STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for SW

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	30	PIMP (%)	100
M5-60 (mm)	19.000	Add Flow / Climate Change (%)	0
Ratio R	0.300	Minimum Backdrop Height (m)	0.600
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	3.000
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

Network Design Table for SW

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	18.580	0.111	167.4	0.144	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	36.068	0.147	245.4	0.087	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.002	35.623	0.253	140.8	0.140	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.003	26.998	0.180	150.0	0.043	0.00	0.0	0.600	o	375	Pipe/Conduit	
2.000	25.358	0.079	321.0	0.099	5.00	0.0	0.600	o	375	Pipe/Conduit	
1.004	36.673	0.091	403.0	0.158	0.00	0.0	0.600	o	450	Pipe/Conduit	
1.005	18.005	0.044	409.2	0.060	0.00	0.0	0.600	o	525	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	5.31	80.320	0.144	0.0	0.0	0.0	1.01	40.1	19.5
1.001	50.00	5.91	80.134	0.231	0.0	0.0	0.0	1.00	70.6	31.3
1.002	50.00	6.36	79.987	0.371	0.0	0.0	0.0	1.32	93.5	50.2
1.003	50.00	6.66	79.659	0.414	0.0	0.0	0.0	1.48	163.1	56.1
2.000	50.00	5.42	79.558	0.099	0.0	0.0	0.0	1.01	111.1	13.4
1.004	50.00	7.27	79.404	0.671	0.0	0.0	0.0	1.01	160.1	90.9
1.005	50.00	7.54	79.238	0.731	0.0	0.0	0.0	1.10	238.3	99.0

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Network Design Table for SW

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
3.000	33.413	0.084	397.8	0.068	5.00	0.0	0.600	o	450	Pipe/Conduit	
1.006	9.625	0.794	12.1	0.023	0.00	0.0	0.600	o	525	Pipe/Conduit	
1.007	7.777	0.100	77.8	0.000	0.00	0.0	0.600	o	525	Pipe/Conduit	
1.008	8.747	0.025	349.9	0.000	0.00	0.0	0.600	o	750	Pipe/Conduit	
1.009	17.540	0.035	501.1	0.176	0.00	0.0	0.600	o	750	Pipe/Conduit	
4.000	14.818	0.111	133.5	0.140	1.00	25.4	0.600	600 []	600	600 Culvert	
4.001	25.456	0.191	133.3	0.000	0.00	0.0	0.600	600 []	600	600 Culvert	
4.002	11.184	0.063	177.5	0.000	0.00	0.0	0.600	600 []	600	600 Culvert	
4.003	4.968	0.049	101.4	0.000	0.00	0.0	0.600	600 []	600	600 Culvert	
4.004	35.913	0.090	399.0	0.000	0.00	0.0	0.600	o	750	Pipe/Conduit	
1.010	21.289	0.055	387.1	0.000	0.00	0.0	0.600	o	750	Pipe/Conduit	
1.011	46.284	0.110	420.8	0.000	0.00	0.0	0.600	o	750	Pipe/Conduit	
1.012	8.255	0.045	183.4	0.000	0.00	0.0	0.600	o	750	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)
3.000	50.00	5.55	79.352	0.068	0.0	0.0	0.0	1.01	161.1	9.2
1.006	50.00	7.57	79.194	0.822	0.0	0.0	0.0	6.46	1398.0	111.3
1.007	50.00	7.62	78.400	0.822	0.0	0.0	0.0	2.54	550.2	111.3
1.008	50.00	7.72	78.300	0.822	0.0	0.0	0.0	1.49	658.4	111.3
1.009	50.00	7.95	78.275	0.998	0.0	0.0	0.0	1.24	549.2	135.1
4.000	50.00	1.12	79.361	0.140	25.4	0.0	0.0	2.06	577.3	44.4
4.001	50.00	1.33	79.250	0.140	25.4	0.0	0.0	2.06	577.7	44.4
4.002	50.00	1.43	79.059	0.140	25.4	0.0	0.0	1.79	500.1	44.4
4.003	50.00	1.46	78.996	0.140	25.4	0.0	0.0	2.37	662.9	44.4
4.004	50.00	1.89	78.330	0.140	25.4	0.0	0.0	1.39	616.2	44.4
1.010	50.00	8.20	78.240	1.138	25.4	0.0	0.0	1.42	625.7	179.5
1.011	50.00	8.77	78.185	1.138	25.4	0.0	0.0	1.36	599.9	179.5
1.012	50.00	8.84	78.075	1.138	25.4	0.0	0.0	2.06	911.4	179.5

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Manhole Schedules for SW

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)	Backdr (mm)
SW1	81.745	1.425	Open Manhole	1350	1.000	80.320	225				
SW2	81.819	1.685	Open Manhole	1350	1.001	80.134	300	1.000	80.209	225	
SW3	81.712	1.725	Open Manhole	1350	1.002	79.987	300	1.001	79.987	300	
SW4	81.234	1.575	Open Manhole	1350	1.003	79.659	375	1.002	79.734	300	
SW15	80.809	1.251	Open Manhole	1500	2.000	79.558	375				
SW5	81.085	1.681	Open Manhole	1800	1.004	79.404	450	1.003	79.479	375	
								2.000	79.479	375	
SW6	81.222	1.984	Open Manhole	2100	1.005	79.238	525	1.004	79.313	450	
SW16	80.628	1.276	Open Manhole	2100	3.000	79.352	450				
SW7	81.043	1.849	Open Manhole	2400	1.006	79.194	525	1.005	79.194	525	
								3.000	79.268	450	
SW8hwall	81.924	3.524	Open Manhole	2400	1.007	78.400	525	1.006	78.400	525	
SW9hwall	81.924	3.624	Open Manhole	2400	1.008	78.300	750	1.007	78.300	525	
S10 HYDROBRAKE	81.000	2.725	Open Manhole	2400	1.009	78.275	750	1.008	78.275	750	
CUL1	81.000	1.639	Open Manhole	1800	4.000	79.361	600				
CUL2	81.200	1.950	Open Manhole	1800	4.001	79.250	600	4.000	79.250	600	
CUL3	81.200	2.141	Open Manhole	1800	4.002	79.059	600	4.001	79.059	600	
CUL4	81.250	2.254	Open Manhole	1800	4.003	78.996	600	4.002	78.996	600	
SW17	80.500	2.170	Open Manhole	1800	4.004	78.330	750	4.003	78.947	600	4
SW11	80.800	2.560	Open Manhole	1800	1.010	78.240	750	1.009	78.240	750	
								4.004	78.240	750	
SW12	80.135	1.950	Open Manhole	1800	1.011	78.185	750	1.010	78.185	750	
SW13	80.025	1.950	Open Manhole	1800	1.012	78.075	750	1.011	78.075	750	
SW14	80.800	2.770	Open Manhole	1800		OUTFALL		1.012	78.030	750	

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SW1	374356.378	442588.682	374356.378	442588.682	Required	
SW2	374345.853	442573.371	374345.853	442573.371	Required	

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Manhole Schedules for SW

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SW3	374326.574	442542.887	374326.574	442542.887	Required	
SW4	374357.544	442525.285	374357.544	442525.285	Required	
SW15	374368.290	442488.889	374368.290	442488.889	Required	
SW5	374380.518	442511.104	374380.518	442511.104	Required	
SW6	374398.081	442543.298	374398.081	442543.298	Required	
SW16	374425.645	442586.317	374425.645	442586.317	Required	
SW7	374409.998	442556.795	374409.998	442556.795	Required	
SW8hwall	374417.883	442551.275	374417.883	442551.275	Required	
SW9hwall	374415.718	442543.805	374415.718	442543.805	Required	
S10 HYDROBRAKE	374412.909	442535.521	374412.909	442535.521	Required	
CUL1	374434.041	442604.590	374434.041	442604.590	Required	
CUL2	374433.478	442589.783	374433.478	442589.783	Required	
CUL3	374431.835	442564.380	374431.835	442564.380	Required	
CUL4	374432.635	442553.225	374432.635	442553.225	Required	

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Manhole Schedules for SW

MH Name	Manhole Easting (m)	Manhole Northing (m)	Intersection Easting (m)	Intersection Northing (m)	Manhole Access	Layout (North)
SW17	374436.943	442550.750	374436.943	442550.750	Required	
SW11	374419.594	442519.305	374419.594	442519.305	Required	
SW12	374436.880	442506.680	374436.880	442506.680	Required	
SW13	374410.100	442468.930	374410.100	442468.930	Required	
SW14	374403.980	442463.390			No Entry	

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PIPELINE SCHEDULES for SW

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)
1.000	o	225	SW1	81.745	80.320	1.200	Open Manhole	1350
1.001	o	300	SW2	81.819	80.134	1.385	Open Manhole	1350
1.002	o	300	SW3	81.712	79.987	1.425	Open Manhole	1350
1.003	o	375	SW4	81.234	79.659	1.200	Open Manhole	1350
2.000	o	375	SW15	80.809	79.558	0.876	Open Manhole	1500
1.004	o	450	SW5	81.085	79.404	1.231	Open Manhole	1800
1.005	o	525	SW6	81.222	79.238	1.459	Open Manhole	2100
3.000	o	450	SW16	80.628	79.352	0.826	Open Manhole	2100
1.006	o	525	SW7	81.043	79.194	1.324	Open Manhole	2400
1.007	o	525	SW8hwall	81.924	78.400	2.999	Open Manhole	2400
1.008	o	750	SW9hwall	81.924	78.300	2.874	Open Manhole	2400
1.009	o	750	S10 HYDROBRAKE	81.000	78.275	1.975	Open Manhole	2400
4.000	600 []	600	CUL1	81.000	79.361	1.039	Open Manhole	1800

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	18.580	167.4	SW2	81.819	80.209	1.385	Open Manhole	1350
1.001	36.068	245.4	SW3	81.712	79.987	1.425	Open Manhole	1350
1.002	35.623	140.8	SW4	81.234	79.734	1.200	Open Manhole	1350
1.003	26.998	150.0	SW5	81.085	79.479	1.231	Open Manhole	1800
2.000	25.358	321.0	SW5	81.085	79.479	1.231	Open Manhole	1800
1.004	36.673	403.0	SW6	81.222	79.313	1.459	Open Manhole	2100
1.005	18.005	409.2	SW7	81.043	79.194	1.324	Open Manhole	2400
3.000	33.413	397.8	SW7	81.043	79.268	1.325	Open Manhole	2400
1.006	9.625	12.1	SW8hwall	81.924	78.400	2.999	Open Manhole	2400
1.007	7.777	77.8	SW9hwall	81.924	78.300	3.099	Open Manhole	2400
1.008	8.747	349.9	S10 HYDROBRAKE	81.000	78.275	1.975	Open Manhole	2400
1.009	17.540	501.1	SW11	80.800	78.240	1.810	Open Manhole	1800
4.000	14.818	133.5	CUL2	81.200	79.250	1.350	Open Manhole	1800

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PIPELINE SCHEDULES for SW

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)
4.001	600 []	600	CUL2	81.200	79.250	1.350	Open Manhole	1800
4.002	600 []	600	CUL3	81.200	79.059	1.541	Open Manhole	1800
4.003	600 []	600	CUL4	81.250	78.996	1.654	Open Manhole	1800
4.004	o	750	SW17	80.500	78.330	1.420	Open Manhole	1800
1.010	o	750	SW11	80.800	78.240	1.810	Open Manhole	1800
1.011	o	750	SW12	80.135	78.185	1.200	Open Manhole	1800
1.012	o	750	SW13	80.025	78.075	1.200	Open Manhole	1800

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)
4.001	25.456	133.3	CUL3	81.200	79.059	1.541	Open Manhole	1800
4.002	11.184	177.5	CUL4	81.250	78.996	1.654	Open Manhole	1800
4.003	4.968	101.4	SW17	80.500	78.947	0.953	Open Manhole	1800
4.004	35.913	399.0	SW11	80.800	78.240	1.810	Open Manhole	1800
1.010	21.289	387.1	SW12	80.135	78.185	1.200	Open Manhole	1800
1.011	46.284	420.8	SW13	80.025	78.075	1.200	Open Manhole	1800
1.012	8.255	183.4	SW14	80.800	78.030	2.020	Open Manhole	1800

Free Flowing Outfall Details for SW

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.012	SW14	80.800	78.030	0.000	1800	0

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Simulation Criteria for SW

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	3	Number of Storage Structures	1	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Storm Duration (mins)	30
Ratio R	0.300		

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Online Controls for SW

Non Return Valve Manhole: SW7, DS/PN: 1.006, Volume (m³): 16.7

Hydro-Brake® Optimum Manhole: S10 HYDROBRAKE, DS/PN: 1.009, Volume (m³): 15.1

Unit Reference	MD-SHE-0135-1090-2100-1090
Design Head (m)	2.100
Design Flow (l/s)	10.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	135
Invert Level (m)	78.275
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.100	10.9	Kick-Flo®	1.207	8.4
Flush-Flo™	0.591	10.6	Mean Flow over Head Range	-	9.4

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	4.9	1.200	8.5	3.000	12.9	7.000	19.3
0.200	8.8	1.400	9.0	3.500	13.9	7.500	20.0
0.300	9.8	1.600	9.6	4.000	14.8	8.000	20.6
0.400	10.3	1.800	10.1	4.500	15.6	8.500	21.2
0.500	10.5	2.000	10.6	5.000	16.4	9.000	21.8
0.600	10.6	2.200	11.1	5.500	17.2	9.500	22.4
0.800	10.4	2.400	11.6	6.000	17.9		
1.000	9.8	2.600	12.0	6.500	18.6		

Non Return Valve Manhole: SW11, DS/PN: 1.010, Volume (m³): 28.4

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Storage Structures for SW

Tank or Pond Manhole: S10 HYDROBRAKE, DS/PN: 1.009

Invert Level (m) 78.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	113.7	2.000	493.6	2.010	0.0

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

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 3 Number of Storage Structures 1 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.298
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 19.400 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, 180, 240, 360, 480, 600, 720, 960, 1440
Return Period(s) (years) 2, 30, 100, 200
Climate Change (%) 0, 0, 40, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow
1.000	SW1	15 Winter	200	+40%	30/15 Summer	100/15 Summer	
1.001	SW2	15 Winter	200	+40%	30/15 Summer		
1.002	SW3	15 Winter	200	+40%	30/15 Summer		
1.003	SW4	480 Winter	200	+40%	100/15 Summer		
2.000	SW15	480 Winter	200	+40%	100/15 Summer		
1.004	SW5	480 Winter	200	+40%	30/15 Summer		
1.005	SW6	480 Winter	200	+40%	100/15 Summer		
3.000	SW16	480 Winter	200	+40%	100/60 Winter	200/180 Winter	
1.006	SW7	480 Winter	200	+40%	100/60 Summer		
1.007	SW8hwall	480 Winter	200	+40%	2/120 Winter		
1.008	SW9hwall	480 Winter	200	+40%	30/30 Summer		
1.009	S10 HYDROBRAKE	480 Winter	200	+40%	30/30 Summer		
4.000	CUL1	15 Summer	200	+40%			
4.001	CUL2	15 Summer	200	+40%			
4.002	CUL3	15 Summer	200	+40%			

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

PN	US/MH Name	Overflow Act.	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)
1.000	SW1		81.754	1.209	8.961	2.46			88.6
1.001	SW2		81.744	1.310	0.000	1.59			103.4
1.002	SW3		81.548	1.261	0.000	1.85			159.4
1.003	SW4		80.713	0.679	0.000	0.25			35.9
2.000	SW15		80.711	0.778	0.000	0.08			8.1
1.004	SW5		80.709	0.855	0.000	0.39			54.5
1.005	SW6		80.705	0.942	0.000	0.34			58.6
3.000	SW16		80.697	0.895	68.729	0.13			17.6
1.006	SW7		80.702	0.983	0.000	0.09			64.7
1.007	SW8hwall		80.701	1.776	0.000	0.26			63.9
1.008	SW9hwall		80.701	1.651	0.000	0.19			63.1
1.009	S10 HYDROBRAKE		80.700	1.675	0.000	0.04			11.4
4.000	CUL1		79.625	-0.336	0.000	0.47			157.9
4.001	CUL2		79.502	-0.348	0.000	0.34			146.3
4.002	CUL3		79.355	-0.304	0.000	0.48			158.4

PN	US/MH Name	Status	Level Exceeded
1.000	SW1	FLOOD	6
1.001	SW2	FLOOD RISK	
1.002	SW3	FLOOD RISK	
1.003	SW4	SURCHARGED	
2.000	SW15	FLOOD RISK	
1.004	SW5	SURCHARGED	
1.005	SW6	SURCHARGED	
3.000	SW16	FLOOD	7
1.006	SW7	SURCHARGED	
1.007	SW8hwall	SURCHARGED	
1.008	SW9hwall	SURCHARGED	
1.009	S10 HYDROBRAKE	FLOOD RISK	
4.000	CUL1	OK	
4.001	CUL2	OK	
4.002	CUL3	OK	

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

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
4.003	CUL4	15 Summer	200	+40%					79.277
4.004	SW17	15 Summer	200	+40%					78.627
1.010	SW11	15 Summer	200	+40%					78.532
1.011	SW12	15 Summer	200	+40%					78.455
1.012	SW13	15 Summer	200	+40%					78.332

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
4.003	CUL4	-0.319	0.000	0.46			152.7	OK	
4.004	SW17	-0.453	0.000	0.30			146.6	OK	
1.010	SW11	-0.458	0.000	0.30			136.3	OK	
1.011	SW12	-0.480	0.000	0.25			126.4	OK	
1.012	SW13	-0.493	0.000	0.26			125.6	OK	

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