Flood Risk Assessment

Land to the Rear of 1-10 Campbell Close, Twickenham, TW2 5BZ

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1 INTRODUCTION

1.1 Existing Site

The proposed development site is located on land to the rear of Campbell Close in Twickenham, Middlesex (Figure 1.1). The site lies adjacent to the River Crane (Figure 1.2) and consists of a greenfield plot with sheds and outbuildings, vegetable plots, a former cold frame, beehives and a chicken run (Figure 1.3) and is mainly permeable cover of vegetation and mature trees as shown on an aerial photograph of the site (Figure 1.4). The site measures 150m by 35m with an area of 5250m^2 and with no formal drainage network it is assumed that storm rainfall and runoff drains informally to the adjacent River Crane.

A topographical survey (Figure 1.5) shows ground levels fall from 12.18m OD at the site entrance on Campbell Close to around 10.0m OD at the top of the river bank with a slope down from south to north across the site.

1.2 Proposed Development

The proposals are to provide a single dwelling close to the access from Campbell Close (Figure 1.6) on an area of higher ground. The new building will have raised floor levels 500mm above existing ground level (Figure 1.7) with a footprint of 130m^2 and will be of an innovative design (Figure 1.8 and 1.9) to match the local environment. This will have a kitchen, living room, dining room and two bedrooms on the ground floor and a further bedroom on the first floor (Figure 1.10). The adjacent car parking area and turning circle will be constructed of permeable material with an area of 122m^2. Most of the greenfield site will be retained as existing with mature trees and low level hedgerows to encourage biodiversity.

1.3 Requirements for a Flood Risk Assessment

A Flood Risk Assessment (FRA) is often required as part of a planning application depending on the nature of a development, the size of the plot and the anticipated flood risk as defined by the Environment Agency's flood risk zones. In England flood risk is divided into three zones:

- Zone 1 areas have little or no risk with an annual probability of flooding of less than 0.1% per year, above the 1000 year flood level.
- Zone 2 areas have a fluvial risk of flooding of between 0.1% and 1% a year, between the 100 year and 1000 year and
- Zone 3 areas are considered to be at high risk with a fluvial risk of flooding of greater than 1% a year, inside the 100 year flood extent.

The site is located alongside the River Crane and the EAs on-line flood map is coarse scale and poorly defined at this location (Figure 1.11) and suggests part of the site is in Zones 2 and 3 with the higher ground in Zone 1. The flood map from Richmond Borough Council's SFRA (Figure 1.12) provides a similar flood outline presumably as the same model or method was used to define the flood zones. The access road and car parking area are in Zone 1 and the building will be located on higher ground also in Zone 1, the gardens and greenfield areas are in Zones 2 and 3.

However as part of the site is in Zone 3 a FRA is required as part of the planning application. The requirement for and the content of a FRA is dictated by the National Planning Policy Framework (NPPF), the National Planning Practice Guidance (NPPG), the Environment Agency's standing advice and guidelines and the local Strategic Flood Risk Assessment (SFRA). The requirements of these documents are summarised below.

1.3.1 National Planning Policy Framework (NPPF)

The Government's revised National Planning Policy Framework (NPPF) is valid from March 2012 and the content, coverage and extent of a site-specific FRA was defined in the NPPF Technical Guidance but which, as detailed below, has since been superseded by NPPG. This requires local planning authorities to consider developments in flood risk areas appropriate only where informed by a site-specific FRA.

The technical approach to a FRA is largely unchanged from the earlier PPS25 with the presumption for development in Flood Zone 1 although development may be permitted in Zones 2 and 3 providing suitable flood risk management and mitigation measures are included. The basic premise is that a new development should (a) not place occupiers at flood risk, by ensuring floor levels are suitably raised, there is safe dry escape route and flood resistance or resilience measures are included, and (b) not increase flood risk to others by ensuring any flood storage volume lost is compensated for and that the developed site runoff does not exceed the existing rate using a sustainable drainage system (SuDS) approach to achieve these objectives. It should also consider the anticipated increase in flow and rainfall due to climate change over the lifetime of the development, taken as 100 years.

1.3.2 National Planning Practice Guidance (NPPG)

In March 2014 the Department for Communities and Local Government (DCLG) launched a web-based planning practice guidance resource. This was accompanied by a Written Ministerial Statement which included a list of the previous planning practice guidance documents cancelled and this included PPS25, the PPS25 Practice Guide and the NNPF Technical Guide.

This new National Planning Practice Guidance (NPPG) requires that a site-specific FRA should assess the flood risks to and from a development site and this should accompany a planning application. The FRA should demonstrate how flood risk will be managed now, and over the lifetime of the development by taking climate change into account, and with regard to the vulnerability of its users. The objectives of a site-specific FRA are to establish whether a proposed development is likely to be affected by current or future flooding from any source or will increase flood risk elsewhere to others and that any measures proposed to deal with these effects and risks are appropriate. The FRA should also consider the Sequential Test and to show that the development will be safe should pass the Exception Test.

A FRA should be proportionate to the degree of flood risk and make optimum use of information already available, including the local SFRA, the Environment Agency's flood maps and the Environment Agency's standing advice. The new guidance provides a checklist to assist in preparing a site-specific FRA.

1.3.3 Environment Agency Guidance

The Environment Agency has produced Standing Advice and Guidance which aims to simplify the requirements for a FRA according to the nature of the development and the relevant flood zone. This advice was updated in 2015 is referred to by NPPG detailed above.

As the proposals are for a new development where part of the site is in Zone 3 a FRA should consider the Environment Agency's Zone 3 specific advice in relation to floor levels, access and evacuation and surface water management (Table 1.1).

Table 1.1 EAs Requirements for a FRA in Flood Zone 3

Information	Requirements of FRA
Plans	• A location plan showing street names, any rivers, streams, ponds, wetlands or other bodies of water and other geographical features. • A plan of the existing site • A plan of the development proposal and any structures that could affect water flow, eg bridges, embankments.
Surveys	• A survey of existing site levels and of the proposed development. • A cross-section showing finished floor, road levels and other relevant levels such as raised banks and flood defence walls. • Site levels to be stated to OD.
Flood risk	• The risk to the development if there was a flood including the 100 year river flood level. • Consider flooding from other sources (eg surface water, groundwater, roads sewers and reservoirs). • Include an allowance for climate change. • Estimate the duration of a flood, rate of surface water runoff, the order in which areas of the site would flooded and the consequences for people living on or using the site. • Details of past floods where this information is available.
Surface water runoff	• Estimate of how much surface water runoff the development will generate compared to existing -volume and the peak flow. • Existing methods for managing surface water runoff, if any. • Plans for managing surface water to ensure there is no increase in surface water runoff in line with the local SFRA based on SUDS.
Managing flood risk.	• Details of any existing flood resistance and resilience measures. • The capacity of drains or sewers (existing and proposed) on the site from the local water company. • How your proposed design will reduce flood risk. • Details of how people will leave buildings during a flood • If any changes to ground levels could affect water flow • If the development could affect rivers and their floodplain. • The residual risks to the site after any necessary flood defences have been built and how these will be managed.
Flood resistance and resilience	• When a development cannot be located in a lower flood risk area consider a raised ground floor level above the estimated flood level. • If other flood resistance and resilience measures are required based on the estimated flood depth.
Main rivers	Sites within 8m of a main river may require an EA flood defence consent.
Functional flood plain	If the site falls within the functional flood plain (land where water has to flow or be stored in times of flood), you need to state this.

For sites in Zone 3 and the LPA may require a sequential test to see if there are any other reasonably available site at a lower flood risk in the LPA area on which the proposed development could take place instead. If not is some cases the exception test is also required to show how flood risk will be managed on and off the site. These are considered in Section 4.

1.3.4 The SFRA

The London Borough of Richmond upon Thames Strategic Flood Risk Assessment (SFRA) dated August 2010 also indicates that proposed developments in Flood Zone 3a require a FRA and that this should include an assessment of:

- The vulnerability of the development from river flooding as well as from other sources (e.g. surface water, groundwater, foul water).
- The vulnerability to flooding over the lifetime of the development (including climate change), i.e. maximum water levels, flow paths and flood extents within the property and surrounding area.
- The potential of the development to increase flood risk elsewhere through the addition of hard surfaces, the effect on surface water runoff to adjacent and surrounding property.
- Demonstrate that residual risks of flooding (after existing and proposed flood management and mitigation measures are taken into account) are acceptable. Measures may include flood defences, flood resistant and resilient design, escape/evacuation, effective flood warning and emergency planning.
- Details of existing site levels, proposed site levels and proposed finished ground floor levels all to Ordnance Datum.
- 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.
- A clear and concise statement summarising how the proposed (re)development has contributed to a positive reduction in flood risk within the Borough.
- The site is not located in close proximity of a raised flood defence hence breach modelling is not required.

The above four documents have therefore been used to guide the content of this FRA which is intended to confirm whether the development proposals, with mitigation measures, are acceptable to the Environment Agency and the Local Planning Authority in terms of flood risk.

1.4 Report Structure

Details of the local hydrology and flooding history from fluvial and other sources are given in Section 2 together with the implications on the design of on the proposed development. The calculation of site runoff and suggestions for sustainable urban drainage systems are given in Section 3. An interpretation of Planning Policy, detailing the Sequential and Exception Tests, is given in Section 4 and the conclusions presented in Section 5.

2 FLOOD RISK

2.1 Fluvial Flooding

The main potential source of fluvial and/or tidal flooding of the site is the River Crane which runs from west to east along the northern boundary of the site (Figure 1.1). There are no other watercourses in the area that may pose a potential risk of flooding to the site.

2.1.1 Flood Maps

The EA and SFRA flood maps (Figures 1.11 and 1.12) both show the lower parts of the site are located in Flood Zone 3 with the higher ground on which the building will be located in Zone 1, above the 1000 year fluvial flood extent with a probability of flooding of less than 0.1% per year. The building plot is therefore outside the functional flood plain as defined by the 20 year flood extent as shown on the EAs more detailed Product 4 flood map (Figure 2.1). However the rectilinear flood outlines suggest that coarse scale LiDAR has been used and a more accurate representation of the flood zones is considered below.

2.1.2 Flood Defences

The EAs data shows the north bank has a form of defence (Asset 125630) but the south bank does not (Figure 2.2) although it is understood that both banks have low level horizontal timber boards to provide bank protection rather than as a flood defence. There are therefore no formal flood defences, such as walls and barriers, to protect the site from flooding apart from proposed plot being located on higher ground above the top of the river banks.

2.1.3 Historical Flood Records

Flow records are available at the EAs flow gauge on the River Crane at Cranford Park (Ref 39057) 8km upstream from 1973 to 2012 with 39 years of record. The structure is bypassed and drowns during extreme flood flows and with no gaugings within 30% of QMED the flow records are not considered to be accurate. However these records provide an indication of the largest floods in the last 39 years which occurred in 1977, 1979 and 2000 (Table 2.1).

Table 2.1 Largest Flood Flows on the River Crane at Cranford Park

Rank	Date	Flow (m^3/s)
1	17-Aug-77	17.94
2	30-Oct-00	17.897
3	08-Apr-79	17.64
4	13-Oct-93	17.299
5	27-Dec-79	17.18

There are no available records of the site flooding at these times in the SFRA, the BHS database or EA records although given its proximity to the river flooding may have occurred on the lower parts of the site but was not necessarily recorded.

2.1.4 Flood Levels

The EA's flood maps and flood levels are based on a 1D hydraulic model of the River Crane and in addition to the flood maps (Figure 2.1) flood levels have also been provided (Table 2.3) based on the EAs River Crane Flood Mapping Study undertaken by Halcrow in 2008. The model provides flood levels and flows at selected "nodes" where C546 is at the upstream boundary of the site and C545 is downstream (Figure 2.3). Flood levels are interpolated to the downstream boundary of the site and at the proposed building plot (Table 2.2) and provides a 100 year flood level of 10.922m OD increasing to 10.978m OD with climate change with a 1000 years flood level of 11.175m OD.

Table 2.2 EAs Estimated Flood Levels on the River Crane

Node	Location	5 yr	20 yr	50 yr	100 yr	100yr + CC	1000yr
C547		10.894	10.997	11.031	11.063	11.108	11.250
C546	Upstream	10.758	10.881	10.922	10.959	11.016	11.200
	Plot	10.722	10.845	10.885	10.922	10.978	11.175
	Downtrm	10.686	10.808	10.848	10.885	10.940	11.150
C545		10.615	10.735	10.774	10.811	10.865	11.100

The climate change allowance is based on the NPPF standard of the 1 in 100 year flood flow plus 20%. The latest national guidance (Feb 2016) suggests a different allowance for climate change may be appropriate but the EA have yet to update their modelling and the above estimates are the best available.

2.1.5 Flood Depths

A comparison of the EAs estimated flood levels with the topographical survey (Figure 1.4) provide flood depths and the shows the 20 year and 100 year flood would affect only the lower part of site (Table 2.3). The proposed location of the new building is 425mm above the 1000 year flood level and the car park is 275mm higher and both clearly in Zone 1. The location of the proposed building is also well above the 20 year flood level of 10.845m OD and hence this part of the site is not in the functional flood plain

Table 2.3 Estimated Flood Depths

Location	Ground Level (m OD)	Return Period and Flood Level (m OD)			
		20 yr (10.845m)	100 yr (10.922m)	100 yr +CC (10.978m)	1000 yr (11.175m)
Campbell Close MH	12.56	-1.715	-1.638	-1.582	-1.385
Campbell Close MH	12.35	-1.505	-1.428	-1.372	-1.175
Site Entrance	12.10	-1.255	-1.178	-1.122	-0.925
Building Plot	11.60	-0.755	-0.678	-0.622	-0.425
Path	11.32	-0.475	-0.398	-0.342	-0.145
Proposed Car Park	11.85	-1.005	-0.928	-0.872	-0.675
Proposed Car Park	11.45	-0.605	-0.528	-0.472	-0.275
Garden	11.12	-0.275	-0.198	-0.142	0.055
Garden	10.44	0.405	0.482	0.538	0.735
Top of River Bank	10.01	0.835	0.912	0.968	1.165

2.1.6 Revised Flood Zone Map

The 20yr and 100yr+CC flood levels have been superimposed on the topographical survey to give a more accurate estimation of flood extents over the site (Figure 2.4) and this confirms that the area for the building and the car park is in Flood Zone 1 and at low flood risk

The implications of these flood depths on the proposed development are considered further in Section 2.3 below.

2.2 Other Sources of Flooding

NPPF emphasise the need to consider other potential sources of flooding when planning a development and for this site these may include:

- Storm Water Flooding. This can occur when excess water runs off the surface of a site or adjacent land particularly during short but intense storms. Flooding occurs because the ground is unable to absorb the high volume of rain water or because the amount of water is greater than the capacity of the drainage system to take it away. This can occur on developed impermeable sites such as concrete, tarmac or buildings. The EAs pluvial flood maps (Figure 2.5) show the site and Campbell Close are at low risk with a risk of surface water flooding of between the 100 (1%) and 1000 (0.1%) year events. There are no records indicating the site or immediate area has been affected. As the floor levels will be raised above local ground level the risk of flooding to the new building from this source is low and will be managed.

- Highway flooding can occur from intense rain storms on road surfaces when the amount of water arriving on the road is greater than the capacity of the drainage facilities that take it away. Exceptional rainfall, a road being in a low lying area, changes in runoff from adjacent areas are situations that can lead to the road flooding or being waterlogged even when drains are in good working order. Material carried into the drains by floods can also lead to them becoming blocked when materials like mud are deposited on the road or when there is a heavy fall of leaves. This type of flooding is difficult to predict but based on the EAs pluvial flood maps (Figure 2.5) suggest the risk is low and as the ground floor level will be raised above the local ground level the risk of flooding from this source is considered to be low.

- Sewer flooding. This can occur when a storm sewer or combined sewer network becomes overwhelmed and its maximum capacity is exceeded. Higher flows are likely to occur during periods of prolonged rainfall, the autumn and winter months, when the capacity of the sewer system is most likely to be reached. During summer periods sewers can become susceptible to blockage as the low flows are unable to transport solids which leads to the gradual build up of solid debris. Thames Water maintain a register of properties/areas which are at risk of flooding from the public sewerage system but the SFRA shows no recorded incidents in the vicinity of the site. This is difficult to predict with any certainty but the raised ground floor levels will provide protection and the risk of flooding from this source is considered to be low.

- The site is far inland and above 11m OD and the impact of rising sea levels and tidal flooding at this site is considered to be low.

- Groundwater flooding is most likely to occur in low-lying areas underlain by permeable rocks (e.g. Chalk or Sandstone) and results from water rising up or from water flowing from abnormal springs. This tends to occur after long periods of sustained high rainfall which can cause the water table to rise above normal levels, particularly in lower lying areas. The risk of groundwater flooding is highly variable and depends on local conditions at any particular time and it is not possible to accurately assess the risk. The SFRA shows there are no records of the area having been affected. Due to the proximity of the Crane groundwater may be close to the level of the river and groundwater is therefore likely to be 1m to 2m below the ground level. Flooding from rising groundwater is unlikely as any groundwater that reaches the surface would drain to the River Crane before any flooding of the building plot would occur. As the ground floor of the dwelling will be raised above the local ground level the risk from groundwater flooding is considered to be low.

- Flooding from Impounded Water Bodies. The SFRA indicates that there are no reservoirs in the upstream catchment whose failure would have an impact on areas alongside the River Crane (Figure 2.6). The risk of failure of these reservoirs is extremely low and this is not be regarded as a constraint for this development.

This above indicates that the SFRA has been referred to and that the risk of flooding from other sources is low or can be managed.

2.3 Implications for the Proposed Development

The SFRA outlines specific development control recommendations for sites in Flood Zone 2 and 3 to minimise damage to property and the risk to life in the case of flooding and these are considered below.

2.3.1 Functional Flood Plain

Under NPPF and NPPG any new development should not be permitted in Zone 3b below the 20 year flood level, defined as the functional flood plain, where "water is stored or transmitted in times of flood". This includes new buildings and ground raising. The new building and car parking area will be located outside this area (Figure 2.4) and the development will be located outside the 1000 year flood extent and this is not in the functional flood plain.

2.3.2 *Floor Levels*

The EA require that the ground floor level of a habitable building should be a minimum of 300mm above the 100 year + CC flood level or 300mm above the local ground level whichever is the greater. With a 100 year + CC flood level of 10.978m OD the ground floor level of the dwellings should be at least 11.278m OD to provide the required level of protection and to ensure that the risk to life and damage to property in the event of a flood is minimised. The ground level on the building plot is 11.60m OD and the proposals are to have floor level raised by 500mm at 12.10m OD which is well above the EAs required standards. The plans do not include a basement.

2.3.3 Safe Escape

The raised first floor level in the building will be above the 100yr + CC and the 1000 year flood level and this will provide protection against flooding. The escape route from the car parking area and the building will be to the south to Campbell Close and this route will be above the 100year and 1000 year flood levels (Table 2.4) and hence a dry escape route is possible. This route leads to an area outside of the flood plain where services and facilities exist.

Table 2.4 Flood Freeboard on Escape Route

Location	Ground Level (m OD)	20 yr 10.845m OD	100 yr 10.922m OD	100 yr +CC 10.978m OD	1000 yr 11.175m OD
Campbell Close MH	12.56	-1.715	-1.638	-1.582	-1.385
Campbell Close MH	12.35	-1.505	-1.428	-1.372	-1.175
Site Entrance	12.10	-1.255	-1.178	-1.122	-0.925
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Path	11.32	-0.475	-0.398	-0.342	-0.145
Proposed Car Park	11.85	-1.005	-0.928	-0.872	-0.675
Proposed Car Park	11.45	-0.605	-0.528	-0.472	-0.275

2.3.4 Volume of Displacement

The proposed development will provide a new building on land above the 1000 year flood extents and hence there will be no loss of flood plain storage, no displaced water and no change in the flooding potential for adjacent sites and hence no requirement for compensatory storage.

2.3.5 Flood Resilience and Resistance Measures

As the building is to be located above the 100yr + CC flood level then flood resilience and resistance measures are not required.

2.3.6 Flood Response Plan

As the building will be above the 1000 year flood level a Flood Response or Evacuation Plan (FEP) is not required but to indicates when the lower garden area could be flooded the occupiers could subscribe the EAs Floodline to give advance warning if this is likely to occur.

2.3.7 Flood Defence Consent

The Thames Water by-laws require a flood defence consent (FDC) for any works within 8m of the river banks. The new building will be located more than 25m from the top of the river bank and hence a flood defence consent is not required.

3 SITE RUNOFF AND SUDS

NPPF and NPPG require that a FRA should demonstrate that measures for reducing surface water runoff will be included in the new development proposals. These require the use of the most sustainable drainage system reasonably practical to ensure the rate of surface water runoff from a developed site does not exceed the existing rate so as not to increase flood risk to others. However the Richmond SFRA and Local Plan Policy DM-SD7 require that a new development should reduce surface water runoff to the Greenfield rate wherever feasible which on this site is the same as the existing rate. This part of the FRA compares the peak flows and volumes for the existing greenfield and the developed site to determine what SUDS measures would be the most appropriate to achieve the required standards for the building.

3.1 Existing Greenfield Site

The CSH and CIRIA guidance on SUDS (CIRIA C697) recommends the use of IH124 for runoff calculations on sites less than 50 ha. However this building is small (130m^2) and far below the lower limit of the IH124 method (110ha) and as the building will not generate flow through a watercourse IH124, which is based on measured flows on rural streams and rivers, is not valid for small buildings where the flow generation processes are quite different. A recent EA R&D report (SC090031) recommended that IH124 should no longer be used for site runoff calculations and this is included in the latest EAs FEH Guidelines. Flood estimates using the Wallingford or Rational method and FEH rainfall are therefore preferred.

Peak flows and volumes are based on the roofed area of the building of 130m^2 and for the existing site the percentage runoff is taken from the FEH SPRHOST value of 23%. It is assumed the remaining garden areas will drain naturally. Rainfall totals are given by the Flood Estimation Handbook (FEH)[1] at the nearest 1km grid point to the site (TQ 150 740). The peak flows and volumes (Table 3.1) are for the present day and hence rainfall totals are not increased to account for climate change. This shows that the 100 year 1 hour storm will produce a peak flow of 0.43 l/s and storm volume of 1.53m^3 whilst the 100 year 6 hour storm a peak flow of 0.10 l/s and volume of 2.17m^3.

Table 3.1 Existing Site Peak Flows and Volumes

Return Period (yrs)	1 hour		3 hour		6 hour	
	Peak Flow (l/s)	Volume (m3)	Peak Flow (l/s)	Volume (m3)	Peak Flow (l/s)	Volume (m3)
2	0.10	0.38	0.05	0.53	0.03	0.65
5	0.16	0.57	0.07	0.78	0.04	0.94
10	0.20	0.74	0.09	0.97	0.05	1.16
25	0.28	0.99	0.12	1.28	0.07	1.50
50	0.34	1.24	0.14	1.56	0.08	1.80
100	0.43	1.53	0.18	1.89	0.10	2.17

[1] *Flood Estimation Handbook, Centre for Ecology and Hydrology 1999*

3.2 Developed Site without SUDS

The developed site will drain the same area of 130m^2 with an assumed percentage runoff of 75% but the garden areas will continue to drain naturally. NPPG also requires the impact of climate change and the latest guidance suggests a 20% increase in rainfall by 2060 and a 30% increase by 2110. As the proposals are for a residential development, with an assumed design life of 100 years, the rainfall totals are increased by 30%. The peak flows from the developed site without SUDS (Table 3.2) suggest the 100 year 1 hour storm will provide a peak flow of 1.81 l/s and volume of 6.51m^3 and the 100 year 6 hour storm a peak flow of 0.43 l/s and volume of 9.20m^3.

Table 3.2 Developed Site Peak Flows and Volumes with Climate Change

Return Period (yrs)	1 hour		3 hour		6 hour	
	Peak Flow (l/s)	Volume (m3)	Peak Flow (l/s)	Volume (m3)	Peak Flow (l/s)	Volume (m3)
2	0.44	1.60	0.21	2.24	0.13	2.77
5	0.68	2.44	0.31	3.29	0.18	3.98
10	0.87	3.13	0.38	4.13	0.23	4.92
25	1.17	4.22	0.50	5.43	0.29	6.36
50	1.46	5.25	0.61	6.62	0.35	7.66
100	1.81	6.51	0.75	8.05	0.43	9.20

This large increase in peak flows and volumes is due to the 30% increase in rainfall from climate change as the roofed area will have a higher percentage runoff but the magnitudes are very small as the roof area is also small. The use of SUDS to reduce the developed site peak flow rates and volumes to the existing greenfield rate are considered in Section 3.3 so that the impact on the flooding potential for other adjacent sites is not increased.

3.3 SUDS

Sustainable Urban Drainage Systems (SUDS) fall into three broad groups;

- Source Control Techniques. These aim to reduce the quantity of runoff at source and include porous pavements, soakaways, rainwater harvesting and/or green roofs;
- Permeable Conveyance Systems. These slow the velocity of runoff between a source and a disposal point to allow infiltration and can include filter drains, infiltration trenches or swales; and
- Passive Treatment Systems. These provide storage and attenuation of collected surface water before discharge into a watercourse or storm sewer and include basins, ponds and wetlands or on smaller sites tanks and Metro cells.

The usual approach is to consider the "SUDS train" where each of the above are considered in turn until a suitable solution is found. Thus source control techniques if suitable on a site, are considered preferable to permeable conveyance and passive treatment systems such as tanks or ponds. The various options are considered below.

3.3.1 Source Control Systems

(i) Soakaways

Soakaways allow water to be dispersed into the ground providing the underlying strata are suitably permeable. The British Geological Survey maps show the site lies on impermeable London Clay (Figure 3.1) and with drift deposits of the Taplow sands and gravels (Figure 3.2) hence the FEH percentage runoff (SPRHOST) is low at 23%.. Infiltration options such as soakaways, permeable pavements, trenches and swales may provide suitable SUDS measures on this site and these options are considered further below. It is likely that the groundwater level below the site will be at a similar level as the adjacent River Crane, between 1m or 2m below the ground surface and this may be a constraint. However there are no BGS boreholes in the immediate vicinity of the site (Figure 3.3) hence this cannot be confirmed at this stage. This assessment assumes that groundwater levels are far enough below the site ground level to allow a soakaway to operate under free drainage. The permeability of the Taplow gravles is quite variable but a value of 1m/day is adopted.

The preliminary design of soakaways has been undertaken in accordance with BRE 365[2] and CIRIA 156[3]. These methods aim to find the number of soakaways required for the 10 year storm of various durations assuming 100% runoff. For this FRA a 100 year storm has been considered with an urban 75% runoff. The FEH rainfall with a 30% allowance for climate change over the impermeable area of the site (130m^2) allows the runoff volume for the 100-year storm to be calculated (Table 3.3).

Table 3.3 Rainfall and Runoff Volumes (m^3) - 100 year Storm + CC

Parameter	30 min	1 hr	3 hr	6 hr	12 hr	24 hr
Rainfall (mm)	58.4	66.8	82.6	94.4	107.9	123.4
Runoff Vol (m3)	5.7	6.5	8.1	9.2	10.5	12.0

The preliminary soakaway designs assume circular concrete ring units with granular surrounds. The available storage volume in an individual soakaway depends on its diameter and depth and the effective volume is taken as the depth between the base of the soakaway and the invert of the drain discharging into the soakaway. The volume of runoff lost by seepage will depend on the diameter, depth and the permeability and can include seepage through the bed and through the sides of each soakaway over the relevant storm duration.

The results, based on a soakaway being 1.2m diameter and 1.0m deep, with a piped feeder network shows that the volume of runoff is greater than the available volume in a single soakaway and by seepage and up to 7 soakaways would be required (Table 3.4).

Table 3.4 Soakaways Required to handle Developed Site Runoff

Permeability (m/day)	30 min	1 hr	3 hr	6 hr	12 hr	24 hr
1.0	6.8	6.4	4.6	3.3	2.1	1.3

Soakaways will therefore not offer a suitable SUDS option.

[2] *BRE Digest 365:* Soakaway design *(BRE, 1991)*
[3] *CIRIA 156* Infiltration drainage - manual of good practice *(CIRIA, 1996).*

(ii) Permeable Pavements

The parking area will cover 122m^2 and will have a permeable surface to allow rainfall to drain through to the underlying strata. No additional SUDS measures are required.

(iii) Rainwater Harvesting

Rainwater harvesting is the collection of runoff from roofs and other surfaces that would otherwise be directed to the local drainage system. Once collected and stored it can be used to replace mains water for non-potable purposes such as toilet flushing. This can reduce storm runoff without the need for treatment or oil separators as the risk of contamination is low. The collected water is held in roof level or underground storage tanks and over the course of a year will reduce the volume of water entering the storm water system.

The BS8515:2009[4] intermediate approach is based on the average annual rainfall (SAAR) of 600mm and the roof area of the building of 130m^2 which gives a total volume of 78m^3 per year. A drainage coefficient (DC) of 0.8 is then used to account for losses such as overflowing gutters and evaporation and it is estimated that only 90% of the water flowing into the system is retained hence a filter coefficient (FC) of 0.9 is also used and the available water is therefore 56m^3/yr (Table 3.5). BS8515 suggests the installed tank size should be 5% of the annual rainwater supply which gives a required storage volume of 2.8m^3.

Table 3.5 Rainwater Harvesting Volumes

Rainfall (mm)	Roof Area (m^2)	Total Runoff Volume (m^3)	Net Runoff Volume (m^3)	Storage Volume (m^3)
600	130	78	56	2.8

As water is collected from roof gutters and down pipes an underground rather than roof level tank of this size is preferred from which a pump would take water to roof level header tank where a gravity feed would distribute water to the dwelling for flushing WCs etc. This will require an overflow from the storage tank to discharge excess runoff. Assuming a grey water use for toilet flushing of 25 litres/day per person the total water requirement of 2 occupants is 50 l/day and hence a 2.8m^3 tank would provide a supply for around 56 days. This may therefore be an economically viable and practical option.

However RWH tanks are intended to provide a reliable water supply and hence the aim would be to keep the tanks as near as full as possible. It cannot be guaranteed that there would be any spare capacity at the start of an extreme rainfall event and hence RWH is not considered to be a suitable option for runoff control on this site.

(iv) Green Roof

A green roof is a multi-layered system that covers the top of a building with vegetation. These can either be extensive roofs which are low maintenance with a 25-125 mm soil layer in which a variety of hardy drought tolerant low plants are grown, or intensive roofs with trees and planters which impose a greater load on the roof structure but are more suitable in certain circumstances. A green roof can provide a degree of rain storm attenuation and a reduction in site runoff but as the proposed roof will be pitched (Figure 1.8) this is not a suitable option.

[4] *British Standard 8515:2009* Rainwater Harvesting Systems – Code of Practice *(BS 8515)*

3.3.2 Permeable Conveyance

There is available space on this site for an open channel swale or an infiltration trench and these may also be appropriate. Assuming a permeability of 1m/day a 15m long 1m wide and 1m deep gravel filled trench of 30% porosity would require 1 soakaways or a 20m long trench no soakaways (Table 3.6). This may be an option between the new building and the River Crane.

Table 3.6 Soakaways Required to handle Developed Site Runoff with a Trench

Trench Length (m)	No Reqd
0	6.8
5	4.7
10	2.5
15	0.3
20	0

3.3.3 Storage and Attenuation

If source control or conveyance systems cannot provide a suitable solution then passive treatment based on storage and attenuation options are considered. For large sites these can include a pond, wetland or a basin and on smaller sites the options can include an underground tank, sub-surface attenuation structures such as Storm cells or an oversized drainage network.

Preliminary routing calculations have been undertaken to assess the required size of a storage facility based on maintaining the maximum runoff at the existing greenfield rate and assuming any excess water is taken into storage. This suggests (Table 3.7) to achieve the existing rate a storage facility of 3.0m^3 would be required for the 1 hour storm and 4.2m^3 for the 6 hour storm. The flow hydrographs and storage required is provided for the 1 hour storm to achieve the existing greenfield rate (Figure 3.5).

Table 3.7 Storage to Maintain Existing and Greenfield Runoff Rates - 100 year storm

Storm Duration (hrs)	Peak Flow (l/s)		Storage Volume (m3)
	Existing	Developed	
1	0.43	1.81	3.0
3	0.18	0.75	3.7
6	0.10	0.43	4.2

The options to achieve the required volume for the 100 year 6 hour storm could include:

- A 4.2m^3 underground tank is too large to be practical although the existing pond could be used.
- A typical storm-cell is 1.2m wide, 2.4m long and 0.52m deep with 95% void space and can provide 1.42m^3 of storage although various sizes are available. To maintain runoff at the existing rate for the 6 hour storm would require 3 storm cells over an area of 8.5m^2. This may be an option but other methods may be preferred.

- An oversized drainage network. A new 20m long 150mm diameter storm water pipe will provide a storage volume of $0.35m^3$ and increasing this to 20m of 250mm diameter pipe will provide $0.98m^3$ of storage which is not sufficient to provide the storage required.

To ensure the developed site runoff with climate changes does not exceed the existing rate, and given the restrictions imposed by the underlying geology, the use of a infiltration trench or rain water harvesting offers the most practical options.

3.4 Outline Drainage Strategy

The above provides outline considerations and the final drainage scheme should be considered at the detailed design stage based on one or a combination of these SUDS options. The flow routes under normal conditions and in the event of a system failure or the storage facility being full, would also be considered as part of these detailed designs. However as the ground floor of the building and access routes are above the local ground level then flooding of the property will not occur in the event of local drainage system failure, whether by extreme rainfall or a lack of maintenance.

4 PLANNING POLICY GUIDANCE

4.1 Appropriate Development

Under NPPF different land use constraints apply in each Flood Zone (Table 4.1) where Zone 3a is the 100 year and 3b the 20 year functional flood plain.

Table 4.1 NPPF Appropriate Land Use by Flood Zone

Classification	Zone			
	1	2	3a	3b
Essential Infrastructure	Appropriate	Appropriate	Exception test	Exception test
Highly Vulnerable	Appropriate	Exception test	Not permitted	Not permitted
More Vulnerable	Appropriate	Appropriate	Exception test	Not permitted
Less Vulnerable	Appropriate	Appropriate	Appropriate	Not permitted
Water Compatible	Appropriate	Appropriate	Appropriate	If it has to be there

The EA and SFRA flood maps indicates that part of the site lies in Flood Zone 3a but the building will be located on higher ground in Zone 1 where the proposed "more vulnerable" residential use is appropriate and the exception test is not required.

4.2 The Sequential Test

The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. Developments in Zones 2 and 3 should not be permitted if there are reasonably available alternative sites appropriate for the proposed development at a lower flood risk (i.e. in Flood Zones 1 and 2) on which the development could take place instead.

The flood maps indicates that the building will be located on higher ground in Zone 1 and the site will be developed sequentially. The sequential test is therefore not required.

5 CONCLUSIONS

- The proposed development site is located on land to the rear of Campbell Close in Twickenham, Middlesex. The mainly greenfield site lies adjacent to the River Crane with an area of 5250m² and with ground levels of 12.18m OD at the site entrance falling to 10.0m OD at the top of the river banks. It is assumed that storm runoff drains informally to the River Crane.

- The proposals are to provide a single 3 bedroom dwelling on an area of higher ground close to the access from Campbell Close. The new building footprint will be 130m² with an adjacent car parking area of 122m² constructed of permeable material. Most of the site will be retained as existing greenfield with mature trees and low level hedgerows.

- The main potential source of fluvial flooding is the River Crane. The EAs and SFRA flood maps show the lower part of the site is in Zones 2 and 3 with the higher ground where the parking and building are to be located in Zone 1. There are no formal flood defences, such as walls and barriers, to protect the site from flooding apart from proposed plot being located on higher ground above the top of the river banks.

- As part of the site is in Zone 3 a FRA is required as part of the planning application as dictated by the National Planning Policy Framework (NPPF), the National Planning Practice Guidance (NPPG), the Environment Agency's standing advice and guidelines and the local Strategic Flood Risk Assessment (SFRA). The requirements of these documents are considered in this FRA.

- Flow records from the EAs gauge on the River Crane at Cranford show the largest floods in the last 39 years occurred in 1977, 1979 and 2000 but there are no available records of the site flooding at these times. Given its proximity to the river flooding may have occurred on the lower parts of the site but was not necessarily recorded.

- The EA's hydraulic model of the River Crane provides a 100 year flood level of 10.922m OD increasing to 10.978m OD with climate change and with a 1000 year flood level of 11.175m OD. The climate change allowance is based on the NPPF standard of 100 year plus 20% and the EA have yet to update their modelling with the revised (Feb 2016) allowances but these flood level estimates are the best available. This shows that the 20 year and 100 year flood would affect only the lower part of site. The location of the new building is 425mm above the 1000 year flood level and the car park is 275mm higher and both are in Zone 1. The proposed building is not in the functional flood plain.

- Other potential sources of flooding may include storm water, roads, sewers, rising sea levels, groundwater and impounded water bodies but the risk from each is considered to be low. There are no records indicating the site or immediate area has been affected by these sources and as the floor level will be raised above local ground level the risk of flooding to the new building from these sources is low.

- The floor level of the building will be raised 500mm above local ground levels and hence well above the 100yr + CC and the 1000 year flood level. The escape route from the site and the building will be to the south to Campbell Close and this dry route, which lies above the 100 year and 1000 year flood level, leads to an area outside of the flood plain where services and facilities exist.

- As the building will be located above the 100yr + CC flood level there will be no loss of flood plain storage, no displaced water and hence no requirement for compensatory storage. Flood resilience and resistance measures and a Flood Response Plan (FEP) is also not required. The new building will be located more than 25m from the top of the river banks and hence a flood defence consent is not required.

- NPPF and NPPG require that a FRA should demonstrate that measures for reducing surface water runoff will be included in the new development proposals to ensure surface water runoff from a developed site does not exceed the existing greenfield rate. A review of SUDS options suggests an infiltration trench leading to the River Crane, rain water harvesting, storm cells or a pond may all be suitable. The parking area will have a permeable surface to allow rainfall to drain through to the underlying strata. The final drainage scheme should be considered at the detailed design stage based on one or a combination of these SUDS options.

- The SUDS plans should consider flow routes under normal conditions and in the event of a system failure or the storage facility being full. However as the ground floor of the building and access routes are above the local ground level then flooding of the property will not occur in the event of local drainage system failure, whether by extreme rainfall or a lack of maintenance.

- Under NPPF the proposed "more vulnerable" residential use is appropriate on the Zone 1 part of the site and the exception test is not required. As the site will be developed sequentially the sequential test is not required.

Figures

Figure 1.1 Site Location

Figure 1.2 Existing Site Layout

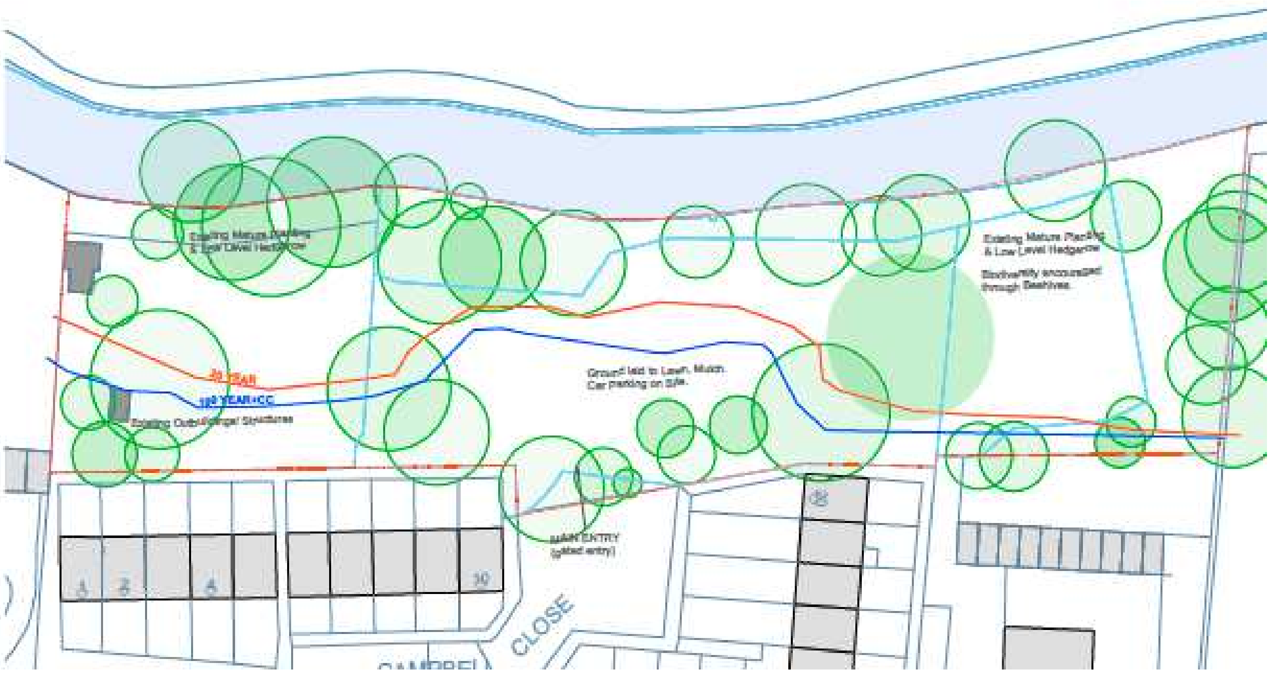

Figure 1.3 Site Photographs

Figure 1.4 Aerial Photograph

Figure 1.5 Topographical Survey

Figure 1.6 Proposed Development Plan

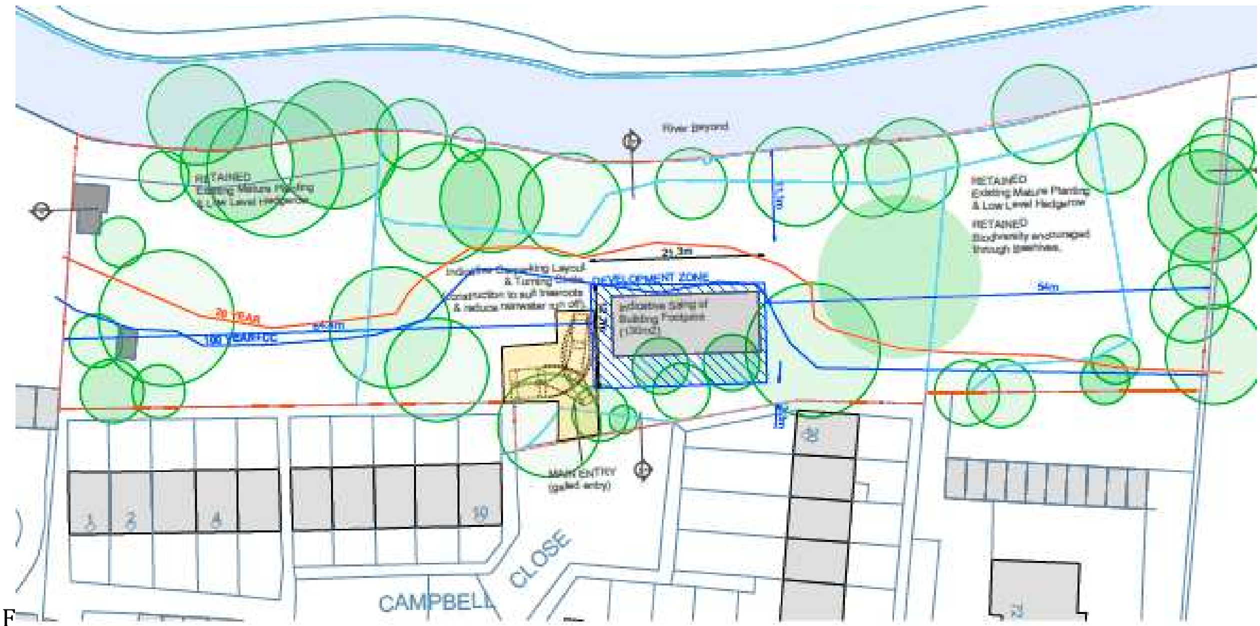

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Figure 1.7 Proposed Development Section

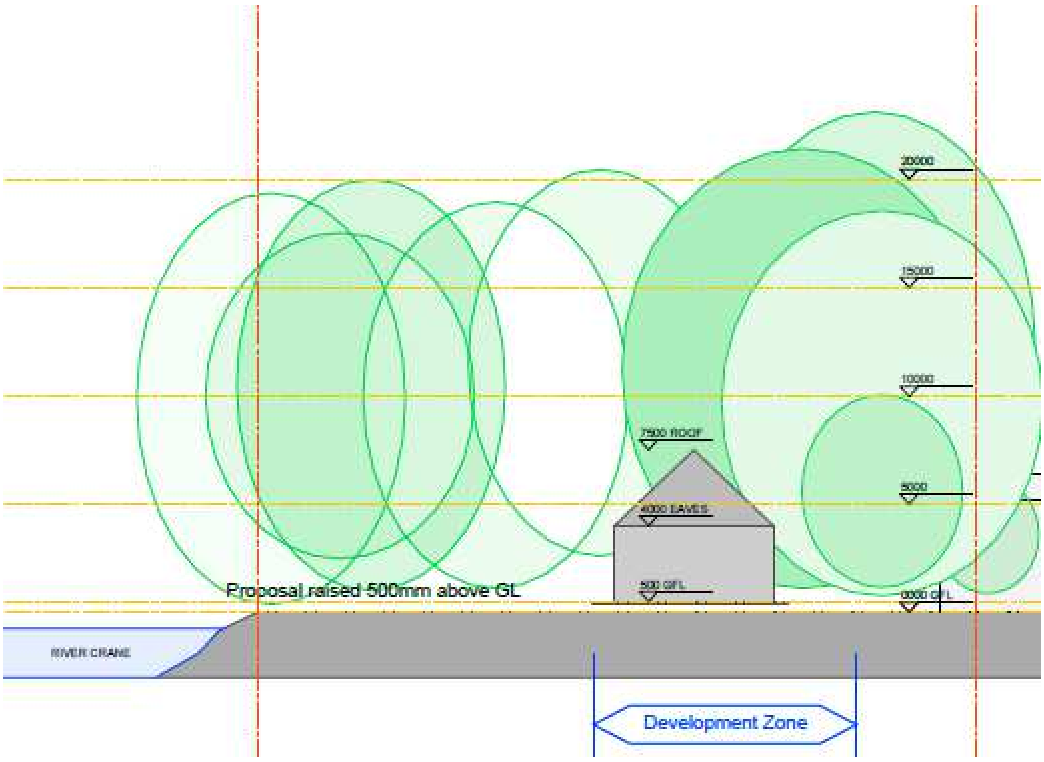

Figure 1.8 Proposed Development Scheme

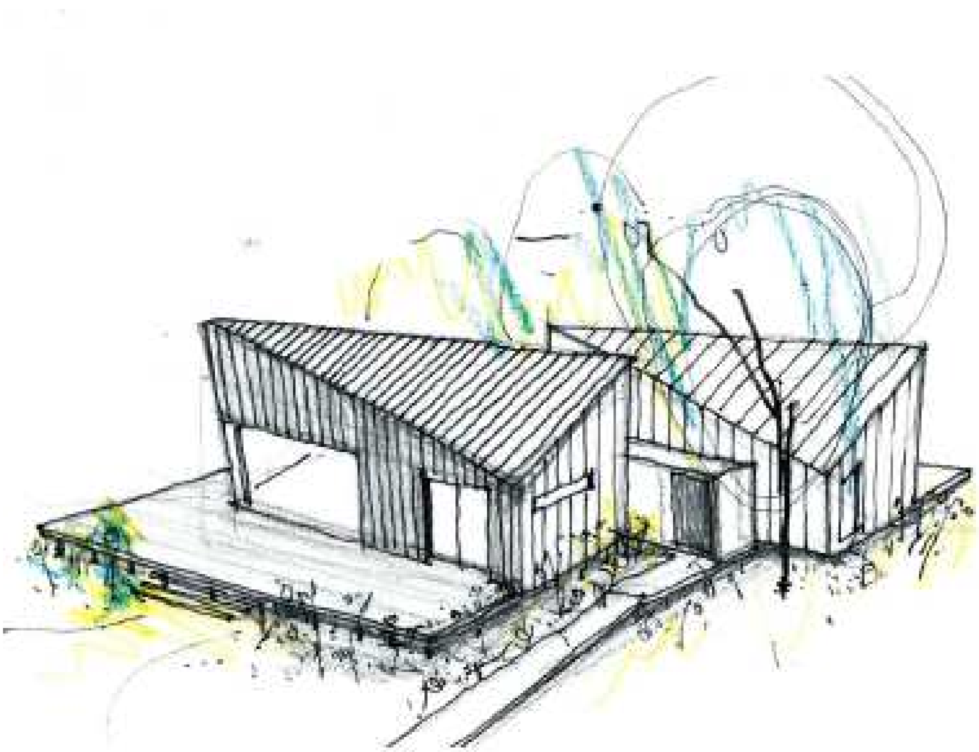

Figure 1.9 Proposed Development Photo Impression

Figure 1.10 Proposed Development Floor Plans

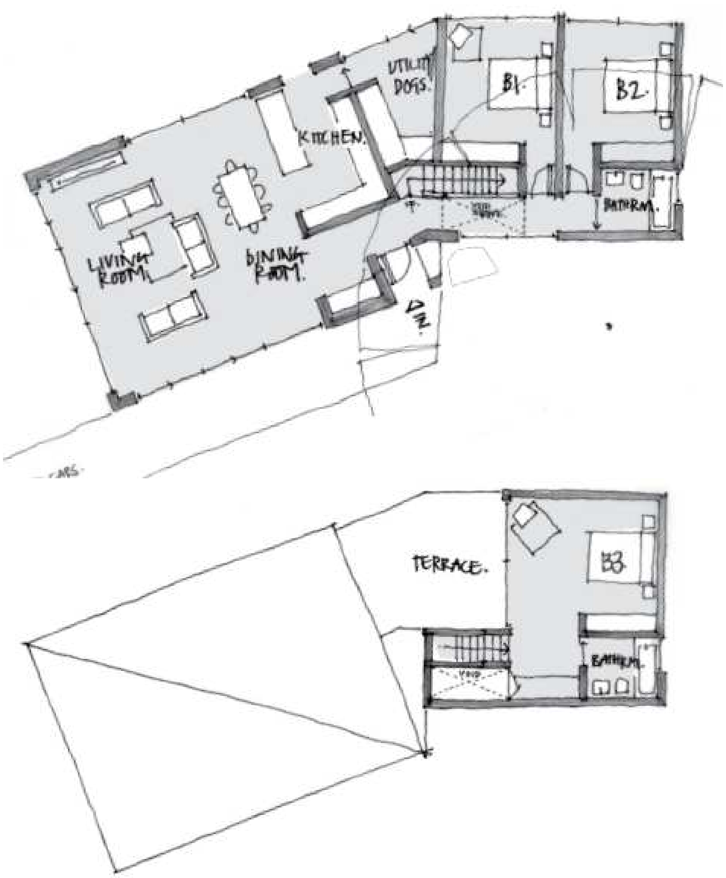

Figure 1.11 Environment Agency's Flood Map

Figure 1.12 Richmond SFRA Flood Map

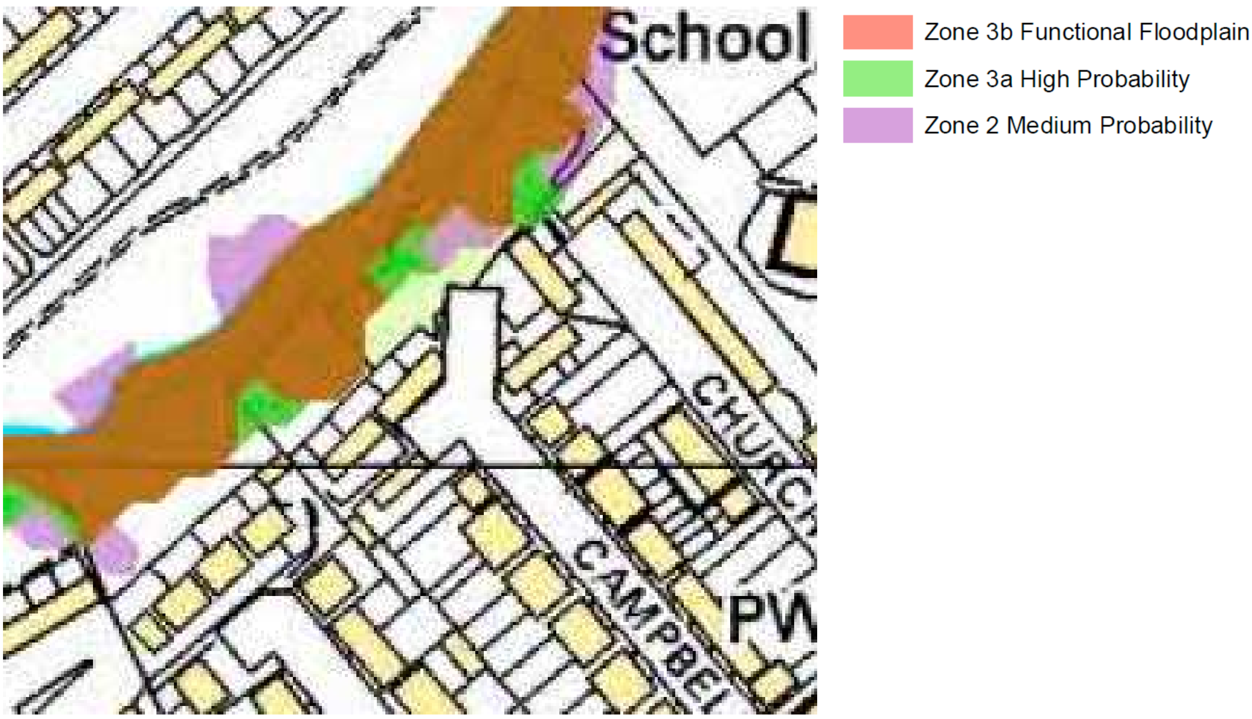

Figure 2.1 EAs Product 4 Flood Map

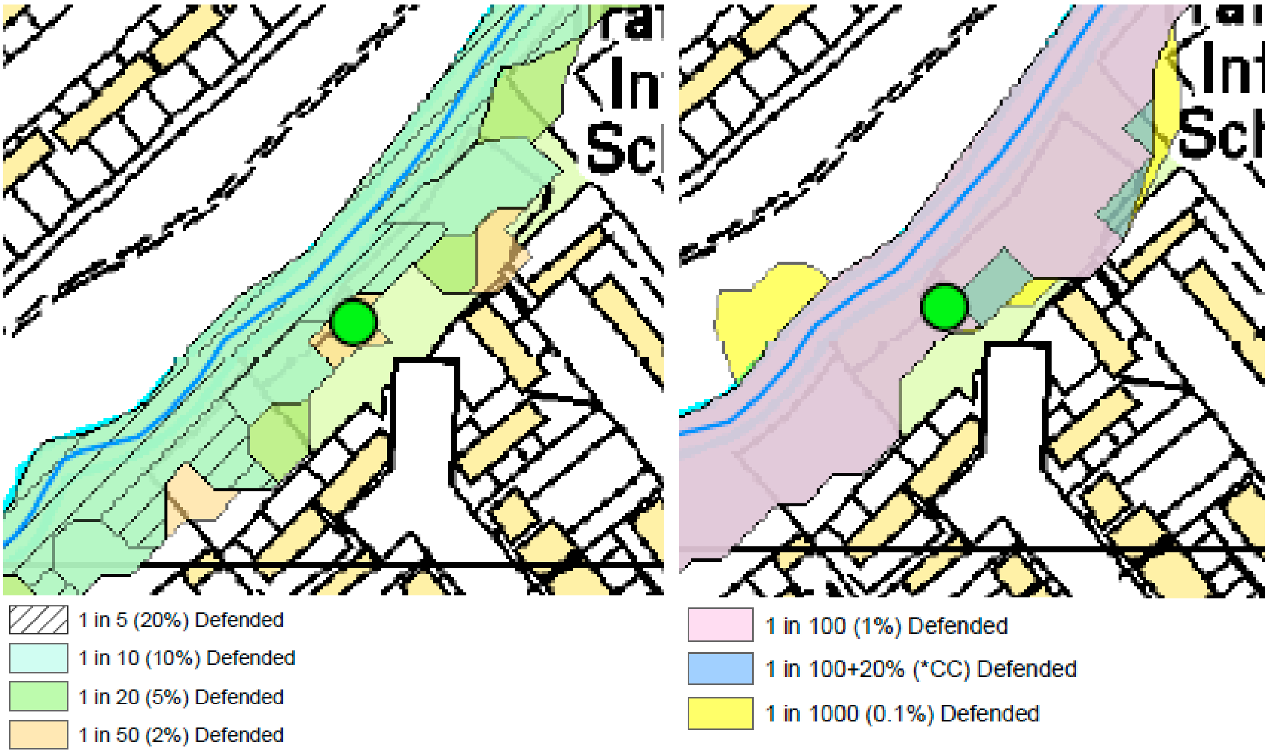

Figure 2.2 Flood Defences

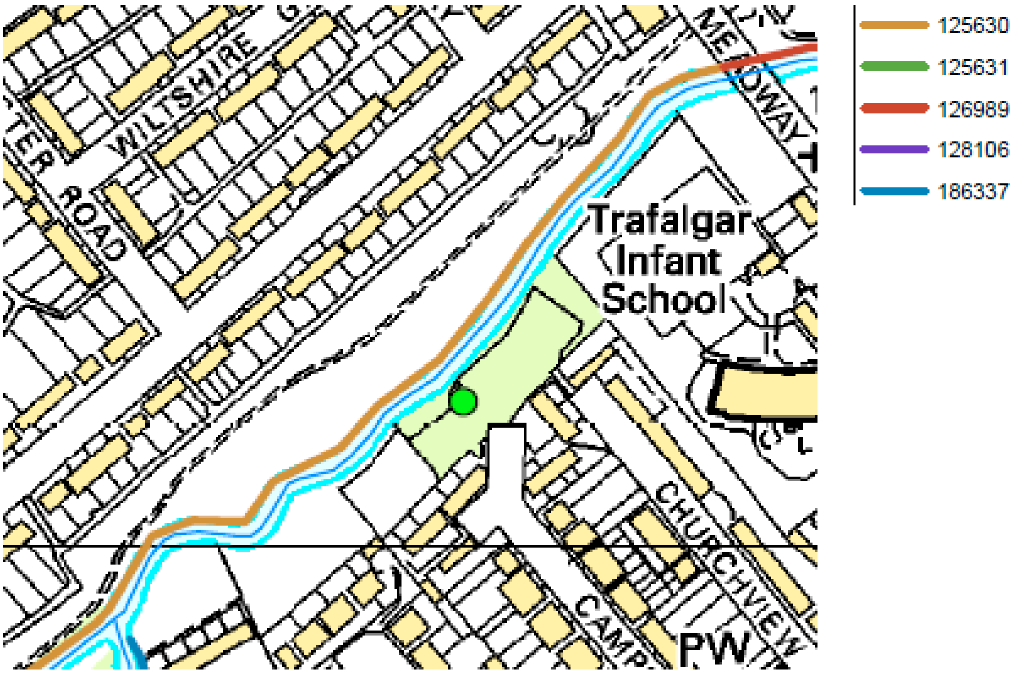

Figure 2.3 EA Model Nodes

Figure 2.4 Flood Zones based on EA Flood Levels and the Topo Survey

Figure 2.5 EA Pluvial Risk Maps (200 year storm)

Figure 2.6 EA Flooding From Reservoirs

Figure 3.1 Bed Rock Geology

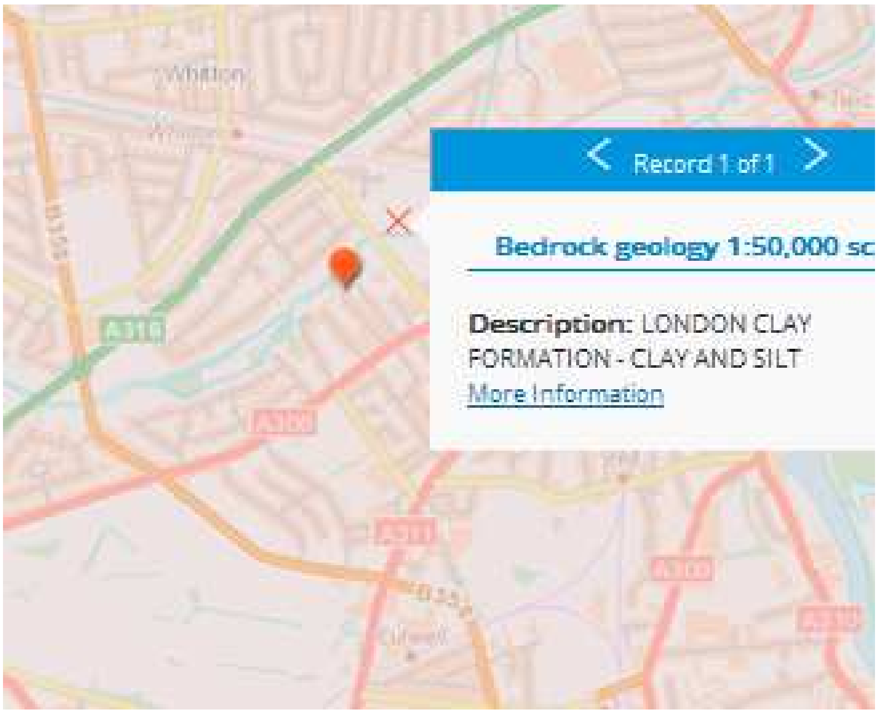

Figure 3.2 Drift Geology

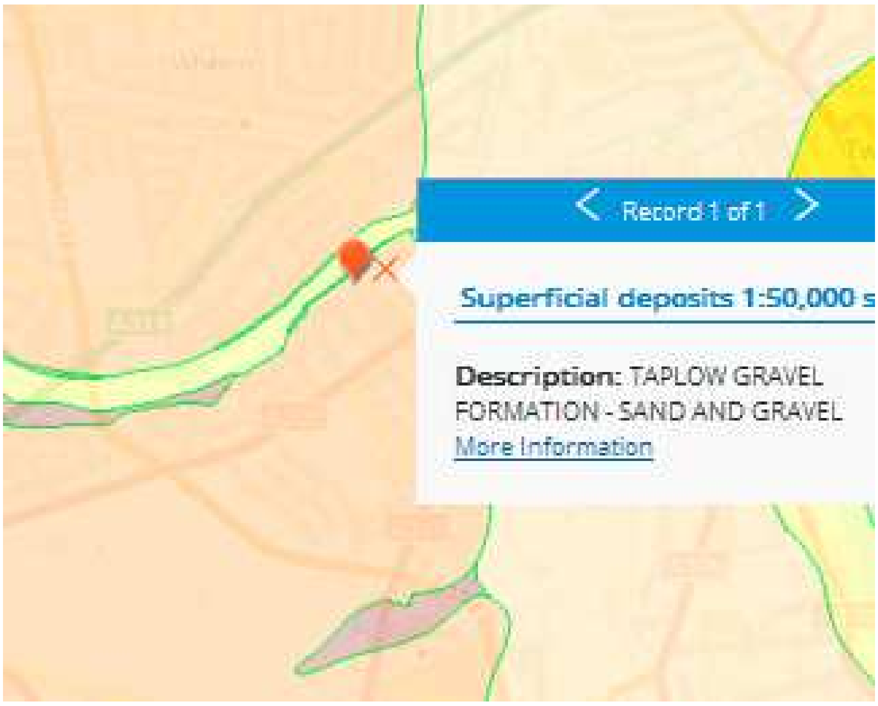

Figure 3.3 BGS Boreholes

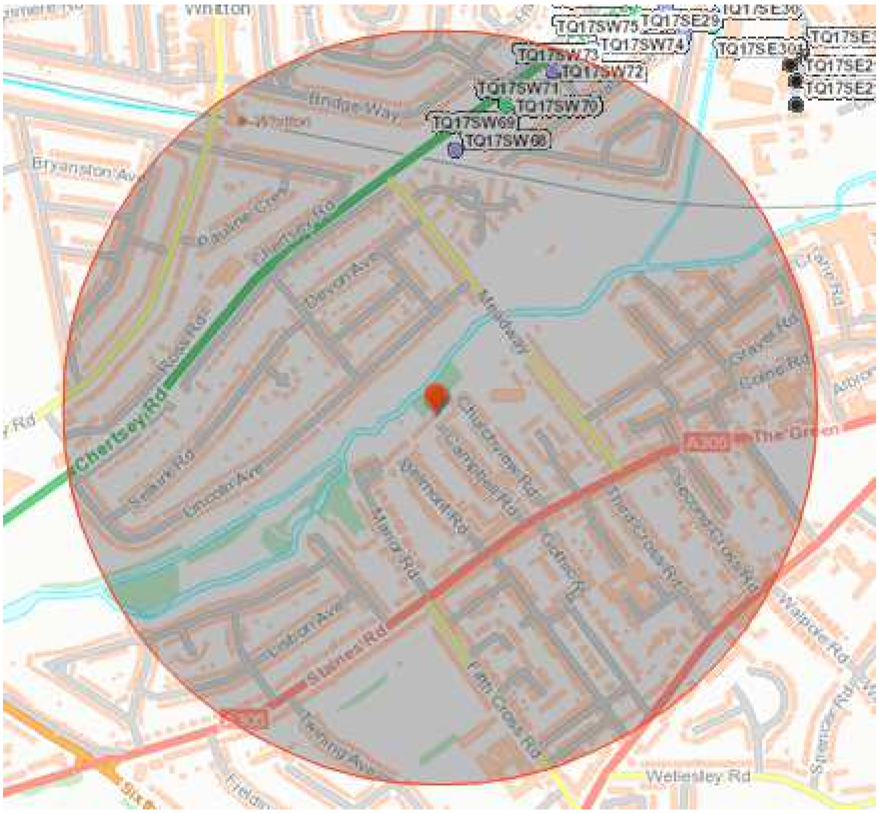

Figure 3.4 BGS Boreholes Log

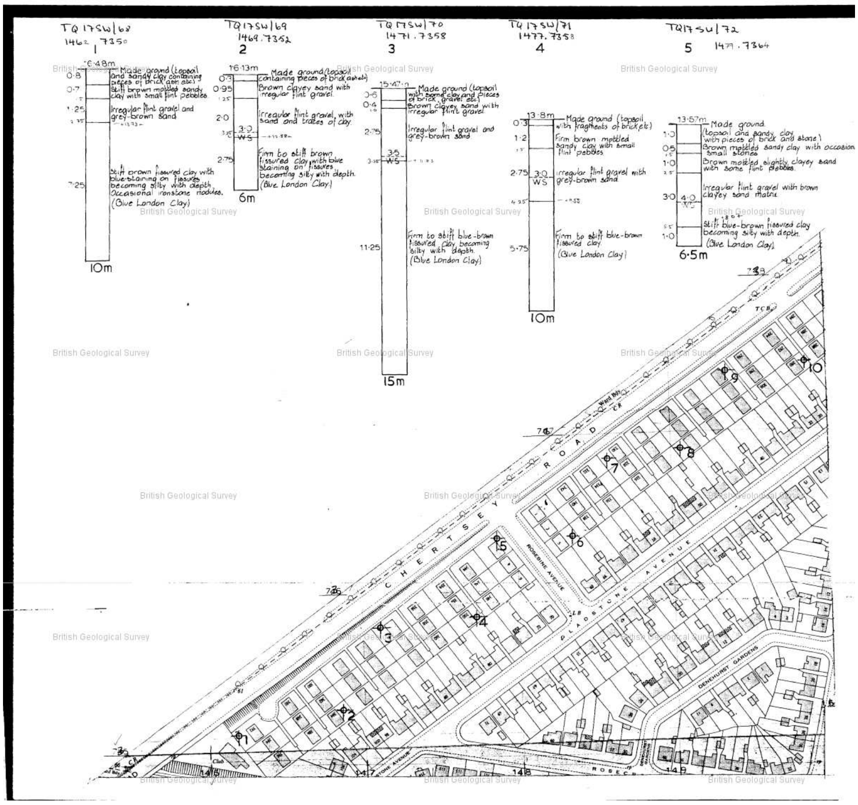

Figure 3.5 Storage to Maintain Developed Site Runoff at the Existing Rate – 1 hr storm