

Highgate School Mallinson Sports Centre 4-Phase Scheme Drainage and SuDS Statement



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Executive Summary

The SuDS strategy addressed 3 components required under local and national planning guidance:

- Sustainable Urban Drainage Systems (SuDS) components to be implemented
- Method of controlling discharge rate
- Method of controlling discharge volume

The Highgate School Mallinson Sports Centre 4-Phase Scheme is large and complex with significant falls in multiple directions. Further complication stems from presence of retained buildings on site, which are subject to some minimal changes, do not form part of the works and are excluded from the calculations.

The 4th revision of this document has been updated to reflect the revised site layout. Architectural changes to the north block have been implemented, along with a modification of the roof structure over the infill extension to the rear of the building.

Proposed SuDS

This report looks in detail at all potential SuDS components listed in technical and non-technical recommendations. The site is resting on extensive clay layer which stretches from the surface down to at least 50m thus infiltration is not viable. With poor infiltration and limited space the site is poorly suited to implements extensive SuDS. As the site is as low pollution risk with discharge to surface water sewer, extensive treatment is not required. The following are the proposed SuDS:

- Green Roofs
- Trees
- Attenuation Tank

Proposed Runoff Rate

The report established existing Brownfield and Greenfield discharge rate for each major event (1-in-1 / 30 / 100 year). Give the site is located within Haringey critical drainage area, the report focused on minimising flood risk and achieving discharge as close as possible to the Greenfield Rate.

With complex site and following detailed technical review of the practical and appropriate flow rate to achieve the target greenfield rate, it was found that both 1-in-1year flows were too low and not impractical for the development.

The proposal is to limit the site to 8.0l/s up to 1-in-30-year storm (greenfield rate) and increase this to 12.0l/s for rainfall up to 1-in-100year +40% Climate Change (greenfield rate), thus delivering as close as possible to greenfield runoff rate during higher intensity and more critical rainfall events. Attenuation structures will be designed to capture and store all storms up to 1-in-100year +40% Climate Change event.

Proposed Runoff Volume

Statutory guidance states that the development site discharge volume, when possible, needs to be as close as possible to Greenfield volume.

Existing and proposed volumes were accessed with and without attenuation to understand the level of mitigation offered by SuDS. It was found that for 1-in-30 and 1-in-100-year events the volumes are significantly reduced from existing. During 1-in-1 year storm the volumes have slightly increased, which is mostly the result of site constraint and cannot be easily mitigated.

Other Considerations

The report includes Thames Water capacity check, Haringey Council communication, detailed calculations, Maintenance Plan and Drainage Design Concept. Detailed design cannot be provided due to complexities of the site. Detailed design to be provided at later stages once all key information is known.

1 Project Introduction

The proposed Highgate School Mallinson Sports Centre 4-Phase Scheme is located within an existing school which has a number of existing and newly proposed buildings and extensions of various heights.

The site area within the application red-line boundary is 13,922m² and is approximately L-shaped. The section of the site where all the buildings are is approximately 135m long and 45m to 65m wide. The remaining site is approximately 80m by 60m in size and contain new Orchard Sportsground. The site has significant fall across: At the high end, on both Southern and Eastern corners, the site level is approximately 110m, however in between the level drops down as low as 107.5m. Longitudinally the level drops down to 106 at the Northern corner.

Not all buildings within the red-line boundary are part of the demolition and re-development; Two large buildings will be subject to refurbishment and some alternations to join them together with proposed buildings, however otherwise they will remain in place and drainage will remain mostly unaltered. Discussion was held with Haringey Council regarding drainage strategy for existing buildings and new buildings and the agreement was that retained buildings can be excluded from drainage calculations. The overall roof area of retaining buildings is 1,754m², resulting in overall reduced drainage area to 12,168m².

The site is currently at risk from surface water flood and is located within critical drainage zone. A separate report has been prepared by Edenvale Young showing in detail how flooding will be mitigated and contained within an upstream dam, located between the buildings and the Orchard Sportsground. Based on proposed mitigation measures flooding will be controlled and won't impact the buildings.

The proposal is for various facilities such as new sports hall, five courts, new teaching office, changing room, new entrance foyer and others. For full details of proposed works please refer to Design and Access Statement submitted under separate cover. The overall impermeable area of the site will increase from the existing 2,185m² (18% impermeable) to 3,846m² (32% impermeable).

The development will discharge surface water in line with the requirements of the local planning authority and statutory undertakers and utilize Sustainable Urban Drainage System. Storm water will discharge to existing Thames Water storm water sewer.

Foul water will discharge to Thames Water sewer. Discharge of foul water is outside the scope of this report.

2 Sustainable Drainage Systems (SuDS) Background

This section looks in detail at the drainage and SuDS provision for the development.

2.1 Planning and Technical Considerations

Haringey Council

- We expect the use of sustainable drainage systems (SuDS) in all locations and all major planning applications must demonstrate the use of sustainable drainage as part of their development.

London Plan

- Policy 5.13 and the new London Plan Policy SI 13: A development should utilise Sustainable Urban Drainage Systems (SuDS) unless there are practical reasons for not doing so and should aim to achieve greenfield runoff rates and ensure that surface water runoff is managed as close to its source as possible.

London Plan "Sustainable Design and Construction SPG":

- Clause 3.4.9: There may be situations where it is not appropriate to discharge at Greenfield runoff rates [due to low flow rates and thus risk of blockages]. An appropriate minimum discharge rate would be 5 litres per second per outfall.

The Non-Statutory Technical Standards (NSTS) for Sustainable Drainage Systems set out general recommendations for control of development runoff, including the requirement to ensure that runoff from the site is not increased by development, and the requirement to manage surface water runoff for events up to the 1-in-100year storm (including an additional allowance for the projected impacts of climate change).

2.2 SuDS Principles

The most appropriate means of surface water control and discharge has been determined based on the hierarchy as set out in the NSFS.

Methods for controlling storm water:

- Storing water for later use
- Infiltration
- Attenuate rainwater in ponds or open water features for gradual release
- Attenuate rainwater by storing in tanks or sealed water features for gradual release

Methods for discharging storm water:

- Discharge rainwater direct to a watercourse
- Discharge rainwater to a surface water sewer/drain
- Discharge rainwater to the combined sewer

Methods for Controlling Storm Water

Storing water for later use

Rainwater harvesting is the collection of rainwater runoff for use and is the most common method of storing water for later use. Other options include storing water in ponds for irrigation. Runoff can be collected from traditional roofs and other impermeable areas, stored, treated (where required) and used as a supply for water for domestic, commercial, industrial and/or institutional properties. Such systems are not intended to control peak runoff rate during critical events and are mainly useful during medium and small events, to capture runoff and thus reduce the over volume entering the drainage system.

Infiltration Techniques

Infiltration is a key planning, building regulations and public water company requirement. Almost all SuDS components could be designed permeable: soakaways, infiltration trenches, filter strips, basins, bio-retention and paving systems. Infiltration contributes to reducing runoff rates and volumes while supporting base flow and groundwater recharge. The four key criteria have to be satisfied before infiltration into the soil can be considered:

- Ground must be suitable for infiltration
- Groundwater generally needs to be 1.0m below base of infiltrating feature
- Ground must be not contaminated, or SuDS designed so that infiltration will not activate pollution
- Soakaways generally should not be placed closer than 5m to a building (15m for boreholes)

Attenuate rainwater in open water features for gradual release

The most commonly known features are detention basins, ponds and wetlands. All of the features are used to control peak runoff rate, while open ponds or detention basins can reduce volume of runoff through retransformation or infiltration (see above).

Attenuate rainwater in tanks (sealed) systems for gradual release

The most common method of controlling runoff on developed sites is through storage in attenuation tanks. The purpose is to collect the water and slowly release it into the drainage network. The attenuation systems, such as geo-cellular tanks below ground provide no volume reduction benefit.

Methods for discharging storm water

Methods for discharging storm water, if infiltration is not viable, is site dependent.

Discharge rainwater direct to a watercourse

Discharge to a watercourse is preferred as this reduces the need to provide a drainage network, allows recharge to rivers and groundwater, and reduces sewer flooding. Discharge to a tidal river can be unattenuated, whilst in other cases Greenfield rates and volumes are appropriate.

Discharge rainwater to a surface water sewer/drain

British standards require that sewers must be kept separate on-site and discharge storm water to storm water sewer if infiltration is not viable and a watercourse discharge is not possible. The key purpose of separate systems is to minimise storm surcharge to foul treatment stations and improve water quality of receiving water courses.

Discharge rainwater to the combined sewer.

Older parts of the country, especially London, do not have separate sewer systems, and in such instances the only viable option is to connect to combined water sewer or foul water sewer.

2.3 Choice of Calculation Methodologies

CIRIA The SuDS Manual C753 provides an overview of all currently available methods of runoff rate and volume calculation and provides the recommended methodology. Table 2 below is taken from the C753 report, Table 24.1, page 509:

Runoff estimation method	Reference	Greenfield site		Developed site	
		Peak runoff rate	Runoff volume	Peak runoff rate	Runoff volume
FEH ReFH2	Kjeldsen (2007)	✓	✓	✓	✓
FEH Statistical Method	Kjeldsen et al (2009)	✓			
IH124	Marshall and Bayliss (1994)	✓			
FSSR16	NERC (1985)		✓		
Modified Rational Method	HR Wallingford (1981)			✓	
Wallingford – Fixed	HR Wallingford (1981)			(see note)	(see note)
Wallingford – Variable	Packman (1990), Osborne (2009)			✓	✓
UKWIR	UKWIR (2014)			✓	✓

(Note) – No Longer recommended, but still used in software packages.

Table 1 - Calculations Methods, CIRIA The SuDS Manual, C753

The two methods for estimating existing peak runoff rates for the current site, based on preferences set out in CIRIA C753 report are:

- Greenfield rate – IH124
- Developed site – Modified Rational Method

CIRIA C753 report states that Modified Rational Method is relevant for initial design estimates and very simple sites.

The UK has two principle data sets of rainfall data to be used for the calculation of peak runoff and volumes:

- The Flood Studies Report (FSR) was published in the mid-1970s and used rainfall from 1941 - 1970
- The Flood Estimation Handbook (FEH) was published in 1999 and used rainfall from a dataset between 1961 - 1990

The FEH has a more recent dataset and used a larger rainfall record for generating the methodology. FEH concentrated on rainfall event durations of one hour and above and returns 1-in-2year and above.

The FSR report analysed sub-hourly rainfall and therefore is more appropriate for shorter storm durations such as required for modelling below ground drainage systems, where short duration storms are critical.

All calculations for 1-in-1year are completed using FSR methodology, whereas all other rainfall events are completed using FEH methodology using point data.

3 Proposed SuDS Elements

3.1 Proposed SuDS

CIRIA The SuDS Manual C753 provides a good guide on all possible SuDS systems, their use and constraints. The below table summarises all available SuDS options listed in C753 and checks their suitability to the development site. Key Benefit Codes are in accordance to C753 listed as “likely valuable contribution to delivering design criteria”:

- P – Peak runoff reduction
- V – Volume reduction
- Q –Water quality improvement
- A – Amenity
- B - Biodiversity

The site has significant open space and thus offers significant SuDS potential. The overall scheme is to implement higher up elements of the SuDS management train, including swale, detention basin, trees and including other elements such as bioretention if they are practical. Some elements lower down the SuDS management train have been excluded. Discussion regarding discharge rate and volume is covered under a separate section.

Component Type	Key Benefit	Development Site		Details
		Viable	Proposed	
<i>Rainwater Harvesting</i>	V, A	No	No	It is not practical to implement harvesting on this site as the area is on clay and suffers from water logging. External garden areas are minimal.
<i>Green Roofs</i>	V, Q, A, B	Yes	Yes	Green roofs are proposed for suitable roofs.
<i>Infiltration Systems Soakaways</i>	P, V, Q, A, B	No	No	Shallow infiltration is not viable due to superficial clay deposits. Borehole soakaways in chalk are potentially viable, subject to detailed investigation.
<i>Proprietary Treatment Systems</i>	Q	No	No	Not required due to low risk profile of the site and SuDS used.
<i>Trees</i>	P, V, Q, A, B	Yes	Yes	Some new trees are proposed where appropriate.
<i>Pervious Pavements</i>	P, V, Q,	Yes	No	The majority of pavements are small and thus would shed the water to neighbouring grass areas.
<i>Attenuation Storage Tanks</i>	P	Yes	Yes	Below ground or blue roof will be provided to meet peak storage requirements.
<i>Swales, Detention Basins, Bioretention</i>	P, V, Q, A, B	No	No	There is an existing swale on site. There's limited space to provide these SuDS features.
<i>Ponds and Wetlands</i>	P, Q, A, B	No	No	There's limited space to provide these SuDS features.

Table 2 - SUDS proposals, CIRIA SuDS Manual C753

3.2 Proposed Discharge Method

The site is in a fully developed area and is not located near watercourses. There is a Thames Water storm water sewer in the area.

Infiltration is not viable, therefore the site will discharge to existing Thames Water storm water sewer at agreed rate, by constructing a new connection to the sewer. New connections are needed to ensure that the proposed site is not combined with existing unrestricted sewer outfall for existing buildings.

4 Runoff Rates

4.1 Background

The site is not suitable for infiltration; ground investigation has confirmed that the site is clay or various densities from the surface until at least 50m below.

Given limited external space and no infiltration, the only viable means of storing surface water is via attenuation tanks within the site boundary, which would be located around the proposed buildings.

PJCE are also examining alternative arrangements to store attenuation volume behind the new dam and within Orchard Sports Ground flood zone (refer to Flood Risk Assessment to better understand the function of the facility), which is being constructed to protect the development from flooding. To achieve this, a hydro-brake would need to be installed within Thames Water sewer upstream to mimic greenfield rate reduction at the site. Close discussion with Thames Water will be required to achieve this, and a number of practical, technical and legal challenges will need to be addressed to enable this solution. This would be explored post planning.

In both scenarios (attenuation tanks around buildings or storage behind the dam), the site will achieve a discharge rate as outlined below, as close to Greenfield runoff rate as possible, by either directly controlling runoff or mimicking greenfield run-off off-site.

4.2 Existing Runoff Rates

The time of concentration for calculating existing discharge rate was taken at 30 minutes to align with Thames Water methodology. The Greenfield estimation tool has been calculated using FEH data and local soil data.

As the site is in a Haringey Critical Drainage Area. The 3 x Greenfield rate, typically applicable to brownfield sites, is not suitable given site location and flood risk downstream, the development will target Greenfield runoff rate.

The table below summarises existing and Greenfield discharge rates. Existing rate includes only roofs and car parking. Other hard standings, such as pathways, typically drain to grass and is therefore ignored in the calculations.

	Existing Site	Greenfield Rate
Site Area (including retained buildings)	13,922 m ²	
Building area not subject to redevelopment	1,754 m ²	
Total Site area (for calculations)	12,168 m ²	
Q _{ex} (1 year)	13.79 l/s	3.22 l/s
Q _{ex} (30 year)	39.21 l/s	8.72 l/s
Q _{ex} (100 year)	52.40 l/s	12.10 l/s

Table 3 - Peak runoff from existing site (15mins)

4.3 Proposed Runoff Rates

The development has limited green space and is challenged by heavy fall between different portions of the site. Finally, the development is physically split by retained buildings. This all means that single discharge rate point for the entire development is unlikely and at least 2 separate connections will be required.

Each connection could be restricted hydro-brake, however the lowest recommended limit to avoid blockages is 2.0l/s, thus minimum discharge rate that site can achieve is 4.0l/s. Further, considering of complexities of installing and maintaining 3 different hydrobrake controls it is proposed to simplify the system with just 2 flow controls which targets higher intensity storms. As a result, the following discharge rates are proposed.

	1-in- year	1-in-30year	1-in-100year	1-in-100year + 40% CC
Proposed Discharge Rate	8.00 l/s	8.00 l/s	12.00 l/s	12.00 l/s
Greenfield Discharge Rate	3.22 l/s	8.72 l/s	12.10 l/s	NA

Table 4 - Proposed vs existing discharge rate comparison

Thames Water Pre-Planning enquiry has been consulted on 10th of September 2019 and confirmed provided Haringey accept Greenfield Rate proposed above, then sufficient capacity exists within existing surface water

network to accept the flows; letter with reference number DS6059960 has been issued and can be seen on the Appendix G.

Thames Water Pre-Planning Enquiry letter reference number DS6059960 was valid for 12 months only; We have consulted Thames Water Pre-Development Team to provide an update regarding the proposed flows discharging into their sewers.

4.4 Attenuation Requirements (peak)

To meet peak runoff discharge rate, an attenuation system is proposed. The SuDS Manual advises that simulation modelling is required for sizing of different components.

Attenuation calculations have been provided for Greenfield discharge rate to the public sewer calculated for 1-in-100year + 40% climate change scenario. Refer to Appendix D for Micro Drainage calculations. The exact attenuation volumes can only be determined when detailed design is complete.

	Discharge Rate	Attenuation Storage
Greenfield Rate (discharge to sewer)	12.0 l/s	221 m ³ – 341 m ³

Table 5 - Peak run-off criteria attenuation requirements

5 Runoff Volumes

This section compares existing and proposed runoff volumes into the public sewer, that occur during 6-hour mark.

5.1 Background

Statutory guidance requires that where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1-in-100year 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. It should ideally not exceed the runoff volume from the development site prior to re-development for that event.

5.2 Existing volumes

CIRIA The SuDS Manual C753 described the preferred method for calculating runoff volumes from the development and is shown in Table 1. The volumetric criteria pre and post development is compared at the 6-hour mark for 1-in-100year storm.

FEH rainfall data is used for the calculation of pre and post development volumes and Greenfield volumes. For comparison with Greenfield discharge rates, only the minimum proposed rate is shown for each scenario. The volume calculations are provided in Appendix C and are summarised below:

	Existing Site	Greenfield Volume	Unmitigated Volume (No SuDS, no flow control)	Mitigated Volume (With SuDS and flow control set at 8.0l/s and 12.0 l/s)
1-in-1	93.70	69.60	112.65	108.38
1-in-30	261.90	188.40	326.92	166.89
1-in-100	363.00	261.40	453.06	250.34
1-in-100 + 40% CC	-	-	634.28	250.34

Table 6 - Volume comparison summary

The absolute minimum flow-rate for the development, considering technical challenges and two outfalls would be around 5.0l/s. Comparison between theoretical 5.0l/s and proposed 8.0l/s during 1-in-1 year storm shows only nominal difference of 6.05m³ over 360 minute duration.

The overall volume increases by 15.6% during 1-in-1year storm compared to existing due to significant increase in impermeable areas. It is consequently reduced by 36.3% during 1-in-30year storm which is

considered critical as it is higher intensity storms when most of the flooding occurs. The change over is expected to occur around 1-in-10year mark, however this was not modelled.

What is evident from the calculations is that by restricting the site to 8.0l/s and 12.0l/s it will mimic natural greenfield rate during larger and more critical events that are typically causes of the flowing. During the lower events, the site discharge cannot be restricted further for practical considerations.

6 Other Considerations

6.1 Exceedance Events

All surface water during exceedance event will be directed away from the building to ensure no flooding of the buildings occurs.

6.2 Pollution prevention

Environment Agency G13 positional statement refers to non-statutory guidance on SuDS design to establish pollution risks. CIRIA The SuDS Manual C753 provides guidance on analysis of potential contamination from various sources and level of remediation that are achieved by various SuDS.

The potential contamination sources are:

- Residential roofs (very low risk)
- Pedestrian non-vehicle areas (low risk)

Based on low-risk nature of the site and discharge to storm water sewer no additional mitigation measures are required to achieve compliance.

6.3 Adoption and Management

Due to the nature of the site, it is unlikely that any SuDS features would be adopted. The ongoing management and maintenance of the proposed surface water management systems will be expected to fall under the responsibility of the school.

The long-term management of surface water drainage assets including any SuDS components, is essential to ensure they continue to function to their design standard. As such, a management and maintenance plan will need to be developed in order to ensure the systems continue to work effectively.

The site will include maintainable elements such as attenuation tanks, green roofs and hydro-brake flow control. A maintenance plan for these elements is provided in Appendix F.

Other elements such as trees are unlikely to require maintenance as these will be planted within natural ground.

6.4 Detailed Development Drainage Plan

Concept sketch is provided in Appendix E.

Given the site has significant falls, detailed drainage design is required to fully understand the complexity and develop detailed design for the site, which is proposed to be completed post-planning.

Appendix A – Thames Water Asset Map

Sewer Asset Map showing extents of proposed development.



Appendix B – Peak Runoff Calculations

Equations Used

GREENFIELD AREAS

IH124: Catchment Descriptor Equation

Peak Runoff

Q_{BAR (rural)}

=

0.00108

AREA^{0.89}

SAAR^{1.17}

SOIL^{2.17}

Q_{BAR (rural)}

=

Mean annual flood (a return period in the region of 2.3 years)

AREA

=

Area of catchment in km²

SAAR

=

Standard average annual rainfall for the period 1941-1970 in mm
soil index, taken from FST soil maps or the WRAP map of the Wellington

SOIL

=

Procedure

Calculation is completed for 50ha and linearly interpolated for required site area.

DEVELOPED AREAS

Calculated using Modified Rational Method and FEH data

Peak Runoff Rate

Q_o

=

2.78

C_v

C_r

i

A

C_v

=

Volumetric runoff coefficient

C_r

=

1.3 (routing Coefficient)

i

=

Rainfall intensity

A

=

Area

2.78

=

Coefficient which accounts for the differences in units used for the inputs and the outputs of the equation

V

=

PR / 100

I

A

V

=

Volume of runoff

PR

=

Percentage of runoff

I

=

Rainfall depth (mm)

A

=

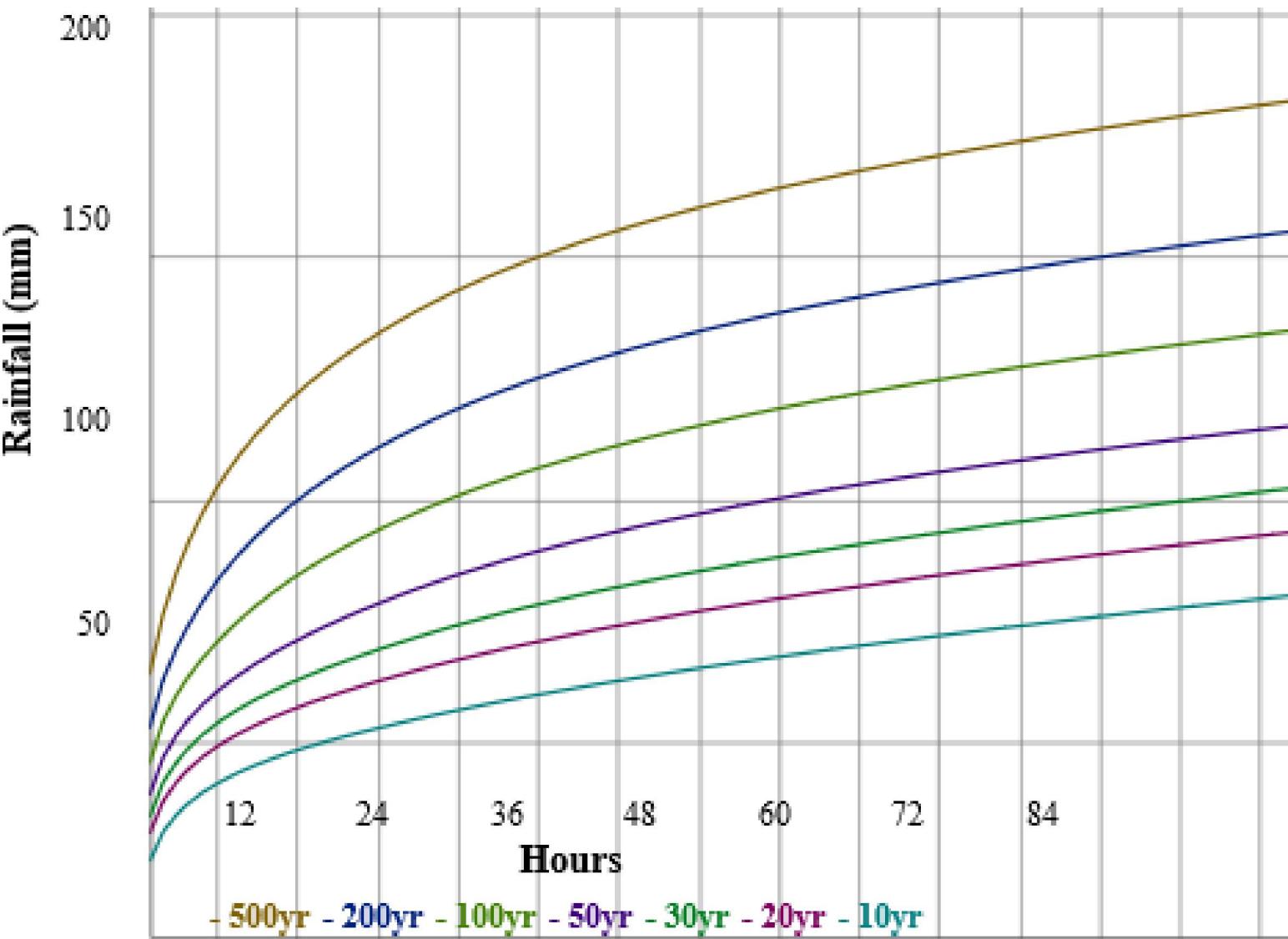
Area

Rainfall Data Used:

FEH and FSR

Growth Factors for FSR rainfall and FEH rainfall are calculated using standard methodology and thus are not included here.

Rainfall Data							
Location		Highgate School	527893	187767			
FEH data							
Return Period		1	2	10	30	100	100+CC (+40%)
Duration (mins)	Duration (hrs)	FSR rainfall depth (mm)	Rainfall depths (mm)				
15	0.25	8.38	7.64	17.49	24.15	31.99	44.79
30	0.5	10.78	9.71	22.13	30.65	40.96	57.34
60	1	13.52	11.74	26.84	37.32	49.92	69.89
120	2	16.55	17.59	35.18	47.77	64.36	90.10
240	4	19.81	23.63	43.55	58.47	80.09	112.13
360	6	21.99	26.91	48.13	64.15	88.85	124.40
600	10	24.68	30.74	53.12	70.39	98.55	137.97
1440	24	30.79	36.99	61.05	79.79	111.23	155.72



Greenfield Runoff Rate

Calculation of Greenfield Runoff Rates - Institute of Hydrology Report 124 FSR 3-parameter equation

Site name		AREA (km ²)	SPRHOST (%)	SAAR (mm)	SOIL (SPR)	QBAR (m ³ /s)
Highgate School		0.5		685	0.3814	0.15
Growth Factors						
Greenfield runoff in m ³ /s for 50ha Area	Return Period Q _{BAR}	1	2	10	30	100
Region	0.15	0.13	0.13	0.24	0.34	0.48
6		0.85	0.88	1.62	2.3	3.19
Greenfield runoff in l/s for 50ha Area	Return Period Q _{BAR}	1	2	10	30	100
	149.58	127.14	131.63	242.31	344.02	477.15
Greenfield runoff in l/s/ha	Return Period Q _{BAR}	1	2	10	30	100
	2.99	2.54	2.63	4.85	6.88	9.54
Actual Site Area (existing)	1.268 ha					
	Return Period Q _{BAR}	1	2	10	30	100
Existing Flood Discharge from site	3.79	3.22	3.34	6.15	8.72	12.10

Peak runoff rate calculations - Existing

IMPERMEABLE AREAS (Pre-development)			
Roofs	=	0.9	normal roofs
Pavements	=	0.75	hard standing
Surface	Area (ha)	Cv	Weighted Cv
Roofs	0.0874	0.9	
Pavement	0.1311	0.75	
TOTAL	0.2185	0	0.81
Permeable/landscaped area (Greenfield rates contribution from overland flows via swale)			
Area		0.9983 Ha	
		QBAR	1-in-1 1-in-30 1-in-100
Greenfield runoff rate (l/s/ha)		2.99	2.54 6.88 9.54
Open Space / landscaped area (l/s)			2.54 6.87 9.53

Return Period		1 in 1			
Duration (mins)	FEH Rainfall Depth (mm)	Intensity (mm/hr)	Impermeable area contribution (l/s)	Greenfield run-off contribution (l/s)	Total Peak Flow
15	8.38	33.52	21.44	2.54	23.98
30	10.78	21.56	13.79	2.54	16.33
60	13.52	13.52	8.65	2.54	11.19

Return Period		1 in 30			
Duration (mins)	FEH Rainfall Depth (mm)	Intensity (mm/hr)	Impermeable area contribution (l/s)	Greenfield run-off contribution (l/s)	Total Peak Flow
15	24.15	96.60	61.79	6.87	68.66
30	30.65	61.30	39.21	6.87	46.08
60	37.32	37.32	23.87	6.87	30.74

Return Period		1 in 100			
Duration (mins)	FEH Rainfall Depth (mm)	Intensity (mm/hr)	Impermeable area contribution (l/s)	Greenfield run-off contribution (l/s)	Total Peak Flow
15	31.99	127.96	81.85	9.53	91.38
30	40.96	81.92	52.40	9.53	61.93
60	49.92	49.92	31.93	9.53	41.46

Appendix C – Peak Volume Calculations

Peak volume calculations – Existing Site

IMPERMEABLE AREAS – Existing			
Surface	Area (ha)	Cv	Weighted Cv
Roof	0.0874	0.9	
Pavements	0.1311	0.75	
TOTAL	0.2185	0	0.81

Permeable/landscaped area (Greenfield rates)				
Area	0.9983 Ha			
	QBAR	1-in-1	1-in-30	1-in-100
Greenfield runoff rate (l/s/ha)	2.99	2.54	6.88	9.54
Open Space / landscaped area (l/s)		2.54	6.87	9.53

Existing site volume 1-in-1 year @ 6-hour

Storm Duration (minutes)	Rainfall Depth (mm)	Pre-development volume, m3
360	21.99	93.70

Existing site volume 1-in-30 year @ 6-hour

Storm Duration (minutes)	Rainfall Depth (mm)	Pre-development volume, m3
360	64.15	261.90

Existing site volume 1-in-100 year @ 6-hour

Storm Duration (minutes)	Rainfall Depth (mm)	Pre-development volume, m3
360	88.85	363.00

Peak volume calculations – Greenfield Site

Greenfield Volume 1-in-1 year @ 6-hour

Storm Duration (minutes)	Greenfield discharge rate, l/s	Greenfield volume, m3
360	3.22	69.60

Greenfield Volume 1-in-30 year @ 6-hour

Storm Duration (minutes)	Greenfield discharge rate, l/s	Greenfield volume, m3
360	8.73	188.40

Greenfield Volume 1-in-100 year @ 6-hour

Storm Duration (minutes)	Greenfield discharge rate, l/s	Greenfield volume, m3
360	12.10	261.40

* Pre-development volume includes all impermeable areas and all greenfield/landscaped areas.

Peak volume calculations – Proposed Site

IMPERMEABLE AREAS – Post-development			
Surface	Area (ha)	Cv	Weighted Cv
Permeable	Greenfield Rate Calculation		
Roof	0.276	0.9	
Pavements	0.079	0.75	
TOTAL	0.355	0	0.87

Permeable/landscaped area (greenfield rates)					
Area	0.8618 Ha				
	QBAR	1-in-1	1-in-30	1-in-100	1-in-100 +40% CC
Greenfield runoff rate (l/s/ha)	2.99	2.54	6.88	9.54	13.36
Open Space / landscaped area (l/s)		2.19	5.93	8.22	11.51

Post-Development volume (no infiltration) - 1-in-1year @ 6-hour

Storm Duration (minutes)	Rainfall Depth, mm	Post Development Volume*, m ³	
		No SuDS, no flow control (impermeable + landscaped)	With SUDS + flow control Peak flow control – 5.0 l/s
360	21.99	112.65	108.38

* Post development volume includes all impermeable areas and all Greenfield/landscaped areas.

Post-Development volume (no infiltration) - 1-in-30year @ 6-hour

Storm Duration (minutes)	Rainfall Depth, mm	Post Development Volume*, m ³	
		No SuDS, no flow control (impermeable + landscaped)	With SUDS + flow control Peak flow control – 8.0 l/s
360	64.15	326.92	166.89

* Post development volume includes all impermeable areas and all Greenfield/landscaped areas.

Post-Development volume (no infiltration) - 1-in-100year @ 6-hour

Storm Duration (minutes)	Rainfall Depth, mm	Post Development Volume*, m ³	
		No SuDS, no flow control (impermeable + landscaped)	With SUDS + flow control Peak flow control – 12.0 l/s
360	88.85	453.06	250.34

* Post development volume includes all impermeable areas and all Greenfield/landscaped areas.

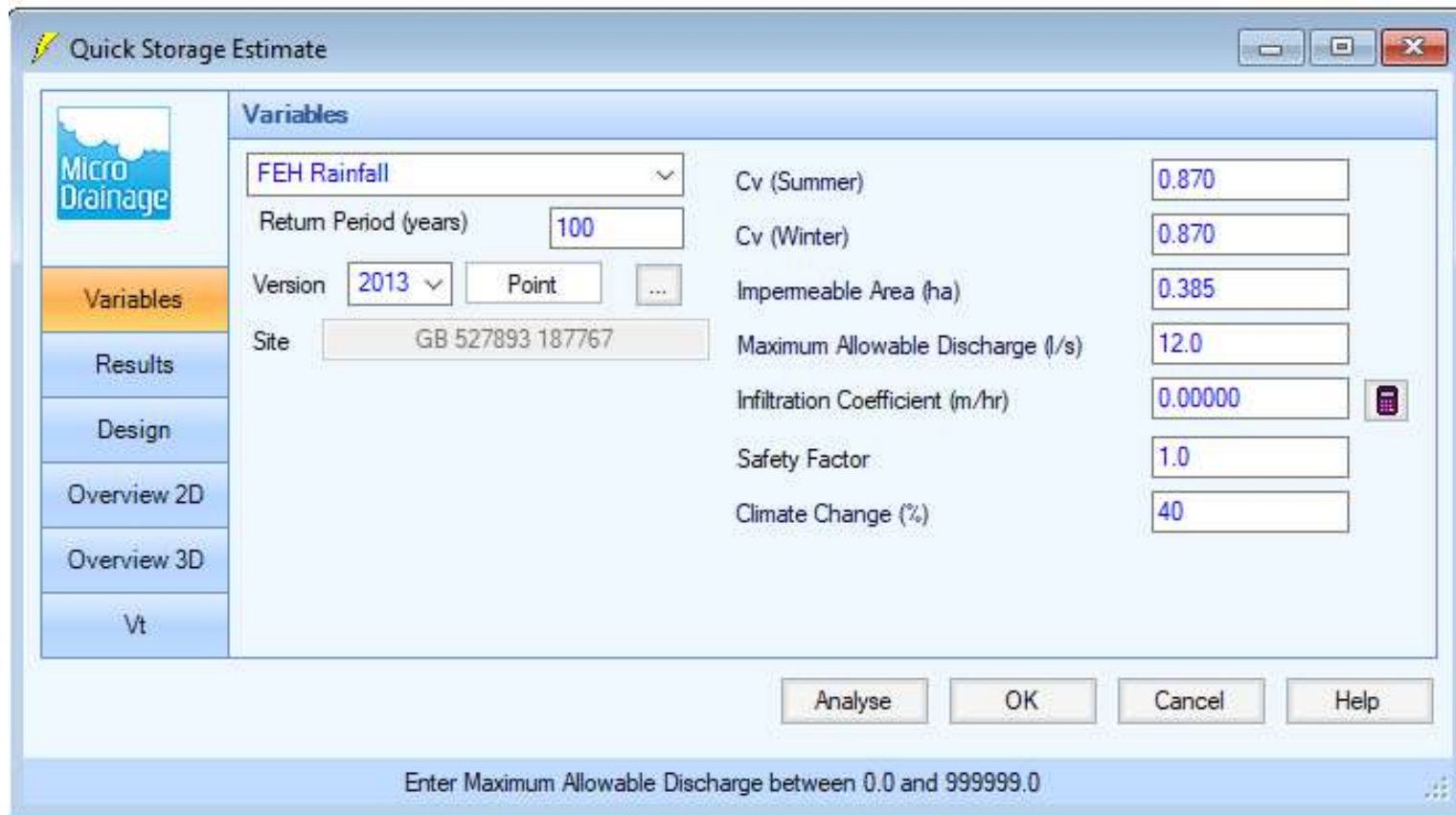
Post-Development volume (no infiltration) – 1-in-100 year + 40% CC @ 6-hour mark

Storm Duration (minutes)	Rainfall Depth, mm (including +40% CC)	Post Development Volume*, m ³	
		No SuDS, no flow control (impermeable + landscaped)	With SUDS + flow control Peak flow control – 12.0 l/s
360	124.39	634.28	250.34

* Post development volume includes all impermeable areas and all Greenfield/landscaped areas.

APPENDIX D – Quick Storage Estimate Calculations

To achieve Greenfield rate to sewer (including + 40% climate change).

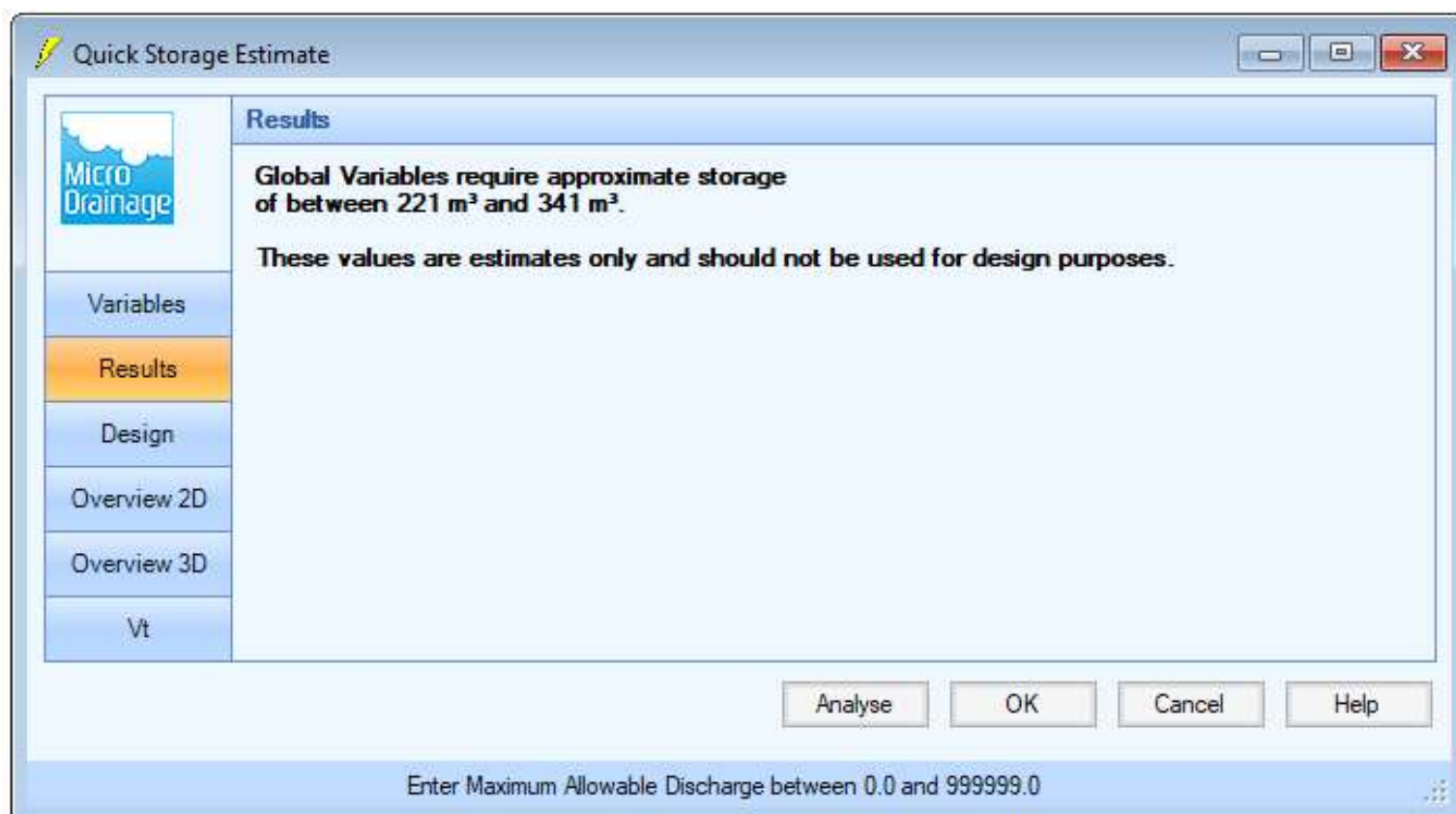


The 'Quick Storage Estimate' dialog box is shown with the 'Variables' tab selected. The left sidebar contains buttons for Variables, Results, Design, Overview 2D, Overview 3D, and Vt. The main area contains the following variables and their values:

Variable	Value
FEH Rainfall	100
Return Period (years)	100
Version	2013
Point	...
Site	GB 527893 187767
Cv (Summer)	0.870
Cv (Winter)	0.870
Impermeable Area (ha)	0.385
Maximum Allowable Discharge (l/s)	12.0
Infiltration Coefficient (m/hr)	0.00000
Safety Factor	1.0
Climate Change (%)	40

Buttons at the bottom: Analyse, OK, Cancel, Help.

Footer: Enter Maximum Allowable Discharge between 0.0 and 999999.0



The 'Quick Storage Estimate' dialog box is shown with the 'Results' tab selected. The left sidebar contains buttons for Variables, Results, Design, Overview 2D, Overview 3D, and Vt. The main area displays the following results:

Global Variables require approximate storage of between 221 m³ and 341 m³.

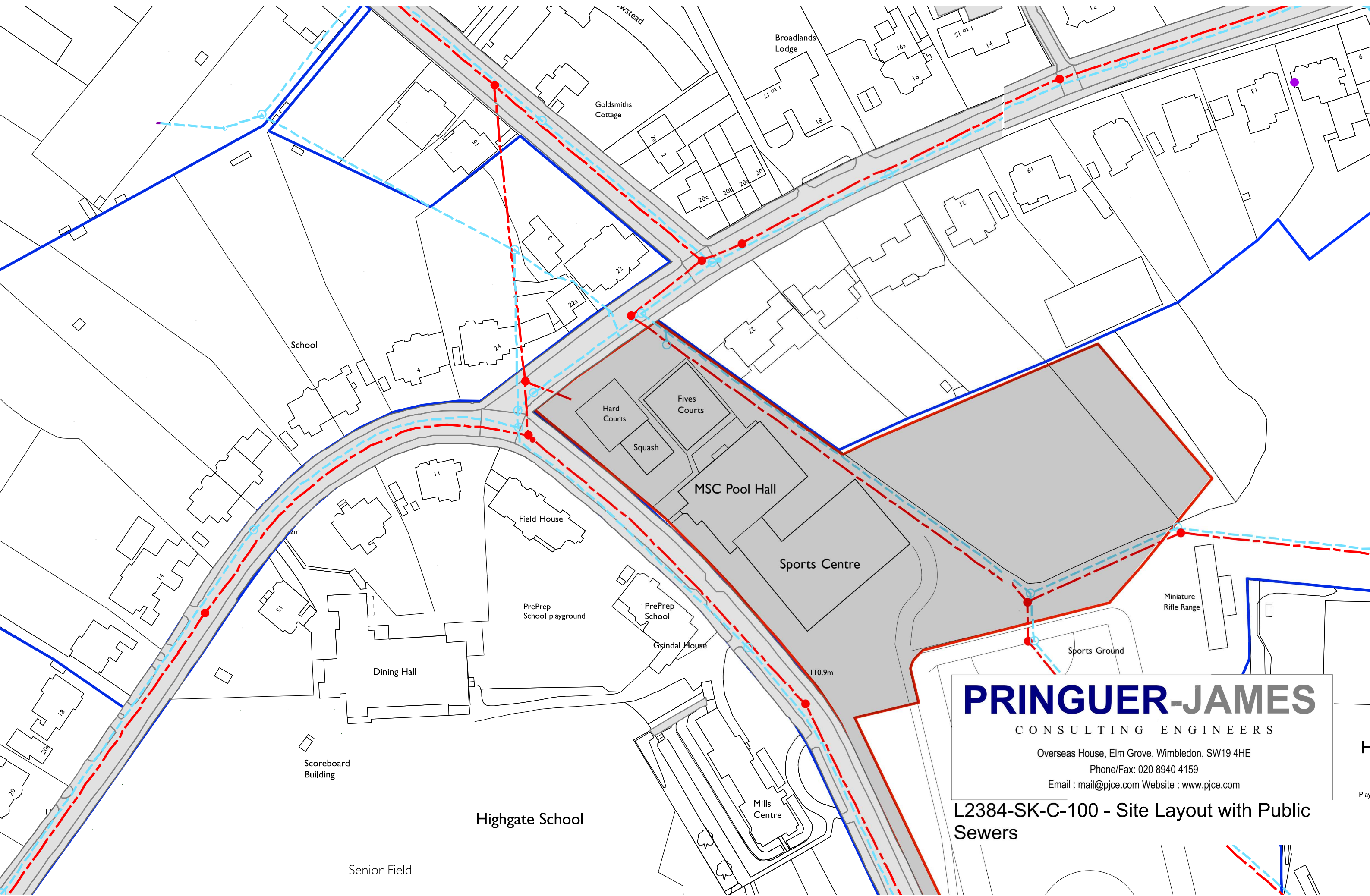
These values are estimates only and should not be used for design purposes.

Buttons at the bottom: Analyse, OK, Cancel, Help.

Footer: Enter Maximum Allowable Discharge between 0.0 and 999999.0

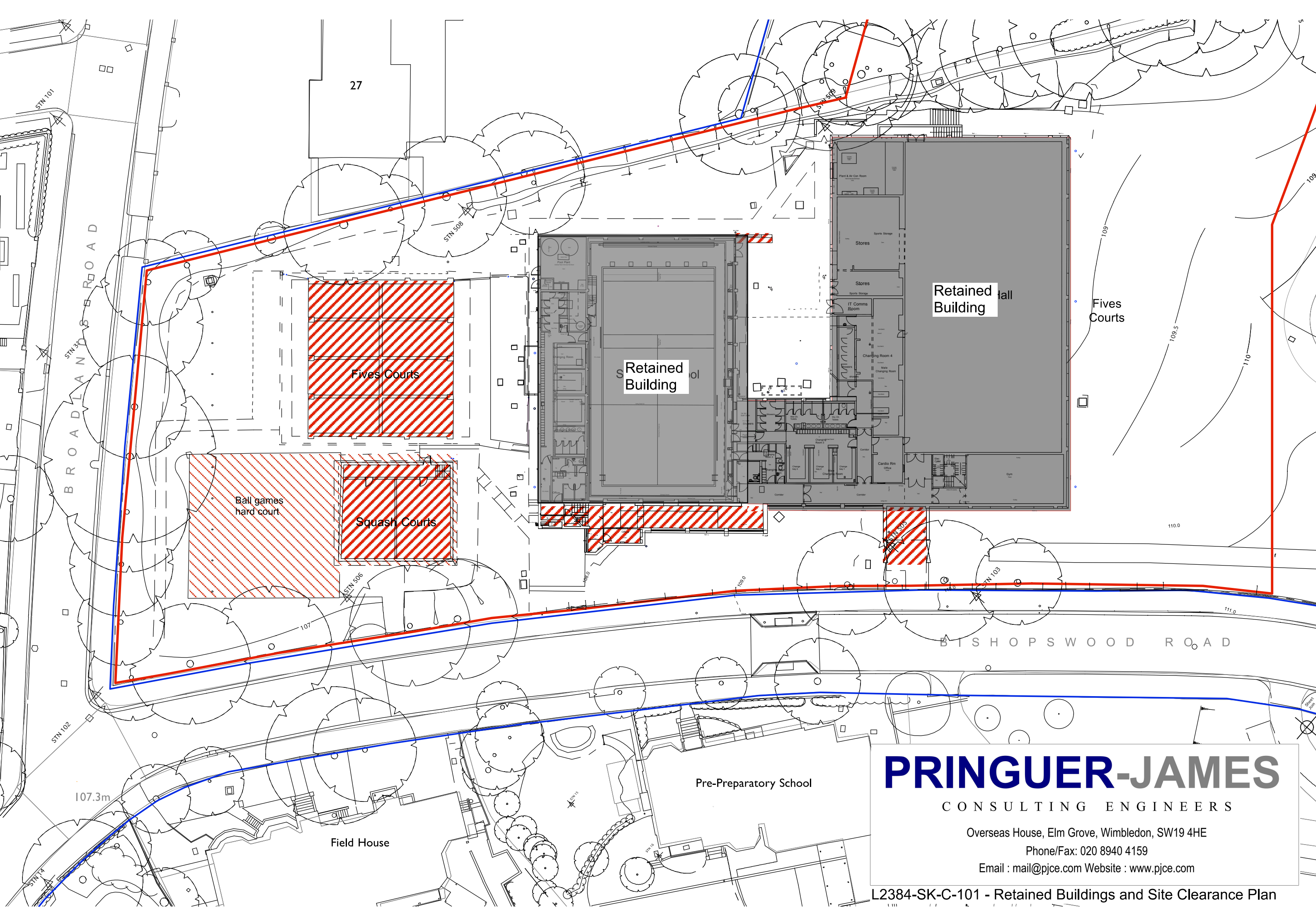
APPENDIX E – Drainage Design Concept

- L2384-SK-C-100 – Site layout with public sewers
- L2384-SK-C-101 – Retained Buildings and Site Clearance Plan
- L2384-SK-C-102 – SuDS Strategy Concept for the development



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L2384-SK-C-100 - Site Layout with Public Sewers



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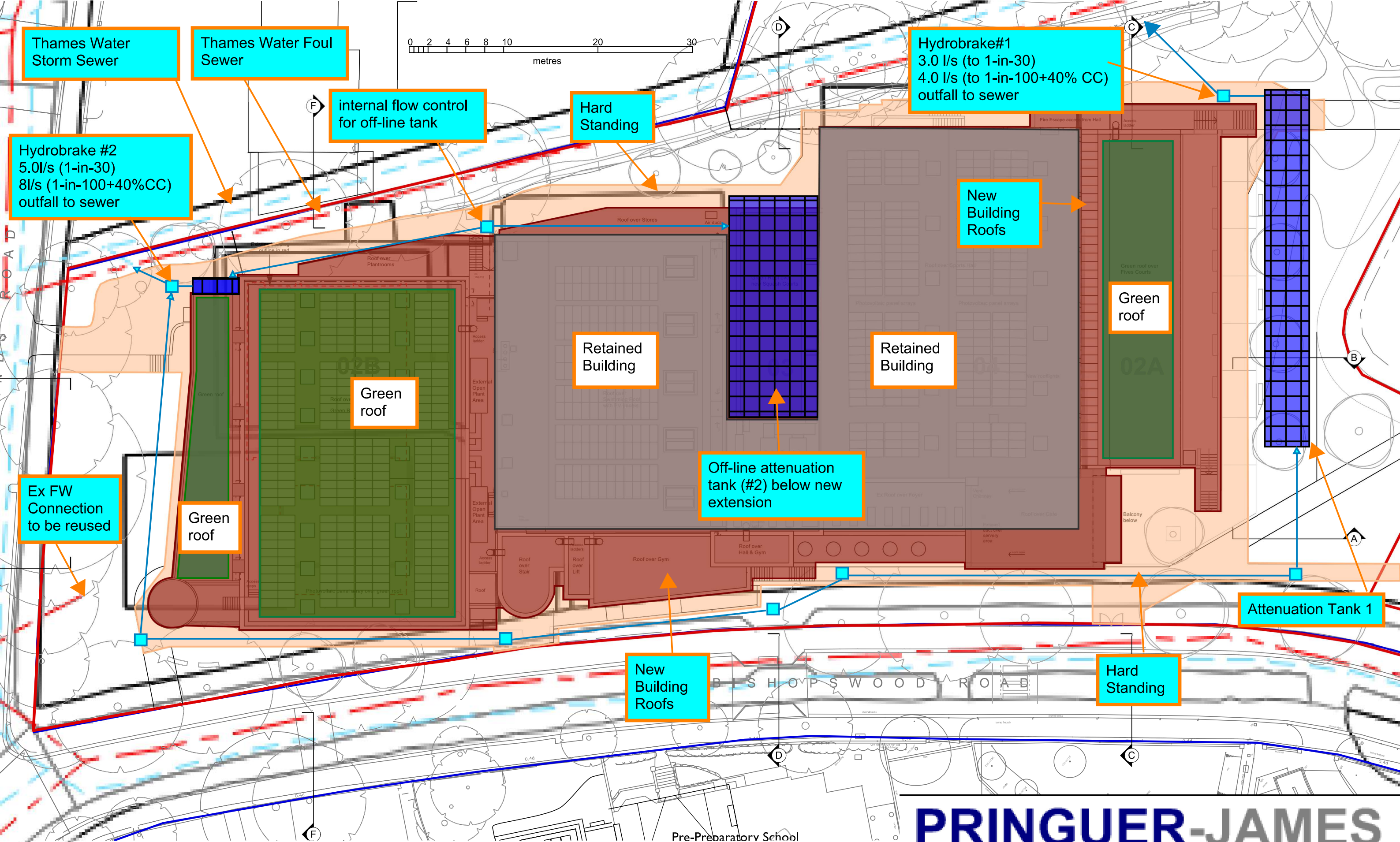
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L2384-SK-C-101 - Retained Buildings and Site Clearance Plan



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APPENDIX F – Maintenance Plan

Maintenance Plan for the following design elements has been provided below:

- Green roofs
- Attenuation Tank
- Hydro-brake
- Trees

Green Roofs – Operations and Maintenance Schedule

	Required Action	Typical Frequency
Regular inspections	Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes and roof structure for proper operation, integrity of waterproofing and structural stability.	Annually and after severe storms
	Inspect soil substrate for evidence of erosion channels and identify any sediment source.	Annually and after severe storms
	Inspect drain inlets to ensure unrestricted runoff from drainage layer to the conveyance or roof drain system.	Annually and after severe storms
	Inspect underside of roof for evidence of leaking.	Annually and after severe storms
Regular maintenance	Remove debris and litter to prevent clogging of inlet drains and interference with plant growth.	Six monthly or as required
	During establishment (i.e. year one), replace dead plants as required.	Monthly (but usually the responsibility of the manufacturer)
	Post establishment, replace dead plants as required (where >5% of coverage).	Annually (in autumn)
	Remove fallen leaves and debris from deciduous plant foliage.	Six monthly or as required
	Remove nuisance and invasive vegetation, including weeds.	Six monthly or as required
	Mow grass, prune and manage other planting (if appropriate) as required – clipping should be removed and not allowed to accumulate.	Six monthly or as required
Remedial action	If erosion channels are evident, these should be stabilized with extra soil substrate similar to the original material, and sources of erosion damage should be identified and controlled.	As required
	If drain inlet has settled, cracked, or moved, investigate and repair as appropriate.	As required.

Attenuation tank – Operations and Maintenance Schedule

	Required Action	Typical Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance).	Monthly
	For systems where rainfall intensities into the tank from above, check surface of filter for blockage by sediment, algae, or other matter: remove and replace surface infiltration medium as necessary.	Annually
	Remove sediment from pre-treatment structures and/or internal forebays.	Annually, or as required
Occasional maintenance	Repair/rehabilitate inlets, outlets, 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
	Survey inside of tank for sediment build-up and remove if necessary.	Every 5 years or as required.

Hydro-brake – Operations and Maintenance Schedule

	Required Action	Typical Frequency
Regular maintenance	Check and empty sump pit. Check orifice plate for any blockages. If fault is identified during routine inspection/monitoring, undertake remedial action.	Every 6 months
Remedial action	Repair and/or replace orifice plate.	As required
Monitoring	Inspection to check orifice performance, condition of the system and to identify any faults.	Every 6 months

Trees – Operations and Maintenance Schedule

	Required Action	Typical Frequency
Regular maintenance	Remove litter and debris.	Monthly (or as required)
	Manage other vegetation and remove nuisance plants.	Monthly (at start, then as required)
	Inspect inlets and outlets.	Inspect monthly
Occasional maintenance	Check tree health and manage tree appropriately.	Annually
	Remove silt build-up from inlets and surface and replace mulch as necessary.	Annually, or as required
	Water.	As required (in periods of drought)
Monitoring	Inspect silt accumulation rates and establish appropriate removal frequencies.	Half yearly

APPENDIX G – Communication

- Thames Water Capacity check.
- Haringey Council email