INTRODUCTION.

The following are the design calculations required for the above-mentioned project.

DESIGN PHILOSOPHY.

Drainage is to be designed and constructed in accordance with the National Planning Policy Framework and Planning Practice Guidance.

A sustainable drainage system is to be designed for this site on affordance with DEFRA Non-statutory technical standards for sustainable drainage systems – March 2015.

DESIGN CODES.

BS 8301	Code of Practice for Building Drainage	1985	Amendment 1991
BS 6367	Code of Practice for Drainage of roofs and Paved Areas	1983	
BS 5572	Code of Practice for Sanitary Pipework	1978	Amendments 1 & 2
	Building Regulations Part H	2002	
	Sewers for Adoption		5th Edition
	Hepworth Design Manual		

ASSUMPTIONS & SPECIFICATIONS

The following calculations contain specifications and instructions concerning construction work on the project mentioned in the title block. Any INSTRUCTIONS / SPECIFICATIONS WILL BE SHOWN IN BOLD CAPITAL LETTERS.

Care has been taken using all the available information which has been provided to us to. In certain cases where information is limited, conservative assumptions are made and generally these will be satisfactory. These ASSUMPTIONS WILL BE NOTED IN RED CAPITAL LETTERS.

ANY STATED ASSUMPTIONS SHOULD BE CHECKED FOR ACCURACY PRIOR TO COMMENCEMENT OF WORKS. IF ANY ASSUMPTIONS ARE FOUND TO BE INCORRECT THEN THE ENGINEER MUST BE INFORMED OF THE NATURE OF THE DISCREPANCIES IMMEDIATELY.

IF THERE IS ANY CONFUSION OR DOUBT ABOUT THE TECHNICALITIES OF ANY INSTRUCTIONS / SPECIFICATIONS EXPRESSED HEREIN PLEASE CONTACT THE ENGINEER.

GENERAL DESCRIPTION.

The site is covered by 2No new buildings and external hardstanding. The external hardstanding can be installed as permeable paving and therefore all rainfall will be collected form the building roofs and routed to an attenuation tank within the site.

DESIGN PARAMETERS.

Proposed Hydraulic Design Criteria

- The drainage system is to be designed for Peak Flow Control. The peak runoff rate from the development for a 1 in 1-year rainfall event and 1 in 100-year rainfall event will not exceed the peak **BROWNFIELD** runoff rate for the same event. Betterment of 30% has been included for climate change.

- The drainage system is to be designed for a Peak Volume Control. The runoff volume from the development to any highway drain, sewer or surface water body up to the 1 in 100-year, 6 hour rainfall event should never exceed the **BROWNFIELD** runoff volume. Betterment of 30% has been included for climate change.

- Flood risk within the development will negated by means of designated attenuation tank capable of storing flows generated up to 100-year return period. Betterment of 30% has been included for climate change.

- In accordance with 'Sewers For Adoption', the general pipe drainage system is to be designed to not surcharge.

Wallingford: Modified Rational Method.

Location		**England**		**(England, Ireland, Scotland, Wales)**
M5 - 60	=	**20**		**(Fig 6.1)**
r	=	**0.42**		**(Fig 6.2)**
Site Area	=	**0.001**	km2	

Total Proposed Impermeable Area

Area (roof) = 2610 m2

ads structural			Client: Liverpool Edge - Hardman Street Limited			
			Project: Hardman House & Educational Buildings			
			Section: Drainage			
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PEAK VOLUME CONTROL

WALLINGFORD PROCEDURE - MODIFIED RATIONAL METHOD

		Fill in this column		
Location		England		(England, Ireland, Scotland, Wales)
M5 - 60	=	19	mm	(Fig 6.1)
r	=	0.42		(Fig 6.2)
Area	=	0.00261	km2	
Growth	=	0	%	

			Fill in this column	Fill in this column	AVERAGE AREAL INTENSITY								INTERPOLATED			
			Z1	ARF Factor												M1
	mins		(Fig 6.3b)	(Fig 6.4)		M1 (mm/hr)	M2 (mm/hr)	M3 (mm/hr)	M4 (mm/hr)	M5 (mm/hr)	M10 (mm/hr)	M20 (mm/hr)	M30 (mm/hr)	M50 (mm/hr)	M100 (mm/hr)	DISCHARGE
	5	=	0.38	0.900	5	48.3	61.6	69.4	75.6	79.5	92.8	106.0	111.5	121.6	139.6	35.08
	10	=	0.52	0.930	10	33.6	43.6	49.6	53.5	56.8	67.3	77.7	82.7	91.0	105.3	24.40
	15	=	0.65	0.940	15	28.3	36.7	41.8	45.0	47.8	56.7	65.5	69.7	76.6	88.7	20.55
	30	=	0.79	0.950	30	17.7	22.8	25.7	27.7	29.4	35.4	41.1	43.6	48.5	56.8	12.83
	60	=	1.00	0.960	60	11.7	14.8	16.4	17.7	18.8	22.6	26.4	28.3	31.6	37.0	8.47
2hr	120	=	1.20	0.965	2hr	7.3	9.0	10.0	10.7	11.3	13.6	15.8	16.9	18.9	22.1	5.27
4hr	240	=	1.50	0.975	4hr	4.7	5.8	6.3	6.7	7.2	8.6	9.9	10.6	11.8	13.7	3.43
6hr	360	=	1.60	0.980	6hr	3.4	4.1	4.5	4.8	5.1	6.2	7.1	7.5	8.4	9.8	2.45
10hr	600	=	1.85	0.985	10hr	2.4	2.9	3.2	3.4	3.5	4.2	4.8	5.1	5.7	6.5	1.76
24hr	1440	=	2.10	0.990	24hr	1.2	1.4	1.5	1.6	1.7	2.0	2.3	2.4	2.7	3.1	0.84
48hr	2880	=	2.50	1.000	48hr	0.7	0.8	0.9	1.0	1.0	1.2	1.3	1.4	1.6	1.8	0.52

Flow Restriction = 35.05 l/s

structural			Client **Liverpool Edge - Hardman Street Limited**			
			Project **Hardman House & Educational Buildings**			
			Section **Drainage**			
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From spreadsheet analysis

WALLINGFORD PROCEDURE - MODIFIED RATIONAL METHOD

		Fill in this column		
Location		England		(England, Ireland, Scotland, Wales)
M5 - 60	=	19	mm	(Fig 6.1)
r	=	0.42		(Fig 6.2)
Area	=	0.00261	km2	
Growth		30	%	
		Fill in this column		Fill in this column

AVERAGE AREAL INTENSITY

	mins		Z1 (Fig 6.3b)	ARF Factor (Fig 6.4)		M1 (mm/hr)	M2 (mm/hr)	M3 (mm/hr)	M4 (mm/hr)	M5 (mm/hr)	M10 (mm/hr)	M20 (mm/hr)	INTERPOLATED M30 (mm/hr)	M50 (mm/hr)	M100 (mm/hr)	M100 DISCHARGE	REDUCED DISCHARGE 35.05	mm/hr	M100 STORAGE	
	5	=	0.38	0.900	5	61.8	80.1	91.2	98.3	104.4	123.7	142.9	152.1	167.3	193.6	140.48	105.43	145.31	31.60	
	10	=	0.52	0.930	10	44.4	57.3	64.5	69.5	73.8	88.9	103.2	109.7	121.8	142.6	103.48	68.43	94.32	41.03	
	15	=	0.65	0.940	15	37.4	48.3	54.3	58.6	62.2	74.9	86.9	92.4	102.6	120.1	87.16	52.11	71.82	46.86	<<
	30	=	0.79	0.950	30	23.7	30.0	33.4	36.0	38.2	46.0	53.8	57.5	64.1	75.3	54.61	19.56	26.96	35.18	
	60	=	1.00	0.960	60	15.6	19.4	21.6	23.0	24.4	29.4	34.1	36.5	40.8	47.7	34.58	-0.47	-0.65	-1.68	
2hr	120	=	1.20	0.965	2hr	9.7	11.9	13.0	13.9	14.7	17.7	20.3	21.7	24.3	28.2	20.44	-14.61	-20.13	-105.09	
4hr	240	=	1.50	0.975	4hr	6.3	7.6	8.3	8.8	9.2	11.0	12.5	13.3	14.8	17.1	12.38	-22.67	-31.24	-326.12	
6hr	360	=	1.60	0.980	6hr	4.5	5.4	5.9	6.3	6.6	7.9	8.9	9.5	10.6	12.2	8.85	-26.20	-36.11	-565.43	
10hr	600	=	1.85	0.985	10hr	3.2	3.8	4.2	4.4	4.6	5.4	6.0	6.4	7.1	8.1	5.91	-29.14	-40.16	-1048.16	
24hr	1440	=	2.10	0.990	24hr	1.5	1.8	2.0	2.1	2.2	2.5	2.9	3.1	3.4	3.9	2.81	-32.24	-44.43	-2783.31	
48hr	2880	=	2.50	1.000	48hr	0.9	1.1	1.2	1.3	1.3	1.5	1.7	1.8	2.0	2.3	1.69	-33.36	-45.98	-5760.09	

FOR M100-6HOUR AND GREENFIELD DISCHARGE RATE OF 35.05 l/s THE REQUIRED STORAGE IS **0 m3**

PEAK VOLUME OCCURS DURING **15 MINUTE** STORM

WITH A GREENFIELD DISCHARGE RATE OF 35.05 l/s THE REQUIRED STORAGE IS **47 m3**

	Client **Liverpool Edge - Hardman Street Limited**		
	Project **Hardman House & Educational Buildings**		
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PIPE - OUTFALL

Hydraulic – Pipe Flow Capacity Table

Table 6 – Pipe flowing full – Roughness K_s=0.60

		Nominal Diameter (mm)															
		100		150		225		300		400		450		500		600	
Hydraulic	Gradient 1 in	velocity m/s	discharge l/s	velocity ms	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity ms	discharge l/s	velocity m/s	discharge l/s
0.0010	1000.0	0.23	1.84	0.31	5.45	0.40	16.06	0.49	34.45	0.59	73.75	0.63	100.66	0.68	132.91	0.76	214.87
0.0011	909.1	0.25	1.93	0.32	5.73	3.42	16.87	0.51	36.18	0.62	77.43	0.66	105.67	0.71	139.52	0.80	225.54
0.0012	833.3	0.26	2.02	0.34	5.99	0.44	17.64	0.54	37.83	0.64	80.96	0.69	110.48	0.74	145.84	0.83	235.74
0.0013	769.2	0.27	2.11	0.35	6.24	0.46	18.38	0.56	39.41	0.67	84.32	0.72	115.06	0.77	151.90	0.87	245.52
0.0014	714.3	0.28	2.19	0.37	6.49	0.48	19.09	0.58	40.93	0.70	87.57	0.75	119.48	0.80	157.74	0.90	254.93
0.0015	666.7	0.29	2.27	0.38	6.72	0.50	19.78	0.60	42.40	0.72	90.70	0.78	123.75	0.83	163.36	0.93	264.01
0.0016	625.0	0.30	2.35	0.39	6.95	0.51	20.44	0.62	43.82	0.75	93.73	0.80	127.88	0.86	168.81	0.96	272.79
0.0017	588.2	0.31	2.43	0.41	7.17	0.53	21.09	0.64	45.20	0.77	96.66	0.83	131.88	0.89	174.09	0.99	281.31
0.0018	555.6	0.32	2.50	0.42	7.39	0.55	21.71	0.66	46.53	0.79	99.51	0.85	135.77	0.91	179.21	1.02	289.58
0.0019	526.3	0.33	2.57	0.43	7.59	0.56	22.32	0.68	47.83	0.81	102.29	0.88	139.54	0.94	184.19	1.05	297.62
0.0020	500.0	0.34	2.64	0.44	7.80	0.58	22.92	0.69	49.10	0.84	104.99	0.90	143.23	0.96	189.05	1.08	305.45
0.0022	454.5	0.35	2.77	0.46	8.19	0.61	24.06	0.73	51.54	0.88	110.19	0.95	150.32	1.01	198.41	1.13	320.55
0.0024	416.7	0.37	2.90	0.44	8.56	0.63	25.15	0.76	53.88	0.92	115.17	0.99	157.10	1.06	207.35	1.18	334.98
0.0026	384.6	0.38	3.02	0.50	8.92	0.66	26.20	0.79	56.12	0.95	119.94	1.03	163.61	1.10	215.92	1.23	348.81
0.0028	357.1	0.40	3.14	0.52	9.27	0.68	27.21	0.82	58.27	0.99	124.53	1.07	169.87	1.14	224.18	1.28	362.13
0.0030	333.3	0.41	3.25	0.54	9.60	0.71	28.18	0.85	60.35	1.03	128.97	1.11	175.90	1.18	232.14	1.33	374.98
0.0032	312.5	0.43	3.36	0.56	9.92	0.73	29.13	0.88	62.36	1.06	133.25	1.14	181.75	1.22	239.85	1.37	387.41
0.0034	294.1	0.44	3.47	0.58	10.24	0.76	30.04	0.91	64.31	1.09	137.41	1.18	187.41	1.26	247.31	1.41	399.45
0.0036	277.8	0.45	3.57	0.60	10.54	0.78	30.92	0.94	66.20	1.13	141.44	1.21	192.90	1.30	254.56	1.45	411.15
0.0038	263.2	0.47	3.67	0.61	10.83	0.80	31.79	0.96	68.04	1.16	145.36	1.25	198.25	1.33	261.61	1.49	422.53
0.0040	250.0	0.48	3.77	0.63	11.12	0.82	32.63	0.99	69.83	1.19	149.19	1.28	203.46	1.37	268.48	1.53	433.61
0.0042	238.1	0.49	3.87	0.65	11.40	0.84	33.44	1.01	71.58	1.22	152.91	1.31	208.54	1.40	275.18	1.57	444.41
0.0044	227.3	0.50	3.96	0.66	11.68	0.86	34.24	1.04	73.29	1.25	156.55	1.34	213.50	1.43	281.72	1.61	454.97
0.0046	217.4	0.52	4.05	0.68	11.94	0.88	35.03	1.06	74.96	1.27	160.11	1.37	218.35	1.47	288.11	1.65	465.28
0.0048	208.3	0.53	4.14	0.69	12.20	0.90	35.79	1.08	76.59	1.30	163.59	1.40	223.09	1.50	294.37	1.68	475.38
0.0050	200.0	0.54	4.23	0.71	12.46	0.92	36.54	1.11	78.19	1.33	167.00	1.43	227.74	1.53	300.50	1.72	485.26
0.0055	181.8	0.57	4.44	0.74	13.08	0.96	38.35	1.16	82.06	1.39	175.24	1.50	238.96	1.61	315.30	1.80	509.15
0.0060	166.7	0.59	4.64	0.77	13.67	1.01	40.08	1.21	85.75	1.46	183.11	1.57	249.69	1.68	329.45	1.88	531.97
0.0065	153.8	0.62	4.84	0.81	14.24	1.05	41.74	1.26	89.29	1.52	190.66	1.63	259.98	1.75	343.01	1.96	553.85
0.0070	142.9	0.64	5.02	0.84	14.79	1.09	43.34	1.31	92.70	1.58	197.93	1.70	269.88	1.81	356.07	2.03	574.92
0.0075	133.3	0.66	5.20	0.87	15.32	1.13	44.88	1.36	95.99	1.63	204.94	1.76	279.43	1.88	368.66	2.11	595.24
0.0080	125.0	0.68	5.38	0.90	15.83	1.17	46.37	1.40	99.17	1.68	211.72	1.82	288.67	1.94	380.85	2.17	614.89
0.0085	117.6	0.71	5.55	0.92	16.32	1.20	47.81	1.45	102.25	1.74	218.29	1.87	297.63	2.00	392.66	2.24	633.94
0.0090	111.1	0.73	5.71	0.95	16.80	1.24	49.21	1.49	105.25	1.79	224.67	1.93	306.32	2.06	404.12	2.31	652.44
0.0095	105.3	0.75	5.87	0.98	17.27	1.27	50.58	1.53	108.16	1.84	230.88	1.98	314.78	2.11	415.27	2.37	670.43
0.0100	100.0	0.77	6.02	1.00	17.72	1.31	51.91	1.57	110.99	1.89	236.92	2.03	323.01	2.17	426.14	2.43	687.96
0.0110	90.9	0.81	6.32	1.05	18.60	1.37	54.47	1.65	116.46	1.98	248.57	2.13	338.89	2.28	447.07	2.55	721.74
0.0120	83.3	0.84	6.61	1.10	19.44	1.43	56.91	1.72	121.68	2.07	259.71	2.23	354.06	2.38	467.08	2.67	754.01
0.0130	76.9	0.88	6.88	1.15	20.24	1.49	59.26	1.79	126.69	2.15	270.39	2.32	368.62	2.48	486.27	2.78	764.97
0.0140	71.4	0.91	7.15	1.19	21.02	1.55	61.52	1.86	131.51	2.23	280.66	2.41	382.62	2.57	504.73	2.88	814.76
0.0150	66.7	0.94	7.40	1.23	21.76	1.60	63.70	1.93	136.17	2.31	290.58	2.49	396.13	2.66	522.55	2.98	843.50
0.0160	62.5	0.97	7.65	1.27	22.48	1.66	65.81	1.99	140.67	2.39	300.17	2.57	409.20	2.75	539.78	3.08	871.30
0.0170	58.8	1.00	7.89	1.31	23.18	1.71	67.85	2.05	145.03	2.46	309.46	2.65	421.86	2.83	556.48	3.18	898.25
0.0180	55.6	1.03	8.12	1.35	23.86	1.76	69.83	2.11	149.26	2.53	318.49	2.73	434.16	2.92	572.70	3.27	924.41
0.0190	52.6	1.06	8.34	1.39	24.52	1.80	71.76	2.17	153.38	2.60	327.26	2.81	446.12	3.00	588.47	3.36	949.85
0.0200	50.0	1.09	8.56	1.42	25.17	1.85	73.64	2.23	157.39	2.67	335.81	2.88	457.77	3.08	603.84	3.45	974.64

USE 225mm diameter pipe @ 1 in 225 (34.5 L/s)

PEAK FLOW RATE CONTROL

RWPs

Area per RWP = 300m2

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

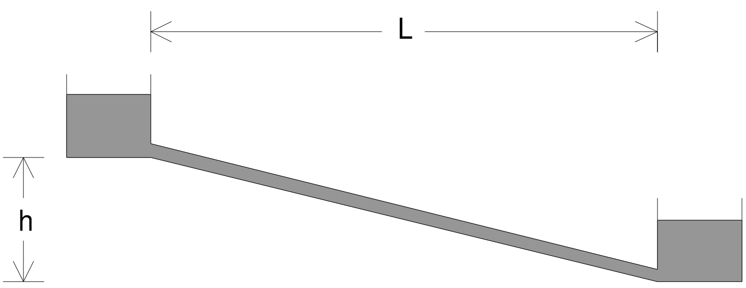
Location of catchment area;	Liverpool
Storm duration;	D = **5** min
Return period;	Period = **100** yr
Ratio 60 min to 2 day rainfall of 5 yr return period;	r = **0.400**
5-year return period rainfall of 60 minutes duration;	M5_60min = **19.0** mm
Increase of rainfall intensity due to global warming;	$p_{climate}$ = **30** %
Factor Z1 (Wallingford procedure);	Z1 = **0.37**
Rainfall for 5min storm with 5 year return period;	$M5\_5min_i = Z1 \times M5\_60min \times (1 + p_{climate})$ = **9.2** mm
Factor Z2 (Wallingford procedure);	Z2 = **1.89**
Rainfall for 5min storm with 100 year return period;	$M100\_5min = Z2 \times M5\_5min_i$ = **17.4** mm
Design rainfall intensity;	$I_{max} = M100\_5min / D$ = **209.3** mm/hr

Maximum surface water runoff

Catchment area;	A_{catch} = **300** m^2
Percentage of area that is impermeable;	p = **100** %
Maximum surface water runoff;	$Q_{max} = A_{catch} \times p \times I_{max}$ = **17.4** l/s

DESIGN OF A SURFACE WATER DRAIN

TEDDS calculation version 1.0.03



Drain design details

Design flow rate;	Q_{design} = **17.4×10^{-3}** m^3/s
Length of the drain;	L = **9.0** m
Fall along length of drain;	h = **0.1** m
Gradient of drain;	i = h / L = **0.010**; **(1 in 100)**
Minimum flow velocity;	V_{min} = **0.750** m/s
Minimum pipe diameter;	D_{min} = **100** mm
Surface roughness;	k_s = **0.6** mm
Mean hydraulic depth factor;	m = **0.25**
Kinematic viscosity of fluid;	ν = **1.31×10^{-6}** m^2/s

Using the Chezy equation

Constant;	$c = 56$
Diameter of pipe required;	$D = ((Q_{design}^2 \times 16) / (\pi^2 \times m \times c^2 \times i \times 1m/s^2))^{0.2}$ = **144** mm
Nearest pipe diameter;	D_{chezy} = **150** mm
Flow velocity using Chezy;	$V_{chezy} = c \times \sqrt{(m \times D_{chezy} \times i \times 1m/s^2)}$ = **1.084** m/s

Using the Escritt equation

Diameter of pipe required;	$D = (Q_{design} \times 1000 \times \sqrt{(1 / i)} / 0.00035\ m^3/s)^{0.382} \times 1mm$ = **150** mm
Nearest pipe diameter;	$D_{escritt}$ = **150** mm
Flow velocity using Escritt;	$V_{escritt} = 26.738 \times (D_{escritt} / 1mm)^{0.62} \times 1\ m/s / (\sqrt{(1 / i)} \times 60)$ = **0.996** m/s

Using the Colebrook-White Equation for pipe running full and partially full

Design pipe diameter;	$D_{design} = \max(D_{chezy}, D_{escritt}, D_{min})$ = **150** mm
Constant;	$Z = \sqrt{(2 \times (g_{acc} / 1m/s^2) \times (D_{design} / 1000mm) \times i)}$ = **0.172**
Flow velocity;	$V_{full} = -2 \times Z \times \log((k_s/(3.7 \times D_{design})) + ((2.51 \times \nu)/(D_{design} \times Z \times 1m/s))) \times 1m/s$
	V_{full} = **1.001** m/s
Flow rate running full;	$Q_{full} = V_{full} \times \pi \times D_{design}^2 / 4$ = **17.7×10^{-3}** m^3/s

PASS - Maximum flow rate is greater than design flow rate

From Hydraulics Research Tables 35 and 36

Depth as proportion of D;	x = **0.809**
Flow velocity at design flow rate;	V_{design} = **1.137** m/s

PASS - Design velocity is greater than 0.750 m/s

USE 150mm diameter pipe @ 1 in 100

PEAK FLOW RATE CONTROL

RWPs

Area per RWP = 600m2

DESIGN RAINFALL

In accordance with the Wallingford Procedure

Tedds calculation version 2.0.00

Design rainfall intensity

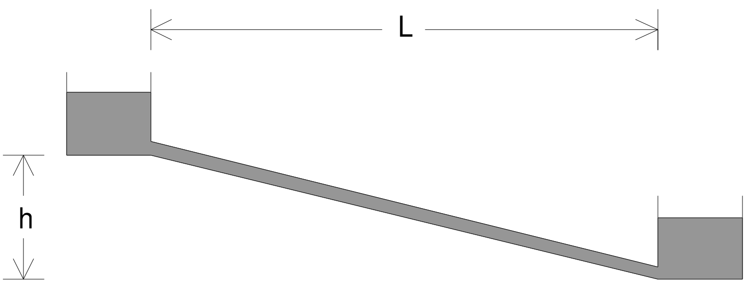
Location of catchment area;	Liverpool
Storm duration;	D = **5** min
Return period;	Period = **100** yr
Ratio 60 min to 2 day rainfall of 5 yr return period;	r = **0.400**
5-year return period rainfall of 60 minutes duration;	M5_60min = **19.0** mm
Increase of rainfall intensity due to global warming;	$p_{climate}$ = **30** %
Factor Z1 (Wallingford procedure);	Z1 = **0.37**
Rainfall for 5min storm with 5 year return period;	$M5\_5min_i = Z1 \times M5\_60min \times (1 + p_{climate})$ = **9.2** mm
Factor Z2 (Wallingford procedure);	Z2 = **1.89**
Rainfall for 5min storm with 100 year return period;	$M100\_5min = Z2 \times M5\_5min_i$ = **17.4** mm
Design rainfall intensity;	I_{max} = M100_5min / D = **209.3** mm/hr

Maximum surface water runoff

Catchment area;	A_{catch} = **600** m^2
Percentage of area that is impermeable;	p = **100** %
Maximum surface water runoff;	$Q_{max} = A_{catch} \times p \times I_{max}$ = **34.9** l/s

DESIGN OF A SURFACE WATER DRAIN

TEDDS calculation version 1.0.03



Drain design details

Design flow rate;	Q_{design} = **34.9×10^{-3}** m^3/s
Length of the drain;	L = **9.0** m
Fall along length of drain;	h = **0.1** m
Gradient of drain;	i = h / L = **0.007**; **(1 in 150)**
Minimum flow velocity;	V_{min} = **0.750** m/s
Minimum pipe diameter;	D_{min} = **100** mm
Surface roughness;	k_s = **0.6** mm
Mean hydraulic depth factor;	m = **0.25**
Kinematic viscosity of fluid;	ν = **1.31×10^{-6}** m^2/s

Using the Chezy equation

Constant; $c = 56$

Diameter of pipe required; $D = ((Q_{design}^2 \times 16) / (\pi^2 \times m \times c^2 \times i \times 1m/s^2))^{0.2} = \mathbf{207}$ mm

Nearest pipe diameter; $D_{chezy} = \mathbf{225}$ mm

Flow velocity using Chezy; $V_{chezy} = c \times \sqrt{(m \times D_{chezy} \times i \times 1m/s^2)} = \mathbf{1.084}$ m/s

Using the Escritt equation

Diameter of pipe required; $D = (Q_{design} \times 1000 \times \sqrt{(1 / i)} / 0.00035\ m^3/s)^{0.382} \times 1mm = \mathbf{211}$ mm

Nearest pipe diameter; $D_{escritt} = \mathbf{225}$ mm

Flow velocity using Escritt; $V_{escritt} = 26.738 \times (D_{escritt} / 1mm)^{0.62} \times 1\ m/s / (\sqrt{(1 / i)} \times 60) = \mathbf{1.045}$ m/s

Using the Colebrook-White Equation for pipe running full and partially full

Design pipe diameter; $D_{design} = \max(D_{chezy}, D_{escritt}, D_{min}) = \mathbf{225}$ mm

Constant; $Z = \sqrt{(2 \times (g_{acc} / 1m/s^2) \times (D_{design} / 1000mm) \times i)} = \mathbf{0.172}$

Flow velocity; $V_{full} = -2 \times Z \times \log((k_s/(3.7 \times D_{design})) + ((2.51 \times \nu)/(D_{design} \times Z \times 1m/s))) \times 1m/s$

$V_{full} = \mathbf{1.061}$ m/s

Flow rate running full; $Q_{full} = V_{full} \times \pi \times D_{design}^2 / 4 = \mathbf{42.2 \times 10^{-3}}\ m^3/s$

PASS - Maximum flow rate is greater than design flow rate

From Hydraulics Research Tables 35 and 36

Depth as proportion of D; $x = \mathbf{0.695}$

Flow velocity at design flow rate; $V_{design} = \mathbf{1.183}$ m/s

PASS - Design velocity is greater than 0.750 m/s

USE 225mm diameter pipe @ 1 in 150

FOUL WATER DRAINAGE.

Design Based on Colebrook-White Equation.

Introduction.

The following calculations have been undertaken to determine the drainage requirement for the above-mentioned site.

SUMMARY	Discharge Unit	Totals	DU
Shower	0.6	335	201
Washbasin	0.6	350	210
WC	2.5	350	875
Urinal	0.8	10	8
Kitchen Sink	1.3	90	117
Dishwasher	0.8	90	72
Floor Drains	2	5	10
Washing Machine	0.8	90	72
			1565
Discharge Rate	**20**	**l/sec**	

Total units = 1565

Q = k √ (∑DU) = 0.5 x √ 1565 = 20 l/sec

From peak flow rate capacity tables

100mm diameter pipe at 1:100 = 6.6 l/sec

150mm diameter pipe at 1:150 = 12.5 l/sec

225m diameter pipe at 1:225 = 29.5 l/sec

300m diameter pipe at 1:300 = 55.2 l/sec

Max per SVP outlet to IC

8 stories

DU per cluster = 13

Total = 8 x 13 = 104

Q = k √ (∑DU) = 0.5 x √ 104 = 5 l/sec

From peak flow rate capacity tables

100mm diameter pipe at 1:100 = 6.6 l/sec

150mm diameter pipe at 1:150 = 12.5 l/sec

225m diameter pipe at 1:225 = 29.5 l/sec