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
FEH Rainfall Version	1999
Site Location	GB 524650 322000 TF 24650 22000
C (1km)	-0.022
D1 (1km)	0.304
D2 (1km)	0.302
D3 (1km)	0.228
E (1km)	0.314
F (1km)	2.480
Maximum Rainfall (mm/hr)	50
Maximum Time of Concentration (mins)	30
Foul Sewage (l/s/ha)	0.000
Volumetric Runoff Coeff.	0.750
PIMP (%)	100
Add Flow / Climate Change (%)	0
Minimum Backdrop Height (m)	0.200
Maximum Backdrop Height (m)	1.500
Min Design Depth for Optimisation (m)	0.900
Min Vel for Auto Design only (m/s)	1.00
Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for Storm at outfall (pipe 1.004)

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.359	4-8	0.132

Total Area Contributing (ha) = 0.491

Total Pipe Volume (m³) = 42.111

Time Area Diagram at outfall (pipe 5.000)

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.022	4-8	0.001

Total Area Contributing (ha) = 0.023

Total Pipe Volume (m³) = 0.073

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Network Design Table for Storm

« - 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	8.975	0.175	51.3	0.000	4.00	0.0	0.600	o	150	Pipe/Conduit	
1.001	19.143	0.077	248.6	0.066	0.00	0.0	0.600	o	225	Pipe/Conduit	
2.000	12.795	0.051	250.9	0.129	4.00	0.0	0.600	o	300	Pipe/Conduit	
2.001	38.256	0.077	496.8	0.022	0.00	0.0	0.600	o	600	Pipe/Conduit	
1.002	41.792	0.084	497.5	0.075	0.00	0.0	0.600	o	600	Pipe/Conduit	
3.000	6.181	0.041	150.8	0.093	4.00	0.0	0.600	o	150	Pipe/Conduit	
3.001	12.411	0.025	496.4	0.000	0.00	0.0	0.600	oo	45	Pipe/Conduit	
1.003	17.913	0.036	497.6	0.051	0.00	0.0	0.600	oo	45	Pipe/Conduit	
4.000	3.524	0.023	153.2	0.024	4.00	0.0	0.600	o	150	Pipe/Conduit	
1.004	4.947	0.016	309.2	0.031	0.00	0.0	0.600	o	300	Pipe/Conduit	
5.000	9.267	0.158	58.7	0.023	4.00	0.0	0.600	o	100	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	4.11	2.531	0.000	0.0	0.0	0.0	1.41	24.9	0.0
1.001	50.00	4.49	2.356	0.066	0.0	0.0	0.0	0.82	32.8	9.0
2.000	50.00	4.22	2.332	0.129	0.0	0.0	0.0	0.99	69.8	17.5
2.001	50.00	4.80	1.981	0.152	0.0	0.0	0.0	1.09	307.0	20.5
1.002	50.00	5.45	1.904	0.292	0.0	0.0	0.0	1.08	306.8	39.6
3.000	50.00	4.13	2.337	0.093	0.0	0.0	0.0	0.82	14.4	12.6
3.001	50.00	4.32	1.845	0.093	0.0	0.0	0.0	1.09	613.3	12.6
1.003	50.00	5.72	1.856	0.436	0.0	0.0	0.0	1.08	612.6	59.1
4.000	50.00	4.07	2.293	0.024	0.0	0.0	0.0	0.81	14.3	3.2
1.004	50.00	5.81	1.820	0.491	0.0	0.0	0.0	0.89	62.8«	66.5
5.000	50.00	4.15	2.650	0.023	0.0	0.0	0.0	1.01	7.9	3.1

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Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam.,L*W (mm)	Pipe Out PN	Pipe Out Invert Level (m)	Pipe Out Diameter (mm)	Pipes In PN	Pipes In Invert Level (m)	Pipes In Diameter (mm)	Backdrop (mm)
BASIN	3.250	0.719	Open Manhole	1200	1.000	2.531	150				
1	3.562	1.206	Open Manhole	1200	1.001	2.356	225	1.000	2.356	150	
2	3.675	1.343	Open Manhole	1200	2.000	2.332	300				
3	3.700	1.719	Open Manhole	1500	2.001	1.981	600	2.000	2.281	300	
4	3.527	1.623	Open Manhole	1500	1.002	1.904	600	1.001	2.279	225	
								2.001	1.904	600	
TANK 1	3.335	0.998	Open Manhole	1200	3.000	2.337	150				
5	3.471	1.626	Open Manhole	3000	3.001	1.845	45	3.000	2.296	150	1
6	3.392	1.572	Open Manhole	3000	1.003	1.856	45	1.002	1.820	600	
								3.001	1.820	45	
TANK 2	3.122	0.829	Open Manhole	1200	4.000	2.293	150				
7	3.179	1.359	Open Manhole	3000	1.004	1.820	300	1.003	1.820	45	
								4.000	2.270	150	300
	3.200	1.396	Open Manhole	0		OUTFALL		1.004	1.804	300	
9	3.650	1.000	Open Manhole	1200	5.000	2.650	100				
	3.581	1.089	Open Manhole	0		OUTFALL		5.000	2.492	100	

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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., L*W (mm)
1.000	o	150	BASIN	3.250	2.531	0.569	Open Manhole	1200
1.001	o	225	1	3.562	2.356	0.981	Open Manhole	1200
2.000	o	300	2	3.675	2.332	1.043	Open Manhole	1200
2.001	o	600	3	3.700	1.981	1.119	Open Manhole	1500
1.002	o	600	4	3.527	1.904	1.023	Open Manhole	1500
3.000	o	150	TANK 1	3.335	2.337	0.848	Open Manhole	1200
3.001	oo	45	5	3.471	1.845	1.026	Open Manhole	3000
1.003	oo	45	6	3.392	1.856	0.936	Open Manhole	3000
4.000	o	150	TANK 2	3.122	2.293	0.679	Open Manhole	1200
1.004	o	300	7	3.179	1.820	1.059	Open Manhole	3000
5.000	o	100	9	3.650	2.650	0.900	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	8.975	51.3	1	3.562	2.356	1.056	Open Manhole	1200
1.001	19.143	248.6	4	3.527	2.279	1.023	Open Manhole	1500
2.000	12.795	250.9	3	3.700	2.281	1.119	Open Manhole	1500
2.001	38.256	496.8	4	3.527	1.904	1.023	Open Manhole	1500
1.002	41.792	497.5	6	3.392	1.820	0.972	Open Manhole	3000
3.000	6.181	150.8	5	3.471	2.296	1.025	Open Manhole	3000
3.001	12.411	496.4	6	3.392	1.820	0.972	Open Manhole	3000
1.003	17.913	497.6	7	3.179	1.820	0.759	Open Manhole	3000
4.000	3.524	153.2	7	3.179	2.270	0.759	Open Manhole	3000
1.004	4.947	309.2		3.200	1.804	1.096	Open Manhole	0
5.000	9.267	58.7		3.581	2.492	0.989	Open Manhole	0

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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)
1.004		3.200	1.804	1.804	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)
5.000		3.581	2.492	1.580	0	0

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	3
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	FEH
Return Period (years)	2
FEH Rainfall Version	1999
Site Location	GB 524650 322000 TF 24650 22000
C (1km)	-0.022
D1 (1km)	0.304
D2 (1km)	0.302
D3 (1km)	0.228
E (1km)	0.314
F (1km)	2.480
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Storm Duration (mins)	30

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Online Controls for Storm

Hydro-Brake® Optimum Manhole: 7, DS/PN: 1.004, Volume (m³): 18.1

Unit Reference	MD-SHE-0240-3230-1361-3230
Design Head (m)	1.361
Design Flow (l/s)	32.3
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	240
Invert Level (m)	1.820
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.361	32.2
Flush-Flo™	0.442	32.2
Kick-Flo®	0.954	27.2
Mean Flow over Head Range	-	27.4

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	7.9	1.200	30.3	3.000	47.1	7.000	71.1
0.200	24.3	1.400	32.7	3.500	50.8	7.500	73.5
0.300	31.4	1.600	34.8	4.000	54.2	8.000	75.8
0.400	32.1	1.800	36.8	4.500	57.3	8.500	78.1
0.500	32.1	2.000	38.8	5.000	60.4	9.000	80.3
0.600	31.7	2.200	40.6	5.500	63.2	9.500	82.5
0.800	30.3	2.400	42.3	6.000	65.9		
1.000	27.8	2.600	44.0	6.500	68.6		

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Storage Structures for Storm

Tank or Pond Manhole: BASIN, DS/PN: 1.000

Invert Level (m) 2.950

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	580.0	0.800	0.0	1.500	0.0	2.100	0.0
0.100	623.5	0.900	0.0	1.600	0.0	2.200	0.0
0.200	668.5	1.000	0.0	1.700	0.0	2.300	0.0
0.300	715.1	1.100	0.0	1.800	0.0	2.400	0.0
0.301	0.0	1.200	0.0	1.900	0.0	2.500	0.0
0.600	0.0	1.300	0.0	2.000	0.0		
0.700	0.0	1.400	0.0	2.010	0.0		

Cellular Storage Manhole: TANK 1, DS/PN: 3.000

Invert Level (m) 2.386 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	200.0	0.0	0.401	0.0	0.0
0.400	200.0	0.0			

Cellular Storage Manhole: TANK 2, DS/PN: 4.000

Invert Level (m) 2.356 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	58.5	0.0	0.401	0.0	0.0
0.400	58.5	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 * 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	3
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	0.400
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	19.000	Cv (Winter)	0.840

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 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	BASIN	15 Winter	1	+0%	100/15 Summer				2.531
1.001	1	15 Winter	1	+0%	100/15 Summer				2.433
2.000	2	15 Summer	1	+0%	100/15 Summer				2.449
2.001	3	15 Winter	1	+0%	100/15 Summer				2.119
1.002	4	30 Winter	1	+0%	100/15 Summer				2.085
3.000	TANK 1	15 Winter	1	+0%	100/15 Summer				2.401
3.001	5	30 Winter	1	+0%	100/15 Summer				2.071
1.003	6	30 Winter	1	+0%	100/15 Summer				2.071
4.000	TANK 2	15 Summer	1	+0%	100/15 Summer				2.351
1.004	7	30 Winter	1	+0%	30/15 Summer				2.069
5.000	9	15 Summer	1	+0%	30/15 Summer				2.697

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	BASIN	-0.150	0.000	0.00		0.0	OK	
1.001	1	-0.148	0.000	0.25		7.4	OK	
2.000	2	-0.183	0.000	0.32		18.3	OK	
2.001	3	-0.462	0.000	0.08		19.9	OK	

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

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.002	4	-0.419	0.000	0.10		25.8	OK	
3.000	TANK 1	-0.086	0.000	0.38		4.6	OK	
3.001	5	-0.374	0.000	0.02		5.0	OK	
1.003	6	-0.385	0.000	0.07		25.3	OK	
4.000	TANK 2	-0.092	0.000	0.31		3.4	OK	
1.004	7	-0.051	0.000	0.57		26.7	OK	
5.000	9	-0.053	0.000	0.44		3.2	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	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	3
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	0.400
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	19.000	Cv (Winter)	0.840

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 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	BASIN	15 Winter	30	+0%	100/15 Summer				2.531
1.001	1	15 Winter	30	+0%	100/15 Summer				2.506
2.000	2	15 Summer	30	+0%	100/15 Summer				2.533
2.001	3	30 Winter	30	+0%	100/15 Summer				2.423
1.002	4	30 Winter	30	+0%	100/15 Summer				2.421
3.000	TANK 1	30 Winter	30	+0%	100/15 Summer				2.435
3.001	5	30 Winter	30	+0%	100/15 Summer				2.416
1.003	6	30 Winter	30	+0%	100/15 Summer				2.416
4.000	TANK 2	30 Winter	30	+0%	100/15 Summer				2.386
1.004	7	30 Winter	30	+0%	30/15 Summer				2.411
5.000	9	15 Winter	30	+0%	30/15 Summer				2.763

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	BASIN	-0.150	0.000	0.00		0.0	OK	
1.001	1	-0.075	0.000	0.77		22.9	OK	
2.000	2	-0.099	0.000	0.78		44.8	OK	
2.001	3	-0.158	0.000	0.15		37.8	OK	

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30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.002	4	-0.083	0.000	0.22		58.3	OK	
3.000	TANK 1	-0.052	0.000	0.75		9.1	OK	
3.001	5	-0.029	0.000	0.03		9.1	OK	
1.003	6	-0.040	0.000	0.10		39.1	OK	
4.000	TANK 2	-0.057	0.000	0.55		5.9	OK	
1.004	7	0.291	0.000	0.69		32.1	SURCHARGED	
5.000	9	0.013	0.000	1.03		7.5	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 3
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 0.400
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 19.000 Cv (Winter) 0.840

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

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60
Return Period(s) (years) 1, 30, 100
Climate Change (%) 0, 0, 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	BASIN	30 Winter	100	+40%	100/15 Summer				2.950
1.001	1	30 Winter	100	+40%	100/15 Summer				2.953
2.000	2	30 Winter	100	+40%	100/15 Summer				2.957
2.001	3	30 Winter	100	+40%	100/15 Summer				2.930
1.002	4	30 Winter	100	+40%	100/15 Summer				2.921
3.000	TANK 1	60 Winter	100	+40%	100/15 Summer				2.671
3.001	5	30 Winter	100	+40%	100/15 Summer				2.897
1.003	6	30 Winter	100	+40%	100/15 Summer				2.903
4.000	TANK 2	30 Winter	100	+40%	100/15 Summer				2.727
1.004	7	30 Winter	100	+40%	30/15 Summer				2.898
5.000	9	15 Winter	100	+40%	30/15 Summer				3.080

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	BASIN	0.269	0.000	0.04		0.9	FLOOD RISK	
1.001	1	0.372	0.000	1.00		29.6	SURCHARGED	
2.000	2	0.325	0.000	1.05		59.8	SURCHARGED	
2.001	3	0.349	0.000	0.23		60.0	SURCHARGED	

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100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
1.002	4	0.417	0.000	0.38		98.7	SURCHARGED	
3.000	TANK 1	0.184	0.000	1.52		18.4	SURCHARGED	
3.001	5	0.452	0.000	0.06		18.4	SURCHARGED	
1.003	6	0.447	0.000	0.17		63.6	SURCHARGED	
4.000	TANK 2	0.284	0.000	1.28		13.9	SURCHARGED	
1.004	7	0.778	0.000	0.69		32.1	FLOOD RISK	
5.000	9	0.330	0.000	1.75		12.8	SURCHARGED	

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