Infrastruct CS Ltd

Consulting Civil Engineers

SURFACE WATER DRAINAGE STRATEGY

PHASE 2 BICESTER ECO VILLAGE

HILL

February 2016

ICS Reference: ICS1859.07.001

Initial Issue

Infrastruct CS Ltd,
The stables, High Cogges Farm,
High Cogges,
Oxon
OX29 6UN

Infrastruct CS Ltd

Contents

1.0 INTRODUCTION

1.1 Infrastruct CS Ltd have compiled this report to provide sufficient information to enable the Environment Agency to discharge condition 69 of the planning consent in relation to Phase 2 of the Bicester Eco Village development.

1.2 The proposed scope of this report covers the surface water drainage design for both the community streets and the private dwellings within Phase 2 of the scheme.

1.3 This report aims to demonstrate how the proposed surface water drainage strategy meets the standard and requirements set within the planning approved flood risk assessment and mirrors the previously approved drainage strategy for Phase 1 of the development.

2.0 PLANNING APPROVED FLOOD RISK ASSESSMENT

2.1 As part of the initial planning application a Flood Risk Assessment (FRA) was produced by Hyder to cover the whole of the Bicester Eco development Ref 3501-UA001881-UU41R-03 dated June 2011.

2.2 In addition to this FRA, Hyder produced a drainage strategy document for the spine road and phase 1 development, Ref 7513-UA001881-UP33R-02 dated September 2012.

2.2 These reports were reviewed prior to the design of the surface water drainage scheme proposed by ICS and the following points were noted;

2.2.1 The superficial deposits across the development site are not classed as an aquifer with the underlying cornbrash formation classified as a secondary A Aquifer which comprises of permeable layers capable of supporting water supplies at a local level, rather than strategic scale and in some cases form an important source of base flows to rivers.

2.2.2 The water table was generally recorded at a depth of below 1.2m.

2.2.3 The development must incorporate Sustainable Urban Drainage Systems (SuDS) wherever possible.

2.2.4 The main spine road is to use positive drainage measures which will direct controlled flows into the watercourses which run through the development site. The design of this system is covered by Hyder and falls outside the scope of this report.

2.2.5 Soakaways and ground infiltration are to used wherever possible.

3.0 PROPOSED DRAINAGE OF COMMUNITY STREETS

3.1 The design of the proposed community streets (accessed off the spine road) is focused around the use of shared surfaces to promote slow vehicle speeds and attractive areas for residents to utilise.

3.2 To promote this, the community streets have been designed with the extensive use of block paving with landscaped areas between the edges of the road and the adjacent dwellings.

3.3 Given the space restrictions between the proposed units, the most appropriate method of draining these areas is via the use of permeable block paving. This method of construction will allow the surface water to migrate down and into the permeable layers at depth.

3.4 The design of these area has been developed in conjunction with Oxfordshire County Council who will be adopting and maintaining the majority of these areas. As such they have been specifically sized to accommodate a 1 in 100yr storm event plus 30% for climate change based on site specific infiltration rates.

3.6 The infiltration potential of the ground conditions does vary with the ground strata showing lower potential for infiltration at the northern end of the phase 2 parcel. As such the drainage design incorporates a filtration trench running parallel to the boundary to provide an emergency outlet to the permeable paving during extreme rainfall events. Surface water entering this system will slowly follow the topographic falls of the site in a southerly direction to where the infiltration potential of the underlying strata improves.

3.7 The design of these community streets is separate to that of the main spine road and all surface water falling on these surfaces will be directed into the underlying ground conditions.

3.8 The proposed use of both permeable block paving and filter trenches utilise granular material which promote the growth of micro bacteria which will provide a degree of surface water quality treatment.

3.9 The microdrainage calculations for these drainage elements has been provided within the pack of information issued to the Environment Agency as part of the discharge of the associated planning condition and can be found within Appendix A of this report together with the drainage drawings.

4.0 PROPOSED PARKING AND PARKING COURTYARDS

4.1 The design of all private parking areas and parking courtyards associated with the proposed residential properties within phase 2 are to be constructed with the use of permeable block paving.

4.2 The sub base below these areas has been specifically sized to accommodate the 1 in 100yr plus climate change storm event.

5.0 PRIVATE ROOF AREAS AND RAINWATER HARVESTING

5.1 Each residential dwelling within phase 2 has been provided with a rainwater harvesting unit located within the rear garden. This unit is primarily used to reduce the demand of fresh water but will also assist in reducing the surface water flows off site. The reclaimed water is to be used for the flushing of wc's within the dwelling. Surface water from the roof areas is directed into these harvesting units with an overflow out of the tanks.

5.2 All surface water leaving the rainwater harvesting units is subsequently discharged either into cellular soakaways located within the rear gardens or areas of private permeable block paving. The soakaway units, where utilised, have been specified as individual units to each dwelling. Discharges into the private permeable block paved areas are combined via a piped system prior to reaching the end discharge unit. Where additional surface water from roof areas is introduced into the permeable block paving, the sub base depth has been increased to reflect the required hydraulic capacity.

5.3 The cellular soakways and private permeable block paved areas have all been sized to accommodate the 1 in 100yr storm event plus 30% for climate change based on site specific infiltration rates. The provision of the rainwater harvesting unit has not been included within the storage calculations and it has been assumed that this will be full of water when a 1 in 100yr plus climate change storm event occurs.

6.0 OWNERSHIP AND FUTURE MAINTENANCE

6.1 As outlined previously the main roads and circulatory areas are to be adopted by Oxfordshire County Council highways for adoption under a Section 38 agreement and as such these areas will be owned and maintained by them.

6.2 The remainder of the parking and roof areas will fall either into the ownership of the individual home owners or A2Dominion. As such these areas need to be maintained by the private individuals and as such an ownership and maintenance document should be provided to homeowners explaining the type and frequency of maintenance required for the specific SuDS elements used within the design.

6.3 ICS have compiled a suitable report, Ref: 1859.07.002, outlining the required maintenance regime for these areas which can be found within Appendix B.

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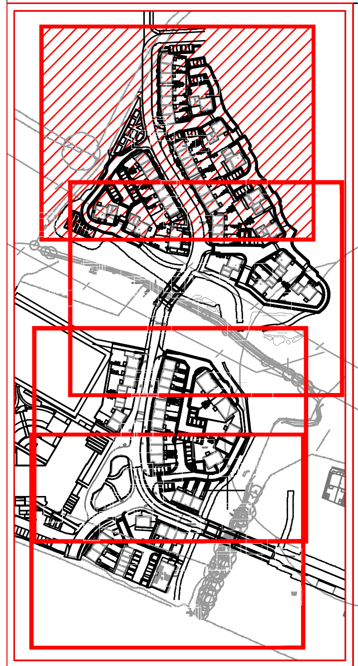
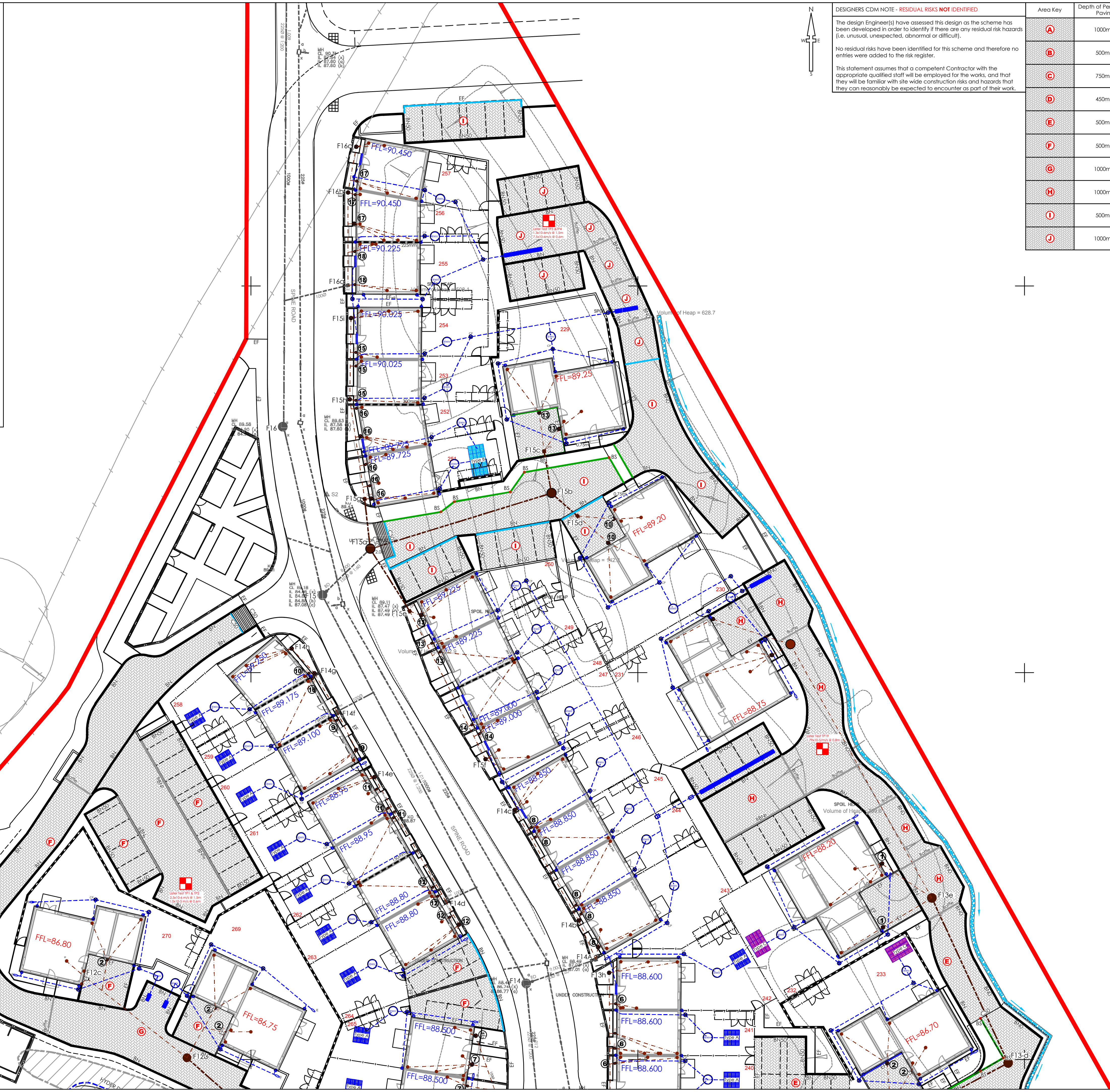
APPENDIX A – DRAINAGE DRAWINGS & CALCULATIONS

Foul Manhole Drainage Schedule					
MANHOLE REF	INVERT LEVEL	COVER LEVEL	GRADE 1 in	PIPE Ø (mm)	LENGTH
F14A	87.306	88.64			
			10.6	100	5.5
F14b	87.825	88.85			
			60	100	16.5
F14c	88.100	88.85			
F14d	87.850	88.82			
			52.8	100	18.5
F14e	88.200	89.00			
F14f	88.000	89.16			
			13	100	5.5
F14g	88.425	89.20			
			60	100	4.5
F14h	88.500	89.25			
F15A	87.009(150) 87.059(100)	89.25			
			21	100	24.5
F15b	88.225	89.19			
			31.4	100	5.5
F15c	88.400	89.25			
F15b	88.225	89.19			
			60	100	4.5
F15d	88.300	89.14			
F15A	87.009(150) 87.059(100)	89.25			
			11.4	100	9.5
F15e	87.891	89.15			
			60	100	21.5
F15f	88.250	89.00			
F15A	87.009(150) 87.059(100)	89.25			
			3.5	100	6.5
F15g	88.883	89.55			
			60	100	13.0
F15h	89.100	90.00			
			60	100	10.5
F15i	89.275	90.00			
F16a	89.400	90.22			
			60	100	12.0
F16b	89.600	90.45			
			60	100	6.0
F16c	89.700	90.45			

(yellow) To be confirmed prior to commencing works on site



Sheet Arrangement (1:2500)



DESIGNERS CDM NOTE - RESIDUAL RISKS **NOT** IDENTIFIED

The design Engineer(s) have assessed this design as the scheme has been developed in order to identify if there are any residual risk hazards (i.e. unusual, unexpected, abnormal or difficult).

No residual risks have been identified for this scheme and therefore no entries were added to the risk register.

This statement assumes that a competent Contractor with the appropriate qualified staff will be employed for the works, and that they will be familiar with site wide construction risks and hazards that they can reasonably be expected to encounter as part of their work.

Area Key	Depth of Permeable Paving
A	1000mm
B	500mm
C	750mm
D	450mm
E	500mm
F	500mm
G	1000mm
H	1000mm
I	500mm
J	1000mm

SURVEY INFORMATION
MK Surveys - 01908 565561
DRG NUMBER: 17523 - Sheets 1-12 DATE RECEIVED: 17/12/2014

ARCHITECT SITE PLAN INFORMATION
PRP Architects - 020 7653 3464
DRG NUMBER: AA2699 DATE RECEIVED: 22/12/2015

NOTES

1. All dimensions and levels are in metres unless otherwise noted
2. This drawing is to be read in conjunction with the relevant Architect's/Engineer's drawings, specifications and CDM documentation
3. This drawings has been produced electronically and may have been photo reduced or enlarged when copied. Work to figured dimensions only (DO NOT SCALE). All dimensions to be checked on site. Any errors or omissions to be reported to the engineer immediately.
4. This drawing contains coloured lines / information that may not be clear if reproduced in black and white.

Drainage Key

Sewers

- Foul water drain (private/non adoptable)
- Surface water drain (private/non adoptable)
- Foul water sewer (Adoptable)
- Surface water sewer (Adoptable)
- Existing foul water sewer (Adopted)
- Existing surface water sewer (Adopted)

Chamber Key

FW	SW	
mac	mac	Mini access chamber (mac) - 300mmØ*
		PPIC - 475mmØ* - CP = Catchpit
		P.C.C. units/brick *
DM	DM	Adoptable demarcation manhole within 1m of boundary *
		Manhole Depth 1.25 to 1.5m * Depth 1.55 to 3.0m *

* General note
(Refer to standard details & long sections for chamber sizes.
Size may need to increase dependant on number of incoming pipes/size of incoming pipes)

RE	Surface water rodding eye
F1	Manhole reference number
	Rain water down pipe (roddable access)
	Soil vent pipe/soil stack
	RWP cellular discharge/collection unit
	Retaining wall
FFL XX.XX	Finished Floor Level (FFL)
	Block paving - Permeable
	Impermeable barrier
	Permeable paving baffle
	Service baffle
	Proposed filter drain (To cater for extreme storm events)

Soakaway Table		
Key	Type	Dimension
	Type A	2m x 2m x 0.8m deep
	Type B	2m x 4m x 0.8m deep
	Type C	2m x 3m x 0.8m deep
	Type D	1.5m x 2m x 0.8m deep

PPIC Invert Levels	
Ref	Level
9	88.35
10	88.40
11	88.20
12	88.05
13	88.50
14	88.25
15	89.25
16	89.00
17	89.70
18	89.45

Rev	Drawn by	Chk'd by	Comments	Date
P01	NJ	TST	Initial issue	03/02/16

DRAWING TITLE
Proposed Drainage Plan
Sheet 1/4

PROJECT
Phase 2
Bicester Eco Village
Bicester
Oxon

DESIGNED BY	DRAFTED BY	APPROVED BY
TST	NJ	DJ

DATE 03/02/2016
STATUS **SUBJECT TO TECHNICAL APPROVAL**

SCALE 1:250 @ A1
0m 6.25m 12.5m
Scale bar @ 1:250

CLIENT
Hill

Infrastruct CS Ltd

JOB NUMBER	DRAWING NUMBER	REVISION
15-1859	03-1	P01

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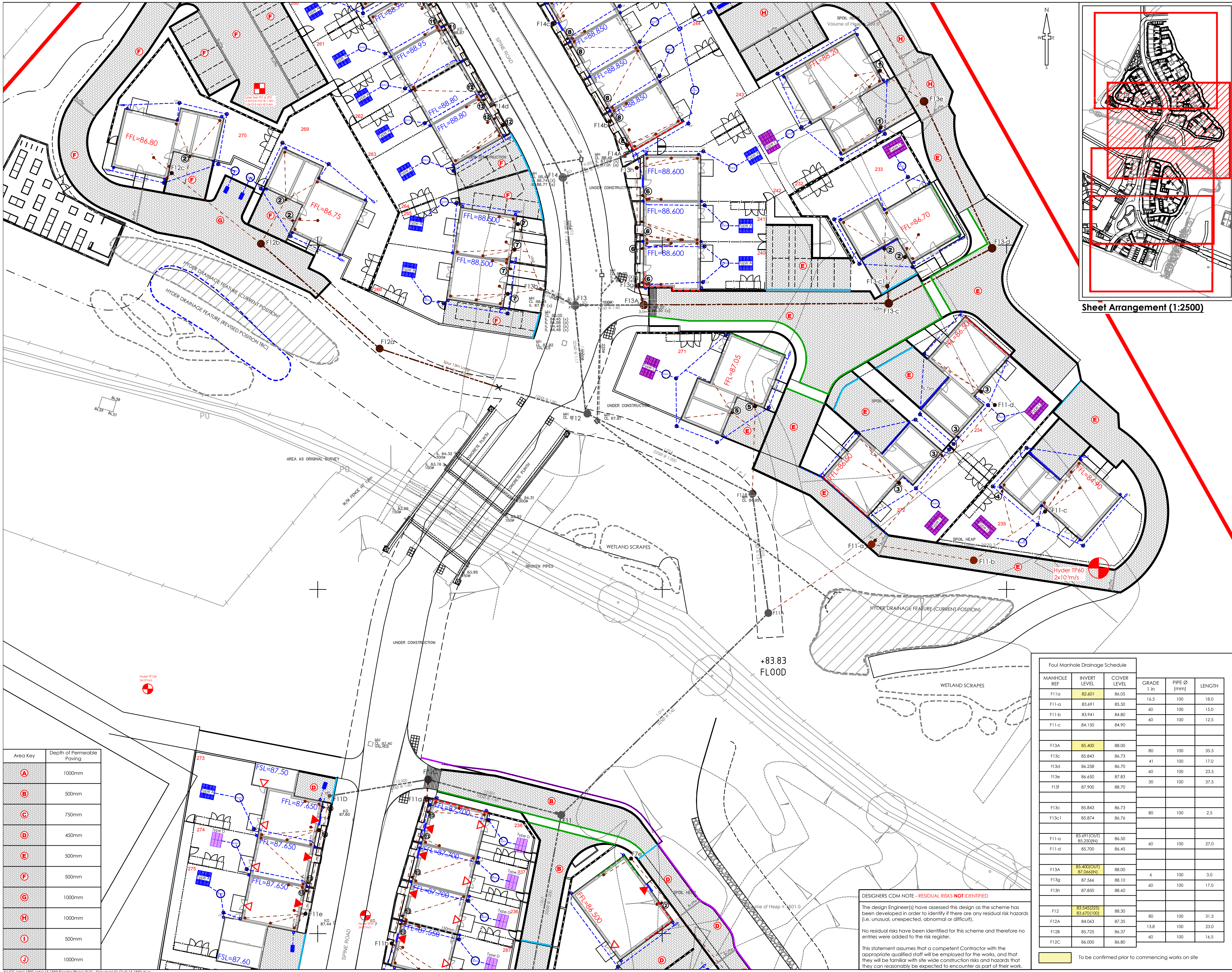

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DRG NUMBER: 17523 - Sheets 1-12	DATE RECEIVED: 17/12/2014

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- Surface water sewer (Adoptable)
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- Existing surface water sewer (Adopted)

Chamber Key

FW	SW	
mac	mac	Mini access chamber (mac) - 300mmØ*
		PPIC - 475mmØ* - CP = Catchpit
		P.C.C. units/brick *
DM	DM	Adoptable demarcation manhole within 1m of boundary *
		Manhole Depth 1.25 to 1.5m * Depth 1.55 to 3.0m *

* General note
(Refer to standard details & long sections for chamber sizes.
Size may need to increase dependant on number of incoming pipes/size of incoming pipes)

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	Rain water down pipe (roddable access)
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	RWP cellular discharge/collection unit
	Retaining wall
FFL XX.XX	Finished Floor Level (FFL)
	Block paving - Permeable
	Impermeable barrier
	Permeable paving baffle
	Service baffle
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Soakaway Table		
Key	Type	Dimension
	Type A	2m x 2m x 0.8m deep
	Type B	2m x 4m x 0.8m deep
	Type C	2m x 3m x 0.8m deep
	Type D	1.5m x 2m x 0.8m deep

PPIC Invert Levels	
Ref	Level
1	87.45
2	86.00
3	85.75
4	84.15
5	86.30
6	87.85
7	87.75
8	88.10

Area Key	Depth of Permeable Paving
A	1000mm
B	500mm
C	750mm
D	450mm
E	500mm
F	500mm
G	1000mm
H	1000mm
I	500mm
J	1000mm

Foul Manhole Drainage Schedule

MANHOLE REF	INVERT LEVEL	COVER LEVEL	GRADE 1 in	PIPE Ø (mm)	LENGTH
F11a	82.601	86.05			
			16.5	100	18.0
F11-a	83.691	85.50			
			60	100	15.0
F11-b	83.941	84.80			
			60	100	12.5
F11-c	84.150	84.90			
F13A	85.400	88.00			
			80	100	35.5
F13c	85.843	86.73			
			41	100	17.0
f13d	86.258	86.70			
			60	100	23.5
f13e	86.650	87.83			
			30	100	37.5
f13f	87.900	88.70			
F13c	85.843	86.73			
			80	100	2.5
F13c1	85.874	86.76			
F11-a	83.691(OUT) 85.250(IN)	86.50			
			60	100	27.0
F11-d	85.700	86.45			
F13A	85.400(OUT) 87.066(IN)	88.00			
			6	100	3.0
F13g	87.566	88.10			
			60	100	17.0
F13h	87.850	88.60			
F12	83.545(225) 83.670(100)	88.30			
			80	100	31.5
F12A	84.063	87.35			
			13.8	100	23.0
F12B	85.725	86.37			
			60	100	16.5
F12C	86.000	86.80			

To be confirmed prior to commencing works on site

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Rev	Drawn by	Chk'd by	Comments	Date
P01	NJ	TST	Initial issue	03/02/16

DRAWING TITLE
Proposed Drainage Plan
Sheet 2/4

PROJECT
Phase 2
Bicester Eco Village
Bicester
Oxon

DESIGNED BY	DRAFTED BY	APPROVED BY
TST	NJ	DJ

DATE
03/02/2016

STATUS
SUBJECT TO TECHNICAL APPROVAL

SCALE
1:250 @ A1

0m 6.25m 12.5m
Scale bar @ 1:250

CLIENT
Hill

Infrastruct CS Ltd

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JOB NUMBER	DRAWING NUMBER	REVISION
15-1859	03-2	P01

Foul Manhole Drainage Schedule

MANHOLE REF	INVERT LEVEL	COVER LEVEL
F6	81.565(225) 81.690(100)	85.30
F6a	82.525	84.00
F6b	83.000	83.70
F6a	82.525	84.00
F6c	83.000(OUT) 84.937(IN)	86.45
F6d	85.700	86.45
F9C	83.900(150) 83.950(100)	87.00
F9c	85.850	87.15
F9d	86.200	86.95
F8	81.924(225) 82.049(100)	84.98
F8a	84.262	85.15
F8b	85.500	86.25
F7	81.894(225) 82.019(100)	85.00
F7a	83.184	84.77
F7b	83.909	84.70
F7c	84.389	85.15
F7d	84.706	85.550
F7e	85.750	86.850
F10A	85.422	87.100
F10a	85.766	87.050
F10b	86.000	86.700
F10A	85.422	87.100
F10c	86.750	87.500
F11c	86.258	87.500
F11a	86.441	87.550
F11b	86.800	87.550
F11D	86.500	87.580
F11e	86.900	87.550

GRADE 1 in	PIPE Ø (mm)	LENGTH
10.8	100	9.0
40	100	19.0
15.8	100	7.5
40	100	30.5
2.9	100	5.5
40	100	14.0
2	100	4.5
20	100	16.5
7.7	100	9.0
40	100	29.0
25	100	12.0
30	100	9.5
23	100	24.0
11.6	100	4.0
60	100	14.0
15.4	100	20.5
16.3	100	3.0
60	100	21.5
43.75	100	17.5

To be confirmed prior to commencing works on site

FFL 87.90

Boundary defining Hyder river corridor works

+83.83 FLOOD

H103 INLET WITH FLOW CONTROL

INFILTRATION POND

Landscaping

CAR PARK

Area Key	Depth of Permeable Paving
A	1000mm
B	500mm
C	750mm
D	450mm

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Chamber Key

FW	SW	
MC	MC	Mini access chamber (mac) - 300mmØ*
PPIC	PPIC	PPIC - 475mmØ* - CP = Catchpit
		P.C.C. units/brick *
DM	DM	Adoptable demarcation manhole within 1m of boundary *
		Manhole Depth 1.25 to 1.5m * Depth 1.55 to 3.0m *

* General note
(Refer to standard details & long sections for chamber sizes. Size may need to increase dependant on number of incoming pipes/size of incoming pipes)

- Surface water rodding eye
- Manhole reference number
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- RWP cellular discharge/collection unit
- Retaining wall
- FFL XX.XX — Finished Floor Level (FFL)
- Block paving - Permeable
- Impermeable barrier
- Permeable paving baffle
- Service baffle
- Proposed filter drain (To cater for extreme storm events)

Soakaway Table		
Key	Type	Dimension
	Type A	2m x 2m x 0.8m deep
	Type B	2m x 4m x 0.8m deep
	Type C	2m x 3m x 0.8m deep
	Type D	1.5m x 2m x 0.8m deep

PPIC Invert Levels	
NO	IL
1	86.20
2	85.77
3	83.20
4	85.50
5	84.35
6	83.90
7	84.70
8	86.00
9	86.15
10	86.30
11	86.60
12	86.75
13	86.95

Sheet Arrangement (1:2500)

Rev	Drawn by	Chk'd by	Comments	Date
P01	NJ	TST	Initial issue	08/01/16

DRAWING TITLE
Proposed Drainage Plan
Sheet 3/4

PROJECT
Phase 2
Bicester Eco Village
Bicester
Oxon

DESIGNED BY	DRAFTED BY	APPROVED BY
TST	NJ	DJ

DATE 08/01/2016

STATUS **SUBJECT TO TECHNICAL APPROVAL**

SCALE 1:250 @ A1

Scale bar @ 1:250 — 0m, 6.25m, 12.5m

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JOB NUMBER	DRAWING NUMBER	REVISION
15-1859	03-3	P01

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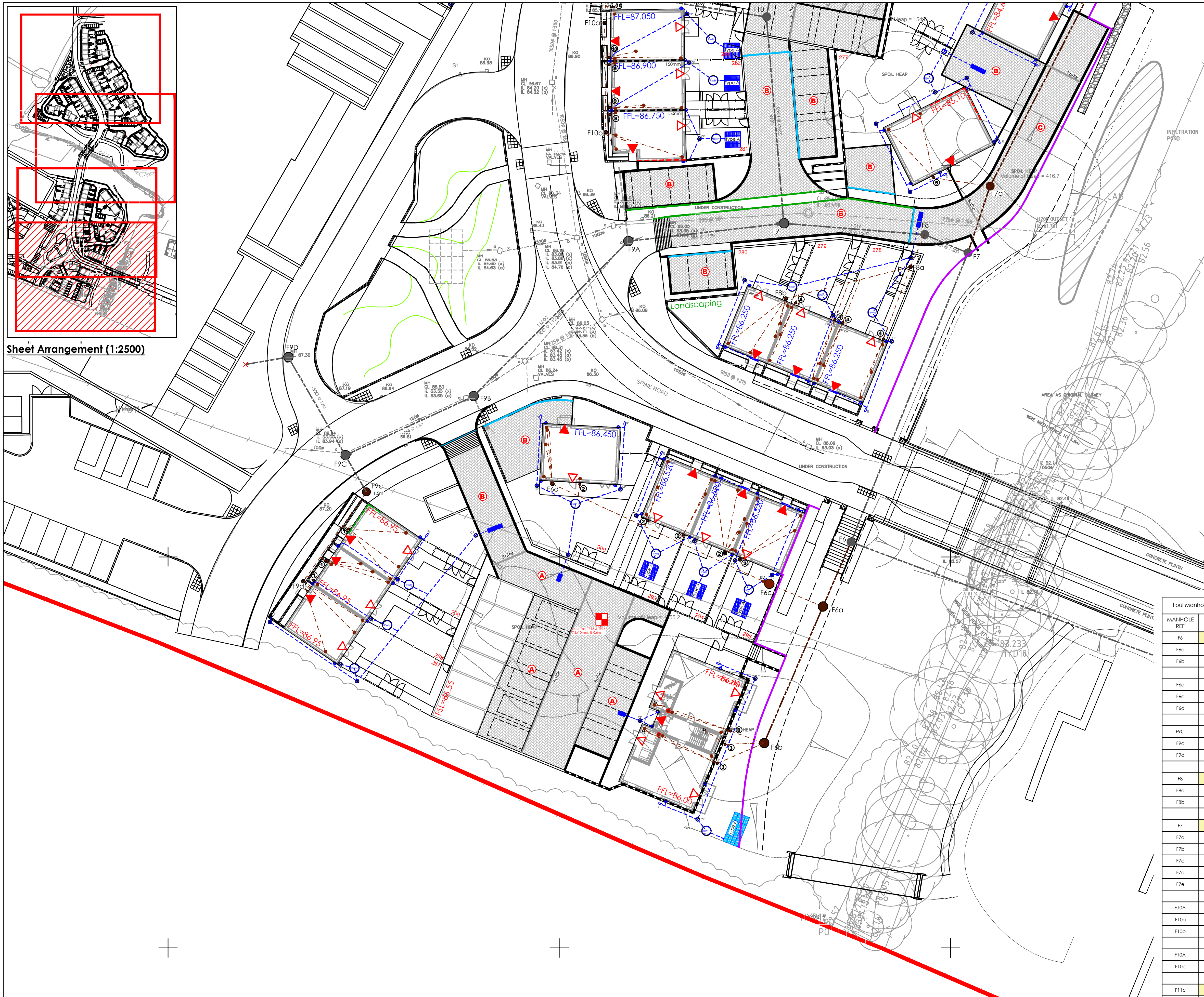

Area Key	Depth of Permeable Paving
A	1000mm
B	500mm
C	750mm

Soakaway Table

Key	Type	Dimension
	Type A	2m x 2m x 0.8m deep
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	Type D	1.5m x 2m x 0.8m deep

X:\ICS Jobs\1800 Jobs\15-1859 Bicester Phase 2\01 - Drawings\01 Civil\15-1859.dwg

Foul Manhole Drainage Schedule

MANHOLE REF	INVERT LEVEL	COVER LEVEL	GRADE 1 in	PIPE Ø (mm)	LENGTH
F6	81.565(225) 81.690(100)	85.30			
F6a	82.525	84.00	10.8	100	9.0
F6b	83.000	83.70	40	100	19.0
F6a	82.525	84.00			
F6c	83.000(OUT) 84.937(IN)	86.45	15.8	100	7.5
F6d	85.700	86.45	40	100	30.5
F9C	83.900(150) 83.950(100)	87.00			
F9c	85.850	87.15	2.9	100	5.5
F9d	86.200	86.95	40	100	14.0
F8	81.924(225) 82.049(100)	84.98			
F8a	84.262	85.15	2	100	4.5
F8b	85.500	86.25	20	100	16.5
F7	81.894(225) 82.019(100)	85.00			
F7a	83.184	84.77	7.7	100	9.0
F7b	83.909	84.70	40	100	29.0
F7c	84.389	85.15	25	100	12.0
F7d	84.706	85.550	30	100	9.5
F7e	85.750	86.850	23	100	24.0
F10A	85.422	87.100			
F10a	85.766	87.050	11.6	100	4.0
F10b	86.000	86.700	60	100	14.0
F10A	85.422	87.100			
F10c	86.750	87.500	15.4	100	20.5
F11c	86.258	87.500			
F11a	86.441	87.550	16.3	100	3.0
F11b	86.800	87.550	60	100	21.5
F11D	86.500	87.580			
F11e	86.900	87.550	43.75	100	17.5

To be confirmed prior to commencing works on site

DESIGNERS CDM NOTE - RESIDUAL RISKS NOT IDENTIFIED

The design Engineer(s) have assessed this design as the scheme has been developed in order to identify if there are any residual risk hazards (i.e. unusual, unexpected, abnormal or difficult).

No residual risks have been identified for this scheme and therefore no entries were added to the risk register.

This statement assumes that a competent Contractor with the appropriate qualified staff will be employed for the works, and that they will be familiar with site wide construction risks and hazards that they can reasonably be expected to encounter as part of their work.

SURVEY INFORMATION

MK Surveys - 01908 565561
DRG NUMBER: 17523 - Sheets 1-12 DATE RECEIVED: 17/12/2014

ARCHITECT SITE PLAN INFORMATION

PRP Architects - 020 7653 3464
DRG NUMBER: AA2699 DATE RECEIVED: 22/12/2015

NOTES

1. All dimensions and levels are in metres unless otherwise noted
2. This drawing is to be read in conjunction with the relevant Architect's/Engineer's drawings, specifications and CDM documentation
3. This drawings has been produced electronically and may have been photo reduced or enlarged when copied. Work to figured dimensions only (DO NOT SCALE). All dimensions to be checked on site. Any errors or omissions to be reported to the engineer immediately.
4. This drawing contains coloured lines / information that may not be clear if reproduced in black and white.

Drainage Key

Sewers

- Foul water drain (private/non adoptable)
- Surface water drain (private/non adoptable)
- Foul water sewer (Adoptable)
- Surface water sewer (Adoptable)
- Existing foul water sewer (Adopted)
- Existing surface water sewer (Adopted)

Chamber Key

FW	SW	
mac	mac	Mini access chamber (mac) - 300mmØ*
		PPIC - 475mmØ* - CP = Catchpit
		P.C.C. units/brick *
DM	DM	Adoptable demarcation manhole within 1m of boundary *
		Manhole Depth 1.25 to 1.5m * Depth 1.55 to 3.0m *

* General note
(Refer to standard details & long sections for chamber sizes. Size may need to increase dependant on number of incoming pipes/size of incoming pipes)

RE	Surface water rodding eye
F1	Manhole reference number
	Rain water down pipe (roddable access)
	Soil vent pipe/soil stack
	RWP cellular discharge/collection unit
	Retaining wall
FFL XX.XX	Finished Floor Level (FFL)
	Block paving - Permeable
	Impermeable barrier
	Permeable paving baffle
	Service baffle
	Proposed filter drain (To cater for extreme storm events)

PPIC Invert Levels

NO	IL
1	86.20
2	85.77
3	83.20
4	85.50
5	84.35
6	83.90
7	84.70
8	86.00
9	86.15
10	86.30
11	86.60
12	86.75
13	86.95

Rev	Drawn by	Chk'd by	Comments	Date
P01	NJ	TST	Initial issue	08/01/16

DRAWING TITLE
Proposed Drainage Plan Sheet 4/4

PROJECT
Phase 2
Bicester Eco Village
Bicester
Oxon

DESIGNED BY	DRAFTED BY	APPROVED BY
TST	NJ	DJ

DATE 08/01/2016
STATUS **SUBJECT TO TECHNICAL APPROVAL**

SCALE 1:250 @ A1
0m 6.25m 12.5m
Scale bar @ 1:250

CLIENT
Hill

Infrastruct CS Ltd

JOB NUMBER	DRAWING NUMBER	REVISION
15-1859	03-4	P01

Infrastruct CS Ltd: The Stables, High Cogges Farm, High Cogges, Witney, OX29 6UN - Tel: 01993 709709: info@infrastructcs.co.uk: www.infrastructcs.co.uk

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 789 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	85.741	0.291	0.0	1.7	O K
30 min Summer	85.829	0.379	0.0	2.2	O K
60 min Summer	85.916	0.466	0.0	2.7	O K
120 min Summer	85.996	0.546	0.0	3.1	O K
180 min Summer	86.034	0.584	0.0	3.3	O K
240 min Summer	86.054	0.604	0.0	3.4	O K
360 min Summer	86.072	0.622	0.0	3.5	O K
480 min Summer	86.076	0.626	0.0	3.6	O K
600 min Summer	86.071	0.621	0.0	3.5	O K
720 min Summer	86.066	0.616	0.0	3.5	O K
960 min Summer	86.054	0.604	0.0	3.4	O K
1440 min Summer	86.026	0.576	0.0	3.3	O K
2160 min Summer	85.983	0.533	0.0	3.0	O K
2880 min Summer	85.943	0.493	0.0	2.8	O K
4320 min Summer	85.872	0.422	0.0	2.4	O K
5760 min Summer	85.812	0.362	0.0	2.1	O K
7200 min Summer	85.760	0.310	0.0	1.8	O K
8640 min Summer	85.716	0.266	0.0	1.5	O K
10080 min Summer	85.678	0.228	0.0	1.3	O K
15 min Winter	85.776	0.326	0.0	1.9	O K
30 min Winter	85.875	0.425	0.0	2.4	O K
60 min Winter	85.973	0.523	0.0	3.0	O K
120 min Winter	86.065	0.615	0.0	3.5	O K
180 min Winter	86.110	0.660	0.0	3.8	Flood Risk
240 min Winter	86.134	0.684	0.0	3.9	Flood Risk
360 min Winter	86.158	0.708	0.1	4.0	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	38
60 min Summer	52.662	0.0	68
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	246
360 min Summer	13.543	0.0	366
480 min Summer	10.792	0.0	484
600 min Summer	9.043	0.0	564
720 min Summer	7.823	0.0	614
960 min Summer	6.219	0.0	738
1440 min Summer	4.493	0.0	1000
2160 min Summer	3.241	0.0	1412
2880 min Summer	2.568	0.0	1824
4320 min Summer	1.847	0.0	2640
5760 min Summer	1.461	0.0	3408
7200 min Summer	1.217	0.0	4176
8640 min Summer	1.048	0.0	4928
10080 min Summer	0.923	0.0	5648
15 min Winter	128.285	0.0	23
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	124
180 min Winter	23.353	0.0	184
240 min Winter	18.644	0.0	242
360 min Winter	13.543	0.0	356

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	86.167	0.717	0.1	4.1	Flood Risk
600 min Winter	86.166	0.716	0.1	4.1	Flood Risk
720 min Winter	86.159	0.709	0.1	4.0	Flood Risk
960 min Winter	86.143	0.693	0.0	3.9	Flood Risk
1440 min Winter	86.108	0.658	0.0	3.7	Flood Risk
2160 min Winter	86.048	0.598	0.0	3.4	O K
2880 min Winter	85.990	0.540	0.0	3.1	O K
4320 min Winter	85.888	0.438	0.0	2.5	O K
5760 min Winter	85.804	0.354	0.0	2.0	O K
7200 min Winter	85.734	0.284	0.0	1.6	O K
8640 min Winter	85.676	0.226	0.0	1.3	O K
10080 min Winter	85.626	0.176	0.0	1.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	468
600 min Winter	9.043	0.0	576
720 min Winter	7.823	0.0	678
960 min Winter	6.219	0.0	766
1440 min Winter	4.493	0.0	1072
2160 min Winter	3.241	0.0	1536
2880 min Winter	2.568	0.0	1968
4320 min Winter	1.847	0.0	2816
5760 min Winter	1.461	0.0	3632
7200 min Winter	1.217	0.0	4400
8640 min Winter	1.048	0.0	5184
10080 min Winter	0.923	0.0	5856

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.007

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000	4	8	0.007

Model Details

Storage is Online Cover Level (m) 86.400

Cellular Storage Structure

Invert Level (m) 85.450 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.02808 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.02808

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	6.0	6.0	0.800	6.0	13.8	0.900	0.0	14.3

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 830 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	83.080	0.280	0.0	2.1	O K
30 min Summer	83.165	0.365	0.0	2.8	O K
60 min Summer	83.250	0.450	0.1	3.4	O K
120 min Summer	83.327	0.527	0.1	4.0	O K
180 min Summer	83.364	0.564	0.1	4.3	O K
240 min Summer	83.384	0.584	0.1	4.4	O K
360 min Summer	83.403	0.603	0.1	4.6	Flood Risk
480 min Summer	83.407	0.607	0.1	4.6	Flood Risk
600 min Summer	83.404	0.604	0.1	4.6	Flood Risk
720 min Summer	83.399	0.599	0.1	4.5	O K
960 min Summer	83.387	0.587	0.1	4.5	O K
1440 min Summer	83.360	0.560	0.1	4.3	O K
2160 min Summer	83.318	0.518	0.1	3.9	O K
2880 min Summer	83.279	0.479	0.1	3.6	O K
4320 min Summer	83.210	0.410	0.0	3.1	O K
5760 min Summer	83.151	0.351	0.0	2.7	O K
7200 min Summer	83.100	0.300	0.0	2.3	O K
8640 min Summer	83.056	0.256	0.0	1.9	O K
10080 min Summer	83.018	0.218	0.0	1.7	O K
15 min Winter	83.114	0.314	0.0	2.4	O K
30 min Winter	83.210	0.410	0.0	3.1	O K
60 min Winter	83.305	0.505	0.1	3.8	O K
120 min Winter	83.394	0.594	0.1	4.5	O K
180 min Winter	83.438	0.638	0.1	4.8	Flood Risk
240 min Winter	83.462	0.662	0.1	5.0	Flood Risk
360 min Winter	83.487	0.687	0.1	5.2	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	38
60 min Summer	52.662	0.0	68
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	246
360 min Summer	13.543	0.0	366
480 min Summer	10.792	0.0	484
600 min Summer	9.043	0.0	578
720 min Summer	7.823	0.0	626
960 min Summer	6.219	0.0	748
1440 min Summer	4.493	0.0	1014
2160 min Summer	3.241	0.0	1428
2880 min Summer	2.568	0.0	1844
4320 min Summer	1.847	0.0	2640
5760 min Summer	1.461	0.0	3408
7200 min Summer	1.217	0.0	4184
8640 min Summer	1.048	0.0	4928
10080 min Summer	0.923	0.0	5648
15 min Winter	128.285	0.0	23
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	126
180 min Winter	23.353	0.0	184
240 min Winter	18.644	0.0	242
360 min Winter	13.543	0.0	356

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	83.496	0.696	0.1	5.3	Flood Risk
600 min Winter	83.496	0.696	0.1	5.3	Flood Risk
720 min Winter	83.491	0.691	0.1	5.2	Flood Risk
960 min Winter	83.474	0.674	0.1	5.1	Flood Risk
1440 min Winter	83.441	0.641	0.1	4.9	Flood Risk
2160 min Winter	83.383	0.583	0.1	4.4	O K
2880 min Winter	83.327	0.527	0.1	4.0	O K
4320 min Winter	83.228	0.428	0.1	3.3	O K
5760 min Winter	83.145	0.345	0.0	2.6	O K
7200 min Winter	83.075	0.275	0.0	2.1	O K
8640 min Winter	83.016	0.216	0.0	1.6	O K
10080 min Winter	82.967	0.167	0.0	1.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	468
600 min Winter	9.043	0.0	578
720 min Winter	7.823	0.0	682
960 min Winter	6.219	0.0	782
1440 min Winter	4.493	0.0	1086
2160 min Winter	3.241	0.0	1540
2880 min Winter	2.568	0.0	1992
4320 min Winter	1.847	0.0	2816
5760 min Winter	1.461	0.0	3632
7200 min Winter	1.217	0.0	4400
8640 min Winter	1.048	0.0	5184
10080 min Winter	0.923	0.0	5856

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.009

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000	4	8	0.009

Model Details

Storage is Online Cover Level (m) 83.700

Cellular Storage Structure

Invert Level (m) 82.800 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.02808 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.02808

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	8.0	8.0	0.800	8.0	17.1	0.900	0.0	17.6

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 721 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	85.812	0.312	0.0	1.2	O K
30 min Summer	85.905	0.405	0.0	1.5	O K
60 min Summer	85.998	0.498	0.0	1.9	O K
120 min Summer	86.083	0.583	0.0	2.2	Flood Risk
180 min Summer	86.123	0.623	0.0	2.4	Flood Risk
240 min Summer	86.143	0.643	0.0	2.4	Flood Risk
360 min Summer	86.160	0.660	0.0	2.5	Flood Risk
480 min Summer	86.162	0.662	0.0	2.5	Flood Risk
600 min Summer	86.157	0.657	0.0	2.5	Flood Risk
720 min Summer	86.152	0.652	0.0	2.5	Flood Risk
960 min Summer	86.140	0.640	0.0	2.4	Flood Risk
1440 min Summer	86.110	0.610	0.0	2.3	Flood Risk
2160 min Summer	86.063	0.563	0.0	2.1	Flood Risk
2880 min Summer	86.020	0.520	0.0	2.0	Flood Risk
4320 min Summer	85.945	0.445	0.0	1.7	O K
5760 min Summer	85.883	0.383	0.0	1.5	O K
7200 min Summer	85.830	0.330	0.0	1.3	O K
8640 min Summer	85.785	0.285	0.0	1.1	O K
10080 min Summer	85.746	0.246	0.0	0.9	O K
15 min Winter	85.849	0.349	0.0	1.3	O K
30 min Winter	85.955	0.455	0.0	1.7	O K
60 min Winter	86.060	0.560	0.0	2.1	Flood Risk
120 min Winter	86.157	0.657	0.0	2.5	Flood Risk
180 min Winter	86.203	0.703	0.0	2.7	Flood Risk
240 min Winter	86.228	0.728	0.0	2.8	Flood Risk
360 min Winter	86.252	0.752	0.0	2.9	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	38
60 min Summer	52.662	0.0	68
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	246
360 min Summer	13.543	0.0	364
480 min Summer	10.792	0.0	482
600 min Summer	9.043	0.0	528
720 min Summer	7.823	0.0	592
960 min Summer	6.219	0.0	716
1440 min Summer	4.493	0.0	986
2160 min Summer	3.241	0.0	1408
2880 min Summer	2.568	0.0	1820
4320 min Summer	1.847	0.0	2600
5760 min Summer	1.461	0.0	3400
7200 min Summer	1.217	0.0	4176
8640 min Summer	1.048	0.0	4920
10080 min Summer	0.923	0.0	5648
15 min Winter	128.285	0.0	23
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	124
180 min Winter	23.353	0.0	184
240 min Winter	18.644	0.0	240
360 min Winter	13.543	0.0	354

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	86.258	0.758	0.0	2.9	Flood Risk
600 min Winter	86.255	0.755	0.0	2.9	Flood Risk
720 min Winter	86.247	0.747	0.0	2.8	Flood Risk
960 min Winter	86.231	0.731	0.0	2.8	Flood Risk
1440 min Winter	86.192	0.692	0.0	2.6	Flood Risk
2160 min Winter	86.127	0.627	0.0	2.4	Flood Risk
2880 min Winter	86.065	0.565	0.0	2.1	Flood Risk
4320 min Winter	85.959	0.459	0.0	1.7	O K
5760 min Winter	85.873	0.373	0.0	1.4	O K
7200 min Winter	85.803	0.303	0.0	1.2	O K
8640 min Winter	85.744	0.244	0.0	0.9	O K
10080 min Winter	85.695	0.195	0.0	0.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	466
600 min Winter	9.043	0.0	570
720 min Winter	7.823	0.0	666
960 min Winter	6.219	0.0	754
1440 min Winter	4.493	0.0	1058
2160 min Winter	3.241	0.0	1516
2880 min Winter	2.568	0.0	1960
4320 min Winter	1.847	0.0	2776
5760 min Winter	1.461	0.0	3584
7200 min Winter	1.217	0.0	4392
8640 min Winter	1.048	0.0	5104
10080 min Winter	0.923	0.0	5848

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.005

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.000	4	8	0.005

Model Details

Storage is Online Cover Level (m) 86.300

Cellular Storage Structure

Invert Level (m) 85.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.02808 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.02808

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	4.0	4.0	0.800	4.0	10.4	0.900	0.0	10.8

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 190 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	83.981	0.481	0.2	2.3	O K
30 min Summer	84.114	0.614	0.2	2.9	O K
60 min Summer	84.225	0.725	0.2	3.4	O K
120 min Summer	84.283	0.783	0.2	3.7	O K
180 min Summer	84.285	0.785	0.2	3.7	O K
240 min Summer	84.274	0.774	0.2	3.7	O K
360 min Summer	84.245	0.745	0.2	3.5	O K
480 min Summer	84.211	0.711	0.2	3.4	O K
600 min Summer	84.178	0.678	0.2	3.2	O K
720 min Summer	84.147	0.647	0.2	3.1	O K
960 min Summer	84.090	0.590	0.2	2.8	O K
1440 min Summer	83.993	0.493	0.2	2.3	O K
2160 min Summer	83.878	0.378	0.1	1.8	O K
2880 min Summer	83.791	0.291	0.1	1.4	O K
4320 min Summer	83.670	0.170	0.1	0.8	O K
5760 min Summer	83.595	0.095	0.1	0.5	O K
7200 min Summer	83.555	0.055	0.1	0.3	O K
8640 min Summer	83.545	0.045	0.1	0.2	O K
10080 min Summer	83.540	0.040	0.1	0.2	O K
15 min Winter	84.041	0.541	0.2	2.6	O K
30 min Winter	84.192	0.692	0.2	3.3	O K
60 min Winter	84.327	0.827	0.2	3.9	O K
120 min Winter	84.712	1.212	0.2	4.3	Flood Risk
180 min Winter	84.729	1.229	0.2	4.3	Flood Risk
240 min Winter	84.653	1.153	0.2	4.2	O K
360 min Winter	84.461	0.961	0.2	4.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	22
30 min Summer	84.226	0.0	37
60 min Summer	52.662	0.0	66
120 min Summer	31.800	0.0	124
180 min Summer	23.353	0.0	154
240 min Summer	18.644	0.0	186
360 min Summer	13.543	0.0	252
480 min Summer	10.792	0.0	322
600 min Summer	9.043	0.0	390
720 min Summer	7.823	0.0	460
960 min Summer	6.219	0.0	594
1440 min Summer	4.493	0.0	856
2160 min Summer	3.241	0.0	1236
2880 min Summer	2.568	0.0	1616
4320 min Summer	1.847	0.0	2336
5760 min Summer	1.461	0.0	3000
7200 min Summer	1.217	0.0	3672
8640 min Summer	1.048	0.0	4400
10080 min Summer	0.923	0.0	5104
15 min Winter	128.285	0.0	22
30 min Winter	84.226	0.0	36
60 min Winter	52.662	0.0	64
120 min Winter	31.800	0.0	120
180 min Winter	23.353	0.0	174
240 min Winter	18.644	0.0	196
360 min Winter	13.543	0.0	270

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	84.299	0.799	0.2	3.8	O K
600 min Winter	84.252	0.752	0.2	3.6	O K
720 min Winter	84.207	0.707	0.2	3.4	O K
960 min Winter	84.124	0.624	0.2	3.0	O K
1440 min Winter	83.988	0.488	0.2	2.3	O K
2160 min Winter	83.836	0.336	0.1	1.6	O K
2880 min Winter	83.726	0.226	0.1	1.1	O K
4320 min Winter	83.586	0.086	0.1	0.4	O K
5760 min Winter	83.545	0.045	0.1	0.2	O K
7200 min Winter	83.538	0.038	0.1	0.2	O K
8640 min Winter	83.533	0.033	0.1	0.2	O K
10080 min Winter	83.529	0.029	0.1	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	346
600 min Winter	9.043	0.0	422
720 min Winter	7.823	0.0	494
960 min Winter	6.219	0.0	638
1440 min Winter	4.493	0.0	912
2160 min Winter	3.241	0.0	1300
2880 min Winter	2.568	0.0	1676
4320 min Winter	1.847	0.0	2340
5760 min Winter	1.461	0.0	2936
7200 min Winter	1.217	0.0	3672
8640 min Winter	1.048	0.0	4368
10080 min Winter	0.923	0.0	5136

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.010

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.000	4	8	0.010

Model Details

Storage is Online Cover Level (m) 85.000

Cellular Storage Structure

Invert Level (m) 83.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.12560 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.12560

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	5.0	5.0	0.800	5.0	12.2	0.900	0.0	12.6

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 420 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	85.952	0.452	0.1	2.6	O K
30 min Summer	86.084	0.584	0.1	3.3	O K
60 min Summer	86.209	0.709	0.1	4.0	O K
120 min Summer	86.312	0.812	0.1	4.6	O K
180 min Summer	86.468	0.968	0.1	4.8	O K
240 min Summer	86.511	1.011	0.1	4.9	O K
360 min Summer	86.463	0.963	0.1	4.8	O K
480 min Summer	86.373	0.873	0.1	4.7	O K
600 min Summer	86.322	0.822	0.1	4.7	O K
720 min Summer	86.300	0.800	0.1	4.6	O K
960 min Summer	86.264	0.764	0.1	4.4	O K
1440 min Summer	86.195	0.695	0.1	4.0	O K
2160 min Summer	86.106	0.606	0.1	3.5	O K
2880 min Summer	86.029	0.529	0.1	3.0	O K
4320 min Summer	85.907	0.407	0.1	2.3	O K
5760 min Summer	85.814	0.314	0.1	1.8	O K
7200 min Summer	85.741	0.241	0.1	1.4	O K
8640 min Summer	85.683	0.183	0.1	1.0	O K
10080 min Summer	85.638	0.138	0.1	0.8	O K
15 min Winter	86.007	0.507	0.1	2.9	O K
30 min Winter	86.157	0.657	0.1	3.7	O K
60 min Winter	86.299	0.799	0.1	4.6	O K
120 min Winter	86.885	1.385	0.1	5.2	O K
180 min Winter	87.154	1.654	0.1	5.5	O K
240 min Winter	87.248	1.748	0.1	5.6	Flood Risk
360 min Winter	87.232	1.732	0.1	5.6	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	37
60 min Summer	52.662	0.0	66
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	244
360 min Summer	13.543	0.0	308
480 min Summer	10.792	0.0	370
600 min Summer	9.043	0.0	436
720 min Summer	7.823	0.0	504
960 min Summer	6.219	0.0	642
1440 min Summer	4.493	0.0	916
2160 min Summer	3.241	0.0	1324
2880 min Summer	2.568	0.0	1708
4320 min Summer	1.847	0.0	2472
5760 min Summer	1.461	0.0	3224
7200 min Summer	1.217	0.0	3960
8640 min Summer	1.048	0.0	4664
10080 min Summer	0.923	0.0	5344
15 min Winter	128.285	0.0	22
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	124
180 min Winter	23.353	0.0	182
240 min Winter	18.644	0.0	238
360 min Winter	13.543	0.0	346

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	87.113	1.613	0.1	5.5	O K
600 min Winter	87.001	1.501	0.1	5.4	O K
720 min Winter	86.865	1.365	0.1	5.2	O K
960 min Winter	86.564	1.064	0.1	4.9	O K
1440 min Winter	86.263	0.763	0.1	4.3	O K
2160 min Winter	86.135	0.635	0.1	3.6	O K
2880 min Winter	86.029	0.529	0.1	3.0	O K
4320 min Winter	85.866	0.366	0.1	2.1	O K
5760 min Winter	85.747	0.247	0.1	1.4	O K
7200 min Winter	85.659	0.159	0.1	0.9	O K
8640 min Winter	85.595	0.095	0.1	0.5	O K
10080 min Winter	85.554	0.054	0.1	0.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	396
600 min Winter	9.043	0.0	468
720 min Winter	7.823	0.0	544
960 min Winter	6.219	0.0	696
1440 min Winter	4.493	0.0	986
2160 min Winter	3.241	0.0	1412
2880 min Winter	2.568	0.0	1820
4320 min Winter	1.847	0.0	2600
5760 min Winter	1.461	0.0	3344
7200 min Winter	1.217	0.0	4040
8640 min Winter	1.048	0.0	4752
10080 min Winter	0.923	0.0	5240

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.011

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.000	4	8	0.011

Model Details

Storage is Online Cover Level (m) 87.500

Cellular Storage Structure

Invert Level (m) 85.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.06480 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.06480

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	6.0	6.0	0.800	6.0	13.8	0.900	0.0	14.3

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 1178 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	86.563	0.313	0.0	1.2	O K
30 min Summer	86.659	0.409	0.0	1.6	O K
60 min Summer	86.756	0.506	0.0	1.9	O K
120 min Summer	86.849	0.599	0.0	2.3	O K
180 min Summer	86.897	0.647	0.0	2.5	O K
240 min Summer	86.925	0.675	0.0	2.6	O K
360 min Summer	86.959	0.709	0.0	2.7	O K
480 min Summer	86.976	0.726	0.0	2.8	O K
600 min Summer	86.983	0.733	0.0	2.8	O K
720 min Summer	86.984	0.734	0.0	2.8	O K
960 min Summer	86.978	0.728	0.0	2.8	O K
1440 min Summer	86.962	0.712	0.0	2.7	O K
2160 min Summer	86.931	0.681	0.0	2.6	O K
2880 min Summer	86.899	0.649	0.0	2.5	O K
4320 min Summer	86.837	0.587	0.0	2.2	O K
5760 min Summer	86.783	0.533	0.0	2.0	O K
7200 min Summer	86.735	0.485	0.0	1.8	O K
8640 min Summer	86.693	0.443	0.0	1.7	O K
10080 min Summer	86.654	0.404	0.0	1.5	O K
15 min Winter	86.601	0.351	0.0	1.3	O K
30 min Winter	86.709	0.459	0.0	1.7	O K
60 min Winter	86.818	0.568	0.0	2.2	O K
120 min Winter	86.923	0.673	0.0	2.6	O K
180 min Winter	86.978	0.728	0.0	2.8	O K
240 min Winter	87.011	0.761	0.0	2.9	O K
360 min Winter	87.051	0.801	0.0	3.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	38
60 min Summer	52.662	0.0	68
120 min Summer	31.800	0.0	128
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	246
360 min Summer	13.543	0.0	366
480 min Summer	10.792	0.0	486
600 min Summer	9.043	0.0	604
720 min Summer	7.823	0.0	724
960 min Summer	6.219	0.0	858
1440 min Summer	4.493	0.0	1100
2160 min Summer	3.241	0.0	1496
2880 min Summer	2.568	0.0	1908
4320 min Summer	1.847	0.0	2728
5760 min Summer	1.461	0.0	3568
7200 min Summer	1.217	0.0	4328
8640 min Summer	1.048	0.0	5104
10080 min Summer	0.923	0.0	5856
15 min Winter	128.285	0.0	23
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	126
180 min Winter	23.353	0.0	184
240 min Winter	18.644	0.0	242
360 min Winter	13.543	0.0	358

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	87.083	0.833	0.0	3.1	O K
600 min Winter	87.155	0.905	0.0	3.2	O K
720 min Winter	87.172	0.922	0.0	3.2	O K
960 min Winter	87.159	0.909	0.0	3.2	O K
1440 min Winter	87.065	0.815	0.0	3.1	O K
2160 min Winter	87.025	0.775	0.0	2.9	O K
2880 min Winter	86.980	0.730	0.0	2.8	O K
4320 min Winter	86.893	0.643	0.0	2.4	O K
5760 min Winter	86.816	0.566	0.0	2.2	O K
7200 min Winter	86.750	0.500	0.0	1.9	O K
8640 min Winter	86.691	0.441	0.0	1.7	O K
10080 min Winter	86.639	0.389	0.0	1.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	474
600 min Winter	9.043	0.0	586
720 min Winter	7.823	0.0	698
960 min Winter	6.219	0.0	910
1440 min Winter	4.493	0.0	1144
2160 min Winter	3.241	0.0	1604
2880 min Winter	2.568	0.0	2056
4320 min Winter	1.847	0.0	2944
5760 min Winter	1.461	0.0	3808
7200 min Winter	1.217	0.0	4616
8640 min Winter	1.048	0.0	5448
10080 min Winter	0.923	0.0	6248

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.005

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.000	4	8	0.005

Model Details

Storage is Online Cover Level (m) 88.250

Cellular Storage Structure

Invert Level (m) 86.250 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.01800 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.01800

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	4.0	4.0	0.800	4.0	10.4	0.900	0.0	10.8

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 918 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	87.812	0.312	0.0	2.4	O K
30 min Summer	87.907	0.407	0.0	3.1	O K
60 min Summer	88.001	0.501	0.1	3.8	O K
120 min Summer	88.090	0.590	0.1	4.5	O K
180 min Summer	88.133	0.633	0.1	4.8	O K
240 min Summer	88.157	0.657	0.1	5.0	O K
360 min Summer	88.182	0.682	0.1	5.2	O K
480 min Summer	88.190	0.690	0.1	5.2	O K
600 min Summer	88.190	0.690	0.1	5.2	O K
720 min Summer	88.185	0.685	0.1	5.2	O K
960 min Summer	88.174	0.674	0.1	5.1	O K
1440 min Summer	88.147	0.647	0.1	4.9	O K
2160 min Summer	88.104	0.604	0.1	4.6	O K
2880 min Summer	88.064	0.564	0.1	4.3	O K
4320 min Summer	87.992	0.492	0.1	3.7	O K
5760 min Summer	87.930	0.430	0.0	3.3	O K
7200 min Summer	87.876	0.376	0.0	2.9	O K
8640 min Summer	87.828	0.328	0.0	2.5	O K
10080 min Summer	87.786	0.286	0.0	2.2	O K
15 min Winter	87.850	0.350	0.0	2.7	O K
30 min Winter	87.956	0.456	0.0	3.5	O K
60 min Winter	88.063	0.563	0.1	4.3	O K
120 min Winter	88.164	0.664	0.1	5.0	O K
180 min Winter	88.215	0.715	0.1	5.4	O K
240 min Winter	88.243	0.743	0.1	5.6	O K
360 min Winter	88.275	0.775	0.1	5.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	38
60 min Summer	52.662	0.0	68
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	246
360 min Summer	13.543	0.0	366
480 min Summer	10.792	0.0	484
600 min Summer	9.043	0.0	604
720 min Summer	7.823	0.0	662
960 min Summer	6.219	0.0	774
1440 min Summer	4.493	0.0	1030
2160 min Summer	3.241	0.0	1452
2880 min Summer	2.568	0.0	1852
4320 min Summer	1.847	0.0	2684
5760 min Summer	1.461	0.0	3464
7200 min Summer	1.217	0.0	4248
8640 min Summer	1.048	0.0	5016
10080 min Summer	0.923	0.0	5752
15 min Winter	128.285	0.0	23
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	126
180 min Winter	23.353	0.0	184
240 min Winter	18.644	0.0	242
360 min Winter	13.543	0.0	358

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	88.289	0.789	0.1	6.0	O K
600 min Winter	88.292	0.792	0.1	6.0	O K
720 min Winter	88.289	0.789	0.1	6.0	O K
960 min Winter	88.274	0.774	0.1	5.9	O K
1440 min Winter	88.242	0.742	0.1	5.6	O K
2160 min Winter	88.184	0.684	0.1	5.2	O K
2880 min Winter	88.127	0.627	0.1	4.8	O K
4320 min Winter	88.024	0.524	0.1	4.0	O K
5760 min Winter	87.936	0.436	0.0	3.3	O K
7200 min Winter	87.861	0.361	0.0	2.7	O K
8640 min Winter	87.796	0.296	0.0	2.3	O K
10080 min Winter	87.741	0.241	0.0	1.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	470
600 min Winter	9.043	0.0	582
720 min Winter	7.823	0.0	690
960 min Winter	6.219	0.0	880
1440 min Winter	4.493	0.0	1100
2160 min Winter	3.241	0.0	1560
2880 min Winter	2.568	0.0	2020
4320 min Winter	1.847	0.0	2860
5760 min Winter	1.461	0.0	3688
7200 min Winter	1.217	0.0	4472
8640 min Winter	1.048	0.0	5272
10080 min Winter	0.923	0.0	6048

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.010

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000	4	8	0.010

Model Details

Storage is Online Cover Level (m) 89.500

Cellular Storage Structure

Invert Level (m) 87.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.02700 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.02700

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	8.0	8.0	0.800	8.0	17.1	0.900	0.0	17.6

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 991 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	85.870	0.320	0.1	3.8	O K
30 min Summer	85.967	0.417	0.1	4.9	O K
60 min Summer	86.064	0.514	0.1	6.1	O K
120 min Summer	86.155	0.605	0.1	7.2	O K
180 min Summer	86.201	0.651	0.1	7.7	O K
240 min Summer	86.227	0.677	0.1	8.0	O K
360 min Summer	86.254	0.704	0.1	8.4	O K
480 min Summer	86.265	0.715	0.1	8.5	O K
600 min Summer	86.267	0.717	0.1	8.5	O K
720 min Summer	86.262	0.712	0.1	8.5	O K
960 min Summer	86.250	0.700	0.1	8.3	O K
1440 min Summer	86.223	0.673	0.1	8.0	O K
2160 min Summer	86.180	0.630	0.1	7.5	O K
2880 min Summer	86.139	0.589	0.1	7.0	O K
4320 min Summer	86.066	0.516	0.1	6.1	O K
5760 min Summer	86.002	0.452	0.1	5.4	O K
7200 min Summer	85.946	0.396	0.1	4.7	O K
8640 min Summer	85.896	0.346	0.1	4.1	O K
10080 min Summer	85.852	0.302	0.1	3.6	O K
15 min Winter	85.908	0.358	0.1	4.3	O K
30 min Winter	86.018	0.468	0.1	5.6	O K
60 min Winter	86.128	0.578	0.1	6.9	O K
120 min Winter	86.232	0.682	0.1	8.1	O K
180 min Winter	86.285	0.735	0.1	8.7	O K
240 min Winter	86.316	0.766	0.1	9.1	O K
360 min Winter	86.350	0.800	0.1	9.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	38
60 min Summer	52.662	0.0	68
120 min Summer	31.800	0.0	128
180 min Summer	23.353	0.0	186
240 min Summer	18.644	0.0	246
360 min Summer	13.543	0.0	366
480 min Summer	10.792	0.0	484
600 min Summer	9.043	0.0	604
720 min Summer	7.823	0.0	704
960 min Summer	6.219	0.0	804
1440 min Summer	4.493	0.0	1056
2160 min Summer	3.241	0.0	1472
2880 min Summer	2.568	0.0	1880
4320 min Summer	1.847	0.0	2688
5760 min Summer	1.461	0.0	3512
7200 min Summer	1.217	0.0	4256
8640 min Summer	1.048	0.0	5016
10080 min Summer	0.923	0.0	5752
15 min Winter	128.285	0.0	23
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	126
180 min Winter	23.353	0.0	184
240 min Winter	18.644	0.0	242
360 min Winter	13.543	0.0	358

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	86.371	0.821	0.1	9.7	O K
600 min Winter	86.381	0.831	0.1	9.8	O K
720 min Winter	86.380	0.830	0.1	9.8	O K
960 min Winter	86.359	0.809	0.1	9.6	O K
1440 min Winter	86.324	0.774	0.1	9.2	O K
2160 min Winter	86.268	0.718	0.1	8.5	O K
2880 min Winter	86.210	0.660	0.1	7.8	O K
4320 min Winter	86.105	0.555	0.1	6.6	O K
5760 min Winter	86.013	0.463	0.1	5.5	O K
7200 min Winter	85.934	0.384	0.1	4.6	O K
8640 min Winter	85.865	0.315	0.1	3.7	O K
10080 min Winter	85.806	0.256	0.1	3.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	472
600 min Winter	9.043	0.0	584
720 min Winter	7.823	0.0	694
960 min Winter	6.219	0.0	900
1440 min Winter	4.493	0.0	1116
2160 min Winter	3.241	0.0	1584
2880 min Winter	2.568	0.0	2024
4320 min Winter	1.847	0.0	2900
5760 min Winter	1.461	0.0	3744
7200 min Winter	1.217	0.0	4536
8640 min Winter	1.048	0.0	5280
10080 min Winter	0.923	0.0	6056

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.016

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.000	4	8	0.016

Model Details

Storage is Online Cover Level (m) 86.750

Cellular Storage Structure

Invert Level (m) 85.550 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.02808 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.02808

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	12.5	12.5	0.800	12.5	23.8	0.900	0.0	24.5

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 345 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	86.063	0.613	0.1	1.2	O K
30 min Summer	86.239	0.789	0.1	1.5	O K
60 min Summer	86.574	1.124	0.1	1.8	O K
120 min Summer	86.813	1.363	0.1	2.0	O K
180 min Summer	86.885	1.435	0.1	2.1	O K
240 min Summer	86.886	1.436	0.1	2.1	O K
360 min Summer	86.859	1.409	0.1	2.1	O K
480 min Summer	86.819	1.369	0.1	2.1	O K
600 min Summer	86.768	1.318	0.1	2.0	O K
720 min Summer	86.711	1.261	0.1	1.9	O K
960 min Summer	86.594	1.144	0.1	1.8	O K
1440 min Summer	86.382	0.932	0.1	1.6	O K
2160 min Summer	86.179	0.729	0.1	1.4	O K
2880 min Summer	86.082	0.632	0.1	1.2	O K
4320 min Summer	85.938	0.488	0.0	0.9	O K
5760 min Summer	85.834	0.384	0.0	0.7	O K
7200 min Summer	85.756	0.306	0.0	0.6	O K
8640 min Summer	85.695	0.245	0.0	0.5	O K
10080 min Summer	85.646	0.196	0.0	0.4	O K
15 min Winter	86.138	0.688	0.1	1.3	O K
30 min Winter	86.452	1.002	0.1	1.7	O K
60 min Winter	86.810	1.360	0.1	2.0	O K
120 min Winter	87.098	1.648	0.1	2.3	O K
180 min Winter	87.200	1.750	0.1	2.4	Flood Risk
240 min Winter	87.221	1.771	0.1	2.5	Flood Risk
360 min Winter	87.177	1.727	0.1	2.4	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	23
30 min Summer	84.226	0.0	37
60 min Summer	52.662	0.0	66
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	184
240 min Summer	18.644	0.0	232
360 min Summer	13.543	0.0	288
480 min Summer	10.792	0.0	350
600 min Summer	9.043	0.0	416
720 min Summer	7.823	0.0	486
960 min Summer	6.219	0.0	620
1440 min Summer	4.493	0.0	884
2160 min Summer	3.241	0.0	1280
2880 min Summer	2.568	0.0	1672
4320 min Summer	1.847	0.0	2424
5760 min Summer	1.461	0.0	3168
7200 min Summer	1.217	0.0	3888
8640 min Summer	1.048	0.0	4584
10080 min Summer	0.923	0.0	5344
15 min Winter	128.285	0.0	22
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	124
180 min Winter	23.353	0.0	180
240 min Winter	18.644	0.0	236
360 min Winter	13.543	0.0	334

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	87.121	1.671	0.1	2.4	O K
600 min Winter	87.052	1.602	0.1	2.3	O K
720 min Winter	86.972	1.522	0.1	2.2	O K
960 min Winter	86.800	1.350	0.1	2.0	O K
1440 min Winter	86.477	1.027	0.1	1.7	O K
2160 min Winter	86.180	0.730	0.1	1.4	O K
2880 min Winter	86.053	0.603	0.1	1.1	O K
4320 min Winter	85.874	0.424	0.0	0.8	O K
5760 min Winter	85.754	0.304	0.0	0.6	O K
7200 min Winter	85.667	0.217	0.0	0.4	O K
8640 min Winter	85.602	0.152	0.0	0.3	O K
10080 min Winter	85.552	0.102	0.0	0.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	378
600 min Winter	9.043	0.0	454
720 min Winter	7.823	0.0	530
960 min Winter	6.219	0.0	676
1440 min Winter	4.493	0.0	944
2160 min Winter	3.241	0.0	1348
2880 min Winter	2.568	0.0	1736
4320 min Winter	1.847	0.0	2512
5760 min Winter	1.461	0.0	3232
7200 min Winter	1.217	0.0	3968
8640 min Winter	1.048	0.0	4672
10080 min Winter	0.923	0.0	5352

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.005

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.000	4	8	0.005

Model Details

Storage is Online Cover Level (m) 87.450

Cellular Storage Structure

Invert Level (m) 85.450 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.07200 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.07200

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	2.0	2.0	0.800	2.0	6.5	0.900	0.0	6.8

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 541 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	88.740	0.490	0.5	13.8	O K
30 min Summer	88.848	0.598	0.5	18.1	O K
60 min Summer	88.951	0.701	0.5	22.3	Flood Risk
120 min Summer	89.041	0.791	0.5	25.9	Flood Risk
180 min Summer	89.079	0.829	0.5	27.5	Flood Risk
240 min Summer	89.094	0.844	0.5	28.1	Flood Risk
360 min Summer	89.099	0.849	0.5	28.3	Flood Risk
480 min Summer	89.088	0.838	0.5	27.9	Flood Risk
600 min Summer	89.076	0.826	0.5	27.4	Flood Risk
720 min Summer	89.062	0.812	0.5	26.8	Flood Risk
960 min Summer	89.032	0.782	0.5	25.6	Flood Risk
1440 min Summer	88.973	0.723	0.5	23.2	Flood Risk
2160 min Summer	88.889	0.639	0.5	19.8	O K
2880 min Summer	88.814	0.564	0.5	16.7	O K
4320 min Summer	88.690	0.440	0.5	11.7	O K
5760 min Summer	88.602	0.352	0.5	8.2	O K
7200 min Summer	88.548	0.298	0.5	6.0	O K
8640 min Summer	88.519	0.269	0.5	4.9	O K
10080 min Summer	88.495	0.245	0.4	4.0	O K
15 min Winter	88.784	0.534	0.5	15.6	O K
30 min Winter	88.905	0.655	0.5	20.5	O K
60 min Winter	89.023	0.773	0.5	25.2	Flood Risk
120 min Winter	89.128	0.878	0.5	29.5	Flood Risk
180 min Winter	89.175	0.925	0.5	31.4	Flood Risk
240 min Winter	89.197	0.947	0.5	32.3	Flood Risk
360 min Winter	89.211	0.961	0.5	32.8	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	22
30 min Summer	84.226	0.0	37
60 min Summer	52.662	0.0	66
120 min Summer	31.800	0.0	126
180 min Summer	23.353	0.0	184
240 min Summer	18.644	0.0	244
360 min Summer	13.543	0.0	362
480 min Summer	10.792	0.0	440
600 min Summer	9.043	0.0	494
720 min Summer	7.823	0.0	556
960 min Summer	6.219	0.0	682
1440 min Summer	4.493	0.0	954
2160 min Summer	3.241	0.0	1360
2880 min Summer	2.568	0.0	1736
4320 min Summer	1.847	0.0	2468
5760 min Summer	1.461	0.0	3168
7200 min Summer	1.217	0.0	3816
8640 min Summer	1.048	0.0	4496
10080 min Summer	0.923	0.0	5240
15 min Winter	128.285	0.0	22
30 min Winter	84.226	0.0	37
60 min Winter	52.662	0.0	66
120 min Winter	31.800	0.0	124
180 min Winter	23.353	0.0	182
240 min Winter	18.644	0.0	238
360 min Winter	13.543	0.0	352

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	89.205	0.955	0.5	32.6	Flood Risk
600 min Winter	89.189	0.939	0.5	31.9	Flood Risk
720 min Winter	89.168	0.918	0.5	31.1	Flood Risk
960 min Winter	89.130	0.880	0.5	29.6	Flood Risk
1440 min Winter	89.046	0.796	0.5	26.2	Flood Risk
2160 min Winter	88.920	0.670	0.5	21.1	O K
2880 min Winter	88.806	0.556	0.5	16.5	O K
4320 min Winter	88.629	0.379	0.5	9.3	O K
5760 min Winter	88.538	0.288	0.5	5.6	O K
7200 min Winter	88.497	0.247	0.4	4.1	O K
8640 min Winter	88.467	0.217	0.4	3.2	O K
10080 min Winter	88.443	0.193	0.3	2.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	462
600 min Winter	9.043	0.0	566
720 min Winter	7.823	0.0	598
960 min Winter	6.219	0.0	738
1440 min Winter	4.493	0.0	1042
2160 min Winter	3.241	0.0	1472
2880 min Winter	2.568	0.0	1872
4320 min Winter	1.847	0.0	2556
5760 min Winter	1.461	0.0	3120
7200 min Winter	1.217	0.0	3824
8640 min Winter	1.048	0.0	4576
10080 min Winter	0.923	0.0	5248

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.062

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.025	4	8	0.037

Model Details

Storage is Online Cover Level (m) 89.250

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.02700	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	37.5	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	88.250	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 153 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	88.916	0.266	0.4	3.8	Flood Risk
30 min Summer	88.957	0.307	0.4	5.1	Flood Risk
60 min Summer	88.988	0.338	0.5	6.2	Flood Risk
120 min Summer	89.003	0.353	0.5	6.7	Flood Risk
180 min Summer	89.006	0.356	0.5	6.9	Flood Risk
240 min Summer	89.006	0.356	0.5	6.8	Flood Risk
360 min Summer	89.001	0.351	0.5	6.6	Flood Risk
480 min Summer	88.994	0.344	0.5	6.4	Flood Risk
600 min Summer	88.986	0.336	0.5	6.1	Flood Risk
720 min Summer	88.977	0.327	0.4	5.8	Flood Risk
960 min Summer	88.961	0.311	0.4	5.2	Flood Risk
1440 min Summer	88.932	0.282	0.4	4.3	Flood Risk
2160 min Summer	88.897	0.247	0.3	3.3	Flood Risk
2880 min Summer	88.870	0.220	0.3	2.6	Flood Risk
4320 min Summer	88.830	0.180	0.2	1.7	O K
5760 min Summer	88.802	0.152	0.2	1.3	O K
7200 min Summer	88.782	0.132	0.2	0.9	O K
8640 min Summer	88.766	0.116	0.2	0.7	O K
10080 min Summer	88.754	0.104	0.1	0.6	O K
15 min Winter	88.935	0.285	0.4	4.4	Flood Risk
30 min Winter	88.979	0.329	0.4	5.8	Flood Risk
60 min Winter	89.012	0.362	0.5	7.1	Flood Risk
120 min Winter	89.029	0.379	0.5	7.8	Flood Risk
180 min Winter	89.031	0.381	0.5	7.8	Flood Risk
240 min Winter	89.029	0.379	0.5	7.8	Flood Risk
360 min Winter	89.021	0.371	0.5	7.4	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	18
30 min Summer	84.226	0.0	33
60 min Summer	52.662	0.0	62
120 min Summer	31.800	0.0	112
180 min Summer	23.353	0.0	140
240 min Summer	18.644	0.0	172
360 min Summer	13.543	0.0	240
480 min Summer	10.792	0.0	310
600 min Summer	9.043	0.0	378
720 min Summer	7.823	0.0	444
960 min Summer	6.219	0.0	578
1440 min Summer	4.493	0.0	834
2160 min Summer	3.241	0.0	1192
2880 min Summer	2.568	0.0	1560
4320 min Summer	1.847	0.0	2288
5760 min Summer	1.461	0.0	3000
7200 min Summer	1.217	0.0	3680
8640 min Summer	1.048	0.0	4416
10080 min Summer	0.923	0.0	5144
15 min Winter	128.285	0.0	18
30 min Winter	84.226	0.0	32
60 min Winter	52.662	0.0	60
120 min Winter	31.800	0.0	116
180 min Winter	23.353	0.0	146
240 min Winter	18.644	0.0	184
360 min Winter	13.543	0.0	260

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	89.010	0.360	0.5	7.0	Flood Risk
600 min Winter	88.998	0.348	0.5	6.5	Flood Risk
720 min Winter	88.986	0.336	0.5	6.1	Flood Risk
960 min Winter	88.964	0.314	0.4	5.3	Flood Risk
1440 min Winter	88.924	0.274	0.4	4.1	Flood Risk
2160 min Winter	88.879	0.229	0.3	2.8	Flood Risk
2880 min Winter	88.845	0.195	0.3	2.0	O K
4320 min Winter	88.799	0.149	0.2	1.2	O K
5760 min Winter	88.770	0.120	0.2	0.8	O K
7200 min Winter	88.751	0.101	0.1	0.6	O K
8640 min Winter	88.737	0.087	0.1	0.4	O K
10080 min Winter	88.727	0.077	0.1	0.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	334
600 min Winter	9.043	0.0	406
720 min Winter	7.823	0.0	476
960 min Winter	6.219	0.0	614
1440 min Winter	4.493	0.0	868
2160 min Winter	3.241	0.0	1236
2880 min Winter	2.568	0.0	1612
4320 min Winter	1.847	0.0	2296
5760 min Winter	1.461	0.0	3000
7200 min Winter	1.217	0.0	3744
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.923	0.0	5144

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.020

Time (mins) From:	To:	Area (ha)
0	4	0.020

Model Details

Storage is Online Cover Level (m) 89.150

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.02700	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	34.0
Max Percolation (l/s)	42.5	Slope (1:X)	80.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	88.650	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 160 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	87.450	0.650	2.1	22.8	O K
30 min Summer	87.543	0.743	2.4	29.8	Flood Risk
60 min Summer	87.611	0.811	2.6	35.5	Flood Risk
120 min Summer	87.644	0.844	2.7	38.5	Flood Risk
180 min Summer	87.649	0.849	2.7	38.9	Flood Risk
240 min Summer	87.645	0.845	2.7	38.6	Flood Risk
360 min Summer	87.630	0.830	2.7	37.2	Flood Risk
480 min Summer	87.612	0.812	2.6	35.6	Flood Risk
600 min Summer	87.591	0.791	2.6	33.8	Flood Risk
720 min Summer	87.571	0.771	2.5	32.1	Flood Risk
960 min Summer	87.531	0.731	2.4	28.9	Flood Risk
1440 min Summer	87.462	0.662	2.1	23.6	O K
2160 min Summer	87.379	0.579	1.9	18.1	O K
2880 min Summer	87.316	0.516	1.7	14.4	O K
4320 min Summer	87.222	0.422	1.4	9.6	O K
5760 min Summer	87.157	0.357	1.2	6.9	O K
7200 min Summer	87.109	0.309	1.0	5.2	O K
8640 min Summer	87.074	0.274	0.9	4.1	O K
10080 min Summer	87.045	0.245	0.8	3.3	O K
15 min Winter	87.493	0.693	2.2	25.9	O K
30 min Winter	87.591	0.791	2.6	33.8	Flood Risk
60 min Winter	87.666	0.866	2.8	40.5	Flood Risk
120 min Winter	87.705	0.905	2.9	44.2	Flood Risk
180 min Winter	87.705	0.905	2.9	44.3	Flood Risk
240 min Winter	87.700	0.900	2.9	43.7	Flood Risk
360 min Winter	87.677	0.877	2.8	41.5	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	22
30 min Summer	84.226	0.0	35
60 min Summer	52.662	0.0	64
120 min Summer	31.800	0.0	112
180 min Summer	23.353	0.0	142
240 min Summer	18.644	0.0	174
360 min Summer	13.543	0.0	242
480 min Summer	10.792	0.0	310
600 min Summer	9.043	0.0	380
720 min Summer	7.823	0.0	446
960 min Summer	6.219	0.0	578
1440 min Summer	4.493	0.0	834
2160 min Summer	3.241	0.0	1196
2880 min Summer	2.568	0.0	1560
4320 min Summer	1.847	0.0	2292
5760 min Summer	1.461	0.0	3000
7200 min Summer	1.217	0.0	3680
8640 min Summer	1.048	0.0	4408
10080 min Summer	0.923	0.0	5144
15 min Winter	128.285	0.0	21
30 min Winter	84.226	0.0	35
60 min Winter	52.662	0.0	62
120 min Winter	31.800	0.0	118
180 min Winter	23.353	0.0	148
240 min Winter	18.644	0.0	186
360 min Winter	13.543	0.0	262

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	87.649	0.849	2.8	39.0	Flood Risk
600 min Winter	87.620	0.820	2.7	36.3	Flood Risk
720 min Winter	87.591	0.791	2.6	33.8	Flood Risk
960 min Winter	87.536	0.736	2.4	29.3	Flood Risk
1440 min Winter	87.443	0.643	2.1	22.3	O K
2160 min Winter	87.335	0.535	1.7	15.5	O K
2880 min Winter	87.256	0.456	1.5	11.2	O K
4320 min Winter	87.150	0.350	1.1	6.6	O K
5760 min Winter	87.083	0.283	0.9	4.3	O K
7200 min Winter	87.038	0.238	0.8	3.0	O K
8640 min Winter	87.005	0.205	0.7	2.3	O K
10080 min Winter	86.981	0.181	0.6	1.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	336
600 min Winter	9.043	0.0	408
720 min Winter	7.823	0.0	478
960 min Winter	6.219	0.0	612
1440 min Winter	4.493	0.0	870
2160 min Winter	3.241	0.0	1240
2880 min Winter	2.568	0.0	1592
4320 min Winter	1.847	0.0	2296
5760 min Winter	1.461	0.0	3000
7200 min Winter	1.217	0.0	3680
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.923	0.0	5144

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.111

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.047	4	8	0.064

Model Details

Storage is Online Cover Level (m) 87.800

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.06480	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	105.0
Max Percolation (l/s)	131.3	Slope (1:X)	80.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	86.800	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 149 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	87.403	0.653	2.1	23.0	O K
30 min Summer	87.496	0.746	2.4	30.1	Flood Risk
60 min Summer	87.565	0.815	2.6	35.9	Flood Risk
120 min Summer	87.599	0.849	2.7	38.9	Flood Risk
180 min Summer	87.604	0.854	2.8	39.3	Flood Risk
240 min Summer	87.600	0.850	2.7	39.0	Flood Risk
360 min Summer	87.586	0.836	2.7	37.7	Flood Risk
480 min Summer	87.567	0.817	2.6	36.0	Flood Risk
600 min Summer	87.547	0.797	2.6	34.3	Flood Risk
720 min Summer	87.526	0.776	2.5	32.5	Flood Risk
960 min Summer	87.487	0.737	2.4	29.3	Flood Risk
1440 min Summer	87.417	0.667	2.1	24.1	O K
2160 min Summer	87.335	0.585	1.9	18.5	O K
2880 min Summer	87.271	0.521	1.7	14.7	O K
4320 min Summer	87.177	0.427	1.4	9.8	O K
5760 min Summer	87.112	0.362	1.2	7.1	O K
7200 min Summer	87.063	0.313	1.0	5.3	O K
8640 min Summer	87.027	0.277	0.9	4.2	O K
10080 min Summer	86.999	0.249	0.8	3.3	O K
15 min Winter	87.446	0.696	2.2	26.2	O K
30 min Winter	87.545	0.795	2.6	34.1	Flood Risk
60 min Winter	87.620	0.870	2.8	40.9	Flood Risk
120 min Winter	87.660	0.910	2.9	44.7	Flood Risk
180 min Winter	87.661	0.911	2.9	44.8	Flood Risk
240 min Winter	87.655	0.905	2.9	44.2	Flood Risk
360 min Winter	87.633	0.883	2.8	42.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	22
30 min Summer	84.226	0.0	35
60 min Summer	52.662	0.0	64
120 min Summer	31.800	0.0	112
180 min Summer	23.353	0.0	142
240 min Summer	18.644	0.0	174
360 min Summer	13.543	0.0	242
480 min Summer	10.792	0.0	312
600 min Summer	9.043	0.0	380
720 min Summer	7.823	0.0	446
960 min Summer	6.219	0.0	578
1440 min Summer	4.493	0.0	836
2160 min Summer	3.241	0.0	1196
2880 min Summer	2.568	0.0	1560
4320 min Summer	1.847	0.0	2292
5760 min Summer	1.461	0.0	3000
7200 min Summer	1.217	0.0	3680
8640 min Summer	1.048	0.0	4408
10080 min Summer	0.923	0.0	5144
15 min Winter	128.285	0.0	21
30 min Winter	84.226	0.0	35
60 min Winter	52.662	0.0	62
120 min Winter	31.800	0.0	118
180 min Winter	23.353	0.0	148
240 min Winter	18.644	0.0	186
360 min Winter	13.543	0.0	262

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	87.605	0.855	2.8	39.5	Flood Risk
600 min Winter	87.576	0.826	2.7	36.9	Flood Risk
720 min Winter	87.548	0.798	2.6	34.4	Flood Risk
960 min Winter	87.493	0.743	2.4	29.8	Flood Risk
1440 min Winter	87.399	0.649	2.1	22.7	O K
2160 min Winter	87.291	0.541	1.7	15.8	O K
2880 min Winter	87.211	0.461	1.5	11.5	O K
4320 min Winter	87.104	0.354	1.1	6.8	O K
5760 min Winter	87.037	0.287	0.9	4.4	O K
7200 min Winter	86.991	0.241	0.8	3.1	O K
8640 min Winter	86.958	0.208	0.7	2.3	O K
10080 min Winter	86.934	0.184	0.6	1.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	336
600 min Winter	9.043	0.0	408
720 min Winter	7.823	0.0	478
960 min Winter	6.219	0.0	614
1440 min Winter	4.493	0.0	870
2160 min Winter	3.241	0.0	1240
2880 min Winter	2.568	0.0	1612
4320 min Winter	1.847	0.0	2296
5760 min Winter	1.461	0.0	3000
7200 min Winter	1.217	0.0	3744
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.923	0.0	5136

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.112

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.048	4	8	0.064

Model Details

Storage is Online Cover Level (m) 87.750

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.06444	Width (m)	6.0
Membrane Percolation (mm/hr)	1000	Length (m)	80.0
Max Percolation (l/s)	133.3	Slope (1:X)	60.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	86.750	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 288 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	85.930	0.630	0.4	8.0	O K
30 min Summer	86.024	0.724	0.5	10.6	Flood Risk
60 min Summer	86.100	0.800	0.5	13.0	Flood Risk
120 min Summer	86.153	0.853	0.6	14.7	Flood Risk
180 min Summer	86.167	0.867	0.6	15.2	Flood Risk
240 min Summer	86.168	0.868	0.6	15.3	Flood Risk
360 min Summer	86.166	0.866	0.6	15.2	Flood Risk
480 min Summer	86.159	0.859	0.6	15.0	Flood Risk
600 min Summer	86.150	0.850	0.6	14.6	Flood Risk
720 min Summer	86.140	0.840	0.6	14.3	Flood Risk
960 min Summer	86.116	0.816	0.6	13.5	Flood Risk
1440 min Summer	86.069	0.769	0.5	12.0	Flood Risk
2160 min Summer	86.005	0.705	0.5	10.1	Flood Risk
2880 min Summer	85.950	0.650	0.4	8.6	O K
4320 min Summer	85.863	0.563	0.4	6.4	O K
5760 min Summer	85.796	0.496	0.3	5.0	O K
7200 min Summer	85.744	0.444	0.3	4.0	O K
8640 min Summer	85.701	0.401	0.3	3.3	O K
10080 min Summer	85.666	0.366	0.2	2.7	O K
15 min Winter	85.971	0.671	0.5	9.1	O K
30 min Winter	86.070	0.770	0.5	12.0	Flood Risk
60 min Winter	86.152	0.852	0.6	14.7	Flood Risk
120 min Winter	86.211	0.911	0.6	16.8	Flood Risk
180 min Winter	86.228	0.928	0.6	17.4	Flood Risk
240 min Winter	86.230	0.930	0.6	17.5	Flood Risk
360 min Winter	86.223	0.923	0.6	17.3	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	22
30 min Summer	84.226	0.0	36
60 min Summer	52.662	0.0	66
120 min Summer	31.800	0.0	122
180 min Summer	23.353	0.0	180
240 min Summer	18.644	0.0	210
360 min Summer	13.543	0.0	270
480 min Summer	10.792	0.0	338
600 min Summer	9.043	0.0	406
720 min Summer	7.823	0.0	474
960 min Summer	6.219	0.0	612
1440 min Summer	4.493	0.0	882
2160 min Summer	3.241	0.0	1272
2880 min Summer	2.568	0.0	1644
4320 min Summer	1.847	0.0	2380
5760 min Summer	1.461	0.0	3112
7200 min Summer	1.217	0.0	3816
8640 min Summer	1.048	0.0	4504
10080 min Summer	0.923	0.0	5248
15 min Winter	128.285	0.0	22
30 min Winter	84.226	0.0	36
60 min Winter	52.662	0.0	64
120 min Winter	31.800	0.0	120
180 min Winter	23.353	0.0	176
240 min Winter	18.644	0.0	230
360 min Winter	13.543	0.0	286

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	86.213	0.913	0.6	16.9	Flood Risk
600 min Winter	86.200	0.900	0.6	16.4	Flood Risk
720 min Winter	86.185	0.885	0.6	15.8	Flood Risk
960 min Winter	86.151	0.851	0.6	14.7	Flood Risk
1440 min Winter	86.085	0.785	0.5	12.5	Flood Risk
2160 min Winter	85.997	0.697	0.5	9.8	O K
2880 min Winter	85.924	0.624	0.4	7.9	O K
4320 min Winter	85.812	0.512	0.3	5.3	O K
5760 min Winter	85.732	0.432	0.3	3.8	O K
7200 min Winter	85.672	0.372	0.3	2.8	O K
8640 min Winter	85.626	0.326	0.2	2.2	O K
10080 min Winter	85.590	0.290	0.2	1.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	362
600 min Winter	9.043	0.0	438
720 min Winter	7.823	0.0	512
960 min Winter	6.219	0.0	660
1440 min Winter	4.493	0.0	940
2160 min Winter	3.241	0.0	1340
2880 min Winter	2.568	0.0	1728
4320 min Winter	1.847	0.0	2464
5760 min Winter	1.461	0.0	3168
7200 min Winter	1.217	0.0	3888
8640 min Winter	1.048	0.0	4584
10080 min Winter	0.923	0.0	5248

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.038

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.016	4	8	0.022

Model Details

Storage is Online Cover Level (m) 86.300

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.03600	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	35.0
Max Percolation (l/s)	43.8	Slope (1:X)	30.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	85.300	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 149 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	87.641	0.341	0.6	5.9	Flood Risk
30 min Summer	87.695	0.395	0.7	8.0	Flood Risk
60 min Summer	87.736	0.436	0.7	9.7	Flood Risk
120 min Summer	87.756	0.456	0.8	10.6	Flood Risk
180 min Summer	87.760	0.460	0.8	10.8	Flood Risk
240 min Summer	87.759	0.459	0.8	10.8	Flood Risk
360 min Summer	87.753	0.453	0.8	10.5	Flood Risk
480 min Summer	87.744	0.444	0.8	10.0	Flood Risk
600 min Summer	87.733	0.433	0.7	9.6	Flood Risk
720 min Summer	87.723	0.423	0.7	9.1	Flood Risk
960 min Summer	87.701	0.401	0.7	8.2	Flood Risk
1440 min Summer	87.663	0.363	0.6	6.7	Flood Risk
2160 min Summer	87.617	0.317	0.5	5.1	Flood Risk
2880 min Summer	87.582	0.282	0.5	4.1	Flood Risk
4320 min Summer	87.530	0.230	0.4	2.7	Flood Risk
5760 min Summer	87.494	0.194	0.3	1.9	O K
7200 min Summer	87.468	0.168	0.3	1.4	O K
8640 min Summer	87.448	0.148	0.3	1.1	O K
10080 min Summer	87.432	0.132	0.2	0.9	O K
15 min Winter	87.666	0.366	0.6	6.8	Flood Risk
30 min Winter	87.723	0.423	0.7	9.1	Flood Risk
60 min Winter	87.767	0.467	0.8	11.1	Flood Risk
120 min Winter	87.790	0.490	0.8	12.2	Flood Risk
180 min Winter	87.791	0.491	0.8	12.3	Flood Risk
240 min Winter	87.789	0.489	0.8	12.2	Flood Risk
360 min Winter	87.778	0.478	0.8	11.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	18
30 min Summer	84.226	0.0	33
60 min Summer	52.662	0.0	62
120 min Summer	31.800	0.0	110
180 min Summer	23.353	0.0	140
240 min Summer	18.644	0.0	172
360 min Summer	13.543	0.0	240
480 min Summer	10.792	0.0	308
600 min Summer	9.043	0.0	376
720 min Summer	7.823	0.0	442
960 min Summer	6.219	0.0	576
1440 min Summer	4.493	0.0	826
2160 min Summer	3.241	0.0	1192
2880 min Summer	2.568	0.0	1556
4320 min Summer	1.847	0.0	2288
5760 min Summer	1.461	0.0	3000
7200 min Summer	1.217	0.0	3680
8640 min Summer	1.048	0.0	4408
10080 min Summer	0.923	0.0	5144
15 min Winter	128.285	0.0	18
30 min Winter	84.226	0.0	32
60 min Winter	52.662	0.0	60
120 min Winter	31.800	0.0	116
180 min Winter	23.353	0.0	146
240 min Winter	18.644	0.0	184
360 min Winter	13.543	0.0	260

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	87.764	0.464	0.8	11.0	Flood Risk
600 min Winter	87.749	0.449	0.8	10.3	Flood Risk
720 min Winter	87.733	0.433	0.7	9.6	Flood Risk
960 min Winter	87.704	0.404	0.7	8.3	Flood Risk
1440 min Winter	87.652	0.352	0.6	6.3	Flood Risk
2160 min Winter	87.592	0.292	0.5	4.4	Flood Risk
2880 min Winter	87.548	0.248	0.4	3.1	Flood Risk
4320 min Winter	87.489	0.189	0.3	1.8	O K
5760 min Winter	87.453	0.153	0.3	1.2	O K
7200 min Winter	87.428	0.128	0.2	0.8	O K
8640 min Winter	87.410	0.110	0.2	0.6	O K
10080 min Winter	87.396	0.096	0.2	0.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	334
600 min Winter	9.043	0.0	404
720 min Winter	7.823	0.0	476
960 min Winter	6.219	0.0	608
1440 min Winter	4.493	0.0	866
2160 min Winter	3.241	0.0	1236
2880 min Winter	2.568	0.0	1588
4320 min Winter	1.847	0.0	2292
5760 min Winter	1.461	0.0	3000
7200 min Winter	1.217	0.0	3680
8640 min Winter	1.048	0.0	4408
10080 min Winter	0.923	0.0	5144

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.032

Time (mins) From:	To:	Area (ha)
0	4	0.032

Model Details

Storage is Online Cover Level (m) 87.800

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.03600	Width (m)	17.0
Membrane Percolation (mm/hr)	1000	Length (m)	16.6
Max Percolation (l/s)	78.4	Slope (1:X)	20.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	87.300	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 15 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	84.181	0.131	1.2	1.3	O K
30 min Summer	84.194	0.144	1.3	1.6	O K
60 min Summer	84.197	0.147	1.3	1.7	O K
120 min Summer	84.186	0.136	1.2	1.4	O K
180 min Summer	84.173	0.123	1.1	1.2	O K
240 min Summer	84.161	0.111	1.0	1.0	O K
360 min Summer	84.144	0.094	0.9	0.7	O K
480 min Summer	84.131	0.081	0.7	0.5	O K
600 min Summer	84.122	0.072	0.7	0.4	O K
720 min Summer	84.114	0.064	0.6	0.3	O K
960 min Summer	84.104	0.054	0.5	0.2	O K
1440 min Summer	84.095	0.045	0.4	0.2	O K
2160 min Summer	84.088	0.038	0.3	0.1	O K
2880 min Summer	84.084	0.034	0.2	0.1	O K
4320 min Summer	84.079	0.029	0.2	0.1	O K
5760 min Summer	84.075	0.025	0.1	0.1	O K
7200 min Summer	84.073	0.023	0.1	0.0	O K
8640 min Summer	84.071	0.021	0.1	0.0	O K
10080 min Summer	84.070	0.020	0.1	0.0	O K
15 min Winter	84.192	0.142	1.3	1.6	O K
30 min Winter	84.204	0.154	1.4	1.8	Flood Risk
60 min Winter	84.202	0.152	1.4	1.8	Flood Risk
120 min Winter	84.184	0.134	1.2	1.4	O K
180 min Winter	84.166	0.116	1.1	1.1	O K
240 min Winter	84.152	0.102	0.9	0.8	O K
360 min Winter	84.131	0.081	0.7	0.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	19
30 min Summer	84.226	0.0	27
60 min Summer	52.662	0.0	44
120 min Summer	31.800	0.0	76
180 min Summer	23.353	0.0	108
240 min Summer	18.644	0.0	138
360 min Summer	13.543	0.0	198
480 min Summer	10.792	0.0	258
600 min Summer	9.043	0.0	318
720 min Summer	7.823	0.0	376
960 min Summer	6.219	0.0	494
1440 min Summer	4.493	0.0	734
2160 min Summer	3.241	0.0	1104
2880 min Summer	2.568	0.0	1448
4320 min Summer	1.847	0.0	2160
5760 min Summer	1.461	0.0	2888
7200 min Summer	1.217	0.0	3616
8640 min Summer	1.048	0.0	4344
10080 min Summer	0.923	0.0	5048
15 min Winter	128.285	0.0	19
30 min Winter	84.226	0.0	28
60 min Winter	52.662	0.0	46
120 min Winter	31.800	0.0	80
180 min Winter	23.353	0.0	112
240 min Winter	18.644	0.0	142
360 min Winter	13.543	0.0	202

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	84.117	0.067	0.6	0.3	O K
600 min Winter	84.107	0.057	0.5	0.3	O K
720 min Winter	84.100	0.050	0.5	0.2	O K
960 min Winter	84.095	0.045	0.4	0.2	O K
1440 min Winter	84.088	0.038	0.3	0.1	O K
2160 min Winter	84.082	0.032	0.2	0.1	O K
2880 min Winter	84.079	0.029	0.2	0.1	O K
4320 min Winter	84.074	0.024	0.1	0.0	O K
5760 min Winter	84.072	0.022	0.1	0.0	O K
7200 min Winter	84.070	0.020	0.1	0.0	O K
8640 min Winter	84.068	0.018	0.1	0.0	O K
10080 min Winter	84.067	0.017	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	260
600 min Winter	9.043	0.0	318
720 min Winter	7.823	0.0	370
960 min Winter	6.219	0.0	488
1440 min Winter	4.493	0.0	738
2160 min Winter	3.241	0.0	1072
2880 min Winter	2.568	0.0	1444
4320 min Winter	1.847	0.0	2156
5760 min Winter	1.461	0.0	2920
7200 min Winter	1.217	0.0	3656
8640 min Winter	1.048	0.0	4344
10080 min Winter	0.923	0.0	4968

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.010

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.000	4	8	0.010

Model Details

Storage is Online Cover Level (m) 84.500

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.12564	Width (m)	8.7
Membrane Percolation (mm/hr)	1000	Length (m)	11.5
Max Percolation (l/s)	27.8	Slope (1:X)	60.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	84.050	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 62 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	84.172	0.422	3.0	11.9	O K
30 min Summer	84.231	0.481	3.0	14.9	Flood Risk
60 min Summer	84.262	0.512	3.0	16.5	Flood Risk
120 min Summer	84.261	0.511	3.0	16.5	Flood Risk
180 min Summer	84.241	0.491	3.0	15.5	Flood Risk
240 min Summer	84.217	0.467	3.0	14.2	Flood Risk
360 min Summer	84.171	0.421	3.0	11.8	O K
480 min Summer	84.134	0.384	3.0	10.0	O K
600 min Summer	84.108	0.358	2.8	8.6	O K
720 min Summer	84.085	0.335	2.6	7.6	O K
960 min Summer	84.048	0.298	2.3	6.0	O K
1440 min Summer	83.993	0.243	1.9	4.0	O K
2160 min Summer	83.941	0.191	1.5	2.5	O K
2880 min Summer	83.908	0.158	1.2	1.7	O K
4320 min Summer	83.867	0.117	0.9	0.9	O K
5760 min Summer	83.843	0.093	0.7	0.6	O K
7200 min Summer	83.828	0.078	0.6	0.4	O K
8640 min Summer	83.817	0.067	0.5	0.3	O K
10080 min Summer	83.809	0.059	0.5	0.2	O K
15 min Winter	84.206	0.456	3.0	13.6	Flood Risk
30 min Winter	84.274	0.524	3.0	17.1	Flood Risk
60 min Winter	84.312	0.562	3.0	19.1	Flood Risk
120 min Winter	84.306	0.556	3.0	18.8	Flood Risk
180 min Winter	84.274	0.524	3.0	17.2	Flood Risk
240 min Winter	84.237	0.487	3.0	15.2	Flood Risk
360 min Winter	84.168	0.418	3.0	11.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	20
30 min Summer	84.226	0.0	33
60 min Summer	52.662	0.0	54
120 min Summer	31.800	0.0	86
180 min Summer	23.353	0.0	120
240 min Summer	18.644	0.0	154
360 min Summer	13.543	0.0	218
480 min Summer	10.792	0.0	278
600 min Summer	9.043	0.0	340
720 min Summer	7.823	0.0	400
960 min Summer	6.219	0.0	522
1440 min Summer	4.493	0.0	756
2160 min Summer	3.241	0.0	1112
2880 min Summer	2.568	0.0	1472
4320 min Summer	1.847	0.0	2204
5760 min Summer	1.461	0.0	2936
7200 min Summer	1.217	0.0	3608
8640 min Summer	1.048	0.0	4400
10080 min Summer	0.923	0.0	5136
15 min Winter	128.285	0.0	20
30 min Winter	84.226	0.0	33
60 min Winter	52.662	0.0	58
120 min Winter	31.800	0.0	94
180 min Winter	23.353	0.0	132
240 min Winter	18.644	0.0	166
360 min Winter	13.543	0.0	232

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	84.120	0.370	2.9	9.2	O K
600 min Winter	84.085	0.335	2.6	7.6	O K
720 min Winter	84.056	0.306	2.4	6.3	O K
960 min Winter	84.011	0.261	2.0	4.6	O K
1440 min Winter	83.950	0.200	1.6	2.7	O K
2160 min Winter	83.898	0.148	1.2	1.5	O K
2880 min Winter	83.868	0.118	0.9	0.9	O K
4320 min Winter	83.835	0.085	0.7	0.5	O K
5760 min Winter	83.817	0.067	0.5	0.3	O K
7200 min Winter	83.806	0.056	0.4	0.2	O K
8640 min Winter	83.799	0.049	0.4	0.2	O K
10080 min Winter	83.796	0.046	0.3	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	290
600 min Winter	9.043	0.0	352
720 min Winter	7.823	0.0	414
960 min Winter	6.219	0.0	532
1440 min Winter	4.493	0.0	768
2160 min Winter	3.241	0.0	1124
2880 min Winter	2.568	0.0	1472
4320 min Winter	1.847	0.0	2204
5760 min Winter	1.461	0.0	2936
7200 min Winter	1.217	0.0	3576
8640 min Winter	1.048	0.0	4376
10080 min Winter	0.923	0.0	4968

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.062

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.026	4	8	0.036

Model Details

Storage is Online Cover Level (m) 84.500

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.12564	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	38.0
Max Percolation (l/s)	47.5	Slope (1:X)	100.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	83.750	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 84 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	86.038	0.138	0.2	1.0	O K
30 min Summer	86.058	0.158	0.2	1.4	O K
60 min Summer	86.071	0.171	0.2	1.6	O K
120 min Summer	86.076	0.176	0.2	1.7	O K
180 min Summer	86.076	0.176	0.2	1.7	O K
240 min Summer	86.073	0.173	0.2	1.6	O K
360 min Summer	86.066	0.166	0.2	1.5	O K
480 min Summer	86.058	0.158	0.2	1.3	O K
600 min Summer	86.051	0.151	0.2	1.2	O K
720 min Summer	86.044	0.144	0.2	1.1	O K
960 min Summer	86.031	0.131	0.2	0.9	O K
1440 min Summer	86.012	0.112	0.2	0.7	O K
2160 min Summer	85.992	0.092	0.1	0.5	O K
2880 min Summer	85.978	0.078	0.1	0.3	O K
4320 min Summer	85.960	0.060	0.1	0.2	O K
5760 min Summer	85.950	0.050	0.1	0.1	O K
7200 min Summer	85.945	0.045	0.1	0.1	O K
8640 min Summer	85.942	0.042	0.0	0.1	O K
10080 min Summer	85.939	0.039	0.0	0.1	O K
15 min Winter	86.048	0.148	0.2	1.2	O K
30 min Winter	86.070	0.170	0.2	1.6	O K
60 min Winter	86.085	0.185	0.2	1.8	O K
120 min Winter	86.089	0.189	0.2	1.9	O K
180 min Winter	86.087	0.187	0.2	1.9	O K
240 min Winter	86.082	0.182	0.2	1.8	O K
360 min Winter	86.070	0.170	0.2	1.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	18
30 min Summer	84.226	0.0	32
60 min Summer	52.662	0.0	56
120 min Summer	31.800	0.0	88
180 min Summer	23.353	0.0	122
240 min Summer	18.644	0.0	156
360 min Summer	13.543	0.0	222
480 min Summer	10.792	0.0	288
600 min Summer	9.043	0.0	352
720 min Summer	7.823	0.0	416
960 min Summer	6.219	0.0	540
1440 min Summer	4.493	0.0	780
2160 min Summer	3.241	0.0	1144
2880 min Summer	2.568	0.0	1500
4320 min Summer	1.847	0.0	2204
5760 min Summer	1.461	0.0	2904
7200 min Summer	1.217	0.0	3632
8640 min Summer	1.048	0.0	4400
10080 min Summer	0.923	0.0	5088
15 min Winter	128.285	0.0	17
30 min Winter	84.226	0.0	31
60 min Winter	52.662	0.0	58
120 min Winter	31.800	0.0	94
180 min Winter	23.353	0.0	132
240 min Winter	18.644	0.0	170
360 min Winter	13.543	0.0	238

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	86.059	0.159	0.2	1.4	O K
600 min Winter	86.049	0.149	0.2	1.2	O K
720 min Winter	86.039	0.139	0.2	1.0	O K
960 min Winter	86.023	0.123	0.2	0.8	O K
1440 min Winter	85.999	0.099	0.1	0.5	O K
2160 min Winter	85.976	0.076	0.1	0.3	O K
2880 min Winter	85.962	0.062	0.1	0.2	O K
4320 min Winter	85.947	0.047	0.1	0.1	O K
5760 min Winter	85.942	0.042	0.1	0.1	O K
7200 min Winter	85.938	0.038	0.0	0.1	O K
8640 min Winter	85.935	0.035	0.0	0.1	O K
10080 min Winter	85.933	0.033	0.0	0.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	306
600 min Winter	9.043	0.0	372
720 min Winter	7.823	0.0	434
960 min Winter	6.219	0.0	560
1440 min Winter	4.493	0.0	796
2160 min Winter	3.241	0.0	1148
2880 min Winter	2.568	0.0	1500
4320 min Winter	1.847	0.0	2204
5760 min Winter	1.461	0.0	2936
7200 min Winter	1.217	0.0	3552
8640 min Winter	1.048	0.0	4400
10080 min Winter	0.923	0.0	5080

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.006

Time (mins) From:	To:	Area (ha)
0	4	0.006

Model Details

Storage is Online Cover Level (m) 86.400

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.02808	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	14.0
Max Percolation (l/s)	17.5	Slope (1:X)	80.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	85.900	Cap Volume Depth (m)	0.000

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 376 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	85.734	0.634	0.8	19.0	O K
30 min Summer	85.832	0.732	0.9	25.3	Flood Risk
60 min Summer	85.914	0.814	1.0	31.3	Flood Risk
120 min Summer	85.976	0.876	1.1	36.3	Flood Risk
180 min Summer	85.998	0.898	1.1	38.1	Flood Risk
240 min Summer	86.004	0.904	1.1	38.6	Flood Risk
360 min Summer	86.004	0.904	1.1	38.6	Flood Risk
480 min Summer	86.002	0.902	1.1	38.4	Flood Risk
600 min Summer	85.997	0.897	1.1	38.0	Flood Risk
720 min Summer	85.990	0.890	1.1	37.5	Flood Risk
960 min Summer	85.974	0.874	1.1	36.1	Flood Risk
1440 min Summer	85.937	0.837	1.0	33.1	Flood Risk
2160 min Summer	85.881	0.781	1.0	28.9	Flood Risk
2880 min Summer	85.831	0.731	0.9	25.3	Flood Risk
4320 min Summer	85.749	0.649	0.8	19.9	O K
5760 min Summer	85.683	0.583	0.7	16.0	O K
7200 min Summer	85.629	0.529	0.6	13.2	O K
8640 min Summer	85.584	0.484	0.6	11.0	O K
10080 min Summer	85.545	0.445	0.5	9.4	O K
15 min Winter	85.776	0.676	0.8	21.6	O K
30 min Winter	85.879	0.779	1.0	28.7	Flood Risk
60 min Winter	85.967	0.867	1.1	35.5	Flood Risk
120 min Winter	86.035	0.935	1.1	41.3	Flood Risk
180 min Winter	86.060	0.960	1.2	43.5	Flood Risk
240 min Winter	86.068	0.968	1.2	44.3	Flood Risk
360 min Winter	86.067	0.967	1.2	44.2	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.285	0.0	22
30 min Summer	84.226	0.0	37
60 min Summer	52.662	0.0	66
120 min Summer	31.800	0.0	124
180 min Summer	23.353	0.0	182
240 min Summer	18.644	0.0	240
360 min Summer	13.543	0.0	298
480 min Summer	10.792	0.0	360
600 min Summer	9.043	0.0	426
720 min Summer	7.823	0.0	494
960 min Summer	6.219	0.0	630
1440 min Summer	4.493	0.0	906
2160 min Summer	3.241	0.0	1300
2880 min Summer	2.568	0.0	1696
4320 min Summer	1.847	0.0	2428
5760 min Summer	1.461	0.0	3168
7200 min Summer	1.217	0.0	3888
8640 min Summer	1.048	0.0	4584
10080 min Summer	0.923	0.0	5344
15 min Winter	128.285	0.0	22
30 min Winter	84.226	0.0	36
60 min Winter	52.662	0.0	64
120 min Winter	31.800	0.0	122
180 min Winter	23.353	0.0	178
240 min Winter	18.644	0.0	234
360 min Winter	13.543	0.0	336

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
480 min Winter	86.062	0.962	1.2	43.7	Flood Risk
600 min Winter	86.055	0.955	1.2	43.1	Flood Risk
720 min Winter	86.045	0.945	1.2	42.2	Flood Risk
960 min Winter	86.021	0.921	1.1	40.1	Flood Risk
1440 min Winter	85.968	0.868	1.1	35.6	Flood Risk
2160 min Winter	85.891	0.791	1.0	29.6	Flood Risk
2880 min Winter	85.824	0.724	0.9	24.7	Flood Risk
4320 min Winter	85.713	0.613	0.8	17.8	O K
5760 min Winter	85.629	0.529	0.7	13.2	O K
7200 min Winter	85.564	0.464	0.6	10.2	O K
8640 min Winter	85.511	0.411	0.5	8.0	O K
10080 min Winter	85.469	0.369	0.5	6.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
480 min Winter	10.792	0.0	378
600 min Winter	9.043	0.0	456
720 min Winter	7.823	0.0	532
960 min Winter	6.219	0.0	684
1440 min Winter	4.493	0.0	970
2160 min Winter	3.241	0.0	1388
2880 min Winter	2.568	0.0	1788
4320 min Winter	1.847	0.0	2548
5760 min Winter	1.461	0.0	3280
7200 min Winter	1.217	0.0	3968
8640 min Winter	1.048	0.0	4672
10080 min Winter	0.923	0.0	5352

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.091

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.046	4	8	0.045

Model Details

Storage is Online Cover Level (m) 86.100

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.02808	Width (m)	4.5
Membrane Percolation (mm/hr)	1000	Length (m)	102.0
Max Percolation (l/s)	127.5	Slope (1:X)	70.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	85.100	Cap Volume Depth (m)	0.000

Infrastruct CS Ltd

APPENDIX B – SUDS OWNERS MANUAL

SUDS MAINTENANCE GUIDE

A GUIDE TO THE MAINTENENCE OF SUSTAINABLE URBAN DRAINAGE SYSYEMS (SUDS)

OWNERS MANUAL

Infrastruct CS Ltd
The Stables
High Cogges Farm
High Cogges
Oxon,
OX29 6UN

ICS Ref: 1859.07.002

FOREWORD

This guidance provides best practice guidance on the maintenance of Sustainable Drainage Systems (SUDS) to facilitate their effective implementation within developments.

The guidance supersedes previous general guidance on SUDS and addresses landscaping, biodiversity issues, public perception and community integration as well as water quality treatment and sustainable flood risk management.

REFERENCES

Ciria 753

Contents Page No.

SCHEME NAME: PHASE 2, BICESTER ECO VILLAGE, BICESTER

SUDS TECHNIQUES USED ON THIS SCHEME:

PERVIOUS PAVEMENTS
GEOCELLULAR/MODULAR SYSTEMS

REFER TO MAINTENANCE CHART ON PAGE 5

INTRODUCTION

Unlike conventional drainage systems, SUDS features should be visible and their function should be easily understood by those responsible for maintenance. When problems occur, they are generally obvious and can be remedied simply, using standard landscaping practice. If systems are properly monitored and maintained, any deterioration in performance can often be managed out.

Like any drainage system maintenance is a necessary and important consideration of SUDS design and sufficient thought should be given to long-term maintenance and its funding during feasibility and planning stages. In particular, the following requirements should be given full consideration:

1 Maintenance access – ensuring appropriate and long-term access to all points in the system where future maintenance may be required.

2 Forebays and/or appropriate pre-treatment structures to facilitate the sediment management process.

3 Bypass systems or appropriate temporary drainage infrastructure for use if required during sediment management or other maintenance activities.

4 The availability of disposal areas for organic arisings (green waste) and sediments.

Appropriate legal agreements between SUDS stakeholders that define maintenance responsibilities are presented in the SUDS Interim Code of Practice (NSWG, 2004) and *Model agreements for SUDS* (CIRIA, 2004). This chapter discusses the principles of good practice operation and maintenance activities and the types of documents that can be developed to define the requirements at a particular site. Specific maintenance requirements for each SUDS component are listed in detail towards the end of each of the component chapters.

1.1 OWNER'S MANUAL

SUDS are different from conventional drainage and require different maintenance regimes. Owners of developments with SUDS should be provided with an owner's manual.
This should include the following:

- location of all SUDS techniques in a site
- brief summary of how the techniques work, their purpose and how they can be damaged
- maintenance requirements (a maintenance plan) and a maintenance record
- explanation of the consequences of not carrying out the maintenance that is specified
- identification of areas where certain activities are prohibited (for example stockpiling materials on pervious surfaces)
- an action plan for dealing with accidental spillages
- advice on what to do if alterations are to be made to a development, if service companies undertake excavations or other similar works carried out that could affect the SUDS.

The owner's manual should also include brief details of the design concepts and criteria for the SUDS scheme and how the owner or operator must ensure that any works undertaken on a development do not compromise this. For example, householders should be made aware that surface water drainage is connected to soakaways.

1.2 LEVEL OF OPERATION AND MAINTENANCE

There are many factors which will influence the type and intensity of maintenance required for SUDS at any particular site, including:

- type of SUDS scheme
- land-use associated with contributing catchment
- level of construction ongoing within the contributing catchment
- planting types
- habitat types that have been created
- amenity requirements of the area.

The demands on the SUDS scheme to perform a particular aesthetic function will be a key driver, with high frequencies of grass cutting and vegetation management often being required for appearance and amenity value rather than for functional reasons.
It is recommended that SUDS are not handed over to maintenance authorities until upstream construction has ceased, the contributing catchment has stabilised, and any rehabilitation of downstream components has been undertaken by the developer/contractor. However, if

maintenance agreements have to be put in place before this, and the level of construction activity in the contributing catchment is high, maintenance specifications should be prepared that take account of high sediment accumulation rates and the increased risks of potential spillages.

1.3 OPERATION AND MAINTENANCE ACTIVITY CATEGORIES

There are likely to be three categories of maintenance activities:

1. **Regular maintenance** (including inspections and monitoring).
2. **Occasional maintenance.**
3. **Remedial maintenance.**

Regular maintenance consists of basic tasks done on a frequent and predictable schedule, including vegetation management, litter and debris removal, and inspections.

Occasional maintenance comprises tasks that are likely to be required periodically, but on a much less frequent and predictable basis than the routine tasks (sediment removal is an example). Table 1.1 summarises the likely maintenance activities required for each SUDS component and guidance on specific maintenance activities is given in the following sections.

Remedial maintenance comprises intermittent tasks that may be required to rectify faults associated with the system, although the likelihood of faults can be minimised by good design. Where remedial work is found to be necessary, it is likely to be due to site-specific characteristics or unforeseen events, and as such timings are difficult to predict. Remedial maintenance items can comprise items such as:

- inlet/outlet repairs
- erosion repairs
- reinstatement or realignment of edgings, barriers, rip-rap or other erosion control
- infiltration surface rehabilitation
- replacement of blocked filter fabrics
- construction stage sediment removal (although this activity should have been undertaken before the maintenance contract)
- system rehabilitation immediately following a pollution event.

Table 1.1 *Typical key SUDS components operation and maintenance activities*
For full specifications, see individual chapters.

O&M activity	SUDS component												
	Pond	Wetland	Detention basin	Infiltration basin	Soakaway	Infiltration trench	Filter trench	Modular storage	Pervious pavement	Swale/bioretention/green roofs	Filter strip	Sand filter	Pre-treatment systems
Regular maintenance													
Inspection	■	■	■	■	■	■	■	■	■	■	■	■	■
Litter/debris removal	■	■	■	■	□	■	■	□	■	■	■	■	■
Grass cutting	■	■	■	■	□	■	■	□	□	■	■	□	□
Weed/invasive plant control	□	□	□	□		□	□		□	□	□	□	□
Shrub management	□	□	□	□					□	□	□		□
Shoreline vegetation management	■	■	□										□
Aquatic vegetation management	■	■	□										□
Occasional maintenance													
Sediment management (*)	■	■	■	■	■	■	■	■	■	■	■	■	■
Vegetation/plant replacement	□	□	□	□						□	□		□
Vacuum sweeping and brushing									■				
Remedial maintenance													
Structure rehabilitation/repair	□	□	□	□	□	□	□	□	□	□	□	□	□
Infiltration surface reconditioning				□	□	□	□		□	□	□	□	

■ Will be required
□ May be required

* Sediment should be collected and managed in pre-treatment systems, upstream of the main device.

The maintenance regime of a site also needs to consider the response to extreme pollution events. A response action plan should be developed and communicated to all those involved in the operation of a site, so that if a spillage occurs it can be prevented from causing pollution to receiving waters.

1.4 HEALTH AND SAFETY

To comply with the Construction (Design and Management) Regulations (DETR, 1994) (see Chapter 32 of CIRIA C753), designers must assess all foreseeable risks during construction and maintenance and the design must minimise them by the following (in order of preference):

1. **Avoid.**
2. **Reduce.**
3. **Identify and mitigate residual risks.**

Designers must also make contractors and others aware of risks in the Health and Safety file, which is a record of the key health and safety risks that will need to be managed during future maintenance work. For example, the file for a SUDS pond should contain information on the collection of hazardous compounds in the sediment so that maintenance contractors are aware of them and can take appropriate precautions. During construction the residual risks must be identified and an action plan developed to deal with them safely (the Health and Safety Plan).
All those responsible for maintenance should take appropriate health and safety precautions for all activities (including lone working, if relevant) and risk assessments should always be undertaken. Guidance on generic health and safety principles is given in see Chapter 32 of CIRIA C753 and component-specific issues are addressed in individual chapters.

1.5 REGULAR MAINTENANCE ACTIVITIES
1.5.1 Inspections and reporting
Regular SUDS scheme inspections will:

- help determine optimum future maintenance activities
- confirm hydraulic, water quality, amenity and ecological performance
- allow identification of potential system failures, eg blockage, poor infiltration, poor water quality etc.

Inspections can generally be required at monthly site visits (eg for grass cutting) for little additional cost, and should, therefore, be subsumed into regular maintenance requirements. During the first year of operation, inspections should ideally be carried out after every significant storm event to ensure proper functioning, but in practice this may be difficult or impractical to arrange.
Typical routine inspection questions that will indicate when occasional or remedial maintenance activities are required, and/or when water quality requires investigation include:

- are inlets or outlets blocked?
- does any part of the system appear to be leaking (especially ponds and wetlands)?
- is the vegetation healthy?
- is there evidence of poor water quality (eg algae, oils, milky froth, odour, unusual colourings)?
- is there evidence of sediment build-up?
- is there evidence of ponding above an infiltration surface?
- is there any evidence of structural damage that requires repair?
- are there areas of erosion or channelling over vegetated surfaces?

Inspections of the construction of a SUDS scheme by the design consultant pre-handover is vital to ensure that the system has been constructed correctly and that design assumptions and criteria are not invalidated, for example, by construction methods, by changes made on site or by variations in ground conditions. Inspections should be undertaken through the construction as necessary but as a minimum would generally be expected to include the following:

1. Pre-excavation inspection to ensure that construction runoff is being adequately dealt with on site and will not cause clogging of the SUDS scheme.
2. Inspections of excavations for ponds, infiltration devices, swales, etc.
3. Inspections during laying of any pipework.
4. Inspections and testing during the placing of earthworks materials or filter materials.
5. Inspection of prepared SUDS technique before planting begins.
6. Inspection of completed planting.
7. Final inspection before handover to client.

When construction is completed the consultant should provide a validation report that discusses the inspections, the reasons for any variations made to the design, any identified non-compliances and how they were rectified. During the first year of operation there may be a need for monitoring to

identify any modifications required to optimise performance. The scope of the monitoring will be site-specific and depends on the sensitivity of the design and the consequences of the SUDS not performing as expected.

For large sites, it is recommended that an annual maintenance report and record should be prepared by the maintenance contractor which should be retained with the owner's manual (see Section 22.2). The report should provide the following information:

- Observations resulting from inspections
- measured sediment depths (where appropriate)
- monitoring results, if flow or water quality monitoring was undertaken
- maintenance and operation activities undertaken during the year
- recommendations for inspection and maintenance programme for the following year.

1.5.2 Litter/debris removal
This is an integral part of SUDS maintenance and reduces the risks of inlet and outlet blockages, retains amenity value and minimises pollution risks. High litter removal frequencies may be required at high profile commercial/retail parks where aesthetics are a major driver.

1.5.3 Grass cutting
It is recommended that grass cutting be minimised around SUDS facilities, apart from swales and filter strips and structural embankments where a height of 100–150 mm is recommended to prevent the plants falling over, or "lodging", when water flows across the surface. In general, allowing grass to grow tends to enhance water quality performance. Short grass around a wet system such as pond or wetland provides an ideal habitat for nuisance species such as geese; allowing the grass to grow is an effective means of discouraging them. Grass around wet pond or wetland systems should not be cut to the edge of the permanent water.

Grass cutting is an activity undertaken primarily to enhance the perceived aesthetics of the facility. The frequency of cutting will tend to depend on surrounding land uses, and public requirements. Therefore, grass cutting should be done as infrequently as possible, recognising the aesthetic concerns of local residents. However, grass around inlet and outlet infrastructure should be strimmed closely to reduce risks to system performance. If a manicured, parkland effect is required, then cutting will need to be undertaken more regularly than for meadow type grass areas, which aim to maximise habitat and biodiversity potential.

1.5.4 Weed/invasive plant control
Weeds are generally defined as vegetation types that are unwanted in a particular area.
For SUDS, weeds are often alien or invasive species, which do not enhance the technical performance or aesthetic value of the system, or non-native species and the spread of which is undesirable.

In some places, weeding has to be done by hand to prevent the destruction of surrounding vegetation (hand weeding should generally be required only during the first year, ie during plant establishment). However, over grassed surfaces, mowing can be an effective management measure. The use of herbicides and pesticides should be prohibited since they cause water quality deterioration. The use of fertilisers should also be limited or prohibited to minimise nutrient loadings which are damaging to water bodies.

1.5.5 Shrub management
Shrubs tend to be densely planted and are likely to require weeding at the base, especially during the first year to ensure that they get enough water. Shrubs should be selected so they can grow to their maximum natural height without pruning.

1.5.6 Aquatic/shoreline vegetation management
Aquatic plant aftercare in the first 1–3 years may be required to ensure establishment of planted vegetation and control nuisance weeds/invasive plants. Once established, the build-up of dead vegetation from previous seasons should be removed at convenient intervals to reduce organic silt accumulation (eg every three years and at the end of landscape contract periods).

Emergent vegetation may need to be harvested every 5–10 years to maintain flood attenuation volumes, optimise water quality treatment potential and ensure fresh growth, although this is often not required. Care should be taken to avoid nesting birds during the breeding season and to avoid great crested newt and water vole habitats.

The typical window for this activity is towards the end of the growing season (September and October). As vegetation matures, plant height may also become a safety issue in residential areas. Where emergent vegetation is managed, up to 25 per cent can be removed by cutting at 100 mm above soil level using shearing action machinery. Up to 25 per cent of submerged vegetation can be cut and raked out at any one time, using approved rakes, grabs or other techniques, depending on whether clay or waterproof membranes are present. Aquatic vegetation arisings should be stacked close to the water's edge for 48 hours to de-water and allow wildlife to return to the SUDS feature. They should then be removed to wildlife piles, compost heaps or off site before decomposition, rotting or damage to existing vegetation can occur.

Algae removal may be undertaken for aesthetic purposes during the first 3–5 years of a pond/wetland's life. The growth of algae, which is considered by some to be visually intrusive, is encouraged by nutrients introduced into the water body. This situation should settle down once upstream construction activities are complete.

1.5.7 Management of green waste
Appropriate methods should be implemented to dispose of green waste, including:

1 The development of wildlife piles
These provide refuges, hibernation shelter, food and egg laying sites for a large number of animals. When rotted down at the end of 3–5 years they provide compost that can be used as fertiliser for planting areas outside of the SUDS system.

In general:

- wildlife piles should be located in sunny or semi-shaded areas away from direct access by people
- their bases should be constructed using substantial prunings or other branch material laid in a criss-cross pattern
- seasonal shrub and other woody prunings should be added through the winter
- non-woody and grass cuttings should be added through the summer
- wildlife piles should comprise tidy piles up to 1.2 m high
- new wildlife piles should be constructed each year and old wildlife piles should be used as compost to plant beds after 3–5 years
- wildlife piles should be located above normal flood level of watercourses and be protected by hedges or similar features.

A schematic of a typical wildlife pile structure is shown in Figure 1.1.

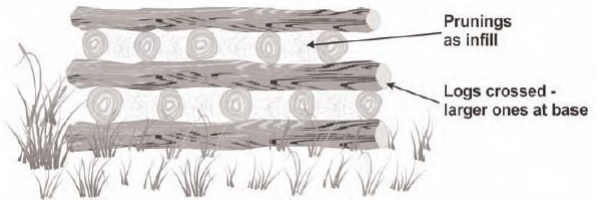

Figure 1.1 *Schematic of a wildlife pile (courtesy of Steve Wilson and Robert Bray of Sustainable Drainage Associates)*

2 On- or off-site composting
A compost facility allows all green waste, particularly grass cuttings and prunings to be recycled and provide compost for mulching ornamental plant beds. The following process should be followed for composting:

- shred all arisings from site
- combine all arisings in active compost bin with grass cuttings not exceeding 70%
- turn and mix active compost when bin is >50% full, at weekly intervals for at least four weeks
- turn and mix full bin every 28 days until used
- combine adjacent compost bins/bays when contents are settled to 50% volume reduction
- Use compost after 3–4 months.

A schematic/photo of a typical composting structure is given in Figure 1.2.

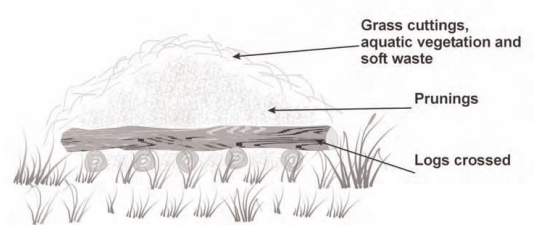

Figure 1.2 *Schematic of a composting structure (courtesy Steve Wilson and Robert Bray of Sustainable Drainage Associates)*

3 Disposal to landfill
As a last resort, green waste can be disposed of to some approved tips or landfill sites, although it is only accepted at certain locations.

1.5.8 Vacuum sweeping and brushing
Pervious surfaces need to be regularly cleaned of silt and other sediments to preserve their infiltration capacity. Advice issued with permeable pre-cast concrete paving suggests a minimum of three sweepings per year. Chapter 12 should be referred to for details of this process.

1.6 IRREGULAR MAINTENANCE ACTIVITIES
1.6.1 Sediment removal
To ensure long-term effectiveness, the sediment that accumulates in SUDS should be removed periodically. The required frequency of sediment removal is dependent on many factors including:

- design of upstream drainage system
- type of system
- design storage volume
- characteristics of upstream catchment area (eg land use, level of imperviousness, upstream construction activities, erosion control management and effectiveness of upstream pre-treatment).

Sediment accumulation will typically be rapid for the entire construction period (including time required for the building, turfing and landscaping of all upstream development plots). Once a catchment is completely developed and all vegetation is well-established, sediment mobility and accumulation is likely to drop significantly.

Detailed information on waste management (in particular sediment removal) is provided in see Chapter 32 of CIRIA C753.

1.6.2 Vegetation/plant replacement
Some replacement of plants may be required in the first 12 months after installation, especially after storm events. Dead or damaged plants should be removed and replaced to restore the prescribed number of living plants per hectare.

Inspection programmes should identify areas of filtration, or infiltration surfaces where vegetation growth is poor and likely to cause a reduced level of system performance.
Such areas can then be rehabilitated and plant growth repaired.

1.7 REMEDIAL MAINTENANCE
1.7.1 Structure rehabilitation/repair
There will come a time with most SUDS techniques when a major overhaul of the system is required to remove clogged filters, geotextiles, gravel etc. This will typically be between 10 and 25 years, depending on the technique and factors such as the type of catchment and sediment load. The SUDS design should allow for vehicle access to undertake this work and consider the need for the overhaul without causing major disruption. For example the use of geotextiles close to the surface in pervious surfaces traps the majority of sediment in a relatively easily accessible location. Reconstruction of the surface layer and bedding layer is all that is required, rather than reconstruction of the whole pavement depth.

Major overhaul is most likely to be required on techniques that rely on filtration through soils or aggregates, such as sand filters and infiltration devices. Other SUDS techniques are unlikely to need major overhaul if routine maintenance is undertaken as required (for example ponds and wetlands). Rehabilitation activities for each SUDS component are described in the individual component chapters. The requirements should be identified in the owner's manual.

1.7.2 Infiltration surface rehabilitation

In the event that grassed surface permeability has reduced, there are a number of landscape techniques that can be used to open the surface to encourage infiltration.
Such activities are not commonplace and are likely to be required only in circumstances where silt has not been effectively managed upstream.

1. Scarifying to remove "thatch". Thatch is a tightly intermingled organic layer of dead and living shoots, stems and roots, developing between the zone of green vegetation and the soil surface. Scarifying with tractor-drawn or self-propelled equipment to a depth of at least 50 mm breaks up silt deposits, removes dead grass and other organic matter and relieves compaction of the soil surface.
2. Spiking or tining the soil, using aerating equipment to encourage water percolation. This is particularly effective if followed by top dressing with a medium to fine sand, and is best undertaken when the soil is moist. Spiking or tining with tractor drawn or self-propelled equipment penetrates and perforates soil layers to a depth of at least 100 mm (at 100 mm centres) and allows the entry of air, water, nutrients and top dressing materials.
3. As a last resort, it may be necessary to remove and replace the grass and topsoil by:
    - removing accumulated silt and (subject to a toxicity test) applying to land or dispose of to landfill
    - removing damaged turf which should be composted
    - cultivating remaining topsoil to required levels
    - re-turfing (using turf of a quality and appearance to match existing) or reseeding (to BS 7370: Part 3, Clause 12.6 (BSI, 1991) using seed to match existing turf) area to required levels. It may be necessary to supply and fix fully biodegradable coir blanket to protect seeded soil. Turf and seeded areas should be top dressed with fine sieved topsoil to BS 3882 (BSI, 1994) to achieve final design levels. Watering will be required to promote successful germination and/or establishment.

1.8 APPLICATIONS OF THE PRINCIPLES OF LANDSCAPE MAINTENANCE

In contrast to conventional drainage, which comprises mainly sub-surface pipework and associated infrastructure, SUDS are predominantly surface systems. A key feature of SUDS is their integration within the local landscape and their amenity contribution, and it is appropriate therefore that landscape maintenance practice is applied to their management.

1.8.1 Landscape maintenance documentation

Typical landscape maintenance documentation and its potential relevance to SUDS systems is summarised below:

(A) Management plan – describing the management objectives for a site over time, and the management strategies that should be employed to realise these objectives and reconcile any potential conflicts that may arise.

Management plans are most appropriate for application in major parks and open spaces, wherever there are alternative choices for future action, and potential conflicts of purpose and priorities that need to be resolved. The following extract from *A guide to management plans for parks and open spaces* (Barber, 1991) sets out the types of management plans that can be prepared:

(i) Management plan

This predicts a degree of physical change, and therefore should present design proposals in its recommendations. It puts the emphasis on the presentation of anticipated physical change with much of the documentation being in support.

(ii) Outline plan

This is generally accepted as a more appropriate title for a management plan that wishes to establish the guiding principles, without providing detailed proposals which might constrain future options for achieving the outline objectives.

(iii) Maintenance plan

This is appropriate if the principal interest is in establishing the best way of maintaining an area, or where there is a need to match maintenance aspirations to a secure financial base. Planned maintenance programmes over longer timescales can be made more secure by the more public exposure of the need and the commitment that the Maintenance Plan should be able to guarantee. A Maintenance Plan can also establish changes in maintenance regimes that may be required to match a change in objectives e.g. the need to adapt operation and maintenance practices to accommodate specific wildlife habitats that may develop.

For a SUDS scheme, the maintenance plan will generally be the most appropriate type of management plan to use. The document should include an explanation of the function of the SUDS scheme and why it is being used on the site.

Where the drainage system has an impact on the wildlife value or public use of a site, it would be prudent to develop this simple explanation further to explain habitat enhancement goals, health and safety issues and long-term management implications.

Sites with special wildlife or amenity interest may require detailed management plans, which monitor habitat development, infrastructure changes or damage to sites and ensure rapid responses to such changes, should they occur.

It is common for smaller commercial, industrial and housing sites to have a simple maintenance statement. In this case, a single page explaining the site management (including the sustainable drainage system) would be useful for all parties involved in the care of the development.

(B) Conditions of contract – appropriate conditions will be required. Advice can be sought from the Landscape Institute. Guidance is also provided in CIRIA publication C625 (Shaffer *et al*, 2004).

(C) Specification – detailing the materials to be used and the standard of work required.
A specification, usually preceded by preliminaries, details how work shall be carried out and contains clauses that give general instructions to the contractor. Specific SUDS maintenance clauses may be included in a general specification or as a separate "Sustainable drainage maintenance specification" section.
(D) Schedule of work – itemising the tasks to be undertaken and the frequency at which they will be performed.

The tasks required to maintain the site and the frequency necessary to achieve an acceptable standard should be set out in the schedule of work.

Smaller sites will usually have simple specification notes given to a contractor as a basis for maintenance on a performance basis. Examples of performance criteria are items such as:

- length of grass
- tidiness
- extent of weed growth, etc.

This document will often form the basis of a pricing mechanism, and can also act as a checklist to ensure the work has been carried out satisfactorily.

For additional information on the development of appropriate schedules, reference should be made to *The operation and maintenance of sustainable drainage systems* (HR Wallingford, 2004).

1.8.2 Frequency of maintenance tasks
Landscape maintenance contract periods are usually of one or three years' duration.
The three-year period is increasingly common to ensure continuity and commitment to long-term landscape care. The frequency of regular landscape maintenance tasks in a contract period can range from daily to once in the contract period. In practice most site tasks are based on monthly or fortnightly site visits, except where grass or weed growth requires a higher frequency of work. In many cases a performance specification is used with terms such as "beds shall be maintained weed-free" or "grass shall be cut to a height of 50 mm with a minimum height of 25 mm and a maximum height of 100 mm" to obtain the required standards.

Frequency can be specified within the schedule to include irregular items such as "'meadow grass' - cut two times annually in July and September to a height of 50 mm, all arisings raked off and removed to wildlife features, compost facility or to tip", which provides flexibility for work that is not critical to the management of the site.

Maintenance tasks which suit a performance approach commonly include plant growth, grass cutting, pruning and tree maintenance. However work tasks such as sweeping paths, regular litter collection and cleaning road surfaces will require work at an agreed frequency with more specific timings such as weekly, monthly or annually.

Where the frequency and timing of tasks is critical, a mixture of performance and frequency specification is necessary to provide effective maintenance.

SUDS maintenance generally tends towards a frequency requirement to ensure a predicable standard of care which can be recorded on site and which provides a reasonable basis for pricing work. A convenient frequency for many tasks is at a monthly inspection as this is the usual minimum site attendance required in a landscape specification. The monthly frequency should provide for an inspection of all SUDS features and checking all inlets and outlets.

Certain SUDS maintenance tasks however fall outside this monthly cycle and need to be accommodated in the contract. The two most obvious are:

- wetland vegetation maintenance
- silt management.

There are other tasks associated with ensuring the long-term performance of the systems that may be more difficult to predict, and could even fall outside any contract period. It may therefore be more appropriate to review requirements for system rehabilitation at interim periods, when contracts are falling due for renewal.

PERVIOUS PAVEMENTS

DESCRIPTION

Pervious pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into the underlying layers. The water is temporarily stored before infiltration to the ground, reuse, or discharge to a watercourse or other drainage system. Pavements with aggregate sub-bases can provide good water quality treatment.

OPERATION AND MAINTENANCE REQUIREMENTS

Regular inspection and maintenance is important for the effective operation of pervious pavements. Maintenance responsibility for a pervious pavement and its surrounding area should be placed with an appropriate responsible organisation. Before handing over the facility to the client, it should be inspected for clogging, litter, weeds and water ponding and all failures should be rectified. After handover, the facility should be inspected regularly, preferably during and after heavy rainfall to check effective operation and to identify any areas of ponding.

Pervious surfaces need to be regularly cleaned of silt and other sediments to preserve their infiltration capability. Experience in the UK is limited, but advice issued with permeable precast concrete paving has suggested a minimum of three surface sweepings per year. Manufacturers' recommendations should always be followed.

A brush and suction cleaner, which can be a lorry-mounted device or a smaller precinct sweeper, should be used and the sweeping regime should be as follows:

1. End of winter (April) – to collect winter debris.
2. Mid-summer (July/August) – to collect dust, flower and grass-type deposits.
3. After autumn leaf fall (November).

Care should be taken in adjusting vacuuming equipment to avoid removal of jointing material. Any lost material should be replaced.

The likely design life (or period before pavement rehabilitation is required) has yet to be established for the UK. However, it should be no different from standard paving assuming that an effective maintenance regime is in place to minimise risks of infiltration clogging.

If reconstruction is necessary, the following procedure should be followed:

1. Lift surface layer and laying course.
2. Remove any geotextile filter layer.
3. Inspect sub-base and remove, wash and replace if required.
4. Renew any geotextile layer.
5. Renew laying course, jointing material and concrete block paving.

The reconstruction of failed areas of concrete block pavement should be less costly and disruptive than the rehabilitation of continuous concrete or asphalt porous surfaces due to the reduced area that is likely to be affected. Materials removed from the voids or the layers below the surface may contain heavy metals and hydrocarbons and may need to be disposed of as controlled waste. Sediment testing should be carried out before disposal to confirm its classification and appropriate disposal methods.

Maintenance plans and schedules should be prepared during the design phase. Specific maintenance needs of the pervious pavement should be monitored and maintenance schedules adjusted to suit requirements.

Table 4.1 *Pervious pavement operation and maintenance requirements*

Maintenance schedule	Required action	Frequency
Regular maintenance	Brushing and vacuuming.	Three times/year at end of winter, mid-summer, after autumn leaf fall, or as required based on site-specific observations of clogging or manufacturers' recommendations.
Occasional maintenance	Stabilise and mow contributing and adjacent areas.	As required.
	Removal of weed.	As required.
	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving.	As required.
Remedial actions	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users.	As required.
	Rehabilitation of surface and upper sub-structure.	As required (if infiltration performance is reduced as a result of significant clogging).
	Initial inspection.	Monthly for 3 months after installation
Monitoring	Inspect for evidence of poor operation and/or weed growth. If required take remedial action.	3-monthly, 48 h after large storms.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.
	Monitor inspection chambers.	Annually.

Maintenance activities should be detailed in the Health and Safety Plan and a risk assessment should be undertaken.

GEOCELLULAR/MODULAR SYSTEMS

DESCRIPTION

Modular plastic geocellular systems with a high void ratio, that can be used to create a below ground infiltration (soakaway) or storage structure.

OPERATION AND MAINTENANCE REQUIREMENTS

Regular inspection and maintenance is required to ensure the effective long-term operation of below ground modular storage systems. Maintenance responsibility for systems should be placed with a responsible organization. Maintenance requirements for modular systems are described in Table 6.1. Maintenance plans and schedules should be developed during the design phase. Specific maintenance needs of the system should be monitored, and maintenance schedules adjusted to suit requirements. Additional detail on the preparation of maintenance specifications and schedules of work is given in see Chapter 32 of CIRIA C753.

Table 6.1 *Modular systems – operation and maintenance requirements*

Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then six monthly
	Debris removal from catchment surface (where may cause risks to performance)	Monthly
	Where rainfall infiltrates into blocks from above, check surface of filter for blockage by silt, algae or other matter. Remove and replace surface infiltration medium as necessary.	Monthly (and after large storms)
	Remove sediment from pre-treatment structures	Annually, or as required
Remedial actions	Repair/rehabilitation of inlets, outlet , overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed	Annually and after large storms

Maintenance activities should be detailed in the Health and Safety Plan and a risk assessment should be undertaken.