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Consulting Structural & Civil Engineers

Northwood and Pinner Cottage Hospital, Pinner Road, HA6 1DE Drainage Strategy

Rev A (1st Issue) – 15h May 2020

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A	Issued for Planning	15.05.20	TM
B	Incorporate comments from Planning Consultant	11.03.21	TM
Revision	Purpose	Date	Checked

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1 Site Location and Setting

The proposed development site is centred at approximate National Grid Reference (510127, 190706) and comprises of the Northwood Health Centre and the former Northwood and Pinner Cottage Hospital.

The proposed areas for re-development total approximately 7413m^2 with 1473 m^2 of Health Care floor space and 5949m^2. The development area is currently 61% impermeable.

The topographical site survey carried out by Alan Rhodes Associates in July 2017. The survey indicates ground levels fall in a south-westerly direction and existing levels range from The survey indicates ground levels fall in a south-westerly direction and existing levels range from 71m AOD at Pinner Road to 75m AOD in the north-east corner of the site.

The British Geological Survey (BGS) geological map for the area shows that the site's solid geology is 'London Clay Formation' - Clay, silt and sand. There are no records of superficial deposits. The BGS archive contains one record of a borehole sunk in the general vicinity of the Site. The borehole is located approximately 50m east of the site boundary and is identified by the BGS as TQ19SW40. The borehole proves approximately 0.2 m of made ground overlying the London Clay Formation to a depth of approximately 12 m below ground level (bgl). The Lambeth Group is present beneath the London Clay to a depth of 27 m bgl followed by the Seaford and Newhaven Formations to a maximum proved depth (i.e. the formation was not penetrated) of 91 m bgl.

A phase 2 Geo-environmental and Geotechnical Site Investigation was carried out by RSK in August 2020 ref. 192113401 (00). This confirmed the general finding from the BGS with 0.2-1.2m of made ground overlaying 7.3m-11.6m of London Clay overlaying the Lambeth Group to 11m+.

2 Proposed Development

This redevelopment includes the demolition of the existing healthcare practice with the construction of two new 4-storey residential block and the refurbishment of the existing cottage hospital into the new Healthcare Centre. This report summarises the brief, the existing buildings and the structural framing required to achieve the proposed redevelopment.

The proposed structure for the residential blocks is as follows;

- Columns typically 200x800, located within partitions /walls
- Flat slab typically 250mm, locally thickened
- Stability cores 250mm thick
- Steel framing to form the mansard roof with a hung plant platform
- 600mm diameter piled pad foundations

The original construction from 1925 for the healthcare centre is proposed to be retained, with local repair works where required. Later additions are to be demolished with a new 2 storey wing constructed to the north east. The proposed structure for this wing is as follows;

- Load bearing masonry walls and partitions
- Steel frame with timber joisted floor
- 600mm diameter piled foundations with a movement joint between the existing and new construction

3 Surface Water Runoff Rates

The discharge from the site must not impact the flood risk of the surrounding developments both upstream and downstream of the site.

The peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event.

In addition to this, the runoff volume for the 1 in 100-year, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event. However, where it is not reasonably practicable to constrain the volume the runoff volume must be discharged at a rate that does not adversely affect flood risk.

As part of the Flood Risk Assessment written by PBA in December 2017 they contacted Thames Water to determine the allowable discharge rates from the site and capacity within the public surface water sewer. Thames Water's response was as follows:

"Only when it can be proven that soakage into the ground or a connection into the adjacent watercourse is not possible would we consider a restricted discharge into the public surface water sewer network.

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We would encourage techniques such as green roofs and/or permeable paving that restricts surface water discharge from your site.

When redeveloping an existing site, policy 5.13 of the London Plan and Policy 3.4 of the Supplementary Planning Guidance (Sustainable Design and Construction) states that every attempt should be made to use flow attenuation and SUDS/storage to reduce the surface water discharge from the site as much as possible.

If they are consulted as part of any planning application Thames Water Planning team would ask to see why it is not practicable to attenuate the flows to Greenfield run-off rates i.e. 5 l/s hectare of the total site area or if the site is less than hectare in size, then the flows should be reduced by 95% of existing flows. Should the policy above be followed, we would envisage no capacity concerns with regards to surface water for this site."

The catchment areas for the existing site drainage layout have been taken from the Alan Rhodes topographical survey drawings and are broken down as follows:

		Area (m²)	Runoff Coefficien	Factored Area (m²)	Total (m²)	Total Factored
Existing D'velpmnt	Roof	2970	0.95	2821.5	9917	6262.95
	Green Roof	0	0.4	0		
	Hardstanding	3157	0.85	2683.45		
	Soft Landscaping	3790	0.2	758		

3.1 Greenfield Runoff Rate Calculation

Using the ICP SUDS Rural Runoff Calculator within Microdrainage the following values have been calculated for the 0.99ha development site catchments. As the site is currently developed (brownfield) and approx. 61% impermeable an urban factor of 0.5 has been applied The results of the calculation are shown below:

```
ICP SUDS Mean Annual Flood

Input

Return Period (years)     1  SAAR (mm)   600        Urban    0.500
          Area (ha)   0.990       Soil  0.300  Region Number  Region 6

Results  l/s

QBAR Rural  1.5
QBAR Urban  3.9

Q1 year  3.3

Q1 year  3.3
Q30 years  7.3
Q100 years  8.8
```

In order to keep the volume of the attenuation down to a minimum a variable flow rate discharge unit (complex outfall) will be used. This means that the corresponding restriction can be applied to the 1:1yr, 1:30yr and 1:100yr rather than restricting the flow to only one of the return periods. Using only one return period could lead to potentially discharging too great a flow for the more frequent storms, or over designing the attenuation for the less frequent.

$Qbar_{urban}$ for the site is shown to be 3.9l/s therefore. A restriction of flows from the site will be set to match the $Qbar_{urban}$ value of 3.9l/s for the 1yr storm, 7.3l/s for the Q30 and 8.8l/s for the 1:100yr flows from the 1.0 ha proposed development site.

3.2 Climate Change

Referencing the gov.uk website we have used table 2 to set our climate change values.

Table 2 peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline)

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

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The proposed development is a mix of; a residential which is considered to have a lifetime of 100 years, and a health centre, which is considered to have a lifetime of approximately 60 years. Based on the longer development lifetime of 100 years, the range of climate change allowances to be considered for the proposed development are 20% to 40%.

4 Hierarchy of Surface Water Disposal

When developing or redeveloping a site, the control and dispersion of surface water falling on the site's catchment always has to be considered. Wherever possible runoff from developments should be managed on the surface. This enables their performance to be more easily inspected and managed with pollution incidents and potential flood risk being visible. But due to the nature of some developments this is not always possible.

If surface water is to be discharged from the site Planning Practice Guidelines state "Generally, the aim should be to discharge surface runoff as high up the following hierarchy of drainage options as reasonably practicable:

1. Into the ground (infiltration)
2. To a surface water body;
3. To a surface water sewer, highway drain or another drainage system;
4. To a combined sewer."

It is recommended to manage surface water as close to the source i.e. where the rain falls. The effective of control and management of surface water runoff will need to be addressed through the application of the above drainage hierarchy

4.1 Discharge to Ground (Infiltration)

The PBA 'Phase 1 Ground Condition Assessment (Contamination and Stability)' report dated August 2017 indicates that the site is underlain by the London Clay Formation and the Lambeth Group with White Chalk located at depth (>60m bgl)

The clays underlying the site are likely to be of low permeability and therefore it is considered that the use of infiltration drainage is unlikely to be feasible at the site. This option has therefore been discounted.

4.2 Discharge to a Surface Water Body

There are no surface water bodies on site or in the vicinity. Discharge to a surface water body is not possible.

4.3 Discharge to a Surface Water Sewer

It is our intention to maintain the existing discharge regime for the surface water from the site and connect into the existing below ground gravity drainage (albeit with a restricted and attenuated discharge rate) and allow the flows to continue to outfall to the public surface water sewer. As set out in the Non-Statutory Technical Standards for Sustainable Drainage the flow rate should be a close as practically possible to matching the 1:1yr and 1:100yr greenfield runoff rate but not exceed the discharge from the previous development.

4.4 Discharge to a Combined Sewer

This option is not applicable as there are no combined sewers in the vicinity.

5 Inclusion of Sustainable Drainage Systems (SuDS)

Sustainable drainage is a departure from the traditional approach to draining sites. There are some key principles that influence the planning and design process enabling SuDS to mimic natural drainage by:

- Storing runoff and releasing it slowly (attenuation)
- Harvesting and using the rain close to where it falls
- Allowing water to soak into the ground (infiltration)
- Slowly transporting (conveying) water on the surface
- Filtering out pollutants
- Allowing sediments to settle out by controlling the flow of the water

To fall in line with the recommendations of The Flood and Water Management Act which requires that *"developers are to put SUDS in place in new developments wherever practicable.",* we have reviewed the main SuDS components in line with the suitability for the proposed development.

SuDS components are a physical part of the drainage system and can be categorised as follows:.

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SuDS Component		Description	Suitability for Development
Green Roof		*A planted soil layer is constructed on the roof of a building to create a living surface. Water is stored in the soil layer and absorbed by vegetation.*	Proposed for area shown on the Architect's and Landscape Architect's plans **Feasible**
Rainwater Harvesting		*Rainwater is collected from the roof of a building or from other paved surfaces and stored in an overground or underground tank for treatment and reuse locally. Water could be used for toilet flushing and irrigation.*	Not currently in design but could be used. To be considered in detailed design **Potentially Feasible**
Soakaway		*A soakaway is designed to allow water to quickly soak into permeable layers of soil. Constructed like a dry well, an underground pit is dug filled with gravel or rubble. Water can be piped to a soakaway where it will be stored and allowed to gradually seep into the ground.*	Onsite infiltration tests show the underlying strata to be not suitable for infiltration drainage. **Unfeasible**
Filter Strip		*Filter strips are grassed or planted areas that runoff is allowed to run across to promote infiltration and cleansing.*	Onsite infiltration tests show the underlying strata to be not suitable for infiltration drainage. **Unfeasible**
Permeable Paving		*Paving which allows water to soak through. Can be in the form of paving blocks with gaps between solid blocks or porous paving where water filters through the block itself. Water can be stored in the sub-base beneath or allowed to infiltrate into ground below.*	External areas could utilise permeable paving discharging to a tanked subbase due to lack of infiltration suitability. **Feasible**
Bioretention Area		*A vegetated area with gravel and sand layers below designed to channel, filter and cleanse water vertically. Water can infiltrate into the ground below or drain to a perforated pipe and be conveyed elsewhere. Bioretention systems can be integrated with tree-pits or gardens.*	Not currently in design but could be used. Planted areas adjacent to parking could be used. To be considered in detailed design **Potentially Feasible**
Swales		*Swales are vegetated shallow depressions designed to convey and filter water. These can be 'wet' where water gathers above the surface, or 'dry' where water gathers in a gravel layer beneath. Can be lined or unlined to allow infiltration.*	Not currently in design but could be used. To be considered in detailed design **Potentially Feasible**
Pond/Basin		*Ponds can be used to store and treat water. 'Wet' ponds have a constant body of water and run-off is additional, while 'dry' ponds are empty during periods without rainfall. Ponds can be designed to allow infiltration into the ground or to store water for a period of time before discharge.*	Not currently in design but could be used. Small pond could be located in landscaping. To be considered in detailed design **Potentially Feasible**

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Wetland		*Wetlands are shallow vegetated water bodies with a varying water level. Specially selected plant species are used to filter water. Water flows horizontally and is gradually treated before being discharged. Wetlands can be integrated with a natural or hardscape environment.*	Not enough space on the development to warrant feature being specified. **Unfeasible**
Underground Storage		*Water can be stored in tanks, gravel or plastic crates beneath the ground to provide attenuation.*	Proposed for attenuation features. **Feasible**

The proposals will utilise the green roofs to the residential and health care centre as well as underground storage as calculated in section 6.

6 Design of Attenuation Storage

The below ground drainage will be designed to ensure:

- No surcharging for the 1:1yr storm
- No flooding for all storms up to and including the critical 1:30yr storm
- Any flooding experienced for all storms in excess of 1:30yr and up to and including the 1:100yr storm will need to be contained on site posing no risk to the building or affecting safe egress from site.
- The design will be checked for the impact of climate change on the 1:100yr storm

As previously mentioned, the 1:1yr storm will be restricted to 3.9l/s, 7.3l/s for the 1:30yr and 8.8l/s for the 1:100yr flows from the 1.0 ha proposed development site. Checks will be made for the additional 40% allowance for climate change.

The catchment areas for the proposed site drainage layout are broken down as follows:

		Area (m²)	Runoff Coefficien	Factored Area (m²)	Total (m²)	Total Factored
Proposed D'velpmnt	Roof	2523	0.95	2396.85	9917	7875.6
	Green Roof	373	0.4	149.2		
	Hardstanding	6039	0.85	5133.15		
	Soft Landscaping	982	0.2	196.4		

In order to restrict the flows ensure that no flooding occurs for the 1:100yr + 40%, 596m³ of storage volume will be required. This will be stored below ground within attenuation crates or, if used, within the voided subbase of any permeable paving. Refer to Appendix A for MicroDrainage Calculations.

7 Surface Water Management Proposal

All drainage on the site will be private and not up for adoption by water authority. An operations and maintenance manual will be issued to the onsite maintenance team at the end of the construction recommending routine tasks and timeframes to ensure that the below ground drainage is maintained in an operable state.

8 Foul Water Drainage

As part of the Flood Risk Assessment written by PBA in December 2017 they contacted Thames Water to determine the allowable foul discharge rates from the site and capacity within the public foul water sewer. Thames Water's response was as follows:

"The existing foul sewer network does have sufficient capacity to accommodate the proposed foul water discharge from the proposed development."

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9 Conclusions and compliance with planning policy

This drainage strategy has been written with note to the council's water cycle strategy of reduce, recycle and re-use. Given the ground conditions the reduction of the surface water into the sewer system is limited however green roofs have been utilised to reduce some of the surface water flows. The scheme does not have any rainwater harvesting and therefore no recycle or re-use of surface water has been utilised.

As set out in the 'Planning and Flood Risk' section in National Planning Policy Framework (NPPF), 'Policy SI 13 Sustainable drainage' in the London Plan (2021) and the sustainability objectives set out in the Hillingdon Local Plan (Part 1 and 2), this drainage strategy sets out SUDS systems (green roofs and attenuation tanks) that are appropriate to the ground conditions to discharge into the surface water system at greenfield run-off rates.

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Appendix A Microdrainage Calculations

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Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.484	0.084	2.0	62.6	O K
30 min Summer	8.507	0.107	2.7	80.6	O K
60 min Summer	8.532	0.132	3.1	99.2	O K
120 min Summer	8.555	0.155	3.5	116.5	O K
180 min Summer	8.566	0.166	3.6	124.8	O K
240 min Summer	8.572	0.172	3.7	129.1	O K
360 min Summer	8.577	0.177	3.8	133.1	O K
480 min Summer	8.580	0.180	3.8	135.3	O K
600 min Summer	8.582	0.182	3.8	136.4	O K
720 min Summer	8.582	0.182	3.8	136.8	O K
960 min Summer	8.581	0.181	3.8	136.0	O K
1440 min Summer	8.575	0.175	3.7	131.3	O K
2160 min Summer	8.563	0.163	3.6	122.0	O K
2880 min Summer	8.550	0.150	3.4	112.9	O K
4320 min Summer	8.530	0.130	3.1	97.4	O K
5760 min Summer	8.515	0.115	2.8	85.9	O K
7200 min Summer	8.503	0.103	2.6	77.5	O K
8640 min Summer	8.496	0.096	2.4	71.7	O K
10080 min Summer	8.490	0.090	2.2	67.4	O K
15 min Winter	8.484	0.084	2.0	62.7	O K
30 min Winter	8.508	0.108	2.7	80.7	O K
60 min Winter	8.532	0.132	3.1	99.3	O K
120 min Winter	8.556	0.156	3.5	116.8	O K
180 min Winter	8.567	0.167	3.6	125.3	O K
240 min Winter	8.573	0.173	3.7	129.9	O K
360 min Winter	8.577	0.177	3.8	132.8	O K
480 min Winter	8.579	0.179	3.8	134.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	33.197	0.0	51.2	26
30 min Summer	21.439	0.0	69.5	41
60 min Summer	13.379	0.0	98.0	68
120 min Summer	8.170	0.0	121.4	126
180 min Summer	6.091	0.0	136.7	182
240 min Summer	4.938	0.0	148.3	240
360 min Summer	3.650	0.0	165.1	294
480 min Summer	2.938	0.0	177.5	356
600 min Summer	2.483	0.0	187.7	424
720 min Summer	2.164	0.0	196.4	492
960 min Summer	1.742	0.0	210.6	628
1440 min Summer	1.283	0.0	231.4	900
2160 min Summer	0.946	0.0	265.9	1296
2880 min Summer	0.761	0.0	284.6	1676
4320 min Summer	0.560	0.0	310.6	2424
5760 min Summer	0.451	0.0	340.4	3120
7200 min Summer	0.381	0.0	358.2	3824
8640 min Summer	0.332	0.0	372.7	4576
10080 min Summer	0.296	0.0	384.0	5256
15 min Winter	33.197	0.0	51.2	26
30 min Winter	21.439	0.0	69.5	40
60 min Winter	13.379	0.0	98.0	68
120 min Winter	8.170	0.0	121.4	124
180 min Winter	6.091	0.0	136.7	180
240 min Winter	4.938	0.0	148.3	234
360 min Winter	3.650	0.0	165.1	302
480 min Winter	2.938	0.0	177.6	374

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
600 min Winter	8.579	0.179	3.8	134.4	O K
720 min Winter	8.578	0.178	3.8	133.6	O K
960 min Winter	8.574	0.174	3.7	130.5	O K
1440 min Winter	8.563	0.163	3.6	121.9	O K
2160 min Winter	8.545	0.145	3.3	108.4	O K
2880 min Winter	8.529	0.129	3.1	96.6	O K
4320 min Winter	8.506	0.106	2.7	79.1	O K
5760 min Winter	8.492	0.092	2.3	69.2	O K
7200 min Winter	8.484	0.084	2.0	62.7	O K
8640 min Winter	8.477	0.077	1.8	57.9	O K
10080 min Winter	8.472	0.072	1.6	54.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	2.483	0.0	187.7	450
720 min Winter	2.164	0.0	196.4	526
960 min Winter	1.742	0.0	210.6	674
1440 min Winter	1.283	0.0	231.5	958
2160 min Winter	0.946	0.0	265.9	1364
2880 min Winter	0.761	0.0	284.7	1740
4320 min Winter	0.560	0.0	310.8	2468
5760 min Winter	0.451	0.0	340.6	3176
7200 min Winter	0.381	0.0	358.5	3896
8640 min Winter	0.332	0.0	373.1	4664
10080 min Winter	0.296	0.0	384.5	5352

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.435	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.771

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.257	4	8	0.257	8	12	0.257

Green Roof

Area (m³)	373	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.006778	32	36	0.001368	64	68	0.000276	96	100	0.000056
4	8	0.005549	36	40	0.001120	68	72	0.000226	100	104	0.000046
8	12	0.004544	40	44	0.000917	72	76	0.000185	104	108	0.000037
12	16	0.003720	44	48	0.000751	76	80	0.000152	108	112	0.000031
16	20	0.003046	48	52	0.000615	80	84	0.000124	112	116	0.000025
20	24	0.002494	52	56	0.000503	84	88	0.000102	116	120	0.000021
24	28	0.002042	56	60	0.000412	88	92	0.000083			
28	32	0.001671	60	64	0.000337	92	96	0.000068			

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

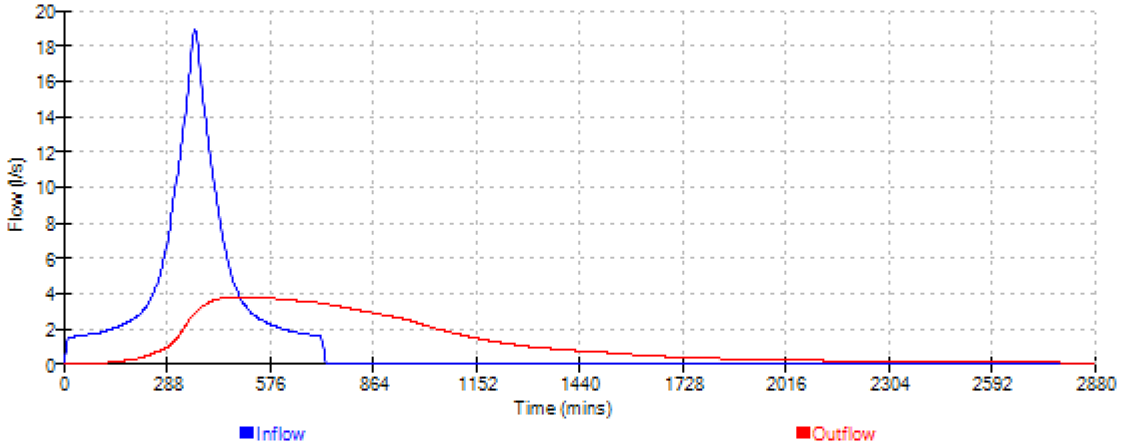
Invert Level (m) 8.400

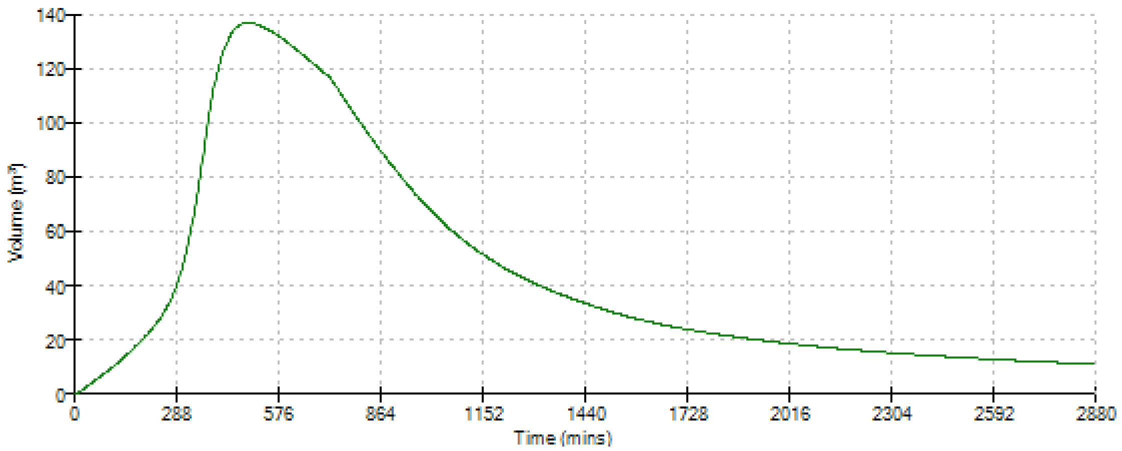
Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	750.0	2.400	0.0	4.800	0.0	7.200	0.0	9.600	0.0
0.400	750.0	2.800	0.0	5.200	0.0	7.600	0.0	10.000	0.0
0.800	750.0	3.200	0.0	5.600	0.0	8.000	0.0		
0.801	0.0	3.600	0.0	6.000	0.0	8.400	0.0		
1.600	0.0	4.000	0.0	6.400	0.0	8.800	0.0		
2.000	0.0	4.400	0.0	6.800	0.0	9.200	0.0		

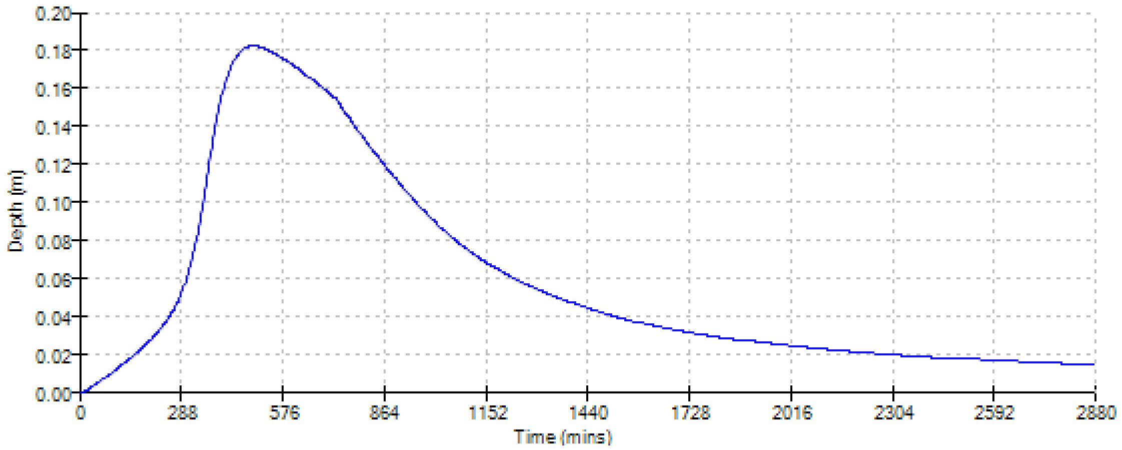
Orifice Outflow Control

Diameter (m) 0.069 Discharge Coefficient 0.600 Invert Level (m) 8.400

Event: 720 min Summer







Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.608	0.208	5.0	155.8	O K
30 min Summer	8.666	0.266	5.8	199.4	O K
60 min Summer	8.721	0.321	6.4	241.0	O K
120 min Summer	8.768	0.368	6.9	276.3	O K
180 min Summer	8.788	0.388	7.1	290.8	O K
240 min Summer	8.795	0.395	7.2	296.4	O K
360 min Summer	8.798	0.398	7.2	298.5	O K
480 min Summer	8.798	0.398	7.2	298.5	O K
600 min Summer	8.796	0.396	7.2	297.2	O K
720 min Summer	8.793	0.393	7.2	294.9	O K
960 min Summer	8.784	0.384	7.1	288.2	O K
1440 min Summer	8.762	0.362	6.9	271.4	O K
2160 min Summer	8.727	0.327	6.5	245.1	O K
2880 min Summer	8.695	0.295	6.1	221.5	O K
4320 min Summer	8.645	0.245	5.5	183.7	O K
5760 min Summer	8.608	0.208	5.0	156.1	O K
7200 min Summer	8.581	0.181	4.6	135.5	O K
8640 min Summer	8.559	0.159	4.2	119.5	O K
10080 min Summer	8.543	0.143	3.9	107.3	O K
15 min Winter	8.608	0.208	5.0	155.9	O K
30 min Winter	8.666	0.266	5.8	199.5	O K
60 min Winter	8.722	0.322	6.4	241.2	O K
120 min Winter	8.769	0.369	6.9	276.8	O K
180 min Winter	8.789	0.389	7.1	291.6	O K
240 min Winter	8.797	0.397	7.2	297.7	O K
360 min Winter	8.799	0.399	7.2	299.4	O K
480 min Winter	8.796	0.396	7.2	297.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	81.530	0.0	145.2	26
30 min Summer	52.321	0.0	189.7	41
60 min Summer	32.061	0.0	248.0	70
120 min Summer	19.063	0.0	296.4	126
180 min Summer	13.919	0.0	325.3	184
240 min Summer	11.091	0.0	345.9	242
360 min Summer	8.041	0.0	376.6	314
480 min Summer	6.397	0.0	399.6	376
600 min Summer	5.354	0.0	418.0	438
720 min Summer	4.628	0.0	433.4	506
960 min Summer	3.675	0.0	458.3	642
1440 min Summer	2.653	0.0	493.8	914
2160 min Summer	1.913	0.0	547.3	1316
2880 min Summer	1.516	0.0	577.3	1704
4320 min Summer	1.092	0.0	619.0	2464
5760 min Summer	0.864	0.0	661.2	3176
7200 min Summer	0.721	0.0	687.8	3896
8640 min Summer	0.621	0.0	709.0	4600
10080 min Summer	0.548	0.0	725.1	5344
15 min Winter	81.530	0.0	145.2	26
30 min Winter	52.321	0.0	189.7	40
60 min Winter	32.061	0.0	248.0	68
120 min Winter	19.063	0.0	296.4	124
180 min Winter	13.919	0.0	325.3	180
240 min Winter	11.091	0.0	345.9	236
360 min Winter	8.041	0.0	376.6	340
480 min Winter	6.397	0.0	399.6	386

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
600 min Winter	8.793	0.393	7.2	294.4	O K
720 min Winter	8.787	0.387	7.1	290.2	O K
960 min Winter	8.772	0.372	7.0	279.3	O K
1440 min Winter	8.740	0.340	6.6	254.7	O K
2160 min Winter	8.693	0.293	6.1	219.7	O K
2880 min Winter	8.654	0.254	5.6	190.3	O K
4320 min Winter	8.596	0.196	4.8	146.9	O K
5760 min Winter	8.557	0.157	4.2	118.1	O K
7200 min Winter	8.531	0.131	3.7	98.5	O K
8640 min Winter	8.514	0.114	3.3	85.1	O K
10080 min Winter	8.503	0.103	3.0	77.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	5.354	0.0	418.0	462
720 min Winter	4.628	0.0	433.4	538
960 min Winter	3.675	0.0	458.3	688
1440 min Winter	2.653	0.0	493.9	980
2160 min Winter	1.913	0.0	547.3	1392
2880 min Winter	1.516	0.0	577.4	1788
4320 min Winter	1.092	0.0	619.3	2552
5760 min Winter	0.864	0.0	661.3	3280
7200 min Winter	0.721	0.0	688.0	3968
8640 min Winter	0.621	0.0	709.4	4664
10080 min Winter	0.548	0.0	725.9	5344

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.435	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.771

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.257	4	8	0.257	8	12	0.257

Green Roof

Area (m^2) 373 Evaporation (mm/day) 3
Depression Storage (mm) 5 Decay Coefficient 0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.006778	32	36	0.001368	64	68	0.000276	96	100	0.000056
4	8	0.005549	36	40	0.001120	68	72	0.000226	100	104	0.000046
8	12	0.004544	40	44	0.000917	72	76	0.000185	104	108	0.000037
12	16	0.003720	44	48	0.000751	76	80	0.000152	108	112	0.000031
16	20	0.003046	48	52	0.000615	80	84	0.000124	112	116	0.000025
20	24	0.002494	52	56	0.000503	84	88	0.000102	116	120	0.000021
24	28	0.002042	56	60	0.000412	88	92	0.000083			
28	32	0.001671	60	64	0.000337	92	96	0.000068			

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

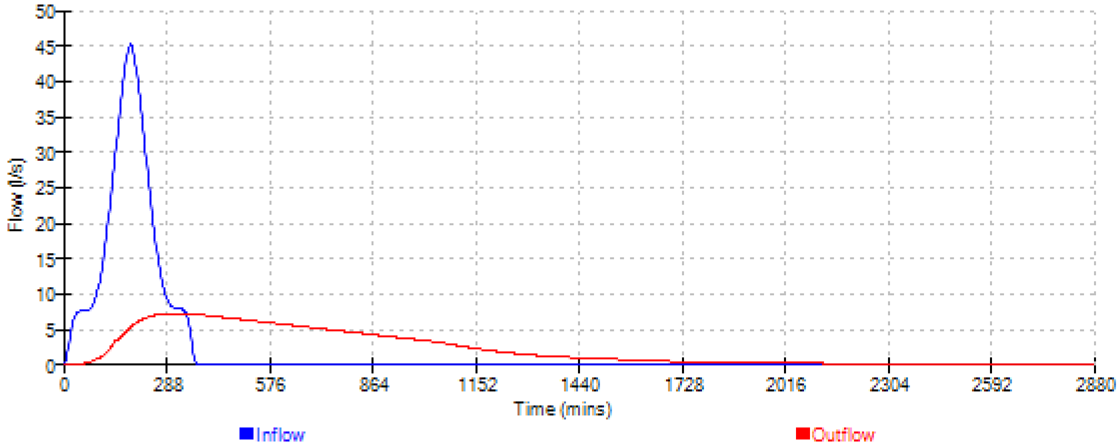
Invert Level (m) 8.400

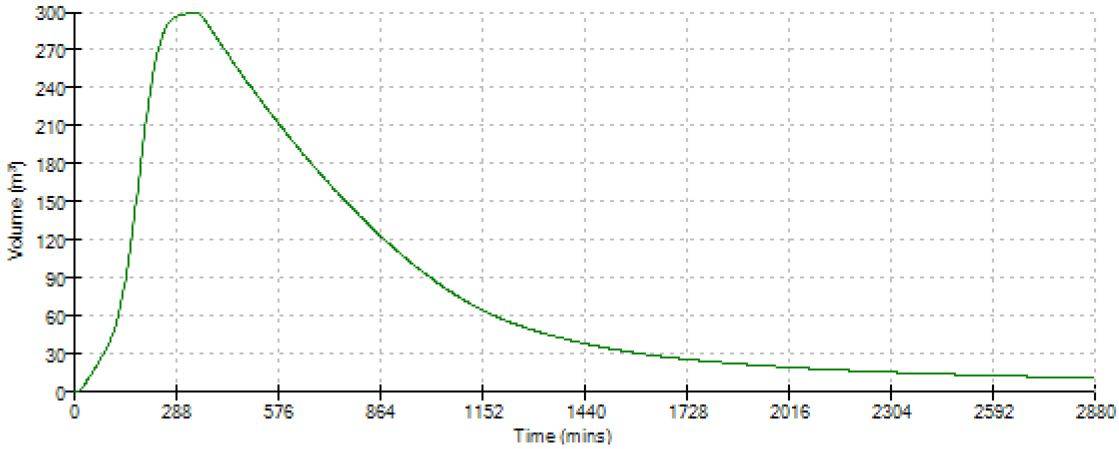
Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	750.0	2.400	0.0	4.800	0.0	7.200	0.0	9.600	0.0
0.400	750.0	2.800	0.0	5.200	0.0	7.600	0.0	10.000	0.0
0.800	750.0	3.200	0.0	5.600	0.0	8.000	0.0		
0.801	0.0	3.600	0.0	6.000	0.0	8.400	0.0		
1.600	0.0	4.000	0.0	6.400	0.0	8.800	0.0		
2.000	0.0	4.400	0.0	6.800	0.0	9.200	0.0		

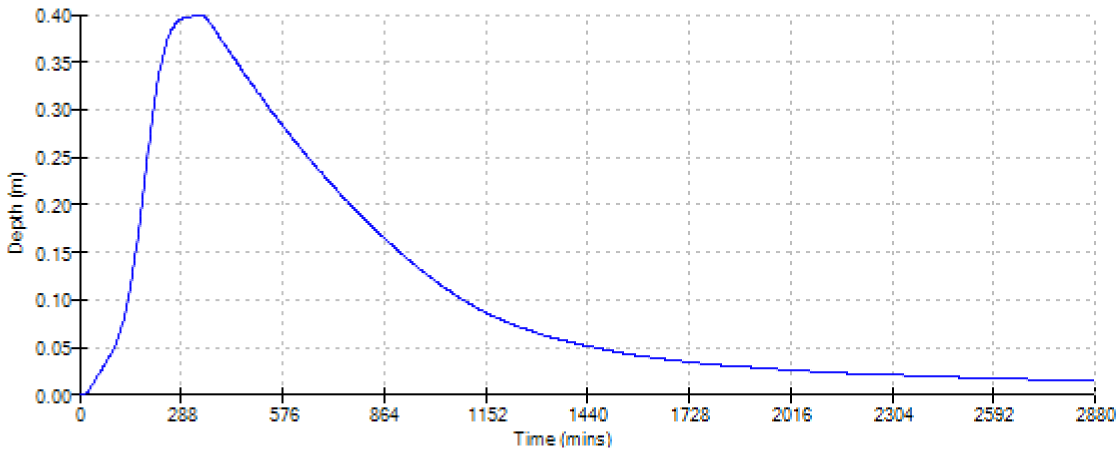
Orifice Outflow Control

Diameter (m) 0.076 Discharge Coefficient 0.600 Invert Level (m) 8.400

Event: 360 min Winter







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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	8.784	0.384	5.9	287.7	O K
30 min Summer	8.896	0.496	6.7	371.9	O K
60 min Summer	9.005	0.605	7.5	453.9	O K
120 min Summer	9.102	0.702	8.1	526.8	O K
180 min Summer	9.147	0.747	8.4	560.2	O K
240 min Summer	9.169	0.769	8.5	577.1	O K
360 min Summer	9.189	0.789	8.6	591.6	O K
480 min Summer	9.190	0.790	8.6	592.7	O K
600 min Summer	9.186	0.786	8.6	589.8	O K
720 min Summer	9.182	0.782	8.6	586.4	O K
960 min Summer	9.170	0.770	8.5	577.7	O K
1440 min Summer	9.141	0.741	8.4	555.6	O K
2160 min Summer	9.090	0.690	8.0	517.4	O K
2880 min Summer	9.040	0.640	7.7	479.8	O K
4320 min Summer	8.952	0.552	7.2	414.1	O K
5760 min Summer	8.882	0.482	6.6	361.2	O K
7200 min Summer	8.825	0.425	6.2	318.4	O K
8640 min Summer	8.778	0.378	5.8	283.4	O K
10080 min Summer	8.739	0.339	5.5	254.5	O K
15 min Winter	8.784	0.384	5.9	287.7	O K
30 min Winter	8.896	0.496	6.7	371.9	O K
60 min Winter	9.005	0.605	7.5	454.1	O K
120 min Winter	9.103	0.703	8.1	527.4	O K
180 min Winter	9.148	0.748	8.4	561.3	O K
240 min Winter	9.172	0.772	8.5	578.8	O K
360 min Winter	9.192	0.792	8.7	594.4	O K
480 min Winter	9.196	0.796	8.7	596.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	148.496	0.0	267.6	27
30 min Summer	96.016	0.0	343.8	42
60 min Summer	59.033	0.0	461.6	70
120 min Summer	35.052	0.0	549.2	128
180 min Summer	25.504	0.0	599.7	186
240 min Summer	20.240	0.0	634.4	246
360 min Summer	14.597	0.0	685.6	362
480 min Summer	11.570	0.0	723.6	474
600 min Summer	9.655	0.0	753.4	520
720 min Summer	8.325	0.0	777.7	580
960 min Summer	6.584	0.0	814.7	704
1440 min Summer	4.724	0.0	857.8	976
2160 min Summer	3.385	0.0	972.9	1388
2880 min Summer	2.670	0.0	1021.6	1792
4320 min Summer	1.908	0.0	1089.0	2592
5760 min Summer	1.503	0.0	1156.1	3352
7200 min Summer	1.248	0.0	1198.2	4104
8640 min Summer	1.072	0.0	1232.1	4840
10080 min Summer	0.942	0.0	1258.6	5552
15 min Winter	148.496	0.0	267.6	27
30 min Winter	96.016	0.0	343.8	41
60 min Winter	59.033	0.0	461.6	70
120 min Winter	35.052	0.0	549.2	126
180 min Winter	25.504	0.0	599.7	184
240 min Winter	20.240	0.0	634.4	240
360 min Winter	14.597	0.0	685.7	354
480 min Winter	11.570	0.0	723.6	462

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
600 min Winter	9.190	0.790	8.6	592.5	O K
720 min Winter	9.181	0.781	8.6	585.7	O K
960 min Winter	9.166	0.766	8.5	574.3	O K
1440 min Winter	9.124	0.724	8.3	543.2	O K
2160 min Winter	9.055	0.655	7.8	491.2	O K
2880 min Winter	8.989	0.589	7.4	442.1	O K
4320 min Winter	8.880	0.480	6.6	360.0	O K
5760 min Winter	8.796	0.396	6.0	297.4	O K
7200 min Winter	8.733	0.333	5.4	249.7	O K
8640 min Winter	8.684	0.284	5.0	212.7	O K
10080 min Winter	8.645	0.245	4.6	183.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
600 min Winter	9.655	0.0	753.5	566
720 min Winter	8.325	0.0	777.8	594
960 min Winter	6.584	0.0	814.9	740
1440 min Winter	4.724	0.0	858.2	1044
2160 min Winter	3.385	0.0	973.0	1488
2880 min Winter	2.670	0.0	1021.7	1908
4320 min Winter	1.908	0.0	1089.2	2724
5760 min Winter	1.503	0.0	1156.2	3512
7200 min Winter	1.248	0.0	1198.4	4256
8640 min Winter	1.072	0.0	1232.5	5008
10080 min Winter	0.942	0.0	1259.4	5664

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	1.000
Region	England and Wales	Cv (Winter)	1.000
M5-60 (mm)	20.800	Shortest Storm (mins)	15
Ratio R	0.435	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.771

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.257	4	8	0.257	8	12	0.257

Green Roof

Area (m³)	373	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.006778	32	36	0.001368	64	68	0.000276	96	100	0.000056
4	8	0.005549	36	40	0.001120	68	72	0.000226	100	104	0.000046
8	12	0.004544	40	44	0.000917	72	76	0.000185	104	108	0.000037
12	16	0.003720	44	48	0.000751	76	80	0.000152	108	112	0.000031
16	20	0.003046	48	52	0.000615	80	84	0.000124	112	116	0.000025
20	24	0.002494	52	56	0.000503	84	88	0.000102	116	120	0.000021
24	28	0.002042	56	60	0.000412	88	92	0.000083			
28	32	0.001671	60	64	0.000337	92	96	0.000068			

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 8.400

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	750.0	2.400	0.0	4.800	0.0	7.200	0.0	9.600	0.0
0.400	750.0	2.800	0.0	5.200	0.0	7.600	0.0	10.000	0.0
0.800	750.0	3.200	0.0	5.600	0.0	8.000	0.0		
0.801	0.0	3.600	0.0	6.000	0.0	8.400	0.0		
1.600	0.0	4.000	0.0	6.400	0.0	8.800	0.0		
2.000	0.0	4.400	0.0	6.800	0.0	9.200	0.0		

Orifice Outflow Control

Diameter (m) 0.069 Discharge Coefficient 0.600 Invert Level (m) 8.400

Evolve		Page 5
20 Baltic Street London EC1Y 0UL	N&P Hospital 1:100YR + 40% CC 8.8l/s	Micro Drainage
Date 01/03/2021 File 210309 Storage Sizing 1...	Designed by PW Checked by	
Innovyze	Source Control 2019.1	

Event: 480 min Winter