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FLOOD RISK ASSESSMENT
& DRAINAGE STRATEGY REPORT

PROPOSED RESIDENTIAL DEVELOPMENT
ST MARGARET'S BUSINESS CAR PARK
MOOR MEAD ROAD
TWICKENHAM
TW1 1JS

PREPARED FOR:

Sheen Lane Developments Ltd

JOB NO: P20-435

DATE: 3 September 2020

ISSUE NO: 3

DOCUMENT HISTORY

Issue No.	Description	Date
1	Issue for comment.	07/08/20
2	Updated to include planning drawings	24/08/20
3	Updated to include latest planning drawings	03/09/20

CONTENTS

APPENDICES

1. INTRODUCTION

1.1 This report has been prepared on behalf of Sheen Lane Developments Ltd to accompany a planning application for a proposed residential development at St Margaret's Business Car Park in Moor Mead Road, Twickenham.

1.2 The report assesses flood risk associated with the development proposals, closely following guidance set out in the National Planning Policy Framework (NPPF), the associated Planning Practice Guidance and the London Borough of Richmond upon Thames Strategic Flood Risk Assessment – Level 1 Update (March 2016).

1.3 The report also details a strategy for the disposal of foul and surface water runoff from the development, closely following guidance on sustainable drainage set out in the London Sustainable Drainage Proforma that was adopted by the London Borough of Richmond upon Thames in April 2019.

2. SITE LOCATION AND CHARACTERISTICS

Site Location

2.1 The site is located at St Margaret's Business Park in Moormead Road Twickenham, TW1 1JS as shown on *Figure 1* below. The site is centred on Ordnance Survey grid reference TQ 16645 74123 and co-ordinates X: 516645, Y: 174123.

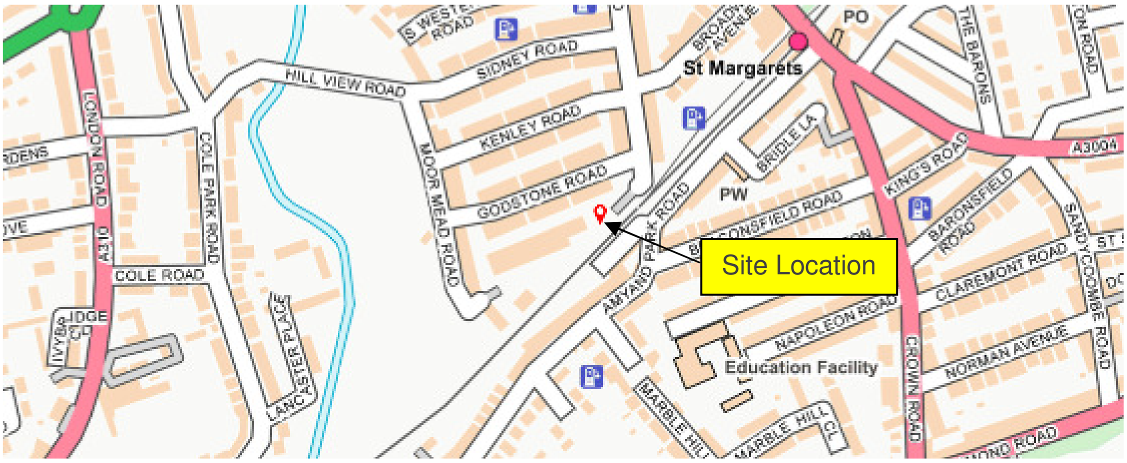


Figure 1: Site Location

Site Description

2.2 The sites measured area is approximately 0.06 Ha and presently comprises of a parking area as shown on the topographical survey included in *Appendix A*.

Topography

2.3 The topographical survey included in Appendix A, shows site levels to be between 6.00mAOD to 6.40mAOD.

Existing Ground Conditions

2.4 *Figure 2* and *Figure 3* below have been taken from the British Geological Survey website and show the superficial geology of the local area to comprise of the Kempton Park Gravel Member, while the bedrock geology is shown to comprise the London Clay Formation. The Kempton Park Gravel Member is indicated to comprise of Sands and Gravels while the London Clay Formation is indicated to comprise of Clays and Silts.

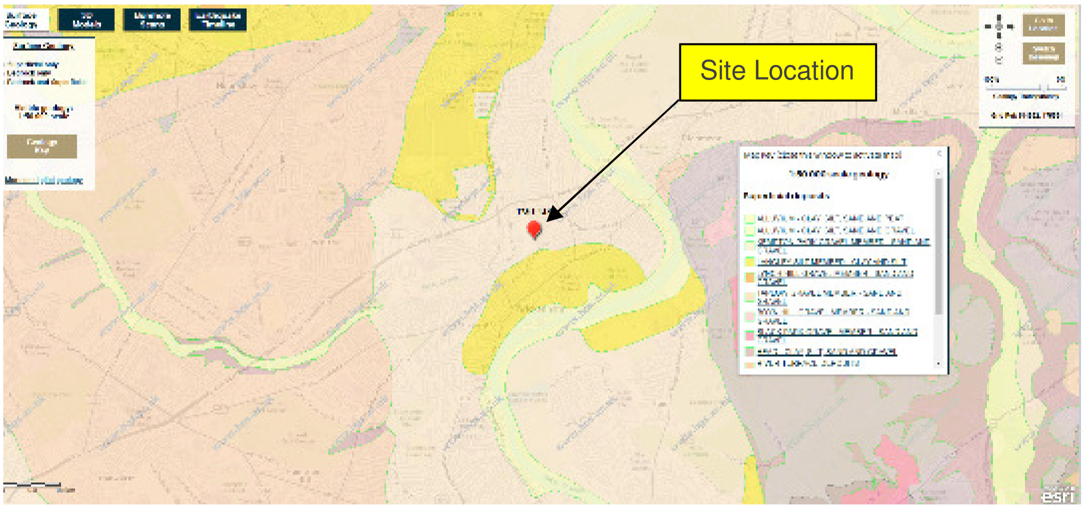


Figure 2: BGS Superficial Geology Map

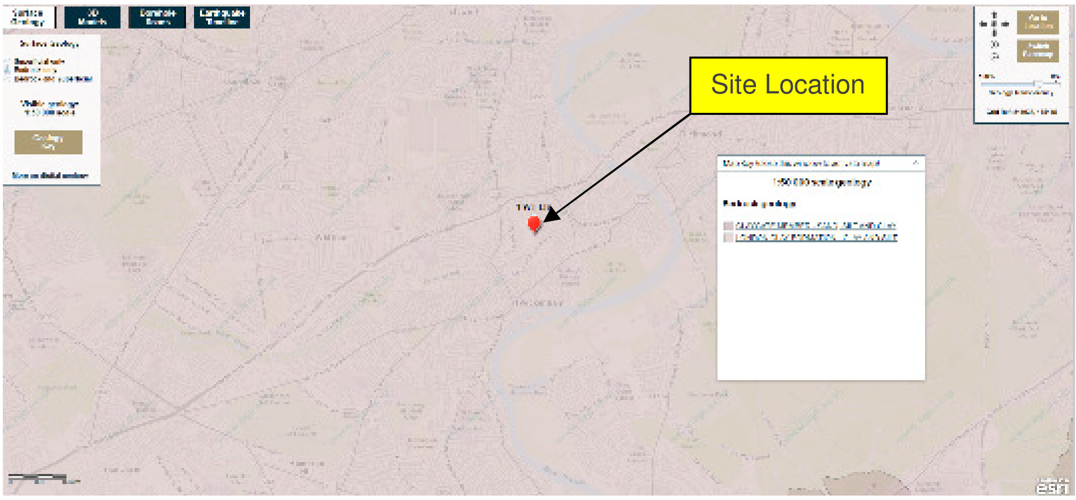


Figure 3: Bed Rock Geology Map

Existing Drainage Arrangements

2.5 *Figure 5* below shows an extract from sewer records provided by Thames Water. The extract shows the local area to be drained by a network of foul and surface water networks present in the surrounding road network.

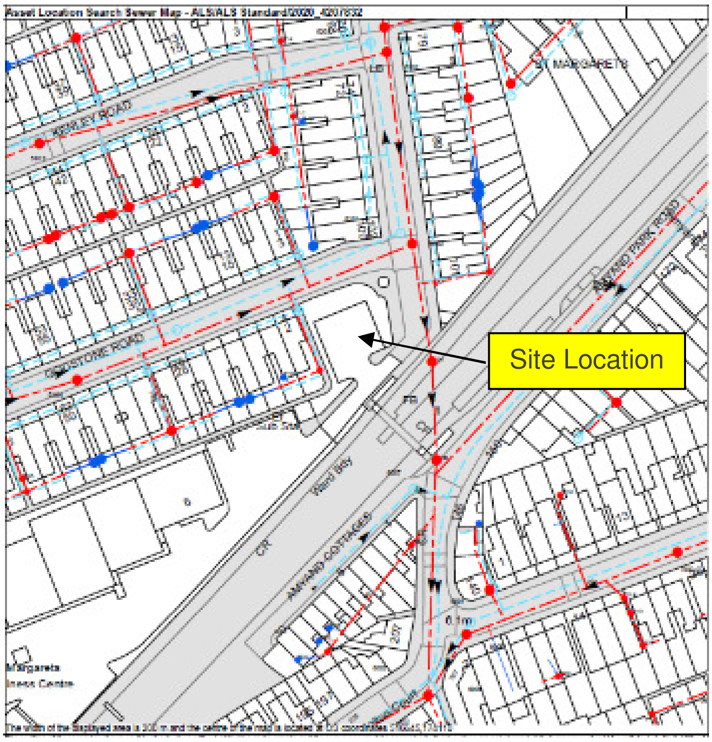


Figure 4: Thames Water Sewer Records

2.6 The topographical survey included in *Appendix A* shows the existing car park to be drained by a dished channel and road gullies.

3. PROPOSED SCHEME

3.1 The proposed development comprises 4 No. residential dwellings with associated gardens and parking spaces.

3.2 A set of drawings illustrating the development proposals is included in *Appendix B*.

4. FLOOD RISK POLICY & GUIDANCE

4.1 At a national level, the National Planning Policy Framework (NPPF) and the Planning Practice Guidance (PPG) to the NPPF ensure flood risk is taken into account at all stages of the planning process, to avoid inappropriate development in areas at risk of flooding and to direct development towards areas at lowest flood risk. The NPPF retains a risk-based approach to the planning process and defines four Flood Zones to be used as the basis for applying the sequential test, as well as flood risk vulnerability classifications, which define the type of development that is considered appropriate within each zone.

4.2 The NPPF establishes the Flood Zones as the starting point for assessment with the overarching aim to steer new development to areas with the lowest probability of flooding. Flood Zone maps are available on the GOV.UK website and the definitions of the Flood Zones extracted from the National Planning Policy Framework (NPPF) are described below:

- Flood Zone 1 – Low probability. This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).

- Flood Zone 2 – Medium probability. This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% - 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% - 0.1%) in any year.

- Flood Zone 3a – High probability. This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

- Flood Zone 3b – The functional floodplain. This zone comprises land where water has to flow or be stored in times of flood. Typically, land which would flood with an annual probability of 1 in 20 (0.5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood.

4.3 The London Borough of Richmond upon Thames have prepared a series of Supplementary Planning Guidance (SPG), which are used to inform the different plans and policies of the Local Development Plan. The list of documents includes a Strategic Flood Risk Assessment's (SFRA), which provide details of sources of flood risk within the local area.

4.4 The following section of this report reviews flood risk associated with sources of flooding identified within the SFRA.

5. SOURCES OF FLOODING

Fluvial Flooding

5.1 The flood zone map in *Figure 5* below has been taken from EA's website and shows the site to be in Flood Zone 2 associated with the River Crane.

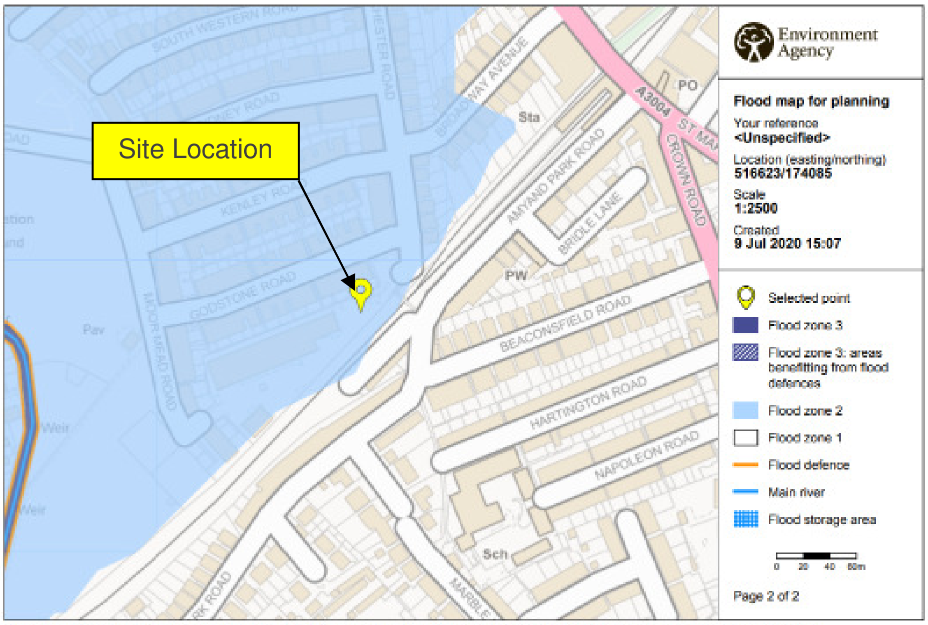


Figure 5: EA Flood Zone Map

5.2 The risk of river / tidal flood map taken from the EA's website in *Figure 6* below shows the shows the risk of fluvial flooding to be low.

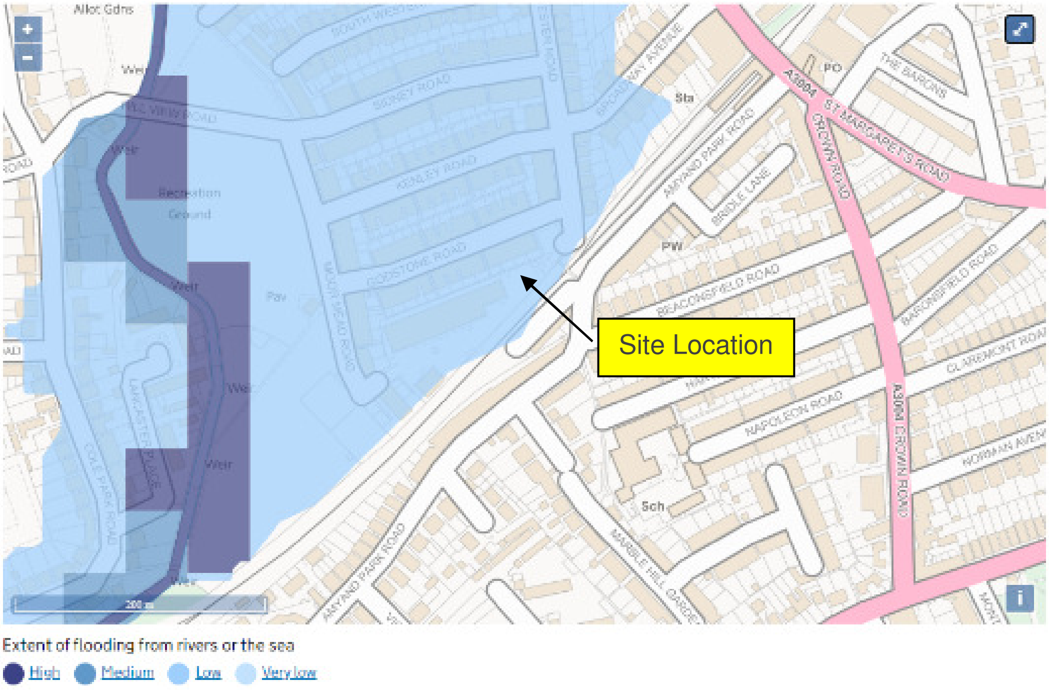


Figure 6: EA Risk of Fluvial / Tidal Flooding Map

5.3 The flood zone map in *Figure 7* below has been taken from the SFRA and shows the flood zones to be consistent with the EA flood zone with the site shown to be in Flood Zone 2.

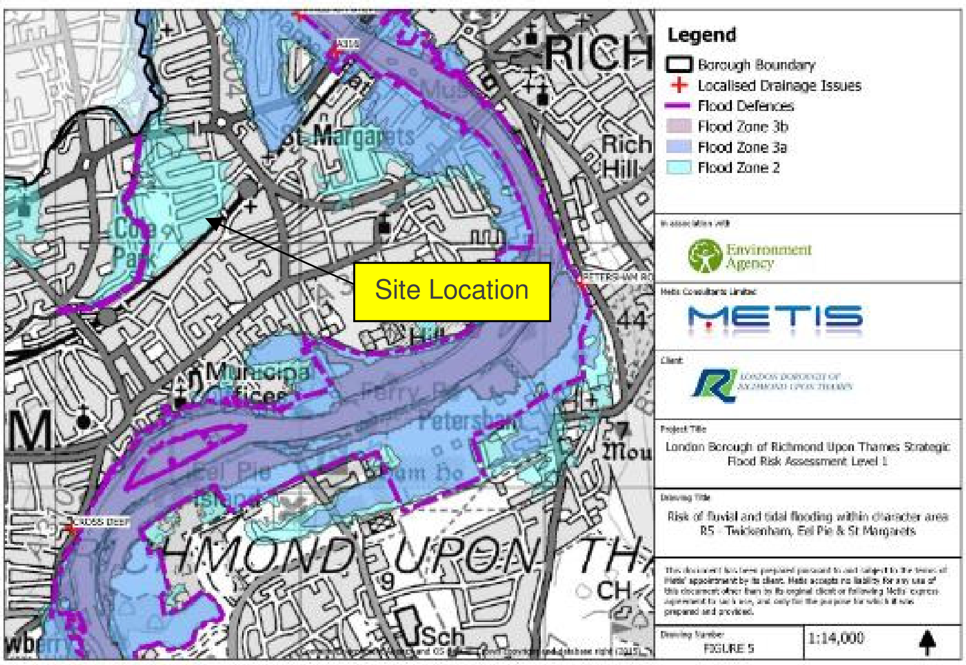


Figure 7: SFRA Flood Zone Map

5.4 The flood hazard map in *Figure 8* below has been taken from the SFRA and shows the flood hazard for the River Crane associated with a modelled 1 in 100 (1%) Annual Exceedance Probability event. The Flood Hazard to the site and surrounding area is shown to be low.

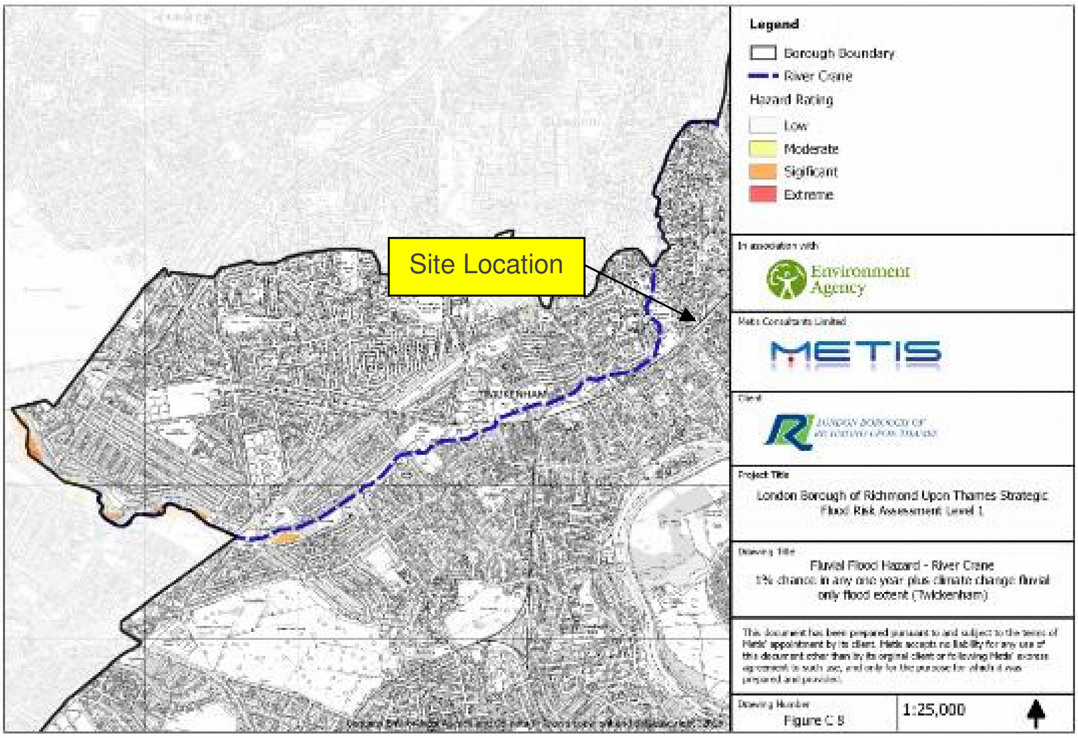


Figure 8: SFRA Flood Hazard Map

5.5 The flood zone maps available on the EA's website and within the SFRA are produced from a combination of a national generalised computer model, detailed modelling and some historic flood event outlines and are intended as a guide only. More detailed flood data received from the EA is included in *Appendix C*.

5.6 The data received from the EA includes a set of flood maps for various Annual Exceedance Probabilities (AEP) at a number of modelled floodplain nodes within and surrounding the site. The maps are shown in *Figure 9* and *Figure 10* below.

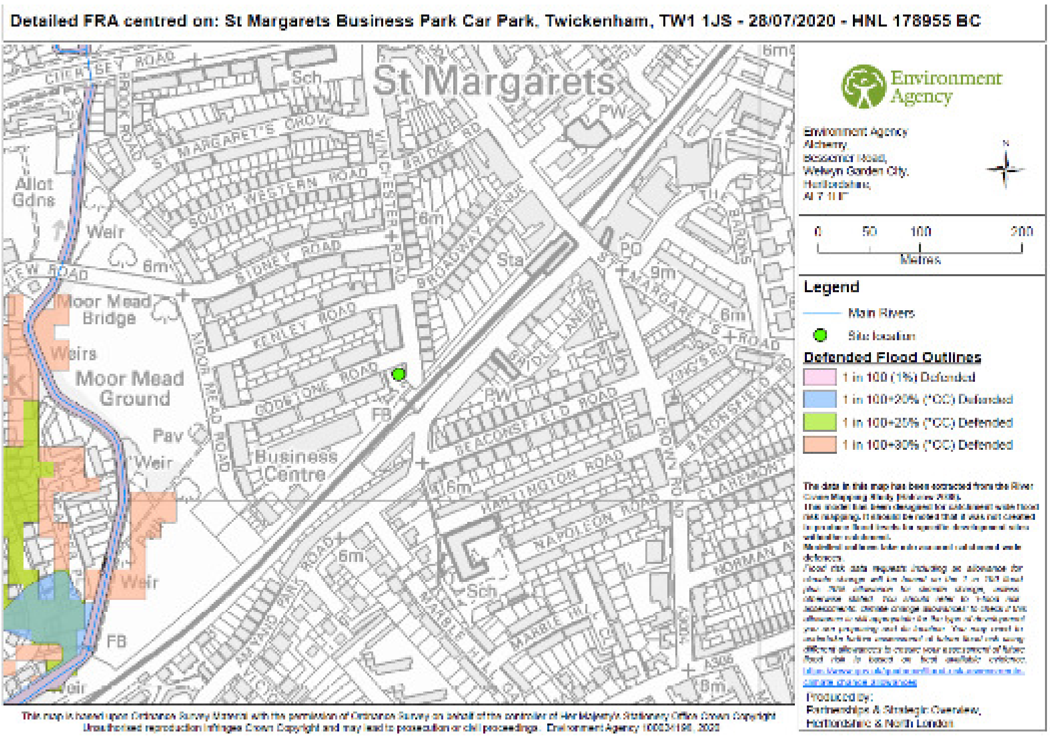


Figure 9: Defended Flood Outline Map 1

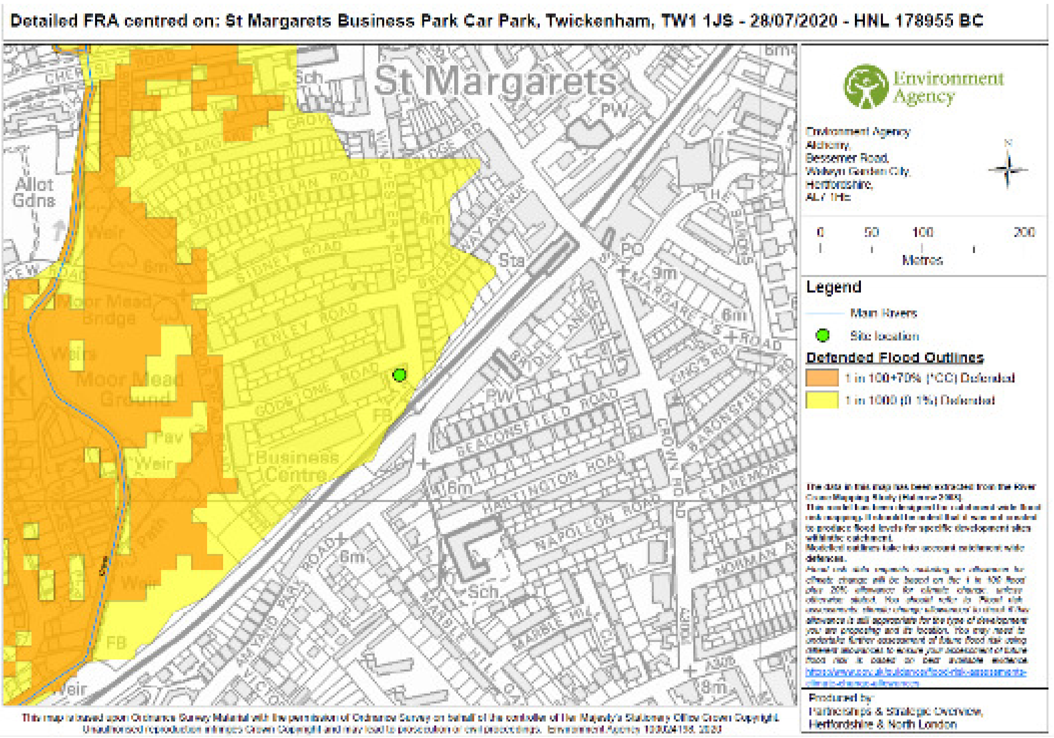


Figure 10: Defended Flood Outline Map 2

5.7 *Figure 9* and *Figure 10* show the site and immediate surrounding area to be unaffected by the 1% plus climate change AEP's but within the flood outline associated with the 0.1% AEP. *Figure 11* below shows the predicted flood level associated with the 0.1% AEP to be 6.34mAOD at the site.

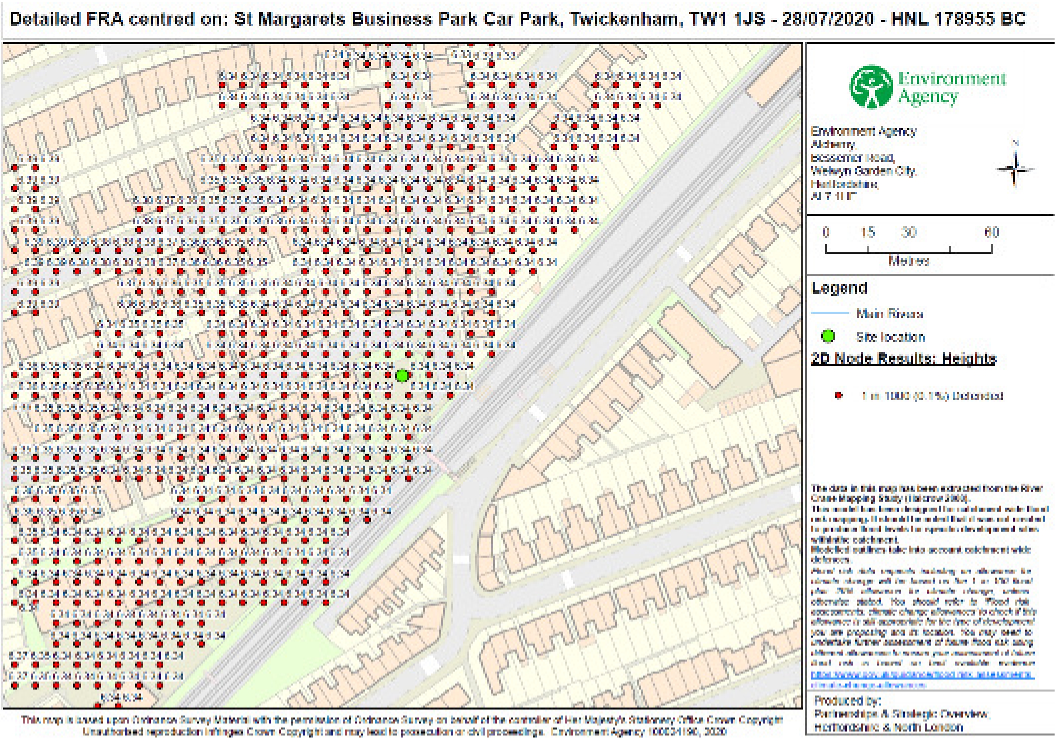


Figure 11: 0.1% AEP Defended Flood Levels

<u>Surface Water Flooding</u>

5.8 The EA have modelled locations along critical flow paths and areas situated in topographic depressions, which could flood following an extreme rainfall event. *Figure 11* below, shows a surface water flood risk map taken from the EA's website with the location of the site identified.

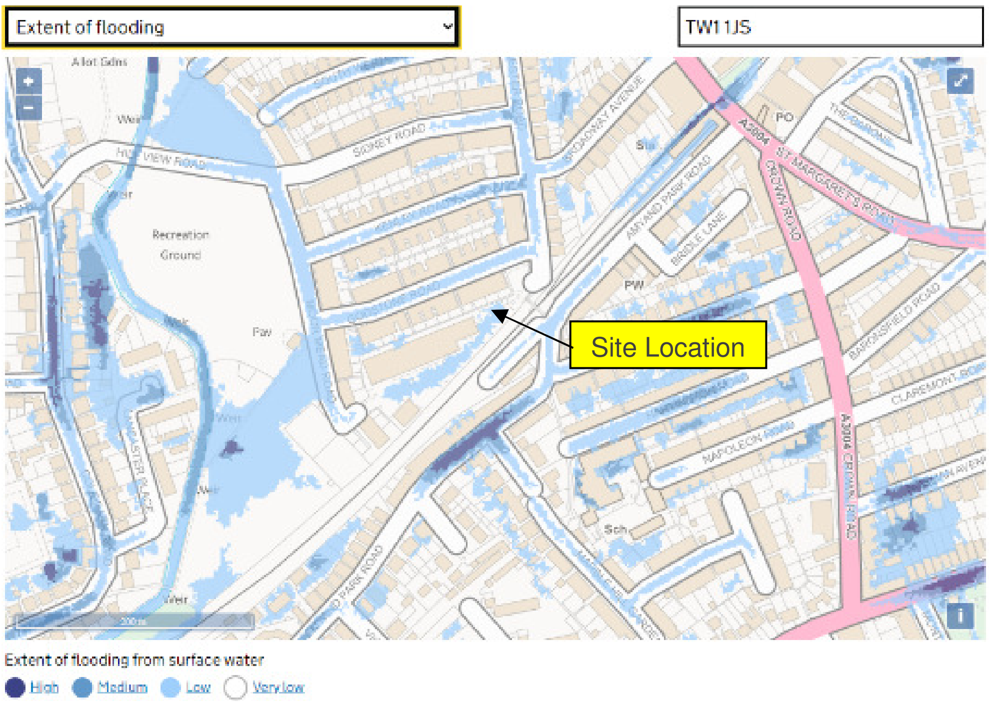


Figure 12: EA Surface Water Flood Risk Map

5.9 *Figure 10* indicates the site to be in an area that could be affected by surface water flooding but the risk is identified to be low, which is associated with flood depths of below 300mm and velocities of less than 0.25 m/s.

Groundwater Flooding

5.10 The Groundwater Flooding Incidents Map in *Figure 12* below has been taken from the SFRA and shows there to be no recorded incidents of groundwater flooding at the site.

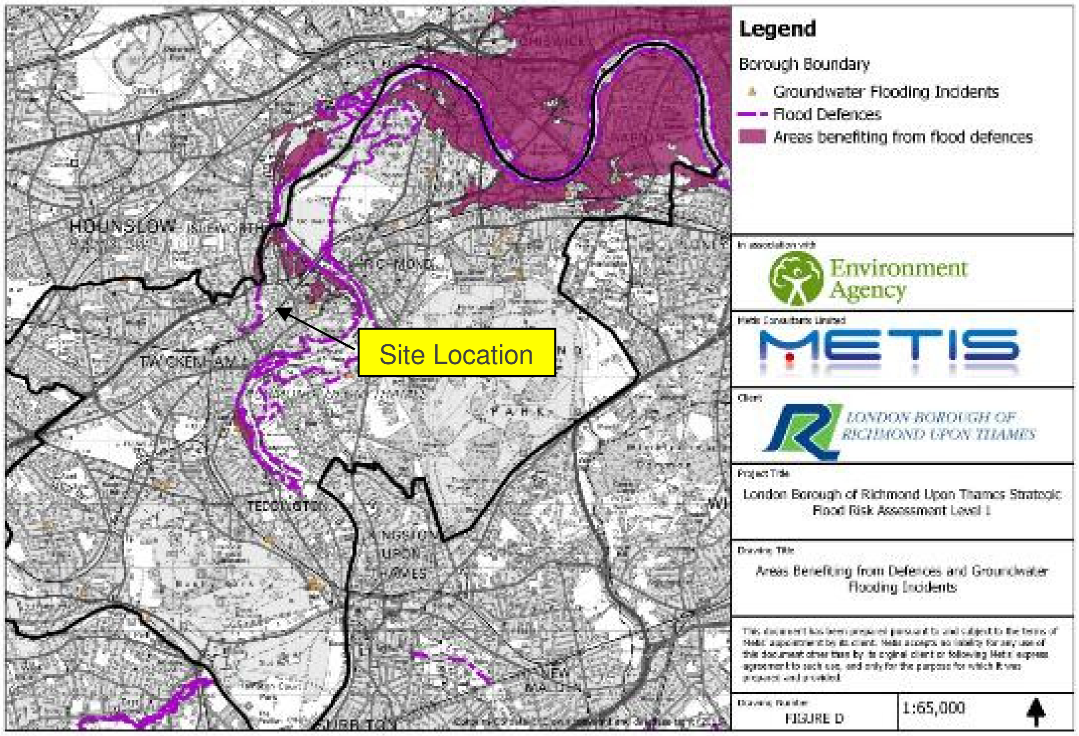


Figure 13: SFRA Groundwater Flooding Incidents Map

5.11 The Susceptibility to Groundwater Flooding Map in *Figure 13* below has been taken from the SFRA and shows the site to be located in an area where there is potential for groundwater flooding to occur at the surface.

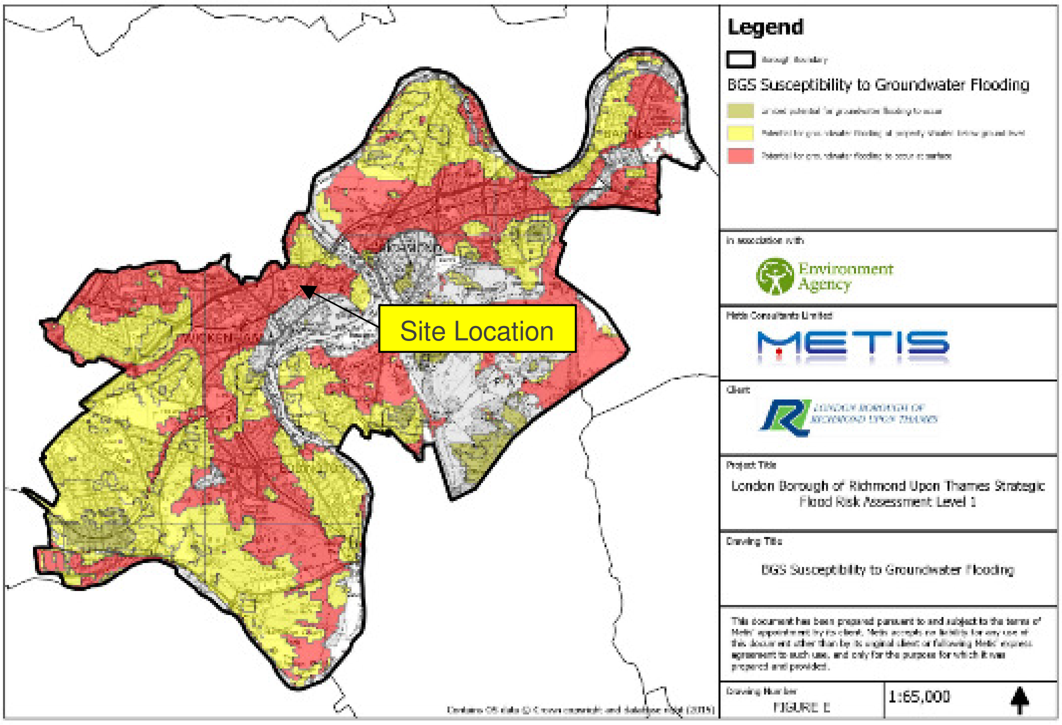


Figure 14: SFRA Susceptibility to Groundwater Flooding Map

<u>Sewer Flooding</u>

5.12 The Sewer Flooding Incidents Map in *Figure 14* below has been taken from the SFRA and shows the local post code to be an area where there have been between 1 to 5 recorded incidents of sewer flooding.

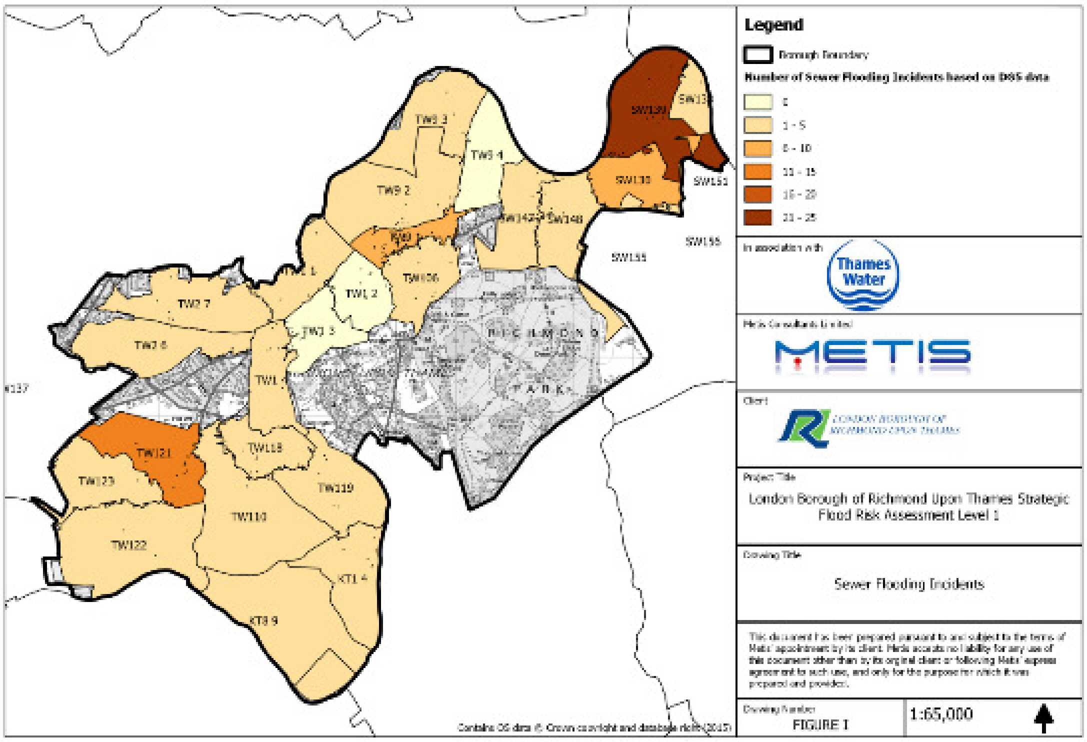


Figure 15: SFRA Sewer Flooding Incidents Map

5.13 Correspondence received from Thames Water is included in *Appendix D*, which advises that there have been no incidents of flooding at the site as a result of surcharging public sewers.

5.14 The correspondence also confirms that the existing foul sewer network would have sufficient capacity for foul water flows from the development and that Thames Water would accept the discharge of surface water runoff from the development to the surface water sewer network at a rate of 2.0 l/s if it is not possible to discharge runoff by infiltration or to a watercourse.

<u>Flooding from Artificial Sources</u>

5.15 Flooding from artificial sources, is most likely to result from burst water mains or from infrastructure failure in an artificial watercourse or water body, i.e. canals or other water features such as reservoirs.

5.16 Flood maps associated with large reservoirs that hold over 25,000 cubic meters of water are available on the EA website. The maps help to identify areas that could potentially be affected by reservoir flooding and display a realistic worst case scenario of the largest area that may be flooded if a reservoir were to fail and release the water it holds.

5.17 *Figure 15* below shows a Reservoir Flood Map taken from the EA's website. The map shows the site to be at risk of flooding from reservoirs.

Figure 16: EA Reservoir Flood Map

5.18 The risk of failure of reservoirs is low as they are maintained, improved and regularly inspected by Thames Water.

5.19 Flood patterns associated with burst water mains would be similar to surface water flood patterns, which have been assessed to be low.

6. THE SEQUENTIAL & EXCEPTION TEST

6.1 The National Planning Policy Framework (NPPF) encourages a sequential risk-based approach to determine the suitability of land for development in flood risk areas. It advises local planning authorities to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.

6.2 In areas at risk of river flooding, NPPF advises that preference be given to new development in Flood Zone 1. If there are no reasonably available sites in Flood Zone 1 the flood vulnerability of the development can be considered in locating development in Flood Zone 2 and then Flood Zone 3. Within each flood zone new development should be directed to sites at the lowest probability of flooding from all sources.

6.3 In Section 5 it was established that the site lies in Flood Zone 2. The NPPF and Local Policy of the London Borough of Richmond upon Thames advises that residential developments are a more vulnerable use and appropriate in Flood Zone 2 provided they pass the sequential test with it not being necessary to apply the exception test.

7. MANAGING THE RISK OF FLOODING

7.1 Section 5 established the site to be in Flood Zone 2, which is an area assessed to be at medium probability of flooding from the River Crane. The site-specific requirements for flood risk assessments within Flood Zone 2 from the London Borough of Richmond upon Thames SFRA are outlined below.

- For all sites within Zone 2 Medium Probability, a high-level FRA should be prepared based upon readily available existing flooding information, sourced from the EA. It will be necessary to demonstrate that the residual risk of flooding to the property is effectively managed through, for example, the provision of raised floor levels and the provision of a planned evacuation route and / or safe haven.

- The risk of other sources of flooding (e.g. urban drainage and/or groundwater) must be considered, and sustainable urban drainage techniques must be employed to ensure no worsening to existing flooding problems elsewhere within the area.

- As part of the high-level FRA, the developer must provide a clear and concise statement summarising how the proposed (re)development has contributed to a positive reduction in flood risk within the Borough.

- Details of proposed sustainable drainage systems (SuDS) that will be implemented to ensure that runoff from the site (post redevelopment) does not exceed greenfield runoff rates. Any SuDS design must take due account of groundwater and geological conditions.

7.2 The measures summarised under the headings below sets out recommendations on how the development could comply with these requirements.

Floor Levels

7.3 It is recommended that that the residual risk of flooding to the property is effectively managed by setting proposed buildings ground floor levels above the predicted flood level of 6.34mAOD for the 0.1% AEP.

Access / Egress

7.4 The flood outline maps provided by the Environment Agency for the 1% plus climate change AEP's showed the site and immediate surrounding area to not be affected by flooding associated with such events. Therefore access / egress routes are not expected to be compromised in such conditions. There would be a residual risk of access / egress routes been compromised by flood events exceeding the 1% plus climate change event, however, the raised floor levels would ensure that the dwellings provide a safe haven for residents in such conditions.

Other sources

7.5 Raising the proposed buildings floor level would largely address the risk of flooding from other sources. However, National and Local Policy requires development to seek opportunities to reduce the overall level of flood risk in the area and beyond through the use of Sustainable Drainage Systems (SuDS). The following section of this report sets out a strategy for the management of surface water runoff from the development using SuDS.

8. SURFACE WATER MANAGEMENT & DRAINAGE STRATEGY

Surface Water Drainage Policy & Guidance

8.1 The London Borough of Richmond upon Thames are one of London's 33 Lead Local Flood Authorities (LLFA's) that have adopted the London Sustainable Drainage (SuDS) Proforma.

8.2 SuDS encompass a wide range of drainage techniques intended to minimise the rate of discharge, volume and environmental impact of runoff and include; blue / green roofs; rainwater harvesting; soakaways / infiltration systems / infiltration trenches / permeable paving; swales / basins / ponds / wetlands / below ground attenuation tanks.

8.3 The proforma advises that drainage strategies for developments in the London Borough of Richmond upon Thames need to comply with the following policies on SuDS:

- London Borough of Richmond upon Thames Local Plan policy LP21
- London Plan policy 5.13 and draft New London Plan policy SI13
- The National Planning Policy Framework (NPPF)

8.4 Section C of policy LP21 advises the following:

- The Council will require the use of Sustainable Drainage Systems (SuDS) in all development proposals. Applicants will have to demonstrate that their proposal complies with the following:

a) A reduction in surface water discharge to greenfield run-off rates wherever feasible.
b) Where greenfield run-off rates are not feasible, this will need to be demonstrated by the applicant, and in such instances, the minimum requirement is to achieve at least a 50% attenuation of the site's surface water runoff at peak times based on the levels existing prior to the development.

8.5 Section 6.2.22 of policy LP 21 advises that to reduce the risk of surface water and sewer flooding, all development proposals in the borough that could lead to changes to, and have impacts on, surface water run-off are required to follow the London Plan drainage hierarchy. The London Plan policy 5.13 advises the following:

- Development should utilise SUDS unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:

i. Store rainwater for later use.
ii. Use infiltration techniques, such as porous surfaces in non-clay areas.
iii. Attenuate rainwater in ponds or open water features for gradual release.
iv. Attenuate rainwater by storing in tanks or sealed water features for gradual release.
v. Discharge rainwater direct to a watercourse.
vi. Discharge rainwater to a surface water sewer/drain.
vii. Discharge rainwater to the combined sewer.

- Drainage should be designed and implemented in ways that deliver other policy objectives of the Plan, including water use efficiency and quality, biodiversity, amenity and recreation

8.6 The Sustainable Design & Construction Supplementary Planning Guidance (SPG) document provides further guidance on the implementation of London Plan policy. Chapter 3 of the SPG advises that London Plan policy recommends that developers should aim for a greenfield runoff rate from their developments with greenfield runoff rates defined as the runoff rates from a site, in its natural state, prior to any development. However, the SPG notes that runoff rates should not be more than three times the calculated greenfield rate on previously developed sites. The only exceptions to this, where greater discharge rates may be acceptable, are where a pumped discharge would be required to meet the standards or where surface water drainage is to tidal waters and therefore would be able to discharge at unrestricted rates provided unacceptable scour would not result.

8.7 The NPPF advise that Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should:

a) take account of advice from the lead local flood authority;
b) have appropriate proposed minimum operational standards;
c) have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development;
d) where possible, provide multifunctional benefits.

8.8 The proforma is required to accompany a drainage strategy prepared for a planning application where required by national or local planning policy. It is to be used to summarise the key outputs from the strategy to allow assessing officers at the LLFA to quickly assess compliance with the above SuDS planning policies.

8.9 The proforma is split into the following 4 specific sections:

I. Site and project information
II. Proposed discharge arrangement
III. Drainage strategy
IV. Supporting information

8.10 Each section has been completed under the following headings.

<u>Site & Project Information</u>

8.11 Site and project information has been provided in Sections 1 to 5 of this report. The site and project information section of the proforma has been completed below.

Table 1: Site & Project Information

Project / Site Name (including sub-catchment / stage / phase where appropriate)	St Margaret's Business Car Park		
Address & post code	Moor Mead Road Twickenham TW1 1JS		
OS Grid ref. (Easting, Northing)	E	516645,	
	N	174123	
LPA reference (if applicable)	N/A		
Brief description of proposed work	The proposed development comprises 4 No. residential dwellings with associated gardens and parking spaces.		
Total site area	628	m^2	
Total existing impervious area	628	m^2	
Total proposed impervious area	628	m^2	
Is the site in a surface water flood risk catchment (ref. local Surface Water Management Plan)?	No.		
Existing drainage connection type and location	Surface water sewer in Godstone Road.		
Designer Name	Gareth Crowther		

Designer Position	Partner
Designer Company	Simpson TWS

Proposed discharge arrangement

8.12 The proforma sets out a hierarchy for the discharge of surface water runoff. The methods of discharge are summarised in *Table 2* below with an assessment of each methods suitability.

Table 2: Surface Water Runoff Discharge Method

System	Assessment
Store rainwater for later use	Rainwater harvesting is not expected to contribute a significant reduction in surface water runoff volumes. In addition, the proposed building footprints will occupy most of the site leaving limited space for above and below ground rainwater harvesting. Therefore, rainwater harvesting has not been considered as part of the surface water drainage strategy for the development.
Use infiltration techniques, such as porous surfaces in non-clay areas	In Section 2 it was identified that the bedrock geology of the local area is shown to be the London Clay Formation, which comprises of Clays and Silts that would be expected to be relatively impermeable in nature. In addition, in Section 4 it was identified that the site is shown to be located in an area where there is potential for groundwater flooding to occur at the surface. Therefore, infiltration techniques, such as porous surfaces in non-clay areas are not assessed to be appropriate.
Attenuation of rainwater in ponds and open water features	The development falls in a town centre environment and areas of soft landscaping are limited to private gardens with no space available for ponds and open water features.
Attenuation of rainwater through tanks or sealed water features	An area of shared parking is proposed as part of the development and a below ground storage tank could be considered beneath this area.
Discharge rainwater direct to a watercourse	The nearest watercourse is located over 250m to the west of the site. Given the substantial distance, it would not be a viable destination for surface water runoff.
Discharge rainwater to a surface water sewer/drain	A surface water sewer is network is present in the roads adjacent the site. Thames Water have advised that it would be acceptable to discharge surface water runoff from the development to the network if flows are restricted to a maximum discharge rate of 2.0 l/s and if other methods of disposal in the surface water drainage hierarchy have been investigated and proven to not be viable. Correspondence received from Thames Water is included in *Appendix D.*
Discharge rainwater to the combined sewer.	As it has been established that discharge from the development could be made to a surface water sewer, it is not appropriate to consider discharge to a combined sewer.

8.13 Based on the assessment in *Table 2*, it is assessed to be appropriate to discharge surface water runoff from the development to the surface water sewer network, if flows are restricted to a maximum discharge rate of 2.0 l/s.

8.14 The proposed discharge arrangement section of the proforma has been completed below.

Table 3: Proposed Discharge Arrangement

2a. Infiltration Feasibility	
Superficial geology classification	Kempton Park Gravel Member
Bedrock geology classification	London Clay
Site infiltration rate	N/A
Depth to groundwater level	Not known but in Section 4 it was identified that the site is shown to be located in an area where there is potential for groundwater flooding to occur at the surface.
Is infiltration feasible?	No

2b. Drainage Hierarchy		
	Feasible (Y/N)	*Proposed (Y/N)*
1 store rainwater for later use	N	N
2 use infiltration techniques, such as porous surfaces in non-clay areas	N	N
3 attenuate rainwater in ponds or open water features for gradual release	N	N
4 attenuate rainwater by storing in tanks or sealed water features for gradual release	Y	Y
5 discharge rainwater direct to a watercourse	N	N
6 discharge rainwater to a surface water sewer/drain	Y	Y
7 discharge rainwater to the combined sewer.	N	N

2c. Proposed Discharge Details	
Proposed discharge location	Surface water sewer in Godstone Road.
Has the owner/regulator of the discharge location been consulted?	Yes (Refer to *Table 3* and correspondence received from Thames Water in *Appendix D*).

Drainage strategy

8.15 The drainage strategy section of the proforma requires an assessment of greenfield and existing discharge rates. Greenfield runoff rates for the required storm events have been estimated based on the IH 124 Facility of the MicroDrainage Software Package. The calculation results are included in *Appendix E* and are based on the sites area of 0.06 Ha. The calculated rates for a variety of storm events up to the 1 in 100-year return period are summarised in *Table 4* below.

Table 4: Runoff Rates

Return Period (Year)	Greenfield Runoff Rate (l/s)	Existing Discharge Rate (l/s)
QBAR	0.9	N/A
1	0.7	2.3
30	1.5	5.1
100	1.7	6.6

8.16 Discharge rates for the existing brownfield site are shown in *Table 2*, which have been established using the Modified Rational Method Formula based on 360-minute rainfall profiles. The Modified Rational Method calculations and rainfall profiles are included in *Appendix E*. The calculation results are also based on the sites area of 0.06 Ha.

8.17 The London Borough of Richmond upon Thames surface water drainage policy recommends that the development should aim to restrict surface water flows from the site to greenfield runoff rates using SuDS to control surface water as close to the source as possible. *Table 5* below lists a range of SuDS techniques that can be used to minimise the rate of discharge, volume and environmental impact of runoff and provides an assessment of each methods suitability.

Table 5: SUDS Assessment

System	Assessment
Rainwater Harvesting / Attenuation Tanks	Rainwater harvesting is not expected to contribute a significant reduction in surface water runoff volumes. In addition, the proposed building footprints will occupy most of the site leaving limited space for above and below ground rainwater harvesting. Therefore, rainwater harvesting has not been considered as part of the surface water drainage strategy for the development. However, rainwater butts could be used to collect rainwater for watering gardens.
Infiltration Systems	In Section 2 it was identified that the bedrock geology of the local area is shown to be the London Clay Formation, which comprises of Clays and Silts that would be expected to be relatively impermeable in nature. In addition, in Section 4 it was identified that the site is shown to be located in an area where there is potential for groundwater flooding to occur at the surface. Therefore, infiltration systems are not assessed to be appropriate.
Blue / Green Roofs	Part of the roof structure will comprise of a flat roof, which could be constructed using green roof systems to intercept and retain precipitation and to help reduce runoff rates and volumes discharged from the site in comparison to the existing situation.
Swales / Basins / Ponds / Wetlands	The development falls in a town centre environment and areas of soft landscaping are limited to private gardens with no space available for swales, basins, ponds, or wetlands.
Bioretention / tree pits	The development falls in a town centre environment and areas of soft landscaping are limited to private gardens with no space available for bioretention or tree pits.
Filter Strips / Filter Drains / Pervious Pavements	Although infiltration systems are not considered to be appropriate for the site, pervious pavements and filter drains could be used to intercept / retain / treat precipitation as well as reduce runoff rates from paved surfaces provided that they are connected to a surface water drainage network.

Attenuation Tanks	An area of shared parking is proposed as part of the development and a below ground storage tank could be considered beneath this area for the attenuation of surface water and for gradual release.

8.18 Based on the assessment in *Table 5*, a surface water drainage scheme has been developed for the site and is shown on the proposed drainage strategy plan included in *Appendix F*. A description of the proposals is provided below.

- Green roof systems are proposed for parts of the roof structure, which will comprise of a flat roof. The remaining areas of roof would be drained by traditional rainwater gutters and downpipes with water butts used to collect rainwater for watering gardens.

- The roof drainage systems would connect to a traditional network of below ground pipework, which would discharge to a 7.6m^3 below ground geocellular attenuation tank located beneath the shared parking spaces.

- The parking spaces are shown to be constructed using a pervious pavement system, which would allow surface water runoff to filter into the below ground geocellular storage tank via a zone of porous sub-base.

- The below ground geocellular storage tank and pervious pavement system would be lined with an impermeable geomembrane to prevent groundwater from entering the system.

- The outfall from the system would be restricted to a maximum allowable discharge rate of 2.0 l/s using a flow control chamber before discharging the surface water sewer network and the below ground geocellular storage tank and pervious pavement system would store excess runoff for all storm return periods up to and including a 1 in 100 year event with 40% allowance for climate change.

8.19 Design results for the system are included in *Appendix G*. A summary of the design results is provided in *Table 6* below.

Table 6: System Design Results

Catchment Area (m^2)	**Max. Storage Volume (m^3)**	**Discharge Rate (l/s)**			
		1 in 1	**1 in 30**	**1 in 100**	**1 in 100 + 40%**
295	17.7	0.8	1.2	1.5	2.0

8.20 The design results show that the system would store surface water up to and including a 1 in 100-year rainfall event with 40% allowance for climate change. However, if the capacity of these systems was exceeded, the buildings would still be protected from surface water flooding as the ground levels of buildings would be raised above surrounding road levels.

8.21 *Table 7* below compares the combined maximum rate of discharge analysed for each storm event to the greenfield / brownfield runoff rates identified in *Table 4*.

Table 7: Comparison of Discharge Rates

Return Period	Greenfield	Brownfield	
		Pre-Development	Post-Development
	Peak Runoff Rate (l/s)	6hr Runoff Rate (l/s)	Peak Runoff Rate (l/s)
1	0.7	2.3	0.8
30	1.5	5.1	1.2
100	1.7	6.6	1.5
100+40	N/A	N/A	2.0

8.22 The above table shows that surface water flows from the development would closely match the greenfield runoff rate for all analysed rainfall events up to and including the 1 in 100 year return period, whilst the rate of discharge for the 1 in 100 year return period with 40% allowance for climate change would be limited to 2.0 l/s. This would be in accordance with the London Borough of Richmond upon Thames surface water drainage policy and advice received from Thames Water.

8.23 The proposed SuDS systems would also fulfil the water quality aims of the London Borough of Richmond upon Thame surface water drainage policy. The CIRIA C753 SuDS Manual 2015 sets out requirements for delivering appropriate levels of treatment to surface water runoff using SuDS. *Table 8* below identifies that the proposed SuDS components would have a total pollution mitigation index equal to or exceeding the recommended pollution hazard index thus confirming the SuDS components would provide suitable treatment to surface water runoff.

Table 8: Comparison of Discharge Rates & Volumes

Use	Pollution Hazard Index			SUDS Component	Mitigation Index		
	TSS	Metals	TPH		TSS	Metals	TPH
Roof	0.3	0.2	0.05	Green Roof	0.8	0.8	0.8
Roads / Parking	0.5	0.4	0.4	Pervious Pavement	0.5	0.4	0.4

8.24 In addition, the proposed SuDS systems would maximise amenity and biodiversity benefits, through the use of green roofs, which would help to improve the roofscape for overlooking floors and neighbouring properties whilst also providing a habitat for local plants and wildlife. The use of green roof and pervious pavements would also provide amenity benefits by providing a secondary function to their primary use through controlling and attenuating surface water as close to the source as possible. The development proposals would also incorporate new soft landscaping, which would further maximise biodiversity benefits over the existing situation.

8.25 The drainage strategy section of the proforma has been completed below.

Table 9: Drainage Strategy

3a. Discharge Rates & Required Storage				
	Greenfield (GF) runoff rate (l/s)	*Existing discharge rate (l/s)*	*Required storage for GF rate (m^3)*	*Proposed discharge rate (l/s)*
Qbar	0.8			
1 in 1	0.7	2.3	2.7 – 4.7	0.8
1 in 30	1.5	5.1	6.9 – 11.0	1.2
1 in 100	1.7	6.6	9.8 – 15.0	1.5
1 in 100 + CC			16.0 – 24.0	2.0
Climate change allowance used		40%		
3b. Principal Method of Flow Control		Green Roof, Pervious Pavements, Below Ground Geocellular Storage Tank and associated flow control devices.		
3c. Proposed SuDS Measures				
		Catchment area (m^2)	*Plan area (m^2)*	*Storage vol. (m^3)*
Rainwater harvesting		0		0
Infiltration systems		0		0
Green roofs		118	118	0
Blue roofs		0	0	0
Filter strips		0	0	0
Filter drains		0	0	0
Bioretention / tree pits		0	0	0
Pervious pavements		58	58	7.8
Swales		0	0	0
Basins/ponds		0	0	0
Attenuation tanks		288		9.9
Total		**464**	**176**	**17.7**

<u>Supporting information</u>

8.26 The supporting information section of the proforma has been completed below.

Table 10: Supporting Information

4a. Discharge & Drainage Strategy	*Page/section of drainage report*
Infiltration feasibility (2a) – geotechnical factual and interpretive reports, including infiltration results	In Section 2 it was identified that the bedrock geology of the local area is shown to be the London Clay Formation, which comprises of Clays and Silts that would be expected to be relatively impermeable in nature. In addition, in Section 4 it was identified that the site is shown to be located in an area where there is potential for groundwater flooding to occur at the surface. Therefore, infiltration systems are not assessed to be appropriate.
Drainage hierarchy (2b)	The hierarchical assessment in *Table 2*, established it to be appropriate to discharge surface water runoff from the development to the surface water sewer network in the roads adjacent the site, if flows are restricted to 2.0 l/s.
Proposed discharge details (2c) – utility plans, correspondence / approval from owner/regulator of discharge location	Thames Water have advised that it would be acceptable to discharge surface water runoff from the development to the discharge surface water runoff from the development to the surface water sewer network in the roads adjacent the site, if flows are restricted to 2.0 l/s. Correspondence received from Thames Water is included in *Appendix D*.
Discharge rates & storage (3a) – detailed hydrologic and hydraulic calculations	Runoff calculations for greenfield conditions and the existing brownfield situation are included in *Appendix E* with the results summarised in *Table 5*. Design results for the systems are included in *Appendix G* with the results summarised in *Table 6*. *Table 7* compares the proposed discharge rates to the rates established for greenfield conditions and the existing brownfield situation. It shows that the that surface water flows from the development would closely match greenfield runoff rates for all analysed rainfall events up to and including the 1 in 100 year return period, whilst the rate of discharge for the 1 in 100 year return period with 40% allowance for climate change would be limited to 2.0 l/s. This would be in accordance with the London Borough of Richmond upon Thames surface water drainage policy and advice received from Thames Water.
Proposed SuDS measures & specifications (3b)	A description of the proposed SuDS measures is provided in paragraph 6.18 with the proposals shown on the surface water drainage strategy plan included in *Appendix F*.
4b. Other Supporting Details	*Page/section of drainage report*
Detailed Development Layout	The proposed development comprises 4 No. residential dwellings with associated

	gardens and parking spaces. A set of drawings illustrating the development proposals is included in *Appendix B*.
Detailed drainage design drawings, including exceedance flow routes	A drainage strategy plan is included in *Appendix F*, whilst recommendations to raise the buildings ground floor to manage the residual risk of fluvial flooding would ensure floor levels are raised above surrounding levels so there would be no risk of buildings being affected by overland flows.
Detailed landscaping plans	Landscaping proposals are shown on the planning drawings included in *Appendix B*.
Maintenance strategy	A drainage maintenance plan is included in *Appendix H*.
Demonstration of how the proposed SuDS measures improve:	
a) water quality of the runoff?	*Table 8* above identifies that the proposed SuDS components would have a total pollution mitigation index equal to or exceeding the recommended pollution hazard index thus confirming the SuDS components would provide suitable treatment to surface water runoff.
b) biodiversity?	The proposed SuDS systems would maximise amenity and biodiversity benefits, through the use of a green roof, which would help to improve the roofscape for overlooking floors and neighbouring properties whilst also providing a habitat for local plants and wildlife. The use of pervious pavements would also provide amenity benefits by providing a secondary function to their primary use through controlling and attenuating surface water as close to the source as possible. The development proposals would also incorporate new soft landscaping, which would further maximise biodiversity benefits over the existing situation.
c) amenity?	

9. CONCLUSIONS

9.1 It has been established that the site is located in Flood Zone 2, which is an area assessed to be at medium probability of flooding from the River Crane. The residual risk of flooding to the site can be effectively managed by setting the proposed buildings ground floor levels above the predicted flood level of 6.34mAOD for the 0.1% AEP.

9.2 National and Local Policy aims to avoid inappropriate development in areas at risk of flooding and recommends that development is directed towards areas at lowest flood risk. The NPPF and Local Policy of the London Borough of Richmond upon Thames advises that residential developments are a more vulnerable use and appropriate in Flood Zone 2 provided they pass the sequential test with it not being necessary to apply the exception test.

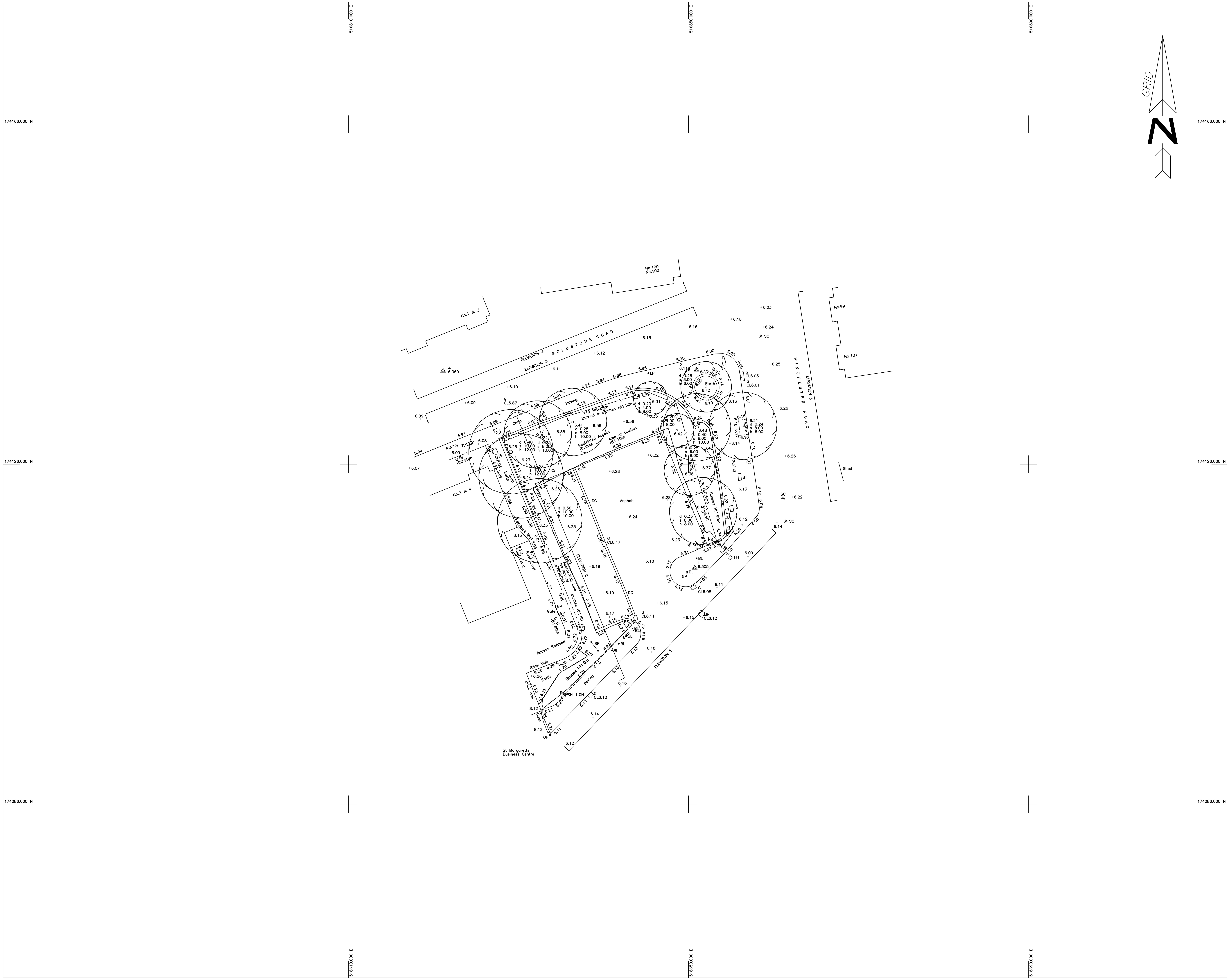
9.3 Raising the proposed buildings floor level would largely address the risk of flooding from other sources. However, National and Local Policy requires development to seek opportunities to reduce the overall level of flood risk in the area and beyond through the use of Sustainable Drainage Systems (SuDS). A hierarchical assessment has established that an existing surface water sewer in the roads adjacent the site would be the most appropriate destination for the disposal of surface water runoff from the development provided that surface water flows are limited to a maximum allowable discharge rate of 2.0 l/s using SuDS.

9.4 A further hierarchical assessment has established that a combination of green roof's, water butt's, pervious pavement's and below ground geocellular storage system's would be the most appropriate SuDS components for minimising the rate of discharge, volume and environmental impact of surface water runoff from the development. A surface water drainage strategy has been developed for the site comprising of these components, which would ensure that surface water flows are controlled as close to the source as possible, prior to discharging to the surface water sewer, with flows restricted to a maximum allowable discharge rate of 2.0 l/s for all analysed rainfall events up to and including the 1 in 100 year return period with 40% allowance for climate change. The systems would also provide sufficient capacity for excess runoff to be stored and attenuated on site for all rainfall events up to and including the 1 in 100-year storm return period with 40% allowance for climate change.

9.5 The proposed SuDS systems would maximise amenity and biodiversity benefits, with green roofs helping to improve the roofscape for overlooking floors and neighbouring properties whilst also providing a habitat for local plants and wildlife. The use of pervious pavements would also provide amenity benefits by providing a secondary function to their primary use through controlling and attenuating surface water as close to the source as possible. The development proposals would also incorporate new soft landscaping, which would further maximise biodiversity benefits over the existing situation.

9.6 In terms of flood risk, it is concluded that the development can be occupied and operated safely and that there will be no increase in the level of flood risk to the site or neighbouring sites because of the development.

APPENDIX A
TOPOGRAPHICAL SURVEY



LASER SURVEYS

LAND AND BUILDING SURVEYS, UNDERGROUND SERVICES LOCATION, CCTV DRAINAGE SURVEYS.

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TEL 01886 833173 email: worcester@lasersurveys.com

THE OLD DAIRY,STUBBERS FARM,MOUNTNESSING ROAD,BLACKMORE,ESSEX CM4 0NX
TEL 01277 821555. email: london@lasersurveys.com

DATUM NOTES

GRID IS BASED UPON SURVEY CONTROL STATION No.1, FIXED TO THE ORDNANCE SURVEY NATIONAL GRID BY GPS SATELLITE ACTIVE NETWORK.

LEVELS ARE RELATED TO :- THE ORDNANCE SURVEY GPS ACTIVE NETWORK AND TRANSFORMED USING THE OSGM15 & OSTN15 MODELS.

BENCH MARK USED IS LOCATED AT :- SURVEY CONTROL STATION No.1

VALUE GIVEN AS 6.305m (NEWLYN DATUM)

SURVEY CONTROL STATIONS SHOWN △

ABBREVIATIONS (where applicable)

AV	Air Valve	MH	Manhole Cover
BK	Brick	MK	Marker
BL	Bollard	MS	Milestone
BS	Bus Stop	MT	Meter
BT	British Telecom	MY	Mercury
C/B	Close Boarded	O/B	Open Boarded
CL	Cover Level	OH	Overhead
CLK	Chainlink	PAV	Paving
CO	Column	PB	Pedestrian Push Button
Conc	Concrete	PE	Pipe
CP	Catch Pit	PM	Parking Meter
CPS	Concrete Paving Slabs	P/R	Post and Rail
CTV	Cable Television	PT	Post
DC	Drainage Channel	P/W	Post and Wire
DP	Drain Pipe	RE	Rodding Eye
EP	Electricity Pole	RET	Retaining
ER	Earthing Rod	RS	Road Sign
FB	Flower Bed	RSJ	Rolled Steel Joist
FE	Fence	SC	Stop Cock
FH	Fire Hydrant	SK	Soakaway
FL	Floor Level	SPT	Septic Tank
FP	Flag Pole	ST	Silt Trap
GP	Gate Post	SV	Stop Valve
GV	Gas Valve	SVC	Security Video Camera
GY,G	Gully	TCB	Telephone Call Box
HT	Height	TL	Traffic Light
IC	Inspection Cover	TK	Tank
IL	Invert Level	TP	Telegraph Pole
IN	Interceptor	UG	Underground
I/R	Iron Railings	UTF	Unable To Trace Further
JB	Junction Box	UTL	Unable To Lift
KO	Kerb Outlet	VP	Vent Pipe
LB	Litter Bin	WL	Water Level
LP	Lamp Post	WM	Water Meter
		WO	Wash Out

NOTES

* Drainage pipe sizes (where shown) have been gauged from the surface for safety reasons and should be regarded as approximate only.
* Tree species (where shown) should be treated with caution and expert identification is advised.
* Although this is a digital survey the accuracy and amount of detail shown is only commensurate with the graphical scale of mapping as specified. Care should be exercised when working to larger scales.
* Visible features in the vicinity of the boundaries as shown above, may not represent the extent of legally conveyed ownership.
* Whilst every effort has been made to achieve accuracy on this plan, CRUCIAL clearance dimensions, levels and invert levels should be checked prior to design and construction.
* Kerb levels have been taken in the bottom of the channel.
* Areas of dense undergrowth cannot be surveyed in detail, these areas will be shown in outline only and marked as "dense undergrowth" on the plan

SHEET LAYOUT

LAND AT ST MARGARET'S WORKS
TWICKENHAM
LONDON
TW1 1JN

TOPOGRAPHICAL SURVEY

SURVEYED FOR GODSTONE DEVELOPMENTS LTD
107 BELL STREET
LONDON
NW1 6TL

SURVEYOR JC
DATE JUNE 2020

NO	DATE	REVISION

DRAWING NO	L 9826/1	REV
SCALE	1 : 200 @ A1	
SEE ALSO DWG NOS	L .	
SHEET	1 of 2	
REF NO	L 9826	

APPENDIX B
PLANNING DRAWINGS

Ground Floor Layouts **1:100 @ A1P**

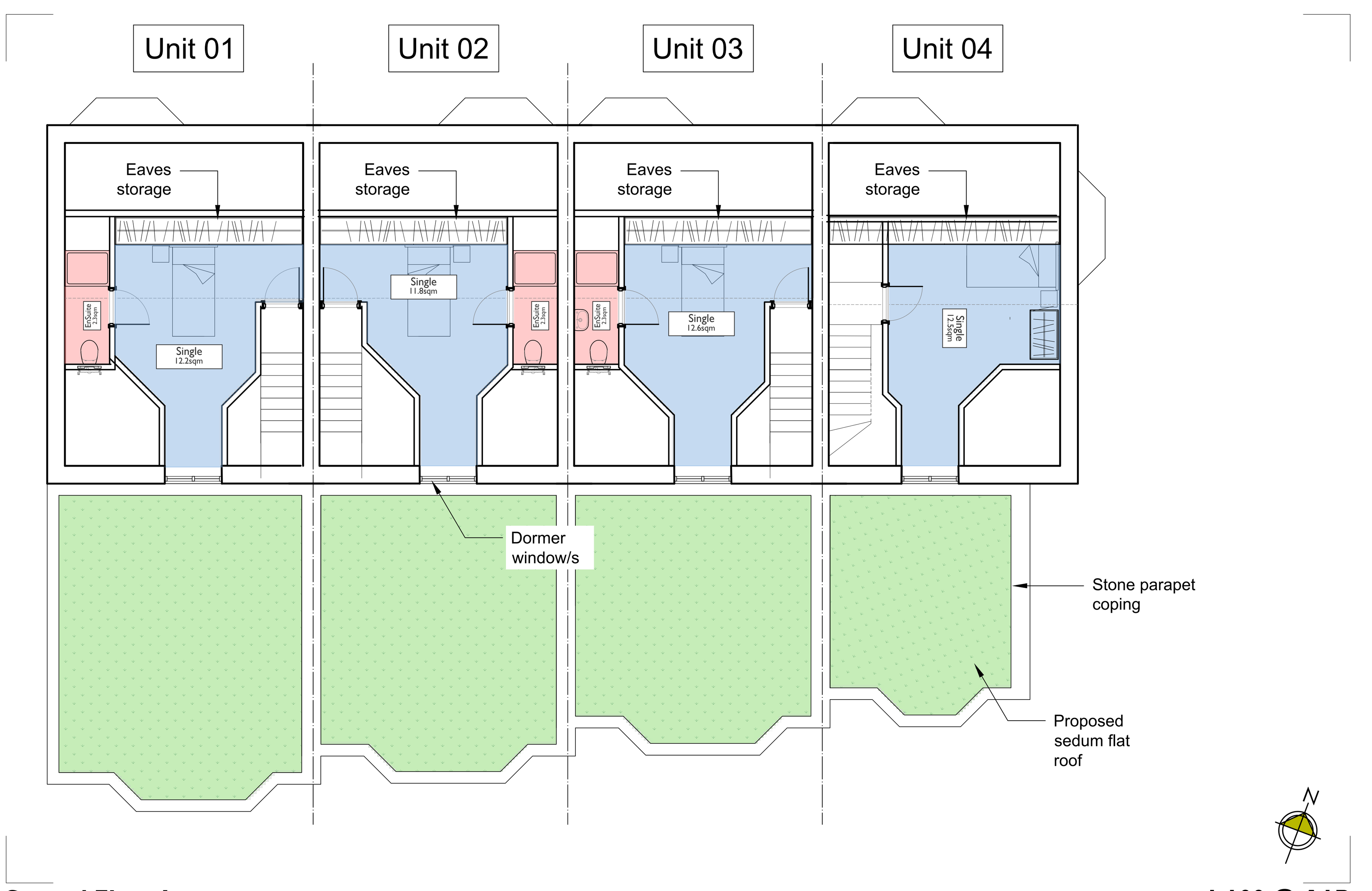
1:100 Scale

Site/Block Plan **1:200 @ A1P**

1:200 Scale

Proposed 1800x840x1090mm Bike Store

First Floor Layouts **1:100 @ A1P**



Second Floor Layouts **1:100 @ A1P**

ISSUED FOR PLANNING

TITLE
ST MARGARET'S BUSINESS CENTRE

CLIENT
SHEEN LANE DEVELOPMENTS LTD

DESCRIPTION
Proposed Layouts

date:	scale	project	drawing	revision
AUG 2020	1:100 @A1P		P-001	B

SILVERLINE ARCHITECTS

EMAIL: INFO@SILVERLINEARCHITECTS.COM

Proposed Godstone Road (North-Facing) Elevation 1:50 @ A1L

Location Plan 1:1250 @ A1L

Proposed Drummond Place (South-Facing) Elevation 1:50 @ A1L

0 500mm 1 m 2 m 3 m 4 m 5 m
1:50 Scale

Site Plan 1:200 @ A1L

Proposed Godstone Road (North-Facing) Elevation **(Render)**

Proposed Drummond Place (South-Facing) Elevation **(Render)**

ISSUED FOR PLANNING

TITLE
ST MARGARET'S BUSINESS CENTRE

CLIENT
SHEEN LANE DEVELOPMENTS LTD

DESCRIPTION
Proposed Front & Rear Elevations

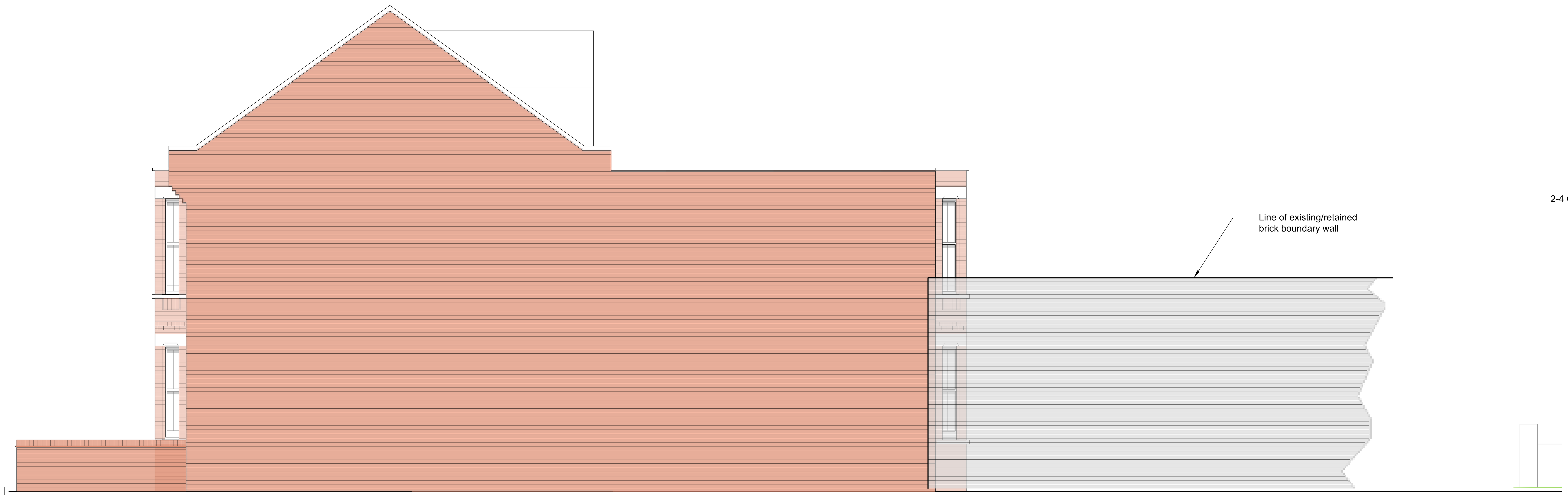
date:	scale	project	drawing	revision
AUG 2020	1:50 @A1L		P-002	A

SILVERLINE ARCHITECTS

EMAIL: INFO@SILVERLINEARCHITECTS.COM

Proposed Winchester Road (East-Facing) Elevation 1:50 @ A1P

Location Plan 1:1250 @ A1P



Proposed Alleyway/Flank (West-Facing) Elevation 1:50 @ A1P

Site Plan 1:200 @ A1L

0 500mm 1 m 2 m 3 m 4 m 5 m
1:50 Scale

ISSUED FOR PLANNING

TITLE	ST MARGARET'S BUSINESS CENTRE			
CLIENT	SHEEN LANE DEVELOPMENTS LTD			
DESCRIPTION	Proposed Side Elevations			
date: AUG 2020	scale: 1:50 @A1L	project	drawing: P-003	revision: A

SILVERLINE ARCHITECTS

EMAIL: INFO@SILVERLINEARCHITECTS.COM

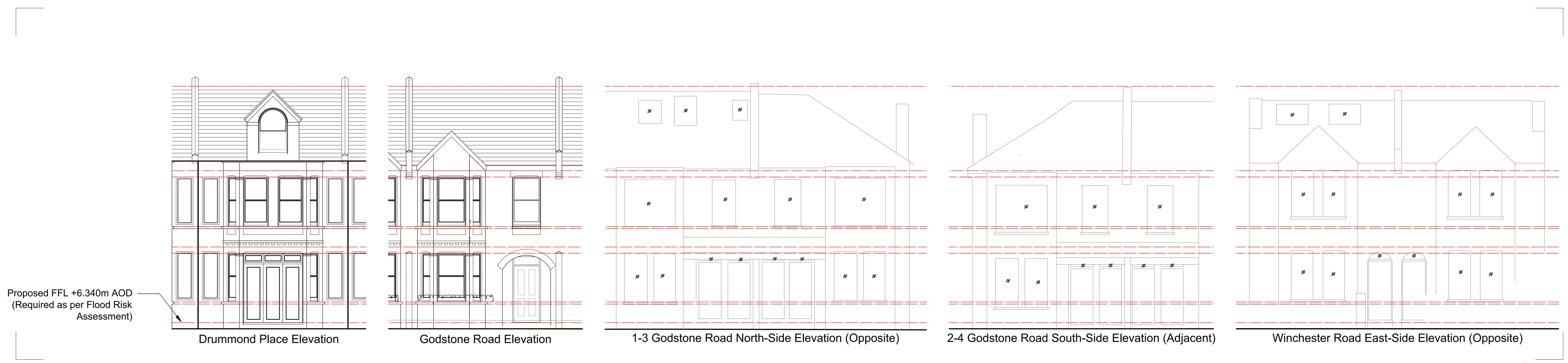
Proposed Godstone Road (North-Facing) Context Elevation 1:100 @ A1L

Location Plan 1:1250 @ A1L

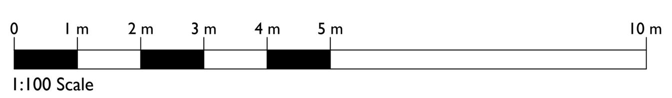
Proposed Drummond Place (South-Facing) Context Elevation 1:50 @ A1P

Site Plan 1:200 @ A1L

Proposed Winchester Road (East-Facing) Context Elevation 1:100 @ A1L



Levels Comparison (Proposed Development/Surrounding Properties) 1:100 @ A1L



ISSUED FOR PLANNING

TITLE
ST MARGARET'S BUSINESS CENTRE

CLIENT
SHEEN LANE DEVELOPMENTS LTD

DESCRIPTION
Proposed Context Elevations

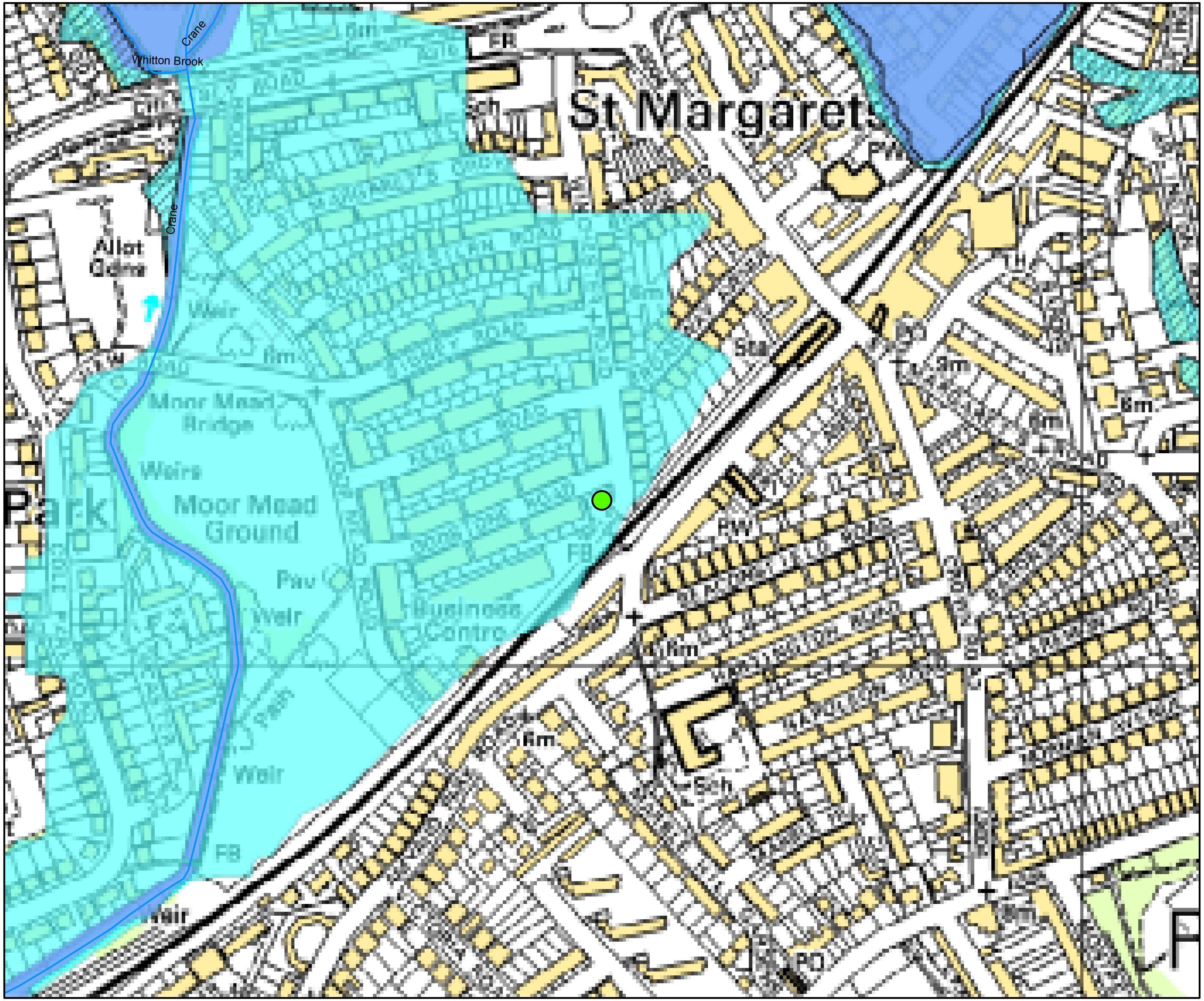
date:	scale	project	drawing	revision
AUG 2020	1:100 @A1L		P-004	A

SILVERLINE ARCHITECTS

EMAIL: INFO@SILVERLINEARCHITECTS.COM

APPENDIX C
EA FLOOD RISK DATA

Flood Map for Planning centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 60 120 240
Metres

Legend

- Main Rivers
- Site location

Flood Map for Planning

- Flood Storage Area
- Areas Benefiting from Flood Defences
- Flood Zone 3
- Flood Zone 2

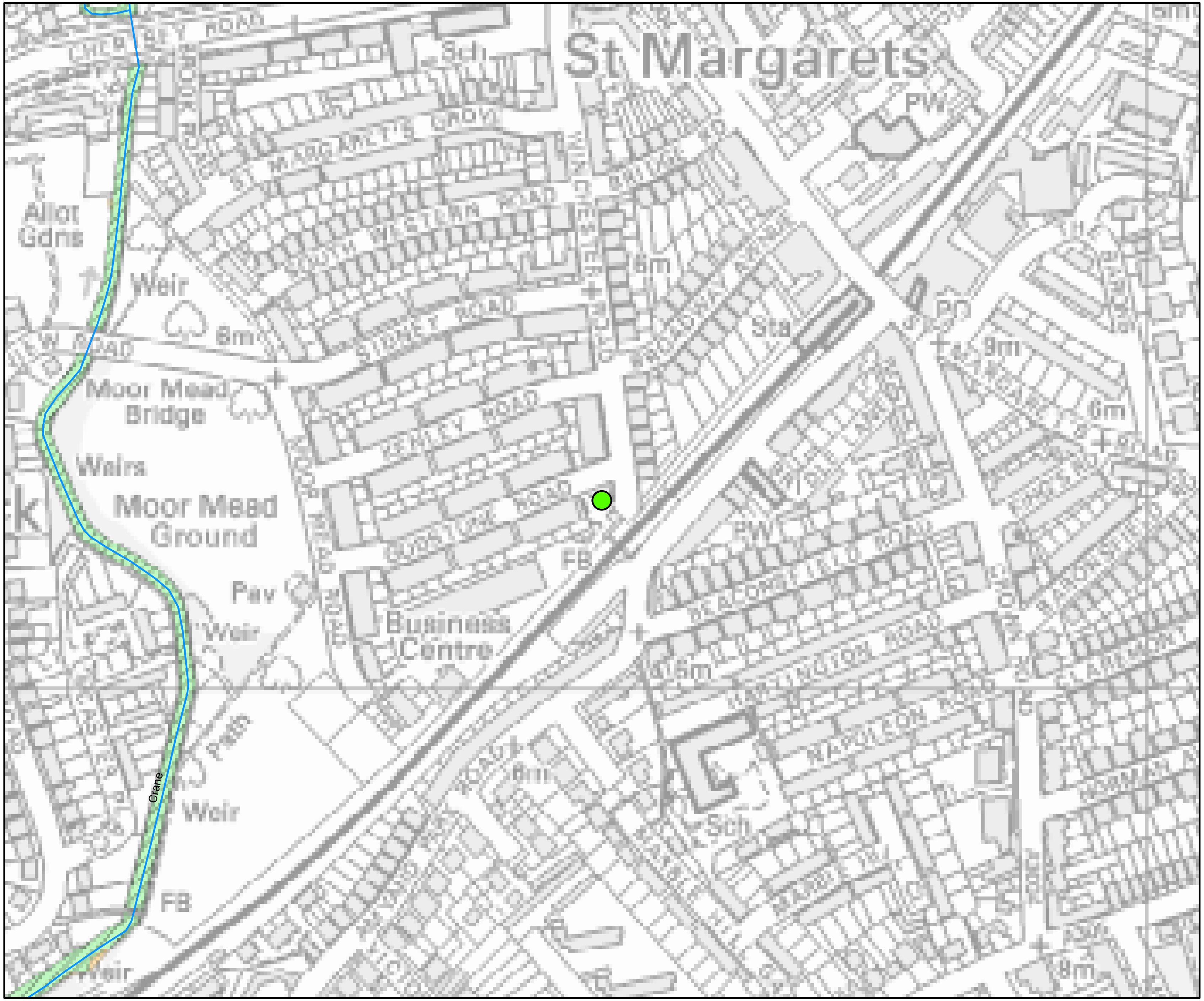
Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

Main Rivers

Site location

Defended Flood Outlines

- 1 in 5 (20%) Defended
- 1 in 10 (10%) Defended
- 1 in 20 (5%) Defended
- 1 in 50 (2%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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Detailed FRA centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC

Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

- Main Rivers
- Site location

Defended Flood Outlines

- 1 in 100 (1%) Defended
- 1 in 100+20% (*CC) Defended
- 1 in 100+25% (*CC) Defended
- 1 in 100+30% (*CC) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

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https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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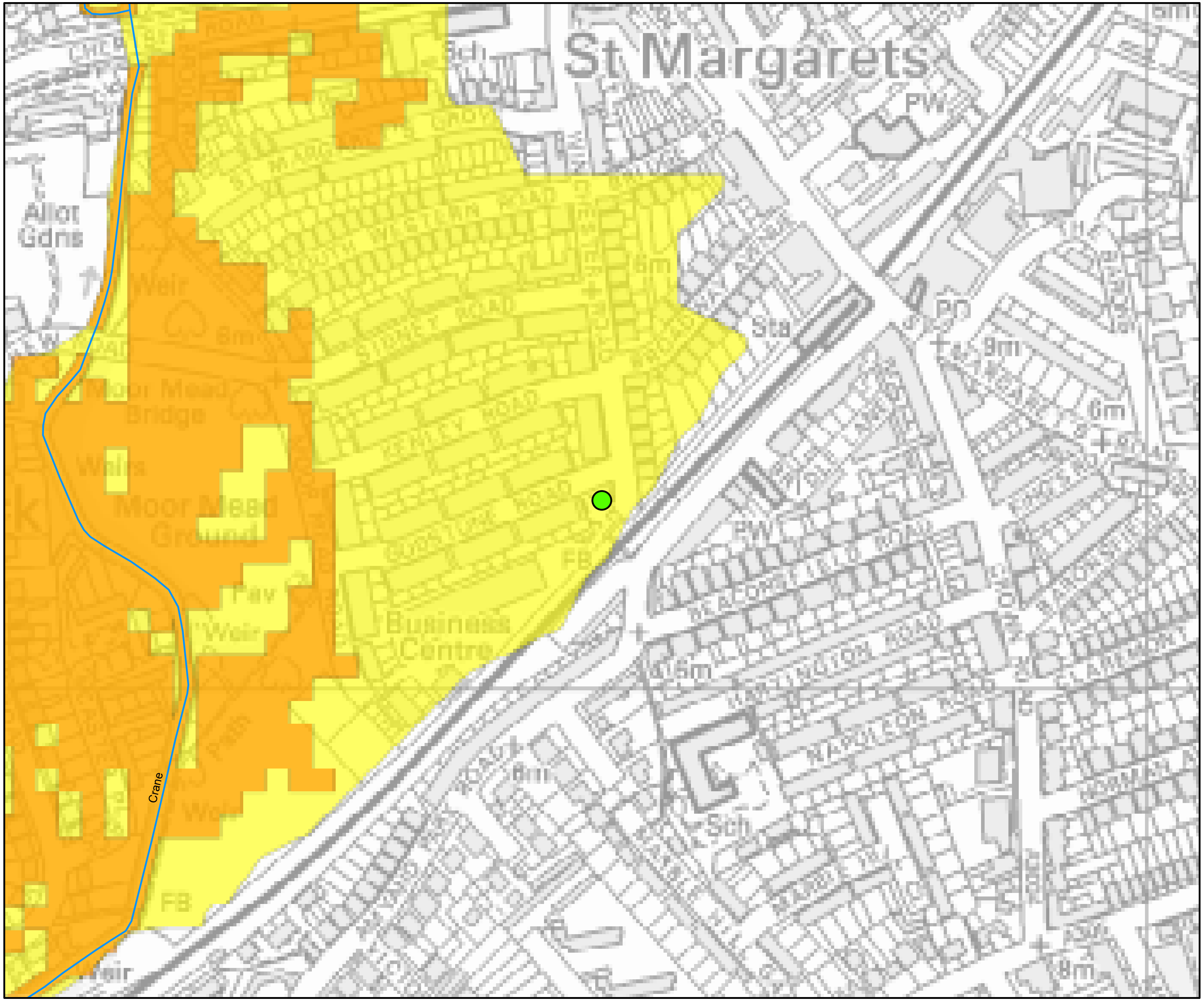

Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

- Main Rivers
- Site location

Defended Flood Outlines

- 1 in 100+70% (*CC) Defended
- 1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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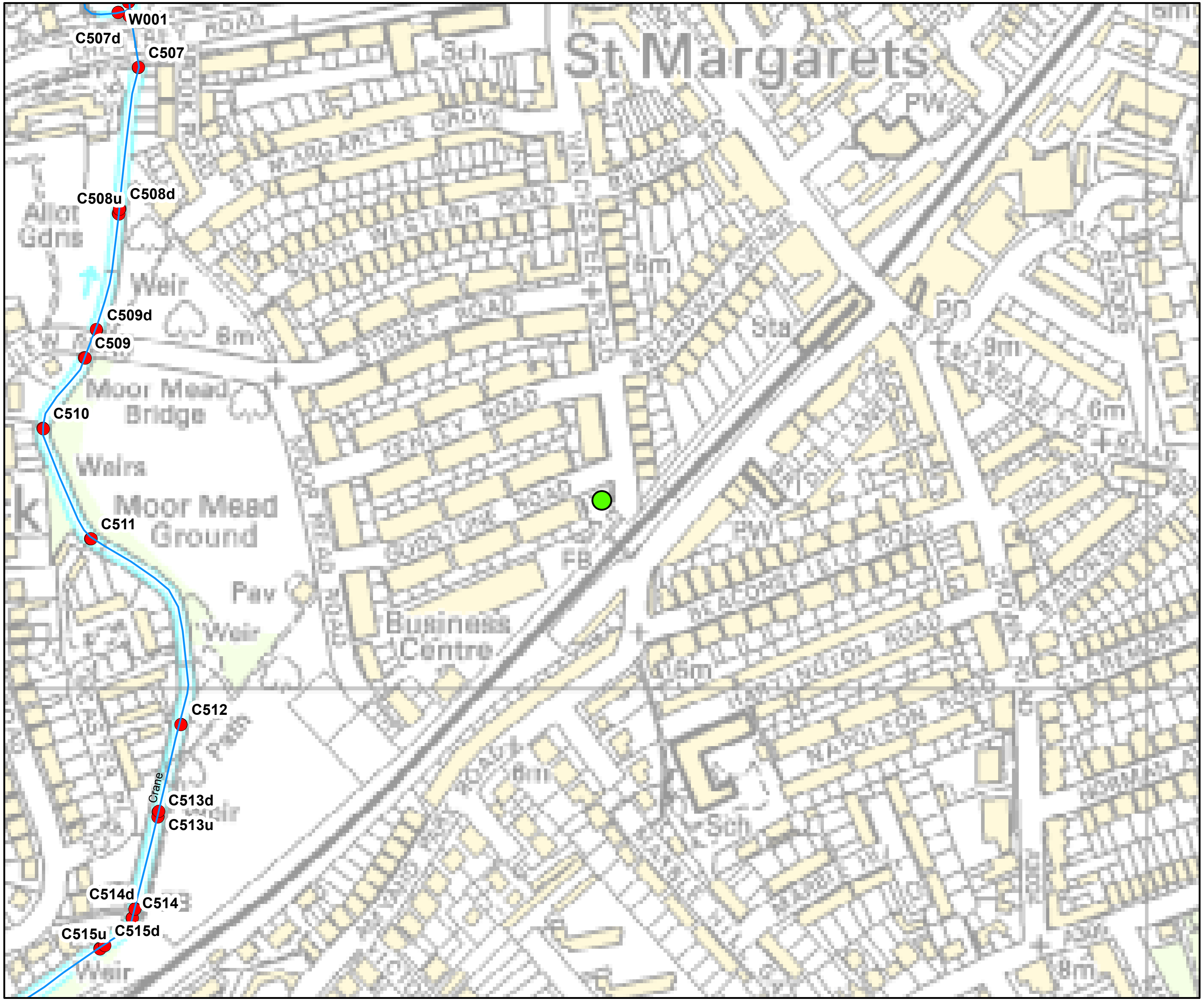
Hertfordshire & North London

Detailed FRA centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC



Environment Agency
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Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

Main Rivers

Site location

1D Node Results

Node Results

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Environment Agency ref: HNL 178955 BC

The following information has been extracted from the River Crane Mapping Study (Halcrow 2008)

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.

https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Caution:

The modelled flood levels and extents are appropriate for catchment wide strategic flood risk mapping. However, for more detailed flood risk assessment it is recommended that each of the underlying flood mapping, hydraulic modelling and hydrological assumptions are re-evaluated to determine the appropriateness in a more detailed analysis.

All flood levels are given in metres Above Ordnance Datum (mAOD)
All flows are given in cubic metres per second (cumecs)

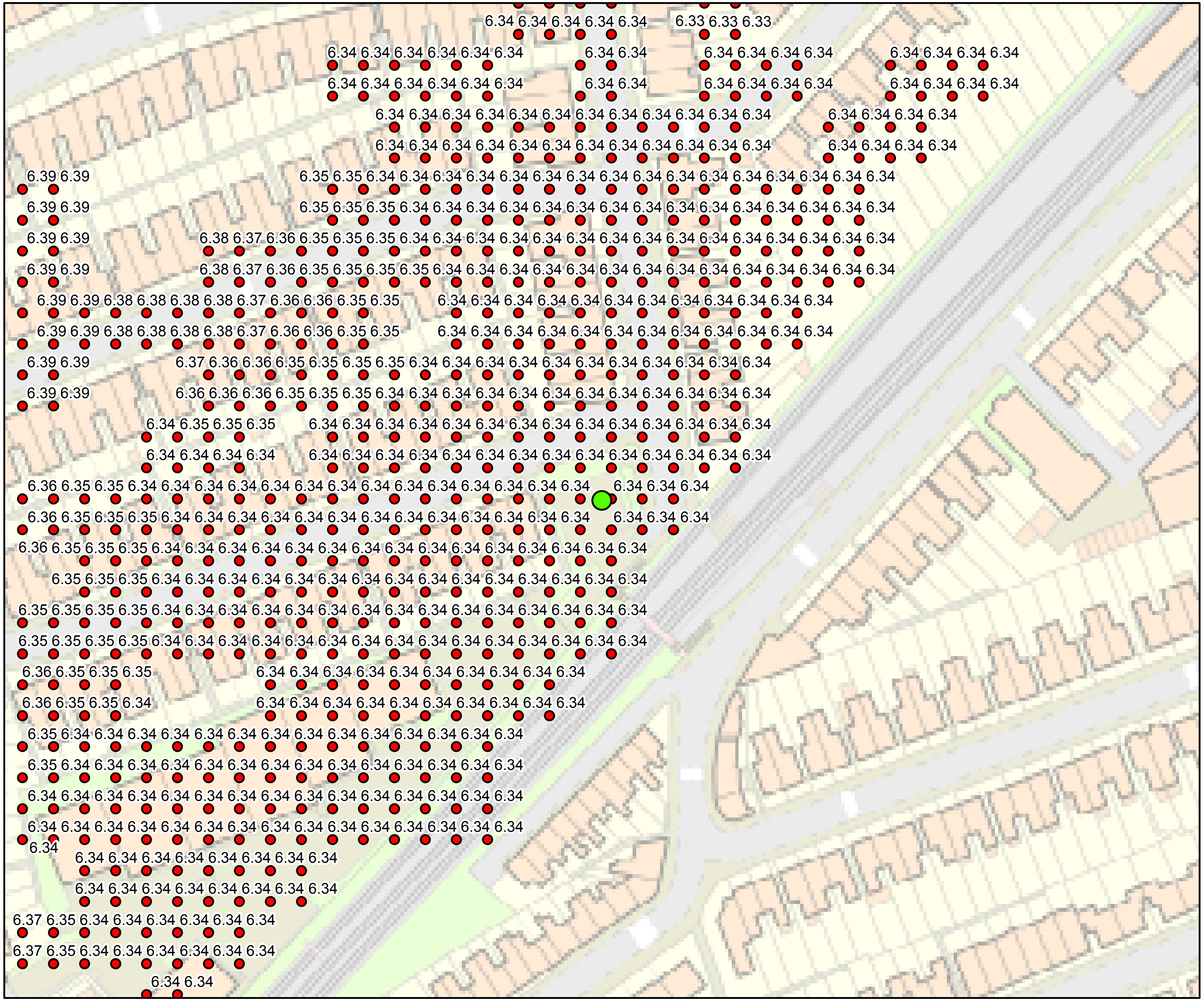
MODELLED FLOOD LEVEL

			Return Period									
Node Label	**Easting**	**Northing**	**5 yr**	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**100yr + 25%**	**100yr + 35%**	**100yr + 70%**	**1000yr**
C515u	516321	173829	6.78	6.84	6.87	6.90	6.92	6.96	6.98	7.09	7.11	7.15
C515d	516321	173829	6.70	6.76	6.78	6.81	6.84	6.88	6.89	7.01	7.03	7.06
C514	516339	173852	6.65	6.70	6.73	6.76	6.78	6.82	6.84	6.95	6.97	7.00
C514d	516339	173852	6.65	6.71	6.74	6.77	6.80	6.85	6.86	6.98	7.00	7.04
C513u	516352	173919	6.57	6.63	6.65	6.68	6.70	6.74	6.76	6.86	6.87	6.90
C513d	516352	173919	6.47	6.52	6.54	6.57	6.59	6.63	6.65	6.74	6.76	6.77
C512	516370	173977	6.41	6.46	6.48	6.51	6.53	6.57	6.58	6.68	6.70	6.71
C511	516311	174096	6.28	6.32	6.35	6.38	6.40	6.44	6.45	6.54	6.57	6.59
C510	516281	174173	6.23	6.28	6.31	6.34	6.36	6.40	6.41	6.51	6.54	6.60
C509	516314	174220	6.21	6.26	6.29	6.31	6.34	6.37	6.39	6.48	6.50	6.54
C509d	516314	174220	6.21	6.25	6.27	6.30	6.31	6.35	6.36	6.43	6.44	6.47
C508u	516332	174310	6.11	6.15	6.17	6.19	6.21	6.24	6.25	6.32	6.33	6.36
C508d	516332	174310	5.41	5.45	5.46	5.48	5.50	5.52	5.53	5.59	5.61	5.70
C507	516338	174406	5.30	5.33	5.35	5.37	5.38	5.41	5.42	5.48	5.50	5.63
C507d	516338	174406	5.22	5.25	5.27	5.29	5.30	5.32	5.33	5.40	5.42	5.58
W001	516330	174440	5.20	5.24	5.25	5.27	5.28	5.31	5.32	5.38	5.40	5.57

MODELLED FLOWS

			Return Period									
Node Label	**Easting**	**Northing**	**5 yr**	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**100yr + 25%**	**100yr + 35%**	**100yr + 70%**	**1000yr**
C515u	516321	173829	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.97	31.56	32.85
C515d	516321	173829	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.97	31.56	32.85
C514	516339	173852	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.97	31.56	32.93
C514d	516339	173852	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.97	31.56	32.93
C513u	516352	173919	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.96	31.54	32.89
C513d	516352	173919	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.96	31.54	32.89
C512	516370	173977	24.16	25.42	26.05	26.69	27.29	28.17	28.51	30.96	31.54	32.80
C511	516311	174096	24.16	25.42	26.05	26.69	27.29	28.18	28.51	30.96	31.50	32.14
C510	516281	174173	24.16	25.42	26.05	26.69	27.29	28.18	28.51	30.85	31.35	31.18
C509	516314	174220	24.20	25.43	26.07	26.74	27.30	28.22	28.55	30.86	31.36	32.18
C509d	516314	174220	24.20	25.43	26.07	26.74	27.30	28.22	28.55	30.86	31.36	32.18
C508u	516332	174310	24.20	25.43	26.07	26.74	27.30	28.22	28.55	30.86	31.36	32.17
C508d	516332	174310	24.20	25.43	26.07	26.74	27.30	28.22	28.55	30.86	31.36	32.17
C507	516338	174406	24.20	25.43	26.07	26.74	27.30	28.22	28.55	30.86	31.36	32.16
C507d	516338	174406	24.20	25.43	26.07	26.74	27.30	28.22	28.55	30.86	31.36	32.16
W001	516330	174440	0.21	0.21	0.21	0.26	0.28	0.32	0.34	0.69	1.39	5.89

Detailed FRA centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60
Metres

Legend

Main Rivers

Site location

2D Node Results: Heights

1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Historic Flood Map centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 150 300 600
Metres

Legend

Main Rivers

Site location

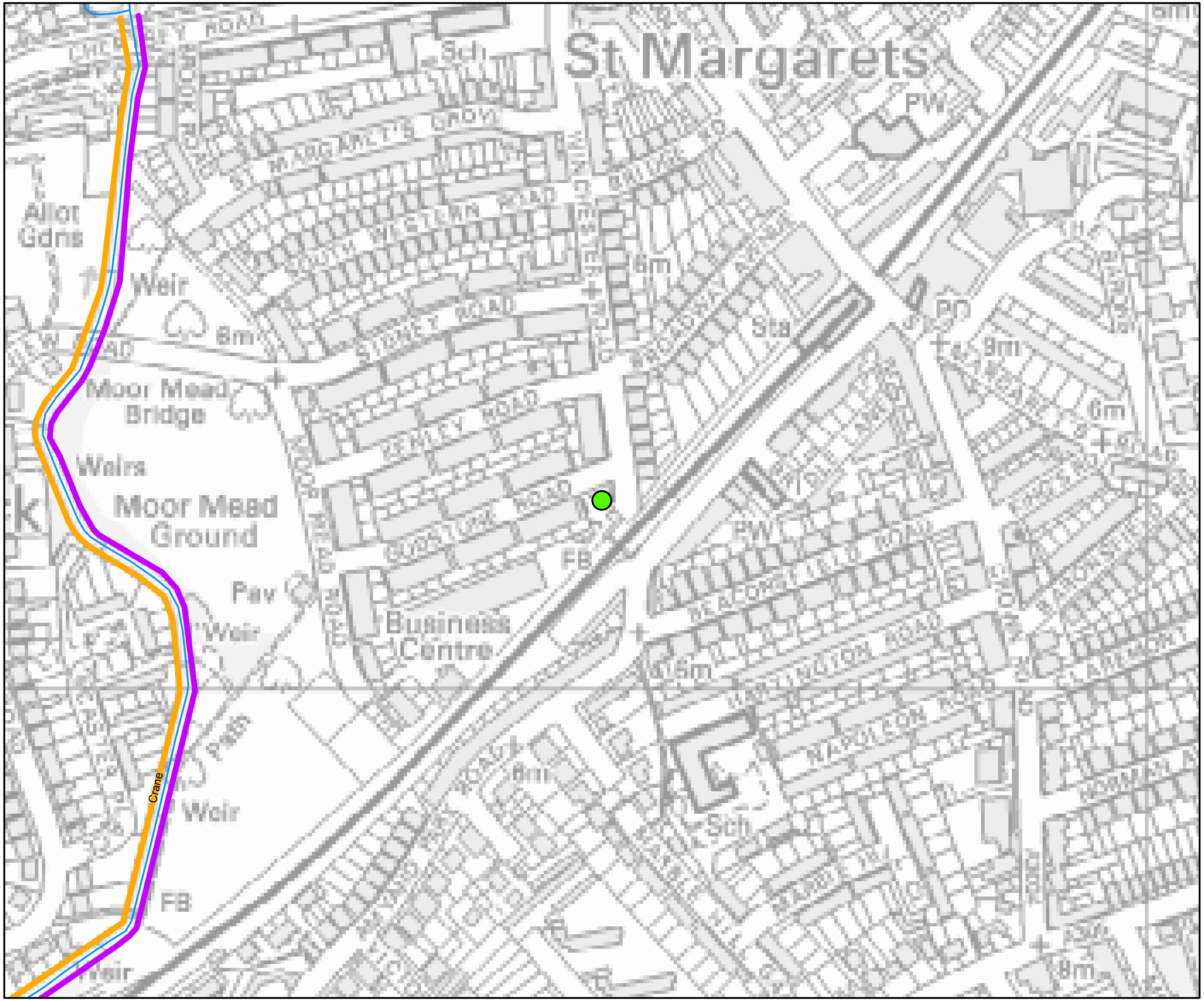
Flood Event Outlines

1965

The historic flood event outlines are based on a combination of anecdotal evidence, Environment Agency staff observations and survey.
Our historic flood event outlines do not provide a definitive record of flooding.
It is possible that there will be an absence of datain places where we have not been able to record the extent of flooding.
It is also possible for errors occur in the digitisation of historic records of flooding.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Structures and Defences centred on: St Margarets Business Park Car Park, Twickenham, TW1 1JS - 28/07/2020 - HNL 178955 BC



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

Main Rivers

Site location

ASSET_ID

42494

151137

The following information on defences has been extracted from the Asset Information Management System (AIMS)

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Environment Agency ref: HNL 178955 BC

The following information on defences has been extracted from the Asset Information Management System (AIMS)

Defences

Asset ID	Asset Type	Asset Protection	Asset Comment	Asset Description	Design Standard of protection (years)	Downstream Crest Level	Upstream Crest Level	Condition of Defences (1=Good, 5 = Poor)
42494	Wall	Fluvial	Channel lined with concrete wall. 1.5m high top to base, raised 0.3m above ground level D/S from Moor Mead Ground.	Cole Park LB channel	100	5.81	7.58	3
151137	Wall	Fluvial	Channel is lined with a concrete wall. 1.5m high from top to base, raised 0.3m above surrounding ground level.	Cole Park RB Channel	100	6.26	7.63	3

APPENDIX D
THAMES WATER CORRESPONDENCE

Sewer Flooding
History Enquiry

Thames Water Property Searches

Simpson Associates

Friday Street

Search address supplied	St Margarets Business Car Park Winchester Road Twickenham TW1 1JS

Your reference	St Margarets Business Car Park
Our reference	SFH/SFH Standard/2020_4207835
Received date	**2 July 2020**
Search date	**2 July 2020**

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

Search address supplied: St Margarets Business Car Park,Winchester Road,Twickenham,TW1 1JS

This search is recommended to check for any sewer flooding in a specific address or area

TWUL, trading as Property Searches, are responsible in respect of the following:-

(i) any negligent or incorrect entry in the records searched;

(ii) any negligent or incorrect interpretation of the records searched;

(iii) and any negligent or incorrect recording of that interpretation in the search report

(iv) compensation payments

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

History of Sewer Flooding

Is the requested address or area at risk of flooding due to overloaded public sewers?

The flooding records held by Thames Water indicate that there have been no incidents of flooding in the requested area as a result of surcharging public sewers.

For your guidance:

- A sewer is "overloaded" when the flow from a storm is unable to pass through it due to a permanent problem (e.g. flat gradient, small diameter). Flooding as a result of temporary problems such as blockages, siltation, collapses and equipment or operational failures are excluded.
- "Internal flooding" from public sewers is defined as flooding, which enters a building or passes below a suspended floor. For reporting purposes, buildings are restricted to those normally occupied and used for residential, public, commercial, business or industrial purposes.
- "At Risk" properties are those that the water company is required to include in the Regulatory Register that is presented annually to the Director General of Water Services. These are defined as properties that have suffered, or are likely to suffer, internal flooding from public foul, combined or surface water sewers due to overloading of the sewerage system more frequently than the relevant reference period (either once or twice in ten years) as determined by the Company's reporting procedure.
- Flooding as a result of storm events proven to be exceptional and beyond the reference period of one in ten years are not included on the At Risk Register.
- Properties may be at risk of flooding but not included on the Register where flooding incidents have not been reported to the Company.
- Public Sewers are defined as those for which the Company holds statutory responsibility under the Water Industry Act 1991.
- It should be noted that flooding can occur from private sewers and drains which are not the responsibility of the Company. This report excludes flooding from private sewers and drains and the Company makes no comment upon this matter.
- For further information please contact Thames Water on Tel: 0800 316 9800 or website www.thameswater.co.uk

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

Mr B Tawton
Simpson Associates
8 Friday st
Henley on Thames
Oxfordshire
RG9 1AH

Our ref: DS6075425

0800 009 3921
Monday to Friday, 8am to 5pm

8th July 2020

Pre-planning enquiry: Wastewater Capacity check

Dear Mr Tawton

Thank you for providing details of your development with the Pre-Planning application dated 2nd July 20 for development @ St. Magarets Buisness Centre Drummond Place Twickenham TW1 1JS

Existing brownfld site ,developed to { 4 dwellings } as per your above application.

We have completed the assessment of the foul water flows and surface water run-off based on the information submitted in your application with the purpose of assessing sewerage capacity within the existing Thames Water sewer network.

Foul

If your proposals progress in line with the details you've provided as above, we're pleased to confirm that there will be sufficient sewerage capacity in the nearest TW foul sewer network to serve your foul discharges from your development, provided it is by gravity.

This confirmation is valid for 12 months or for the life of any planning approval that this information is used to support, to a maximum of three years.

You'll need to keep us informed of any changes to your design – for example, an increase in the number or density of homes. Such changes could mean there is no longer sufficient capacity and has to be investigated again.

Surface Water
When developing a site, policy 5.13 of the London Plan and Policy 3.4 of the Supplementary Planning Guidance (Sustainable Design And Construction) states that every attempt should be made to use flow attenuation and SuDS/Storage to reduce the surface water discharge from the site as much as possible.

In accordance with the Building Act 2000 Clause H3.3, positive connection of surface water to a public sewer will only be consented when it can be demonstrated that the hierarchy of disposal methods have been examined and proven to be impracticable. Before we can consider your surface water needs, you'll need written approval from the lead local flood authority that you have followed the sequential approach to the disposal of surface water and considered all practical means.

The disposal hierarchy being:

1. store rainwater for later use.
2. use infiltration techniques where possible.
3. attenuate rainwater in ponds or open water features for gradual release.
4. attenuate rainwater by storing in tanks or sealed water features for gradual release.
5. discharge rainwater direct to a watercourse.
6. discharge rainwater to a surface water sewer/drain.
7. discharge rainwater to the combined sewer.
8. discharge rainwater to the foul sewer

Where connection to the public sewerage network is still required to manage surface water flows we will accept these flows at a discharge rate in line with CIRIA's best practice guide on SuDS or that stated within the sites planning approval.

If the above surface water hierarchy has been followed and if the flows are restricted to a total of 2 l/s to TW surface water sewer , then Thames Water would not have any objections to the proposal.

Please see the attached 'Planning your wastewater' leaflet for additional information. At the appropriate time, you will have to apply for a S106 connection application to DS Connection team

This confirmation is valid for 12 months or for the life of any planning approval that this information is used to support, to a maximum of three years.

Please note that you must keep us informed of any changes to your design – for example, an increase in the number or density of homes. Such changes could mean there is no longer sufficient sewerage capacity.

What happens next?

Please make sure you submit your connection application, when you are ready, giving us at least 21 days' notice of the date you wish to make your new connection/s.

If you've any further questions, please contact me.

Yours sincerely

Siva Sivarajan

Developer Services- Wastewater Adoptions Engineer
Office:0203 577 7752 Mobile: 07747842608
siva.sivarajan@thameswater.co.uk

Thames Water Utilities Ltd, Clearwater Court, Vastern Road, Reading, Berkshire, RG1 8DB
Find us online at developers.thameswater.co.uk

TW Int ref : DTS 66298

APPENDIX E
RUNOFF CALCULATIONS

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.500
Area (ha)	0.060	Urban	0.750
SAAR (mm)	700	Region Number	Region 6

Results	**l/s**
QBAR Rural	0.3
QBAR Urban	0.9
Q100 years	1.7
Q1 year	0.7
Q30 years	1.5
Q100 years	1.7

P20-435, St Margarets Business Car Park - Modified Rational Method Runoff Calculations (Pre-Development)

Peak Runoff Rate = 3.61 x Runoff Volume Coefficient (Cv) x Area (A) x Peak Rainfall Intensity (I_{peak})

Runoff Volume = Runoff Coefficient (C) x Area (A) x Average Rainfall intensity (I_{ave}) x Storm Duration

Pre-development Runoff

Return Period	Cv	$I_{(peak)}$ (mm)	$I_{(ave)}$ (mm)	A (Ha)	Peak Runoff Rate (l/s)	Runoff Volume (m^3)
1	0.75	14.118	3.601	0.060	2.3	9.7
30	0.75	31.172	7.952	0.060	5.1	21.5
100	0.75	40.444	10.317	0.060	6.6	27.9

Notes

1. Rainfall intensities generated from the FSR rainfall model facility in MicroDrainage.
2. Peak and average rainfall intensities are based on the following FSR data:

Storm Duration:	360 min (6hrs)
M5-60 (mm):	20.000
Ratio R	0.410

APPENDIX F
PROPOSED DRAINAGE STRATEGY PLAN

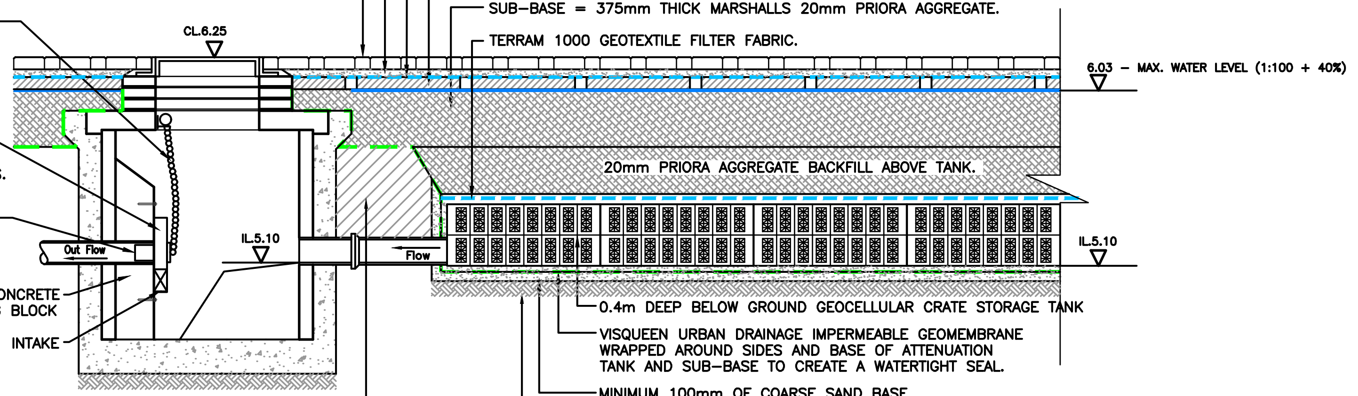
LEGEND

- PROPOSED SURFACE WATER DRAINAGE
- PROPOSED FILTER DRAIN
- PROPOSED PERMEABLE PAVING AREA = 58m²
- PROPOSED GREEN ROOF. AREA = 118m²
- PAVED AREA TO BE DRAINED BY FILTER DRAIN. AREA = 110m²
- PROPOSED PITCHED ROOF TO BE DRAINED BY TRADITIONAL RAINWATER GUTTERS AND DOWNPIPES WITH WATER BUTTS USED TO COLLECT RAINWATER FOR WATERING GARDENS. AREA = 178m²
- SITE BOUNDARY.

DO NOT SCALE

PROPOSED 2.0 x 13.0 x 0.4m GEOCELLULAR ATTENUATION TANK TO STORE AND ATTENUATE EXCESS RUNOFF FOR ALL RAINFALL EVENTS UP TO AND INCLUDING THE 1 IN 100 YEAR EVENT WITH AN ALLOWANCE OF 40% FOR CLIMATE CHANGE.

FLOW CONTROL CHAMBER TO BE FITTED WITH A HYDROBRAKE FLOW CONTROL DEVICE RESTRICTED TO A MAXIMUM DISCHARGE RATE OF 2.0 l/s BEFORE DISCHARGING TO SURFACE WATER SEWER NETWORK.



SURFACE COURSE = 80mm THICK MARSHALLS TEGULA PRIORA PERMEABLE PAVING BLOCKS LAID IN A 90° HERRINGBONE PATTERN IN ACCORDANCE WITH THE MANUFACTURERS SPECIFICATION AND DETAILS. PERMEABLE JOINTS TO BE FILLED WITH MARSHALLS 6mm PRIORA AGGREGATE.

LAYING COURSE = 50mm THICK MARSHALLS 6mm PRIORA AGGREGATE.

TERRAM 1000 GEOTEXTILE FILTER FABRIC.

BASE COURSE = 80mm THICK AC32 DENSE BASE COURSE WITH 100/150 PEN BINDER MIX TO BS EN 13108–1:2006. 75mm Ø HOLES TO BE CUT THROUGH BASE COURSE AT 750mm CENTRES TO SUB–BASE FOR DRAINAGE. HOLES TO BE FILLED WITH MARSHALLS 6mm PRIORA AGGREGATE.

SUB–BASE = 375mm THICK MARSHALLS 20mm PRIORA AGGREGATE.

TERRAM 1000 GEOTEXTILE FILTER FABRIC.

CHAIN (TO BE FIXED BELOW CHAMBER COVER TO ENABLE BYPASS TO BE OPENED FROM OUTSIDE MANHOLE)

HYDROBRAKE OR SIMILAR APPROVED INSTALLED IN ACCORDANCE WITH MANUFACTURER'S REQUIREMENTS.

OUTLET SPIGOT

GEN 3 CONCRETE MOUNTING BLOCK

INTAKE

FLOW CONTROL CHAMBER

TYPE 1 GRANULAR MATERIAL SUITABLY COMPACTED.

0.4m DEEP BELOW GROUND GEOCELLULAR CRATE STORAGE TANK

VISQUEEN URBAN DRAINAGE IMPERMEABLE GEOMEMBRANE WRAPPED AROUND SIDES AND BASE OF ATTENUATION TANK AND SUB–BASE TO CREATE A WATERTIGHT SEAL.

MINIMUM 100mm OF COARSE SAND BASE AND SURROUND SUITABLY COMPACTED.

SUB–GRADE = EXISTING ACCEPTABLE MATERIAL. ANY SOFT SPOTS OR WEAK SPOTS ARE TO BE EXCAVATED AND REPLACED WITH SUB–BASE (AS DEFINED ABOVE), FORMATION TO BE PREPARED IN ACCORDANCE WITH CLAUSE 616.

TYPICAL SECTION THROUGH ATTENUATION TANK AND FLOW CONTROL CHAMBER WITH PERMEABLE PAVING ABOVE.

SCALE 1:25

MK	REVISION	BY	DATE
A	UPDATED IN ACCORDANCE WITH LATEST PLANNING DRAWINGS	GSC	03.09.20

DRAWING STATUS
PRELIMINARY

DRAWING TITLE
SURFACE WATER DRAINAGE STRATEGY PLAN

PROJECT — Project Number P20-435
ST MARGARET'S BUSINESS CAR PARK
MOOR MEAD ROAD
TWICKENHAM TW1 1JS

simpson | tws
8 Friday Street
Henley on Thames
Oxfordshire RG9 1AH
T.01491 576221
London, Henley-on Thames, Gloucester and Exeter

Drawn	Ch'kd	Scales	Date
J.J.H.	G.S.C.	1:100@A1	AUG'20

Purpose of Issue: PLANNING

Drawing Number: P20-435-SK01 — Revision: A

A1

APPENDIX G
DRAINAGE STRATEGY DESIGN RESULTS

Summary of Results for 1 year Return Period

Half Drain Time : 34 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	5.160	0.060	0.0	0.6	0.6	1.5	O K
30 min Summer	5.173	0.073	0.0	0.6	0.6	1.8	O K
60 min Summer	5.182	0.082	0.0	0.7	0.7	2.0	O K
120 min Summer	5.192	0.092	0.0	0.7	0.7	2.3	O K
180 min Summer	5.193	0.093	0.0	0.7	0.7	2.3	O K
240 min Summer	5.191	0.091	0.0	0.7	0.7	2.2	O K
360 min Summer	5.183	0.083	0.0	0.7	0.7	2.1	O K
480 min Summer	5.175	0.075	0.0	0.7	0.7	1.9	O K
600 min Summer	5.167	0.067	0.0	0.6	0.6	1.7	O K
720 min Summer	5.161	0.061	0.0	0.6	0.6	1.5	O K
960 min Summer	5.153	0.053	0.0	0.5	0.5	1.3	O K
1440 min Summer	5.143	0.043	0.0	0.4	0.4	1.1	O K
2160 min Summer	5.135	0.035	0.0	0.3	0.3	0.9	O K
2880 min Summer	5.130	0.030	0.0	0.3	0.3	0.7	O K
4320 min Summer	5.125	0.025	0.0	0.2	0.2	0.6	O K
5760 min Summer	5.122	0.022	0.0	0.2	0.2	0.6	O K
7200 min Summer	5.120	0.020	0.0	0.1	0.1	0.5	O K
8640 min Summer	5.119	0.019	0.0	0.1	0.1	0.5	O K
10080 min Summer	5.118	0.018	0.0	0.1	0.1	0.4	O K
15 min Winter	5.169	0.069	0.0	0.6	0.6	1.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	31.246	0.0	1.8	16
30 min Summer	20.306	0.0	2.6	27
60 min Summer	12.800	0.0	3.5	54
120 min Summer	7.903	0.0	4.6	84
180 min Summer	5.931	0.0	5.3	118
240 min Summer	4.833	0.0	5.8	150
360 min Summer	3.601	0.0	6.5	214
480 min Summer	2.913	0.0	7.1	276
600 min Summer	2.471	0.0	7.6	336
720 min Summer	2.161	0.0	7.9	392
960 min Summer	1.748	0.0	8.6	512
1440 min Summer	1.296	0.0	9.5	750
2160 min Summer	0.962	0.0	10.5	1104
2880 min Summer	0.779	0.0	11.2	1472
4320 min Summer	0.577	0.0	12.1	2204
5760 min Summer	0.467	0.0	12.7	2936
7200 min Summer	0.396	0.0	13.2	3672
8640 min Summer	0.347	0.0	13.7	4400
10080 min Summer	0.310	0.0	14.0	5088
15 min Winter	31.246	0.0	2.1	16

Summary of Results for 1 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	5.184	0.084	0.0	0.7	0.7	2.1	O K
60 min Winter	5.198	0.098	0.0	0.7	0.7	2.4	O K
120 min Winter	5.205	0.105	0.0	0.8	0.8	2.6	O K
180 min Winter	5.202	0.102	0.0	0.7	0.7	2.5	O K
240 min Winter	5.196	0.096	0.0	0.7	0.7	2.4	O K
360 min Winter	5.181	0.081	0.0	0.7	0.7	2.0	O K
480 min Winter	5.168	0.068	0.0	0.6	0.6	1.7	O K
600 min Winter	5.159	0.059	0.0	0.6	0.6	1.4	O K
720 min Winter	5.152	0.052	0.0	0.5	0.5	1.3	O K
960 min Winter	5.144	0.044	0.0	0.5	0.5	1.1	O K
1440 min Winter	5.135	0.035	0.0	0.3	0.3	0.9	O K
2160 min Winter	5.129	0.029	0.0	0.3	0.3	0.7	O K
2880 min Winter	5.125	0.025	0.0	0.2	0.2	0.6	O K
4320 min Winter	5.121	0.021	0.0	0.2	0.2	0.5	O K
5760 min Winter	5.119	0.019	0.0	0.1	0.1	0.5	O K
7200 min Winter	5.117	0.017	0.0	0.1	0.1	0.4	O K
8640 min Winter	5.116	0.016	0.0	0.1	0.1	0.4	O K
10080 min Winter	5.115	0.015	0.0	0.1	0.1	0.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	20.306	0.0	3.1	29
60 min Winter	12.800	0.0	4.1	58
120 min Winter	7.903	0.0	5.3	90
180 min Winter	5.931	0.0	6.0	126
240 min Winter	4.833	0.0	6.6	160
360 min Winter	3.601	0.0	7.5	224
480 min Winter	2.913	0.0	8.1	286
600 min Winter	2.471	0.0	8.6	340
720 min Winter	2.161	0.0	9.0	400
960 min Winter	1.748	0.0	9.7	518
1440 min Winter	1.296	0.0	10.8	750
2160 min Winter	0.962	0.0	11.9	1112
2880 min Winter	0.779	0.0	12.8	1468
4320 min Winter	0.577	0.0	13.9	2224
5760 min Winter	0.467	0.0	14.7	2912
7200 min Winter	0.396	0.0	15.3	3680
8640 min Winter	0.347	0.0	15.7	4256
10080 min Winter	0.310	0.0	16.1	5136

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.035

Time From:	(mins) To:	Area (ha)
0	4	0.035

Green Roof

Area (m³)	118	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.002144	32	36	0.000433	64	68	0.000087	96	100	0.000018
4	8	0.001756	36	40	0.000354	68	72	0.000072	100	104	0.000014
8	12	0.001437	40	44	0.000290	72	76	0.000059	104	108	0.000012
12	16	0.001177	44	48	0.000238	76	80	0.000048	108	112	0.000010
16	20	0.000963	48	52	0.000195	80	84	0.000039	112	116	0.000008
20	24	0.000789	52	56	0.000159	84	88	0.000032	116	120	0.000006
24	28	0.000646	56	60	0.000130	88	92	0.000026			
28	32	0.000529	60	64	0.000107	92	96	0.000022			

Model Details

Storage is Online Cover Level (m) 6.250

Complex Structure

Cellular Storage

Invert Level (m) 5.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	26.0	26.0	0.500	0.0	38.0
0.400	26.0	38.0			

Infiltration Blanket

Infiltration Coefficient Base (m/hr) 0.00000 Diameter/Width (m) 2.0
Safety Factor 2.0 Length (m) 13.0
Porosity 0.30 Cap Volume Depth (m) 0.165
Invert Level (m) 5.500

Porous Car Park

Infiltration Coefficient Base (m/hr) 0.00000 Width (m) 2.4
Membrane Percolation (mm/hr) 1000 Length (m) 24.0
Max Percolation (l/s) 16.0 Slope (1:X) 0.0
Safety Factor 2.0 Depression Storage (mm) 5
Porosity 0.30 Evaporation (mm/day) 3
Invert Level (m) 5.745 Cap Volume Depth (m) 0.375

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0044-2000-0940-2000
Design Head (m)	0.940
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Linear discharge profile
Application	Surface
Sump Available	Yes
Diameter (mm)	44
Invert Level (m)	5.100
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.940	2.0
Flush-Flo™	0.066	0.6
Kick-Flo®	0.066	0.6

Hydro-Brake® Optimum Outflow Control

Control Points	Head (m)	Flow (l/s)
Mean Flow over Head Range	-	1.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.7	1.200	2.2	3.000	3.4	7.000	5.1
0.200	1.0	1.400	2.4	3.500	3.7	7.500	5.3
0.300	1.2	1.600	2.6	4.000	3.9	8.000	5.4
0.400	1.4	1.800	2.7	4.500	4.1	8.500	5.6
0.500	1.5	2.000	2.8	5.000	4.4	9.000	5.8
0.600	1.6	2.200	3.0	5.500	4.6	9.500	5.9
0.800	1.9	2.400	3.1	6.000	4.7		
1.000	2.1	2.600	3.2	6.500	4.9		

Summary of Results for 30 year Return Period

Half Drain Time : 67 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	5.274	0.174	0.0	0.9	0.9	4.3	O K
30 min Summer	5.333	0.233	0.0	1.1	1.1	5.7	O K
60 min Summer	5.377	0.277	0.0	1.2	1.2	6.8	O K
120 min Summer	5.390	0.290	0.0	1.2	1.2	7.2	O K
180 min Summer	5.388	0.288	0.0	1.2	1.2	7.1	O K
240 min Summer	5.379	0.279	0.0	1.2	1.2	6.9	O K
360 min Summer	5.355	0.255	0.0	1.1	1.1	6.3	O K
480 min Summer	5.332	0.232	0.0	1.1	1.1	5.7	O K
600 min Summer	5.309	0.209	0.0	1.0	1.0	5.2	O K
720 min Summer	5.289	0.189	0.0	1.0	1.0	4.7	O K
960 min Summer	5.256	0.156	0.0	0.9	0.9	3.9	O K
1440 min Summer	5.210	0.110	0.0	0.8	0.8	2.7	O K
2160 min Summer	5.172	0.072	0.0	0.6	0.6	1.8	O K
2880 min Summer	5.155	0.055	0.0	0.6	0.6	1.3	O K
4320 min Summer	5.140	0.040	0.0	0.4	0.4	1.0	O K
5760 min Summer	5.134	0.034	0.0	0.3	0.3	0.8	O K
7200 min Summer	5.130	0.030	0.0	0.3	0.3	0.7	O K
8640 min Summer	5.127	0.027	0.0	0.2	0.2	0.7	O K
10080 min Summer	5.125	0.025	0.0	0.2	0.2	0.6	O K
15 min Winter	5.300	0.200	0.0	1.0	1.0	4.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	76.671	0.0	5.8	19
30 min Summer	49.712	0.0	7.8	33
60 min Summer	30.811	0.0	9.9	60
120 min Summer	18.537	0.0	12.0	96
180 min Summer	13.628	0.0	13.4	126
240 min Summer	10.910	0.0	14.3	160
360 min Summer	7.952	0.0	15.7	226
480 min Summer	6.352	0.0	16.7	292
600 min Summer	5.333	0.0	17.6	356
720 min Summer	4.621	0.0	18.3	418
960 min Summer	3.685	0.0	19.4	540
1440 min Summer	2.675	0.0	21.1	780
2160 min Summer	1.940	0.0	22.8	1128
2880 min Summer	1.543	0.0	24.0	1472
4320 min Summer	1.117	0.0	25.7	2204
5760 min Summer	0.887	0.0	26.9	2936
7200 min Summer	0.742	0.0	27.7	3664
8640 min Summer	0.641	0.0	28.4	4304
10080 min Summer	0.567	0.0	28.8	5104
15 min Winter	76.671	0.0	6.6	19

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	5.367	0.267	0.0	1.1	1.1	6.6	O K
60 min Winter	5.419	0.319	0.0	1.2	1.2	7.9	O K
120 min Winter	5.432	0.332	0.0	1.2	1.2	8.2	O K
180 min Winter	5.424	0.324	0.0	1.2	1.2	8.0	O K
240 min Winter	5.407	0.307	0.0	1.2	1.2	7.6	O K
360 min Winter	5.368	0.268	0.0	1.1	1.1	6.6	O K
480 min Winter	5.332	0.232	0.0	1.1	1.1	5.7	O K
600 min Winter	5.300	0.200	0.0	1.0	1.0	4.9	O K
720 min Winter	5.273	0.173	0.0	0.9	0.9	4.3	O K
960 min Winter	5.231	0.131	0.0	0.8	0.8	3.2	O K
1440 min Winter	5.180	0.080	0.0	0.7	0.7	2.0	O K
2160 min Winter	5.151	0.051	0.0	0.5	0.5	1.3	O K
2880 min Winter	5.141	0.041	0.0	0.4	0.4	1.0	O K
4320 min Winter	5.132	0.032	0.0	0.3	0.3	0.8	O K
5760 min Winter	5.127	0.027	0.0	0.2	0.2	0.7	O K
7200 min Winter	5.125	0.025	0.0	0.2	0.2	0.6	O K
8640 min Winter	5.122	0.022	0.0	0.2	0.2	0.6	O K
10080 min Winter	5.121	0.021	0.0	0.2	0.2	0.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	49.712	0.0	8.8	33
60 min Winter	30.811	0.0	11.2	60
120 min Winter	18.537	0.0	13.6	100
180 min Winter	13.628	0.0	15.1	134
240 min Winter	10.910	0.0	16.2	172
360 min Winter	7.952	0.0	17.7	242
480 min Winter	6.352	0.0	18.9	308
600 min Winter	5.333	0.0	19.8	372
720 min Winter	4.621	0.0	20.6	434
960 min Winter	3.685	0.0	21.9	558
1440 min Winter	2.675	0.0	23.8	794
2160 min Winter	1.940	0.0	25.8	1124
2880 min Winter	1.543	0.0	27.2	1472
4320 min Winter	1.117	0.0	29.2	2172
5760 min Winter	0.887	0.0	30.5	2848
7200 min Winter	0.742	0.0	31.5	3648
8640 min Winter	0.641	0.0	32.3	4408
10080 min Winter	0.567	0.0	32.9	4960

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.035

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.035

Green Roof

Area (m³) 118 Evaporation (mm/day) 3
Depression Storage (mm) 5 Decay Coefficient 0.050

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.002144	32	36	0.000433	64	68	0.000087	96	100	0.000018
4	8	0.001756	36	40	0.000354	68	72	0.000072	100	104	0.000014
8	12	0.001437	40	44	0.000290	72	76	0.000059	104	108	0.000012
12	16	0.001177	44	48	0.000238	76	80	0.000048	108	112	0.000010
16	20	0.000963	48	52	0.000195	80	84	0.000039	112	116	0.000008
20	24	0.000789	52	56	0.000159	84	88	0.000032	116	120	0.000006
24	28	0.000646	56	60	0.000130	88	92	0.000026			
28	32	0.000529	60	64	0.000107	92	96	0.000022			

Model Details

Storage is Online Cover Level (m) 6.250

Complex Structure

Cellular Storage

Invert Level (m) 5.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	26.0	26.0	0.500	0.0	38.0
0.400	26.0	38.0			

Infiltration Blanket

Infiltration Coefficient Base (m/hr)	0.00000	Diameter/Width (m)	2.0
Safety Factor	2.0	Length (m)	13.0
Porosity	0.30	Cap Volume Depth (m)	0.165
Invert Level (m)	5.500		

Porous Car Park

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	2.4
Membrane Percolation (mm/hr)	1000	Length (m)	24.0
Max Percolation (l/s)	16.0	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	5.745	Cap Volume Depth (m)	0.375

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0044-2000-0940-2000
Design Head (m)	0.940
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Linear discharge profile
Application	Surface
Sump Available	Yes
Diameter (mm)	44
Invert Level (m)	5.100
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.940	2.0
Flush-Flo™	0.066	0.6
Kick-Flo®	0.066	0.6

Hydro-Brake® Optimum Outflow Control

Control Points	Head (m)	Flow (l/s)
Mean Flow over Head Range	-	1.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.7	1.200	2.2	3.000	3.4	7.000	5.1
0.200	1.0	1.400	2.4	3.500	3.7	7.500	5.3
0.300	1.2	1.600	2.6	4.000	3.9	8.000	5.4
0.400	1.4	1.800	2.7	4.500	4.1	8.500	5.6
0.500	1.5	2.000	2.8	5.000	4.4	9.000	5.8
0.600	1.6	2.200	3.0	5.500	4.6	9.500	5.9
0.800	1.9	2.400	3.1	6.000	4.7		
1.000	2.1	2.600	3.2	6.500	4.9		

Summary of Results for 100 year Return Period

Half Drain Time : 79 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	5.339	0.239	0.0	1.1	1.1	5.9	O K
30 min Summer	5.422	0.322	0.0	1.2	1.2	7.9	O K
60 min Summer	5.488	0.388	0.0	1.3	1.3	9.6	O K
120 min Summer	5.507	0.407	0.0	1.4	1.4	10.1	O K
180 min Summer	5.504	0.404	0.0	1.4	1.4	10.0	O K
240 min Summer	5.493	0.393	0.0	1.3	1.3	9.7	O K
360 min Summer	5.462	0.362	0.0	1.3	1.3	8.9	O K
480 min Summer	5.430	0.330	0.0	1.2	1.2	8.2	O K
600 min Summer	5.400	0.300	0.0	1.2	1.2	7.4	O K
720 min Summer	5.374	0.274	0.0	1.1	1.1	6.8	O K
960 min Summer	5.329	0.229	0.0	1.1	1.1	5.6	O K
1440 min Summer	5.265	0.165	0.0	0.9	0.9	4.1	O K
2160 min Summer	5.208	0.108	0.0	0.8	0.8	2.7	O K
2880 min Summer	5.176	0.076	0.0	0.7	0.7	1.9	O K
4320 min Summer	5.150	0.050	0.0	0.5	0.5	1.2	O K
5760 min Summer	5.140	0.040	0.0	0.4	0.4	1.0	O K
7200 min Summer	5.135	0.035	0.0	0.3	0.3	0.9	O K
8640 min Summer	5.131	0.031	0.0	0.3	0.3	0.8	O K
10080 min Summer	5.129	0.029	0.0	0.3	0.3	0.7	O K
15 min Winter	5.373	0.273	0.0	1.1	1.1	6.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	99.536	0.0	7.8	19
30 min Summer	65.075	0.0	10.5	33
60 min Summer	40.510	0.0	13.3	62
120 min Summer	24.362	0.0	16.1	100
180 min Summer	17.855	0.0	17.8	130
240 min Summer	14.239	0.0	19.0	164
360 min Summer	10.317	0.0	20.7	230
480 min Summer	8.210	0.0	22.0	296
600 min Summer	6.871	0.0	23.0	362
720 min Summer	5.939	0.0	23.8	424
960 min Summer	4.714	0.0	25.2	548
1440 min Summer	3.400	0.0	27.2	792
2160 min Summer	2.448	0.0	29.2	1148
2880 min Summer	1.937	0.0	30.7	1500
4320 min Summer	1.391	0.0	32.7	2204
5760 min Summer	1.099	0.0	34.0	2936
7200 min Summer	0.915	0.0	35.0	3648
8640 min Summer	0.787	0.0	35.7	4392
10080 min Summer	0.693	0.0	36.3	5088
15 min Winter	99.536	0.0	8.8	19

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	5.467	0.367	0.0	1.3	1.3	9.1	O K
60 min Winter	5.549	0.449	0.0	1.4	1.4	11.0	O K
120 min Winter	5.606	0.506	0.0	1.5	1.5	11.5	O K
180 min Winter	5.580	0.480	0.0	1.5	1.5	11.3	O K
240 min Winter	5.539	0.439	0.0	1.4	1.4	10.8	O K
360 min Winter	5.488	0.388	0.0	1.3	1.3	9.6	O K
480 min Winter	5.440	0.340	0.0	1.3	1.3	8.4	O K
600 min Winter	5.398	0.298	0.0	1.2	1.2	7.4	O K
720 min Winter	5.361	0.261	0.0	1.1	1.1	6.4	O K
960 min Winter	5.302	0.202	0.0	1.0	1.0	5.0	O K
1440 min Winter	5.228	0.128	0.0	0.8	0.8	3.2	O K
2160 min Winter	5.171	0.071	0.0	0.6	0.6	1.8	O K
2880 min Winter	5.151	0.051	0.0	0.5	0.5	1.3	O K
4320 min Winter	5.137	0.037	0.0	0.4	0.4	0.9	O K
5760 min Winter	5.131	0.031	0.0	0.3	0.3	0.8	O K
7200 min Winter	5.128	0.028	0.0	0.2	0.2	0.7	O K
8640 min Winter	5.125	0.025	0.0	0.2	0.2	0.6	O K
10080 min Winter	5.124	0.024	0.0	0.2	0.2	0.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	65.075	0.0	11.8	33
60 min Winter	40.510	0.0	15.0	60
120 min Winter	24.362	0.0	18.2	104
180 min Winter	17.855	0.0	20.1	138
240 min Winter	14.239	0.0	21.4	176
360 min Winter	10.317	0.0	23.3	246
480 min Winter	8.210	0.0	24.7	314
600 min Winter	6.871	0.0	25.9	380
720 min Winter	5.939	0.0	26.8	444
960 min Winter	4.714	0.0	28.4	568
1440 min Winter	3.400	0.0	30.7	808
2160 min Winter	2.448	0.0	33.0	1152
2880 min Winter	1.937	0.0	34.6	1472
4320 min Winter	1.391	0.0	36.9	2188
5760 min Winter	1.099	0.0	38.5	2936
7200 min Winter	0.915	0.0	39.7	3728
8640 min Winter	0.787	0.0	40.6	4408
10080 min Winter	0.693	0.0	41.3	5072

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.035

Time (mins) From:	To:	Area (ha)
0	4	0.035

Green Roof

Area (m³)	118	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.002144	32	36	0.000433	64	68	0.000087	96	100	0.000018
4	8	0.001756	36	40	0.000354	68	72	0.000072	100	104	0.000014
8	12	0.001437	40	44	0.000290	72	76	0.000059	104	108	0.000012
12	16	0.001177	44	48	0.000238	76	80	0.000048	108	112	0.000010
16	20	0.000963	48	52	0.000195	80	84	0.000039	112	116	0.000008
20	24	0.000789	52	56	0.000159	84	88	0.000032	116	120	0.000006
24	28	0.000646	56	60	0.000130	88	92	0.000026			
28	32	0.000529	60	64	0.000107	92	96	0.000022			

Model Details

Storage is Online Cover Level (m) 6.250

Complex Structure

Cellular Storage

Invert Level (m) 5.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	26.0	26.0	0.500	0.0	38.0
0.400	26.0	38.0			

Infiltration Blanket

Infiltration Coefficient Base (m/hr) 0.00000 Diameter/Width (m) 2.0
Safety Factor 2.0 Length (m) 13.0
Porosity 0.30 Cap Volume Depth (m) 0.165
Invert Level (m) 5.500

Porous Car Park

Infiltration Coefficient Base (m/hr) 0.00000 Width (m) 2.4
Membrane Percolation (mm/hr) 1000 Length (m) 24.0
Max Percolation (l/s) 16.0 Slope (1:X) 0.0
Safety Factor 2.0 Depression Storage (mm) 5
Porosity 0.30 Evaporation (mm/day) 3
Invert Level (m) 5.745 Cap Volume Depth (m) 0.375

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0044-2000-0940-2000
Design Head (m)	0.940
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Linear discharge profile
Application	Surface
Sump Available	Yes
Diameter (mm)	44
Invert Level (m)	5.100
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.940	2.0
Flush-Flo™	0.066	0.6
Kick-Flo®	0.066	0.6

Hydro-Brake® Optimum Outflow Control

Control Points	Head (m)	Flow (l/s)
Mean Flow over Head Range	-	1.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.7	1.200	2.2	3.000	3.4	7.000	5.1
0.200	1.0	1.400	2.4	3.500	3.7	7.500	5.3
0.300	1.2	1.600	2.6	4.000	3.9	8.000	5.4
0.400	1.4	1.800	2.7	4.500	4.1	8.500	5.6
0.500	1.5	2.000	2.8	5.000	4.4	9.000	5.8
0.600	1.6	2.200	3.0	5.500	4.6	9.500	5.9
0.800	1.9	2.400	3.1	6.000	4.7		
1.000	2.1	2.600	3.2	6.500	4.9		

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

Half Drain Time : 91 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control Σ (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	5.455	0.355	0.0	1.3	1.3	8.8	O K
30 min Summer	5.630	0.530	0.0	1.5	1.5	11.7	O K
60 min Summer	5.862	0.762	0.0	1.8	1.8	14.0	O K
120 min Summer	5.909	0.809	0.0	1.9	1.9	14.8	O K
180 min Summer	5.905	0.805	0.0	1.9	1.9	14.8	O K
240 min Summer	5.884	0.784	0.0	1.8	1.8	14.4	O K
360 min Summer	5.829	0.729	0.0	1.8	1.8	13.4	O K
480 min Summer	5.775	0.675	0.0	1.7	1.7	12.5	O K
600 min Summer	5.635	0.535	0.0	1.5	1.5	11.8	O K
720 min Summer	5.547	0.447	0.0	1.4	1.4	11.0	O K
960 min Summer	5.481	0.381	0.0	1.3	1.3	9.4	O K
1440 min Summer	5.387	0.287	0.0	1.2	1.2	7.1	O K
2160 min Summer	5.297	0.197	0.0	1.0	1.0	4.9	O K
2880 min Summer	5.242	0.142	0.0	0.9	0.9	3.5	O K
4320 min Summer	5.183	0.083	0.0	0.7	0.7	2.0	O K
5760 min Summer	5.157	0.057	0.0	0.6	0.6	1.4	O K
7200 min Summer	5.147	0.047	0.0	0.5	0.5	1.1	O K
8640 min Summer	5.140	0.040	0.0	0.4	0.4	1.0	O K
10080 min Summer	5.136	0.036	0.0	0.4	0.4	0.9	O K
15 min Winter	5.503	0.403	0.0	1.4	1.4	10.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	139.350	0.0	11.3	22
30 min Summer	91.106	0.0	15.0	34
60 min Summer	56.713	0.0	19.0	62
120 min Summer	34.106	0.0	23.0	102
180 min Summer	24.997	0.0	25.3	132
240 min Summer	19.934	0.0	27.0	164
360 min Summer	14.444	0.0	29.4	232
480 min Summer	11.493	0.0	31.2	296
600 min Summer	9.620	0.0	32.6	366
720 min Summer	8.314	0.0	33.8	434
960 min Summer	6.600	0.0	35.8	558
1440 min Summer	4.760	0.0	38.7	806
2160 min Summer	3.427	0.0	41.6	1168
2880 min Summer	2.712	0.0	43.7	1524
4320 min Summer	1.948	0.0	46.7	2224
5760 min Summer	1.538	0.0	48.8	2936
7200 min Summer	1.281	0.0	50.4	3672
8640 min Summer	1.102	0.0	51.6	4400
10080 min Summer	0.970	0.0	52.6	5056
15 min Winter	139.350	0.0	12.8	23

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	5.816	0.716	0.0	1.8	1.8	13.2	O K
60 min Winter	5.976	0.876	0.0	1.9	1.9	16.0	O K
120 min Winter	6.033	0.933	0.0	2.0	2.0	17.0	O K
180 min Winter	6.019	0.919	0.0	2.0	2.0	16.7	O K
240 min Winter	5.982	0.882	0.0	1.9	1.9	16.1	O K
360 min Winter	5.893	0.793	0.0	1.8	1.8	14.5	O K
480 min Winter	5.809	0.709	0.0	1.8	1.8	13.1	O K
600 min Winter	5.745	0.645	0.0	1.7	1.7	12.0	O K
720 min Winter	5.546	0.446	0.0	1.4	1.4	10.9	O K
960 min Winter	5.457	0.357	0.0	1.3	1.3	8.8	O K
1440 min Winter	5.340	0.240	0.0	1.1	1.1	5.9	O K
2160 min Winter	5.242	0.142	0.0	0.9	0.9	3.5	O K
2880 min Winter	5.192	0.092	0.0	0.7	0.7	2.3	O K
4320 min Winter	5.152	0.052	0.0	0.5	0.5	1.3	O K
5760 min Winter	5.141	0.041	0.0	0.4	0.4	1.0	O K
7200 min Winter	5.135	0.035	0.0	0.4	0.4	0.9	O K
8640 min Winter	5.132	0.032	0.0	0.3	0.3	0.8	O K
10080 min Winter	5.129	0.029	0.0	0.3	0.3	0.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	91.106	0.0	17.0	33
60 min Winter	56.713	0.0	21.3	60
120 min Winter	34.106	0.0	25.8	110
180 min Winter	24.997	0.0	28.5	140
240 min Winter	19.934	0.0	30.3	176
360 min Winter	14.444	0.0	33.0	246
480 min Winter	11.493	0.0	35.1	314
600 min Winter	9.620	0.0	36.7	380
720 min Winter	8.314	0.0	38.0	456
960 min Winter	6.600	0.0	40.3	586
1440 min Winter	4.760	0.0	43.5	834
2160 min Winter	3.427	0.0	46.8	1188
2880 min Winter	2.712	0.0	49.2	1528
4320 min Winter	1.948	0.0	52.7	2204
5760 min Winter	1.538	0.0	55.1	2928
7200 min Winter	1.281	0.0	56.9	3640
8640 min Winter	1.102	0.0	58.4	4376
10080 min Winter	0.970	0.0	59.6	5128

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.410	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.035

Time From:	(mins) To:	Area (ha)
0	4	0.035

Green Roof

Area (m³)	118	Evaporation (mm/day)	3
Depression Storage (mm)	5	Decay Coefficient	0.050

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.002144	32	36	0.000433	64	68	0.000087	96	100	0.000018
4	8	0.001756	36	40	0.000354	68	72	0.000072	100	104	0.000014
8	12	0.001437	40	44	0.000290	72	76	0.000059	104	108	0.000012
12	16	0.001177	44	48	0.000238	76	80	0.000048	108	112	0.000010
16	20	0.000963	48	52	0.000195	80	84	0.000039	112	116	0.000008
20	24	0.000789	52	56	0.000159	84	88	0.000032	116	120	0.000006
24	28	0.000646	56	60	0.000130	88	92	0.000026			
28	32	0.000529	60	64	0.000107	92	96	0.000022			

Model Details

Storage is Online Cover Level (m) 6.250

Complex Structure

Cellular Storage

Invert Level (m)	5.100	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000	Porosity	0.95
Infiltration Coefficient Side (m/hr)	0.00000		

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	26.0	26.0	0.500	0.0	38.0
0.400	26.0	38.0			

Infiltration Blanket

Infiltration Coefficient Base (m/hr)	0.00000	Diameter/Width (m)	2.0
Safety Factor	2.0	Length (m)	13.0
Porosity	0.30	Cap Volume Depth (m)	0.165
Invert Level (m)	5.500		

Porous Car Park

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	2.4
Membrane Percolation (mm/hr)	1000	Length (m)	24.0
Max Percolation (l/s)	16.0	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	5.745	Cap Volume Depth (m)	0.375

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0044-2000-0940-2000
Design Head (m)	0.940
Design Flow (l/s)	2.0
Flush-Flo™	Calculated
Objective	Linear discharge profile
Application	Surface
Sump Available	Yes
Diameter (mm)	44
Invert Level (m)	5.100
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.940	2.0
Flush-Flo™	0.066	0.6
Kick-Flo®	0.066	0.6

Hydro-Brake® Optimum Outflow Control

Control Points	Head (m)	Flow (l/s)
Mean Flow over Head Range	-	1.4

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.7	1.200	2.2	3.000	3.4	7.000	5.1
0.200	1.0	1.400	2.4	3.500	3.7	7.500	5.3
0.300	1.2	1.600	2.6	4.000	3.9	8.000	5.4
0.400	1.4	1.800	2.7	4.500	4.1	8.500	5.6
0.500	1.5	2.000	2.8	5.000	4.4	9.000	5.8
0.600	1.6	2.200	3.0	5.500	4.6	9.500	5.9
0.800	1.9	2.400	3.1	6.000	4.7		
1.000	2.1	2.600	3.2	6.500	4.9		

APPENDIX H
DRAINAGE MAINTENANCE PLAN

DRAINAGE MAINTENANCE & MANAGEMENT PLAN

PROPOSED RESIDENTIAL DEVELOPMENT

ST MARGARETS BUSINESS CAR PARK, TWICKENHAM

On occupation of the development, this maintenance and management plan should be incorporated into the sites Operation and Maintenance Manual with the as-built drainage system operated and maintained in accordance with the regime set out in the tables below.

The Property Management Company should ensure that the Maintenance Contractor tasked with carrying out any maintenance works provides a risk assessment and method statement that adopts best practice health and safety policies for maintenance personnel throughout the duration of any maintenance works. Measures may include:

- Ensure the use of safe systems of work and procedures are followed.
- Certificated operatives only to be used for all confined space entry.
- Ensure appropriate ppe is worn at all times including the use of safety goggles, ear defenders and other relevant equipment when using high pressure jetting.
- Do not work in weather conditions where flooding or surging is likely.
- Erect barriers where appropriate and provide adequate lighting.
- No operations to be carried out by operatives working alone.
- Time maintenance to not conflict with other on-site activities.
- Method statement to be prepared and approved prior to entry into confined space.

Table 1: Below Ground Drainage System - Operation and Maintenance Requirements

Maintenance schedule	Required action	Frequency
Regular maintenance	Remove all litter and debris from external hard landscaped areas and adjacent landscaping, which may pose a risk to the performance of the system.	Monthly.
	Remove build-up of sediment / silt in catch-pits and dispose of oils / petrol residues using safe standard practices.	As required.
	Stabilise and mow adjacent landscaped areas and remove weeds.	
Remedial actions	Repair or rehabilitate inlet and outlets to ensure they are in good condition and operating as designed.	
	Remediate any landscaping, which has raised to within 50mm of the level of adjacent hard landscaping.	
Monitoring	Check of all inlets / outlets for blockages or evidence of physical damage with any necessary remedial action or clearance carried out if required.	On a monthly basis for the first 3 months of operation, thereafter every 6 months & following severe rainfall events.
	Inspect all surfaces for ponding, or silt accumulation. Record areas where water is ponding for more than 48 hours and carry out any remedial work deemed necessary.	After severe storms.

Table 2: Permeable Paving - Operation and Maintenance Requirements

Maintenance schedule	Required action	Frequency
Regular maintenance	Remove all litter and debris from drained surfaces areas and adjacent hard / soft landscaping, which may pose a risk to the performance of the system.	Monthly.
	Sweep permeable paved areas. If necessary use jet wash or suction sweeper. Any jointing aggregate lost from the joints must be replaced as necessary with 2/6.3mm single sized aggregate, brushed into joints.	Three times a year at end of winter, mid-summer, after autumn leaf fall, or as required based on site-specific observations of clogging.
	Stabilise and mow adjacent landscaped areas and remove weeds.	As required.
Remedial actions	Remediate any landscaping, which has raised to within 50mm of the level of adjacent hard landscaping.	
	Carry out remedial work to any depressions, rutting and cracked or broken paving blocks within the permeable paved areas that are considered detrimental to the structural performance or a hazard to users.	
	Carry out repair / rehabilitation works to inlets, outlets, overflows and vents.	
Monitoring	Inspect silt accumulation rates within the permeable paved areas and establish appropriate brushing frequencies.	Annually.
	Check of all inlets, outlets, overflows and vents for blockages or evidence of physical damage with any necessary remedial action or clearance carried out if required.	On a monthly basis for the first 3 months of operation, thereafter every 6 months & following severe rainfall events.
	Inspect and identify any areas that are not operating correctly	On a monthly basis for the first 3 months of operation, thereafter every 6 months & following severe rainfall events.

Table 3: Flow Control Chamber - Operation and Maintenance Requirements

Maintenance schedule	Required action	Frequency
Regular maintenance	Cleaning off the flow control device of any debris/ sediment	As required
Remedial Actions	Flow control device repairs.	As required
	Repair of erosion damage, or damage to chamber.	
Monitoring	Inspection of the chamber for debris and sediment build up.	Monthly for first 3 months, thereafter, every 6 months and following severe storm events.

Table 4: Geocellular Storage Tank - Operation and Maintenance Requirements

Maintenance schedule	Required action	Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for first 3 months of operation, then every 6 months.
	Debris removal from catchment surface (where may cause risks to performance).	Monthly.
	Where rainfall infiltrates into blocks from above, check surface of filter for blockage by silt, algae or other matter. Remove and replace surface infiltration medium as necessary.	Monthly / after severe storms.
	Remove sediment from pre-treatment structures.	Annually, or as required.
Remedial actions	Repair/rehabilitation of inlets, outlet, overflows and vents.	As required.
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed.	Annually and after large storms.