Forge Engineering Design Solutions

Sustainable Drainage System Calculations

332 Abingdon Road,
Oxford

Mr Amad Hassan
Minuteman Press Oxford
16-17 Hollybush Row,
Oxford
OX1 1JH

Forge Engineering Design Solutions Ltd
Forge House, 30 Digging Lane
Fyfield, Abingdon
Oxfordshire
OX13 5LY

T 01865 546 092
T 01865 362 780
Company Registration No. 8713789

Project No.	FEDS-222106	**By:**	DKP	**Chkd:**	SLD
Title					
332 Abingdon Road, Oxford OX1 4TQ					
Sheet No.	1	**Date:**	October 2023		

1. Surface Water Design - Contributing Areas:

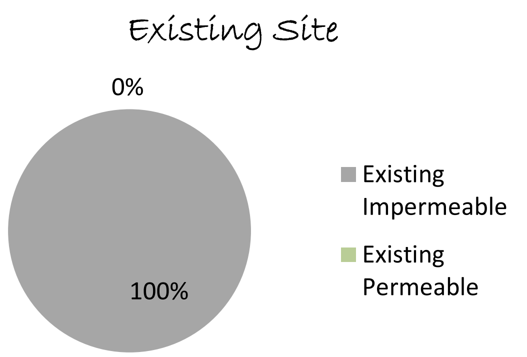
Total site area =	356.1	m²	=	0.0356	ha

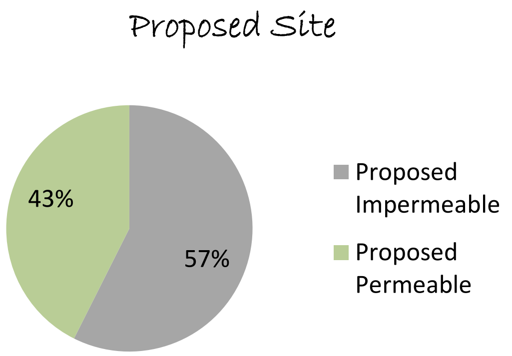
1.1 Existing Site:

Impermeable Area - Existing Building =	114.4	m²	=	0.0114	ha
Impermeable Area - Existing Hardstanding =	241.7	m²	=	0.0242	ha
Existing Impermeable Contributing Area =	356.1	m²	=	0.0356	ha
% of total site:	100.0%				
Existing Permeable Area =	0.0	m²	=	0.0000	ha
% of total site:	0.0%				

1.1 Proposed Site:

Impermeable Area - Proposed Building =	202.3	m²	=	0.0202	ha
Impermeable Area - Proposed Hardstanding =	2.1	m²	=	0.0002	ha
Proposed Impermeable Contributing Area =	204.4	m²	=	0.0204	ha
% of total site:	57.4%				
Proposed Permeable Area =	151.7	m²	=	0.0152	ha
% of total site:	42.6%				





The total impermeable contributing area - post development - shows a 42.6% decrease compared to the existing total impermeable contributing areas.

The new SuDS are designed to mitigate the new impermeable areas of the proposed development to current design standards, therefore, reducing the post development surface water run-off to less than existing.

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2. Surface Water Run-off Flow and Volumes

2.1 Greenfield Run-off Rates, QBar $_{Green}$

IHR 124 Equation 7.1 gives:

$QBAR_{rural} = 0.00108 * AREA^{0.89}\ SAAR^{1.17}\ SOIL^{2.17}$

AREA (km^2)	0.50
SAAR (mm)	631
SOIL	0.37
$QBAR_{green}$ (m^3/s/50ha)	0.1272
$QBAR_{green}$ (l/s/50ha)	127.2
$QBAR_{green}$ (l/s/ha)	2.54

SITE AREA (m^2)	356.1
SITE AREA (ha)	0.036
Existing CA (m^2)	356.1
Proposed CA (m^2)	204.4

Table 2a: Greenfield run off rates:

STORM EVENT (1 in n year)	Growth Curve Factor	Site Run-off Peak Flows (l/s)	Site Run-off Peak Volume (m3)
QBARGreenfield	-	0.091	1.96
1 in 1 year	0.85	0.077	1.66
1 in 30 year	2.30	0.208	4.50
1 in 100 year	3.19	0.289	6.24
1 in 100 year +40%	4.47	0.405	8.74

2.2 Existing Brownfield Run-off Rates, QBar $_{Brown\ Existing}$

The IHR 124 method requires Brownfield run-off rates are calculated using the Greenfield run-off rates and an adjustment for urbanisastion.

$R = QBar_{Brownfield} / QBar_{Greenfield} = (1+URBAN)^{2NC} \times (1+URBAN \times ((21/CIND) - 0.3))$

NC	0.77
CIND	27.53
CWI	88.0
URBAN	1.00
$R_{existing}$	4.25

Table 2b: Existing Site run off rates:

STORM EVENT (1 in n year)	Growth Curve Factor	Site Run-off Peak Flows (l/s)	Site Run-off Peak Volume (m3)
QBARBrownfield	-	0.385	8.31
1 in 1 year	0.85	0.327	7.06
1 in 30 year	2.30	0.885	19.11
1 in 100 year	3.19	1.227	26.50
1 in 100 year+40%	4.47	1.718	37.11

2.3 Proposed Brownfield Run-off Rates, QBar Brown Proposed

NC	0.77
CIND	27.53
CWI	88.0
URBAN	0.57
$R_{proposed}$	**2.54**

Therefore, the site's brownfiield run-off rates and volumes are as follows:

Table 2c: Proposed Site run off rates:

STORM EVENT (1 in n year)	Growth Curve Factor	Site Run-off Peak Flows (l/s)	Site Run-off Peak Volume (m3)
QBARBrownfield	-	0.230	4.97
1 in 1 year	0.85	0.196	4.23
1 in 30 year	2.30	0.530	11.44
1 in 100 year	3.19	0.735	15.87
1 in 100 year+40%	4.47	1.029	22.22

Tables 2b and 2c demonstrate that there is a significant potential 40.1% decrease in the run-off peak flow rates and volumes for the proposed site development, prior to the implementation of mitigating SuDS. Therefore, there would NOT be a need to implement mitigating SuDS measures. However, it is proposed to use infiltrating SuDS to manage surface water from the new impermeable areas and mitigate Climate Change to provide further betterment.

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3. Surface Water SuDS Design - Infiltration via Porous Paving:

Total Impermeable Roof Area - Buidlings =	87.9	m²	=	0.0088	ha
Total Contributing Area - Hardstandings =	136.3	m²	=	0.0136	ha
Proposed Impermeable Contributing Area =	224.2	m²	=	0.0224	ha

The SuDS are designed to mitigate impermeable areas to provide betterment. The worst case BRE 365 Infiltration test was used for the SuDS design:

T1 - Infiltration Rate =	3.75E-05
T2 - Infiltration Rate =	2.58E-05
T3 - Infiltration Rate =	2.16E-05

New Extension

Extension roof and pervious paving to discharge surface water to SuDS pervious paving.

T3 Soil Infiltration Rate (worst case) =	2.16E-05	m/s	=	0.078	m/hr
Design Storm Event = 1 : 100 year plus 40% Climate Change.					
Allowable outflow =	Zero				
FEH Revision =	2022				
Run-off Coefficient Cv =	0.95				
Urban Creep =	1.10			10%	
Contributing Impermeable Area =	247	m²		0.025	ha
Design Factor of Safety =	2.0				

Using Micro Drainage and the above design parameters:

Minimum SuDS Porous Paving Area Required =	124.8	m²
Minimum SuDS Porous Paving Volume Required =	10.30	m³
Minimum SuDS Porous Paving Depth Required =	0.275	m

From the proposed site layout:

Minimum SuDS Porous Paving Area Provided =	133.9	m²
Minimum SuDS Porous Paving Volume Provided =	11.0	m³
Minimum SuDS Porous Paving Sub-base Depth Provided =	0.275	m

Therefore, new hardstanding should be constructed as SuDS porous paving hardstanding with a Type 3 stone sub-base depth of 275mm and a minimum plan area of 133.9m². See enclosed MicroDrainage Calculations.

The SuDS have been designed with a zero piped outflow. Therefore, the areas draining to them would not have a Greenfield or Brownfield surface water run-off. Subsequently, the post development site's run-off rates and volumes would be less than the existing development's run-off rates and volumes providing betterment.

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 66 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	55.521	0.131	1.5	5.3	O K
30 min Summer	55.559	0.169	1.5	6.8	O K
60 min Summer	55.578	0.188	1.5	7.6	O K
120 min Summer	55.578	0.188	1.5	7.5	O K
180 min Summer	55.566	0.176	1.5	7.1	O K
240 min Summer	55.551	0.161	1.5	6.4	O K
360 min Summer	55.518	0.128	1.5	5.2	O K
480 min Summer	55.490	0.100	1.5	4.0	O K
600 min Summer	55.467	0.077	1.5	3.1	O K
720 min Summer	55.451	0.061	1.5	2.4	O K
960 min Summer	55.436	0.046	1.3	1.8	O K
1440 min Summer	55.423	0.033	1.0	1.3	O K
2160 min Summer	55.414	0.024	0.7	1.0	O K
2880 min Summer	55.409	0.019	0.5	0.8	O K
4320 min Summer	55.403	0.013	0.4	0.5	O K
5760 min Summer	55.401	0.011	0.3	0.4	O K
7200 min Summer	55.399	0.009	0.3	0.3	O K
8640 min Summer	55.398	0.008	0.2	0.3	O K
10080 min Summer	55.397	0.007	0.2	0.3	O K
15 min Winter	55.567	0.177	1.5	7.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	153.568	0.0	22
30 min Summer	100.695	0.0	34
60 min Summer	62.504	0.0	56
120 min Summer	37.820	0.0	88
180 min Summer	27.985	0.0	122
240 min Summer	22.480	0.0	156
360 min Summer	16.339	0.0	220
480 min Summer	12.929	0.0	280
600 min Summer	10.738	0.0	336
720 min Summer	9.204	0.0	390
960 min Summer	7.187	0.0	500
1440 min Summer	5.032	0.0	742
2160 min Summer	3.509	0.0	1104
2880 min Summer	2.721	0.0	1472
4320 min Summer	1.916	0.0	2204
5760 min Summer	1.504	0.0	2936
7200 min Summer	1.257	0.0	3624
8640 min Summer	1.091	0.0	4360
10080 min Summer	0.973	0.0	5056
15 min Winter	153.568	0.0	23

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	55.618	0.228	1.5	9.2	O K
60 min Winter	55.647	0.257	1.5	10.3	O K
120 min Winter	55.645	0.255	1.5	10.2	O K
180 min Winter	55.626	0.236	1.5	9.5	O K
240 min Winter	55.601	0.211	1.5	8.5	O K
360 min Winter	55.548	0.158	1.5	6.4	O K
480 min Winter	55.501	0.111	1.5	4.4	O K
600 min Winter	55.464	0.074	1.5	3.0	O K
720 min Winter	55.441	0.051	1.5	2.1	O K
960 min Winter	55.430	0.040	1.2	1.6	O K
1440 min Winter	55.418	0.028	0.8	1.1	O K
2160 min Winter	55.410	0.020	0.6	0.8	O K
2880 min Winter	55.406	0.016	0.5	0.6	O K
4320 min Winter	55.401	0.011	0.3	0.4	O K
5760 min Winter	55.399	0.009	0.3	0.3	O K
7200 min Winter	55.397	0.007	0.2	0.3	O K
8640 min Winter	55.396	0.006	0.2	0.2	O K
10080 min Winter	55.396	0.006	0.2	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	100.695	0.0	35
60 min Winter	62.504	0.0	60
120 min Winter	37.820	0.0	98
180 min Winter	27.985	0.0	136
240 min Winter	22.480	0.0	172
360 min Winter	16.339	0.0	240
480 min Winter	12.929	0.0	300
600 min Winter	10.738	0.0	352
720 min Winter	9.204	0.0	390
960 min Winter	7.187	0.0	504
1440 min Winter	5.032	0.0	752
2160 min Winter	3.509	0.0	1116
2880 min Winter	2.721	0.0	1464
4320 min Winter	1.916	0.0	2212
5760 min Winter	1.504	0.0	2840
7200 min Winter	1.257	0.0	3552
8640 min Winter	1.091	0.0	4256
10080 min Winter	0.973	0.0	5072

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2022
Site Location	GB 451845 204253 SP 51845 04253
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.025

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.008	4	8	0.008	8	12	0.008

Model Details

Storage is Online Cover Level (m) 55.795

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.07800	Width (m)	9.3
Membrane Percolation (mm/hr)	1000	Length (m)	14.4
Max Percolation (l/s)	37.2	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	55.390	Membrane Depth (m)	0

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4. Surface Water Design - Manholes & Connecting Pipes Network:

PP1 FGL (m) = 55.795

Manhole		Invert Level	Cover Level	Depth
SWMH01 =	55.795 - 0.350 - (1/150 x 0.500) =	55.442	55.795	0.353
SWMH02 =	55.795 - 0.350 - (1/150 x 0.500) =	55.442	55.795	0.353
SWMH03 =	55.795 - 0.350 - (1/150 x 0.500) =	55.442	55.795	0.353

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Sheet No. 10 **Date:** January 2022

Test Date: 11th January 2022

Weather conditions: Light rain

1. INPUTS

Trial Pit Dimensions

Length	0.800	m
Width	0.900	m
Depth	1.000	m
Inlet Depth	0.640	m
Effective Depth	0.360	m

Soil Infiltration Rate = $\frac{Vp_{75-25}}{ap_{50} \times tp_{75-25}}$

Vp_{75-25} the effective storage volume of water in the trial pit between 75% and 25% effective depth = 0.130 m^3

ap_{50} the internal surface area of the trial pit up to 50% effective depth and including the base = 1.332 m^2

tp_{75-25} the time for the water level to fall from 75% and 25% effective depth = 75.2 minutes 4509.9 seconds (lowest)

f = **Soil Infiltration Rate for Design** = **2.2E-05** m/s (lowest)

= **0.078** m/hr (lowest)

2. INPUT OF PERMEABILITY TEST DATA

TEST 1

Time	Water level	Water Depth
0	570	430
4	670	330
9	710	290
14	740	260
19	770	230
24	790	210
29	800	200
34	810	190
38	810	190
45	870	130
52	920	80
55	940	60
60	1000	0

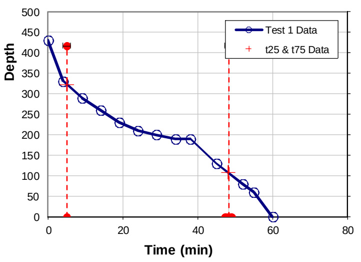
TEST 2

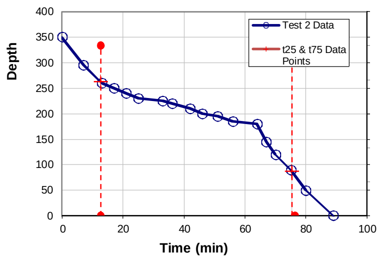
Time	Water level	Water Depth
0	650	350
7	705	295
13	740	260
17	750	250
21	760	240
25	770	230
33	775	225
36	780	220
42	790	210
46	800	200
51	805	195
56	815	185
64	820	180
67	855	145
70	880	120
75	910	90
80	950	50
89	1000	0

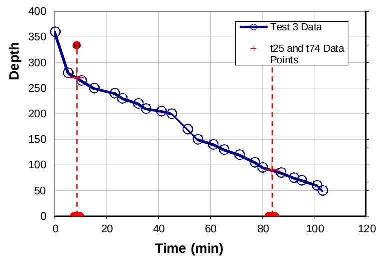
TEST 3

Time	Water level	Water Depth
0	640	360
5	720	280
10	735	265
15	750	250
23	760	240
26	770	230
32	780	220
35	790	210
41	795	205
45	800	200
51	830	170
55	850	150
61	860	140
65	870	130
71	880	120
77	895	105
80	905	95
87	915	85
92	925	75
95	930	70
101	940	60
103	950	50

3. DATA ANALYSIS







Test 1

Depth at t=	430			
Depth 75%	322.5			
Depth 25%	107.5			
5	322.5			
48	107.50			
tp75-25	43	minutes	2593	seconds
f1 =	3.75E-05	m/s		

Test 2

Depth at t=0	350			
Depth 75%	262.5			
Depth 25%	87.5			
13	262.50			
75	87.50			
tp75-25	63	minutes	3764	seconds
f2 =	2.58E-05	m/s		

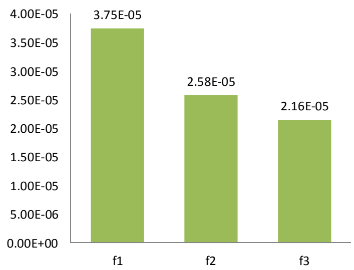
Test 3

Depth at t=0	360			
Depth 75%	270			
Depth 25%	90			
8.3	270.00			
83.5	90.00			
tp75-25	75	minutes	4510	seconds
f3=	2.16E-05	m/s		

4. SUMMARY

Infiltration Rate

f1	3.75E-05
f2	2.58E-05
f3	2.16E-05



Pervious Pavements Operation and Maintenance in Accordance with The SuDS Manual 2015

Maintenance Schedule	**Required Action**	**Typical Frequency**
Monitoring	Initial inspection	Monthly for three months after installation.
	Inspect for evidence of poor operation and weed growth. Take remedial action if required.	Three-monthly and 48 hours after large storms for the first six months.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually
	Monitor the whole system including all inspection chambers, silt sump catch pits, gullies, inlets, vents, vortex control chambers, flood grilles and overflows to ensure that they are in good condition and operating as designed.	Annually and after flood events
Regular Maintenance	Brushing and vacuuming (standard cosmetic sweep over whole surface)	One year after construction, annually after autumn leaf fall or reduced frequency as required, based on site specific conditions of clogging. Particular attention should be paid to areas where water runs onto pervious surface from adjacent impermeable areas as this area is most likely to collect the most sediment.
Occasional Maintenance	Removal of weeds or management using glyphosate applied directly to the weeds by an applicator rather than a spray.	As required or once per year on less frequently used pavements
Remediation Actions	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance, or a hazard to users and replacement of lost jointing material.	Check within the first 12 months of construction and then annually and arrange remedial works if/as required.
	Rehabilitation of surface and upper substructure by remedial sweeping.	Every 10 to 15 years or as required if infiltration performance appears to be reduced due to significant clogging.
	Remediate any landscaping that through vegetation maintenance or soil slip has been raised to within 50mm of the level of the paving.	Check within the first 12 months of construction and then annually and arrange remedial works if/as required.
Sump Manholes, Inspection Chambers and flood grilles	Monitor the whole system including all silt sump catch pits, gullies, inlets, vents, grilles vortex control chambers and overflows for silt build up and empty/de-silt as required.	One year after construction, annually after autumn leaf fall or reduced frequency as required, based on site specific conditions of clogging.
Roof gutters and downpipes	Monitor for silt build up and empty/de-silt as required.	One year after construction, annually after autumn leaf fall or reduced frequency as required, based on site specific conditions of clogging.

CIRIA (2015), The CIRIA C753 SuDS Manual, Part D, 20 Previous Pavements, Table 20.15, London.