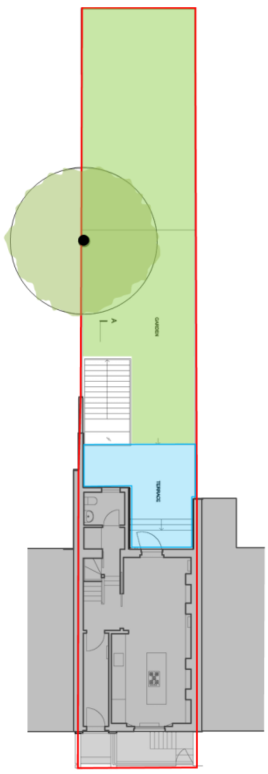
SUDS Strategy

in connection with the proposed development at

No. 64 Delancey Street
Camden
London
NW1 7RY

for

Dr Pooja Shah & Dr Samit Shah



LBH4576suds Ver 1.0

April 2019

LBH WEMBLEY

ENGINEERING

DOCUMENT CONTROL

Report Ref: LBH4343suds

Version	Date	Comment	Authorised
			Seamus Lefroy-Brooks BSc(hons) MSc CEng MICE CGeol FGS CEnv MIEnvSc FRGS SiLC RoGEP UK Registered Ground Engineering Adviser NQMS SQP DoWCoP QP
1.0	3rd April 2019		

LBH WEMBLEY ENGINEERING
12 Little Balmer
Buckingham Industrial Park
Buckingham
MK18 1TF

Tel: 01280 812310
email: enquiry@lbhgeo.co.uk
website: www.lbhgeo.co.uk

Contents

Foreword - Guidance Notes

GENERAL

This report has been prepared for a specific client and to meet a specific brief. The preparation of this report may have been affected by limitations of scope, resources or time scale required by the client. Should any part of this report be relied on by a third party, that party does so wholly at its own risk and LBH WEMBLEY disclaims any liability to such parties.

The observations and conclusions described in this report are based solely upon the agreed scope of work. LBH WEMBLEY has not performed any observations, investigations, studies or testing not specifically set out in the agreed scope of work and cannot accept any liability for the existence of any condition, the discovery of which would require performance of services beyond the agreed scope of work.

VALIDITY

Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances shall be at the client's sole and own risk. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable.

THIRD PARTY INFORMATION

The report may present an opinion based upon information received from third parties. However, no liability can be accepted for any inaccuracies or omissions in that information.

1. Introduction

It is proposed to extend the existing basement at these property rearwards, with stepped access up to the rear garden.

1.1 Brief

LBH WEMBLEY have been commissioned by Dr Pooja Shah and Dr Samit Shah to prepare an outline SuDS strategy.

1.2 Guidance

The government advice is that developers should seek opportunities to reduce the overall level of flood risk through the appropriate application of sustainable drainage systems.

Sustainable drainage systems are designed to control surface water run off close to where it falls and mimic natural drainage as closely as possible. They provide opportunities to:

- reduce the causes and impacts of flooding;
- remove pollutants from urban run-off at source;
- combine water management with green space with benefits for amenity, recreation and wildlife.

The aim is to discharge surface run off 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.

The London Borough of Camden requires drainage solutions to incorporate SuDS principles as laid out in the Non-Statutory Technical Standards[1] for Sustainable Drainage Systems and the London Plan[2].

For redevelopment sites where there is a net increase in impermeable area, development must include at least one ‘source control’ SuDS measure. Examples of potential Source Control measures include:

- blue/green roof
- rainwater harvesting
- bio-retention
- rain garden
- permeable paving

Underground storage/attenuation tanks are not encouraged and should be used as a last resort.

The Camden Local plan provides guidance for water and flooding under Policy CC3, where the council will seek to ensure a development reduces the risk of flooding where possible and will require a development to utilise Sustainable Drainage Systems (SuDS) in line with the drainage hierarchy to achieve a greenfield run-off rate where feasible.

---

[1] DEFRA March 2015 Non-Statutory Technical Standards (NSTS) for sustainable drainage systems
[2] London Plan Chapter Five - London’s Responses to Climate Change Policy 5.1.3 Sustainable Drainage

Additionally, the Camden Planning Guidance for Sustainability (CPG3) (July 2015, updated March 2018) states the following:

"All developments are expected to manage drainage and surface water on-site or as close to the site as possible, using Sustainable Drainage Systems (SUDS) and the hierarchy set out below.

The Council will expect plans and application documents to describe how water will be managed within the development, including an explanation of the proposed SUDS, the reasons why certain SUDS have been ruled out and detailed information on materials and landscaping.

The Council will expect developments to achieve a greenfield surface water run-off rate once SUDS have been installed. As a minimum, surface water run-off rates should be reduced by 50% across the development."

1.3 Report Structure

This report describes the site characteristics, following which consideration is given to the feasibility of SUDS techniques for this site. Finally, the recommended SUDS strategy to mitigate the risk of flooding across the site is presented in accordance with the 2015 CIRIA C753 SUDS Manual.

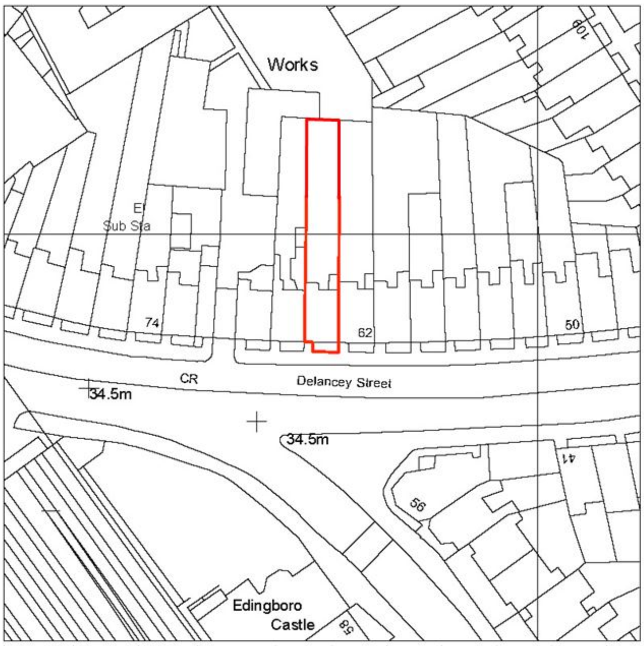
The assessment has been based on information held in public records together with archive information.

2. The Site

2.1 Site Location

The site is situated on the northern side of Delancey Street, opposite the junction with Mornington Terrace, within the Camden Town Conservation Area.

A section of the West Coast Main Railway Line to London Euston Station runs in a nearby cutting, approximately 40m to the southwest of the site.

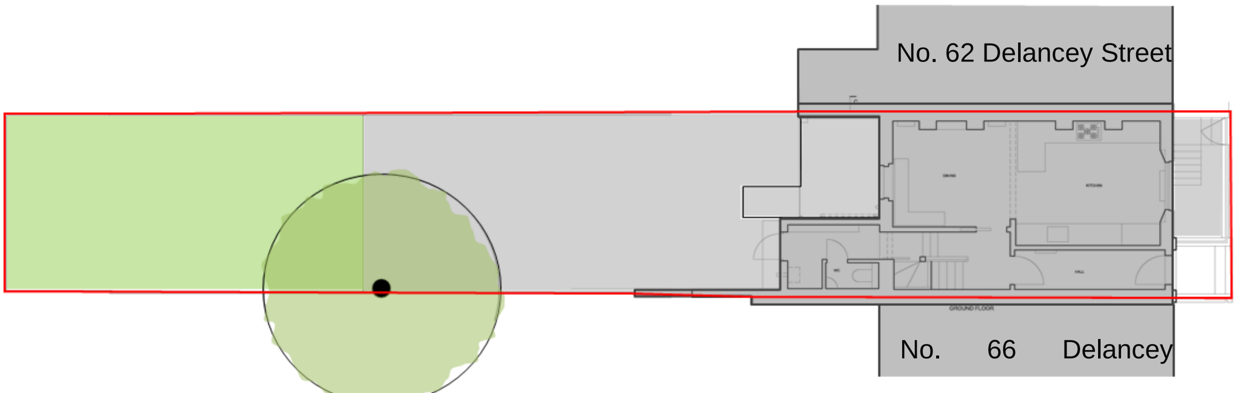


Location plan

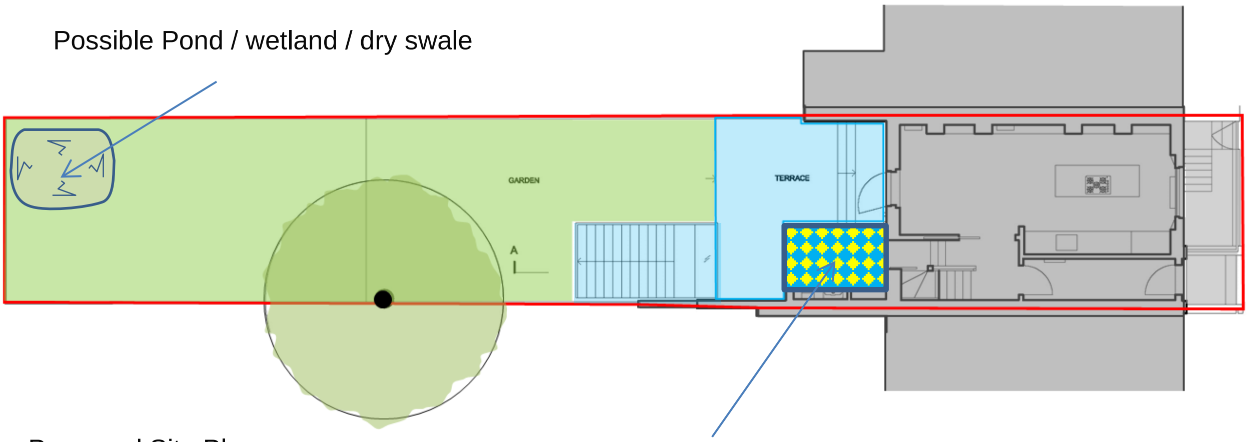
2.2 Site Description

The site is occupied by an early 19th Century three storey terraced house.

A front lightwell is present giving access to the basement level, as well as a small basement patio area to the rear. A staircase leads up to the rear garden that lies at approximately ground floor level.



Existing Site Plan



Proposed Site Plan

The rear garden is relatively level and comprises a patio with a lawn at the rear. The latter area appears to possibly slightly north sloping. A mature sycamore tree is present on the boundary with No. 66.

The property boundaries are marked by wooden fencing, together with brick garden walls within the extent of the basement patio areas.

The rear boundary is formed by a former television studio that has recently been developed in to a private residential property.

The impermeable areas of the property at present drain directly to a combined sewer below Delancey Street.

2.3 Proposed Development

It is proposed that the rear section of the existing roof should drain to a blue roof or green roof situated on top of the rear extension. The remaining impermeable areas will drain in the same manner as at present to the sewer, but are significantly reduced in area. A non-return valve should be fitted to the system to guard against any potential sewer flooding.

It is suggested that there may be scope for a further above ground water retention feature to be situated in the rear garden; possibly a pond or wetland but alternatively simply a dry swale.

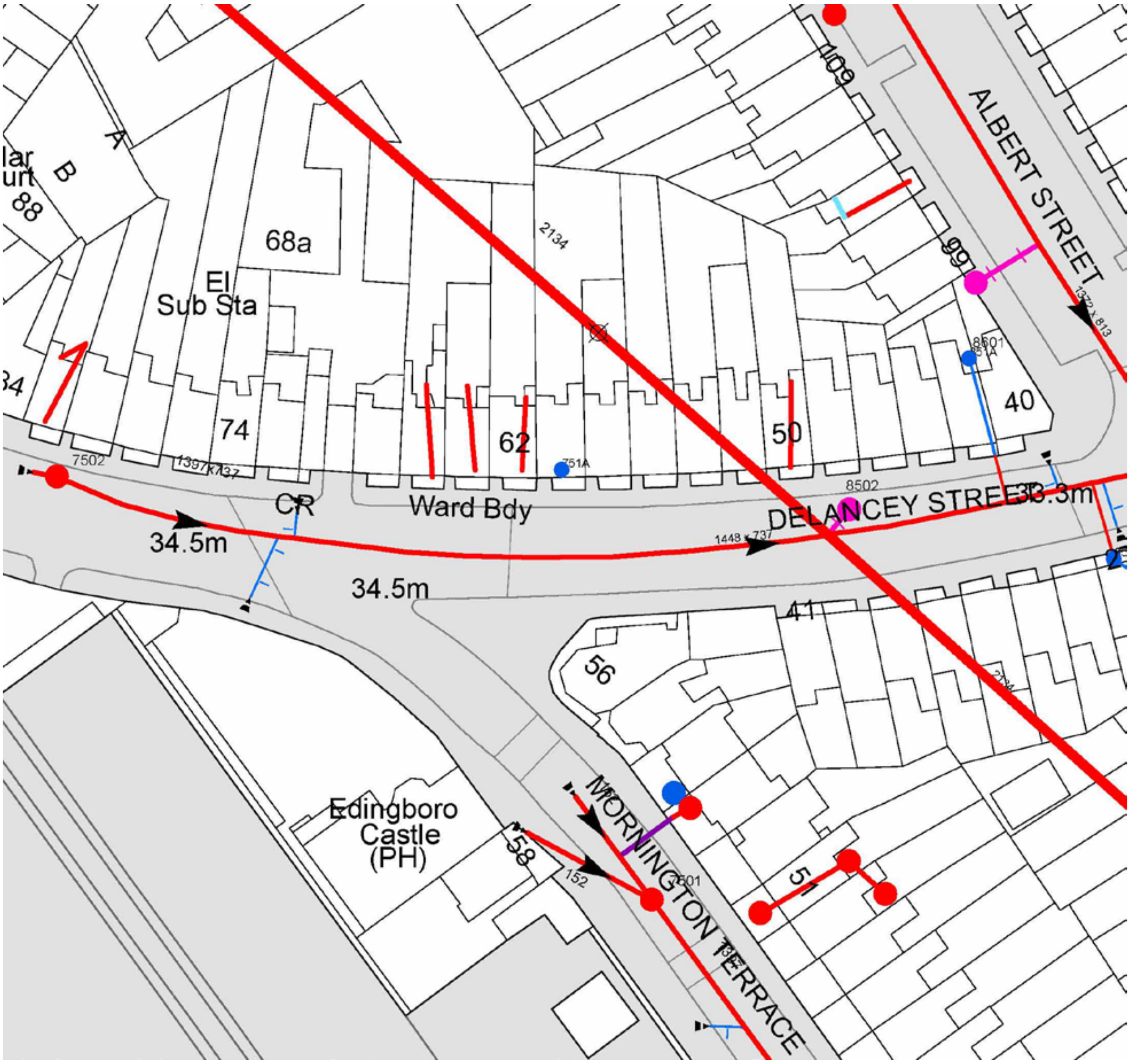
The following table summarises the envisaged potential changes to the drainage arrangements associated with the proposed scheme.

<table>
<tr><td colspan="9">Schedule of estimated approximate areas for outline SuDS assessment</td></tr>
<tr><td></td><td>Existing</td><td>Cv</td><td>%</td><td>%</td><td>Proposed</td><td>Cv</td><td>%</td><td>%</td></tr>
<tr><td>Garden</td><td>52 m^2</td><td>0.40</td><td>29</td><td>50</td><td>112 m^2</td><td>0.40</td><td>62</td><td>62</td></tr>
<tr><td>Building (to sewer)</td><td>40 m^2</td><td>0.77</td><td>22</td><td rowspan="3">50</td><td>40 m^2</td><td>0.77</td><td>22</td><td rowspan="3">38</td></tr>
<tr><td>Green</td><td></td><td></td><td></td><td>10 m^2</td><td>0.50</td><td>5</td></tr>
<tr><td>Impermeable</td><td>90m^2</td><td>0.77</td><td>49</td><td>20 m^2</td><td>0.77</td><td>11</td></tr>
<tr><td>Total:</td><td>182 m^2</td><td></td><td>100</td><td>100</td><td>182 m^2</td><td></td><td>100</td><td>100</td></tr>
</table>

3. Surface Water Management (SWM)

3.1 Site characteristics

Thames Water records shows a section of sewer running from the rear of the property to the front, together with a combined trunk sewer located beneath Delancey Street. In addition, the plan below indicate the presence of a deep sewer crossing beneath the rear garden at about 20m depth. This is thought to be a section of the Middle Level Sewer No. 2.



3.2 Ground Conditions

The site is underlain by the London Clay Formation, which is essentially impermeable.

3.3 SWM objectives for the development

The drainage strategy follows the guidance set out in the 2015 CIRIA C753 SUDS Manual; the principle of SUDS design is that surface water runoff is managed for maximum benefit. The types of benefits that may be achieved by utilising SUDS are categorised by the design objectives outlined in the following section.

3.3.1 Water quantity

The design objective is to control the quantity of runoff to support the management of flood risk and maintain and protect the natural water cycle.

In order to ensure that the surface water runoff from a developed site does not have a detrimental impact on people, property and the environment, it is important to control the rate and volume of the discharge from the site.

Sustainable Drainage Systems (SuDS) should be incorporated into the design of a development unless there are practical reasons for not doing so. In aiming to achieve greenfield runoff rates, surface water runoff should be managed using the following techniques, as outlined in order of priority by the following drainage hierarchy:

SUDS Drainage Hierarchy	Suitable for the site? (Y/N)	Comment
Store rainwater for later use	Y	Consideration could be given to harvesting the discharge from roof of the rear extension..
Use infiltration techniques	N	The London Clay is unsuitable for soakaway infiltration.
Attenuate rainwater in ponds or open water features for gradual release	Y	Attenuation storage will be provided by a green or roof. A further open water feature may be considered for the rear garden.
Attenuate rainwater by storing in tanks or sealed water features for gradual release	N	There is not scope for the construction of sealed tanks
Discharge rainwater direct to a watercourse	N	There is no available watercourse.
Discharge rainwater to a surface water sewer/drain	N	No surface water sewer is serving the site.
Discharge rainwater to the combined sewer	Y	Discharge to existing combined sewer serving the site.

The hierarchy above seeks to ensure that surface water runoff is controlled as near to its source as possible to mimic natural drainage systems and retain water on or near to the site.

Before disposal of surface water to the public sewer is considered, all other options set out in the above hierarchy need to be exhausted.

3.3.2 Water quality

The water quality design objective is to manage the quality of runoff to prevent pollution, supporting the management of water quality in the receiving surface waters and groundwater and design system resilience to cope with future change.

3.3.3 Amenity

The amenity design objective is to create and sustain better places for people by implementing the following criteria for the site:

- Maximise multi-functionality
- Enhance visual character
- Deliver safe surface water management systems
- Support development resilience/adaptability to future change
- Maximise legibility
- Support community environmental learning

3.3.4 Biodiversity

The biodiversity design objective is to create and sustain better places for nature by implementing the following criteria for the site:

- Support and protect natural local habitats and species
- Contribute to the delivery of local biodiversity objectives
- Contribute to habitat connectivity
- Create diverse, self-sustaining and resilient ecosystems

4. Discussion

The following sections discuss the presently envisaged proposals for drainage components.

4.1 Feasible Discharge routes

The surface water falling on the rear of the main roof will be directed to the area of green/blue roof and thence to the sewer.

4.2 Feasible Drainage Components

SUDS Component	Description	Suitable for the site? (Y/N)	Comment
Rainwater harvesting	Collection of rainwater runoff from roofs or impermeable areas for reuse.	Y	Consideration could be given to harvesting the discharge from the roof of the rear extension.
Green roofs	Vegetated areas installed on the top of buildings provide visual and ecological benefits in addition to surface water runoff reduction and enhanced building performance.	?Y	Attenuation storage could possibly be provided by a green roof to the rear extension at between first and second floor level.
Blue roofs	Roof design intended to store water providing attenuation storage.	?Y	A blue roof can be adopted as an alternative to the above.
Infiltration systems	Infiltration can contribute to reducing runoff rates and volumes while supporting base flow and groundwater recharge processes.	N	The London Clay is not suitable for soakaway infiltration.
Proprietary treatment systems	Proprietary treatment systems are manufactured products which remove specified pollutants from surface water runoff.	N	Not required
Filter strips/drains	Filter strips are gently sloping strips of grass that provide treatment of runoff from adjacent impermeable areas. Filter drains are gravel or stone filled trenches which provide temporary subsurface storage for attenuation conveyance and filtration of surface water runoff.	N	Not possible.
Swales	Swales are shallow, flat bottomed, vegetated open channels designed to convey, treat, and attenuate surface water runoff.	? Y	The rear garden is of limited size but a small area of swale could possibly be considered to manage any overland flow.
Bioretention	Rain gardens or shallow	? Y	Again there may be limited scope for

systems	landscaped depressions that may reduce surface water runoff rates and volumes and/or treat pollution using engineered soils and vegetation.		a small area of shallow landscaped depression
Trees	Trees aid surface water management through transpiration, inception, infiltration and phytoremediation.	Y	There are a number of trees in the rear garden.
Pervious Pavements	Pervious pavements facilitate the infiltration of surface water into a subsurface structure where filtration, adsorption, biodegradation or sedimentation may also provide treatment of the runoff.	N	Not required.
Attenuation storage tanks	Attenuation storage tanks provide below-ground void space for the temporary storage of surface water before infiltration, controlled release or use.	N	Not possible.
Detention basins	Attenuation storage in the form of dry landscaped depressions.	?Y	There is limited scope for such a feature in the rear garden.
Ponds and wetlands	Permanent water filled ponds or wetlands that provide attenuation storage or treatment of surface water runoff.	?Y	There is limited scope for such a feature in the rear garden.

4.3 Water Quantity

Runoff rates and volumes will be reduced by various SUDS components.

4.4 Water Quality

The soil and uptake zone of a green roof would filter airborne pollutants and pollutants within rainwater, reducing the amount of pollution delivered to the local drainage system. Given that only roof runoff is contemplated, there is no expectation that any treatment will be necessary to meet the appropriate water quality requirements for the method of discharge.

4.5 Amenity

The proposed green roof or garden SuDs feature could provide valuable amenity.

4.6 Biodiversity

The green roof would act as a “stepping stone” or “island” habitat providing ecological value in an urbanised area.

It is recommended that a sufficient depth of substrate is used on the green roof (no less than 80mm) and the topography is varied (80mm-150mm) in order to provide a range of habitats for invertebrates.

4.7 Maintenance

Maintenance plans and schedules should be prepared in the design phase for the specific maintenance needs of each SUDS component, and necessary adjustments made to suit requirements.

5. Initial Design Considerations

An analysis has been undertaken of the pre- and post- development surface water run-off rates and volumes over a range of storm intensities and durations.

5.1 Greenfield runoff rate

The Greenfield runoff rates from the site have been calculated using the UK SuDS online tool and the Institute of Hydrology (IoH) 124 methodology.

Greenfield Rates:	
Qbar:	**0.08 l/sec**
1 in 1	**0.07 l/sec**
1 in 30	**0.18 l/sec**
1 in 100	**0.25 l/sec**
1 in 200	**0.29 l/sec**

5.2 Existing runoff rate

The site comprises an area of approximately 380m^2 of which 50% is impermeably surfaced. There are considered to be no present SuDS features.

The existing peak storm runoff for the 1% (1 in 100 year) annual probability rainfall event on the site is estimated to be 5.0 l/sec. The calculation was based on the Wallingford Procedure and the resulting runoff was calculated using the Modified Rational Method with an M5-60 of 20mm, an 'r' value of 0.42 and a critical rainfall intensity of 163.2 mm/hr.

The rainfall runoff volume for the 1% (1 in 100 year) annual probability, 6 hour duration storm from the existing site is estimated to be 11.2m^3

5.3 Proposed Drainage Scheme

The proposed development will reduce the amount of impermeable surfacing by almost 25%.

The guidance seeks to limit the peak storm runoff for the 1% (1 in 100) annual probability rainfall event plus 40% allowance for future climate change to at least 50% of the current rate.

5.4 Attenuation storage

In order to limit the discharge rate, attenuation storage is to be included as a SuDS element.

HR Wallingford's Surface water storage volume estimation tool has been used to undertake attenuation storage volume calculations. On the basis of a minimum discharge rate of 1l/sec these calculations indicate that some 3 m^3 attenuation storage is required for the 1 in 100 year rainfall event in consideration of up to 40% climate change allowance.

It is proposed that the surface water could possibly be collected in green / blue roofs potentially providing approximately 1-2 m^3 of attenuation in conjunction with a garden SuDS feature to provide a similar a similar amount of storage / attenuation.

6. Conclusion

It has been demonstrated that there are limited opportunities to introduce SuDS features as part of the proposed development and that a combination of storage features can be used to mitigate the risk of future surface water flooding, taking into account potential climate change.

Appendix

DRAINAGE PRO-FORMA

PRELIMINARY DRAINAGE CALCULATIONS

Surface Water Drainage Pro-forma for new developments

LBH 4576

1. Site Details

Site	64 Delancey Street
Address & post code or LPA reference	NW1 7RY
Grid reference	528795, 183585
Is the existing site developed or Greenfield?	Developed
Is the development in a LFRZ or in an area known to be at risk of surface or ground water flooding? If yes, please demonstrate how this is managed, in line with DP23?	No
Total Site Area served by drainage system (excluding open space) (Ha)*	0.019

* The Greenfield runoff off rate from the development which is to be used for assessing the requirements for limiting discharge flow rates and attenuation storage from a site should be calculated for the area that forms the drainage network for the site whatever size of site and type of drainage technique. Please refer to the Rainfall Runoff Management document or CIRIA manual for detail on this.

2. Impermeable Area

	Existing	Proposed	Difference (Proposed-Existing)	Notes for developers
Impermeable area (ha)	0.013	0.007	0.006	If the proposed amount of impermeable surface is greater, then runoff rates and volumes will increase. Section 6 must be filled in. If proposed impermeability is equal or less than existing, then section 6 can be skipped and section 7 filled in.
Drainage Method (infiltration/sewer/watercourse)	Combined Sewer	Combined Sewer	N/A	If different from the existing, please fill in section 3. If existing drainage is by infiltration and the proposed is not, discharge volumes may increase. Fill in section 6.

3. Proposing to Discharge Surface Water via

	Yes	No	Evidence that this is possible	Notes for developers
Existing and proposed Drainage calculations	Yes		HR Wallingford	Please provide calculations of existing and proposed run-off rates and volumes in accordance with a recognised methodology or the results of a full infiltration test (see line below) if infiltration is proposed.
Infiltration		No	Soakage will not be possible as the site is directly underlain by impermeable London Clay.	e.g. soakage tests. Section 6 (infiltration) must be filled in if infiltration is proposed.
To watercourse		No	There is no nearby watercourse.	e.g. Is there a watercourse nearby?
To surface water sewer		No	There is no nearby surface water sewer	Confirmation from sewer provider that sufficient capacity exists for this connection.
Combination of above		No	See above - Not possible.	e.g. part infiltration part discharge to sewer or watercourse. Provide evidence above.
Has the drainage proposal had regard to the SuDS hierarchy?	Yes		HR Wallingford	Evidence must be provided to demonstrate that the proposed Sustainable Drainage strategy has had regard to the SuDS hierarchy as outlined in Section 2.5 above.
Layout plan showing where the sustainable drainage infrastructure will be located on site.	Yes		See SUDS Layout Plan	Please provide plan reference numbers showing the details of the site layout showing where the sustainable drainage infrastructure will be located on the site. If the development is to be constructed in phases this should be shown on a separate plan and confirmation should be provided that the sustainable drainage proposal for each phase can be constructed and can operate independently and is not reliant on any later phase of development.

4. Peak Discharge Rates – This is the maximum flow rate at which storm water runoff leaves the site during a particular storm event.

	Existing Rates (l/s) (from Wallingford online tool and Procedure)	Proposed Rates (l/s) (taken as 50% Existing)	Difference (l/s) (Proposed - Existing)	% Difference (Difference / existing x 100)	Notes for developers
Greenfield QBAR	0.08	N/A	N/A	N/A	QBAR is approx. 1 in 2 storm event. Provide this if Section 6 (QBAR) is proposed.
1 in 1	0.07	0.035	0.00	-50%	Proposed discharge rates (with mitigation) should aim to be equivalent to greenfield rates for all corresponding storm events. As a minimum, peak discharge rates must be reduced by 50% from the existing sites for all corresponding rainfall events.
1 in 30	0.18	0.095	0.10	-50%	
1in 100	0.25	0.13	0.01	-50%	
1 in 100 plus climate change	N/A	0.13	N/A	N/A	The proposed 1 in 100 +CC peak discharge rate (with mitigation) should aim to be equivalent to greenfield rates. As a minimum, proposed 1 in 100 +CC peak discharge rate must be reduced by 50% from the existing 1 in 100 runoff rate sites.

5. Calculate additional volumes for storage – The total volume of water leaving the development site. New hard surfaces potentially restrict the amount of stormwater that can go to the ground, so this needs to be controlled so not to make flood risk worse to properties downstream.

	Greenfield runoff volume (m^3)	Existing Volume (m^3)	Proposed Volume (m^3)	Difference (m^3) (Proposed-Existing)	Notes for developers
1 in 1	1	3	7	0	Proposed discharge volumes (with mitigation) should be constrained to a value as close as is reasonably practicable to the greenfield runoff volume wherever practicable and as a minimum should be no greater than existing volumes for all corresponding storm events. Any increase in volume increases flood risk elsewhere. Where volumes are increased section 6 must be filled in.
1 in 30	4	8	6	-2	
1 in 100 6 hour	5	10	8	-2	
1 in 100 6 hour plus climate change	N/A	N/A	11	1	The proposed 1 in 100 +CC discharge volume should be constrained to a value as close as is reasonably practicable to the greenfield runoff volume wherever practicable. As a minimum, to mitigate for climate change the proposed 1 in 100 +CC volume discharge from site must be no greater than the existing 1 in 100 storm event. If not, flood risk increases under climate change.

6. Calculate attenuation storage – Attenuation storage is provided to enable the rate of runoff from the site into the receiving watercourse to be limited to an acceptable rate to protect against erosion and flooding downstream. The attenuation storage volume is a function of the degree of development relative to the greenfield discharge rate.

		Notes for developers
Storage Attenuation volume (Flow rate control) required to meet greenfield run off rates (m^3)	6	Volume of water to attenuate on site if discharging at a greenfield run off rate. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to reduce rates by 50% (m^3)	2.5	Volume of water to attenuate on site if discharging at a 50% reduction from existing rates. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to meet [OTHER RUN OFF RATE (as close to greenfield rate as possible] (m^3) . 3 x Greenfield	7.5	Volume of water to attenuate on site if discharging at a rate different from the above – please state in 1st column what rate this volume corresponds to. On previously developed sites, runoff rates should not be more than three times the calculated greenfield rate. Can't be used where discharge volumes are increasing
Storage Attenuation volume (Flow rate control) required to retain rates as existing (m^3)	1	Volume of water to attenuate on site if discharging at existing rates. Can't be used where discharge volumes are increasing
Percentage of attenuation volume stored above ground,	100%	Percentage of attenuation volume which will be held above ground in swales/ponds/basins/green roofs etc. If 0, please demonstrate why.

LBH WEMBLEY ENGINEERING

7. How is Storm Water stored on site?

Storage is required for the additional volume from site but also for holding back water to slow down the rate from the site. This is known as attenuation storage and long term storage. The idea is that the additional volume does not get into the watercourses, or if it does it is at an exceptionally low rate. You can either infiltrate the stored water back to ground, or if this isn't possible hold it back with on site storage. Firstly, can infiltration work on site?

			Notes for developers
Infiltration	**State the Site's Geology and known Source Protection Zones (SPZ)**	**London Clay (nil SPZ)**	Avoid infiltrating in made ground. Infiltration rates are highly variable and refer to Environment Agency website to identify and source protection zones (SPZ)
	Are infiltration rates suitable?	**No**	Infiltration rates should be no lower than 1x10 $^{-6}$ m/s.
	State the distance between a proposed infiltration device base and the ground water (GW) level	**n/a**	Need 1m (min) between the base of the infiltration device & the water table to protect Groundwater quality & ensure GW doesn't enter infiltration devices. Avoid infiltration where this isn't possible.
	Were infiltration rates obtained by desk study or infiltration test?	**n/a**	Infiltration rates can be estimated from desk studies at most stages of the planning system if a back up attenuation scheme is provided..
	Is the site contaminated? If yes, consider advice from others on whether infiltration can happen.	**No**	Advice on contaminated Land in Camden can be found on our supporting documents webpage Water should not be infiltrated through land that is contaminated. The Environment Agency may provide bespoke advice in planning consultations for contaminated sites that should be considered.
In light of the above, is infiltration feasible?	**Yes/No? If the answer is No, please identify how the storm water will be stored prior to release**	**No**	If infiltration is not feasible how will the additional volume be stored?. The applicant should then consider the following options in the next section.

Storage requirements

The developer must confirm that either of the two methods for dealing with the amount of water that needs to be stored on site.

Option 1 Simple – Store both the additional volume and attenuation volume in order to make a final discharge from site at the greenfield run off rate. This is preferred if no infiltration can be made on site. This very simply satisfies the runoff rates and volume criteria.

Option 2 Complex – If some of the additional volume of water can be infiltrated back into the ground, the remainder can be discharged at a very low rate of 2 l/sec/hectare. A combined storage calculation using the partial permissible rate of 2 l/sec/hectare and the attenuation rate used to slow the runoff from site.

		Notes for developers
Please confirm what option has been chosen and how much storage is required on site.	Simple	The developer at this stage should have an idea of the site characteristics and be able to explain what the storage requirements are on site and how it will be achieved.

8. Please confirm

		Notes for developers
Which Drainage Systems measures have been used, including green roofs?	3 m^3 Storage comprising 1-2m3 in blue / green roof and balance in garden swale	SUDS can be adapted for most situations even where infiltration isn't feasible e.g. impermeable liners beneath some SUDS devices allows treatment but not infiltration. See CIRIA SUDS Manual C697.
Drainage system can contain in the 1 in 30 storm event without flooding	YES	This a requirement for sewers for adoption & is good practice even where drainage system is not adopted.
Will the drainage system contain the 1 in 100 +CC storm event? If no please demonstrate how buildings and utility plants will be protected.	YES	National standards require that the drainage system is designed so that flooding does not occur during a 1 in 100 year rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.
Any flooding between the 1 in 30 & 1 in 100 plus climate change storm events will be safely contained on site.	YES	**Safely:** not causing property flooding or posing a hazard to site users i.e. no deeper than 300mm on roads/footpaths. Flood waters must drain away at section 6 rates. Existing rates can be used where runoff volumes are not increased.

How will exceedance events be catered on site without increasing flood risks (both on site and outside the development)?	**As present**	**Safely:** not causing property flooding or posing a hazard to site users i.e. no deeper than 300mm on roads/footpaths. Flood waters must drain away at section 6 rates. Existing rates can be used where runoff volumes are not increased. Exceedance events are defined as those larger than the 1 in 100 +CC event.
How are rates being restricted (vortex control, orifice etc)	**Orifice**	Detail of how the flow control systems have been designed to avoid pipe blockages and ease of maintenance should be provided.
Please confirm the owners/adopters of the entire drainage systems throughout the development. Please list all the owners.	**Dr Pooja Shah & Dr Samit Shah**	If these are multiple owners then a drawing illustrating exactly what features will be within each owner's remit must be submitted with this Proforma.
How is the entire drainage system to be maintained?	**by owners**	If the features are to be maintained directly by the owners as stated in answer to the above question please answer yes to this question and submit the relevant maintenance schedule for each feature. If it is to be maintained by others than above please give details of each feature and the maintenance schedule. Clear details of the maintenance proposals of all elements of the proposed drainage system must be provided. Details must demonstrate that maintenance and operation requirements are economically proportionate. Poorly maintained drainage can lead to increased flooding problems in the future.

9. Evidence Please identify where the details quoted in the sections above were taken from. i.e. Plans, reports etc. Please also provide relevant drawings that need to accompany your proforma, in particular exceedance routes and ownership and location of SuDS (maintenance access strips etc

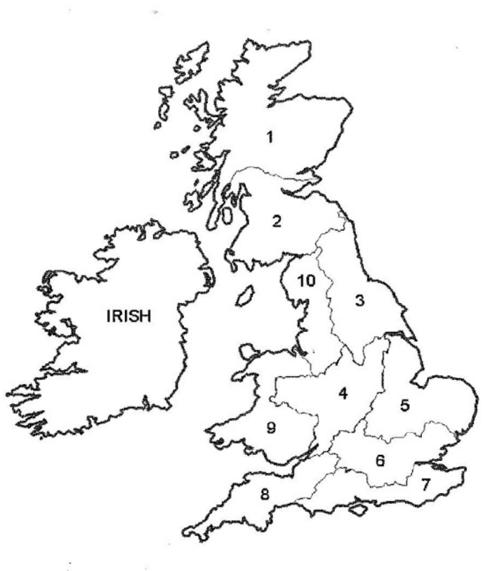
Pro-forma Section	Document reference where details quoted above are taken from	Page Number
Section 2	Suds Report	var
Section 3	Suds Report	var
Section 4	Calculation Sheets	var
Section 5	Calculation Sheets	var
Section 6	Calculation Sheets	var
Section 7	Suds Report	var
Section 8	Suds Report	var

The above form should be completed using evidence from the Flood Risk Assessment and site plans. It should serve as a summary sheet of thedrainage proposals and should clearly show that the proposed rate and volume as a result of development will not be increasing. If there is an increase in rate or volume, the rate or volume section should be completed to set out how the additional rate/volume is being dealt with.drainage proposals and should clearly show that the proposed rate and volume as a result of development will not be increasing. If there is an increase in rate or volume, the rate or volume section should be completed to set out how the additional rate/volume is being dealt with.

This form is completed using factual information from the Flood Risk Assessment and Site Plans and can be used as a summary of the surface water drainage strategy on this site.

VERSION	DATE	COMMENT	AUTHORISED
1	4th April 2019	Initial Issue	

GREENFIELD RUN-OFF



Catchment Area:	182sqm	0.018ha	
PO Code :	NW1 7RY		
Hydrological Region:	6	*From Wallingford on-line tool*	
SAAR:	625mm	*From Wallingford on-line tool*	
SOIL type:	4	*From Wallingford on-line tool*	
SPR:	0.47	*Derived as follows:*	

SOIL	*Sand*	*Clayey Sand*	*Sandy Clay*	*Clay*	*Rock*
	1	*2*	*3*	*4*	*5*
SPR	*0.1*	*0.3*	*0.37*	*0.47*	*0.53*

From Wallingford on-line tool using IH 124 Method

Qbar:	211.42	*Calculated from SPR and SAAR*	
Greenfield Peak Run-off Rate:			*Growth curve Factor*
1 in 1	*179.7 l/sec*		*0.85*
1 in 30	*486.3 l/sec*		*2.30*
1 in 100	*674.4 l/sec*		*3.19*
1 in 200	*790.7 l/sec*		*3.74*

Qbar:	**0.08 l/sec**
Greenfield Peak Run-off Rate:	
1 in 1	**0.07 l/sec**
1 in 30	**0.18 l/sec**
1 in 100	**0.25 l/sec**
1 in 200	**0.29 l/sec**

National Non-Statutory Guidance:
For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event.

For developments which were previously developed, 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.

Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event.

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 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.

SuDs CALCULATIONS	
Project:	64 Delancey Street
GREENFIELD RUN-OFF	
Sheet 1 of 7	
Project Reference:	LBH 4576
Date: 04/04/2019	Rev: 0
Client:	Dr Pooja Shah & Dr Samit Shah

LBH WEMBLEY ENGINEERING

RAINFALL PEAK INTENSITY (i)

M5-60 : 20 *From Wallingford Fig A1*

r: 0.42 *From Wallingford Fig A2*

D Duration		Z1	M5-D
5min	5min	0.38	7.6mm
10min	10min	0.55	11.0mm
15min	15min	0.65	13.0mm
30min	30min	0.75	15.0mm
1hr	60min	1.00	20.0mm
2hr	120min	1.20	24.0mm
4hr	240min	1.40	28.0mm
6hr	360min	1.60	32.0mm
10hr	600min	1.70	34.0mm
24hr	1440min	2.20	44.0mm
48hr	2880min	2.50	50.0mm

			Z2								
D Duration		M5-D	M1-D	M2-D	M3-D	M4-D	M5-D	M10-D	M20-D	M30-D	M100-D
5min	5min	7.6mm	0.62	0.79	0.89	0.97	1.02	1.19	1.36	1.43	1.79
10min	10min	11.0mm	0.61	0.79	0.90	0.97	1.03	1.22	1.41	1.49	1.91
15min	15min	13.0mm	0.61	0.79	0.90	0.97	1.03	1.22	1.41	1.49	1.91
30min	30min	15.0mm	0.62	0.81	0.90	0.97	1.03	1.24	1.44	1.53	1.99
1hr	60min	20.0mm	0.64	0.81	0.90	0.97	1.03	1.24	1.45	1.54	2.03
2hr	120min	24.0mm	0.64	0.81	0.90	0.97	1.03	1.24	1.45	1.54	2.03
4hr	240min	28.0mm	0.66	0.82	0.91	0.97	1.03	1.24	1.44	1.53	2.01
6hr	360min	32.0mm	0.68	0.83	0.91	0.97	1.03	1.22	1.42	1.51	1.97
10hr	600min	34.0mm	0.68	0.83	0.91	0.97	1.03	1.22	1.42	1.51	1.97
24hr	1440min	44.0mm	0.70	0.84	0.92	0.97	1.02	1.19	1.38	1.47	1.89
48hr	2880min	50.0mm	0.72	0.85	0.93	0.98	1.02	1.17	1.34	1.42	1.81

			MT-D								
D Duration		M5-D	M1-D	M2-D	M3-D	M4-D	M5-D	M10-D	M20-D	M30-D	M100-D
5min	5min	7.6mm	4.7mm	6.0mm	6.8mm	7.4mm	7.8mm	9.0mm	10.3mm	10.8mm	13.6mm
10min	10min	11.0mm	6.7mm	8.7mm	9.9mm	10.7mm	11.3mm	13.4mm	15.5mm	16.4mm	21.0mm
15min	15min	13.0mm	7.9mm	10.3mm	11.7mm	12.6mm	13.4mm	15.9mm	18.3mm	19.4mm	24.8mm
30min	30min	15.0mm	9.3mm	12.2mm	13.5mm	14.6mm	15.5mm	18.6mm	21.6mm	22.9mm	29.9mm
1hr	60min	20.0mm	12.8mm	16.2mm	18.0mm	19.4mm	20.6mm	24.8mm	29.0mm	30.9mm	40.6mm
2hr	120min	24.0mm	15.4mm	19.4mm	21.6mm	23.3mm	24.7mm	29.8mm	34.8mm	37.0mm	48.7mm
4hr	240min	28.0mm	18.5mm	23.0mm	25.5mm	27.2mm	28.8mm	34.7mm	40.3mm	42.9mm	56.3mm
6hr	360min	32.0mm	21.8mm	26.6mm	29.1mm	31.0mm	33.0mm	39.0mm	45.4mm	48.4mm	63.0mm
10hr	600min	34.0mm	23.1mm	28.2mm	30.9mm	33.0mm	35.0mm	41.5mm	48.3mm	51.5mm	67.0mm
24hr	1440min	44.0mm	30.8mm	37.0mm	40.5mm	42.7mm	44.9mm	52.4mm	60.7mm	64.5mm	83.2mm
48hr	2880min	50.0mm	36.0mm	42.5mm	46.5mm	49.0mm	51.0mm	58.5mm	67.0mm	71.0mm	90.5mm

			Intensity i								
D Duration			M1-D	M2-D	M3-D	M4-D	M5-D	M10-D	M20-D	M30-D	M100-D
5min	5min	0.08hr	56.5mm/hr	72.0mm/hr	81.2mm/hr	88.5mm/hr	93.0mm/hr	108.5mm/hr	124.0mm/hr	130.1mm/hr	163.2mm/hr
10min	10min	0.17hr	40.3mm/hr	52.1mm/hr	59.4mm/hr	64.0mm/hr	68.0mm/hr	80.5mm/hr	93.1mm/hr	98.3mm/hr	126.1mm/hr
15min	15min	0.25hr	31.7mm/hr	41.1mm/hr	46.8mm/hr	50.4mm/hr	53.6mm/hr	63.4mm/hr	73.3mm/hr	77.5mm/hr	99.3mm/hr
30min	30min	0.50hr	18.6mm/hr	24.3mm/hr	27.0mm/hr	29.1mm/hr	30.9mm/hr	37.2mm/hr	43.2mm/hr	45.8mm/hr	59.7mm/hr
1hr	60min	1.00hr	12.8mm/hr	16.2mm/hr	18.0mm/hr	19.4mm/hr	20.6mm/hr	24.8mm/hr	29.0mm/hr	30.9mm/hr	40.6mm/hr
2hr	120min	2.00hr	7.7mm/hr	9.7mm/hr	10.8mm/hr	11.6mm/hr	12.4mm/hr	14.9mm/hr	17.4mm/hr	18.5mm/hr	24.4mm/hr
4hr	240min	4.00hr	4.6mm/hr	5.7mm/hr	6.4mm/hr	6.8mm/hr	7.2mm/hr	8.7mm/hr	10.1mm/hr	10.7mm/hr	14.1mm/hr
6hr	360min	6.00hr	3.6mm/hr	4.4mm/hr	4.9mm/hr	5.2mm/hr	5.5mm/hr	6.5mm/hr	7.6mm/hr	8.1mm/hr	10.5mm/hr
10hr	600min	10.00hr	2.3mm/hr	2.8mm/hr	3.1mm/hr	3.3mm/hr	3.5mm/hr	4.1mm/hr	4.8mm/hr	5.1mm/hr	6.7mm/hr
24hr	1440min	24.00hr	1.3mm/hr	1.5mm/hr	1.7mm/hr	1.8mm/hr	1.9mm/hr	2.2mm/hr	2.5mm/hr	2.7mm/hr	3.5mm/hr
48hr	2880min	48.00hr	0.6mm/hr	0.8mm/hr	0.8mm/hr	0.9mm/hr	0.9mm/hr	1.1mm/hr	1.3mm/hr	1.3mm/hr	1.7mm/hr
48hr	2880min	48.00hr	0.8mm/hr	0.9mm/hr	1.0mm/hr	1.0mm/hr	1.1mm/hr	1.2mm/hr	1.4mm/hr	1.5mm/hr	1.9mm/hr

GREENFIELD PEAK RUN-OFF

Hydrological Region: 6 *From Wallingford on-line tool* **Qbar: 0.08 l/sec**

			Run-Off Q								
D Duration			**M1-D**	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
10min	10min	0.17hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
15min	15min	0.25hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
30min	30min	0.50hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
1hr	60min	1.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
2hr	120min	2.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
4hr	240min	4.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
6hr	360min	6.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
10hr	600min	10.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
24hr	1440min	24.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec
48hr	2880min	48.00hr	0.07 l/sec	0.07 l/sec	0.08 l/sec	0.09 l/sec	0.10 l/sec	0.13 l/sec	0.15 l/sec	0.19 l/sec	0.25 l/sec

			Run-Off Volume								
D Duration			**M1-D**	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.0 m3	0.0 m3	0.0 m3	0.0 m3	0.0 m3	0.0 m3	0.0 m3	0.1 m3	0.1 m3
10min	10min	0.17hr	0.0 m3	0.0 m3	0.0 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3
15min	15min	0.25hr	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.2 m3	0.2 m3
30min	30min	0.50hr	0.1 m3	0.1 m3	0.1 m3	0.2 m3	0.2 m3	0.2 m3	0.3 m3	0.3 m3	0.4 m3
1hr	60min	1.00hr	0.2 m3	0.2 m3	0.3 m3	0.3 m3	0.4 m3	0.5 m3	0.6 m3	0.7 m3	0.9 m3
2hr	120min	2.00hr	0.5 m3	0.5 m3	0.6 m3	0.6 m3	0.7 m3	0.9 m3	1.1 m3	1.4 m3	1.8 m3
4hr	240min	4.00hr	1.0 m3	1.0 m3	1.1 m3	1.3 m3	1.4 m3	1.8 m3	2.2 m3	2.7 m3	3.6 m3
6hr	360min	6.00hr	1.4 m3	1.5 m3	1.7 m3	1.9 m3	2.2 m3	2.7 m3	3.3 m3	4.1 m3	5.4 m3
10hr	600min	10.00hr	2.4 m3	2.5 m3	2.9 m3	3.2 m3	3.6 m3	4.6 m3	5.5 m3	6.8 m3	9.0 m3
24hr	1440min	24.00hr	5.7 m3	5.9 m3	6.8 m3	7.7 m3	8.7 m3	10.9 m3	13.3 m3	16.2 m3	21.6 m3
48hr	2880min	48.00hr	11.5 m3	11.9 m3	13.7 m3	15.5 m3	17.3 m3	21.9 m3	26.6 m3	32.4 m3	43.1 m3

SuDs CALCULATIONS

Project: 64 Delancey Street

GREENFIELD PEAK RUN-OFF

Sheet 3 of 7

Project Reference: LBH 4576

Date: 04/04/2019 Rev: 0

Client: Dr Pooja Shah & Dr Samit Shah

LBH WEMBLEY ENGINEERING

EXISTING PEAK RUN-OFF

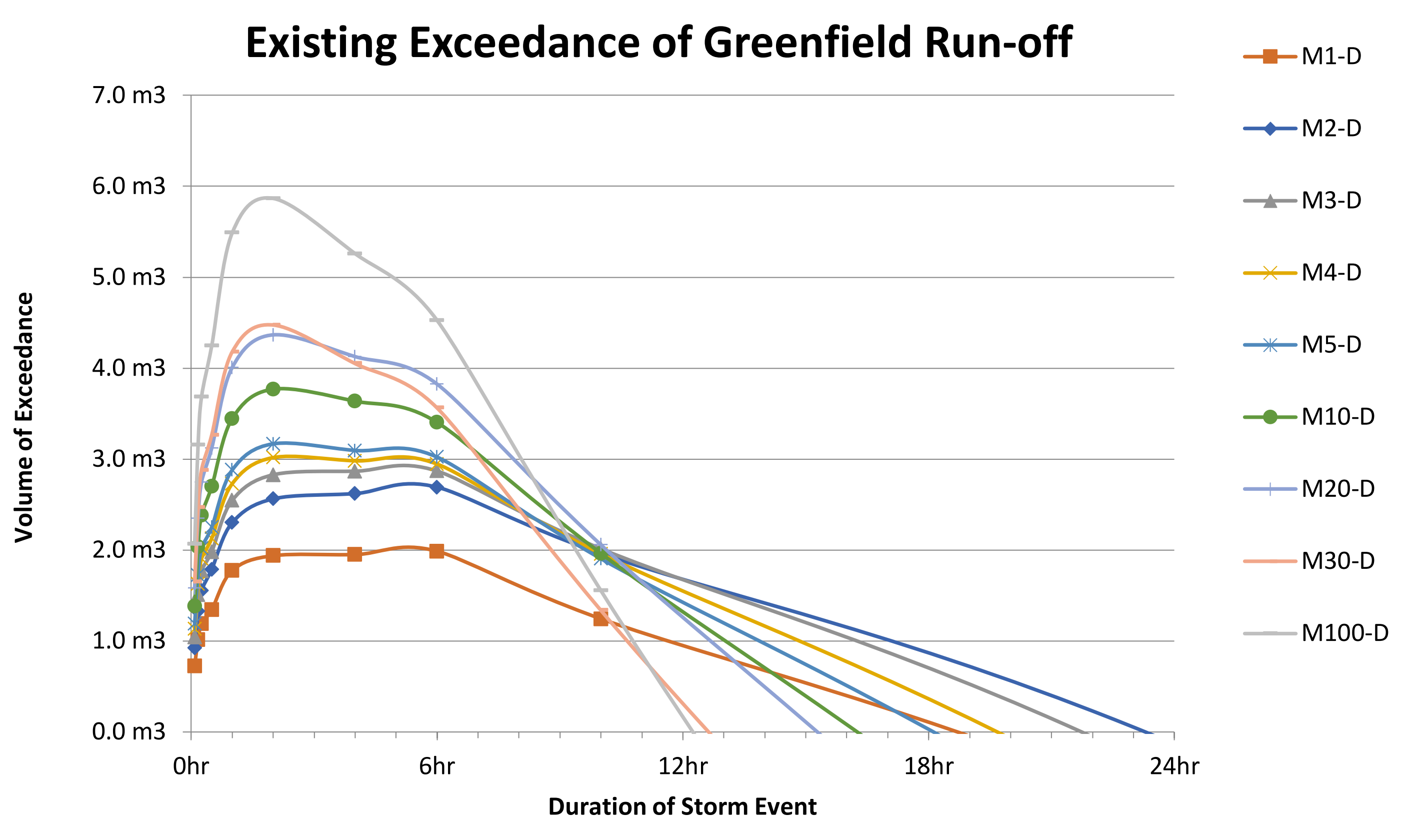
C_V:	0.66	*Volumetric Run-Off Coefficient*
C_R:	1.3	*Routing Coefficient*

D Duration			Run-Off Q								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	2.5 l/sec	3.1 l/sec	3.5 l/sec	3.9 l/sec	4.1 l/sec	4.7 l/sec	5.4 l/sec	5.7 l/sec	7.1 l/sec
10min	10min	0.17hr	1.8 l/sec	2.3 l/sec	2.6 l/sec	2.8 l/sec	3.0 l/sec	3.5 l/sec	4.1 l/sec	4.3 l/sec	5.5 l/sec
15min	15min	0.25hr	1.4 l/sec	1.8 l/sec	2.0 l/sec	2.2 l/sec	2.3 l/sec	2.8 l/sec	3.2 l/sec	3.4 l/sec	4.3 l/sec
30min	30min	0.50hr	0.8 l/sec	1.1 l/sec	1.2 l/sec	1.3 l/sec	1.4 l/sec	1.6 l/sec	1.9 l/sec	2.0 l/sec	2.6 l/sec
1hr	60min	1.00hr	0.6 l/sec	0.7 l/sec	0.8 l/sec	0.8 l/sec	0.9 l/sec	1.1 l/sec	1.3 l/sec	1.3 l/sec	1.8 l/sec
2hr	120min	2.00hr	0.3 l/sec	0.4 l/sec	0.5 l/sec	0.5 l/sec	0.5 l/sec	0.7 l/sec	0.8 l/sec	0.8 l/sec	1.1 l/sec
4hr	240min	4.00hr	0.2 l/sec	0.3 l/sec	0.3 l/sec	0.3 l/sec	0.3 l/sec	0.4 l/sec	0.4 l/sec	0.5 l/sec	0.6 l/sec
6hr	360min	6.00hr	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.3 l/sec	0.3 l/sec	0.4 l/sec	0.5 l/sec
10hr	600min	10.00hr	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.3 l/sec
24hr	1440min	24.00hr	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.2 l/sec
48hr	2880min	48.00hr	0.0 l/sec	0.0 l/sec	0.0 l/sec	0.0 l/sec	0.0 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec

D Duration			Run-Off Volume								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.7 m3	0.9 m3	1.1 m3	1.2 m3	1.2 m3	1.4 m3	1.6 m3	1.7 m3	2.1 m3
10min	10min	0.17hr	1.1 m3	1.4 m3	1.6 m3	1.7 m3	1.8 m3	2.1 m3	2.4 m3	2.6 m3	3.3 m3
15min	15min	0.25hr	1.2 m3	1.6 m3	1.8 m3	2.0 m3	2.1 m3	2.5 m3	2.9 m3	3.0 m3	3.9 m3
30min	30min	0.50hr	1.5 m3	1.9 m3	2.1 m3	2.3 m3	2.4 m3	2.9 m3	3.4 m3	3.6 m3	4.7 m3
1hr	60min	1.00hr	2.0 m3	2.5 m3	2.8 m3	3.1 m3	3.2 m3	3.9 m3	4.6 m3	4.9 m3	6.4 m3
2hr	120min	2.00hr	2.4 m3	3.1 m3	3.4 m3	3.7 m3	3.9 m3	4.7 m3	5.5 m3	5.8 m3	7.7 m3
4hr	240min	4.00hr	2.9 m3	3.6 m3	4.0 m3	4.3 m3	4.5 m3	5.5 m3	6.3 m3	6.8 m3	8.9 m3
6hr	360min	6.00hr	3.4 m3	4.2 m3	4.6 m3	4.9 m3	5.2 m3	6.1 m3	7.1 m3	7.6 m3	9.9 m3
10hr	600min	10.00hr	3.6 m3	4.4 m3	4.9 m3	5.2 m3	5.5 m3	6.5 m3	7.6 m3	8.1 m3	10.5 m3
24hr	1440min	24.00hr	4.8 m3	5.8 m3	6.4 m3	6.7 m3	7.1 m3	8.2 m3	9.6 m3	10.2 m3	13.1 m3
48hr	2880min	48.00hr	5.7 m3	6.7 m3	7.3 m3	7.7 m3	8.0 m3	9.2 m3	10.5 m3	11.2 m3	14.2 m3

D Duration			Exceedance of Greenfield Run-Off Volume								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.7 m3	0.9 m3	1.0 m3	1.1 m3	1.2 m3	1.4 m3	1.6 m3	1.6 m3	2.1 m3
10min	10min	0.17hr	1.0 m3	1.3 m3	1.5 m3	1.6 m3	1.7 m3	2.0 m3	2.3 m3	2.5 m3	3.2 m3
15min	15min	0.25hr	1.2 m3	1.6 m3	1.8 m3	1.9 m3	2.0 m3	2.4 m3	2.7 m3	2.9 m3	3.7 m3
30min	30min	0.50hr	1.3 m3	1.8 m3	2.0 m3	2.1 m3	2.2 m3	2.7 m3	3.1 m3	3.3 m3	4.2 m3
1hr	60min	1.00hr	1.8 m3	2.3 m3	2.5 m3	2.7 m3	2.9 m3	3.4 m3	4.0 m3	4.2 m3	5.5 m3
2hr	120min	2.00hr	1.9 m3	2.6 m3	2.8 m3	3.0 m3	3.2 m3	3.8 m3	4.4 m3	4.5 m3	5.9 m3
4hr	240min	4.00hr	1.9 m3	2.6 m3	2.9 m3	3.0 m3	3.1 m3	3.6 m3	4.1 m3	4.0 m3	5.3 m3
6hr	360min	6.00hr	2.0 m3	2.7 m3	2.9 m3	2.9 m3	3.0 m3	3.4 m3	3.8 m3	3.6 m3	4.5 m3
10hr	600min	10.00hr	1.2 m3	2.0 m3	2.0 m3	2.0 m3	1.9 m3	2.0 m3	2.1 m3	1.3 m3	1.6 m3
24hr	1440min	24.00hr	-0.9 m3	-0.1 m3	-0.5 m3	-1.0 m3	-1.6 m3	-2.7 m3	-3.7 m3	-6.1 m3	-8.5 m3
48hr	2880min	48.00hr	-5.8 m3	-5.2 m3	-6.4 m3	-7.8 m3	-9.3 m3	-12.7 m3	-16.0 m3	-21.3 m3	-28.9 m3

			C_V:
Catchment Area:	182sqm	100%	
Permeable:	52sqm	29%	0.40
Impermeable:	130sqm	71%	0.77
			0.66



SuDs CALCULATIONS

Project: 64 Delancey Street

EXISTING PEAK RUN-OFF

Sheet 4 of 7

Project Reference: LBH 4576

Date: 04/04/2019 | Rev: 0

Client: Dr Pooja Shah & Dr Samit Shah

LBH WEMBLEY ENGINEERING

POST- DEVELOPMENT PEAK RUN-OFF + CC

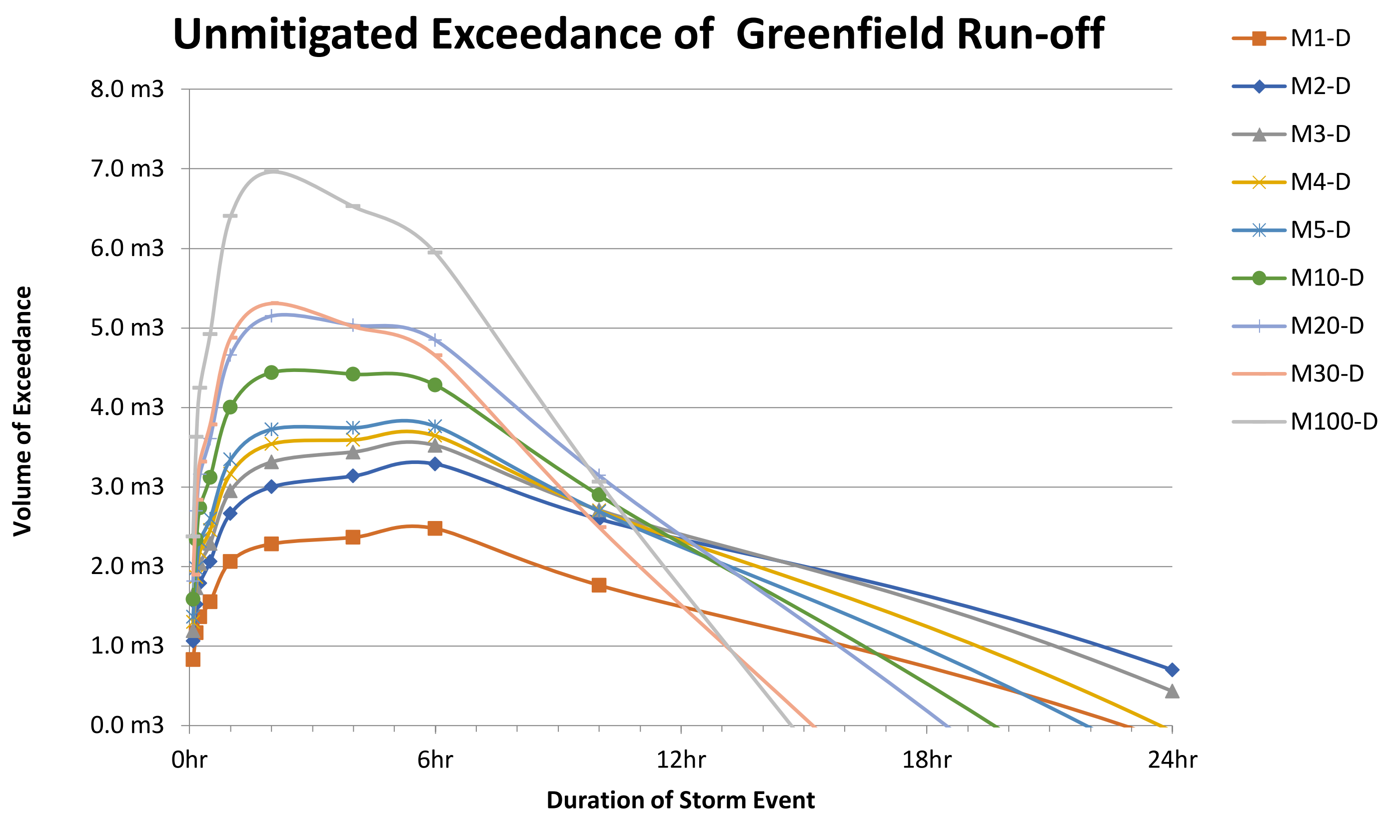
C_V:	0.54	*Volumetric Run-Off Coefficient*	Climate Change Allowance:	40%
C_R:	1.3	*Routing Coefficient*		

D Duration			Run-Off Q								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	2.8 l/sec	3.6 l/sec	4.1 l/sec	4.4 l/sec	4.6 l/sec	5.4 l/sec	6.2 l/sec	6.5 l/sec	8.2 l/sec
10min	10min	0.17hr	2.0 l/sec	2.6 l/sec	3.0 l/sec	3.2 l/sec	3.4 l/sec	4.0 l/sec	4.6 l/sec	4.9 l/sec	6.3 l/sec
15min	15min	0.25hr	1.6 l/sec	2.1 l/sec	2.3 l/sec	2.5 l/sec	2.7 l/sec	3.2 l/sec	3.7 l/sec	3.9 l/sec	5.0 l/sec
30min	30min	0.50hr	0.9 l/sec	1.2 l/sec	1.3 l/sec	1.5 l/sec	1.5 l/sec	1.9 l/sec	2.2 l/sec	2.3 l/sec	3.0 l/sec
1hr	60min	1.00hr	0.6 l/sec	0.8 l/sec	0.9 l/sec	1.0 l/sec	1.0 l/sec	1.2 l/sec	1.4 l/sec	1.5 l/sec	2.0 l/sec
2hr	120min	2.00hr	0.4 l/sec	0.5 l/sec	0.5 l/sec	0.6 l/sec	0.6 l/sec	0.7 l/sec	0.9 l/sec	0.9 l/sec	1.2 l/sec
4hr	240min	4.00hr	0.2 l/sec	0.3 l/sec	0.3 l/sec	0.3 l/sec	0.4 l/sec	0.4 l/sec	0.5 l/sec	0.5 l/sec	0.7 l/sec
6hr	360min	6.00hr	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.3 l/sec	0.3 l/sec	0.3 l/sec	0.4 l/sec	0.4 l/sec	0.5 l/sec
10hr	600min	10.00hr	0.1 l/sec	0.1 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.2 l/sec	0.3 l/sec	0.3 l/sec
24hr	1440min	24.00hr	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.2 l/sec
48hr	2880min	48.00hr	0.0 l/sec	0.0 l/sec	0.0 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec	0.1 l/sec

D Duration			Run-Off Volume								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.8 m3	1.1 m3	1.2 m3	1.3 m3	1.4 m3	1.6 m3	1.9 m3	1.9 m3	2.4 m3
10min	10min	0.17hr	1.2 m3	1.6 m3	1.8 m3	1.9 m3	2.0 m3	2.4 m3	2.8 m3	2.9 m3	3.8 m3
15min	15min	0.25hr	1.4 m3	1.8 m3	2.1 m3	2.3 m3	2.4 m3	2.9 m3	3.3 m3	3.5 m3	4.5 m3
30min	30min	0.50hr	1.7 m3	2.2 m3	2.4 m3	2.6 m3	2.8 m3	3.3 m3	3.9 m3	4.1 m3	5.4 m3
1hr	60min	1.00hr	2.3 m3	2.9 m3	3.2 m3	3.5 m3	3.7 m3	4.5 m3	5.2 m3	5.5 m3	7.3 m3
2hr	120min	2.00hr	2.8 m3	3.5 m3	3.9 m3	4.2 m3	4.4 m3	5.4 m3	6.3 m3	6.7 m3	8.8 m3
4hr	240min	4.00hr	3.3 m3	4.1 m3	4.6 m3	4.9 m3	5.2 m3	6.2 m3	7.2 m3	7.7 m3	10.1 m3
6hr	360min	6.00hr	3.9 m3	4.8 m3	5.2 m3	5.6 m3	5.9 m3	7.0 m3	8.2 m3	8.7 m3	11.3 m3
10hr	600min	10.00hr	4.2 m3	5.1 m3	5.6 m3	5.9 m3	6.3 m3	7.5 m3	8.7 m3	9.3 m3	12.0 m3
24hr	1440min	24.00hr	5.5 m3	6.6 m3	7.3 m3	7.7 m3	8.1 m3	9.4 m3	10.9 m3	11.6 m3	15.0 m3
48hr	2880min	48.00hr	6.5 m3	7.6 m3	8.4 m3	8.8 m3	9.2 m3	10.5 m3	12.0 m3	12.8 m3	16.3 m3

D Duration			Exceedance of Greenfield Run-Off Volume								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.8 m3	1.1 m3	1.2 m3	1.3 m3	1.4 m3	1.6 m3	1.8 m3	1.9 m3	2.4 m3
10min	10min	0.17hr	1.2 m3	1.5 m3	1.7 m3	1.9 m3	2.0 m3	2.3 m3	2.7 m3	2.8 m3	3.6 m3
15min	15min	0.25hr	1.4 m3	1.8 m3	2.0 m3	2.2 m3	2.3 m3	2.7 m3	3.2 m3	3.3 m3	4.2 m3
30min	30min	0.50hr	1.6 m3	2.1 m3	2.3 m3	2.5 m3	2.6 m3	3.1 m3	3.6 m3	3.8 m3	4.9 m3
1hr	60min	1.00hr	2.1 m3	2.7 m3	3.0 m3	3.2 m3	3.3 m3	4.0 m3	4.7 m3	4.9 m3	6.4 m3
2hr	120min	2.00hr	2.3 m3	3.0 m3	3.3 m3	3.5 m3	3.7 m3	4.4 m3	5.1 m3	5.3 m3	7.0 m3
4hr	240min	4.00hr	2.4 m3	3.1 m3	3.4 m3	3.6 m3	3.7 m3	4.4 m3	5.0 m3	5.0 m3	6.5 m3
6hr	360min	6.00hr	2.5 m3	3.3 m3	3.5 m3	3.6 m3	3.8 m3	4.3 m3	4.8 m3	4.7 m3	5.9 m3
10hr	600min	10.00hr	1.8 m3	2.6 m3	2.7 m3	2.7 m3	2.7 m3	2.9 m3	3.1 m3	2.5 m3	3.1 m3
24hr	1440min	24.00hr	-0.2 m3	0.7 m3	0.4 m3	-0.1 m3	-0.6 m3	-1.5 m3	-2.4 m3	-4.6 m3	-6.6 m3
48hr	2880min	48.00hr	-5.0 m3	-4.3 m3	-5.3 m3	-6.7 m3	-8.1 m3	-11.4 m3	-14.5 m3	-19.7 m3	-26.9 m3

			C_V:
Catchment Area:	182sqm	100%	
Permeable	112sqm	62%	0.40
Impermeable:	70sqm	38%	0.77
			0.54



SuDs CALCULATIONS	
Project:	64 Delancey Street
POST-DEV. PEAK RUN-OFF	
Sheet 5 of 7	
Project Reference:	LBH 4576
Date: 04/04/2019	Rev: 0
Client:	Dr Pooja Shah & Dr Samit Shah

LBH WEMBLEY ENGINEERING

POST- DEVELOPMENT & SOURCE MITIGATION PEAK RUN-OFF + CC ATTENUATION STORAGE REQUIREMENTS

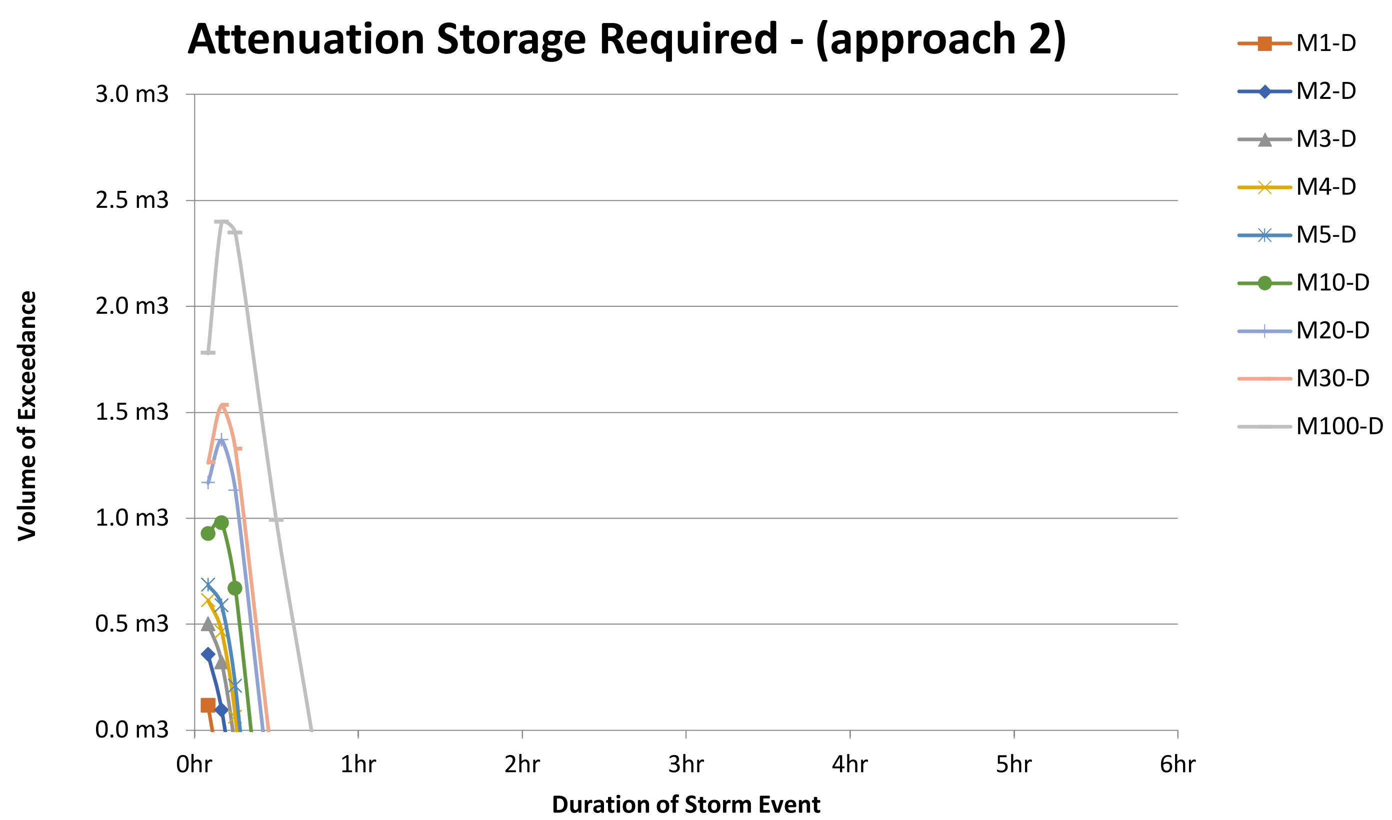
Proposed Discharge Rate: **2.55 l/sec** (approach 2 - 50% Existing)
0.08 l/sec *QBar*

D Duration			INFLOW								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.9 m3	1.1 m3	1.3 m3	1.4 m3	1.4 m3	1.7 m3	1.9 m3	2.0 m3	2.5 m3
10min	10min	0.17hr	1.3 m3	1.6 m3	1.9 m3	2.0 m3	2.1 m3	2.5 m3	2.9 m3	3.1 m3	3.9 m3
15min	15min	0.25hr	1.5 m3	1.9 m3	2.2 m3	2.4 m3	2.5 m3	3.0 m3	3.4 m3	3.6 m3	4.6 m3
30min	30min	0.50hr	1.7 m3	2.3 m3	2.5 m3	2.7 m3	2.9 m3	3.5 m3	4.0 m3	4.3 m3	5.6 m3
1hr	60min	1.00hr	2.4 m3	3.0 m3	3.4 m3	3.6 m3	3.8 m3	4.6 m3	5.4 m3	5.8 m3	7.6 m3
2hr	120min	2.00hr	2.9 m3	3.6 m3	4.0 m3	4.4 m3	4.6 m3	5.6 m3	6.5 m3	6.9 m3	9.1 m3
4hr	240min	4.00hr	3.5 m3	4.3 m3	4.8 m3	5.1 m3	5.4 m3	6.5 m3	7.5 m3	8.0 m3	10.5 m3
6hr	360min	6.00hr	4.1 m3	5.0 m3	5.4 m3	5.8 m3	6.2 m3	7.3 m3	8.5 m3	9.1 m3	11.8 m3
10hr	600min	10.00hr	4.3 m3	5.3 m3	5.8 m3	6.2 m3	6.5 m3	7.8 m3	9.0 m3	9.6 m3	12.5 m3
24hr	1440min	24.00hr	5.8 m3	6.9 m3	7.6 m3	8.0 m3	8.4 m3	9.8 m3	11.3 m3	12.1 m3	15.5 m3
48hr	2880min	48.00hr	6.7 m3	7.9 m3	8.7 m3	9.2 m3	9.5 m3	10.9 m3	12.5 m3	13.3 m3	16.9 m3

D Duration			OUTFLOW								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3
10min	10min	0.17hr	1.5 m3	1.5 m3	1.5 m3	1.5 m3	1.5 m3	1.5 m3	1.5 m3	1.5 m3	1.5 m3
15min	15min	0.25hr	2.3 m3	2.3 m3	2.3 m3	2.3 m3	2.3 m3	2.3 m3	2.3 m3	2.3 m3	2.3 m3
30min	30min	0.50hr	4.6 m3	4.6 m3	4.6 m3	4.6 m3	4.6 m3	4.6 m3	4.6 m3	4.6 m3	4.6 m3
1hr	60min	1.00hr	9.2 m3	9.2 m3	9.2 m3	9.2 m3	9.2 m3	9.2 m3	9.2 m3	9.2 m3	9.2 m3
2hr	120min	2.00hr	18.4 m3	18.4 m3	18.4 m3	18.4 m3	18.4 m3	18.4 m3	18.4 m3	18.4 m3	18.4 m3
4hr	240min	4.00hr	36.7 m3	36.7 m3	36.7 m3	36.7 m3	36.7 m3	36.7 m3	36.7 m3	36.7 m3	36.7 m3
6hr	360min	6.00hr	55.1 m3	55.1 m3	55.1 m3	55.1 m3	55.1 m3	55.1 m3	55.1 m3	55.1 m3	55.1 m3
10hr	600min	10.00hr	91.8 m3	91.8 m3	91.8 m3	91.8 m3	91.8 m3	91.8 m3	91.8 m3	91.8 m3	91.8 m3
24hr	1440min	24.00hr	220.3 m3	220.3 m3	220.3 m3	220.3 m3	220.3 m3	220.3 m3	220.3 m3	220.3 m3	220.3 m3
48hr	2880min	48.00hr	440.6 m3	440.6 m3	440.6 m3	440.6 m3	440.6 m3	440.6 m3	440.6 m3	440.6 m3	440.6 m3

D Duration			ATTENUATION STORAGE REQUIRED TO MEET PROPOSED DISCHARGE RATE								
			M1-D	**M2-D**	**M3-D**	**M4-D**	**M5-D**	**M10-D**	**M20-D**	**M30-D**	**M100-D**
5min	5min	0.08hr	0.1 m3	0.4 m3	0.5 m3	0.6 m3	0.7 m3	0.9 m3	1.2 m3	1.3 m3	1.8 m3
10min	10min	0.17hr	-0.3 m3	0.1 m3	0.3 m3	0.5 m3	0.6 m3	1.0 m3	1.4 m3	1.5 m3	2.4 m3
15min	15min	0.25hr	-0.8 m3	-0.4 m3	-0.1 m3	0.1 m3	0.2 m3	0.7 m3	1.1 m3	1.3 m3	2.3 m3
30min	30min	0.50hr	-2.9 m3	-2.3 m3	-2.1 m3	-1.9 m3	-1.7 m3	-1.1 m3	-0.6 m3	-0.3 m3	1.0 m3
1hr	60min	1.00hr	-6.8 m3	-6.2 m3	-5.8 m3	-5.6 m3	-5.3 m3	-4.5 m3	-3.8 m3	-3.4 m3	-1.6 m3
2hr	120min	2.00hr	-15.5 m3	-14.7 m3	-14.3 m3	-14.0 m3	-13.7 m3	-12.8 m3	-11.9 m3	-11.4 m3	-9.3 m3
4hr	240min	4.00hr	-33.3 m3	-32.4 m3	-32.0 m3	-31.6 m3	-31.3 m3	-30.2 m3	-29.2 m3	-28.7 m3	-26.2 m3
6hr	360min	6.00hr	-51.0 m3	-50.1 m3	-49.6 m3	-49.3 m3	-48.9 m3	-47.8 m3	-46.6 m3	-46.0 m3	-43.3 m3
10hr	600min	10.00hr	-87.5 m3	-86.5 m3	-86.0 m3	-85.6 m3	-85.3 m3	-84.0 m3	-82.8 m3	-82.2 m3	-79.3 m3
24hr	1440min	24.00hr	-214.6 m3	-213.4 m3	-212.8 m3	-212.3 m3	-211.9 m3	-210.5 m3	-209.0 m3	-208.3 m3	-204.8 m3
48hr	2880min	48.00hr	-433.9 m3	-432.7 m3	-431.9 m3	-431.5 m3	-431.1 m3	-429.7 m3	-428.1 m3	-427.4 m3	-423.7 m3

Approach 2 ATTENUATION STORAGE REQUIRED: 2.4 m3



SuDs CALCULATIONS	
Project:	64 Delancey Street
STORAGE REQUIREMENTS	
Sheet 6 of 7	
Project Reference:	LBH 4576
Date: 04/04/2019	Rev: 0
Client:	Dr Pooja Shah & Dr Samit Shah

LBH WEMBLEY ENGINEERING

POST- DEVELOPMENT & SOURCE MITIGATION PEAK RUN-OFF + CC ATTENUATION STORAGE REQUIREMENTS

Proposed Discharge Rate: **0.23 l/sec** (3 x Qbar approach 2)
0.08 l/sec *QBar* 0.04 l/sec *(2.0 l/sec/ha)*

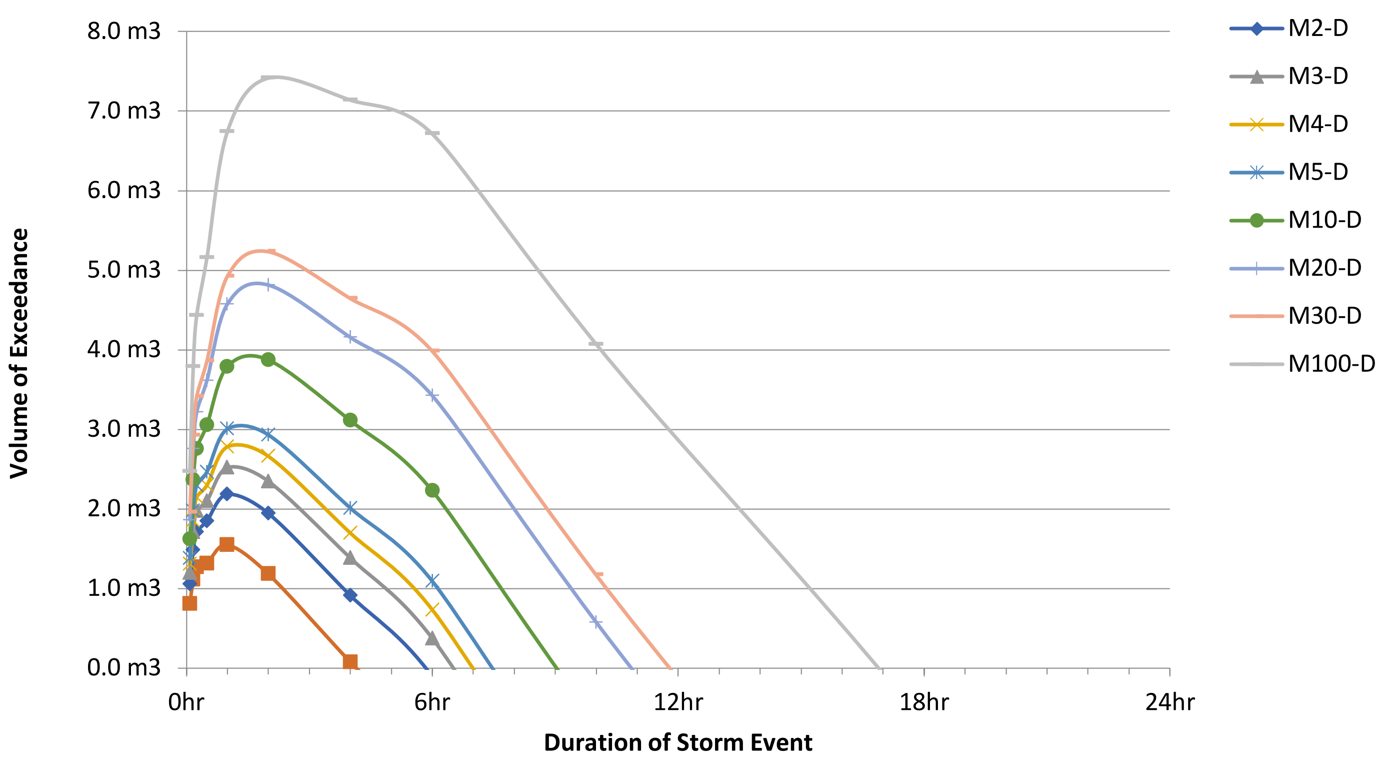
			INFLOW								
D Duration			M1-D	M2-D	M3-D	M4-D	M5-D	M10-D	M20-D	M30-D	M100-D
5min	5min	0.08hr	0.9 m3	1.1 m3	1.3 m3	1.4 m3	1.4 m3	1.7 m3	1.9 m3	2.0 m3	2.5 m3
10min	10min	0.17hr	1.3 m3	1.6 m3	1.9 m3	2.0 m3	2.1 m3	2.5 m3	2.9 m3	3.1 m3	3.9 m3
15min	15min	0.25hr	1.5 m3	1.9 m3	2.2 m3	2.4 m3	2.5 m3	3.0 m3	3.4 m3	3.6 m3	4.6 m3
30min	30min	0.50hr	1.7 m3	2.3 m3	2.5 m3	2.7 m3	2.9 m3	3.5 m3	4.0 m3	4.3 m3	5.6 m3
1hr	60min	1.00hr	2.4 m3	3.0 m3	3.4 m3	3.6 m3	3.8 m3	4.6 m3	5.4 m3	5.8 m3	7.6 m3
2hr	120min	2.00hr	2.9 m3	3.6 m3	4.0 m3	4.4 m3	4.6 m3	5.6 m3	6.5 m3	6.9 m3	9.1 m3
4hr	240min	4.00hr	3.5 m3	4.3 m3	4.8 m3	5.1 m3	5.4 m3	6.5 m3	7.5 m3	8.0 m3	10.5 m3
6hr	360min	6.00hr	4.1 m3	5.0 m3	5.4 m3	5.8 m3	6.2 m3	7.3 m3	8.5 m3	9.1 m3	11.8 m3
10hr	600min	10.00hr	4.3 m3	5.3 m3	5.8 m3	6.2 m3	6.5 m3	7.8 m3	9.0 m3	9.6 m3	12.5 m3
24hr	1440min	24.00hr	5.8 m3	6.9 m3	7.6 m3	8.0 m3	8.4 m3	9.8 m3	11.3 m3	12.1 m3	15.5 m3
48hr	2880min	48.00hr	6.7 m3	7.9 m3	8.7 m3	9.2 m3	9.5 m3	10.9 m3	12.5 m3	13.3 m3	16.9 m3

			OUTFLOW								
D Duration			M1-D	M2-D	M3-D	M4-D	M5-D	M10-D	M20-D	M30-D	M100-D
5min	5min	0.08hr	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3
10min	10min	0.17hr	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3	0.1 m3
15min	15min	0.25hr	0.2 m3	0.2 m3	0.2 m3	0.2 m3	0.2 m3	0.2 m3	0.2 m3	0.2 m3	0.2 m3
30min	30min	0.50hr	0.4 m3	0.4 m3	0.4 m3	0.4 m3	0.4 m3	0.4 m3	0.4 m3	0.4 m3	0.4 m3
1hr	60min	1.00hr	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3	0.8 m3
2hr	120min	2.00hr	1.7 m3	1.7 m3	1.7 m3	1.7 m3	1.7 m3	1.7 m3	1.7 m3	1.7 m3	1.7 m3
4hr	240min	4.00hr	3.4 m3	3.4 m3	3.4 m3	3.4 m3	3.4 m3	3.4 m3	3.4 m3	3.4 m3	3.4 m3
6hr	360min	6.00hr	5.1 m3	5.1 m3	5.1 m3	5.1 m3	5.1 m3	5.1 m3	5.1 m3	5.1 m3	5.1 m3
10hr	600min	10.00hr	8.4 m3	8.4 m3	8.4 m3	8.4 m3	8.4 m3	8.4 m3	8.4 m3	8.4 m3	8.4 m3
24hr	1440min	24.00hr	20.3 m3	20.3 m3	20.3 m3	20.3 m3	20.3 m3	20.3 m3	20.3 m3	20.3 m3	20.3 m3
48hr	2880min	48.00hr	40.6 m3	40.6 m3	40.6 m3	40.6 m3	40.6 m3	40.6 m3	40.6 m3	40.6 m3	40.6 m3

			ATTENUATION STORAGE REQUIRED TO MEET PROPOSED DISCHARGE RATE								
D Duration			M1-D	M2-D	M3-D	M4-D	M5-D	M10-D	M20-D	M30-D	M100-D
5min	5min	0.08hr	0.8 m3	1.1 m3	1.2 m3	1.3 m3	1.4 m3	1.6 m3	1.9 m3	2.0 m3	2.5 m3
10min	10min	0.17hr	1.1 m3	1.5 m3	1.7 m3	1.9 m3	2.0 m3	2.4 m3	2.8 m3	2.9 m3	3.8 m3
15min	15min	0.25hr	1.3 m3	1.7 m3	2.0 m3	2.1 m3	2.3 m3	2.8 m3	3.2 m3	3.4 m3	4.4 m3
30min	30min	0.50hr	1.3 m3	1.8 m3	2.1 m3	2.3 m3	2.5 m3	3.1 m3	3.6 m3	3.9 m3	5.2 m3
1hr	60min	1.00hr	1.5 m3	2.2 m3	2.5 m3	2.8 m3	3.0 m3	3.8 m3	4.6 m3	4.9 m3	6.7 m3
2hr	120min	2.00hr	1.2 m3	1.9 m3	2.3 m3	2.7 m3	2.9 m3	3.9 m3	4.8 m3	5.2 m3	7.4 m3
4hr	240min	4.00hr	0.1 m3	0.9 m3	1.4 m3	1.7 m3	2.0 m3	3.1 m3	4.2 m3	4.6 m3	7.1 m3
6hr	360min	6.00hr	-1.0 m3	-0.1 m3	0.4 m3	0.7 m3	1.1 m3	2.2 m3	3.4 m3	4.0 m3	6.7 m3
10hr	600min	10.00hr	-4.1 m3	-3.2 m3	-2.7 m3	-2.3 m3	-1.9 m3	-0.7 m3	0.6 m3	1.2 m3	4.1 m3
24hr	1440min	24.00hr	-14.5 m3	-13.4 m3	-12.7 m3	-12.3 m3	-11.9 m3	-10.5 m3	-8.9 m3	-8.2 m3	-4.7 m3
48hr	2880min	48.00hr	-33.8 m3	-32.6 m3	-31.9 m3	-31.4 m3	-31.0 m3	-29.6 m3	-28.0 m3	-27.3 m3	-23.6 m3

Approach 2 ATTENUATION STORAGE REQUIRED: 7.4 m3

Attenuation Storage Required - (approach 2)



SuDs CALCULATIONS	
Project:	64 Delancey Street
STORAGE REQUIREMENTS	
Sheet 7 of 7	
Project Reference:	LBH 4576
Date: 04/04/2019	Rev: 0
Client:	Dr Pooja Shah & Dr Samit Shah

LBH WEMBLEY ENGINEERING