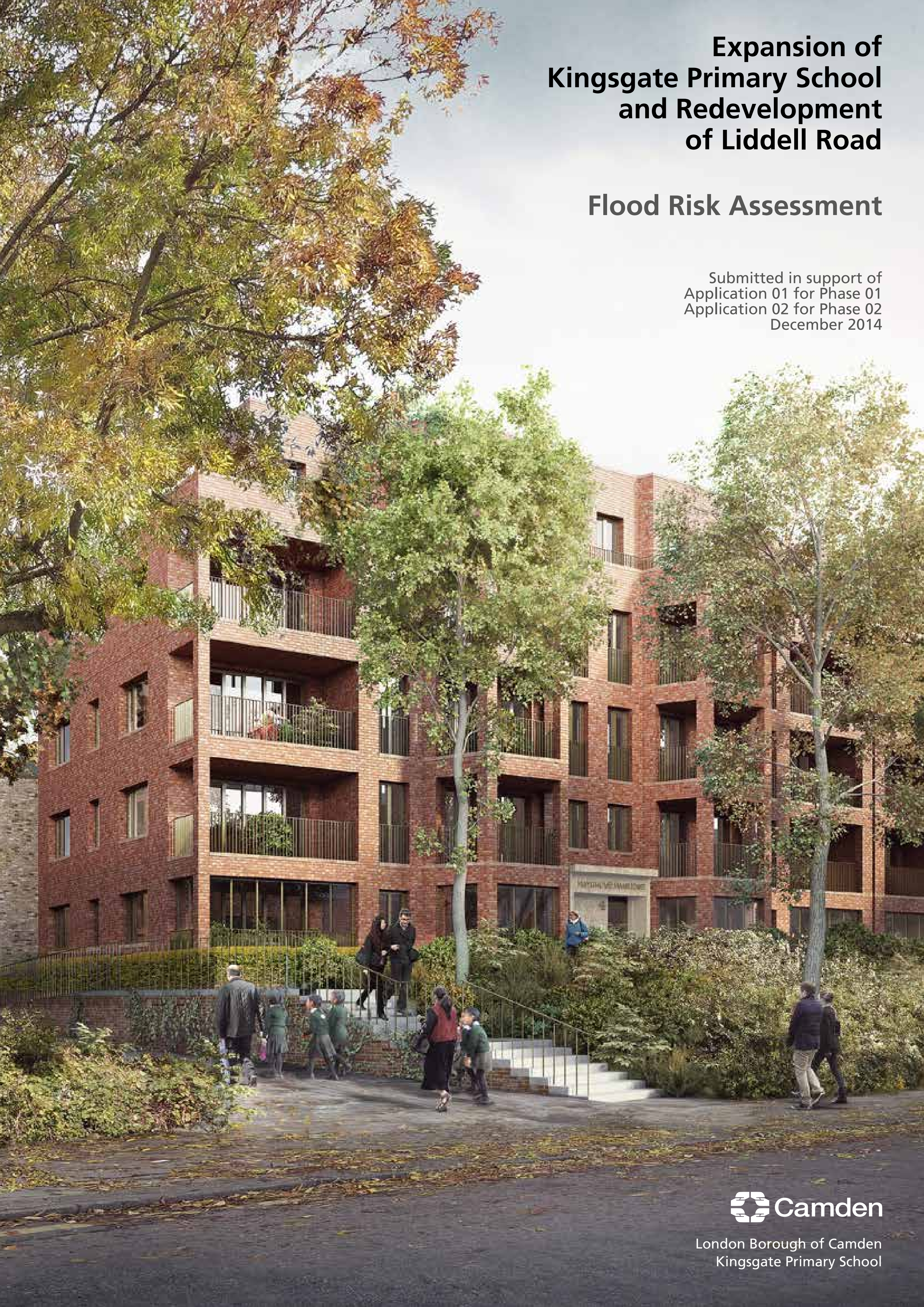
Expansion of Kingsgate Primary School and Redevelopment of Liddell Road

Flood Risk Assessment

Submitted in support of
Application 01 for Phase 01
Application 02 for Phase 02
December 2014



Camden

London Borough of Camden
Kingsgate Primary School

PRICE&MYERS

Expansion of Kingsgate Primary School & Redevelopment of Liddell Road

Flood Risk Assessment

Revision 04

Submitted in support of the Application for Phases 1 and 2

Prepared by: Kirsty Burwood MEng
October 2014
22885
Checked by: Dimitris Linardatos BEng MSc CEng MICE

Revisions

Rev	Date	By	Notes
DRAFT	17/10/14	KB	Draft Report
01	18/11/14	KB	Issue report for planning
02	21/11/14	KB	Issue report for planning
03	26/11/14	KB	Issue report for planning
04	04/12/14	KB	Issue report for planning

Contents

1 Introduction

Price & Myers have been commissioned to undertake a Flood Risk Assessment (FRA) in support of both planning applications for phase 1 and 2 of a proposed mixed use development. The existing industrial units are to be demolished as part of the works

This FRA is prepared in accordance with the National Planning Policy Framework (NPPF), NPPF accompanying Technical Guidance, The North London Strategic Flood Risk Assessment (SFRA) and the London Plan.

This report is based on a desk-top review of published information. The objectives of this FRA are to:

- Identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed (if possible).
- Provide evidence to the local planning authority for the purposes of a sequential test; and
- Establish whether the proposed development will be safe from all sources of flooding.

The location of the proposed site is shown below in Figure 1.

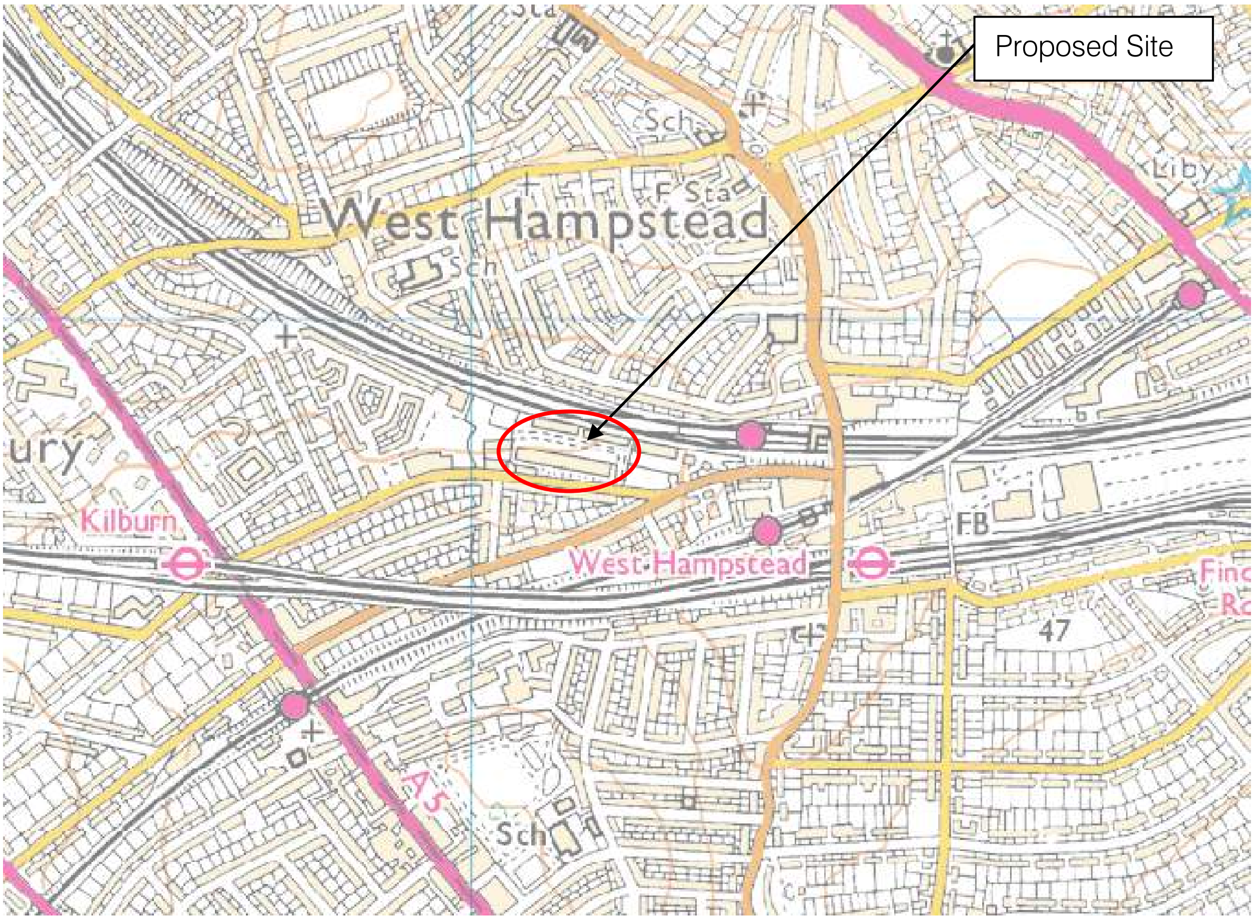


Figure 1 - Site Location (© Environment Agency copyright and database rights 2014. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, License Number 100026380.)

2 Existing Development Site

2.1 Location and Description

The existing industrial estate is located within West Hampstead in the London Borough of Camden. The postcode is NW6 2EW, national grid reference TQ 25129 84794. The location of the existing industrial estate is shown in the figure below.

Figure 2 – Existing Site Imagery © 2014. The GeoInformation Group, Map data © 2014 Google.

The site is bounded by the Thames Link and South Eastern Railway line in the north, an embankment sloping down to Maygrove Road in the South, Maygrove Peace Park in the West and commercial businesses to the East. The site is occupied by two blocks of single storey commercial units in the north and 17 single storey units in the south with associated parking. Liddell Road runs centrally through the site and joins with Maygrove Road in the southeast.

The site is approximately 1.2Ha in size and is set on a slope falling towards the southeast with a difference of levels of up to 4.5m.

2.2 Existing Hydraulic Features

There are no rivers or other water features within 500m of the site as seen in Figure 3.

The Hampstead and Highgate Ponds are approximately 2.5-3.5km to the north east of the site. They were constructed to increase London's water supply and are fed by the River Fleet. The River Fleet is a subterranean river which historically originates from the springs on Hampstead Heath and drains to the River Thames.

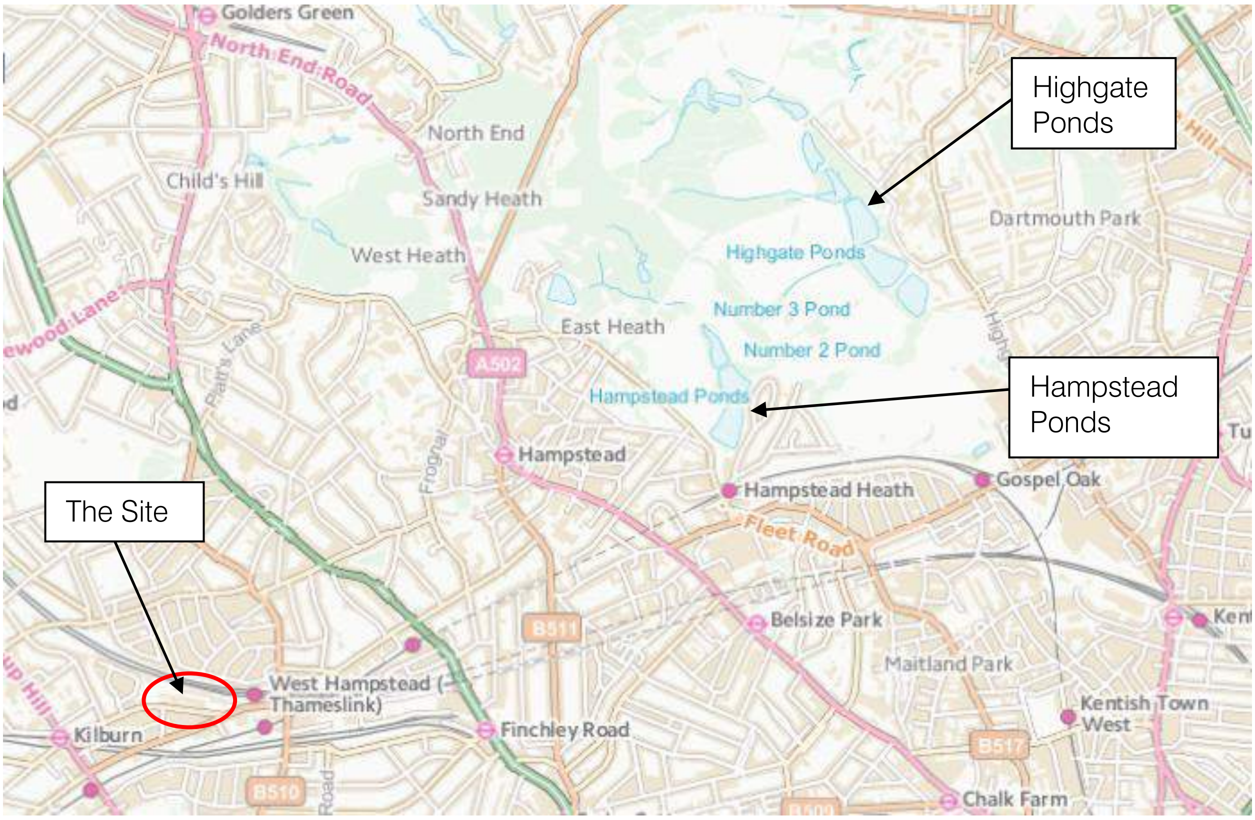


Figure 3 – Existing Watercourses and features © Environment Agency copyright and database rights 2014. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380. Contains Royal Mail data © Royal Mail copyright and database right 2014

2.3 Existing Sewerage Infrastructure

The Thames Water records show that a 305mm diameter combined drainage pipe currently runs from east to west along Maygrove Road to the south of the site. There is also an 1143x787 combined sewer beyond the northwest corner of the site. The Thames Water records can be seen in Appendix A.

Within the site there is a 150mm combined sewer in the east of Liddell Road which discharges to the south into Maygrove Road. This picks up the foul water from the industrial units to the south of Liddell Road and a couple of road gullies. The foul water from the units to the north of Liddell Road is taken to the west of the site where it is thought to discharge to the large combined sewer in the northwest. There is also an existing 400mm diameter concrete surface water pipe which runs from the east along Liddell Road to the west where it exits the site. This sewer picks up the surface water run-off from the buildings and the majority of the road gullies on Liddell Road.

2.4 Geology and Hydrogeology

GEA, Geotechnical & Environmental Associates have carried out a Ground Investigation Study. At the time of writing this report only a Summary of Ground Investigation Preliminary Findings [1] was available.

The report states that varying thicknesses of made ground was found to overlay the London Clay Formation. The made ground generally comprised of a concrete slab over very dark grey and blackish silty very gravelly sand with brick and concrete fragments, frequent coal, ash and rare pockets of clay. It extended to depths of between 2.90 – 4.60m. Below this the London Clay comprised of brown clay with occasional grey markings to depths of between 10.60m and 12.20m, over grey clay which was encountered to the full depth investigated, of 25.00m.

The property is not located within a groundwater source protection zone or groundwater vulnerability zone as shown in Figure 4 below.

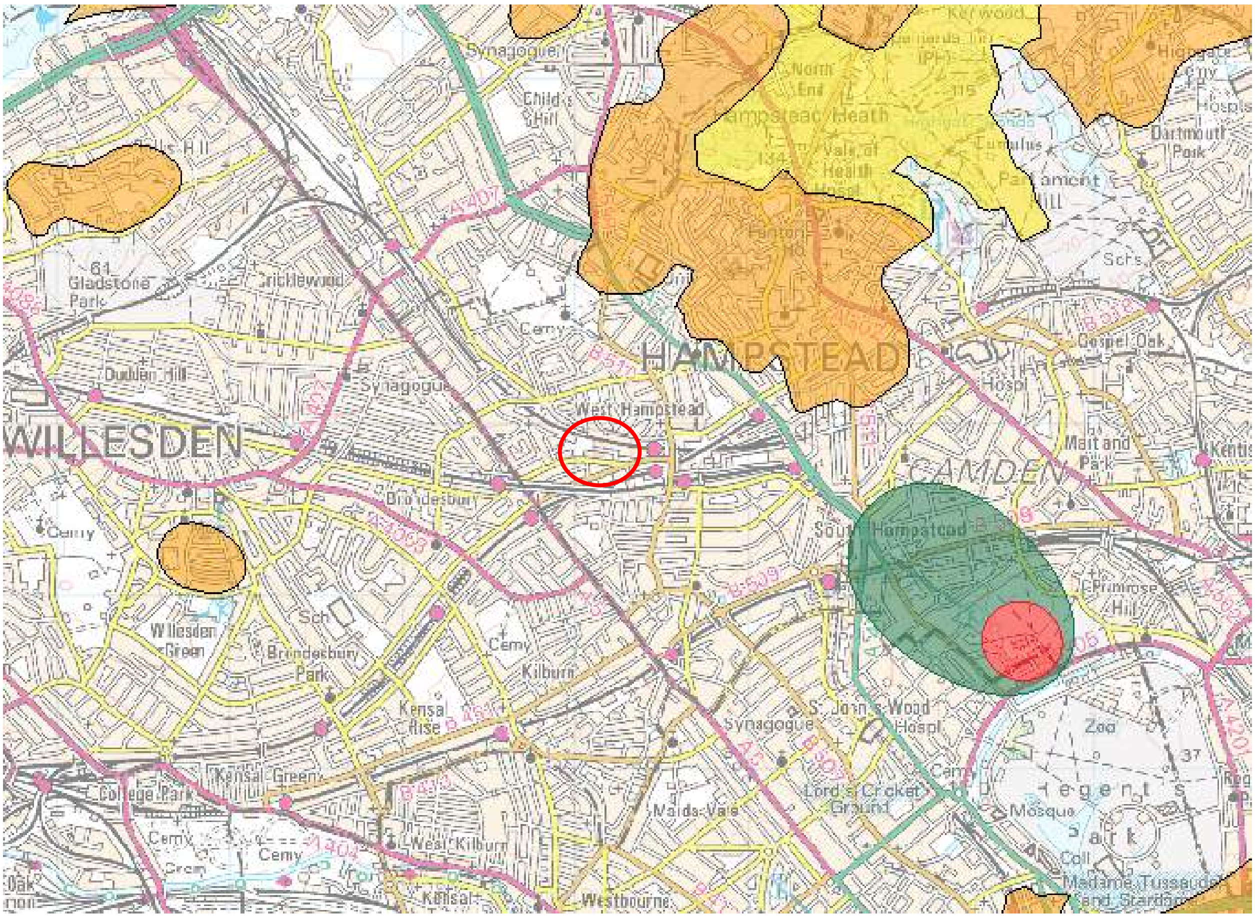


Figure 4 – Groundwater source protection zones and groundwater vulnerability zones. Existing Watercourses © Environment Agency copyright and database rights 2014. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380. Contains Royal Mail data © Royal Mail copyright and database right 2014

3 Development Proposals

The proposed mixed-use development will comprise of a school, employment and residential units with two vehicular accesses.

A master plan produced by Maccreanor Lavington Architects can be found in Appendix B.

The development has been split into two phases and a separate planning application has been submitted for each. This report supports both phases. Drawings showing the boundary of each phase can be found in Appendix B.

4 Flood Risks

The following possible sources of flooding will be considered for this site:

- Rivers and/or Sea
- Groundwater
- Sewers and Overland flow

4.1 Flood Risk from Rivers and/or the Sea

The Environment Agency's (EA) indicative flood outline map, shown below in Figure 5, shows that the site is not at risk of flooding from rivers.

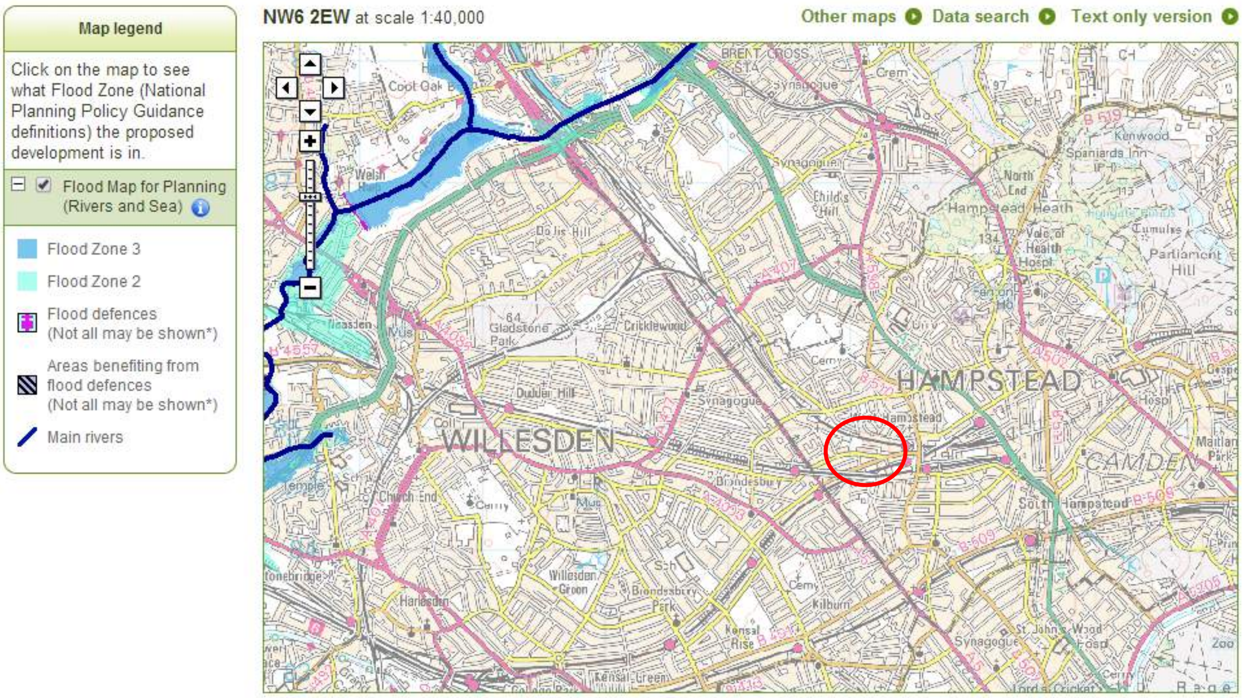


Figure 5 - Flood Map for Flooding from Rivers and the Sea © Environment Agency copyright and database rights 2014. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380. Contains Royal Mail data © Royal Mail copyright and database right 2014

The two small reservoirs on Hampstead Heath are considered to present a low risk to the site as seen in Figure 6.

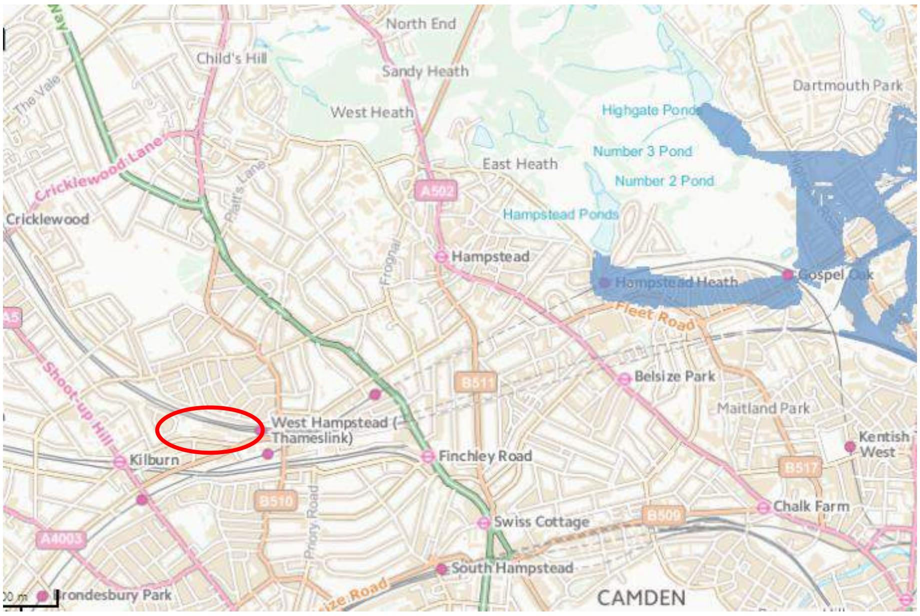


Figure 6 - Flood Map for Flooding from Reservoirs © Environment Agency copyright and database rights 2014. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380. Contains Royal Mail data © Royal Mail copyright and database right 2014

4.2 The Sequential and Exception Tests

The Sequential Test is to be carried out during the planning process. It aims to ensure that preference for developable land is given to land that has the lowest risk of flooding, based on the data available. The test begins by determining the system of 'Flood Zoning', a system that assesses the risk posed by rivers and in coastal areas; estuaries and the sea. This information is made available by the EA and the LPA. The flood zoning system in England is described in Table 1 below.

Flood Zone	Definition
Zone 1 Low Probability	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding (<0.1%)
Zone 2 Medium Probability	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.
Zone 3a High Probability	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Zone 3b Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment 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.

Table 1 - Flood Zone Descriptions from the Framework [2]

The aim of the Sequential Test is to propose development in land which lies within Zone 1, prior to developing in high risk Zones 2, 3a and 3b. It also considers the vulnerability of the site to flooding when considering developments within the higher risk flood zones. See Table 2 for the flood risk vulnerability and flood zone compatibility table used. Land uses which are more vulnerable to flooding should be constructed in lower flood risk zones.

Flood risk vulnerability classification		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b	Exception Test required	✓	×	×	×

Table 2 - Flood Risk Vulnerability & Flood Zone Compatibility [3]

The school and residential uses of the proposed development are classified as "more vulnerable" whilst the rest is classified as "less vulnerable". The EA's map confirms that the site is within Flood Zone 1. Table 2 confirms that the proposed development is suitable in Zone 1 and the Exception Test is not required.

4.3 Groundwater Flood Risk

Flooding can occur in locations where groundwater naturally exists at shallow depths. Prolonged periods of rainfall can result in elevated groundwater levels that may reach the surface. This can pose a flood risk, particularly for basements and cellars. Elevated groundwater can prevent infiltration occurring and could promote the occurrence of overland flow. In addition, groundwater could leak into existing surface water drainage systems that have poor integrity, reducing their ability to accommodate surface water runoff.

The SFRA [4] states that very few groundwater flooding records have been provided by the EA, none of which have occurred within the London Borough of Camden, as seen in Figure 7. During the site investigation groundwater was encountered at a single location within the made ground at a depth of 4.75m, rising to 4.44m following drilling after an hour.

Considering the above and the fact the proposals do not include any basements or lower ground floors, the flood risk from groundwater is considered low.

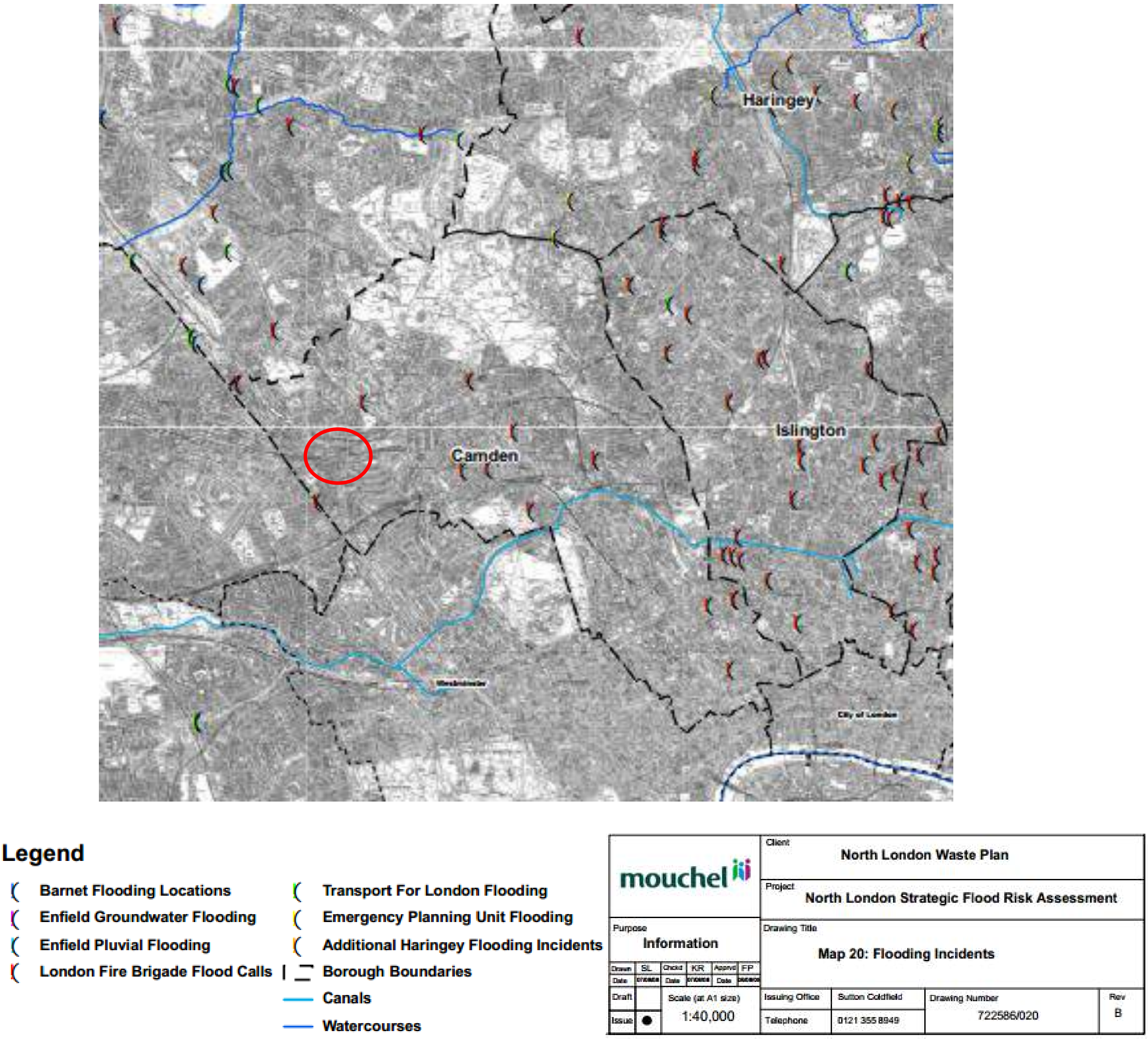


Figure 7 – Map of Groundwater Flooding Incidents

4.4 Sewers and Overland Flow Flood Risk

Sewer systems in London are often very old, and are sometimes only designed to convey storms of relatively low return periods such as a 1 in 10 year rainfall event. As a result sewer flooding events can often be frequent but with smaller consequences than 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.

Thames Water have provided information on sewer flooding by truncated postcode over the last 10 years, the results of which can be seen in Figure 8.

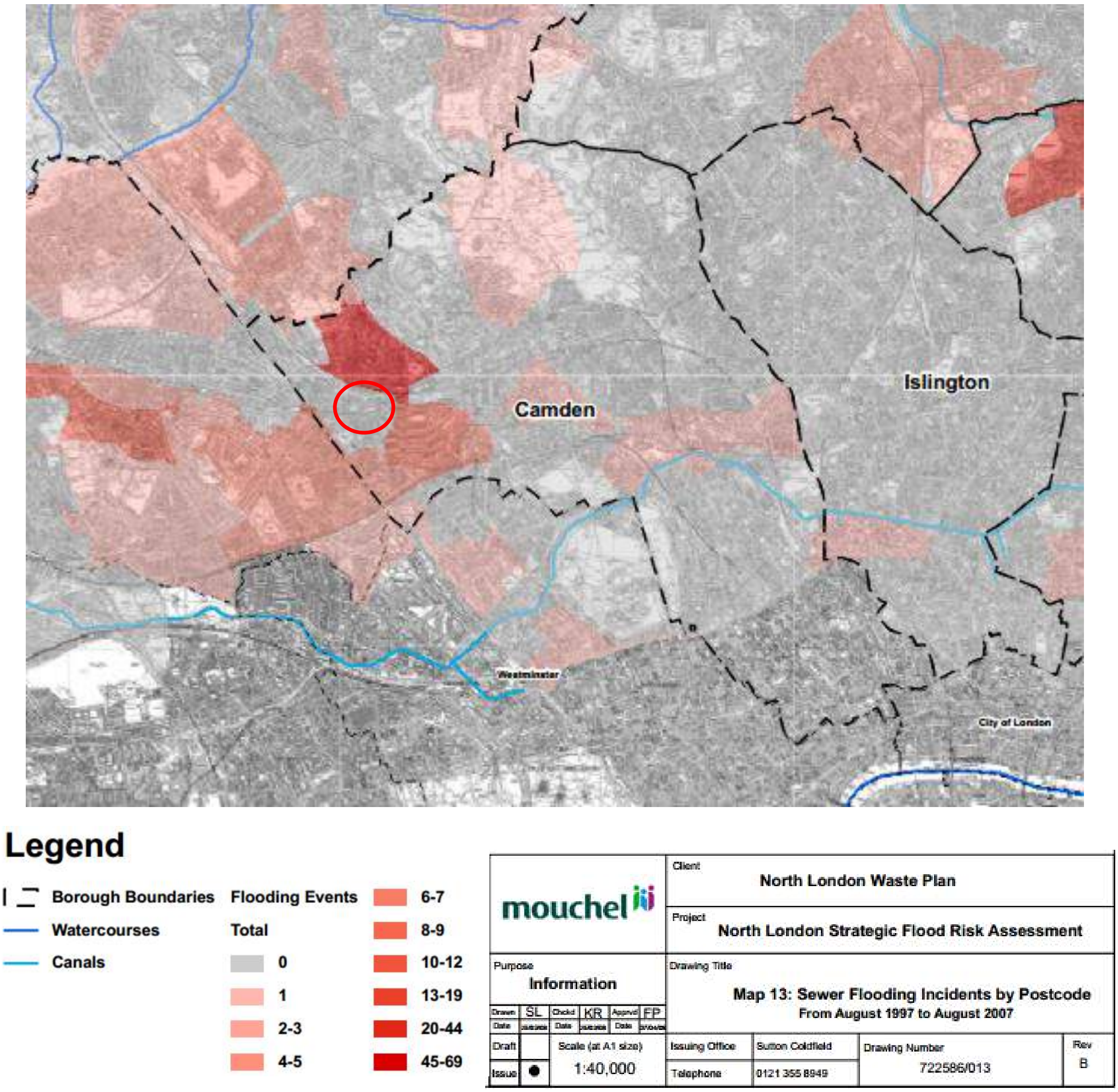


Figure 8 – Sewer Flooding Incidents

As can be seen the site is located outside of a postcode where sewer flooding has been reported. The postcode immediately to the north of the property has suffered from a large number of incidents.

In August 2002 there were some serious floods in the London Borough of Camden. It inflicted considerable damage on some Camden residents and their homes, public services and facilities, and private businesses. High rainfalls levels and flood events are a recurring feature in Camden due to the nature of summer thunderstorms and the topography of Hampstead. It has been found that there are similarities between these floods and those that hit Camden in 1975.

The flood event on the 7th August 2002 was caused by excessive rainfall causing the main sewer system to become completely inundated. The surcharge pressure forced the water to back onto the streets through manholes and gully gratings and into residents' homes at basement and ground floor level. Thames Water's confirmed that the flooding was caused by its sewer system reaching maximum capacity very quickly so that surface water could not be drained at the rate as the rain fell. The map in Figure 9 shows the roads affected by flooding during the August 2002 floods.

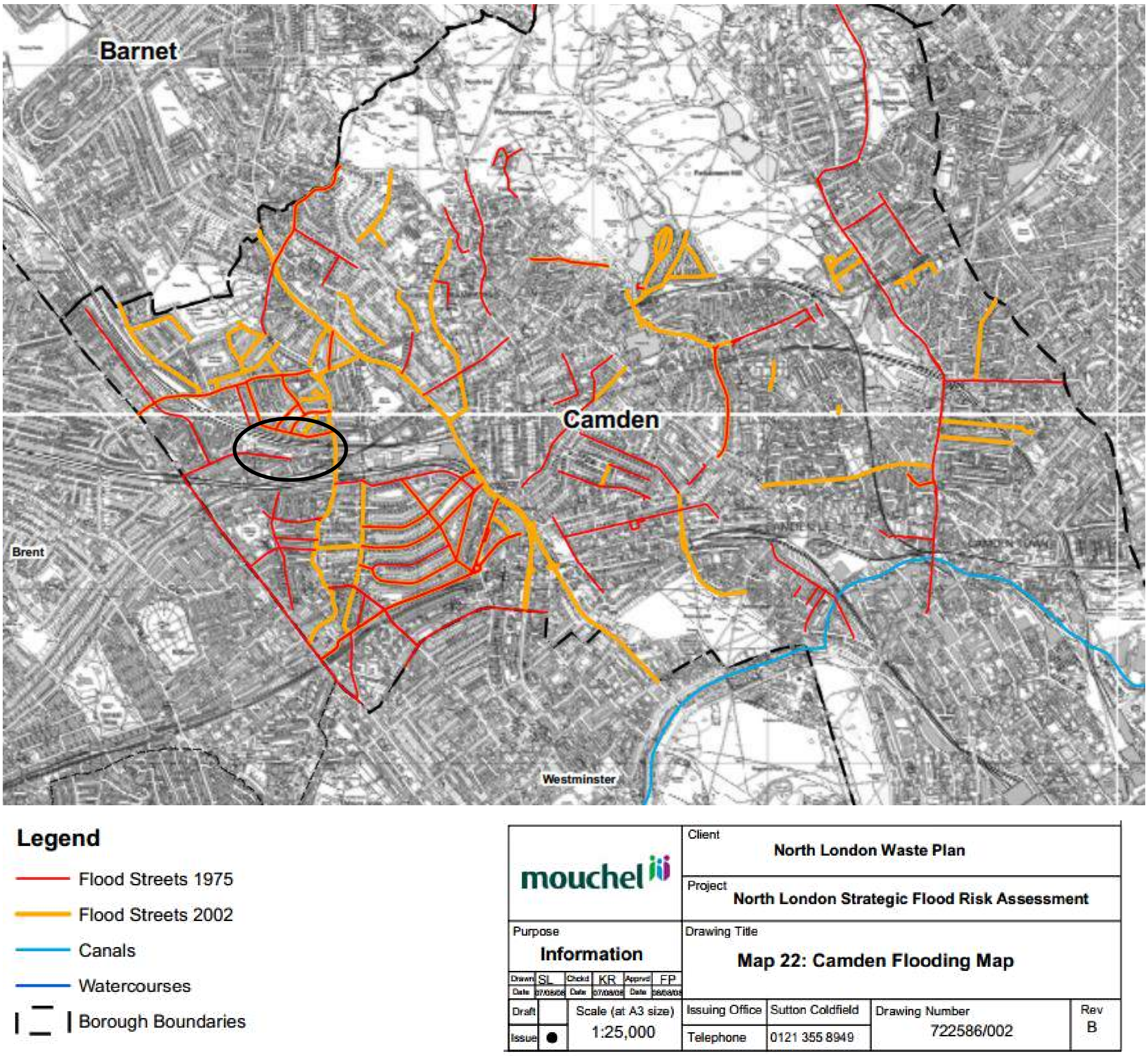


Figure 9 – Camden Flooding Map [4]

Figure 8 and Figure 9 show reasonable correlation although the Camden floods appear to be more widespread in Figure 8 than in the Thames Water records. This can be attributed to the fact that some of the properties flooded in 2002 will not be included on the Thames Water database unless they flood twice in ten years. The road to the south of the development, Maygrove Road appears to have flooded in 1975, but not in the 2002 floods.

Figure 10 below shows the levels of the surrounding area where it can be seen that the levels fall from north to south. Within the site the levels falls towards the south east with a change in level of up to 4.5m. During intense rainfall events the water should flow away from the site therefore not causing flooding within the development.

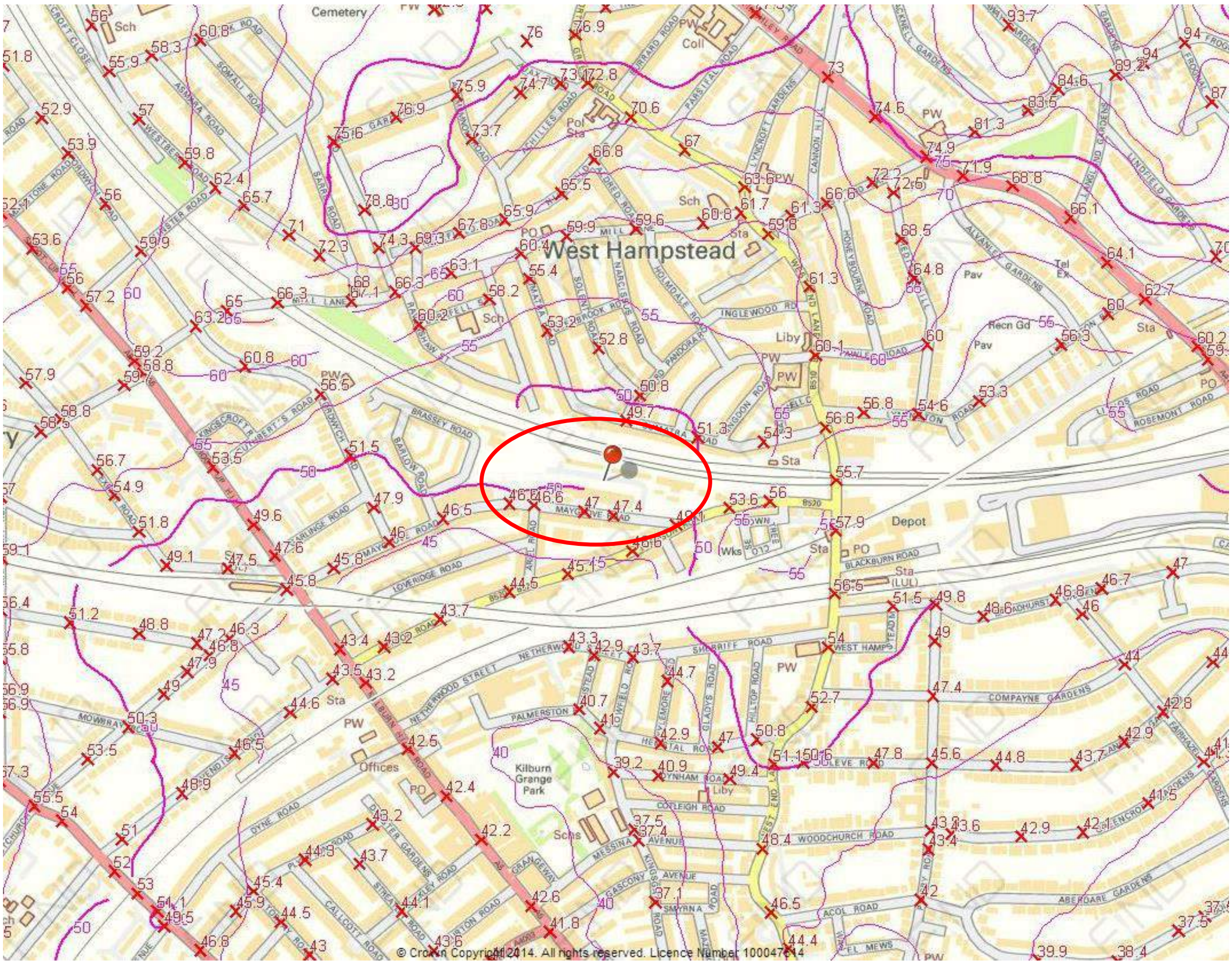


Figure 10 - Surrounding Area Topography (1:7000) Findmaps.co.uk Professional Mapping Intelligence © Crown Copyright 2014. License Number 100047514.

Taking the above into consideration it can be concluded that the site is at a low risk of flooding from sewer failure and overland flow as it is not within a valley, where overland flows will be collected during a storm event which can cause localised flooding. It is however important to ensure there is sufficient discharge capacity and that flood risk is not increased due to the development proposals.

The EA's surface water flood map, shown in Figure 11, also shows that the risk is low in this area. Overland flows will be maintained within the road channels and will flow downstream without affecting the surrounding areas.

Figure 11 – Risk of Flooding from Surface Water © Environment Agency copyright and database rights 2014. © Ordnance Survey Crown copyright. All rights reserved. Environment Agency, 100026380. Contains Royal Mail data © Royal Mail copyright and database right 2014

5 Run-off Assessment

As discussed in section 2 the existing surface water drainage exits the site in two different locations: into a combined sewer in the southeast and in a surface water sewer to the west.

5.1 Existing Run-off

The topographical survey drawing of the site shows that the impermeable area currently covers about 87% of the total site (10,480m^2). The total run-off rate was estimated for the 1 in 100 year storm event using the modified rational method, as shown below.

Q_{100} = 2.78 x A x i

Where

A = Catchment area (Ha)
i = Rainfall intensity (mm/hr)

Q_{100} = 2.78 x 1.048 x 107.183 = 312 l/s

Of this approximately 450m^2 of surface water can be seen to connect into the combined sewer in Maygrove Road. The existing discharge of which has been calculated below.

Q_{100} = 2.78 x 0.045 x 107.183 =13.4 l/s

The rest of the site discharges into the large surface water sewer which is taken off to the west of the site. It is unknown where this discharges into the Thames Water sewer. The utility survey can be seen in Appendix C.

5.2 Proposed Run-off

In accordance with the London Plan, EA guidelines, Building Regulations and Water Authorities advice the preferred means of surface water drainage for any new development is into a suitable soakaway or infiltration drainage system. Sustainable Drainage Systems (SUDS) can reduce the impact of urbanisation on watercourse flows, ensure the protection and enhancement of water quality and encourage recharge of groundwater in a manner that mimics natural conditions. If drainage to an infiltration system proved to be an unsuitable option for the site then drainage to public sewers will be assessed. Drainage to the public sewers can be considered only when all other options proved unsuitable.

The ground within the site is not suitable for accommodating infiltration systems as it is made ground underlain with London Clay. The proposed development will be reducing the amount of hardstanding area to approximately 83%. The proposed run-off for a 1 in 100year storm with 30% climate change has been calculated below.

$Q_{100+30\%}$ = 2.78 x 1.0 x 139.338 = 387 l/s

The London Plan requires attenuation to Greenfield run-off rates from new developments. Using the online “Greenfield Run-off Estimation for sites” the allowable discharge limit for the site based on the FEH method has been calculated as 14.97l/s for a 1 in 100 year storm with a 30% allowance for climate change. The summary sheet for this calculation can be found in Appendix D.

Preliminary calculations using MicroDrainage software, available in Appendix E, show that a storage volume of approximately 560m^3 must be provided in order to attenuate surface water from the site to the Greenfield run-off rate.

The surface water is proposed to discharge in two locations, with an outfall for each phase.

Phase 1 (Planning Application 1)
The school which is the north/northeast of the site will discharge into Maygrove Road in the southeast of the site. The school takes up approximately 50% of the site, therefore a similar proportion of the allowable surface water run-off will discharge at this location. This calculation can be found in Appendix E.

It is proposed that the schools playground surfacing, will utilise permeable paving in order to attenuate the surface water run-off to the discharge limit. Preliminary calculations have been carried out and show that there is a sufficient area of paving available to be made porous. The site falls at around 1:80 and will require a depth of approximately 650mm of type 3 material to provide sufficient attenuation. Other sustainable drainage systems (SuDS), such as ponds and rain gardens, have been proposed as part of the landscape design. Their storage capacity will be developed during the detailed design stage, thus allowing a reduction in the depth of permeable fill.

Phase 2 (Planning Application 2)
The remaining 50% of the site will discharge into Maygrove Road in the south of the site. This area will require approximately 350m^3 of storage. This calculation can also be found in Appendix E. This can be provided through the use of a number of SuDS, which will be determined during the detailed design stage:

- Cellular attenuation tank
- Linear planting strips
- Stockholm tree planting
- Permeable paving

6 Conclusions and Recommendations

The key flood risk conclusions and how they are to be managed are as follows:

- River and/or Sea
    - The site lies within Flood Zone 1 where there is less than 1 in 1000 annual probability of river or sea flooding (<0.1%).
    - The proposed mixed use development is classified as more vulnerable within the flood risk vulnerability classification. These are appropriate within Flood Zone 1.
- Groundwater
    - Groundwater is assumed to be deep.
    - The proposals will not affect the local hydrogeology. Therefore the proposed development will not increase the flood risk from groundwater on site or the surrounding areas.
    - The likelihood of groundwater emerging from the ground is considered to be very low.
    - Excavations must be made safely with due regard to ground water.
- Sewers and Overland Flow
    - The levels in the surrounding area fall from north to south therefore overland flow generated by the proposed development site or adjacent sites should flow away from the development.
    - In 2002 there were some extreme flood events in Camden due to the failure of the sewer network. The site was unaffected by these floods.
    - The site is at low risk of flooding from sewer failure and overland flow.
    - Consultation should continue with Thames Water regarding the proposed discharge into the existing sewer.
- Proposed Discharge
    - The overall existing surface water discharge from the site is 312 l/s
    - The surface water from the proposed development will be attenuated to meet the Greenfield Run-off Rate.

It can be concluded that the proposed mixed use development will not adversely affect onsite or neighbouring properties or their residual flood risk. This report has not identified any significant risks that should prevent the re-development of the site.

It is recommended that during the detailed design stage:

- Existing drainage infrastructure is confirmed; and
- Existing and proposed discharges allowances are confirmed.

7 References

[1] Summary of Ground Investigation Preliminary Findings, GEA, Revision no. 1, August 2014.

[2] National Planning Policy Framework, Department for Communities and Local Government, March 2012. http://www.nationalarchives.gov.uk/doc/open-government-licence/

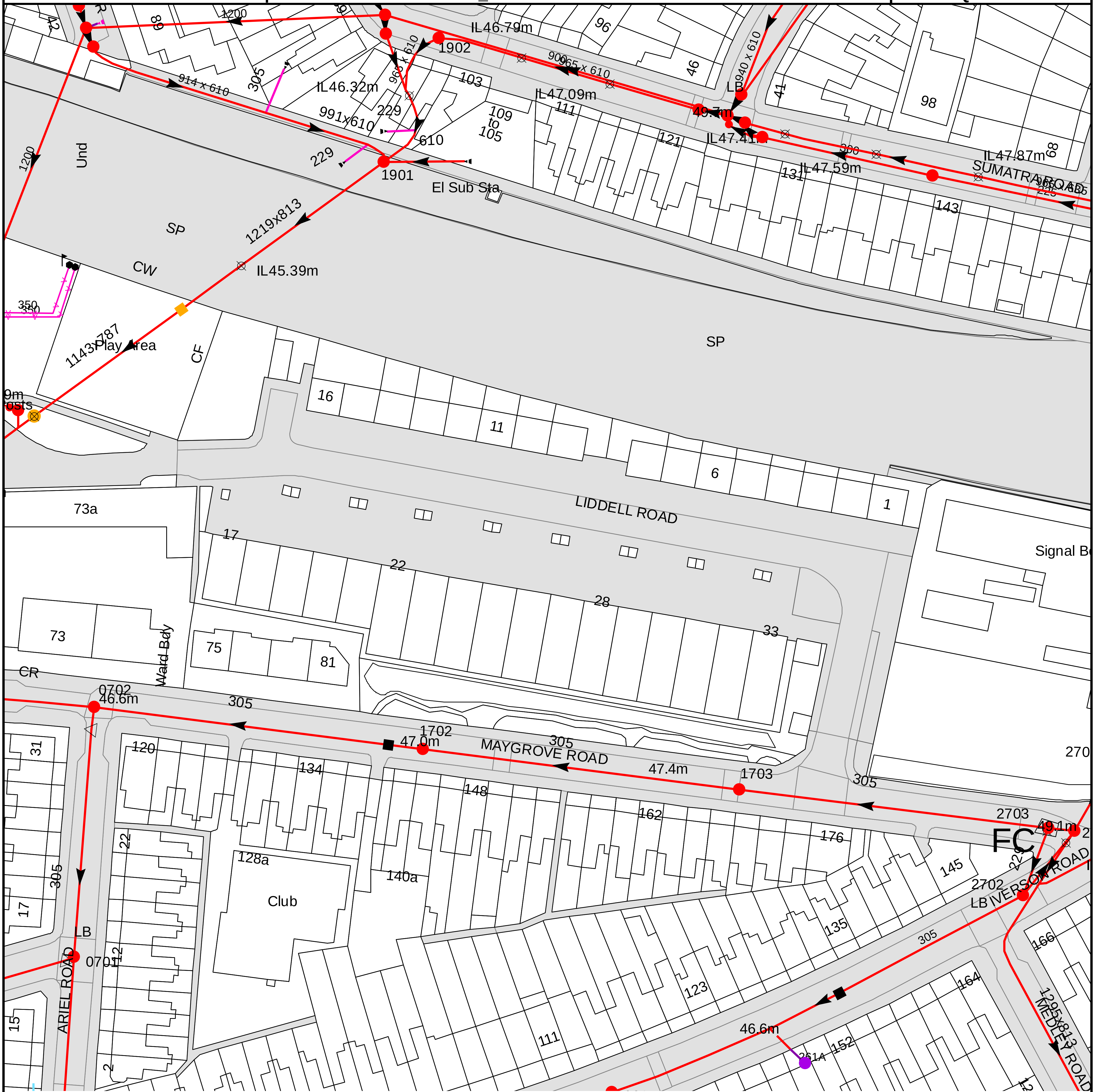
[3] Technical Guidance to the National Planning Policy Framework, Department for Communities and Local Government, March 2012 http://www.nationalarchives.gov.uk/doc/open-government-licence/

[4] North London Strategic Flood Risk Assessment (SFRA), Final Report. Mouchel, August 2008

[5] The London Plan, Spatial Development Strategy for Greater London. Greater London Authority, July 2011.

APPENDIX A – Existing Thames Water Records

Asset Location Search Sewer Map - ALS/ALS Standard/2013_2435446	TQ2584NW



The width of the displayed area is 254m and the centre of the map is located at OS coordinates 525144,184813

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

APPENDIX B – Masterplan

KEY

- Existing tree
- Proposed tree
- Porous Tarmac
- Existing vegetation
- Proposed planting
- Bonded rubber mulch softplay surface
- Wetpour softplay surface
- Permeable resin-bond surface
- Linear concrete slabs
- Grass mown/ wildflower meadows
- Loose gravel
- Concrete patio paving

N

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Notes

- Do not scale from drawings.
- To be read in conjunction with all relevant Architects', Services and Structural Engineers' drawings.
- All existing site, tree and building information has been compiled from different sources.
- All dimensions to be checked on site.

Revisions

Project Kingsgate Liddell

Project No. KL037

Revision D

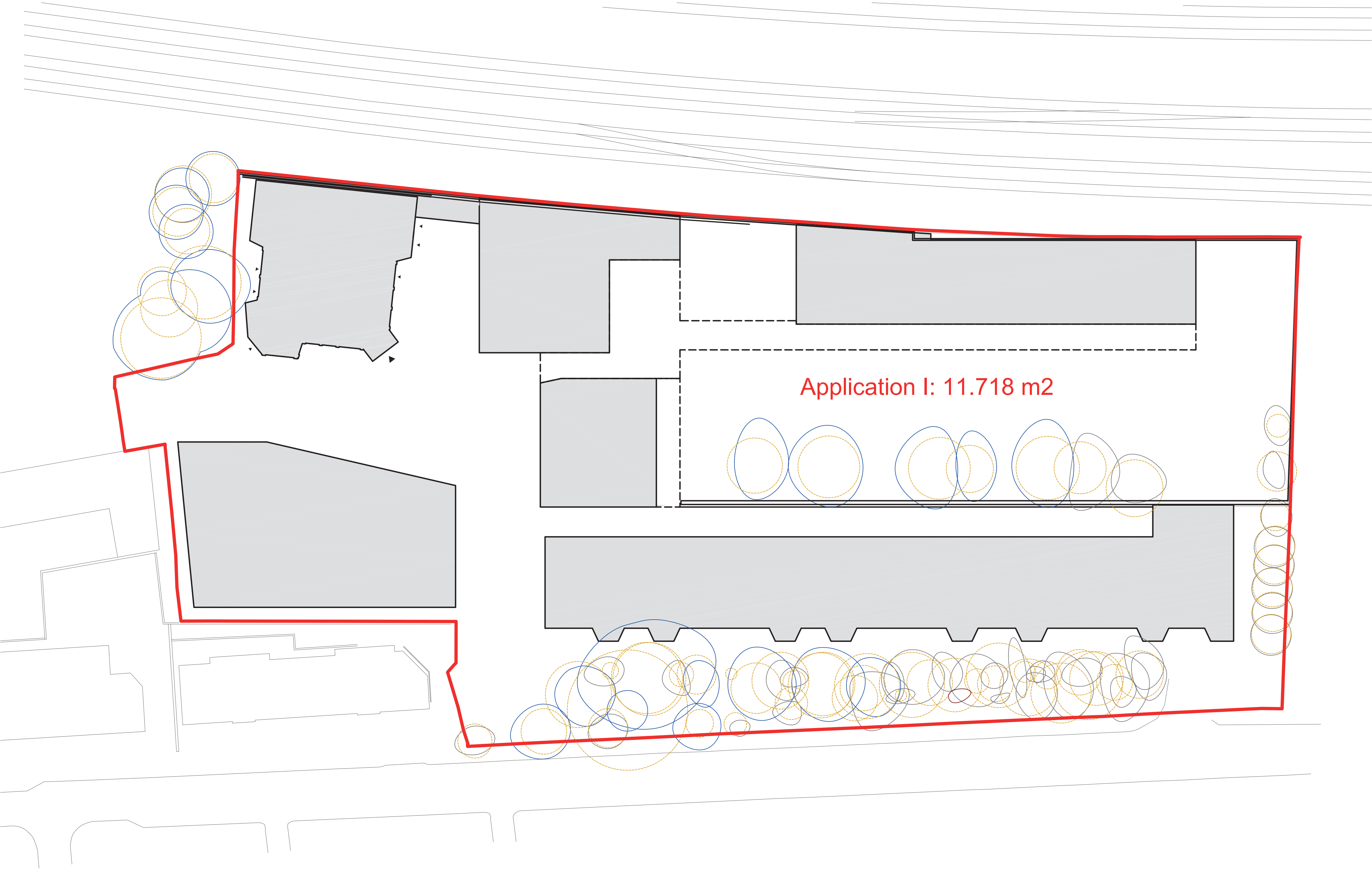
Client London Borough of Camden

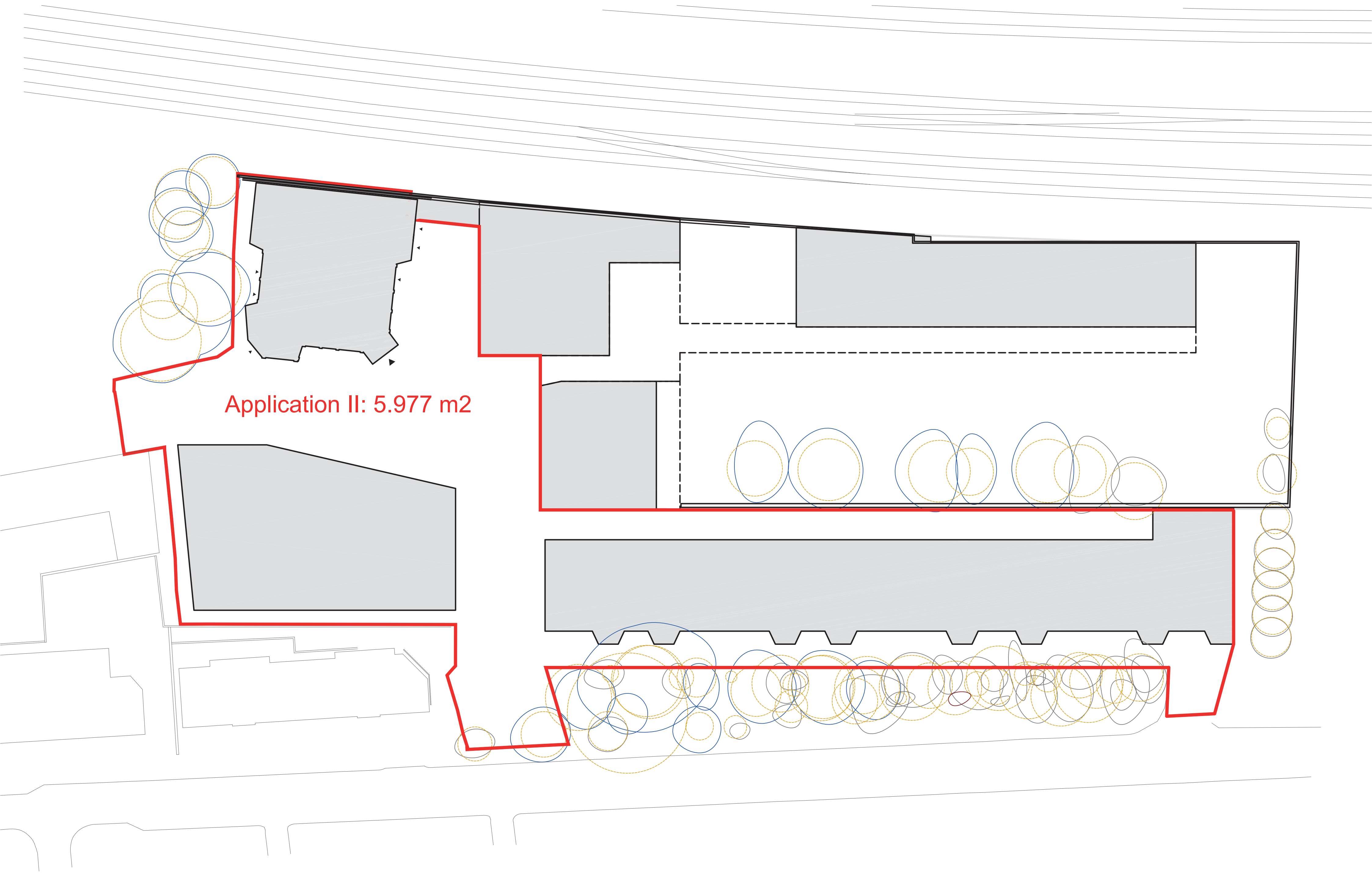
Date 20 November 2014

Scale 1:250 @ A1

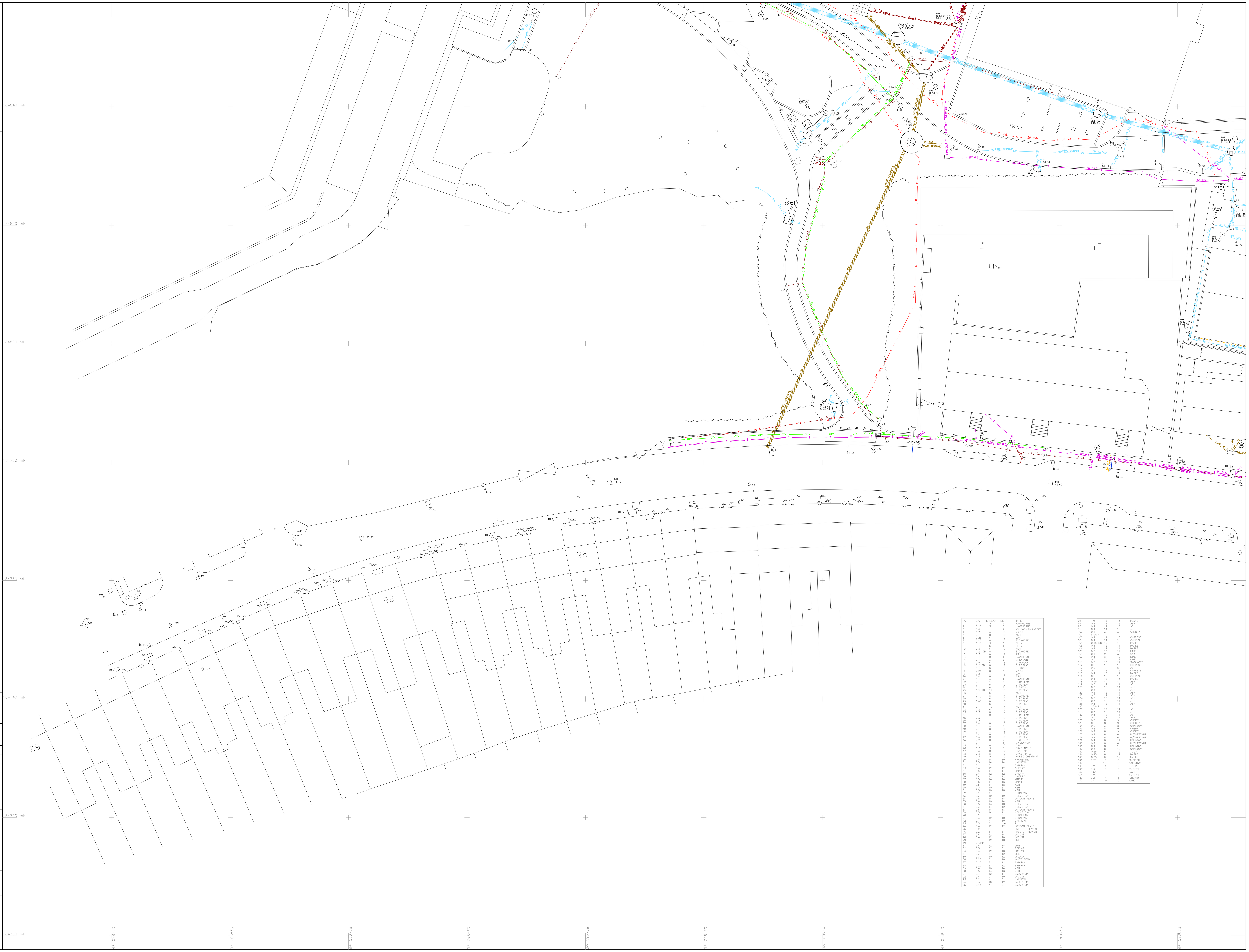
Drawing Name. Stage D: Landscape plan

Dwg No. KL037.D.01.LP.RevD


Application I: 11.718 m2


Application II: 5.977 m2

APPENDIX C – Utility Survey



LEVEL NOTE.

ALL CO-ORDINATES RELATE TO THE ORDNANCE SURVEY GRID AND DATUM VIA GPS OBSERVATIONS.

UNDERGROUND SERVICES LEGEND

- EL — ELECTRICAL LIGHTING CABLE
- TL — TRAFFIC LIGHTING
- T — TELECOM CABLE
- CTV — TELEVISION CABLE
- W — WATER PIPE
- G — GAS PIPE
- O — OIL PIPE
- U — UNKNOWN SERVICE
- CABLE — CABLES UNKNOWN
- ED — EMPTY DUCTS
- FO — FIBER OPTIC
- SW — SURFACE WATER
- FW — FOUL WATER
- CM — COMBINED SEWER
- DP0.80 — BUND OF CABLES
- CHAMBER

NOTES

Depth values on drainage is to the top of the pipe.
Depth value on all other services is to the centre.
The location and/or identification of a service will not necessarily indicate whether it is live or dead.
The fact that a service has not been located or identified does not necessarily imply that it does not exist or is dead, however their presence should be anticipated.
Before mechanical plant is used, the actual position of mains and services must be established and verified on site.

SHEET LAYOUT

3	4
1	2

All underground services information shown on this plan cannot be guaranteed and users should satisfy themselves of the type, size and route before commencing work on site.
Tree types shown on this drawing cannot be guaranteed and if critical should be verified by an arboriculturist.
Tree spreads and diameters are averages unless otherwise indicated.
This plan has been produced for the client detailed below or their appointed agent to an agreed specification and defines the limit of APR Services liability

ISO 9001 :2008 certificate no A4047

THE SURVEY ASSOCIATION

Revisions	Date

Date MAY 2014	Drawn JM
Scale A0@ 1:200	Checked ASB
Dwg. No.914153 U1	Job No. 914153

Client

LONDON BOROUGH OF CAMDEN

Dwg. Title

UNDERGROUND SERVICES SURVEY

Project Title

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WEST HAMPSTEAD

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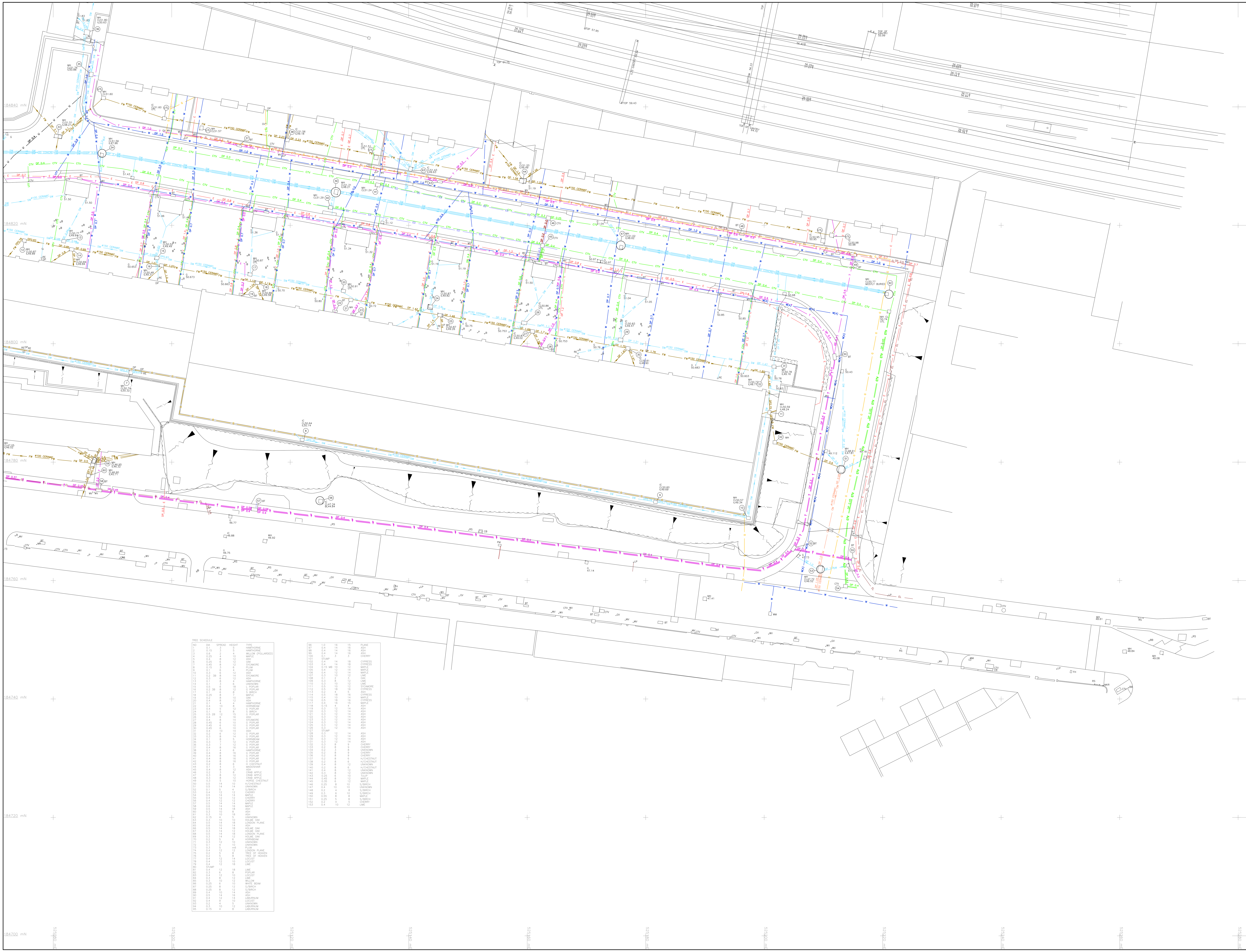
www.aprservices.net
Area Offices in:
Salisbury and Plymouth



ABBREVIATIONS

LEVEL NOTE:
ALL CO-ORDINATES RELATE TO THE ORDNANCE SURVEY GRID AND DATUM VIA GPS OBSERVATIONS.

COORDINATE SCHEDULE

STN	EASTINGS	NORTHINGS	LEVEL
202	525085.856	184838.018	51.684
204	525133.635	184828.364	51.346
205	525157.437	184814.364	51.236
206	525172.846	184811.574	51.111
207	525192.567	184809.648	50.882
208	525213.212	184813.636	50.831
209	525211.595	184791.092	50.169
210	525215.123	184749.252	47.712
211	525185.540	184763.205	47.462
212	525147.957	184756.757	47.133
213	525109.753	184773.071	46.966
214	525068.846	184767.987	46.752
215	525022.374	184774.777	46.552
216	525003.253	184784.190	46.546
217	524966.742	184772.367	46.401
218	524910.435	184768.532	46.489
219	524882.128	184758.457	46.401
220	524869.422	184788.784	48.188
221	524882.276	184805.506	49.531
222	524915.547	184820.964	51.675
223	524932.274	184838.079	52.043
224	524946.282	184874.238	52.804
225	524976.238	184864.221	52.364
226	525016.624	184845.125	51.886
227	525043.453	184832.979	51.801
301	525083.947	184829.687	51.463
401	525096.459	184825.217	51.558

UNDERGROUND SERVICES LEGEND

BLK	BLOCKED
UTT	UNABLE TO TRACE
DP0.50	DEPTH BELOW SURFACE (METERS)
ø250	DIAMETER OF PIPE IN MM.
D-U	DEPTH UNKNOWN
(R)	FROM RECORDS
(A)	ASSUMED RUN
E	ELECTRICITY CABLE
EL	ELECTRICAL LIGHTING CABLE
TL	TRAFFIC LIGHTING
T	TELECOM CABLE
CTV	TELEVISION CABLE
W	WATER PIPE
G	GAS PIPE
O	OIL PIPE
U	UNKNOWN SERVICE
CABLE	CABLES UNKNOWN
ED	EMPTY DUCTS
FO	FIBER OPTIC
SW	SURFACE WATER
FW	FOUL WATER
CM	COMBINED SEWER
DP0.80	BUND OF CABLES
	CHAMBER

NOTES
Depth values on drainage is to the top of the pipe.
Depth value on all other services is to the centre.
The location and/or identification of a service will not necessarily indicate whether it is live or dead.
The fact that a service has not been located or identified does not necessarily imply that it does not exist or is dead, however their presence should be anticipated.
Before mechanical plant is used, the actual position of mains and services must be established and verified on site.

SHEET LAYOUT

TREE SCHEDULE

NO	DIA	SPREAD	HEIGHT	TYPE
1	0.1	3	5	HAWTHORNE
2	0.15	3	5	HAWTHORNE
3	0.6	2	4	WILLOW (POLLARDED)
4	0.25	4	10	MAPLE
5	0.4	8	12	ASH
6	0.25	6	12	OAK
7	0.45	8	12	SYCAMORE
8	0.15	3	6	PLUM
9	0.1	6	4	PLUM
10	0.3	6	12	ASH
11	0.2 3B	8	14	SYCAMORE
12	0.3	6	12	ASH
13	0.1	8	4	HAWTHORNE
14	0.1	3	6	UNKNOWN
15	0.5	6	18	L POPLAR
16	0.2 3B	8	12	G POPLAR
17	0.1	6	8	S BIRCH
18	0.25	8	7	MAPLE
19	0.2	8	10	OAK
20	0.4	8	12	ASH
21	0.1	4	4	HAWTHORNE
22	0.4	10	8	HORNBEAM
23	0.4	5	12	G POPLAR
24	0.1	6	8	S BIRCH
25	0.5 2B	12	15	G POPLAR
26	0.4	6	16	ASH
27	0.4	8	14	SYCAMORE
28	0.45	6	10	G POPLAR
29	0.45	6	10	G POPLAR
30	0.45	6	10	G POPLAR
31	0.4	10	14	ASH
32	0.2	6	12	G POPLAR
33	0.3	8	14	G POPLAR
34	0.1	8	5	HORNBEAM
35	0.3	7	12	G POPLAR
36	0.3	7	12	G POPLAR
37	0.4	8	16	G POPLAR
38	0.1	4	6	HAWTHORNE
39	0.4	8	16	G POPLAR
40	0.4	8	16	G POPLAR
41	0.4	8	16	G POPLAR
42	0.4	8	16	G POPLAR
43	0.2	8	6	H CHESTNUT
44	0.1	4	3	MAIDENHAIR
45	0.4	8	12	ASH
46	0.2	3	8	CRAB APPLE
47	0.3	8	12	CRAB APPLE
48	0.3	8	12	CRAB APPLE
49	0.3	5	10	HORSE CHESTNUT
50	0.5	14	10	H/CHESTNUT
51	0.5	14	14	UNKNOWN
52	0.1	5	4	S/BIRCH
53	0.4	12	12	CHERRY
54	0.5	14	14	MAPLE
55	0.4	12	12	CHERRY
56	0.4	12	12	CHERRY
57	0.5	14	14	MAPLE
58	0.6	14	16	MAPLE
59	0.5	14	18	ASH
60	0.3	10	8	ASH
61	0.3	10	18	ASH
62	0.15	4	5	UNKNOWN
63	0.3	10	10	HOLME OAK
64	0.5	14	18	LONDON PLANE
65	0.6	10	14	ASH
66	0.5	14	18	HOLME OAK
67	0.3	14	12	HOLME OAK
68	0.5	14	18	LONDON PLANE
69	0.3	14	12	HOLME OAK
70	0.2	5	6	HORNBEAM
71	0.3	12	10	UNKNOWN
72	0.1	4	10	UNKNOWN
73	0.3	5	m6	PLUM
74	0.4	12	12	LONDON PLANE
75	0.2	5	8	TREE OF HEAVEN
76	0.2	5	8	TREE OF HEAVEN
77	0.4	12	14	LOCUST
78	0.4	12	10	LOCUST
79	0.4	12	18	LIME
80	STUMP			
81	0.4	12	18	LIME
82	0.3	6	8	POPLAR
83	0.4	12	10	LOCUST
84	0.3	8	12	LIME
85	0.3	10	12	WILLOW
86	0.25	6	10	WHITE BEAM
87	0.25	8	12	S/BIRCH
88	0.25	8	12	S/BIRCH
89	0.4	10	14	ASH
90	0.5	14	16	ASH
91	0.4	12	14	LABURNUM
92	0.4	9	10	LOCUST
93	0.2	4	5	UNKNOWN
94	0.3	10	12	LABURNUM
95	0.15	4	8	LABURNUM

TREE SCHEDULE (continued)

NO	DIA	SPREAD	HEIGHT	TYPE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ISO 9001:2008

THE SURVEY ASSOCIATION

Revisions	Date
Date MAY 2014	Drawn JM
Scale A0@ 1:200	Checked ASB
Dwg. No.914153 U2	Job No. 914153

Client
LONDON BOROUGH OF CAMDEN

Dwg. Title
UNDERGROUND SERVICES SURVEY

Project Title
LIDDEL ROAD
WEST HAMPSTEAD

apr services
land, building surveys & 3d laser scanning
Block B, 1st Floor
Queens Road
Barnet
London EN5 4DL
t:020 8449 9143
f:020 8449 9153
www.aprservices.net

ABBREVIATIONS

AB	Air Brick	DH	Duct Height	PRF	Post & Rail Fence
B	Bollard or Bottom Heights	DP	Down Pipe	PWF	Post & Wire Fence
BB	Belisha Beacon	ECB	Electricity Control Box	R	Render
BD	Back Drop	ELEC	Electricity	RAD	Radiator
BH	Borehole or Beam Height	EP	Electricity Pole	RE	Rodding Eye
BL	Bed Level	FB	Flower Bed	RG	Rough Ground
BP	Brick Paviors	FH	Fire Hydrant	RS	Road Sign
BRW	Brick Retaining Wall	FL	Floor Level	RSJ	Rolled Steel Joist
BS	Bus Stop	G	Gully	RWP	Rain Water Pipe
BT	British Telecom	GV	Gas Valve	S	Spread or Stone
BTCB	BT Control Box	H	Height in Metres	SC	Stop Cock
BW	Brick Wall	H	Window Head Height	SL	Soffit Level or Skylight
BWF	Barbed Wire Fence	HT	Height	SP	Arch Springer Height
C	Window Cill Height	IC	Inspection Cover	SPS	Stone Paving Slabs
CB	Control Box	IL	Invert Level	SW	Stone Wall
CBF	Close Boarded Fence	IRF	Iron Railing Fence	TCSU	Traffic Control
CBW	Concrete Block Wall	IWF	Interwoven Fence	T	Top Heights
CCB	Cable TV Control Box	KO	Kerb Outlet	TL	Traffic Light
CIF	Corrugated Iron Fence	L	Light	TP	Telephone Pole
CL	Cover Level	LP	Lamp Post	TPS	Tactile Paving Slabs
CLF	Chain Link Fence	MH	Manhole	UTL	Unable To Lift
CLSF	Chain Link Security Fence	MKR	Marker	V	Vent
CPF	Concrete Panel Fence	OV	Over Flow Pipe	VP	Vent Pipe
CPS	Concrete Paving Slabs	O/H	Overhead	W	Window
CR	Arch Crown Height	P	Post	WL	Water Level
CRW	Concrete Retaining Wall	PALF	Palisade Fence	WM	Water Meter
CSU	Ceiling Slopes Up	PF	Picket Fence	WMF	Wire Mesh Fence
CTV	Cable Television	PIT	Trial Pit	WPF	Wooden Panel Fence
CW	Concrete Wall	PL	Pavement Light	WV	Water Valve
D	Diameter or Doors	PM	Parking Meter	ø	Diameter

Top
Banks
Bottom
Drop Kerbs
Overhead Detail
Change in Elevation
Fences
Overhead Cables
Change in Surface
Edge of Vegetation
3.28 Floor to Ceiling Height
3.28 F False Ceiling Height
Gate
Survey Station
Foul Water Sewer
Surface Water Sewer
Combined Sewer

LEVEL NOTE.

ALL CO-ORDINATES RELATE TO THE ORDNANCE SURVEY GRID AND DATUM VIA GPS OBSERVATIONS.

COORDINATE SCHEDULE

STN	EASTINGS	NORTHINGS	LEVEL
202	525085.856	184838.018	51.684
204	525133.635	184828.364	51.346
205	525157.437	184814.364	51.236
206	525172.846	184811.574	51.111
207	525192.567	184809.648	50.882
208	525213.212	184813.636	50.831
209	525211.595	184791.092	50.169
210	525215.123	184749.252	47.712
211	525185.540	184763.205	47.462
212	525147.957	184756.757	47.133
213	525109.753	184773.071	46.966
214	525068.846	184767.987	46.752
215	525022.374	184774.777	46.552
216	525003.253	184784.190	46.546
217	524966.742	184772.367	46.401
218	524910.435	184768.532	46.489
219	524882.128	184758.457	46.401
220	524869.422	184788.784	48.188
221	524882.276	184805.506	49.531
222	524915.547	184820.964	51.675
223	524932.274	184838.079	52.043
224	524946.282	184874.238	52.804
225	524976.238	184864.221	52.364
226	525016.624	184845.125	51.886
227	525043.453	184832.979	51.801
301	525083.947	184829.687	51.463
401	525096.459	184825.217	51.558

UNDERGROUND SERVICES LEGEND

BLK	BLOCKED
UTT	UNABLE TO TRACE
DP0.50	DEPTH BELOW SURFACE (METERS)
ø250	DIAMETER OF PIPE IN MM.
D-U	DEPTH UNKNOWN
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CABLE	CABLES UNKNOWN
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NOTES
Depth values on drainage is to the top of the pipe.
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Before mechanical plant is used, the actual position of mains and services must be established and verified on site.

SHEET LAYOUT

3	4
1	2

All underground services information shown on this plan cannot be guaranteed and users should satisfy themselves of the type, size and route before commencing work on site.
Tree types shown on this drawing cannot be guaranteed and if critical should be verified by an arboriculturist.
Tree spreads and diameters are averages unless otherwise indicated.
This plan has been produced for the client detailed below or their appointed agent to an agreed specification and defines the limit of APR Services liability

ISO 9001 :2008
certificate no A4047

THE SURVEY ASSOCIATION

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Area Offices in:
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11	0.2 3B	8	14	SYCAMORE
12	0.3	6	12	ASH
13	0.1	8	4	HAWTHORNE
14	0.1	3	6	UNKNOWN
15	0.5	6	18	L POPLAR
16	0.2 3B	8	12	G POPLAR
17	0.1	6	8	S BIRCH
18	0.25	8	7	MAPLE
19	0.2	8	10	OAK
20	0.4	8	12	ASH
21	0.1	4	4	HAWTHORNE
22	0.4	10	8	HORNBEAM
23	0.4	5	12	G POPLAR
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25	0.5 2B	12	15	G POPLAR
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28	0.45	6	10	G POPLAR
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30	0.45	6	10	G POPLAR
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39	0.4	8	16	G POPLAR
40	0.4	8	16	G POPLAR
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43	0.2	8	6	H CHESTNUT
44	0.1	4	3	MAIDENHAIR
45	0.4	8	12	ASH
46	0.2	3	8	CRAB APPLE
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48	0.3	8	12	CRAB APPLE
49	0.3	5	10	HORSE CHESTNUT
50	0.5	14	10	H/CHESTNUT
51	0.5	14	14	UNKNOWN
52	0.1	5	4	S/BIRCH
53	0.4	12	12	CHERRY
54	0.5	14	14	MAPLE
55	0.4	12	12	CHERRY
56	0.4	12	12	CHERRY
57	0.5	14	14	MAPLE
58	0.6	14	16	MAPLE
59	0.5	14	18	ASH
60	0.3	10	8	ASH
61	0.3	10	18	ASH
62	0.15	4	5	UNKNOWN
63	0.3	10	10	HOLME OAK
64	0.5	14	18	LONDON PLANE
65	0.6	10	14	ASH
66	0.5	14	18	HOLME OAK
67	0.3	14	12	HOLME OAK
68	0.5	14	18	LONDON PLANE
69	0.3	14	12	HOLME OAK
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71	0.3	12	10	UNKNOWN
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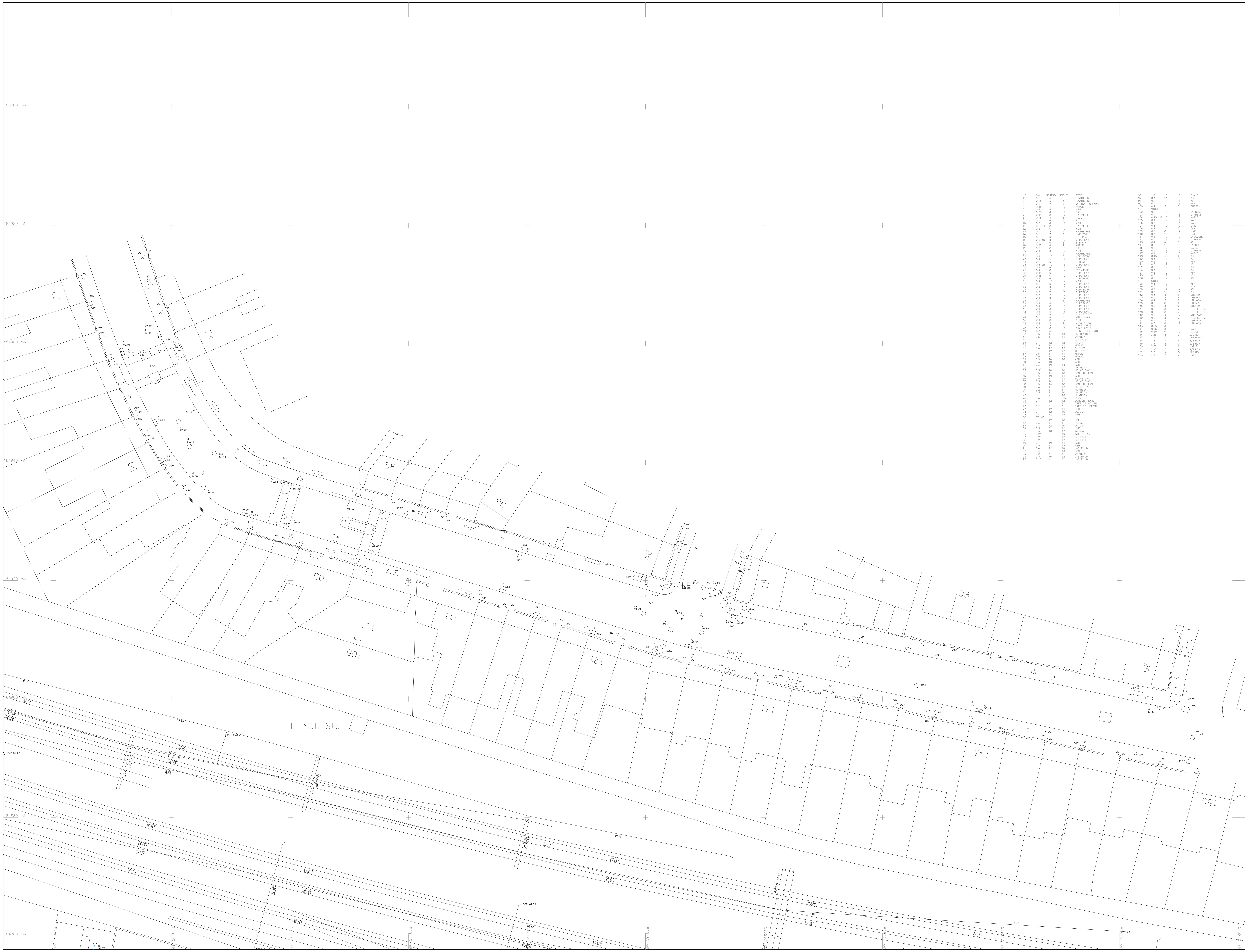
73	0.3	5	m6	PLUM
74	0.4	12	12	LONDON PLANE
75	0.2	5	8	TREE OF HEAVEN
76	0.2	5	8	TREE OF HEAVEN
77	0.4	12	14	LOCUST
78	0.4	12	10	LOCUST
79	0.4	12	18	LIME
80	STUMP			
81	0.4	12	18	LIME
82	0.3	6	8	POPLAR
83	0.4	12	10	LOCUST
84	0.3	8	12	LIME
85	0.3	10	12	WILLOW
86	0.25	6	10	WHITE BEAM
87	0.25	8	12	S/BIRCH
88	0.25	8	12	S/BIRCH
89	0.4	10	14	ASH
90	0.5	14	16	ASH
91	0.4	12	14	LABURNUM
92	0.4	9	10	LOCUST
93	0.2	4	5	UNKNOWN
94	0.3	10	12	LABURNUM
95	0.15	4	8	LABURNUM

96	1.0	16	15	PLANE
97	0.4	14	16	ASH
98	0.4	14	16	ASH
99	0.4	14	16	ASH
100	0.1	3	3	CHERRY
101	STUMP			
102	0.4	14	18	CYPRESS
103	0.4	14	18	CYPRESS
104	0.15 MB	10	12	MAPLE
105	0.4	12	14	MAPLE
106	0.4	12	14	MAPLE
107	0.3	10	12	LIME
108	0.1	2	3	OAK
109	0.3	8	12	LIME
110	0.3	10	12	LIME
111	0.5	10	12	SYCAMORE
112	0.5	18	16	CYPRESS
113	0.2	4	5	ASH
114	0.5	18	16	CYPRESS
115	0.4	10	14	MAPLE
116	0.5	18	16	CYPRESS
117	0.4	16	15	MAPLE
118	0.15	4	4	ASH
119	0.3	12	14	ASH
120	0.3	12	14	ASH
121	0.3	12	14	ASH
122	0.3	12	14	ASH
123	0.3	12	14	ASH
124	0.3	12	14	ASH
125	0.3	12	14	ASH
126	0.3	12	14	ASH
127	STUMP			
128	0.3	12	14	ASH
129	0.3	12	14	ASH
130	0.3	12	14	ASH
131	0.3	12	14	ASH
132	0.3	8	9	CHERRY
133	0.2	8	9	CHERRY
134	0.2	3	8	UNKNOWN
135	0.2	8	9	CHERRY
136	0.2	8	9	CHERRY
137	0.2	8	6	H/CHESTNUT
138	0.2	8	6	H/CHESTNUT
139	0.4	8	12	UNKNOWN
140	0.2	8	6	H/CHESTNUT
141	0.4	8	12	UNKNOWN
142	0.3	8	12	UNKNOWN
143	0.25	6	10	TULIP
144	0.45	8	12	MAPLE
145	0.35	6	12	MAPLE
146	0.25	8	10	S/BIRCH
147	0.4	10	10	UNKNOWN
148	0.2	4	8	S/BIRCH
149	0.3	6	10	S/BIRCH
150	0.55	8	8	MAPLE
151	0.25	5	8	S/BIRCH
152	0.2	4	5	CHERRY
153	0.4	10	12	LIME



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105	0.4	12	14	MAPLE
106	0.4	12	14	MAPLE
107	0.3	10	12	LIME
108	0.1	2	3	OAK
109	0.3	8	12	LIME
110	0.3	10	12	LIME
111	0.5	10	12	SYCAMORE
112	0.5	18	16	CYPRESS
113	0.2	4	5	ASH
114	0.5	18	16	CYPRESS
115	0.4	10	14	MAPLE
116	0.5	18	16	CYPRESS
117	0.4	16	15	MAPLE
118	0.15	4	4	ASH
119	0.3	12	14	ASH
120	0.3	12	14	ASH
121	0.3	12	14	ASH
122	0.3	12	14	ASH
123	0.3	12	14	ASH
124	0.3	12	14	ASH
125	0.3	12	14	ASH
126	0.3	12	14	ASH
127	STUMP			
128	0.3	12	14	ASH
129	0.3	12	14	ASH
130	0.3	12	14	ASH
131	0.3	12	14	ASH
132	0.3	8	9	CHERRY
133	0.2	8	9	CHERRY
134	0.2	3	8	UNKNOWN
135	0.2	8	9	CHERRY
136	0.2	8	9	CHERRY
137	0.2	8	6	H/CHESTNUT
138	0.2	8	6	H/CHESTNUT
139	0.4	8	12	UNKNOWN
140	0.2	8	6	H/CHESTNUT
141	0.4	8	12	UNKNOWN
142	0.3	8	12	UNKNOWN
143	0.25	6	10	TULIP
144	0.45	8	12	MAPLE
145	0.35	6	12	MAPLE
146	0.25	8	10	S/BIRCH
147	0.4	10	10	UNKNOWN
148	0.2	4	8	S/BIRCH
149	0.3	6	10	S/BIRCH
150	0.55	8	8	MAPLE
151	0.25	5	8	S/BIRCH
152	0.2	4	5	CHERRY
153	0.4	10	12	LIME

ABBREVIATIONS

AB	Air Brick	DH	Duct Height	PRF	Post & Rail Fence
B	Bollard or Bottom Heights	DP	Down Pipe	PWF	Post & Wire Fence
BB	Belisha Beacon	ECB	Electricity Control Box	R	Render
BD	Back Drop	ELEC	Electricity	RAD	Radiator
BH	Borehole or Beam Height	EP	Electricity Pole	RE	Rodding Eye
BL	Bed Level	FB	Flower Bed	RG	Rough Ground
BP	Brick Paviors	FH	Fire Hydrant	RS	Road Sign
BRW	Brick Retaining Wall	FL	Floor Level	RSJ	Rolled Steel Joist
BS	Bus Stop	G	Gully	RWP	Rain Water Pipe
BT	British Telecom	GV	Gas Valve	S	Spread or Stone
BTCB	BT Control Box	H	Height in Metres	SC	Stop Cock
BW	Brick Wall	H	Window Head Height	SL	Soffit Level or Skylight
BWF	Barbed Wire Fence	HT	Height	SP	Arch Springer Height
C	Window Cill Height	IC	Inspection Cover	SPS	Stone Paving Slabs
CB	Control Box	IL	Invert Level	SW	Stone Wall
CBF	Close Boarded Fence	IRF	Iron Railing Fence	TCSU	Traffic Control
CBW	Concrete Block Wall	IWF	Interwoven Fence	T	Top Heights
CCB	Cable TV Control Box	KO	Kerb Outlet	TL	Traffic Light
CIF	Corrugated Iron Fence	L	Light	TP	Telephone Pole
CL	Cover Level	LP	Lamp Post	TPS	Tactile Paving Slabs
CLF	Chain Link Fence	MH	Manhole	UTL	Unable To Lift
CLSF	Chain Link Security Fence	MKR	Marker	V	Vent
CPF	Concrete Panel Fence	OV	Over Flow Pipe	VP	Vent Pipe
CPS	Concrete Paving Slabs	O/H	Overhead	W	Window
CR	Arch Crown Height	P	Post	WL	Water Level
CRW	Concrete Retaining Wall	PALF	Palisade Fence	WM	Water Meter
CSU	Ceiling Slopes Up	PF	Picket Fence	WMF	Wire Mesh Fence
CTV	Cable Television	PIT	Trial Pit	WPF	Wooden Panel Fence
CW	Concrete Wall	PL	Pavement Light	WV	Water Valve
D	Diameter or Doors	PM	Parking Meter	ø	Diameter

Top / Bottom — Banks
Drop Kerbs
Overhead Detail
Change in Elevation
Fences
Overhead Cables
Change in Surface
Edge of Vegetation
3.28 Floor to Ceiling Height
3.28 F False Ceiling Height
Gate
Survey Station
Foul Water Sewer
Surface Water Sewer
Combined Sewer

LEVEL NOTE.

ALL CO-ORDINATES RELATE TO THE ORDNANCE SURVEY GRID AND DATUM VIA GPS OBSERVATIONS.

COORDINATE SCHEDULE

STN	EASTINGS	NORTHINGS	LEVEL
202	525085.856	184838.018	51.684
204	525133.635	184828.364	51.346
205	525157.437	184814.364	51.236
206	525172.846	184811.574	51.111
207	525192.567	184809.648	50.882
208	525213.212	184813.636	50.831
209	525211.595	184791.092	50.169
210	525215.123	184749.252	47.712
211	525185.540	184763.205	47.462
212	525147.957	184756.757	47.133
213	525109.753	184773.071	46.966
214	525068.846	184767.987	46.752
215	525022.374	184774.777	46.552
216	525003.253	184784.190	46.546
217	524966.742	184772.367	46.401
218	524910.435	184768.532	46.489
219	524882.128	184758.457	46.401
220	524869.422	184788.784	48.188
221	524882.276	184805.506	49.531
222	524915.547	184820.964	51.675
223	524932.274	184838.079	52.043
224	524946.282	184874.238	52.804
225	524976.238	184864.221	52.364
226	525016.624	184845.125	51.886
227	525043.453	184832.979	51.801
301	525083.947	184829.687	51.463
401	525096.459	184825.217	51.558

UNDERGROUND SERVICES LEGEND

BLK	BLOCKED
UTT	UNABLE TO TRACE
DP0.50	DEPTH BELOW SURFACE (METERS)
ø250	DIAMETER OF PIPE IN MM.
D-U	DEPTH UNKNOWN
(R)	FROM RECORDS
(A)	ASSUMED RUN
E	ELECTRICITY CABLE
EL	ELECTRICAL LIGHTING CABLE
TL	TRAFFIC LIGHTING
T	TELECOM CABLE
CTV	TELEVISION CABLE
W	WATER PIPE
G	GAS PIPE
O	OIL PIPE
U	UNKNOWN SERVICE
CABLE	CABLES UNKNOWN
ED	EMPTY DUCTS
FO	FIBER OPTIC
SW	SURFACE WATER
FW	FOUL WATER
CM	COMBINED SEWER
DP0.80	BUND OF CABLES
	CHAMBER

NOTES
Depth values on drainage is to the top of the pipe.
Depth value on all other services is to the centre.
The location and/or identification of a service will not necessarily indicate whether it is live or dead.
The fact that a service has not been located or identified does not necessarily imply that it does not exist or is dead, however their presence should be anticipated.
Before mechanical plant is used, the actual position of mains and services must be established and verified on site.

SHEET LAYOUT

3	4
1	2

ISO 9001:2008

THE SURVEY ASSOCIATION

Revisions | Date

Date	MAY 2014	Drawn	JM
Scale A0@	1:200	Checked	ASB
Dwg. No.914153 U4		Job No.	914153

Client
LONDON BOROUGH OF CAMDEN

Dwg. Title
UNDERGROUND SERVICES SURVEY

Project Title
LIDDEL ROAD
WEST HAMPSTEAD

apr services
Block B, 1st Floor
Queens Road
Barnet
London EN5 4DL
t:020 8449 9143
f:020 8449 9153
www.aprservices.net

APPENDIX D – Greenfield Run-Off

HR Wallingford
Working with water

Greenfield runoff estimation for sites

Site name:	Liddell Road
Site location:	West Hampstead

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the CIRIA SUDS Manual (2007). It is not to be used for detailed design of drainage systems. It is recommended that every drainage scheme uses hydraulic modelling software to finalise volume requirements and design details before drawings are produced.

Site coordinates

Latitude:	51.54823° N
Longitude:	0.19645° W
Reference:	gcpv780fnqs3 / 1.2
Date:	21 Nov 2014

Site characteristics

Total site area	1.2	ha
Significant public open space	0.2	ha
Area positively drained	1	ha

Methodology

Greenfield runoff method	FEH	
Qmed estimation method	Calculate from BFI and SAAR	
BFI and SPR estimation method	Specify BFI manually	
HOST class	N/A	
BFI / BFIHOST	0.24	
Qmed	4.13	l/s
Qbar / Qmed Conversion Factor	1.136	

Hydrological characteristics

	Default	Edited	
SAAR	640	640	mm
M5-60 Rainfall Depth	20	20	mm
'r' Ratio M5-60/M5-2 day	0.4	0.4	
FEH/FSR conversion factor	0.75	0.75	
Hydrological region	6	6	
Growth curve factor: 1 year	0.85	0.85	
Growth curve factor: 10 year	1.62	1.62	
Growth curve factor: 30 year	2.3	2.3	
Growth curve factor: 100 year	3.19	3.19	

Greenfield runoff rates

	Default	Edited	
Qbar	4.69	4.69	l/s
1 in 1 year	5.00	5.00	l/s
1 in 30 years	10.79	10.79	l/s
1 in 100 years	14.97	14.97	l/s

Please note that a minimum flow of 5 l/s applies to any site

APPENDIX E – Surface Water Calculations

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 342 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control Σ (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.883	0.383	0.0	10.3	10.3	254.9	O K
30 min Summer	8.988	0.488	0.0	11.7	11.7	324.7	O K
60 min Summer	9.082	0.582	0.0	12.9	12.9	387.3	O K
120 min Summer	9.153	0.653	0.0	13.7	13.7	433.9	O K
180 min Summer	9.172	0.672	0.0	13.9	13.9	447.1	O K
240 min Summer	9.172	0.672	0.0	13.9	13.9	447.1	O K
360 min Summer	9.167	0.667	0.0	13.8	13.8	443.9	O K
480 min Summer	9.159	0.659	0.0	13.7	13.7	438.1	O K
600 min Summer	9.147	0.647	0.0	13.6	13.6	430.6	O K
720 min Summer	9.134	0.634	0.0	13.5	13.5	421.7	O K
960 min Summer	9.105	0.605	0.0	13.1	13.1	402.4	O K
1440 min Summer	9.046	0.546	0.0	12.4	12.4	363.4	O K
2160 min Summer	8.970	0.470	0.0	11.5	11.5	312.5	O K
2880 min Summer	8.908	0.408	0.0	10.7	10.7	271.4	O K
4320 min Summer	8.818	0.318	0.0	9.3	9.3	211.4	O K
5760 min Summer	8.757	0.257	0.0	8.3	8.3	170.7	O K
7200 min Summer	8.713	0.213	0.0	7.5	7.5	141.8	O K
8640 min Summer	8.681	0.181	0.0	6.9	6.9	120.5	O K
10080 min Summer	8.658	0.158	0.0	6.3	6.3	105.2	O K
15 min Winter	8.930	0.430	0.0	11.0	11.0	285.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	139.338	0.0	248.4	19
30 min Summer	90.071	0.0	323.5	33
60 min Summer	55.351	0.0	409.1	62
120 min Summer	32.840	0.0	486.2	122
180 min Summer	23.880	0.0	530.6	180
240 min Summer	18.941	0.0	561.3	228
360 min Summer	13.666	0.0	607.7	282
480 min Summer	10.831	0.0	642.2	346
600 min Summer	9.038	0.0	669.8	412
720 min Summer	7.792	0.0	692.9	482
960 min Summer	6.162	0.0	730.3	618
1440 min Summer	4.421	0.0	784.5	892
2160 min Summer	3.167	0.0	851.4	1280
2880 min Summer	2.498	0.0	894.8	1668
4320 min Summer	1.785	0.0	956.0	2380
5760 min Summer	1.406	0.0	1009.8	3120
7200 min Summer	1.167	0.0	1047.5	3824
8640 min Summer	1.002	0.0	1078.4	4504
10080 min Summer	0.881	0.0	1103.0	5248
15 min Winter	139.338	0.0	279.2	18

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	9.048	0.548	0.0	12.5	12.5	364.4	O K
60 min Winter	9.155	0.655	0.0	13.7	13.7	435.6	O K
120 min Winter	9.237	0.737	0.0	14.5	14.5	489.9	O K
180 min Winter	9.263	0.763	0.0	14.8	14.8	507.2	O K
240 min Winter	9.266	0.766	0.0	14.8	14.8	509.6	O K
360 min Winter	9.254	0.754	0.0	14.7	14.7	501.6	O K
480 min Winter	9.241	0.741	0.0	14.6	14.6	493.1	O K
600 min Winter	9.224	0.724	0.0	14.4	14.4	481.3	O K
720 min Winter	9.203	0.703	0.0	14.2	14.2	467.8	O K
960 min Winter	9.160	0.660	0.0	13.7	13.7	438.8	O K
1440 min Winter	9.075	0.575	0.0	12.8	12.8	382.4	O K
2160 min Winter	8.969	0.469	0.0	11.5	11.5	311.6	O K
2880 min Winter	8.887	0.387	0.0	10.4	10.4	257.2	O K
4320 min Winter	8.775	0.275	0.0	8.6	8.6	183.0	O K
5760 min Winter	8.706	0.206	0.0	7.4	7.4	137.2	O K
7200 min Winter	8.662	0.162	0.0	6.4	6.4	107.8	O K
8640 min Winter	8.634	0.134	0.0	5.8	5.8	89.4	O K
10080 min Winter	8.623	0.123	0.0	5.1	5.1	81.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	90.071	0.0	363.3	33
60 min Winter	55.351	0.0	458.7	62
120 min Winter	32.840	0.0	545.1	120
180 min Winter	23.880	0.0	594.9	176
240 min Winter	18.941	0.0	629.3	230
360 min Winter	13.666	0.0	681.2	296
480 min Winter	10.831	0.0	719.9	368
600 min Winter	9.038	0.0	750.8	446
720 min Winter	7.792	0.0	776.7	520
960 min Winter	6.162	0.0	818.6	668
1440 min Winter	4.421	0.0	879.4	952
2160 min Winter	3.167	0.0	954.0	1360
2880 min Winter	2.498	0.0	1002.7	1732
4320 min Winter	1.785	0.0	1071.8	2468
5760 min Winter	1.406	0.0	1131.2	3176
7200 min Winter	1.167	0.0	1173.6	3888
8640 min Winter	1.002	0.0	1208.4	4496
10080 min Winter	0.881	0.0	1236.7	5152

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	21.000	Shortest Storm (mins)	15
Ratio R	0.435	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 1.000

Time From:	(mins) To:	Area (ha)
0	4	1.000

Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

Invert Level (m) 8.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	700.0	700.0	0.900	0.0	788.0
0.800	700.0	788.0			

Pipe Outflow Control

Diameter (m) 0.100 Entry Loss Coefficient 0.500
Slope (1:X) 100.0 Coefficient of Contraction 0.600
Length (m) 8.000 Upstream Invert Level (m) 8.500
Roughness k (mm) 0.600

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 265 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.360	0.360	0.0	6.6	6.6	101.8	O K
30 min Summer	0.444	0.444	0.0	6.6	6.6	130.5	O K
60 min Summer	0.516	0.516	0.0	6.6	6.6	155.1	O K
120 min Summer	0.560	0.560	0.0	6.6	6.6	170.2	O K
180 min Summer	0.564	0.564	0.0	6.6	6.6	171.5	O K
240 min Summer	0.553	0.553	0.0	6.6	6.6	167.8	O K
360 min Summer	0.529	0.529	0.0	6.6	6.6	159.6	O K
480 min Summer	0.505	0.505	0.0	6.6	6.6	151.5	O K
600 min Summer	0.482	0.482	0.0	6.6	6.6	143.3	O K
720 min Summer	0.457	0.457	0.0	6.6	6.6	134.8	O K
960 min Summer	0.408	0.408	0.0	6.6	6.6	118.1	O K
1440 min Summer	0.325	0.325	0.0	6.6	6.6	89.8	O K
2160 min Summer	0.231	0.231	0.0	6.6	6.6	57.6	O K
2880 min Summer	0.171	0.171	0.0	6.5	6.5	37.2	O K
4320 min Summer	0.123	0.123	0.0	5.7	5.7	20.7	O K
5760 min Summer	0.104	0.104	0.0	4.7	4.7	14.8	O K
7200 min Summer	0.092	0.092	0.0	4.0	4.0	11.7	O K
8640 min Summer	0.084	0.084	0.0	3.4	3.4	9.6	O K
10080 min Summer	0.077	0.077	0.0	3.0	3.0	8.2	O K
15 min Winter	0.399	0.399	0.0	6.6	6.6	115.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	137.494	0.0	106.7	18
30 min Summer	88.809	0.0	139.4	33
60 min Summer	54.549	0.0	172.5	62
120 min Summer	32.365	0.0	205.7	122
180 min Summer	23.543	0.0	224.8	180
240 min Summer	18.683	0.0	238.1	222
360 min Summer	13.462	0.0	257.6	280
480 min Summer	10.666	0.0	272.2	346
600 min Summer	8.898	0.0	283.8	414
720 min Summer	7.671	0.0	293.6	484
960 min Summer	6.064	0.0	309.3	608
1440 min Summer	4.349	0.0	332.2	866
2160 min Summer	3.115	0.0	355.9	1212
2880 min Summer	2.456	0.0	372.9	1556
4320 min Summer	1.755	0.0	397.2	2208
5760 min Summer	1.381	0.0	414.3	2936
7200 min Summer	1.147	0.0	427.2	3672
8640 min Summer	0.985	0.0	437.5	4400
10080 min Summer	0.866	0.0	445.9	5136
15 min Winter	137.494	0.0	120.1	18

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control Σ (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.495	0.495	0.0	6.6	6.6	147.9	O K
60 min Winter	0.577	0.577	0.0	6.6	6.6	175.9	O K
120 min Winter	0.631	0.631	0.0	6.6	6.6	194.6	O K
180 min Winter	0.641	0.641	0.0	6.6	6.6	197.7	O K
240 min Winter	0.632	0.632	0.0	6.6	6.6	194.9	O K
360 min Winter	0.601	0.601	0.0	6.6	6.6	184.1	O K
480 min Winter	0.572	0.572	0.0	6.6	6.6	174.1	O K
600 min Winter	0.540	0.540	0.0	6.6	6.6	163.3	O K
720 min Winter	0.507	0.507	0.0	6.6	6.6	152.1	O K
960 min Winter	0.436	0.436	0.0	6.6	6.6	127.6	O K
1440 min Winter	0.308	0.308	0.0	6.6	6.6	83.9	O K
2160 min Winter	0.180	0.180	0.0	6.5	6.5	40.1	O K
2880 min Winter	0.129	0.129	0.0	6.0	6.0	22.9	O K
4320 min Winter	0.099	0.099	0.0	4.4	4.4	13.4	O K
5760 min Winter	0.085	0.085	0.0	3.5	3.5	9.8	O K
7200 min Winter	0.075	0.075	0.0	2.9	2.9	7.8	O K
8640 min Winter	0.069	0.069	0.0	2.5	2.5	6.5	O K
10080 min Winter	0.064	0.064	0.0	2.2	2.2	5.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	88.809	0.0	156.8	33
60 min Winter	54.549	0.0	193.9	62
120 min Winter	32.365	0.0	231.1	118
180 min Winter	23.543	0.0	252.5	176
240 min Winter	18.683	0.0	267.4	230
360 min Winter	13.462	0.0	289.3	294
480 min Winter	10.666	0.0	305.7	368
600 min Winter	8.898	0.0	318.8	446
720 min Winter	7.671	0.0	329.7	522
960 min Winter	6.064	0.0	347.4	666
1440 min Winter	4.349	0.0	373.2	922
2160 min Winter	3.115	0.0	399.9	1236
2880 min Winter	2.456	0.0	419.2	1528
4320 min Winter	1.755	0.0	446.8	2208
5760 min Winter	1.381	0.0	466.3	2936
7200 min Winter	1.147	0.0	481.3	3672
8640 min Winter	0.985	0.0	493.2	4408
10080 min Winter	0.866	0.0	503.1	5136

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.700	Shortest Storm (mins)	15
Ratio R	0.438	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.436

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.436

Model Details

Storage is Online Cover Level (m) 1.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	114.0
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	316.7	Slope (1:X)	80.0
Safety Factor	5.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	0.000	Cap Volume Depth (m)	0.650

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0125-6600-0645-6600
Design Head (m)	0.645
Design Flow (l/s)	6.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	125
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	0.645	6.6
Flush-Flo™	0.212	6.6
Kick-Flo®	0.462	5.6
Mean Flow over Head Range	-	5.5

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

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	4.5	1.200	8.8	3.000	13.5	7.000	20.3
0.200	6.6	1.400	9.4	3.500	14.6	7.500	21.0
0.300	6.4	1.600	10.1	4.000	15.5	8.000	21.7
0.400	6.1	1.800	10.6	4.500	16.4	8.500	22.4
0.500	5.8	2.000	11.2	5.000	17.3	9.000	23.0
0.600	6.3	2.200	11.7	5.500	18.1	9.500	23.6
0.800	7.3	2.400	12.2	6.000	18.9		
1.000	8.1	2.600	12.7	6.500	19.5		

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 341 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.892	0.392	0.0	8.4	8.4	164.0	O K
30 min Summer	8.999	0.499	0.0	8.4	8.4	208.8	O K
60 min Summer	9.095	0.595	0.0	8.4	8.4	248.6	O K
120 min Summer	9.166	0.666	0.0	8.4	8.4	278.3	O K
180 min Summer	9.186	0.686	0.0	8.4	8.4	286.6	O K
240 min Summer	9.184	0.684	0.0	8.4	8.4	285.9	O K
360 min Summer	9.164	0.664	0.0	8.4	8.4	277.4	O K
480 min Summer	9.142	0.642	0.0	8.4	8.4	268.2	O K
600 min Summer	9.118	0.618	0.0	8.4	8.4	258.5	O K
720 min Summer	9.095	0.595	0.0	8.4	8.4	248.5	O K
960 min Summer	9.047	0.547	0.0	8.4	8.4	228.7	O K
1440 min Summer	8.959	0.459	0.0	8.4	8.4	191.7	O K
2160 min Summer	8.850	0.350	0.0	8.4	8.4	146.2	O K
2880 min Summer	8.770	0.270	0.0	8.2	8.2	112.7	O K
4320 min Summer	8.676	0.176	0.0	7.7	7.7	73.4	O K
5760 min Summer	8.637	0.137	0.0	6.8	6.8	57.4	O K
7200 min Summer	8.619	0.119	0.0	5.9	5.9	49.7	O K
8640 min Summer	8.607	0.107	0.0	5.2	5.2	44.6	O K
10080 min Summer	8.598	0.098	0.0	4.6	4.6	41.0	O K
15 min Winter	8.941	0.441	0.0	8.4	8.4	184.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	139.338	0.0	166.2	18
30 min Summer	90.071	0.0	215.6	33
60 min Summer	55.351	0.0	268.0	62
120 min Summer	32.840	0.0	318.3	122
180 min Summer	23.880	0.0	347.3	182
240 min Summer	18.941	0.0	367.3	240
360 min Summer	13.666	0.0	397.6	304
480 min Summer	10.831	0.0	420.2	362
600 min Summer	9.038	0.0	438.3	424
720 min Summer	7.792	0.0	453.5	492
960 min Summer	6.162	0.0	478.2	624
1440 min Summer	4.421	0.0	514.3	882
2160 min Summer	3.167	0.0	554.7	1256
2880 min Summer	2.498	0.0	583.1	1612
4320 min Summer	1.785	0.0	624.0	2292
5760 min Summer	1.406	0.0	657.1	2952
7200 min Summer	1.167	0.0	681.8	3680
8640 min Summer	1.002	0.0	702.3	4408
10080 min Summer	0.881	0.0	719.2	5136
15 min Winter	139.338	0.0	186.4	18

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control Σ (l/s)	Max Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	9.062	0.562	0.0	8.4	8.4	234.9	O K
60 min Winter	9.172	0.672	0.0	8.4	8.4	280.8	O K
120 min Winter	9.259	0.759	0.0	8.4	8.4	317.1	O K
180 min Winter	9.288	0.788	0.0	8.4	8.4	329.5	O K
240 min Winter	9.294	0.794	0.0	8.4	8.4	331.8	O K
360 min Winter	9.279	0.779	0.0	8.4	8.4	325.7	O K
480 min Winter	9.243	0.743	0.0	8.4	8.4	310.5	O K
600 min Winter	9.209	0.709	0.0	8.4	8.4	296.2	O K
720 min Winter	9.174	0.674	0.0	8.4	8.4	281.7	O K
960 min Winter	9.103	0.603	0.0	8.4	8.4	252.0	O K
1440 min Winter	8.969	0.469	0.0	8.4	8.4	195.9	O K
2160 min Winter	8.811	0.311	0.0	8.3	8.3	129.9	O K
2880 min Winter	8.710	0.210	0.0	8.0	8.0	87.8	O K
4320 min Winter	8.633	0.133	0.0	6.6	6.6	55.5	O K
5760 min Winter	8.609	0.109	0.0	5.3	5.3	45.6	O K
7200 min Winter	8.596	0.096	0.0	4.4	4.4	40.1	O K
8640 min Winter	8.587	0.087	0.0	3.8	3.8	36.4	O K
10080 min Winter	8.580	0.080	0.0	3.4	3.4	33.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	90.071	0.0	241.7	33
60 min Winter	55.351	0.0	300.4	62
120 min Winter	32.840	0.0	356.6	120
180 min Winter	23.880	0.0	389.1	178
240 min Winter	18.941	0.0	411.6	234
360 min Winter	13.666	0.0	445.5	346
480 min Winter	10.831	0.0	470.8	440
600 min Winter	9.038	0.0	491.1	466
720 min Winter	7.792	0.0	508.1	540
960 min Winter	6.162	0.0	535.7	684
1440 min Winter	4.421	0.0	576.3	954
2160 min Winter	3.167	0.0	621.4	1320
2880 min Winter	2.498	0.0	653.2	1644
4320 min Winter	1.785	0.0	699.3	2288
5760 min Winter	1.406	0.0	736.0	2992
7200 min Winter	1.167	0.0	763.8	3680
8640 min Winter	1.002	0.0	786.8	4408
10080 min Winter	0.881	0.0	806.0	5144

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	21.000	Shortest Storm (mins)	15
Ratio R	0.435	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.650

Time From:	(mins) To:	Area (ha)
0	4	0.650

Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

Invert Level (m) 8.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	440.0	440.0	0.900	0.0	507.2
0.800	440.0	507.2			

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0131-8400-1200-8400
Design Head (m)	1.200
Design Flow (l/s)	8.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	131
Invert Level (m)	8.500
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	8.4
Flush-Flo™	0.355	8.4
Kick-Flo®	0.768	6.8
Mean Flow over Head Range	-	7.3

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.7	1.200	8.4	3.000	12.9	7.000	19.3
0.200	7.9	1.400	9.0	3.500	13.9	7.500	20.0
0.300	8.3	1.600	9.6	4.000	14.8	8.000	20.6
0.400	8.3	1.800	10.1	4.500	15.6	8.500	21.2
0.500	8.2	2.000	10.6	5.000	16.4	9.000	21.8
0.600	7.9	2.200	11.1	5.500	17.2	9.500	22.4
0.800	6.9	2.400	11.6	6.000	17.9		
1.000	7.7	2.600	12.0	6.500	18.6		