.52	26.9	0.0


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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)	Auto Design
1.004	45.169	0.115	392.8	0.053	0.00	0.0	0.600	o	450	
2.000	24.880	0.130	191.4	0.076	5.00	0.0	0.600	o	375	
2.001	6.893	0.027	255.3	0.000	0.00	0.0	0.600	o	375	
1.005	28.960	0.050	579.2	0.008	0.00	0.0	0.600	o	600	
3.000	25.800	0.112	230.4	0.028	5.00	0.0	0.600	oo	41	
1.006	10.020	0.017	589.4	0.049	0.00	0.0	0.600	o	600	
1.007	21.048	0.156	134.9	0.000	0.00	0.0	0.600	o	150	
1.008	16.030	0.300	53.4	0.000	0.00	0.0	0.600	o	150	
1.009	71.700	0.910	78.8	0.000	0.00	0.0	0.600	o	225	
4.000	42.980	0.233	184.5	0.500	5.00	0.0	0.600	o	225	
5.000	8.290	0.537	15.4	0.050	5.00	0.0	0.600	o	150	
4.001	7.220	0.030	240.7	0.000	0.00	0.0	0.600	o	300	

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	0.00	5.91	121.863	0.119	0.0	0.0	0.0	1.02	162.2	0.0
2.000	0.00	5.32	121.980	0.076	0.0	0.0	0.0	1.31	144.3	0.0
2.001	0.00	5.42	121.850	0.076	0.0	0.0	0.0	1.13	124.7	0.0
1.005	0.00	6.39	121.598	0.203	0.0	0.0	0.0	1.00	284.1	0.0
3.000	0.00	5.42	121.660	0.028	0.0	0.0	0.0	1.03	145.2	0.0
1.006	0.00	6.56	121.548	0.280	0.0	0.0	0.0	1.00	281.6	0.0
1.007	0.00	6.97	121.531	0.280	0.0	0.0	0.0	0.86	15.3	0.0
1.008	0.00	7.16	121.375	0.280	0.0	0.0	0.0	1.38	24.4	0.0
1.009	0.00	7.97	121.000	0.280	0.0	0.0	0.0	1.47	58.6	0.0
4.000	0.00	5.75	121.507	0.500	0.0	0.0	0.0	0.96	38.1	0.0
5.000	0.00	5.05	121.961	0.050	0.0	0.0	0.0	2.58	45.5	0.0
4.001	0.00	5.87	121.274	0.550	0.0	0.0	0.0	1.01	71.3	0.0


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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)	Auto Design
4.002	41.565	0.354	117.4	0.020	0.00	0.0	0.600	o	300	
6.000	17.914	0.241	74.3	0.020	5.00	0.0	0.600	o	100	
6.001	47.052	0.866	54.3	0.022	0.00	0.0	0.600	o	150	
6.002	64.199	0.985	65.2	0.000	0.00	0.0	0.600	o	150	
4.003	63.899	0.200	319.5	0.000	0.00	0.0	0.600	o	300	
7.000	128.657	0.762	168.8	0.250	5.00	0.0	0.600	o	300	
7.001	14.690	0.130	113.0	0.020	0.00	0.0	0.600	o	300	
4.004	17.440	0.150	116.3	0.000	0.00	0.0	0.600	oo	42	
4.005	150.030	0.750	200.0	0.000	0.00	0.0	0.600	o	525	
1.010	50.410	0.120	420.1	0.000	0.00	0.0	0.600	o	525	
1.011	10.500	0.030	350.0	0.000	0.00	0.0	0.600	o	525	
1.012	37.570	0.090	417.4	0.000	0.00	0.0	0.600	o	525	
1.013	43.870	0.110	398.8	0.000	0.00	0.0	0.600	o	525	
1.014	9.140	0.030	304.7	0.000	0.00	0.0	0.600	o	525	

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)
4.002	0.00	6.34	121.244	0.570	0.0	0.0	0.0	1.45	102.5	0.0
6.000	0.00	5.33	123.132	0.020	0.0	0.0	0.0	0.89	7.0	0.0
6.001	0.00	5.91	122.891	0.042	0.0	0.0	0.0	1.37	24.2	0.0
6.002	0.00	6.77	122.025	0.042	0.0	0.0	0.0	1.25	22.0	0.0
4.003	0.00	7.98	120.890	0.612	0.0	0.0	0.0	0.87	61.8	0.0
7.000	0.00	6.78	121.882	0.250	0.0	0.0	0.0	1.21	85.3	0.0
7.001	0.00	6.94	121.120	0.270	0.0	0.0	0.0	1.48	104.5	0.0
4.004	0.00	8.16	120.690	0.882	0.0	0.0	0.0	1.68	371.3	0.0
4.005	0.00	9.74	120.540	0.882	0.0	0.0	0.0	1.58	342.0	0.0
1.010	0.00	10.51	119.790	1.162	0.0	0.0	0.0	1.09	235.2	0.0
1.011	0.00	10.66	119.670	1.162	0.0	0.0	0.0	1.19	257.9	0.0
1.012	0.00	11.23	119.640	1.162	0.0	0.0	0.0	1.09	236.0	0.0
1.013	0.00	11.89	119.550	1.162	0.0	0.0	0.0	1.12	241.5	0.0
1.014	0.00	12.01	119.440	1.162	0.0	0.0	0.0	1.28	276.6	0.0

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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)	Auto Design
1.015	19.993	0.710	28.2	0.000	0.00	0.0	0.600	o	525	

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)
1.015	0.00	12.09	119.410	1.162	0.0	0.0	0.0	4.23	916.3	0.0

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)
1.015		119.500	118.700	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 * 10m ³ /ha Storage	1.000
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)	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 3 Number of Storage Structures 1 Number of Real Time Controls 0


Synthetic Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 450500 225250 SP 50500 25250
C (1km)	-0.023
D1 (1km)	0.328
D2 (1km)	0.309
D3 (1km)	0.264
E (1km)	0.292
F (1km)	2.461
Summer Storms	No
Winter Storms	Yes

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Synthetic Rainfall Details

Cv (Summer) 0.750
Cv (Winter) 0.840
Storm Duration (mins) 15

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Online Controls for Storm

Orifice Manhole: Swale, DS/PN: 1.001, Volume (m³): 32.6

Diameter (m) 0.050 Discharge Coefficient 0.600 Invert Level (m) 123.200


Orifice Manhole: Swale, DS/PN: 1.002, Volume (m³): 32.5

Diameter (m) 0.050 Discharge Coefficient 0.600 Invert Level (m) 122.700

Hydro-Brake® Manhole: Bl- 9, DS/PN: 1.007, Volume (m³): 5.6

Design Head (m) 1.200 Hydro-Brake® Type Md5 SW Only Invert Level (m) 121.531
Design Flow (l/s) 15.0 Diameter (mm) 150

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.0	1.200	14.8	3.000	23.5	7.000	35.8
0.200	9.8	1.400	16.0	3.500	25.3	7.500	37.1
0.300	10.9	1.600	17.1	4.000	27.1	8.000	38.3
0.400	10.8	1.800	18.2	4.500	28.7	8.500	39.5
0.500	10.8	2.000	19.2	5.000	30.3	9.000	40.6
0.600	11.1	2.200	20.1	5.500	31.8	9.500	41.7
0.800	12.3	2.400	21.0	6.000	33.2		
1.000	13.6	2.600	21.8	6.500	34.5		

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Storage Structures for Storm

Complex Manhole: SW MH, DS/PN: 2.001


Tank or Pond

Invert Level (m) 121.840

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	69.0	0.401	0.0	0.403	7.0	0.704	0.0
0.400	69.0	0.402	0.0	0.703	7.0		

Porous Car Park

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	8.7
Membrane Percolation (mm/hr)	1000	Length (m)	60.0
Max Percolation (l/s)	145.0	Slope (1:X)	80.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	5
Invert Level (m)	122.630	Cap Volume Depth (m)	0.000

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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 1.000
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 Time/Area Diagrams 0
Number of Online Controls 3 Number of Storage Structures 1 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FEH D3 (1km) 0.264
Site Location GB 450500 225250 SP 50500 25250 E (1km) 0.292
C (1km) -0.023 F (1km) 2.461
D1 (1km) 0.328 Cv (Summer) 0.750
D2 (1km) 0.309 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 (%) 30

PN	Storm	Return Period	Climate Change	First X Surcharge	First Y Flood	First Z Overflow	O/F Act.	Lvl Exc.
1.000	15 Winter	100	+30%					
1.001	15 Winter	100	+30%					
1.002	60 Winter	100	+30%					
1.003	60 Winter	100	+30%	100/15 Winter				
1.004	60 Winter	100	+30%	100/15 Summer				
2.000	60 Winter	100	+30%	100/15 Winter				
2.001	60 Winter	100	+30%	100/15 Summer				
1.005	60 Winter	100	+30%	100/15 Summer				
3.000	60 Winter	100	+30%	100/15 Summer				
1.006	60 Winter	100	+30%	100/15 Summer				
1.007	60 Winter	100	+30%	100/15 Summer	100/60 Winter			1
1.008	60 Winter	100	+30%					
1.009	60 Winter	100	+30%					
4.000	15 Winter	100	+30%	100/15 Summer	100/15 Summer			8
5.000	15 Winter	100	+30%	100/15 Summer	100/15 Summer			4

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

PN	Storm	Return Climate Period	Change	First X SurchARGE	First Y Flood	First Z O/F Overflow Act.	Lvl Exc.
4.001	15 Summer	100	+30%	100/15 Summer			
4.002	15 Winter	100	+30%	100/15 Summer			
6.000	15 Winter	100	+30%	100/15 Summer			
6.001	15 Winter	100	+30%	100/15 Summer			
6.002	15 Winter	100	+30%	100/15 Summer			
4.003	15 Winter	100	+30%	100/15 Summer			
7.000	15 Winter	100	+30%	100/15 Summer	100/15 Summer		2
7.001	15 Winter	100	+30%	100/15 Summer			
4.004	15 Winter	100	+30%				
4.005	15 Winter	100	+30%				
1.010	15 Winter	100	+30%	100/15 Summer			
1.011	15 Winter	100	+30%	100/15 Summer			
1.012	15 Winter	100	+30%	100/15 Summer			
1.013	15 Winter	100	+30%	100/15 Summer			
1.014	15 Winter	100	+30%	100/15 Winter			
1.015	15 Winter	100	+30%				

PN	US/MH Name	Water Level (m)	Surch'd Depth (m)	Flooded Volume (m³)	Flow / Cap.	O'flow (l/s)	Pipe Flow (l/s)	Status
1.000	Swale	124.052	-0.798	0.000	0.00	0.0	19.9	OK
1.001	Swale	124.052	-0.148	0.000	0.00	0.0	4.2	FLOOD RISK
1.002	Swale	123.468	-0.232	0.000	0.00	0.0	4.4	FLOOD RISK
1.003	Swale	122.828	0.228	0.000	0.31	0.0	7.5	SURCHARGED
1.004	B1- 5	122.816	0.503	0.000	0.14	0.0	20.1	SURCHARGED
2.000	SW MH	122.815	0.460	0.000	0.20	0.0	24.7	SURCHARGED
2.001	SW MH	122.812	0.587	0.000	0.14	0.0	11.8	FLOOD RISK
1.005	B1- 6	122.813	0.615	0.000	0.08	0.0	17.5	FLOOD RISK
3.000	B1- 13	122.814	0.854	0.000	0.07	0.0	8.5	SURCHARGED
1.006	B1- 8	122.813	0.665	0.000	0.12	0.0	17.9	FLOOD RISK
1.007	B1- 9	122.811	1.130	0.091	1.03	0.0	14.8	FLOOD
1.008	Ex MH	121.464	-0.061	0.000	0.66	0.0	14.8	OK
1.009	Ex MH	121.078	-0.147	0.000	0.26	0.0	14.8	OK
4.000	Ex MH 1113	123.284	1.552	107.172	2.44	0.0	88.7	FLOOD
5.000	Ex MH 1109	122.564	0.453	2.932	0.62	0.0	24.5	FLOOD
4.001	Ex MH 1111	122.422	0.848	0.000	1.87	0.0	97.3	SURCHARGED
4.002	Ex MH 1110	122.295	0.751	0.000	1.13	0.0	107.8	SURCHARGED
6.000	Ex MH 1097	124.301	1.069	0.000	1.73	0.0	11.7	FLOOD RISK
6.001	Ex MH 1115	123.594	0.553	0.000	1.01	0.0	23.8	SURCHARGED
6.002	Ex MH 1071	122.810	0.635	0.000	0.98	0.0	21.2	SURCHARGED
4.003	Ex MH 121.857		0.667	0.000	2.07	0.0	122.0	SURCHARGED
7.000	Ex MH 1112	123.607	1.425	7.952	1.64	0.0	136.2	FLOOD
7.001	Ex PI 121.562		0.142	0.000	1.48	0.0	129.5	SURCHARGED
4.004	Ex MH 120.986		-0.079	0.000	0.82	0.0	249.8	OK

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

PN	US/MH Name	Water	Flooded		Pipe		Status	
		Level (m)	Surch'd Depth (m)	Volume (m ³)	Flow / Cap. (l/s)	O'flow (l/s)		Flow (l/s)
4.005	Ex MH	120.884	-0.181	0.000	0.75	0.0	245.3	OK
1.010	Ex MH	120.434	0.119	0.000	1.16	0.0	242.6	SURCHARGED
1.011	Ex MH	120.281	0.086	0.000	1.48	0.0	237.4	SURCHARGED
1.012	Ex MH	120.224	0.059	0.000	1.16	0.0	237.2	SURCHARGED
1.013	Ex MH	120.105	0.030	0.000	1.11	0.0	236.2	SURCHARGED
1.014	Ex MH	119.972	0.007	0.000	1.34	0.0	236.3	SURCHARGED
1.015	Ex PI	119.629	-0.306	0.000	0.37	0.0	236.3	OK