

ARP Associates		Page 1
Northwest House Servia Hill Leeds LS6 2QH		
Date 08/03/2022 11:39am	Designed by RyanJones	
File 1375-02-V5-1.100YR +30%.MDX	Checked by	
Elstree Computing Ltd		Network 2020.1

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)	100	PIMP (%)	100
M5-60 (mm)	19.000	Add Flow / Climate Change (%)	0
Ratio R	0.317	Minimum Backdrop Height (m)	0.000
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	0.237	4-8	0.296

Total Area Contributing (ha) = 0.533

Total Pipe Volume (m³) = 12.989

Network Design Table for Storm

- Indicates pipe length does not match coordinates
« - Indicates pipe capacity < flow

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	35.269	2.425	14.5	0.085	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	38.672	2.763	14.0	0.210	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.002	9.367	0.287	32.6	0.167	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.003	11.044	0.737	15.0	0.031	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.004	9.566#	0.900	10.6	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
2.000	7.180#	0.100	71.8	0.040	5.00	0.0	0.600	o	150	Pipe/Conduit	
1.005	2.780#	0.010	278.0	0.000	0.00	0.0	0.600	o	600	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	5.17	115.375	0.085	0.0	0.0	0.0	3.45	137.1	11.5
1.001	50.00	5.32	112.950	0.295	0.0	0.0	0.0	4.22	298.6	39.9
1.002	50.00	5.38	110.187	0.462	0.0	0.0	0.0	2.76	195.2	62.6
1.003	50.00	5.42	109.900	0.493	0.0	0.0	0.0	4.08	288.5	66.8
1.004	50.00	5.46	109.163	0.493	0.0	0.0	0.0	4.85	342.8	66.8
2.000	50.00	5.10	109.250	0.040	0.0	0.0	0.0	1.19	21.0	5.4
1.005	50.00	5.49	106.770	0.533	0.0	0.0	0.0	1.46	411.6	72.2

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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
1.006	11.550#	0.116	99.6	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.007	92.870#	0.929	100.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.008	39.050#	0.391	99.9	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.009	2.930	0.030	97.7	0.000	0.00	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)
1.006	50.00	5.64	106.760	0.533	0.0	0.0	0.0	1.31	52.1«	72.2
1.007	50.00	6.82	106.644	0.533	0.0	0.0	0.0	1.31	52.0«	72.2
1.008	50.00	7.32	105.715	0.533	0.0	0.0	0.0	1.31	52.0«	72.2
1.009	50.00	7.35	105.324	0.533	0.0	0.0	0.0	1.32	52.6«	72.2

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam., L*W (mm)	PN	Pipe Out Invert Level (m)	Diameter (mm)	PN	Pipes In Invert Level (m)	Diameter (mm)	Backdrop (mm)
1	117.038	1.663	Open Manhole	1200	1.000	115.375	225				
2	115.599	2.649	Open Manhole	1200	1.001	112.950	300	1.000	112.950	225	
3	112.614	2.427	Open Manhole	1200	1.002	110.187	300	1.001	110.187	300	
4	111.767	1.867	Open Manhole	1200	1.003	109.900	300	1.002	109.900	300	
5	110.950	1.787	Open Manhole	1200	1.004	109.163	300	1.003	109.163	300	
6	110.600	1.350	Open Manhole	1200	2.000	109.250	150				
7	110.800	4.030	Open Manhole	1500	1.005	106.770	600	1.004	108.263	300	1193
								2.000	109.150	150	1930
8	110.200	3.440	Open Manhole	1500	1.006	106.760	225	1.005	106.760	600	
9	111.100	4.456	Open Manhole	1200	1.007	106.644	225	1.006	106.644	225	
10	111.800	6.085	Open Manhole	1200	1.008	105.715	225	1.007	105.715	225	
11	106.900	1.576	Open Manhole	1200	1.009	105.324	225	1.008	105.324	225	
	106.530	1.236	Open Manhole	0		OUTFALL		1.009	105.294	225	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
1	414568.192	415416.673	414568.192	415416.673	Required	
2	414598.629	415398.855	414598.629	415398.855	Required	
3	414631.800	415378.975	414631.800	415378.975	Required	
4	414641.060	415377.562	414641.060	415377.562	Required	
5	414647.124	415386.791	414647.124	415386.791	Required	
6	414659.762	415402.128	414659.762	415402.128	Required	
7	414647.213	415405.491	414647.213	415405.491	Required	
8	414645.564	415416.931	414645.564	415416.931	Required	
9	414564.256	415464.958	414564.256	415464.958	Required	
10	414584.312	415498.458	414584.312	415498.458	Required	
11	414584.312	415498.458	414584.312	415498.458	Required	

Manhole Schedules for Storm

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
	414584.302	415501.392			No Entry	

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PIPELINE SCHEDULES for Storm

Upstream Manhole

- Indicates pipe length does not match coordinates

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	o	225	1	117.038	115.375	1.438	Open Manhole	1200
1.001	o	300	2	115.599	112.950	2.349	Open Manhole	1200
1.002	o	300	3	112.614	110.187	2.127	Open Manhole	1200
1.003	o	300	4	111.767	109.900	1.567	Open Manhole	1200
1.004	o	300	5	110.950	109.163	1.487	Open Manhole	1200
2.000	o	150	6	110.600	109.250	1.200	Open Manhole	1200
1.005	o	600	7	110.800	106.770	3.430	Open Manhole	1500
1.006	o	225	8	110.200	106.760	3.215	Open Manhole	1500
1.007	o	225	9	111.100	106.644	4.231	Open Manhole	1200
1.008	o	225	10	111.800	105.715	5.860	Open Manhole	1200
1.009	o	225	11	106.900	105.324	1.351	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)
1.000	35.269	14.5	2	115.599	112.950	2.424	Open Manhole	1200
1.001	38.672	14.0	3	112.614	110.187	2.127	Open Manhole	1200
1.002	9.367	32.6	4	111.767	109.900	1.567	Open Manhole	1200
1.003	11.044	15.0	5	110.950	109.163	1.487	Open Manhole	1200
1.004	9.566#	10.6	7	110.800	108.263	2.237	Open Manhole	1500
2.000	7.180#	71.8	7	110.800	109.150	1.500	Open Manhole	1500
1.005	2.780#	278.0	8	110.200	106.760	2.840	Open Manhole	1500
1.006	11.550#	99.6	9	111.100	106.644	4.231	Open Manhole	1200
1.007	92.870#	100.0	10	111.800	105.715	5.860	Open Manhole	1200
1.008	39.050#	99.9	11	106.900	105.324	1.351	Open Manhole	1200
1.009	2.930	97.7		106.530	105.294	1.011	Open Manhole	0

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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	1	225	1.438	2.424	Unclassified	1200	0	1.438	Unclassified
1.001	2	300	2.127	2.349	Unclassified	1200	0	2.349	Unclassified
1.002	3	300	1.567	2.127	Unclassified	1200	0	2.127	Unclassified
1.003	4	300	1.487	1.567	Unclassified	1200	0	1.567	Unclassified
1.004	5	300	1.487	2.237	Unclassified	1200	0	1.487	Unclassified
2.000	6	150	1.200	1.500	Unclassified	1200	0	1.200	Unclassified
1.005	7	600	2.840	3.430	Unclassified	1500	0	3.430	Unclassified
1.006	8	225	3.215	4.231	Unclassified	1500	0	3.215	Unclassified
1.007	9	225	4.231	5.860	Unclassified	1200	0	4.231	Unclassified
1.008	10	225	1.351	5.860	Unclassified	1200	0	5.860	Unclassified
1.009	11	225	1.011	1.351	Unclassified	1200	0	1.351	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)
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1.009		106.530	105.294	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 * 10m ³ /ha Storage	0.000
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 Online Controls	2	Number of Time/Area Diagrams	0
		Number of Storage Structures	1
		Number of Real Time Controls	0

Synthetic Rainfall Details

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)	19.000	Storm Duration (mins)	30
Ratio R	0.317		

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: 8, DS/PN: 1.006, Volume (m³): 6.4

Unit Reference	MD-SHE-0080-5000-3500-5000
Design Head (m)	3.500
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	80
Invert Level (m)	106.760
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)	3.500	5.0	Kick-Flo®	0.717	2.4
Flush-Flo™	0.348	3.0	Mean Flow over Head Range	-	3.6

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)	Depth (m)	Flow (l/s)
0.100	2.3	0.800	2.5	2.000	3.8	4.000	5.3	7.000	6.9
0.200	2.8	1.000	2.8	2.200	4.0	4.500	5.6	7.500	7.1
0.300	3.0	1.200	3.0	2.400	4.2	5.000	5.9	8.000	7.4
0.400	3.0	1.400	3.3	2.600	4.3	5.500	6.2	8.500	7.6
0.500	2.9	1.600	3.5	3.000	4.6	6.000	6.4	9.000	7.8
0.600	2.8	1.800	3.7	3.500	5.0	6.500	6.7	9.500	8.0

Orifice Manhole: 9, DS/PN: 1.007, Volume (m³): 5.4

Diameter (m) 0.033 Discharge Coefficient 0.600 Invert Level (m) 106.644

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Storage Structures for Storm

Tank or Pond Manhole: 7, DS/PN: 1.005

Invert Level (m) 107.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	170.0	2.500	170.0	2.501	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 * 10m ³ /ha Storage	0.000
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	2	Number of Time/Area Diagrams	0
		Number of Storage Structures	1
		Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR M5-60 (mm)	19.000	Cv (Summer)	0.750	
Region	England and Wales	Ratio R	0.317	Cv (Winter)	0.850
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, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760				
Return Period(s) (years)					1, 30, 100
Climate Change (%)					0, 0, 30

US/MH		Return Climate		First (X)		First (Y)		First (Z)		Overflow	Water	Surcharged
PN	Name	Storm	Period	Change	Surcharge	Flood	Overflow	Act.			Level (m)	Depth (m)
1.000	1	15 Winter	1	+0%							115.418	-0.182
1.001	2	15 Winter	1	+0%							113.018	-0.232
1.002	3	15 Winter	1	+0%	30/15 Summer						110.314	-0.173
1.003	4	15 Winter	1	+0%	100/15 Summer						110.002	-0.198
1.004	5	15 Winter	1	+0%	100/15 Summer						109.260	-0.203
2.000	6	15 Winter	1	+0%	100/15 Summer						109.304	-0.096
1.005	7	600 Winter	1	+0%	1/180 Winter						107.428	0.058
1.006	8	360 Winter	1	+0%	1/15 Summer						107.464	0.479
1.007	9	1440 Winter	1	+0%	1/15 Summer						107.275	0.406
1.008	10	1440 Winter	1	+0%							105.742	-0.198
1.009	11	1440 Winter	1	+0%							105.359	-0.190

Flooded				Half Drain Pipe					
US/MH	Volume	Flow /	Overflow	Time	Flow	Level			
PN	Name	(m ³)	Cap.	(l/s)	(mins)	(l/s)	Status	Exceeded	
1.000	1	0.000	0.08			10.5	OK		
1.001	2	0.000	0.12			32.5	OK		
1.002	3	0.000	0.37			49.7	OK		
1.003	4	0.000	0.25			53.0	OK		
1.004	5	0.000	0.22			53.3	OK		
2.000	6	0.000	0.27			4.9	OK		
1.005	7	0.000	0.04			8.2	SURCHARGED		
1.006	8	0.000	0.05			2.1	SURCHARGED		
1.007	9	0.000	0.04			1.8	SURCHARGED		
1.008	10	0.000	0.04			1.8	OK		
1.009	11	0.000	0.06			1.8	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 0.000
 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 2 Number of Storage Structures 1 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR M5-60 (mm) 19.000 Cv (Summer) 0.750
 Region England and Wales Ratio R 0.317 Cv (Winter) 0.850

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, 180, 240, 360, 480, 600, 720, 960,
 1440, 2160, 2880, 4320, 5760
 Return Period(s) (years) 1, 30, 100
 Climate Change (%) 0, 0, 30

PN	US/MH		Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water	Surcharged
	Name	Storm							Level (m)	Depth (m)
1.000	1	15 Winter	30	+0%					115.443	-0.157
1.001	2	15 Winter	30	+0%					113.070	-0.180
1.002	3	15 Winter	30	+0%	30/15 Summer				110.536	0.049
1.003	4	15 Winter	30	+0%	100/15 Summer				110.092	-0.108
1.004	5	15 Winter	30	+0%	100/15 Summer				109.342	-0.121
2.000	6	15 Winter	30	+0%	100/15 Summer				109.341	-0.059
1.005	7	720 Winter	30	+0%	1/180 Winter				108.139	0.769
1.006	8	600 Winter	30	+0%	1/15 Summer				108.274	1.289
1.007	9	600 Winter	30	+0%	1/15 Summer				107.834	0.965
1.008	10	600 Winter	30	+0%					105.747	-0.193
1.009	11	600 Winter	30	+0%					105.367	-0.182

PN	US/MH Name	Flooded		Half Drain		Pipe Flow (l/s)	Status	Level Exceeded
		Volume (m ³)	Flow / Cap. (l/s)	Time (mins)	Flow (l/s)			
1.000	1	0.000	0.20		25.8	OK		
1.001	2	0.000	0.34		93.6	OK		
1.002	3	0.000	1.10		147.5	SURCHARGED		
1.003	4	0.000	0.73		157.0	OK		
1.004	5	0.000	0.66		155.9	OK		
2.000	6	0.000	0.67		12.1	OK		
1.005	7	0.000	0.04		8.4	SURCHARGED		
1.006	8	0.000	0.06		2.5	SURCHARGED		
1.007	9	0.000	0.05		2.5	SURCHARGED		
1.008	10	0.000	0.05		2.5	OK		
1.009	11	0.000	0.08		2.5	OK		

