LANMOR Consulting

Civil Engineers & Transport Planners

Land adjacent to Whiteheath Junior School, Whiteheath Avenue, Ruislip

Drainage Assessment

May 2023

231672/DS/AG/KL/01

LANMOR Consulting

Civil Engineers & Transport Planners

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1 INTRODUCTION

1.1 General

1.1.1 Lanmor Consulting Ltd has been appointed to complete a drainage assessment for the proposed development at Whiteheath Avenue, Ruislip, HA4 7PR.

1.1.2 The site is a small plot located between 1 Whiteheath Avenue and Whiteheath Junior School's playground areas, within the West London locality of Ruislip. The location of the site is indicated below in Figure 1.1.

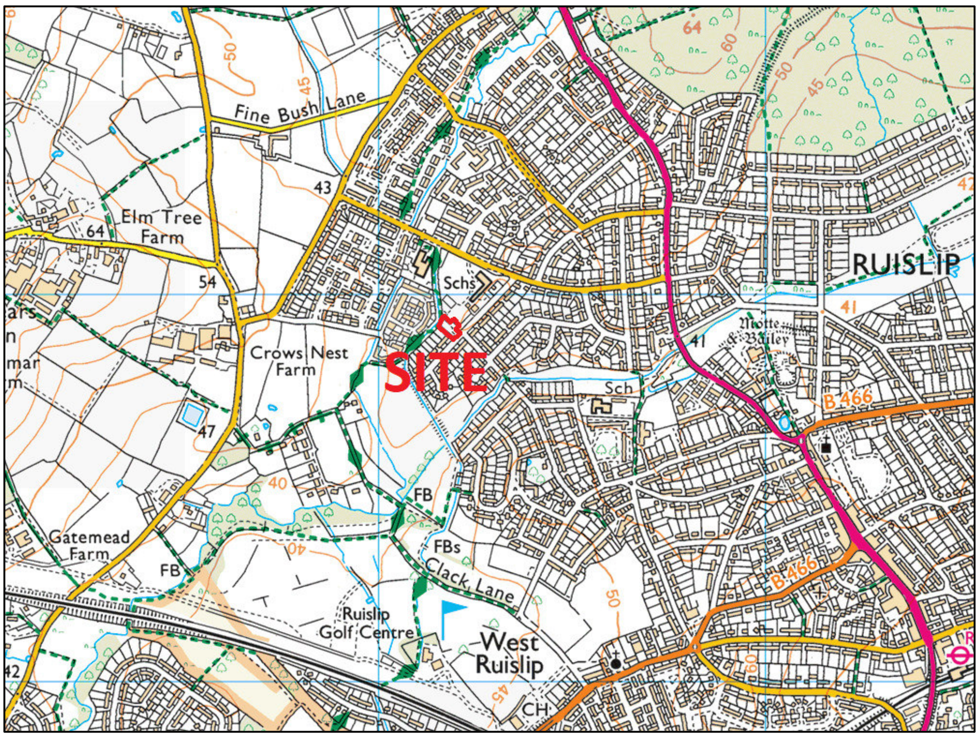


Figure 1.1 – Site Location

1.2 Scope

1.2.1 This report will consider the proposed drainage strategy regime for the above site. It will assess the site's current discharge, its Greenfield and Brownfield runoff rates, suitable methods of discharging the runoff from the development and will set out the drainage strategy for the development, including proposed discharge rates and any requirements for attenuation.

2 SITE LOCATION AND DESCRIPTION

2.1 Existing Site

2.1.1 The site is located adjacent to Whiteheath Junior School in West London and so the land use in the surrounding vicinity is generally highly developed. The site was owned by Hillingdon Council and previously accommodated two single storey detached buildings which were occupied by Hillingdon Grid For Learning for the store and repair of ICT equipment. The use of these buildings was absorbed elsewhere within the School site and so these buildings became redundant and fell into a state of disrepair. A decision was undertaken to demolish the buildings in 2018. The site covers an area of approximately 0.08 hectares and is currently a neglected vacant plot consisting of areas of concrete, tarmac, trees, and shrubbery, with an electrical Sub Station located to the rear (outside of the site boundary). The site is currently separated from the school grounds via a chain link fence.

2.2 Regional Geology

2.2.1 The British Geological Survey (BGS) indicates that the location of the site is underlain by Lambeth Group - Clay, silt, and sand. Vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate. The sedimentary bedrock formed between 59.2 and 47.8 million years ago during the Palaeogene period. There is no available information with regards the superficial geology for the site.

2.3 Proposed Development

2.3.1 Planning permission was granted by Hillingdon Borough Council for the erection of two 4-bedroom properties on 19th March 2020. The applicant seeks to implement the approved scheme in full. The applicant therefore seeks to discharge the necessary planning conditions.

2.3.2 The approved scheme 64510/APP/2019/1412 consists of the erection of two x 4 bed dwellings with associated landscaping, car parking and ecological area to the rear of the site. Both properties (houses A and B) will have a GIA of approximately 150m^2. House A will have a garden amenity area of 230m^2, while House B will have a garden area of 143m^2. Both houses will be allocated 2 parking spaces. A copy of the proposed site layout for the development has been included in Appendix A as drawing 2018/D271/P/03.

3 EXISTING DRAINAGE

3.1 Foul Drainage

3.1.1 The site is currently vacant so there is no existing drainage regime for the site, however the pervious building did have drainage and there is a manhole cover located towards the rear site boundary. Sewer records have therefore been obtained from Thames Water in order to establish the most suitable method of drainage for the development. These indicate that there is an adopted foul sewer which runs beneath Whiteheath Avenue, flowing southwest and then northwest at manhole 1802. It has a diameter of 225mm, increasing to 375mm and runs beneath the north of the road before turning northwest beneath 7 and 9 Whiteheath Avenue.

3.2 Surface Water Drainage

3.2.1 The sewer records obtained from Thames Water indicate that there is also an adopted surface water sewer which runs beneath Whiteheath Avenue, parallel to the foul sewer. The surface water sewer flows southeast and has a diameter of 225mm, increasing to 375mm past the site. A copy of the Thames Water sewer records has been included in Appendix B.

4 PROPOSED DRAINAGE

4.1 Foul Water

4.1.1 The planning application is for the renewal of a vacant plot of land with the erection of two 4-bedroom properties and associated landscaping. Since the sewer records indicate that there is a foul sewer which runs beneath whiteheath Road and the existing discharge from the site cannot be established at this time, the preferred option is discharge wastewater into this sewer. Any new connection to the sewer will be subject to an S106 application.

4.2 Surface Water

4.2.1 With regards to discharge of surface water runoff from the development, the SuDS hierarchy has been considered when designing the drainage strategy for the site. Since the properties will have pitched roofs, blue/green roof attenuation was not considered to be a viable option for this development and has therefore been discounted.

4.2.2 Rainwater harvesting was also considered as a means of reusing surface water runoff, Rain water butts will be installed on each downpipe to provide water for irrigation of the landscaped areas.

4.2.3 Next on the Sustainable Drainage Hierarchy is the use of ground infiltration techniques such as soakaways and infiltration basins. The BGS indicates that the site is underlain by Lambeth Group – clay, silt, and sand. The high presence of clay is likely to prevent the use of soakaways as clay soils generally have poor infiltration, leading to waterlogging etc. The site is also relatively small at 0.08 hectares and so it would not be possible to incorporate soakaways into the drainage regime for the development while also ensuring that they are kept >5m away from the foundations of the proposed dwellings in accordance with Building Regulations. It is for these reasons that soakaways are not considered to be viable for this development and have been discounted.

4.2.4 Discharging to a watercourse is the next option on the Sustainable Drainage Hierarchy. There is no ditch with or on the boundary of the application site to connect to and for this reason, and so this option has been discounted.

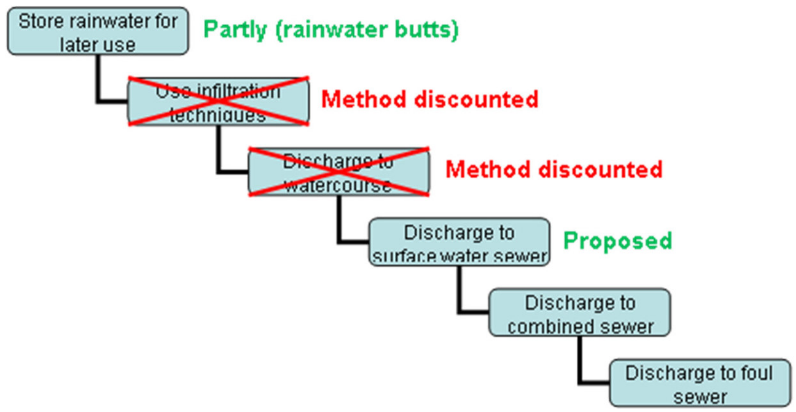


Figure 4.1 – SuDS Hierarchy

4.2.5 Next on the SuDS hierarchy is discharging runoff to a surface water sewer and attenuating the flows. The sewer records obtained from Thames Water indicate that there is an adopted surface water sewer directly adjacent to the site which runs beneath Whiteheath Avenue. This would therefore be the preferred option for discharging surface water from the development, the new sewer connection will be subject to a S106 application.

4.2.6 The proposed buildings each have a pitch roof and rainwater pipe on each corner, the new access and parking areas will be formed in a permeable construction and each rainwater pipe will discharge to the granular sub-base of the paving via a diffuser unit. The sub-base will act as storage for the hardstanding areas and buildings.

4.2.7 The paving will tanked as infiltration is not achievable and the outflow from the paving will be controlled via a Hydrobrake with a restricted discharge rate of 2 l/s. Drawing 231672-DS-01 included in Appendix C, shows an indicative drainage layout for the development.

4.2.8 Drainage calculations have been undertaken to determine the size of attenuation needed for a 1 in 100 year return period plus 40% climate change. The sub-base will need to have a minimum thickness of 400mm to cater for the surface water runoff from the building roofs and driveway.

4.2.9 The full microdrainage calculations are included in Appendix C for the different return periods.

5 SURFACE WATER/SUDS MAINTENANCE

5.1.1 Regularly inspecting the surface water drainage network for blockages and clearing unwanted debris / silt from the system should improve the performance of the surface water network and decrease the need for future repairs. In the event that road gullies become blocked, high pressure water jets can be used to clear the gully and ensure they are functioning correctly, this should be undertaken by certified trained professionals.

5.1.2 The level and frequency of maintenance required on site is dependent on the type of facility. The type of maintenance will fall into one of three categories "regular maintenance", "occasional maintenance" and "remedial maintenance".

5.1.3 Regular maintenance of the drainage and SuDS features will include inspections, removal of litter / debris and sweeping of the surfaces. Occasional maintenance will include removal of sediment etc. and remedial maintenance may include structural repairs and infiltration reconditioning if required.

5.1.4 The drainage and SuDS elements after an initial inspection following construction should be inspected on a monthly basis for the first 12 months and after large storms, thereafter the following maintenance regime should be applied and adjusted if the 12-month monitoring process has identified any issues.

5.1.5 Following completion of the development each property owner will be responsible for the drainage within their demise and a maintenance agreement will be entered into for shared items such as the hydrobrake etc.

5.1.6 The appropriate health and safety equipment must be used when accessing manholes. Confined space certificates must be held by any personnel entering a manhole and the appropriate permits should be obtained.

5.1.7 Below are the typical maintenance requirements for the proposed SuDS features, these will need to be reviewed regularly and adjusted to suit the site needs.

Permeable Paving

5.1.8 For permeable paving areas, the following maintenance is recommended.

Permeable Paving Maintenance Schedule		
	Required Action	**Typical Frequency**
Regular maintenance	Remove debris and leaves etc.	Once a year, after autumn leaf fall, or reduced frequency as required, based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto pervious surfaces from adjacent impermeable areas as this area is most likely to collect the most sediment.
Occasional maintenance	Stabilise and mow contributing and adjacent areas	As required
	Removal of weeds	As required- once per year on less frequently used pavements
Remedial Actions	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 work to any depressions, rutting etc	As required
	Rehabilitation of surface and upper substructure	Every 10 to 15 years or as required (if infiltration performance is reduced due to significant clogging)
Monitoring	Inspect for evidence of poor operation and/or weed growth - if required, take remedial action.	Three-monthly, 48 hours after large storms in the first six months
	Inspect silt accumulation rates and establish appropriate frequencies for rehabilitation	Annually
	Monitor inspection chambers	Annually

Table 5.1 – Permeable Paving Maintenance Schedule

6 SUMMARY AND CONCLUSION

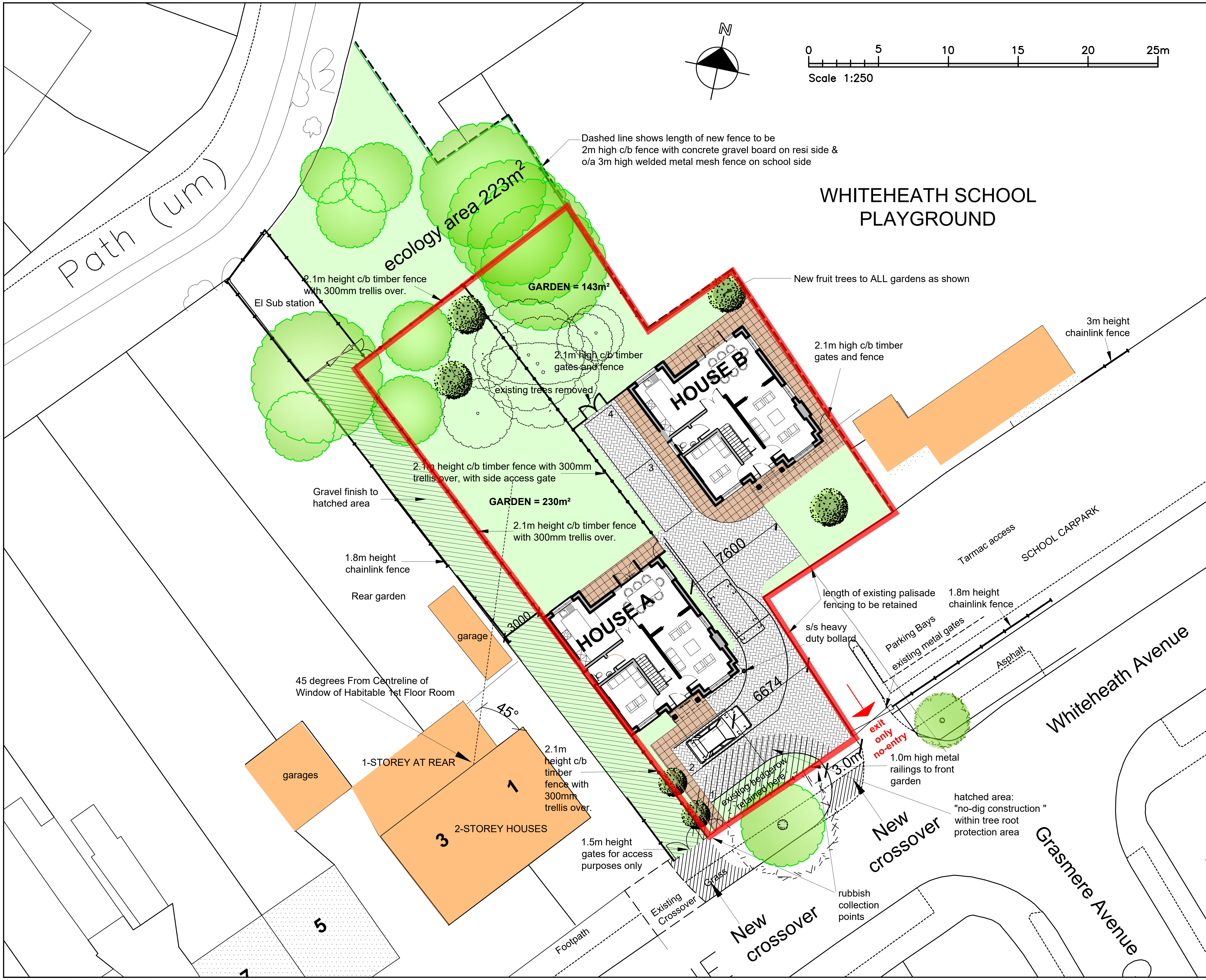
6.1.1 This Drainage Assessment has been prepared to identify how surface water runoff and foul sewage will be discharge from the proposed development.

6.1.2 As part of the assessment, SuDS was considered for the discharge of surface water runoff from the proposed buildings and parking areas. The proposals will use an rainwater butts for irrigation, and permeable paving to attenuate the runoff from the parking area and roofs. The storage provided in the granular sub-base will cater for all events up to and including the 1 in 100 year storm plus 40% climate change allowance. The discharge from the tank will be restricted by a Hydro Brake to 2 l/s.

6.1.3 This statement clearly demonstrates that the proposed development can be served in terms of discharge of foul and surface water runoff from the site without increasing the risk of flooding in the area.

APPENDIX A

Drawing 2018/D271/P/03/ - Proposed Site Layout



NOTES

The Contractor must verify all dimensions at the site before setting out, commencing work, or making any shop drawings. Any discrepancies must be reported to the Contract Administrator before proceeding.

DO NOT SCALE FROM THIS DRAWING

SCHEDULE OF ACCOMMODATION

HOUSE A
1 x 4B, 6P HOUSES EACH @ GIA = 150m²
REAR GARDEN AMENITY 230m²
2 CAR PARKING SPACES EACH

HOUSE B
1 X 4B, 6P HOUSES EACH @ GIA = 150M²
REAR GARDEN AMENITY 143M²
2 CAR PARKING SPACES EACH

ECOLOGY AREA
@ 223m²

TREE KEY

Existing tree retaimed
Existing tree removed
Proposed tree

Rev	Revision notes	Initials	Date
I	Gates added between access way and ecology area	MY	09.11.22
H	House moved back to allow sub-station access road width of 3m, bollard added, garden area amended.	DB	14.01.21
G	Habitable room angle moved to correct location and note added.	DB	22.12.20
F	Fenced access to existing sub station, and rearrangement to parking House A. House A set back 1m. Turning circle added. RPA hatch added	DB	10.12.20
E	Scheme amended to two detached houses with tandem parking.	DB	06.03.20
D	Gardens resized, balanced trees removed, patios to House 1 and 2 reduced. Key added.	DB	18.11.19
C	Dedicated 1.8m wide paved footpath with 1.8m high C/B fence added to the boundary of house no. 1. Rear Garden amenity area amended and bushes to west boundary fence removed for access purposes.	ST	04.11.19
B	Footpath to front garden removed and replaced with soft landscaping. Rear garden fencing amended. Bin store removed and replaced with collection area.	ST	14.10.19
A	Block B updated and moved forward, House C moved 4m away from substation, and path moved forward at House C, More fruit trees added.	db	15.05.19

HILLINGDON
LONDON
RESIDENTS SERVICES, CAPITAL PROGRAMME & WORKS SERVICE
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PROJECT
PROPOSED HOUSING DEVELOPMENT AT
WHITEHEATH AVENUE,
RUISLIP, HA4 7PR

DESCRIPTION
PROPOSED SITE PLAN

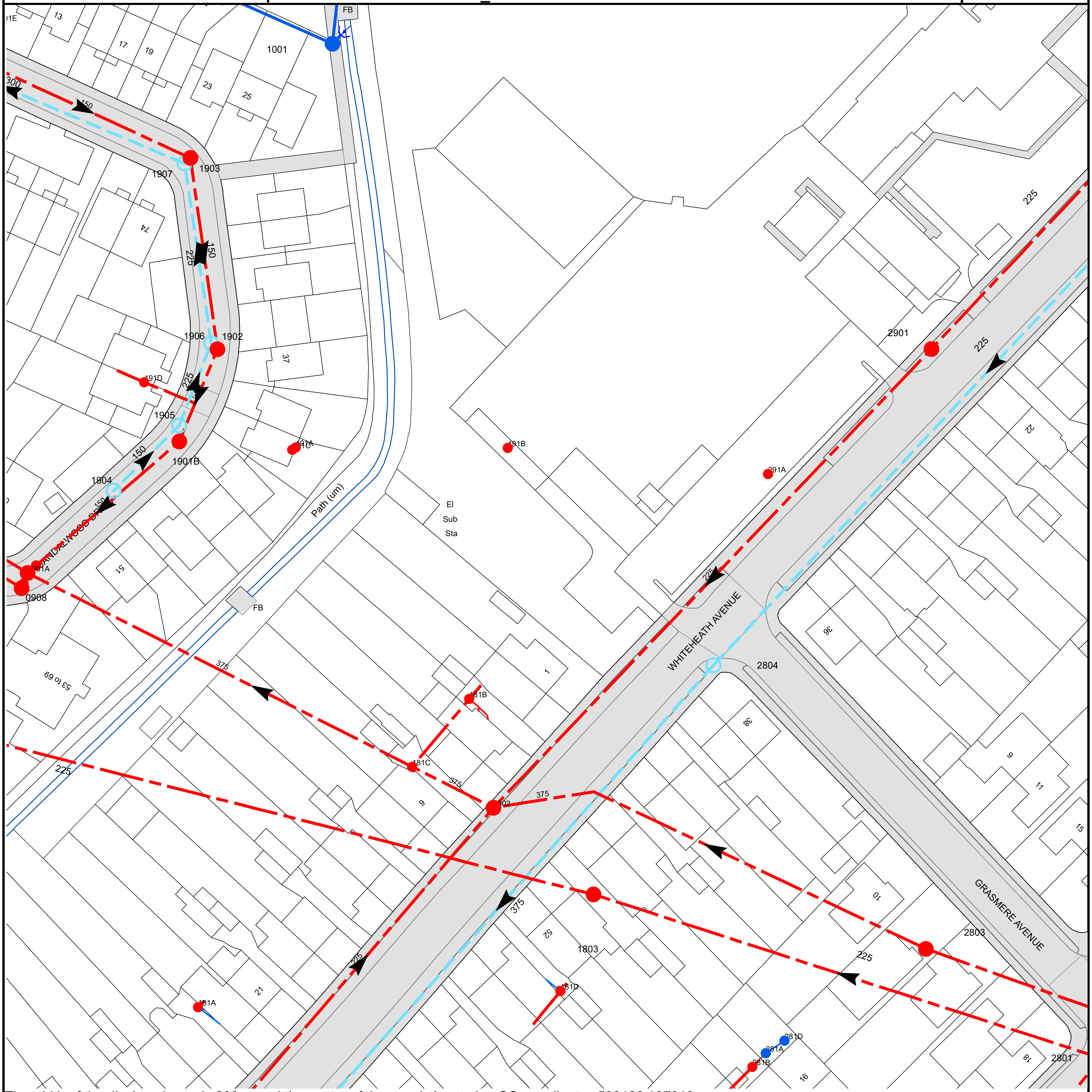
SCALE	DRAWN BY	CHECKED BY	DATE
1:250@A3	DB		DEC 2019

DRAWING No.	REV.
2018/D271/P/03	I

APPENDIX B

Thames Water Sewer Records

Asset Location Search Sewer Map - ALS/ALS Standard/2023_4820087

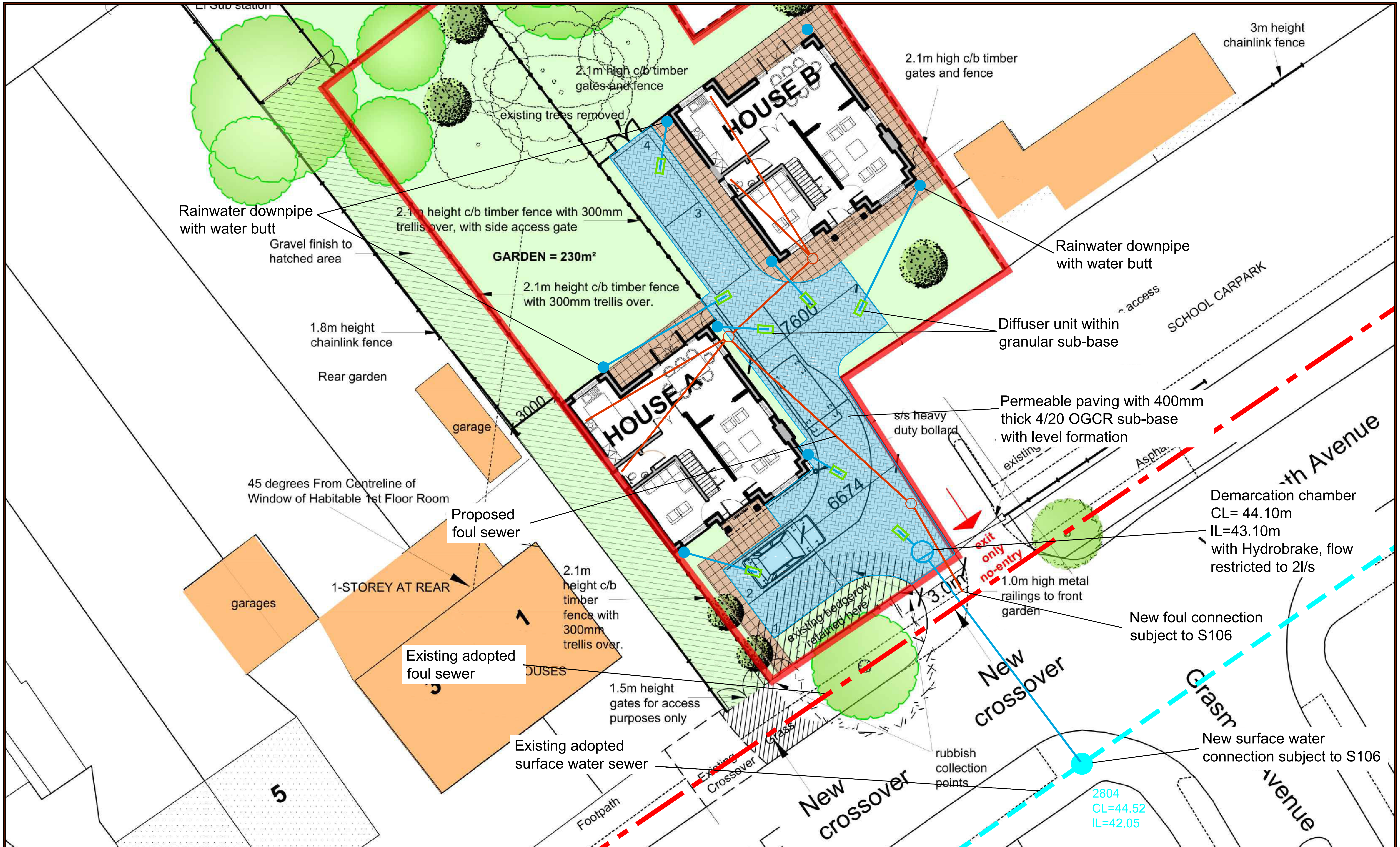


The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 508186,187913

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

APPENDIX C

Drawing 231672/DS/01



Reynolds
Ground Services

Land adjacent to Whiteheat School
Whiteheath Avenue

Proposed Drainage
Layout

SCALE	DRAWN BY	PRJ No.	DWG No.
1:200	KBL	231672	231672/DS/01

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Microdrainage Calculations

Summary of Results for 1 year Return Period

Half Drain Time : 6 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	59.448	0.048	0.0	1.7	1.7	0.8	O K
30 min Summer	59.453	0.053	0.0	1.8	1.8	1.0	O K
60 min Summer	59.449	0.049	0.0	1.8	1.8	0.9	O K
120 min Summer	59.431	0.031	0.0	1.8	1.8	0.4	O K
180 min Summer	59.413	0.013	0.0	1.8	1.8	0.1	O K
240 min Summer	59.400	0.000	0.0	1.6	1.6	0.0	O K
360 min Summer	59.400	0.000	0.0	1.2	1.2	0.0	O K
480 min Summer	59.400	0.000	0.0	1.0	1.0	0.0	O K
600 min Summer	59.400	0.000	0.0	0.8	0.8	0.0	O K
720 min Summer	59.400	0.000	0.0	0.7	0.7	0.0	O K
960 min Summer	59.400	0.000	0.0	0.6	0.6	0.0	O K
1440 min Summer	59.400	0.000	0.0	0.4	0.4	0.0	O K
2160 min Summer	59.400	0.000	0.0	0.3	0.3	0.0	O K
2880 min Summer	59.400	0.000	0.0	0.3	0.3	0.0	O K
4320 min Summer	59.400	0.000	0.0	0.2	0.2	0.0	O K
5760 min Summer	59.400	0.000	0.0	0.2	0.2	0.0	O K
7200 min Summer	59.400	0.000	0.0	0.1	0.1	0.0	O K
8640 min Summer	59.400	0.000	0.0	0.1	0.1	0.0	O K
10080 min Summer	59.400	0.000	0.0	0.1	0.1	0.0	O K
15 min Winter	59.454	0.054	0.0	1.8	1.8	1.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	31.571	0.0	1.7	13
30 min Summer	20.531	0.0	2.4	22
60 min Summer	12.944	0.0	3.2	38
120 min Summer	7.994	0.0	4.1	68
180 min Summer	6.000	0.0	4.7	96
240 min Summer	4.890	0.0	5.2	0
360 min Summer	3.641	0.0	5.9	0
480 min Summer	2.946	0.0	6.3	0
600 min Summer	2.499	0.0	6.7	0
720 min Summer	2.184	0.0	7.1	0
960 min Summer	1.767	0.0	7.6	0
1440 min Summer	1.311	0.0	8.5	0
2160 min Summer	0.973	0.0	9.4	0
2880 min Summer	0.787	0.0	10.0	0
4320 min Summer	0.584	0.0	10.8	0
5760 min Summer	0.472	0.0	11.4	0
7200 min Summer	0.401	0.0	11.8	0
8640 min Summer	0.351	0.0	12.1	0
10080 min Summer	0.313	0.0	12.3	0
15 min Winter	31.571	0.0	2.0	14

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	59.457	0.057	0.0	1.8	1.8	1.2	O K
60 min Winter	59.448	0.048	0.0	1.8	1.8	0.9	O K
120 min Winter	59.414	0.014	0.0	1.8	1.8	0.1	O K
180 min Winter	59.400	0.000	0.0	1.4	1.4	0.0	O K
240 min Winter	59.400	0.000	0.0	1.2	1.2	0.0	O K
360 min Winter	59.400	0.000	0.0	0.9	0.9	0.0	O K
480 min Winter	59.400	0.000	0.0	0.7	0.7	0.0	O K
600 min Winter	59.400	0.000	0.0	0.6	0.6	0.0	O K
720 min Winter	59.400	0.000	0.0	0.5	0.5	0.0	O K
960 min Winter	59.400	0.000	0.0	0.4	0.4	0.0	O K
1440 min Winter	59.400	0.000	0.0	0.3	0.3	0.0	O K
2160 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
2880 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
4320 min Winter	59.400	0.000	0.0	0.1	0.1	0.0	O K
5760 min Winter	59.400	0.000	0.0	0.1	0.1	0.0	O K
7200 min Winter	59.400	0.000	0.0	0.1	0.1	0.0	O K
8640 min Winter	59.400	0.000	0.0	0.1	0.1	0.0	O K
10080 min Winter	59.400	0.000	0.0	0.1	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	20.531	0.0	2.8	24
60 min Winter	12.944	0.0	3.6	42
120 min Winter	7.994	0.0	4.7	68
180 min Winter	6.000	0.0	5.4	0
240 min Winter	4.890	0.0	5.9	0
360 min Winter	3.641	0.0	6.7	0
480 min Winter	2.946	0.0	7.2	0
600 min Winter	2.499	0.0	7.7	0
720 min Winter	2.184	0.0	8.1	0
960 min Winter	1.767	0.0	8.7	0
1440 min Winter	1.311	0.0	9.6	0
2160 min Winter	0.973	0.0	10.6	0
2880 min Winter	0.787	0.0	11.4	0
4320 min Winter	0.584	0.0	12.4	0
5760 min Winter	0.472	0.0	13.1	0
7200 min Winter	0.401	0.0	13.6	0
8640 min Winter	0.351	0.0	14.0	0
10080 min Winter	0.313	0.0	14.3	0

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.200	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.041

Time From:	(mins) To:	Area (ha)
0	4	0.041

Model Details

Storage is Online Cover Level (m) 60.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	41.7	Slope (1:X)	500.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	59.400	Cap Volume Depth (m)	0.400

Hydro-Brake Optimum® Outflow Control

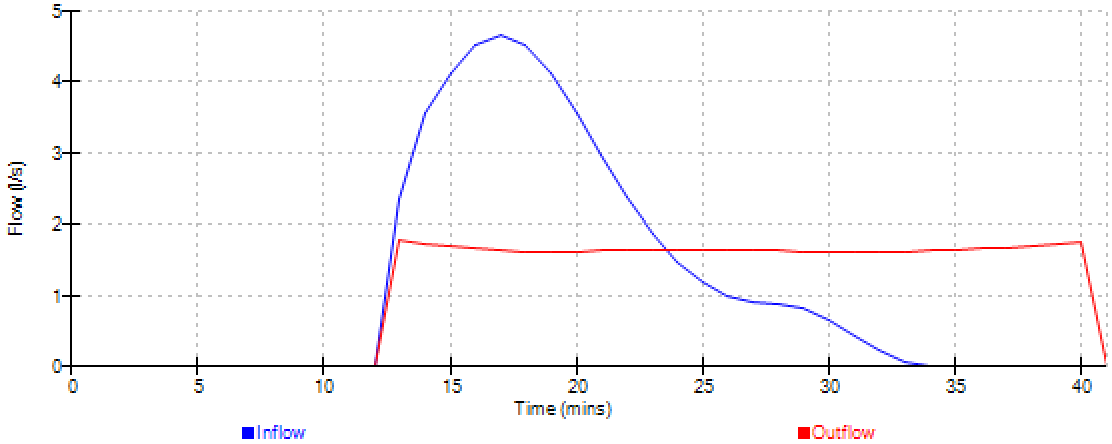
Unit Reference	MD-SHE-0071-2000-0700-2000
Design Head (m)	0.700
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	71
Invert Level (m)	59.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

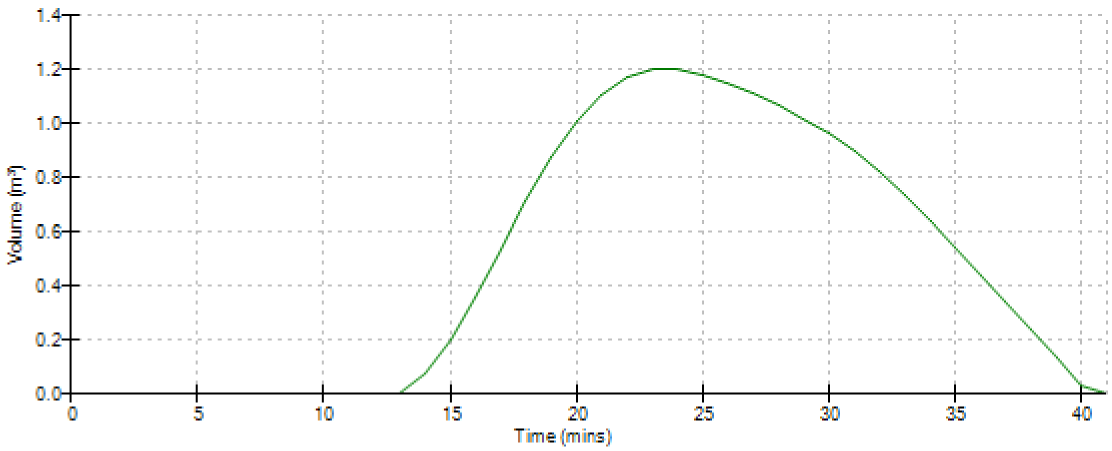
Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.700	2.0
Flush-Flo™	0.206	2.0
Kick-Flo®	0.446	1.6
Mean Flow over Head Range	-	1.7

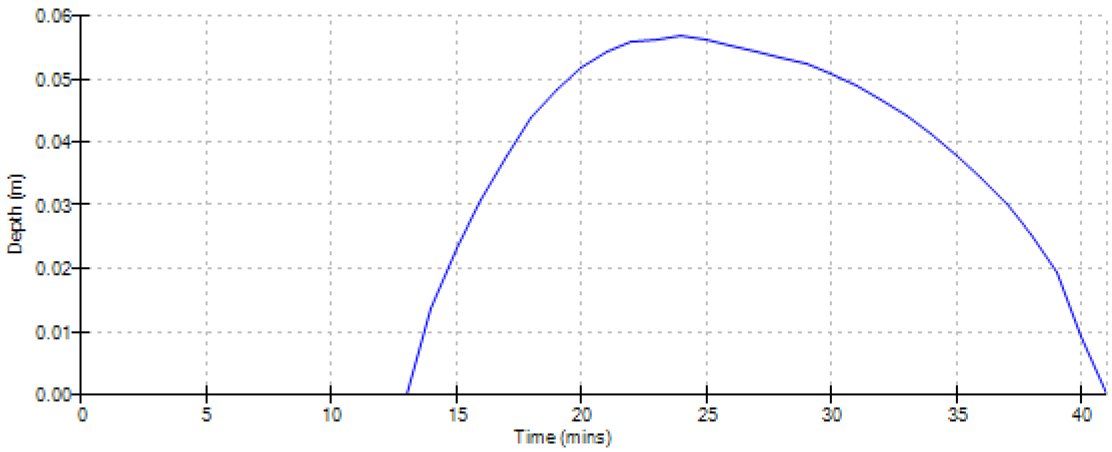
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	1.8	1.200	2.5	3.000	3.9	7.000	5.7
0.200	2.0	1.400	2.7	3.500	4.1	7.500	5.9
0.300	1.9	1.600	2.9	4.000	4.4	8.000	6.1
0.400	1.8	1.800	3.0	4.500	4.7	8.500	6.3
0.500	1.7	2.000	3.2	5.000	4.9	9.000	6.5
0.600	1.8	2.200	3.3	5.500	5.1	9.500	6.7
0.800	2.1	2.400	3.5	6.000	5.3		
1.000	2.3	2.600	3.6	6.500	5.5		

Event: 30 min Winter







Summary of Results for 30 year Return Period

Half Drain Time : 27 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	59.519	0.119	0.0	1.8	1.8	4.0	O K
30 min Summer	59.533	0.133	0.0	1.8	1.8	4.6	O K
60 min Summer	59.533	0.133	0.0	1.8	1.8	4.6	O K
120 min Summer	59.518	0.118	0.0	1.8	1.8	4.0	O K
180 min Summer	59.501	0.101	0.0	1.8	1.8	3.2	O K
240 min Summer	59.485	0.085	0.0	1.8	1.8	2.5	O K
360 min Summer	59.458	0.058	0.0	1.8	1.8	1.3	O K
480 min Summer	59.433	0.033	0.0	1.8	1.8	0.4	O K
600 min Summer	59.406	0.006	0.0	1.8	1.8	0.0	O K
720 min Summer	59.400	0.000	0.0	1.6	1.6	0.0	O K
960 min Summer	59.400	0.000	0.0	1.2	1.2	0.0	O K
1440 min Summer	59.400	0.000	0.0	0.9	0.9	0.0	O K
2160 min Summer	59.400	0.000	0.0	0.6	0.6	0.0	O K
2880 min Summer	59.400	0.000	0.0	0.5	0.5	0.0	O K
4320 min Summer	59.400	0.000	0.0	0.4	0.4	0.0	O K
5760 min Summer	59.400	0.000	0.0	0.3	0.3	0.0	O K
7200 min Summer	59.400	0.000	0.0	0.2	0.2	0.0	O K
8640 min Summer	59.400	0.000	0.0	0.2	0.2	0.0	O K
10080 min Summer	59.400	0.000	0.0	0.2	0.2	0.0	O K
15 min Winter	59.534	0.134	0.0	1.7	1.7	4.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	77.483	0.0	5.2	16
30 min Summer	50.231	0.0	6.9	28
60 min Summer	31.124	0.0	8.7	44
120 min Summer	18.717	0.0	10.8	78
180 min Summer	13.755	0.0	11.8	112
240 min Summer	11.007	0.0	12.7	144
360 min Summer	8.025	0.0	14.0	204
480 min Summer	6.410	0.0	14.9	258
600 min Summer	5.381	0.0	15.6	306
720 min Summer	4.663	0.0	16.2	0
960 min Summer	3.718	0.0	17.2	0
1440 min Summer	2.699	0.0	18.7	0
2160 min Summer	1.957	0.0	20.2	0
2880 min Summer	1.556	0.0	21.3	0
4320 min Summer	1.127	0.0	22.8	0
5760 min Summer	0.895	0.0	23.9	0
7200 min Summer	0.749	0.0	24.6	0
8640 min Summer	0.647	0.0	25.2	0
10080 min Summer	0.571	0.0	25.6	0
15 min Winter	77.483	0.0	5.9	16

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	59.552	0.152	0.0	1.8	1.8	5.5	O K
60 min Winter	59.551	0.151	0.0	1.8	1.8	5.4	O K
120 min Winter	59.527	0.127	0.0	1.8	1.8	4.4	O K
180 min Winter	59.500	0.100	0.0	1.8	1.8	3.2	O K
240 min Winter	59.476	0.076	0.0	1.8	1.8	2.1	O K
360 min Winter	59.428	0.028	0.0	1.8	1.8	0.3	O K
480 min Winter	59.400	0.000	0.0	1.5	1.5	0.0	O K
600 min Winter	59.400	0.000	0.0	1.3	1.3	0.0	O K
720 min Winter	59.400	0.000	0.0	1.1	1.1	0.0	O K
960 min Winter	59.400	0.000	0.0	0.9	0.9	0.0	O K
1440 min Winter	59.400	0.000	0.0	0.6	0.6	0.0	O K
2160 min Winter	59.400	0.000	0.0	0.5	0.5	0.0	O K
2880 min Winter	59.400	0.000	0.0	0.4	0.4	0.0	O K
4320 min Winter	59.400	0.000	0.0	0.3	0.3	0.0	O K
5760 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
7200 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
8640 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
10080 min Winter	59.400	0.000	0.0	0.1	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	50.231	0.0	7.9	30
60 min Winter	31.124	0.0	10.0	48
120 min Winter	18.717	0.0	12.1	86
180 min Winter	13.755	0.0	13.5	120
240 min Winter	11.007	0.0	14.4	152
360 min Winter	8.025	0.0	15.7	204
480 min Winter	6.410	0.0	16.8	0
600 min Winter	5.381	0.0	17.6	0
720 min Winter	4.663	0.0	18.3	0
960 min Winter	3.718	0.0	19.4	0
1440 min Winter	2.699	0.0	21.1	0
2160 min Winter	1.957	0.0	22.8	0
2880 min Winter	1.556	0.0	24.1	0
4320 min Winter	1.127	0.0	25.8	0
5760 min Winter	0.895	0.0	27.1	0
7200 min Winter	0.749	0.0	28.0	0
8640 min Winter	0.647	0.0	28.7	0
10080 min Winter	0.571	0.0	29.2	0

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.200	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.041

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.041

Model Details

Storage is Online Cover Level (m) 60.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	41.7	Slope (1:X)	500.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	59.400	Cap Volume Depth (m)	0.400

Hydro-Brake Optimum® Outflow Control

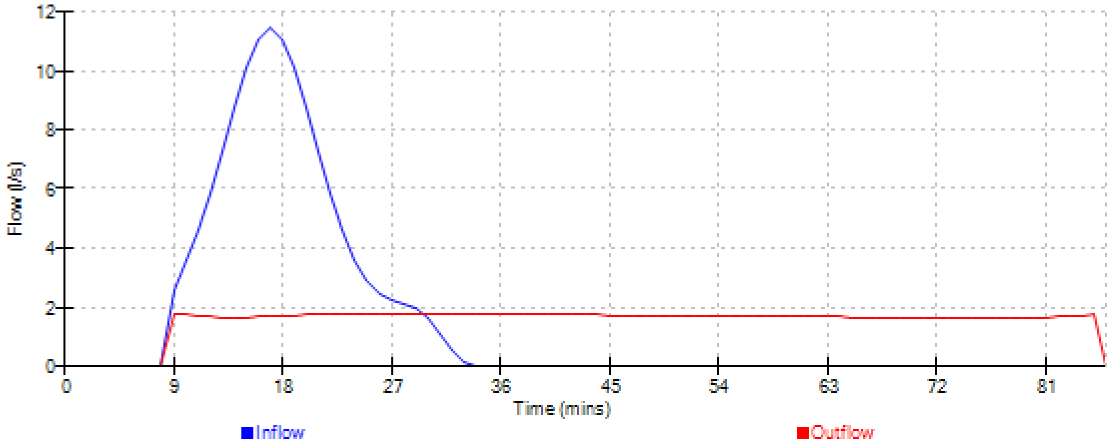
Unit Reference	MD-SHE-0071-2000-0700-2000
Design Head (m)	0.700
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	71
Invert Level (m)	59.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

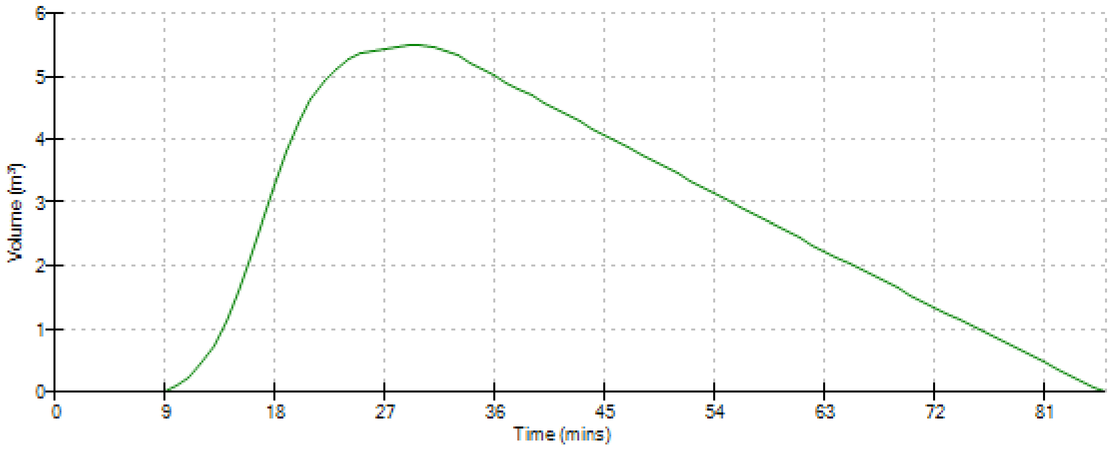
Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.700	2.0
Flush-Flo™	0.206	2.0
Kick-Flo®	0.446	1.6
Mean Flow over Head Range	-	1.7

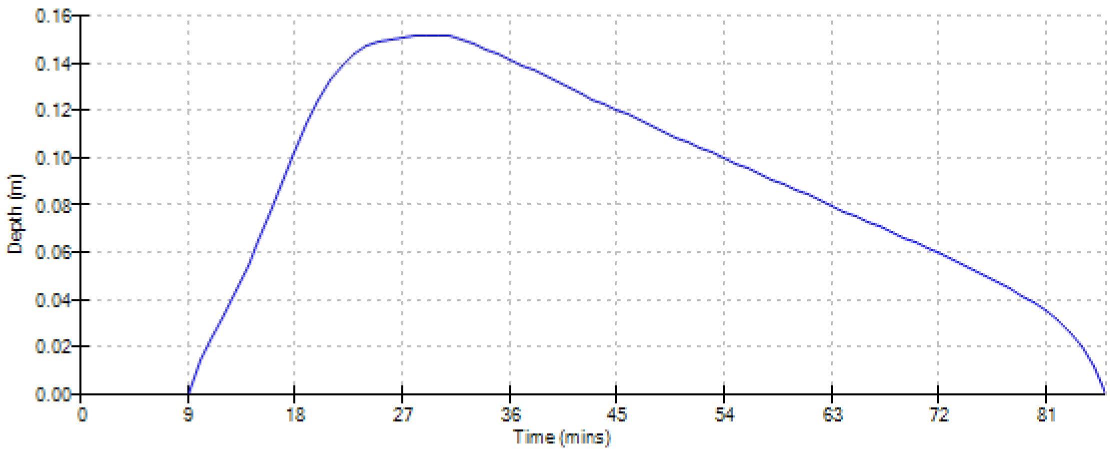
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	1.8	1.200	2.5	3.000	3.9	7.000	5.7
0.200	2.0	1.400	2.7	3.500	4.1	7.500	5.9
0.300	1.9	1.600	2.9	4.000	4.4	8.000	6.1
0.400	1.8	1.800	3.0	4.500	4.7	8.500	6.3
0.500	1.7	2.000	3.2	5.000	4.9	9.000	6.5
0.600	1.8	2.200	3.3	5.500	5.1	9.500	6.7
0.800	2.1	2.400	3.5	6.000	5.3		
1.000	2.3	2.600	3.6	6.500	5.5		

Event: 30 min Winter







Summary of Results for 100 year Return Period

Half Drain Time : 46 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	59.557	0.157	0.0	1.8	1.8	5.7	O K
30 min Summer	59.580	0.180	0.0	1.8	1.8	6.8	O K
60 min Summer	59.584	0.184	0.0	1.8	1.8	6.9	O K
120 min Summer	59.570	0.170	0.0	1.8	1.8	6.3	O K
180 min Summer	59.552	0.152	0.0	1.8	1.8	5.5	O K
240 min Summer	59.533	0.133	0.0	1.8	1.8	4.6	O K
360 min Summer	59.500	0.100	0.0	1.8	1.8	3.1	O K
480 min Summer	59.473	0.073	0.0	1.8	1.8	1.9	O K
600 min Summer	59.452	0.052	0.0	1.8	1.8	1.0	O K
720 min Summer	59.429	0.029	0.0	1.8	1.8	0.3	O K
960 min Summer	59.400	0.000	0.0	1.6	1.6	0.0	O K
1440 min Summer	59.400	0.000	0.0	1.1	1.1	0.0	O K
2160 min Summer	59.400	0.000	0.0	0.8	0.8	0.0	O K
2880 min Summer	59.400	0.000	0.0	0.6	0.6	0.0	O K
4320 min Summer	59.400	0.000	0.0	0.5	0.5	0.0	O K
5760 min Summer	59.400	0.000	0.0	0.4	0.4	0.0	O K
7200 min Summer	59.400	0.000	0.0	0.3	0.3	0.0	O K
8640 min Summer	59.400	0.000	0.0	0.3	0.3	0.0	O K
10080 min Summer	59.400	0.000	0.0	0.2	0.2	0.0	O K
15 min Winter	59.575	0.175	0.0	1.8	1.8	6.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	100.627	0.0	6.9	17
30 min Summer	65.774	0.0	9.4	30
60 min Summer	40.926	0.0	11.7	48
120 min Summer	24.593	0.0	14.3	82
180 min Summer	18.013	0.0	15.8	116
240 min Summer	14.357	0.0	16.9	148
360 min Summer	10.406	0.0	18.4	212
480 min Summer	8.279	0.0	19.5	272
600 min Summer	6.929	0.0	20.3	328
720 min Summer	5.988	0.0	21.1	378
960 min Summer	4.753	0.0	22.3	0
1440 min Summer	3.428	0.0	24.1	0
2160 min Summer	2.468	0.0	25.9	0
2880 min Summer	1.953	0.0	27.2	0
4320 min Summer	1.402	0.0	28.9	0
5760 min Summer	1.107	0.0	30.1	0
7200 min Summer	0.922	0.0	31.0	0
8640 min Summer	0.793	0.0	31.7	0
10080 min Summer	0.698	0.0	32.2	0
15 min Winter	100.627	0.0	7.9	17

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	59.606	0.206	0.0	1.9	1.9	7.9	O K
60 min Winter	59.611	0.211	0.0	1.9	1.9	8.2	O K
120 min Winter	59.591	0.191	0.0	1.8	1.8	7.2	O K
180 min Winter	59.562	0.162	0.0	1.8	1.8	6.0	O K
240 min Winter	59.534	0.134	0.0	1.8	1.8	4.7	O K
360 min Winter	59.485	0.085	0.0	1.8	1.8	2.5	O K
480 min Winter	59.444	0.044	0.0	1.8	1.8	0.7	O K
600 min Winter	59.400	0.000	0.0	1.7	1.7	0.0	O K
720 min Winter	59.400	0.000	0.0	1.4	1.4	0.0	O K
960 min Winter	59.400	0.000	0.0	1.1	1.1	0.0	O K
1440 min Winter	59.400	0.000	0.0	0.8	0.8	0.0	O K
2160 min Winter	59.400	0.000	0.0	0.6	0.6	0.0	O K
2880 min Winter	59.400	0.000	0.0	0.5	0.5	0.0	O K
4320 min Winter	59.400	0.000	0.0	0.3	0.3	0.0	O K
5760 min Winter	59.400	0.000	0.0	0.3	0.3	0.0	O K
7200 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
8640 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K
10080 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	65.774	0.0	10.5	30
60 min Winter	40.926	0.0	13.4	50
120 min Winter	24.593	0.0	16.1	88
180 min Winter	18.013	0.0	17.8	126
240 min Winter	14.357	0.0	18.9	160
360 min Winter	10.406	0.0	20.6	224
480 min Winter	8.279	0.0	21.9	278
600 min Winter	6.929	0.0	22.9	0
720 min Winter	5.988	0.0	23.8	0
960 min Winter	4.753	0.0	25.1	0
1440 min Winter	3.428	0.0	27.1	0
2160 min Winter	2.468	0.0	29.2	0
2880 min Winter	1.953	0.0	30.6	0
4320 min Winter	1.402	0.0	32.7	0
5760 min Winter	1.107	0.0	34.1	0
7200 min Winter	0.922	0.0	35.1	0
8640 min Winter	0.793	0.0	35.9	0
10080 min Winter	0.698	0.0	36.5	0

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)	20.200	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.041

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.041

Model Details

Storage is Online Cover Level (m) 60.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	41.7	Slope (1:X)	500.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	59.400	Cap Volume Depth (m)	0.400

Hydro-Brake Optimum® Outflow Control

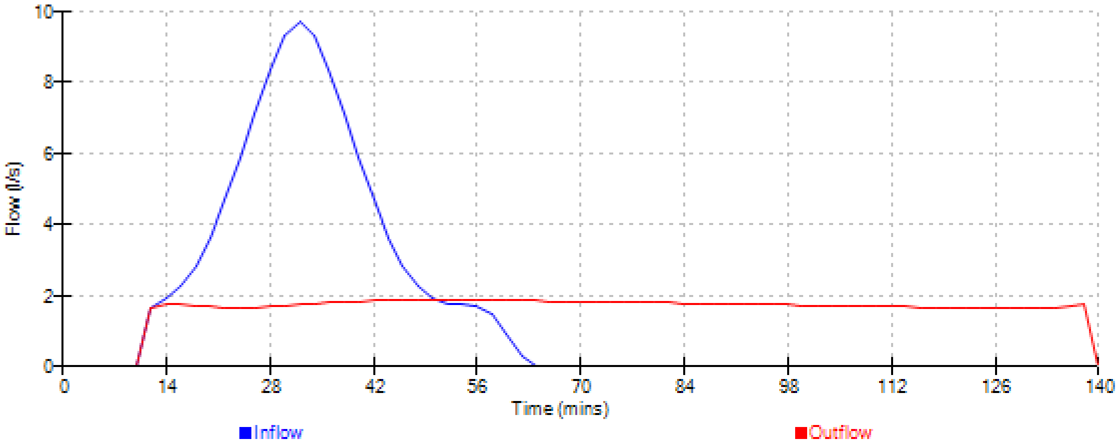
Unit Reference	MD-SHE-0071-2000-0700-2000
Design Head (m)	0.700
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	71
Invert Level (m)	59.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

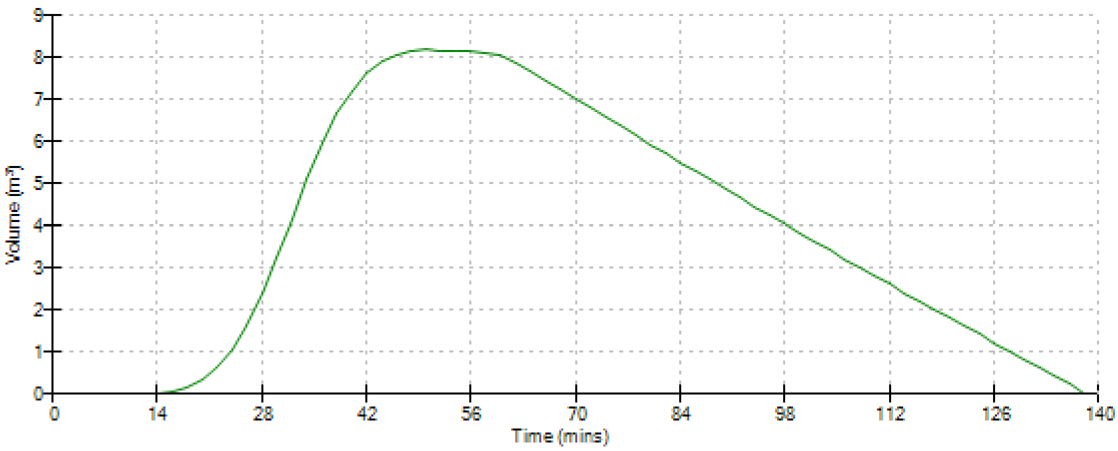
Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.700	2.0
Flush-Flo™	0.206	2.0
Kick-Flo®	0.446	1.6
Mean Flow over Head Range	-	1.7

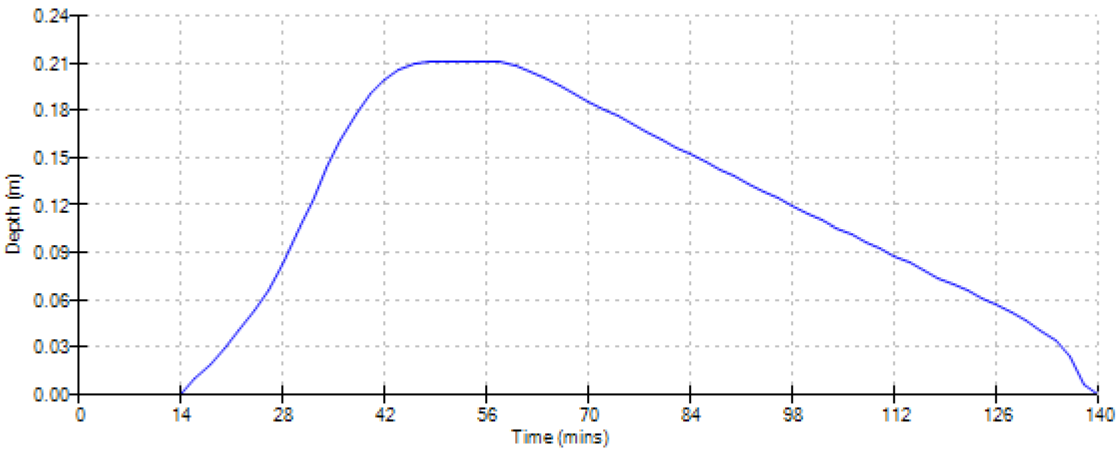
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	1.8	1.200	2.5	3.000	3.9	7.000	5.7
0.200	2.0	1.400	2.7	3.500	4.1	7.500	5.9
0.300	1.9	1.600	2.9	4.000	4.4	8.000	6.1
0.400	1.8	1.800	3.0	4.500	4.7	8.500	6.3
0.500	1.7	2.000	3.2	5.000	4.9	9.000	6.5
0.600	1.8	2.200	3.3	5.500	5.1	9.500	6.7
0.800	2.1	2.400	3.5	6.000	5.3		
1.000	2.3	2.600	3.6	6.500	5.5		

Event: 60 min Winter







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

Half Drain Time : 69 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	59.622	0.222	0.0	1.9	1.9	8.6	O K
30 min Summer	59.664	0.264	0.0	1.9	1.9	10.6	O K
60 min Summer	59.678	0.278	0.0	1.9	1.9	11.2	O K
120 min Summer	59.664	0.264	0.0	1.9	1.9	10.5	O K
180 min Summer	59.645	0.245	0.0	1.9	1.9	9.7	O K
240 min Summer	59.625	0.225	0.0	1.9	1.9	8.8	O K
360 min Summer	59.586	0.186	0.0	1.8	1.8	7.0	O K
480 min Summer	59.552	0.152	0.0	1.8	1.8	5.5	O K
600 min Summer	59.522	0.122	0.0	1.8	1.8	4.1	O K
720 min Summer	59.497	0.097	0.0	1.8	1.8	3.0	O K
960 min Summer	59.459	0.059	0.0	1.8	1.8	1.3	O K
1440 min Summer	59.400	0.000	0.0	1.6	1.6	0.0	O K
2160 min Summer	59.400	0.000	0.0	1.2	1.2	0.0	O K
2880 min Summer	59.400	0.000	0.0	0.9	0.9	0.0	O K
4320 min Summer	59.400	0.000	0.0	0.7	0.7	0.0	O K
5760 min Summer	59.400	0.000	0.0	0.5	0.5	0.0	O K
7200 min Summer	59.400	0.000	0.0	0.4	0.4	0.0	O K
8640 min Summer	59.400	0.000	0.0	0.4	0.4	0.0	O K
10080 min Summer	59.400	0.000	0.0	0.3	0.3	0.0	O K
15 min Winter	59.650	0.250	0.0	1.9	1.9	9.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	140.877	0.0	10.0	17
30 min Summer	92.084	0.0	13.4	31
60 min Summer	57.296	0.0	17.0	54
120 min Summer	34.430	0.0	20.4	86
180 min Summer	25.218	0.0	22.4	120
240 min Summer	20.099	0.0	23.8	154
360 min Summer	14.568	0.0	26.0	220
480 min Summer	11.591	0.0	27.6	286
600 min Summer	9.701	0.0	28.9	346
720 min Summer	8.384	0.0	30.0	406
960 min Summer	6.655	0.0	31.6	520
1440 min Summer	4.799	0.0	34.2	0
2160 min Summer	3.455	0.0	36.8	0
2880 min Summer	2.734	0.0	38.7	0
4320 min Summer	1.963	0.0	41.4	0
5760 min Summer	1.550	0.0	43.2	0
7200 min Summer	1.290	0.0	44.6	0
8640 min Summer	1.110	0.0	45.7	0
10080 min Summer	0.977	0.0	46.6	0
15 min Winter	140.877	0.0	11.4	17

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	59.701	0.301	0.0	2.0	2.0	12.2	Flood Risk
60 min Winter	59.723	0.323	0.0	2.0	2.0	13.2	Flood Risk
120 min Winter	59.704	0.304	0.0	2.0	2.0	12.3	Flood Risk
180 min Winter	59.676	0.276	0.0	1.9	1.9	11.1	O K
240 min Winter	59.645	0.245	0.0	1.9	1.9	9.7	O K
360 min Winter	59.587	0.187	0.0	1.8	1.8	7.1	O K
480 min Winter	59.537	0.137	0.0	1.8	1.8	4.8	O K
600 min Winter	59.495	0.095	0.0	1.8	1.8	2.9	O K
720 min Winter	59.460	0.060	0.0	1.8	1.8	1.3	O K
960 min Winter	59.400	0.000	0.0	1.6	1.6	0.0	O K
1440 min Winter	59.400	0.000	0.0	1.2	1.2	0.0	O K
2160 min Winter	59.400	0.000	0.0	0.8	0.8	0.0	O K
2880 min Winter	59.400	0.000	0.0	0.7	0.7	0.0	O K
4320 min Winter	59.400	0.000	0.0	0.5	0.5	0.0	O K
5760 min Winter	59.400	0.000	0.0	0.4	0.4	0.0	O K
7200 min Winter	59.400	0.000	0.0	0.3	0.3	0.0	O K
8640 min Winter	59.400	0.000	0.0	0.3	0.3	0.0	O K
10080 min Winter	59.400	0.000	0.0	0.2	0.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	92.084	0.0	15.1	31
60 min Winter	57.296	0.0	19.0	58
120 min Winter	34.430	0.0	22.9	92
180 min Winter	25.218	0.0	25.2	130
240 min Winter	20.099	0.0	26.9	168
360 min Winter	14.568	0.0	29.3	236
480 min Winter	11.591	0.0	31.0	302
600 min Winter	9.701	0.0	32.5	362
720 min Winter	8.384	0.0	33.7	418
960 min Winter	6.655	0.0	35.6	0
1440 min Winter	4.799	0.0	38.5	0
2160 min Winter	3.455	0.0	41.4	0
2880 min Winter	2.734	0.0	43.5	0
4320 min Winter	1.963	0.0	46.6	0
5760 min Winter	1.550	0.0	48.7	0
7200 min Winter	1.290	0.0	50.3	0
8640 min Winter	1.110	0.0	51.6	0
10080 min Winter	0.977	0.0	52.7	0

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)	20.200	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.041

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.041

Model Details

Storage is Online Cover Level (m) 60.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	5.0
Membrane Percolation (mm/hr)	1000	Length (m)	30.0
Max Percolation (l/s)	41.7	Slope (1:X)	500.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	59.400	Cap Volume Depth (m)	0.400

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0071-2000-0700-2000
Design Head (m)	0.700
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	71
Invert Level (m)	59.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.700	2.0
Flush-Flo™	0.206	2.0
Kick-Flo®	0.446	1.6
Mean Flow over Head Range	-	1.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	1.8	1.200	2.5	3.000	3.9	7.000	5.7
0.200	2.0	1.400	2.7	3.500	4.1	7.500	5.9
0.300	1.9	1.600	2.9	4.000	4.4	8.000	6.1
0.400	1.8	1.800	3.0	4.500	4.7	8.500	6.3
0.500	1.7	2.000	3.2	5.000	4.9	9.000	6.5
0.600	1.8	2.200	3.3	5.500	5.1	9.500	6.7
0.800	2.1	2.400	3.5	6.000	5.3		
1.000	2.3	2.600	3.6	6.500	5.5		

Event: 60 min Winter