UCL Student Centre

Flood Risk Assessment

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1.0 Introduction

1.1 Project Background

1.1.1 Curtins Consulting has been appointed by University College London (UCL) to undertake a Flood Risk Assessment (FRA) for the proposal to erect a new Student Centre for UCL. The FRA provides information on the nature of flood risk at the site and follows Government guidance with regards to development and flood risk. A site plan is shown in Figure 1.

1.1.2 The report is based on currently available information, preliminary discussions and the Strategic Flood Risk Assessment (SFRA) for North London.

1.1.3 Proposals contained or forming part of this report represent the design intent and may be subject to alteration or adjustment in completing the detailed design for this project. Where such adjustments are undertaken as part of the detailed design and are deemed a material derivation from the intent contained in this document, prior approval shall be obtained from the relevant authority in advance of commencing such works.

1.1.4 Where the proposed works to which this report refers are undertaken more than twelve months following the issue of this report, Curtins shall reserve the right to re-validate the findings and conclusions by undertaking appropriate further investigations at no cost to Curtins.

1.2 Scope of Flood Risk Assessment and Drainage Impact Assessment

1.2.1 The assessment is to be undertaken in accordance with the standing advice and requirements of the Environment Agency for Flood Risk Assessments as outlined in the Communities and Local Governments National Planning Policy Framework (NPPF).

1.2.2 The assessment will:

- Investigate all potential risks of flooding to the site.
- Consider the impact the development may have elsewhere with regards to flooding.
- Consider outlined design proposals to mitigate any potential risk of flooding determined to be present.

1.3 Proposed Development

1.3.1 The current proposal for the development is to erect a new Student Centre at UCL within a vacant space on campus adjacent to the Bloomsbury Theatre site. This development will provide additional student resources and study space, along with a new common and a cafe.

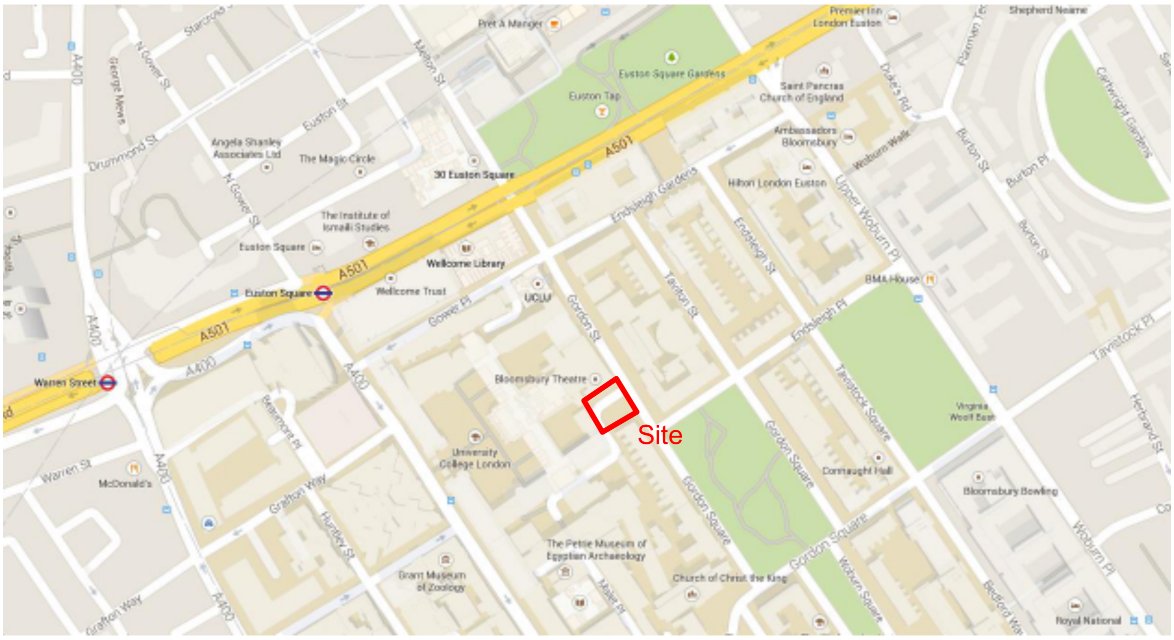
2.0 Existing Site Details

2.1 History and Current Use

2.1.1 The development area is approximately 0.12 hectares in size and located off of Gordon Street, next door to the Bloomsbury Theatre.

2.1.2 The site is currently an area of hard-standing being used by UCL as a storage yard.

Figure 1: Site Location Plan



2.2 Existing Watercourse

2.2.1 The site is located approximately 1.5km north of the Thames, which is the closest above ground watercourse.

2.3 Existing Drainage

2.3.1 Existing drainage on site has been located by a full CCTV survey. This survey has found several manholes positioned within the site boundary, and a map of this can be found in Appendix A. It is noted that some of the drains in this area are fully operational and receiving flows from adjacent science blocks, amongst other areas. The site outfall is located outside of the proposed building curtilage along the south eastern boundary.

2.4 Topography

2.4.1 Proposed levels across the site will be as per the existing arrangement with minor alterations to suit the new floor levels where necessary. The site is also adjacent to a major road and a main campus access, meaning the topography can be considered to be of a consistent level.

3.0 Development and Flood Risk

3.1 National Planning Policy Framework

3.1.1 In March 2012 the Department of Communities and Local Government published NPPF which provides technical guidance on how flood risk should be assessed during the planning and development process. This document supersedes PPS25. NPPF details a Sequential Test which local Planning Authorities should apply to all future development proposals to steer new developments away from areas liable to flooding.

3.2 Table 1 (National Planning Policy Framework extract (NPPF)) Flood Zone Classifications

Zone 1 Low Probability

Definition

This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%)

Appropriate Uses

All uses of land are appropriate in this zone

Zone 2 Medium Probability

Definition

This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.

Appropriate uses

Essential infrastructure and the water-compatible, less vulnerable and more vulnerable uses, as set out in Table 2, are appropriate in this zone. The highly vulnerable uses are *only* appropriate in this zone if the Exception Test is passed.

Zone 3a High Probability

Definition

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.

Appropriate uses

The water compatible and less vulnerable uses of land (table 2) are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone. The more vulnerable and essential infrastructure should only be permitted if the Exception Test is passed. Essential infrastructure permitted should be designed and constructed to remain operational and safe for users in times of flood.

Zone 3b The Functional Flood Plain

Definition

This zone comprises land where water *has* to flow or be stored in times of flood. Local planning authorities should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environmental Agency. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

Appropriate uses

Only the water-compatible uses and essential infrastructure listed in Table 2 should be permitted in this zone. It should be designed and constructed to:

- Remain operational and safe for users in a flood
- Result in no loss of floodplain storage
- Not impede water flows
- Not increase flood risk elsewhere

Essential infrastructure in this zone should pass the Exception Test.

3.3 Table 2 (NPPF extract) Flood Risk Vulnerability Classification

Essential Infrastructure

- Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk
- Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operation in times of flood
- Wind turbines.

Highly Vulnerable

- Police, Ambulance and Fire stations and command Centres and communications required during flooding.
- Emergency dispersal points
- Basement dwellings
- Caravans, mobile homes and park homes for permanent residence
- Installations requiring hazardous substance consent

More Vulnerable

- Hospitals
- Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels
- Buildings used for dwelling houses, student hall, hotels etc.
- Non-residential for health services, nurseries and educational establishments
- Landfill and sites used for waste management facilities or hazardous waste
- Sites used for holiday or short-let caravans and camping, *subject to a specific warning and evacuation plan*

Less Vulnerable

- Police, ambulance and fire stations which are *not* required to be operational during flooding
- Buildings used for shops, financial, professional and other services

3.4 Table 3 (NPPF extract) Flood Risk Vulnerability and Flood Zone 'Compatibility'

	Flood Risk Vulnerability classification	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	/	/	/	/
	Zone 2	/	Exception test Required	/	/
	Zone 3a	Exception test Required	x	Exception test Required	/
	Zone 3b	Exception test Required	x	x	x

/ Development permitted

x Development should not be permitted

Shaded Area shows classification of this site

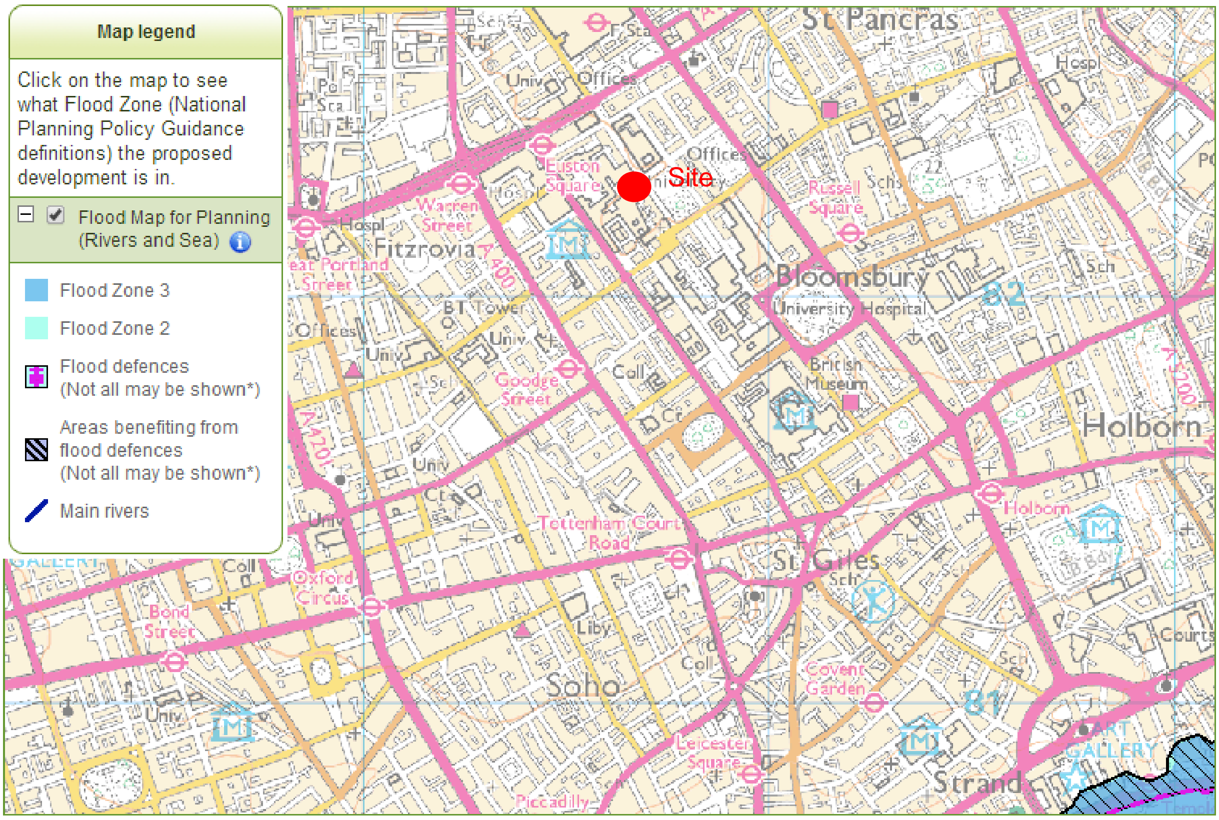
3.5 Site Specific NPPF Flood Risk Categorisation

3.5.1 To assess the NPPF flood risk classification for the site the first step was to inspect the Environment Agency (EA) web based flood mapping data (Extract shown in Figure 2). It can be seen from this data that the site (shown in red) is clear of the blue shaded section noted on the drawing key as areas subject to either river or tidal flooding (blue).

3.5.2 The site is located in the clear, unshaded areas shown on the Environment Agency web based flood mapping, where it is deemed to be classified as **Flood Zone 1**.

3.5.3 Referring to Table 1, Flood Zone Classifications from NPPF, this site comprises land assessed as having less than 1 in 1000 probability of river or sea flooding in any given year (<0.1%) and therefore all uses of land are appropriate in this zone.

Figure 2: Environmental Agency Online Mapping



3.6 Sequential and Exception Tests

3.6.1 As the site is located within Flood Zone 1, the sequential and exception tests are not required to be undertaken.

3.7 Planning Policies – London Plan

3.7.1 The London Plan was adopted in July 2011 and sets out a strategic plan for development and growth in London. The policies of the London Plan have been identified as having possible relevance for this FRA.

3.7.2 **Policy 5.12: Flood Risk Management**

Development proposals must comply with the Flood Risk Assessment and management requirements set out in National Planning Policy Framework over the lifetime of the development.

3.7.3 **Policy 5.13: Sustainable Drainage**

Developments should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that run-off is managed as close to its source as possible as per the drainage hierarchy.

In addition to the London Plan, supporting information is contained within the London Plan Supplementary Planning Guidance: Sustainable Design and Construction, May 2006. Key information regarding the requirements for the drainage from the proposed site have been detailed in Chapter 6.0 of this report in conjunction with the requirements set out in Section 2.4.4 Water Pollution and Flooding as indicated below:

Water Pollution and Flooding

Essential Standard

- Use of Sustainable Drainage Systems (SDS) measures, wherever practical
- Achieve 50% attenuation of the undeveloped site's surface water run-off at peak times

Preferred Standard

- Achieve 100% attenuation of the undeveloped site's surface water run-off at peak times

Strategic Flood Risk Assessment

It is noted that a key document in the compiling of this Flood Risk Assessment is the North London Strategic Flood Risk Assessment (SFRA) prepared by Ian Bakewell of Mouchel, August 2008. This report analyses the flood risk of the wider Borough area, inclusive of the site.

4.0 Hydrological Assessment

4.1 Assessment Approach

4.1.1 This study assesses the risk from different types of flooding to the development and the risk of flooding from the development, taking into consideration climate change, alongside how flood risks should be managed. The main types of flooding that may apply to the proposed development site are as follows:

- Surface water flooding (from sewers or overland flow)
- Rising groundwater
- Infrastructure failure

4.2 Summary of Flood Risk

4.2.1 A Strategic Flood Risk Assessment (SFRA) for North London was carried out in August 2008 by Mouchel. The data and findings of the report have been used for this assessment, and relevant documents can be found in Appendix B.

4.3 Summary of Fluvial and Tidal Flood Risk

4.3.1 The development site is approximately 1.5km north of the Thames River and a check of the Environmental Agency's web based flood map indicates that the site lies within a flood zone 1 area.

4.3.2 The aforementioned SFRA confirms that the site is located within a flood risk zone 1, with no further evidence of flood issues within the immediate vicinity of the site.

4.3.3 Flood risk from fluvial and tidal sources is therefore considered low.

4.4 Historical Flooding

4.4.1 The SFRA indicates that even though there has been a history of flooding within the Borough of Camden, these events have not been within the immediate vicinity of the site in question. There is also suggestion that the majority of flood events are generally in close proximity to a major watercourse, which is not the case for this development.

4.4.2 There is anecdotal evidence to suggest that there has been one case of localised flooding in the development area due to a storm event. However, this event was restricted to the existing network and areas. It is expected that this was a result of deficiencies within the existing system which should be neglected by remedial works as recommended by the CCTV report.

4.5 Risk of Groundwater Flooding

4.5.1 Groundwater flooding is caused by the natural emergence of water at surface level originating from underlying permeable sediments or rocks (aquifers). The groundwater may emerge as one or more point discharges (springs) over an extended area. Groundwater flooding tends to be more persistent than other sources of flooding, typically lasting for weeks or months rather than hours or days. Groundwater flooding does not generally pose a significant risk to life due to the slow rate at which the water level rises, however it can cause significant damage to property, especially in urban areas.

4.5.2 A groundwater flooding assessment was carried out within the SFRA. The findings state that there are areas in North London susceptible to groundwater flooding due to the Lee Valley; however this does not affect the area around the development site.

4.5.3 As the site's existing drainage network is to be utilised for this development, and there are no reports of any recent flooding from groundwater in this area, it can be established that groundwater levels are sufficiently below ground level so can be considered to be of no concern.

4.6 Risk of Surface Water Flooding to the Site

4.6.1 Surface water sewers are at risk of surcharging during extreme rainfall events with flooding occurring principally from manholes and gullies. Surcharging sewers can result in overland flow which, if originating at a higher elevation than a development site can potentially pose a flood risk.

4.6.2 Surface water run off will bypass the site as per the existing drainage arrangements.

4.6.3 The SFRA indicates that Thames Water have no record of flooding in this postcode in the last ten years.

4.6.4 Flooding risk from surface water is, therefore, considered to be low.

4.7 Risk of Surface Water Flooding from the Site

4.7.1 There are no external works of note proposed at the site and subsequently, the existing manholes and their connections will be used. In line with the London Plan, flow rates from the site will be reduced; flood risk and run off rates decrease accordingly. The current external hard landscaped areas will drain as per their existing arrangements.

4.7.2 Developers are responsible for ensuring that any new development does not increase the flood risk elsewhere. Developers are typically required to consider the 100 year storm with an allowance for climate change to ensure the run off can be managed safely on site, and to restrict any flows leaving the site to the current discharge rates or less.

4.7.3 A detailed assessment of any proposed surface flows is carried out within the drainage impact assessment in Section 6 of this report.

5.0 Mitigation

5.1 Fluvial Flooding Mitigation

5.1.1 The development site lies within flood zone 1 and therefore is at low risk of fluvial flooding.

5.2 Groundwater Flooding Mitigation

5.2.1 Groundwater flooding tends to be more persistent than other sources of flooding and typically lasts for weeks or months rather than hours or days. Generally, groundwater flooding does not pose a significant risk to life due to the slow rate at which the water level rises; however, it can cause significant damage to property.

5.2.2 As per the SFRA, there has been no groundwater flooding in this area for at least the last ten years.

5.2.3 The risk of groundwater flooding to the site can therefore be considered low.

5.3 Mitigation of Surface Water Flooding from the Site

5.3.1 Assuming all existing drainage is remediated correctly and sufficiently, it can be assumed risk of flood from blockage or overloading is minimal.

5.3.2 To minimise localised flooding within the site, the proposed drainage scheme should ensure that all drains and their connections are not damaged or blocked. If any damage is found, it is to be replaced or repaired accordingly. All networks should be subject to a documented routine maintenance and cleansing regime.

5.3.3 Should the above points be incorporated into the final design, the flood risk from the development site to the surrounding areas can be considered low.

5.4 Mitigation of Surface Water Flooding to the Site

5.4.1 Run off from surrounding infrastructure will be directed as per the current site layout, i.e. following the contours of the site.

5.4.2 Due to the congested nature of the development and expected reuse of the sites existing drainage layout, there is no potential for soakaways. An inclusion of green roofs should be reviewed by the design team. Furthermore, based on experience of the local area, the site will likely be underlain by Made Ground, silts, gravels and then impermeable London Clay (as quoted in the SFRA). The gravel and silt layers are expected to be underneath the water table and thus not suitable for infiltration.

5.4.3 It is necessary as part of the Flood Risk Assessment to consider the impact of the proposed development on surface water drainage elsewhere within the local catchment areas, both upstream and downstream to ensure that the risk of flooding is not increased. However as previously mentioned, the proposed drainage should be designed in accordance with the London Plan and introduce a reduction in flows over the existing system; hence, surface water flooding is unlikely due to the geography and history of the site.

6.0 Drainage Impact Assessment

6.1 Storm Water Discharge

6.1.1 The design of the storm water network should be in accordance with legislation set by the Mayor of London (London Plan), Environmental Agency and Thames Water.

6.1.2 The peak runoff rates will need to be reduced in comparison with the existing rates in line with the London Plan. This will represent a minimum reduction of 50% of predevelopment discharge. To account for this reduction in flows, suitable SuDS techniques will need to be employed to attenuate and manage the water. Techniques such as green roof should be considered when developing the design in accordance with the SuDS hierarchy.

6.2 Drainage Strategy

6.2.1 The final design is expected to drain all surface water via flow control into the existing drains and connections to the local public sewer network.

7.0 Conclusions and Recommendations

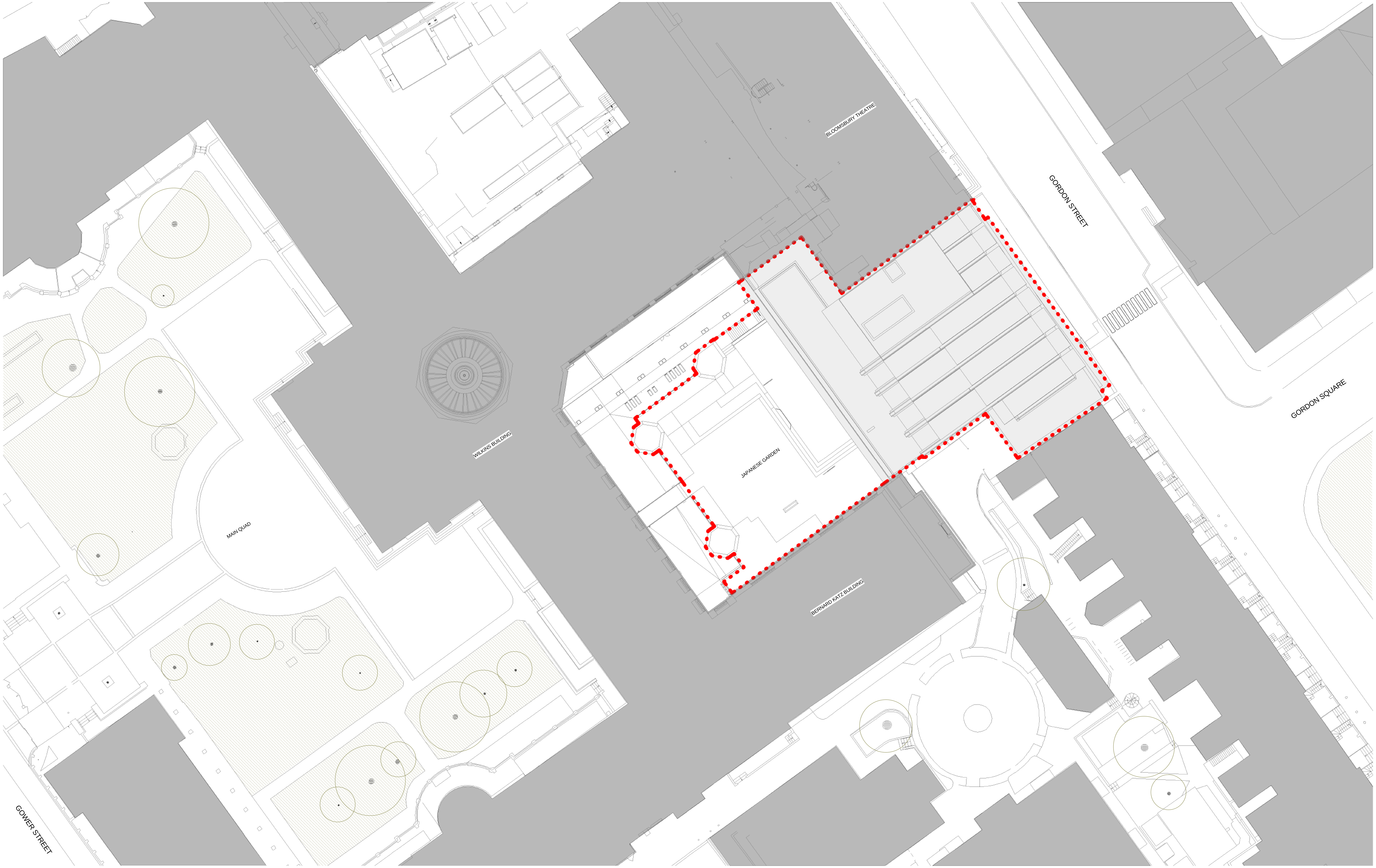
- This Flood Risk Assessment has been conducted for the proposed construction of the new UCL Student Centre on Gordon Street and in accordance with the requirements of the NPPF.
- The site should discharge surface water to the existing drainage network/Thames Sewer via suitable flow controls and SuDS techniques in line with the London Plan. Prior to development, these drainage components should be checked for line, blockages and collapse; any defects should be corrected accordingly.
- The online EA flood map and SFRA for North London show the development site in Flood Zone 1. In line with table 3 of the NPPF, the site is suitable for classification.
- Therefore, if the principles set out within the previous sections of this report are followed and developed at detailed design stage by the design engineer, the site can be considered:
  - To have a low probability of suffering from any form of flooding
  - To be proved as not increasing the probability of flood risk to the local catchment area

8.0 Appendices

Appendix A – Plans

Proposed Site Plan

Utilities drawing



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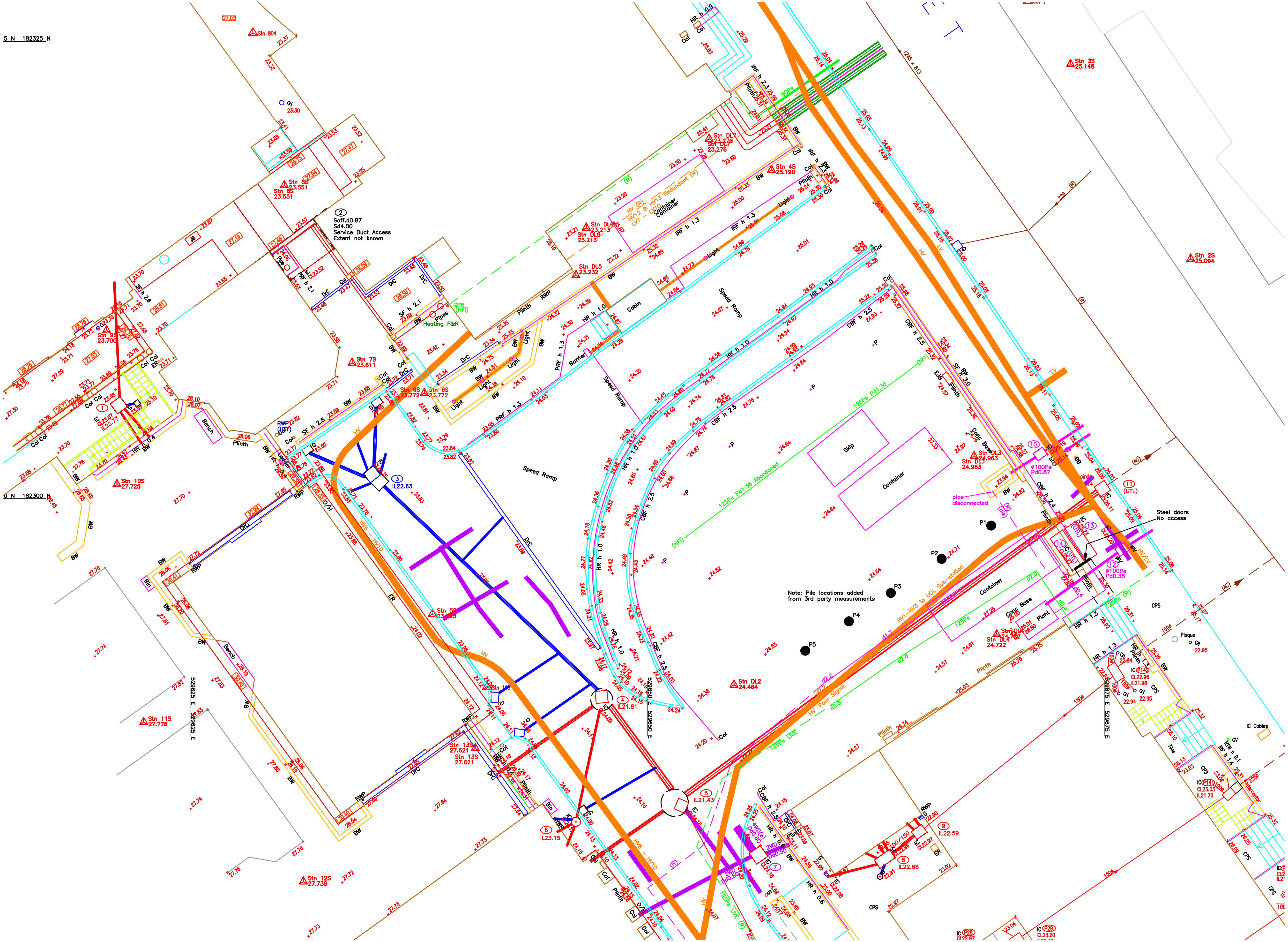

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Steel doors
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Appendix B – Document Extracts

SFRA Extracts

4.10 Community Risk Registers

The Civil Contingencies Act 2004 places a legal duty on Category 1 responders to produce a Community Risk Register. The Resilience forums that cover several authorities in an area produce a Community Risk Register. The study area contains two Resilience Forums each of which have their own Community Risk Register; the North Central London Resilience Forum and the North East London Resilience Forum. The North Central London Community Risk Register covers Barnet, Camden, Enfield, Hackney, Haringey and Islington while the North East London Community Risk Register includes Waltham Forest. Both the registers identify flooding from two main sources: surface water, coastal and fluvial as hazards.

4.11 Groundwater Data

Borehole data has been received from the Environment Agency stating details of the boreholes and groundwater levels dating back to January 2004. The information about the boreholes is not filtered and shows ALL the boreholes both active and disused known to the EA in the study area. Boreholes are predominately located towards the south of the region towards the Thames, and within the Lee catchment area. The boreholes are sparsely located within the Brent catchment area. Borehole records dating back further than 2004 have also been requested. It should be noted that 217 of the 509 borehole are of an unknown status or type, 71 of the 509 are disused and 105 of the 509 are for observational information. The EA were also able to provide the depth Groundwater contours. It is hoped that these records will allow assessment of the long term trend in groundwater levels.

4.12 Flood Records

Flood records have been collected and collated from a range of sources to produce the most complete flood history of North London as possible. Records have been obtained from the borough councils, Transport for London, London Fire Brigade and the EA. Other organisations were asked for information but were unable to share their records.

4.12.1 Individual Boroughs

All the boroughs were asked for their flood records. Camden and Enfield were able to provided GIS mapping of recent flood events that occurred within their borough. Haringey were able to provide an Inception Report for Haringey Flood Management Strategy. The Enfield SFRA also contains locations of flood records. Barnet provided a range of flood records, most of which related to isolated highway flooding incidents.

4.12.2 Transport for London

Transport for London is responsible for the management of the 580km of main road within the M25. They maintain a list of flood events related to these road assets. A list of flooding incidents has been obtained, dating only from May 2006 to August 2007.

4.12.3 London Underground

Several requests have been made for information on flooding incidents at underground stations within the seven London Boroughs but no response has been received.

4.12.4 The London Fire Brigade

The London Fire Brigade (LFB) have provided an extract of calls received about flooding in the seven London boroughs from April 1999 to August 2007. The 15,500 calls handled by the LFB were concerned with different types of flooding that include fluvial, surface water and burst pipes. The data has been filtered down to exclude calls where no location has been recorded and calls that appear unrelated to flooding. The records were then reduced further by using data from grouped flood events that were defined by receiving 12 or more calls in 48 hours. These were then cross referenced with rain gauge data from the EA to try and determine whether events could be attributed to pluvial flooding or whether events may be attributed to other factors.

4.13 Public Reservoirs

A public list of reservoirs as defined by the 1975 Reservoirs Act in the North London SFRA study area has been received from the Environment Agency as part of their GIS mapping layers. This data list specifies the locations, capacities, age, type and the operators of each reservoir. A request has been made for further details regarding the condition and maintenance of the reservoirs but no information has been received.

The EA are responsible for the enforcement of the Reservoirs Act which defines reservoirs as having 25,000m^2 of storage above the natural ground level. The EA are responsible for the management of EA owned reservoirs. The list provided by the EA provides details of any reservoirs within the study boundary which come under this category. There are other reservoirs which are smaller or not raised above ground which are not included as part of this assessment. Reservoirs set below the natural ground level have a much lower flood risk and smaller reservoirs, particularly those associated with clean water supply have reduced flooding consequences due to their size.

4.14 British Waterways

A request has been made for information on the canals in the North London region. However, no information has been received from British Waterways.

Table 10 - Rivers List

Watercourse Name	River Status	Boroughs Affected	Length (km)	Catchment Area (ha)	Hydraulic Studies
Barnet Ditches	Main River	Barnet	3.1	2,918	JFLOW
Mimmshall Brook	Main River	Barnet	12.5		JFLOW
River Brent	Main River	Barnet	25.1	10,150	JFLOW
Broomsfields Ditch	Main River	Barnet	0.79		JFLOW
Deans Brook	Main River	Barnet	5		JFLOW
Deers Hill Road	Main River	Barnet	0.3		JFLOW
Dollis Brook	Main River	Barnet	13.7		JFLOW
Edwarebury Brook	Main River	Barnet	1.8		JFLOW
Edgeware Brook	Main River	Barnet	9		JFLOW
Hendon Cemetery Drain	Main River	Barnet	1.4		JFLOW
Mutton Brook	Main River	Barnet	5		JFLOW
Oakhampton Road Drain	Main River	Barnet	0.2		JFLOW
Springwood Crescent Drain	Main River	Barnet	1.0		JFLOW
Silk Stream	Main River	Barnet	8		JFLOW
Tramway Ditch Colindale	Main River	Barnet	0.5		JFLOW
Watling Ditch	Main River	Barnet	1.8		JFLOW
Folly Brook	Main River	Barnet	1.1		JFLOW
Victoria Water Course	Main River	Barnet	0.4		JFLOW
Cuffley Brook	Main River	Enfield	9.2		JFLOW
Enfield Ditch	Main River	Enfield	1.7		ISIS
Boundary Ditch	Main River	Enfield			TUFLOW
Glenbrook South Drain	Main River	Enfield	0.8		ISIS
Holyhill Brook	Main River	Enfield	1.6		JFLOW
Hounsden Gutter	Main River	Enfield	4.0		JFLOW
Leeging Beech Brook	Main River	Enfield	1.2		JFLOW
Small Lee	Main River	Enfield	9.0		ISIS
Merryl Hills Brook	Main River	Enfield	2.7		JFLOW
Monken Mead Brook	Main River	Enfield	4.0		ISIS
Salmons Brook	Main River	Enfield	14.4	4,149	ISIS
Sadlers Mill Stream	Main River	Enfield	6.6		TUFLOW
Turkey Brook	Main River	Enfield	13.7	4,158	ISIS
Bounds Green Brook	Main River	Enfield, Barnet	3.7		ISIS
Pymmes Brook	Main River	Enfield, Barnet	15.5	4,427	TUFLOW
River Lee	Main River	Hackney, Waltham Forest, Enfield, Haringey	33	141,234	ISIS
Lee Navigation (Lower)	Main River	Hackney, Waltham Forest	22.9		ISIS
Lee New Cut	Main River	Haringey	9.5		ISIS
Moselle Brook	Main River	Haringey	8.5		TUFLOW
Stonebridge Brook	Main River	Haringey	1.7	726	ISIS

Intercepting Drain	Main River	Haringey, Enfield	5.4		ISIS
The Ching	Main River	Waltham Forest	6.8	1,747	ISIS
Dagenham Brook	Main River	Waltham Forest	5.3		ISIS
Eastern Flood Channel	Main River	Waltham Forest	9.1		ISIS

5.2.1 *Lower River Lee (Lee)*

The River Lee is one of the largest Thames tributaries which drains a large rural catchment to the north of London. The total catchment is about 1415 km^2 and extends as far north as Luton, encompassing a large part of Hertfordshire and parts of west Essex.

The Lee catchment within the study area can be characterised as developed flood plain with built flood defences, with tributaries which rise in the green belt with undeveloped natural flood plains. The Lee Valley forms the eastern borders of Enfield, Haringey and Hackney and borders Waltham Forest to the West. The River Lee flows into the River Thames through the Borough of Newham. The downstream side of Lee Bridge Road marks the tidal extent on the River Lee which is within the Boroughs of Waltham Forest and Hackney.

The River Lee experienced severe flooding in 1947 and since then the Lee has been heavily altered and defended. The development of several man-made channels has provided flood relief in the area by increasing conveyance capacity through the catchment. The River Lee Flood Relief Channel was designed to protect against the 1947 event which was believed to be approximately a 1 in 70 year flood. This is below the level of protection that might be considered acceptable for new development. Furthermore the level of protection is known to have been reduced further by the extensive development in the upper catchment.

The EA provides a flood warning service to properties in flood zones 2 and 3 along the River Lee. The EA will aim to provide a lead time of 2 hours wherever possible. Many of the tributaries of the Lee have fast response times due to their small urban catchments and impermeable London Clay associated with North London.

In recent years, the River Lee has been studied quite intensively due to its importance in the London 2012 Olympics. The most recent was the *'Lee Flood Risk Mapping Study'* (March 2007) undertaken by Halcrow for the EA which used TUFLOW and ISIS to model the watercourses. The May 2007 Olympic FRA and the Lower Lee Valley SFRA models are more detailed for the area downstream of Lee Bridge Sluices than the Lee Hydrology and Mapping Study. Further information about the Olympics can be found in section 4.9.5.

The EA is concerned that there is insufficient space available for much needed flood alleviation schemes. They are pursuing a long term approach that could consider ideas like land swaps to remove more vulnerable development from the floodplain and release land for flood storage. The Thames CFMP provides further more localised guidance on the approaches most applicable to the sub-catchments as further discussed in the following sections.

The hydrology of North London is influenced primarily by the high urbanisation and impermeable geology of the London Clay which is typical of the area. The Upper Lee catchment is founded on the chalk uplands and is predominantly rural. The soils are slowly permeable in nature which gives the Upper Lee an increased response time.

The Lee and its tributaries in North London have little supply from groundwater sources and rise quickly during rainfall. Rainfall in clay areas cannot penetrate into the ground and instead runs off quickly into the rivers. The rivers flow over the London Clay which overlies the chalk aquifer and generally prevents interaction of surface water with the groundwater.

5.2.2 River Lee Tributaries

The River Lee has many tributaries that enter the watercourse mostly from the west. These watercourses form a dense drainage network across the western side of the Lower Lee catchment.

The catchment includes several large tributaries which are prone to localised flooding; these include Salmons Brook, Turkey Brook and Pymmes Brook. Many of the Lee tributaries have extensively developed catchments which experience a rapid response to rainfall. The EA provides a flood warning service to properties in flood zones 2 and 3 along the Lee Tributaries.

The Ching Brook, located in the northern part of the Waltham Forest, arises at Connaught Water and flows south then west to enter the River Lee to the north of Banbury Reservoir. The total catchment area for the Ching Brook is 1747 hectares.

Turkey Brook drains a more rural catchment with an urban extent of just 4%, the total area is 4,158 hectares. The source of Turkey Brook lies just outside the northern boundary of Enfield. Its main tributary is the Cuffley Brook which rises 5 kilometres to the north of Enfield and flows through predominately agricultural land to meet with Turkey Brook. Turkey Brook then flows eastwards to the confluence with the Small River Lee, before entering the River Lee to the north of the King George V reservoir. The other main tributary of the Turkey Brook is the Holyhill Brook.

The Salmons Brook catchment covers a total area of 4149 hectares. The rivers tributaries include Merryl Hills Brook, Leeging Beech Brook, Gelnbrook South Drain, Saddlers Mill Stream and Houndsden Gutter. The Salmons Brook rises in the east of Barnet and runs through fairly flat agricultural land for approximately 6km, picking up a number of small tributaries from the south. The underlying geology of the catchment is predominantly London Clay with sporadic gravel beds. As it enters the urban areas of Enfield the watercourse is culverted in a number of locations. The Salmons Brook joins the Pymmes Brook to the south of the North Circular Road.

The Pymmes Brook catchment covers a total area of 4,427 hectares with an urban extent of 44%. The heavily engineered watercourse passes through over 4 kilometres of concrete lined channels and almost 2 kilometres of culvert. The river rises in Barnet and flows through Hadley Wood, flowing eastward through Enfield towards the River Lee, picking up Bounds Green Brook along the way.

The Thames CFMP suggests that whilst these urban watercourses experience rapid runoff, floodplain encroachment and modified channels, they still have sufficient river corridors that to support more sustainable approaches. The implementation of sustainable approaches would be most appropriate during the development or redevelopment of sites along with maintaining existing open space.

5.2.3 River Brent and Tributaries Upstream of the Brent Reservoir

A small reach of the River Brent connects Dollis Brook to the Brent reservoir. For completeness this reach will be included within the Brent tributaries. The River Brent tributaries within the study area are Folly Brook, Dollis Brook, Springwood Crescent Drain, Watling Ditch, Silk Stream, Hendon Cemetery Drain, Tramway Ditch Colindale, Oakhampton Road Drain, Edgeware Brook, Mutton Brook flow into the Brent Reservoir.

Some of the tributaries have been recently taken on as main rivers by the EA due the level of fluvial flood risk. These are the Broomfields Ditch, Deer Hill Road Brook, Edwarebury Brook, Deans Brook, Hendon Cemetery Drain, Watling Ditch, Tramway Ditch Colindale, Springwood Crescent Drain and Oakhampton Road Drain.

The Dollis Brook becomes the Brent once it confluences with Mutton Brook in the South of Barnet. The Dollis Brooks tributaries include Folly Brook, Hendon Cemetery Drain, Deers Hill Road and Oakhampton. The Brent confluences with the Silk Stream at the Brent Reservoir.

The Silk Streams main tributary is Deans Brook which flows south, meeting Springwood Crescent Drain, Broomfields Ditch and Edwarebury Brook before forming the Silk Stream at the confluence with Edgware Brook. Watling Ditch and Tramway Ditch both enter the Silk Stream before it reaches the Brent Reservoir.

The CFMP suggested that flood risk along these watercourses should be accepted in the short term but the long term flood risk should be prevented from rising beyond the existing level. It is suggested that the as opportunities arise through re-development the urban layout can be changed to ensure greater flood resilience and sustainability.

All these watercourses are defended in places and a low standard of protection is offered to properties in the floodplain. In recent years, a flood alleviation scheme has raised the standard of protection to properties along the silk stream. The EA provides a flood warning service to properties in flood zones 2 and 3 along the Brent Tributaries. The Silk Stream is noted for being flashier than the neighbouring watercourses.

5.2.4 *Subterranean and Culverted Rivers*

Historically a number of watercourses in London have been integrated into the urban environment through canalisation and culverting. In some cases these watercourses have been entirely incorporated into the sewer network and are often referred to as London's "Lost Rivers".

The River Fleet is one such subterranean river. The River Fleet historically originates from springs on Hampstead Heath and drains to the Thames approximately via Kentish Town, Camden Town and Holborn. Through Camden and the City of London the Fleet is entirely incorporated within the sewer network, owned and maintained by Thames Water. For the purposes of this study it is considered as a sewer. The catchment of what was the River Fleet is shown on map 11, the catchment is extracted from Flood Estimation Handbook (FEH) and has not been verified for accuracy. The Fleet would have been the main drainage body for the Camden area and any future development activities in Camden could have significant impacts on flood risk within the City of London if they are not adequately managed.

The Hackney Brook is also a subterranean river located in the Borough of Hackney, which is also now incorporated into the sewer network. Before 1860 the Hackney Brook had been heavily culverted and in was increasing being used as a sewer. In 1860, the Hackney Brook was incorporated into the Northern High Level Sewer. Map No. 11 in Appendix A, shows the catchment as extracted from the FEH. Again the catchment has not been verified for accuracy and is intended as a guide only.

The Moselle Brook in the Borough of Haringey has been mostly culverted with a small reach of the river above ground in Tottenham Cemetery. Culverting of key sections of the Moselle started in 1836 and further culverting of the watercourse took place in 1906. The original culverting is believed to have taken place in order to reduce flood risk. However, this often has the opposite effect.

5.3 Fluvial Flooding

Fluvial flooding occurs when the capacity of a watercourse is exceeded and flood plains become inundated. In urban environments, man made structures within the watercourse or flood plain can also cause inundation of areas outside of the natural floodplains. Fluvial flooding also occurs when flood defences are overtopped or breached. Overtopping usually results in a gradual inundation of the defended areas and is usually easier to predict through flood warnings. Breaching can be much more difficult to predict and can result in rapid inundation with little warning.

5.3.1 Historic Fluvial Flood Events

Historic flood records have been supplied from a variety of sources. The key flood events are summarised below and referenced on map 10 included in Appendix A.

5.3.1.1 March 1947 floods

The floods of 1947 were the largest since records began over 100 years previous to this event. A large rainfall event and thawing of snow in the Thames catchment combined with a storm surge in the North Sea, causing flooding in the River Thames and its associated tributaries.

The 1947 floods also affected some of the Lee tributaries including the Cuffley Brook, Turkey Brook, Salmons Brook (predominately between Leeging Beech Brook and Hounsden Gutter, and the Ching.

The areas immediately around the Warwick Reservoirs were flooded which include the Walthamstow Marshes and Nature Reserve downstream, Leyton Industrial Village, the Cromwell Estate, Riding School, Roxwell Trading Park, Forest Business Park, Fairways Business Park, filter beds south of the Lee Bridge at Hackney Marsh. Since 1947 areas that were inundated by flood waters have been developed. This is most noticeable between the Stonebridge Brook junction with the Lee Navigation (Lower) and where the Pymmes Brook meets the Salmons Brook.

The flooding in 1947 led to the construction of the River Lee Flood Relief Channel, which became operational in 1976. There has been no major flooding in this region since then, although the flood relief channel almost reached full capacity in 1987, 1993 and 2000.

5.3.1.2 December 2000 Floods

In October 2000, flooding occurred at the confluence between Salmons Brook and Sadlers Mill Stream, and along a reach of the Eastern Flood Channel at Douglas Eyre playing fields and in Walthamstow Marshes nature reserve. The most severe flood event occurred when the Montagu Road culvert became overloaded. All of the flood locations are within flood risk zone 3.

5.3.1.3 Silk Stream Floods

The Silk Stream flooded twice in the 1990's, once in 1992 and once in 1999. The trigger to these flood events is not known, however, the lead time of the watercourses would indicate that they are susceptible to flooding caused by short, intense rainfall events typical of summer storms.

5.3.1.4 Other Localised Fluvial Flooding

Other smaller more localised flood events have occurred since 1947. Most of these flood events took place in the summer as a result of intense rainfall events. All of the historic flooding is located within flood risk zones and in some instances (where no hydraulic study has been undertaken) it is evident that the flood risk zones have been derived from the historic flood events.

5.3.1.5 Haringey Council Flood Management Strategy Report Review

The Borough of Haringey commissioned a report to consider flood risk from a spectrum of sources in their borough and produce appropriate strategies for the management of flood risk. The report identifies the council as the riparian owner on much of the Moselle Brook meaning that they have a greater responsibility than realised prior to this report.

A number of flooding incidents were reported, the most significant of which was flooding occurring in July 1965. The area around White Hart Lane appeared to be most affected including the White Hart Lane Station and properties on The Roundway. Montagu Road flooded during this event and is also reported to have flooded in 1956. White Hart Lane is also reported to have flooded in 1993 with the Wedges Yard Trash Screen a particular flood hazard.

An outline analysis of the affects of flooding on transportation suggested that rail and tube lines are unlikely to be flooded but may be affected if the embankments are eroded or washed away.

It was concluded that Haringey was at risk from fluvial, sewer and pluvial flooding but not groundwater or tidal flooding. Several strategies were put forward that included the improvement of flood risk mapping, emergency planning and development planning.

The Haringey flood locations are represented on maps 10, 13 and 20 in appendix A.

5.3.2 Tidal Flooding

Tidal flooding can also occur as a result of overtopping or breaching of flood defences, wave action or where tide-locking causes ponding of fluvial or surface water flows.

Parts of the south of Waltham Forest and Hackney are located within the tidal reach of the River Thames, which extends up the Lower Lee Valley to the Lee Bridge sluices. The flood levels in the River Lee can therefore be affected by tidal processes as very extreme tidal events in the Thames could result in flooding of these areas. The areas are defended against such flooding with local flood defences and crucially, the Thames Barrier, which currently provides tidal flooding protection in excess of 0.1% annual probability flood event. The Thames Barrier combined with local flood defences means that any extreme tide level would have to be accompanied by a breach in flood defence to result in severe flooding. Localised flooding could still occur where surface water outfalls become tide-locked, causing short term ponding behind defences.

The River Lee has been altered within the Lower Lee Valley in order to manage flood risk and prevent a reoccurrence of the 1947 floods, whilst encouraging development in the area. The Lee New Cut and Eastern Flood Channel are both artificial channels designed to take flood waters away from the main river. The main river itself forms the Lee Navigation that since the River Lee Act 1766 has been operated like a canal that runs from Hertford to the Thames. The Act authorised improvement works, the construction of locks and new channel sections which include the Limehouse Cut, a connecting canal at the southern end of the watercourse.

River Lee flood relief channel and associated structures were designed to have a standard of protection of approximately 1 in 70 return period. However, urbanisation of the upstream catchment has significantly reduced this standard of protection in some locations. Overall the standard of protection of the defences is generally above 2% (1 in 50) annual probability, but is as low as 5% (1 in 20) in some areas. In some locations the standard of protection is greater than 1% (1 in 100) annual probability. It is intended to produce a map highlighting the areas with defences which have a low standard of protection, however, identifying the exact standard of protection of each defence, and therefore the areas of highest risk has not been entirely possible due to the limited data in the NFCDD. Further information on flood defence levels will be required to enable these areas to be mapped with any degree of accuracy. Where possible the standard of protection by locality is described below. Although there is a lack of standard of protection information for the catchment, the Lee and Brent mapping studies produced defended outlines which would give an idea of risk.

The flood defences on the fluvial reach of the Lower Lee through Hackney affords a high standard of protection (greater than 1 in 100 years (1%), with the exception of properties along Mandeville, Oswald and Pedro Streets. Other open spaces in this area also have a lower standard of protection.

Properties along the Lower Lee through Waltham Forest appear to be protected to a standard lower than 1 in 100 years (1%), in particular properties near the confluence with the Ching Brook, from Uplands Business Park to Douglas Eyre Playing Fields including Eward Road, the area between Coppermill Lane and Salop Road and from St James Park down to Roxwell Trading Centre, including Cromwell Estates and residential properties near Lee Bridge Road. Other areas with low standards of protection include Walthamstow Marshes and the railway sidings opposite Hackney marsh.

The defences along the River Lee are estimated to have a residual life of 50 to 60 years. While most of these assets are assessed as being in good to fair condition, several reaches of the Lee tributaries are in a wider variety of conditions with some sections being in poor condition. These are listed in Table 12 below.

The Housden Gutter, Pymmes Brook, Moselle Brook, Interceptor Drain, Saddlers Stream, The Ching and Bounds Green Brook all have associated flood defences.

In the Finchley and Hendon area to the north of Hampstead, a Till, chalky sandy clay and gravel outcrop lies on the surface that may lead to a localised groundwater flooding, although there is no history of groundwater flooding in this location.

5.4.2 *Groundwater Flooding*

Very few groundwater flooding records have been provided by the EA and all of those that are recorded lie within the London Borough of Enfield. The locations of the flooding incidents are shown on map 20.

Almost all of the recorded incidents occur within the upland areas of the Borough in the vicinity of the drift deposits which overlay the impermeable London Clay. A small cluster of flood events also occur further west within the Borough. These three events are located on the down slope from an outcrop of Stanmore Gravels, which may account for these localised flooding incidents.

A small number of flooding incidents are located in the Lee Valley to the north of the Borough. These flooding incidents are most likely to be attributed to the low lying areas where the groundwater table is relatively close to the surface.

Identifying the cause of each of these flood incidents is outside the scope of this report, however, it does identify a number of flooding trends which should be considered at a site specific stage.

5.4.3 *Borehole Data and Groundwater Contour Data*

The EA has supplied a series of borehole records which provide a snapshot of the groundwater levels across the study area on recorded date of February 2007. The borehole data matches the groundwater levels provided, validating in places the contours provided. The boreholes are sparsely located across the study area, especially in the larger boroughs of Barnet and Enfield. The majority of the borehole data is situated at the lower end of the Lee catchment in Waltham Forest, Hackney and further south of the study area. Boreholes in the Brent catchment are very limited.

The groundwater contours representing depth below ground are shown on map 12. These groundwater levels are for the chalk aquifer underlying the confining clay, which are not necessarily the level of the groundwater beneath any particular location and relate to the peizometric pressure of the groundwater at that point. This means, the water level in the borehole would rise up to the stated value due to the pressure under the confining clay, it does not mean that the water in the ground is at that level. Therefore, flooding from the chalk aquifer is not that likely in areas where the chalk is confined by the clay even though groundwater levels may read that groundwater is only a few meters below ground level.

The groundwater profile through London shows relatively little change in elevation, however, the topography of the North London sub-region shows significant variation, with a general fall in an easterly direction from the higher ground in Barnet to the Lee Valley, where much of the areas is only a few metres above sea level. As expected, groundwater levels are closest to the surface around watercourses, particularly in the low lying Lee Valley. The groundwater levels in the Lee catchment are significantly closer by approximately 30m to the surface than within the Brent catchment. A region of higher ground between river catchments stretches from central Camden and up through central Barnet to the north west of the overall assessment region. Throughout this region the groundwater levels are at a depth of 80-90m below the surface.

The borehole data provided records the depth of the groundwater table in the chalk aquifer. It does not record the intermittent groundwater levels which occur where the gravel and silt deposits overlay the London Clay layer.

5.4.4 GARDIT

During the 19th and 20th centuries significant volumes of groundwater were abstracted from the deep aquifer below London to support the industries prevalent at the time. This intensive abstraction of groundwater had a dramatic impact on the groundwater levels. As these industries began to decline the volume of water extracted correspondingly reduced and groundwater levels began to rise back to their natural levels. The decline in abstraction began in the 1940's and from around the 1970's onwards groundwater levels began to rise dramatically, at more than 1m / year[14] in many areas. Building foundations and infrastructure which had previously been designed with little regard for groundwater began to be at risk as the water table began returning to its natural level. It is estimated that during the period of heavy abstraction groundwater levels may have lowered by as much as 90m[15], and a corresponding rise could cause a substantial flood risk to critical infrastructure and basements, while also causing instability to building foundations.

In 1992 GARDIT (General Aquifer Research, Development and Investigation Team), an umbrella organisation consisting of Thames Water, London Underground and the EA, was formed to address the issue of rising groundwater. The GARDIT group established a five stage solution to maintain groundwater levels at an acceptably agreed level on an area by area basis. The solution involved reusing existing boreholes and creating a series of new boreholes which would extract a total of 70Ml/day across London. The project was due to be fully implemented by 2005 and as such groundwater levels are expected to stabilise to a manageable level.

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[14] CIRIA Special Publication 69 (1989) *The Engineering Implications of rising groundwater levels in the deep aquifer beneath London*

[15] Thames Water *Central London Rising Groundwater*

The GARDIT report states that "as a result of the GARDIT strategy and the controls imposed on central London, the whole of the London Basin Chalk aquifer is becoming a highly managed entity". Also included is that the ground water contours "have barely changed compared to last year, so the groundwater level can now be considered static."

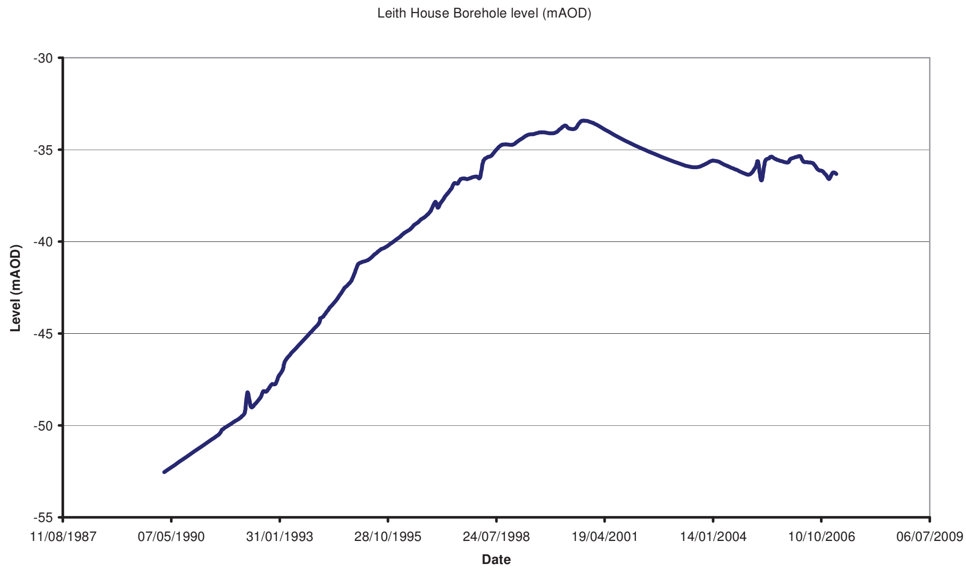
The monitored area consists of observation boreholes stretching from Hatfield in the north to Epsom in the south, with Dagenham and Dartford on the eastern boundary and Staines and Uxbridge to the west.

The continued increase in use of abstraction licences is demonstrated within the report. It is intended that "substantial further increase in abstraction will control groundwater levels at significantly lower levels than previously seen."

5.4.5 Groundwater trends

The EA's groundwater monitoring team have provided historic levels of a borehole located within the City of London Boundary (other more relevant borehole data has also been requested but not received) at Leith House, Gresham Street. A graph of the boreholes recorded levels from 1990 to 2006 are presented in Figure 3. A plan showing the location of the borehole is included in Appendix A, (Map No. 12).

Figure 3 - Leith House Borehole Level



The borehole record shows the trend of rising in groundwater during the 1990's with an approximate rise of 2m/year occurring from 1990 to 1998. Since then levels have stabilised below -35m AOD (Above Ordnance Datum) as a result of abstraction of groundwater across London.

The actions of the GARDIT team will significantly reduce the future risk of groundwater flooding in London providing the current abstraction rates are maintained indefinitely. However, a residual risk of groundwater flooding could still remain to some new developments or below ground infrastructure.

The impacts of the groundwater levels within the chalk aquifer on proposed development and the planning process are not considered further in this report as the overall risk of groundwater flooding is considered to be low given the current stability in groundwater levels. However, groundwater flooding is still a potential issue within some of the permeable soils which overlay the London Clay including the River Lee Valley. Further discussion on this groundwater flooding problem is discussed in Section 0.

5.5 Sewer and Surface Water Flooding

5.5.1 Sewer Flooding

Sewer and surface water flooding generally results in localised short term flooding caused by intense rainfall events which overload the capacity of sewers or run off adjacent land as sheet flow. Flooding can also occur as a result of blockage, poor maintenance or structural failure. Sewer systems in London are often very old, particularly within the Boroughs of Camden, Islington and Hackney. These older sewers were sometimes designed to convey storms of relatively low return periods such as a 1 in 10 year rainfall event. Even new surface water systems are designed to a minimum standard of 1 in 30 years, much less than the 1 in 100 year standard of protection expected from fluvial flooding. As a result sewer flooding events where they occur can often be frequent, although the scale of consequence is generally smaller than those associated with fluvial flooding. Some of the London sewer network is a combined system with storm and foul drainage served by a single sewer. This makes flash flood events particularly inconvenient and unpleasant as floodwaters will often be contaminated with sewage.

The annual rainfall for the North London area is 640mm, somewhat less than the national annual average of 897mm. Rainfall in London also experiences less seasonal variation than other areas of the country, with the winter months experiencing only marginally higher rainfall than summer months, however, the rainfall in summer months will often occur in a smaller number of rainfall events leading to intense rainfall peaks which can lead to flash flooding and overloading of sewer systems. Climate change predictions indicate that these intense summer storms will become more frequent. Over time the standard of protection of existing sewers will reduce leading to an increase in localised flooding incidents.

Sewer flooding does not always respect the topography of a catchment and flooding can just as easily occur at the head of a network as it can near to the outfall. However, flood events occurring at the downstream end of a drainage system are likely to be more severe due to the sheer volumes of flow involved. London’s sewer network is generally protected from such large scale flooding by storm overflows which discharge high storm flows from the sewer system into watercourses, thus preventing flooding from the sewer network. In the event that an extreme fluvial event coincided with heavy rainfall within the catchment, storm water would be unable to discharge via storm overflows and would therefore surcharge within the sewer network. This could result in significant sewer flooding problems. Without access to hydraulic sewer models it is not possible to determine the extent of this risk or the areas most likely to be affected. Naturally low lying areas such as the river valleys and the areas immediately behind the locally raised flood defences could be potential receptors of such a flood event.

The Pitt Review looked at sewer flooding and considered the current regulations that allow the automatic right to connect surface water to sewers. The report recommends that this right should be removed (Recommendation 10) to encourage greater consideration of SUDS in the management of storm water runoff.

It is essential that any new development takes account of known sewer flooding problems to ensure that the development is not put at risk and that the development does not worsen an existing problem. Future development if not adequately planned can increase the flood risk from sewer flooding and in some cases cause new flood problems to occur. Potential increases in surface water or sewage discharge from new development must be adequately managed and mitigation measures introduced.

5.5.2 Thames Water Flood Database

Thames Water have provided an extract of their flood register for use in this study, however, the data is referenced by truncated postcode only and therefore cannot specifically identify a particular flooding problem. This is not a unique situation as Water Authorities have in general been reluctant to release flooding data for use in other SFRAs due to the sensitive nature of the information. The results of the Thames Water data is referenced on map 13 in appendix A. Table 14 below shows the number of flood records by Borough.

Table 14 - Thames Water Flooding Records by Borough

Borough	No. of Properties on Thames Water Flooding Database
Barnet	42
Camden	90
Enfield	5
Hackney	47
Haringey	12
Islington	1
Waltham Forest	55

Water Authorities are only required to maintain records of flood events which occurred more frequently than once in ten years. This is primarily down to targets set by OFWAT, the regulating body of the water industry. This inconsistent approach in recording sewer flooding compared with the EA's recording of fluvial flooding can make it difficult to assess the risks and consequences of sewer flooding. It is possible that a less frequent but substantial flood risk from sewers exists in the North London, but without the requisite information these potential risks cannot always be addressed by a pro-active approach, such as mitigation at the planning stage of a new development. Instead such risks often have to be addressed through a reactionary approach once a flood event had occurred.

It should be noted that the flood records provided by Thames Water may not be a complete and accurate record of flood events in the boroughs over the last 10 years. Some minor flooding incidents may go unreported, particularly if no property is affected by such flooding.

The Thames Water records shows a reasonable correlation with other historic flood records, including those of the Camden floods discussed later in this chapter. A substantial number of the postcode zones include a small number of isolated flooding incidents with no correlation to the adjacent postcode zones, however, there are five locations which should be highlighted, either because they contain a higher number of flooding incidents or there is a cluster of postcodes all containing flood events. These locations are listed in Table 15 and account for approximately half of the events on the Thames list.

Table 15 - Thames Water Flooding Records, Highlighted Areas

Location	North London Borough(s) Affected	Other London Borough(s) Affected	Comments
Edgware and Cannon Hill	Barnet	Harrow	Flooding occurs around the upper tributaries of the Silk Stream
West Hampstead, Cricklewood, South Hampstead and west to Church End	Barnet / Camden	Brent	
Stamford Hill	Hackney		Flooding incidents located south of Seven Sisters Road.
Leyton, Leytonstone	Waltham Forest		
South Tottenham	Haringey		Flooding occurs around the Stonebridge Brook Area

The scale and exact cause of the individual flooding problems is unknown and further investigation of each incident is clearly outside of the both the timescale and economic constraints of this study. However, the data has been combined with other flood history data discussed below and used to identify those areas which may be susceptible to surface water, this approach discussed in more detail in chapter 6.

5.5.3 Impermeable Surfaces and Urban Creep

Over the past couple of decades, there has been a growing trend of paving front gardens in urban areas to provide additional car parking. This practise has lead to urban creep that increases the impermeable area and the associated run off.

The Communities and Local Government website provides an Impact Assessment of Permeable Surfaces (January 2008) which considers the problem of paving front gardens further. This document provides evidence about the problem and reviews the permitted development rights for permeable surfacing.

The Pitt Review also considers the growth of paving front gardens and made a recommendation (Recommendation 9) that householders should no longer be able to lay impermeable surfaces as a right on front gardens and that the government should consult on whether to extend this to back gardens and business premises.

5.5.4 Basement Flooding

Flooding of basements of buildings is flooding of space below ground level. In the mildest case this may involve seepage of small volumes through walls, temporary loss of services. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity.

5.5.5 Other surface water flooding records

5.5.5.1 Barnet Flood Hot Spots

The London borough of Barnet has provided a list of flood locations within Barnet over the last 2 years. The flood locations also include the associated reasons for flooding. A substantial number of the flood events were attributed to maintenance of gullies and this data has been removed from the data set.

The remaining recorded flood events are generally in close proximity to a major watercourse. The large majority are in the west of the borough along stretches of the Silk Stream and Edgware Brook, predominately along the western banks of the watercourses. These incidents generally correlate with the Thames Water flood records. The Edgware area appears particularly prone to surface water flooding problems. Other significant flooding problems are identified in the Colindale area and around the Silk Bridge in West Hendon.

5.5.5.2 Review Transport For London flood records

Transport for London is the authority that manage and maintain public transportation within the M25. On request they have made their flooding records available for use in

9 Guidance for Developers

9.1 Development and the management of residual flood risk

The following section is provided as a guide to developers on the management of flood risk and provision of flood risk assessments for future development. The guidance is based on recommendations arising from the findings of the SFRA while also following the requirements of PPS25.

At a site level, developers should consult the Environment Agency, sewerage undertakers, highways authorities and any other relevant bodies to supply information for a Flood Risk Assessment (FRA) of the site. This will provide information to the Local Planning Authority from which they can reach a decision on the development application.

Developers are recommended to consult with the LPA over all developments in Flood Zones 2 and 3 at the earliest opportunity to ensure that the Sequential Test has been satisfied. This should be done before a FRA is undertaken as it may be the case that the proposal is refused on Sequential Test grounds.

Planning applications for development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a local FRA. For developments in Flood Zones 2 and 3, the FRA should identify opportunities to reduce the probability and consequence of flooding.

With reference to PPS25, the objectives of an FRA are to establish:

- Whether a proposed development is likely to be affected by current or future flooding from any source.
- Whether it will increase flood risk elsewhere
- Whether the measures proposed to deal with these effects and risks are appropriate
- Whether the developer will be able to demonstrate that the site will be safe, without increasing flood risk elsewhere and where possible will reduce flood risk overall (part c of the exception test).

The scope of each FRA should be agreed with the LPA, EA and any other relevant consultees but it may include some or all of the following outputs:

- Development description and location

Birmingham
2 The Wharf
Bridge Street
Birmingham B1 2JS
T. 0121 643 4694
birmingham@curtins.com

Bristol
3/8 Redcliffe Parade West
Bristol
BS1 6SP
T. 0117 925 2825
bristol@curtins.com

Cardiff
3 Cwrt-y-Parc
Earlswood Road
Cardiff
CF14 5GH
T. 029 2068 0900
cardiff@curtins.com

Douglas
Varley House
29-31 Duke Street
Douglas Isle of Man
IM1 2AZ
T. 01624 624 585
douglas@curtins.com

Edinburgh
35 Manor Place
Edinburgh
EH3 7DD
T. 0131 225 2175
edinburgh@curtins.com

Kendal
28 Lower Street
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