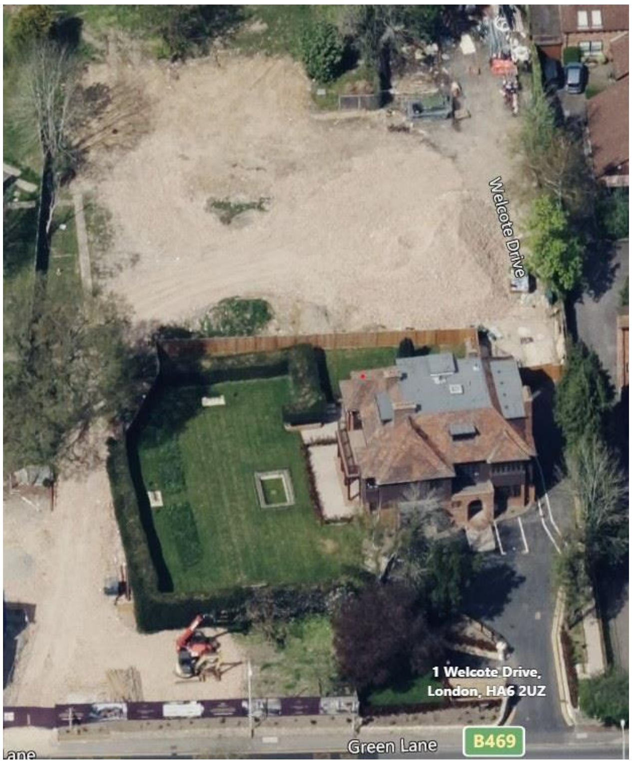
H Fraser Consulting
Contaminated Land and Hydrogeology

Land to the east of London School of Theology, Green Lane, Northwood, HA6 2UW

Groundwater Basement Impact Assessment (BIA)



Prepared for: Westcombe Homes Ltd
7 Churchill Court
58 Station Road
HA2 7SA

Date: 31/03/2022

Status: Final

Reference: 30626R1

Prepared by: H Fraser Consulting Ltd

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EXECUTIVE SUMMARY

Westcombe Homes Ltd instructed H Fraser Consulting Ltd (HFCL) to provide the groundwater aspects of a Basement Impact Assessment (BIA) at Land to the east of London School of Theology, Green Lane, Northwood, HA6 2UW, in the London Borough of Hillingdon, in order to comply with planning conditions (10112/APP/2021/3709).

The site was levelled between January and March 2022, but previously included a two-storey student accommodation block and a pair of semi-detached houses. The proposed development involves construction of a residential building comprising 15 No. flats, including a basement level housing two flats with patios, 12 No. car parking spaces, cycle storage, motorcycle parking, and bin storage. Excavation of up to at least 4.64 m was required across the footprint of the proposed building and in the proposed parking area to the south/east of the building to achieve a basement floor level of 68.5 m aOD.

The mapped bedrock geology comprises Lambeth Group and London Clay, with no superficial sediments present. Site investigation recorded silty Clay to 8 m below basement level. The majority of the site (i.e. all but the access road) is designated by the Environment Agency as unproductive strata, with the access road underlain by a Secondary A aquifer (bedrock). The site lies in Zone 2 of a SPZ.

During excavation of the site to its full depth, between January and March 2022, no seepage was encountered. The water table is thought to be at least 16 m below basement level, but perched groundwater could cause seepage. Provided the following mitigation measures are adopted, hydrogeological impacts on the proposed development would be negligible:

- The basement should be appropriately waterproofed to British Standard BS 8102 in order to mitigate against any seepage. NHBC requirements should be included in the detailed design.
- The excavation should be kept dry. Any seepage from the open sides of the excavation is likely to be minimal and would be dealt with using provisions made for removal of rainwater.

No significant groundwater flow is predicted around the building, and the proposed development is not considered to cause any adverse hydrogeological impacts. No mitigation measures are considered necessary in order to maintain groundwater flow around the building.

In order to inform the SuDS design, it is recommended that additional infiltration testing be undertaken in the area where a soakaway would potentially be located, in accordance with BS EN ISO 22282-5:2012.

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APPENDICES

1 INTRODUCTION

Westcombe Homes Ltd have instructed H Fraser Consulting Ltd (HFCL) to provide the groundwater aspects of a Basement Impact Assessment (BIA) at the following property:

Land to the east of London School of Theology, Green Lane, Northwood, HA6 2UW.

The site is in the London Borough of Hillingdon. The proposed development is subject to planning conditions (10112/APP/2021/3709), including a BIA which covers:

i) The results of an appropriate site investigation that has identified the nature of the underlying geology and confirmed the depth of any groundwater beneath the site (taking into account the seasonal variability of groundwater);

ii) An assessment to identify any mitigation measures that need to be put in place to maintain the passage of groundwater around the building without impacting local groundwater levels; it should include an assessment of local ground conditions, water movement and drainage of the site. The monitoring results shall be regularly reviewed. Where groundwater is found, suitable mitigation must be provided. and

iii) Shallow infiltration rates to inform the utilisation of Sustainable Drainage Systems (SuDS) on the site.

1.1 Objective

The purpose of this assessment is to consider the effects of a proposed basement development at Land to the east of London School of Theology, Green Lane, Northwood, HA6 2UW on the local hydrogeology, and potential impacts to neighbours and the wider environment.

1.2 Scope of works

The agreed scope of work was to undertake:

- Desk study
- Screening and scoping
- Basement impact assessment (BIA)
- Provision of a report in pdf format

1.3 Authors

The report was authored by Emilie Roberts, a hydrogeologist (MSc) and Fellow of the Geological Society of London (FGS) with 11 years of experience as a hydrogeologist and consultant.

The report has been reviewed and approved by Chartered Geologist (hydrogeologist) Hannah Fraser (CGeol). Hannah is Director of H Fraser Consulting Ltd and has 24 years' experience as a hydrogeologist and consultant.

Emilie and Hannah have extensive experience of undertaking BIAs in many London Boroughs.

2 DESK STUDY

2.1 Sources of information

The desk study has been derived the following data:

- Existing and proposed plans (Appendix A)
- Surface Water Drainage Strategy, Ambiental Technical Solutions, May 2017 (Appendix B)
- Site investigation report "Project no. RML 6980, Phase I & Phase II Site investigation at London School of Theology, Northwood on behalf of Westcombe Homes Limited, June 2019" (Appendix C), referred to as RML, 2019, including:
    - EnviroCheck report
    - Historic maps
    - On-site borehole logs
- Online mapping and aerial photography have been derived from Streetmap, Googlemaps and Google Earth Pro
- Geological mapping: British Geological Survey 1:50,000 series, England and Wales Sheet 255. Beaconsfield. Bedrock and Superficial Deposits Geology; Geology of Britain Viewer; GeoIndex.
- Flood risk mapping https://flood-warning-information.service.gov.uk/long-term-flood-risk;

2.2 Site description

The site comprises land to the east of the London School of Theology, Green Lane, Northwood, HA6 2UW, located to the north of the London Borough of Hillingdon. The site forms part of the London School of Theology, with the main building of the London School of Theology to the west of the site. It is bounded by Green Lane to the south, several dwellings to the north (Firs Walk) and the east (Welcote Drive), while the is to the west.

The location is presented in Figure 2-1.

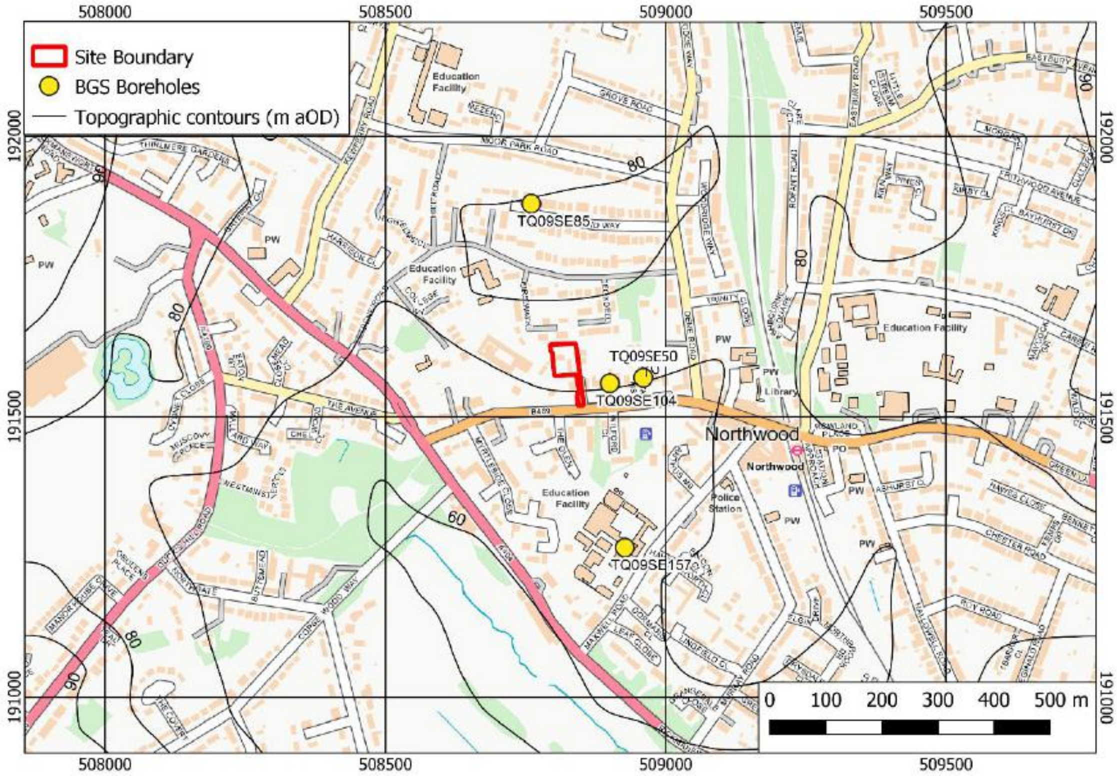


Figure 2-1 Site Location

Contains Ordnance Survey data © Crown copyright and database right 2022

2.2.1 Existing development

The site was levelled, and excavated to the proposed depth, between January and March 2022.[1] Previously, the site comprised a two-storey student accommodation block, a pair of semi-detached houses, a square grass area, parking area and access from Green Lane.

The levels plan in Appendix A shows that measured existing site levels range from 73.94 m above Ordnance Datum (m aOD) in the north of the site to 70.50 m aOD where the access road joins the main site.

2.2.2 Proposed development

The proposed development involves construction of a residential building comprising 15 No. flats. The proposed building is L-shaped, with a wing running approximately east-west, and another wing running approximately north-south, joined together in the north/west corner of the building. The east-west wing comprises four storeys of flats (at basement, ground, first and second floor level). The site slopes down towards the south, therefore ground will be excavated to the north of this wing to create basement level patios along the north of the building for the two basement flats.

Ground levels will be set such that the lowest level of the north-south wing is at ground level, becoming a partial basement where it joins the east-west wing. The lowest level of the north-south wing will comprise 12 No. car parking spaces, cycle storage, motorcycle parking, and bin storage.

[1] Client correspondence

The proposed development requires excavation (which has been completed) across the footprint of the proposed building and in the proposed parking area to the south/east of the building. The levels plan in Appendix A shows that basement level will be at 68.5 m aOD, with the building's ground level at 72.5 m aOD. The existing level of the proposed patios, in the north of the building, is 73.15 m aOD, requiring excavation of at least 4.64 m. In the south of the proposed north-south wing and the proposed outdoor parking area immediately to the east, existing level is 71.84 m aOD to 71.98 m aOD, requiring excavation of at least 3.48 m.

A Surface Water Drainage Strategy was prepared by Ambiental Technical Solutions in May 2017 (Appendix B). The report proposed drainage via the sewer, due the likely poor infiltration potential of the soil and the unviability of discharging to a watercourse.

2.3 Background information

Table 2-1 presents relevant background information for the site.

Table 2-1 Background information

Site history	The oldest available map (1883 1:2,500 scale) shows the site located within farmland, just north of Green Lane road. A well can be seen c.30 m southeast of the site, as well as a circular feature which might be a pond c.50 m south of the site. The nearest buildings are unlabelled structures overlapping the southernmost edge of the site, Greenhill Farm is c.120 m to the northeast and Northwood House c.200 m to the west. In the 1896 map (1:2,500 scale) within 250 m of the site additional residential buildings and roads to the north and east of the site are present. The well and possible pond to the south of the site are still shown. The 1913 1:2,500 map shows significant urbanisation around the site, with the building directly to the east of the southern limb of the site now present, as well as Northwood college (c.300 m to the south). The well is no longer shown. In the 1935 1:2,500 map the possible pond to the south of the site is no longer shown. In the 1960 1:2,500 map St. Johns Hall, directly to the west of the site, is shown. The northern half of the site is now depicted as woodland. The recently demolished properties on the site are first present on the 1:2,500 scale map of 1970-1976.
Nearby basements	No existing or approved basements were identified in a search of the Hillingdon planning portal for neighbouring roads / properties (Welcote Drive, Firs Walk or the London School of Theology).
Topography	The original site elevation lay at between 73.9 m aOD in the north and 70.5 m aOD in the south of the main part of the site (i.e. not including the access road), with a gentle slope down towards the south. The local high ground is a small hill in the vicinity of Halland Way and Dene Road, c.170 m north of the site. The site slopes down towards the Northwood Golf Course, immediately south of the A404 (Rickmansworth Road)
Geology	The British Geological Survey (BGS) 1:50,000 map of Beaconsfield[2] indicates that the geological boundary between the London Clay and the underlying

[2] British Geological Survey 1:50,000 series, England and Wales Sheet 255. Beaconsfield. Bedrock and Superficial Deposits Geology, 2005

	Lambeth Group passes through the site. The bedrock geology comprises Lambeth Group, overlain in the north of the site (i.e. across all but the access road) by a layer of London Clay. However the geological map is not accurate at the precision of 10's of m therefore the extent and thickness of the overlying London Clay may vary from the mapping. There are no superficial deposits mapped in the vicinity of the site. The Lambeth Group comprises vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate.[3] The London Clay mainly comprises bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, silty to very silty clay, clayey silt and sometimes silt, with some layers of sandy clay. The lower boundary of the London Clay is usually marked by a thin bed of well-rounded flint gravel or a glauconitic horizon, or both, typically resting on a sharply defined planar surface, although locally uneven.[4] Figure 2-1 shows the location of selected BGS boreholes, which are described in Table 2-2. Boreholes TQ09SE50, located c. 110 m to the east of the site, recorded Clay to 4 m, underlain by Sand, which is in agreement with the mapped geology.
Aquifer status	The majority of the site (this area mapped as London Clay, i.e. all but the access road) is designated by the Environment Agency as unproductive strata. These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.[5] The access road is underlain by a Secondary A aquifer (bedrock). These are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. They are generally aquifers formerly classified as minor aquifers.
Watercourses	The nearest watercourse is located c.150 m south of the site[6], in Northwood Golf Course. This feeds into the Cannon Brook, the Ruislip Lido (c.1.7 km to the south) and then the River Pinn, which flows into the River Colne near West Drayton, c.12km south of the site.
Springs	There are no springs mapped within 500 m of the site.[7]

[3] https://webapps.bgs.ac.uk/lexicon/lexicon.cfm?pub=LMBE

[4] https://www.bgs.ac.uk/lexicon/lexicon.cfm?pub=LC

[5] Envirocheck report in Appendix B

[6] Envirocheck report in Appendix B

[7] 1:25 000 mapping

Wells	There are no water abstractions within 1000 m of the site.[8] The site is in the Outer zone (Zone 2) of a Source Protection Zone (SPZ), with the closest SPZ Inner zone (Zone 1) located c.550 m to the south.[9]
Surface water flooding	The site is in flood zone 1 (FZ1).[10] There is a low risk of surface water flooding within 20 m radius of the site.[11]
Groundwater flooding	The site is in an area which the Environment Agency classifies as having no potential for groundwater flooding to occur.[12]

[8] Envirocheck report in Appendix B

[9] Envirocheck report in Appendix B

[10] https://flood-map-for-planning.service.gov.uk/

[11] https://check-long-term-flood-risk.service.gov.uk/risk

[12] Envirocheck report in Appendix B

Table 2-2 Selected BGS borehole records

Ref	Name	Easting	Northing	Description
TQ09SE104	GREEN LANE NORTHWOOD HA2	508900	191560	TOPSOIL to 0.15 m. Soft mottled light brown grey silty CLAY with numerous traces of organic material and some root fibres to 1 m. Firm to very stiff light brown grey silty CLAY with traces of organic material to 2.73 m (end of borehole).
TQ09SE50	25 GREEN LANE NORTHWOOD	508960	191570	MADE GROUND to 0.45 m. Firm to stiff CLAY to 4.0 m, followed by SAND to 10.2 m, GRAVEL to 10.8 m, CLAY to 11.0 m, and sandy GRAVEL to 13.7 m. This sequence is labelled as the Woolwich and Reading Beds, known as the Lambeth Group today. CHALK is then found to 18.3 m (end of the borehole).
TQ09SE157	NORTHWOOD COLLEGE DINING HUB MUGA/EARLY YEARS CENTRE NORTHWOOD 3	508927	191267	MADE GROUND to 0.3 m. CLAY to 7.2 m. A water strike at 2.8 m when a 0.2 m band of SAND is present (2.8 - 3 m), showing no rise after 20 minutes. SAND to 8.8 m, followed by GRAVEL to 12.1 m. CHALK is then found to 25 m (end of the borehole). Water strike at 7.2 m (no rise after 20 mins), 8.8 m (rising to 7.9 m after 20 mins), and 22.9 m (rising to 20.9 m after 20 mins).
TQ09SE85	28 HALLAND WAY, NORTHWOOD 1	508760	191880	MADE GROUND to 1.3 m. CLAY to 17.0 m (end of borehole), contains pockets of fine sand and silt. Water strike at 11.0 m noted as slight seepage.

3 SITE INVESTIGATION

3.1 Overview

Site investigation was undertaken between 20 and 24 May 2019 by Risk Management Limited (RML; Appendix C), with an additional borehole installed 23 February 2022, also by RML (Appendix D). The site investigation was not commissioned or specified by HFCL.

The site investigation comprises the following:

<u>2019 site investigation</u>

- 1 No. cable percussion borehole (BH1) to a depth of 20 m.
- 6 No. drive-in-sampler boreholes (DIS1-DIS6). Boreholes DIS1 and DIS3-DIS6 were drilled to a depth of 3 m. Borehole DIS2 was drilled to a depth of 5 m and was installed as a groundwater and gas monitoring borehole.

<u>2022 site investigation</u>

- 1 No. drive-in-sampler borehole (DIS7) drilled to a depth of 3 m and was installed as a groundwater monitoring borehole. The ground had been levelled therefore the borehole was installed at basement formation level.

Site investigation borehole locations are shown in Figure 3-1.

Figure 3-1 Location of site investigation boreholes (based on RML, 2019 and RML, 2022)

3.2 Geology

3.2.1 Results

The geology encountered during the site investigations is summarised in Table 3-1

Table 3-1 Summary geology at boreholes DIS1 to DIS7

Borehole ID	Summary description
BH1	Topsoil to 0.2 m; Made Ground to 1.4 m; Soft to stiff brown grey mottled silty Clay to 8.8 m; Stiff to very stiff mottled grey silty Clay with pockets of orange-brown Sand to 11.6 m; Fine to coarse Gravel to 13.6 m; Chalk to 20.0 m.
DIS1	Made Ground to 0.3 m; Soft brown silty CLAY with fragments of siltstone and root to 2.7 m; Firm to stiff brown mottled grey silty CLAY to 3.0 m
DIS2	Made Ground to 0.4 m; Firm brown silty CLAY with roots to 2.9 m; Firm to stiff orange-brown mottled grey silty CLAY to 5.0 m
DIS3	Made Ground to 0.6 m; Firm orange-brown silty Clay to 1.8 m; Firm to stiff red-orange silty CLAY to 3.0 m
DIS4	Made Ground to 0.7 m; Firm orange-brown silty Clay to 2.2 m; Firm to stiff orange-brown mottled grey silty CLAY to 3.0 m
DIS5	Made Ground to 0.4 m; Firm orange-brown silty CLAY with occasional grey mottling to 3.0 m
DIS6	Made Ground to 0.2 m; Soft orange-brown silty Clay with pockets of grey silt to 1.4 m; Firm orange-brown silty CLAY to 2.2 m, Firm to stiff grey silty CLAY with occasional orange-red mottling to 3.0 m
DIS7	Orange-brown mottled grey and red-brown silty CLAY with occasional fragments of siltstone, becoming grey mottled orange-brown from 1 m, to 3.0 m

The deeper geology (encountered at borehole BH1) is summarised in Table 3-2. The datum of BH1 has not been provided, but is estimated to be c.72.0 m aOD, based on the site level plan in Appendix A.

Table 3-2 Geological model (at BH1, from RML, 2019)

Depth from (m)	Depth to (m)	Approx. elevation top (m aOD)	Approx. elevation base (m aOD)	Geology
0	0.2	72.0	71.8	Grass over Topsoil
0.2	1.4	71.8	70.6	Made Ground
1.4	11.6	70.6	60.4	Silty Clay
11.6	13.6	60.4	58.4	Rounded Gravel
13.6	20.0	58.4	52.0	Chalk

3.2.2 Interpretation

The shallow geology was found to be broadly similar across the site, with up to 1.4 m of Topsoil / Made Ground, underlain by soft to stiff brown/grey/orange silty Clay to at least 3 m. The proven site geology comprises up to 1.4 m of Topsoil / Made Ground underlain by silty Clay to 11.6 m (c.60.4 m aOD; at least 8 m below the proposed basement level of 68.5 m aOD).

BGS mapping indicates that the bedrock geology comprises Lambeth Group, overlain in the north of the site (i.e. across all but the access road) by a layer of London Clay. The base of the London Clay is usually marked by a thin bed of well-rounded flint gravel or a glauconitic horizon. However, the gravel / glauconitic horizon was not noted during site investigation, suggesting that the London Clay may be absent at the site, and that the whole site is underlain by Lambeth Group.

3.3 Groundwater

3.3.1 Results

Groundwater was noted in boreholes DIS1 and DIS2 during boring at 1.8 m and 2.0 m depth respectively. No groundwater was encountered during the drilling of borehole BH1 or shallow boreholes DIS3 to DIS6 in May 2019. Shallow borehole DIS7, drilled in February 2022 to 3 m, was also dry.

Groundwater monitoring results for borehole DIS2 are shown in Table 3-3. The datum of DIS2 has not been provided, but is estimated to be c.73.5 m aOD, based on the site level plan in Appendix A.

Table 3-3 Groundwater monitoring results for DIS2

Date	Groundwater level (m below datum)	Groundwater level (m aOD) assuming ground level of c.73.5 m aOD
3 June 2019	1.47	72.0
11 June 2019	1.57	71.9
20 June 2019	1.24	72.3

Groundwater at borehole DIS2 was measured between 1.24 m and 1.57 metres below datum (m bd) in June 2019. This is equivalent to a groundwater elevation of between 71.9 m aOD and 72.3 m aOD, assuming a ground level at DIS2 of 73.5 m aOD.

Groundwater level was measured at borehole DIS7 on 22 March 2022. The borehole, which is 3 m deep and was installed at basement level, was found to be dry. The groundwater level is therefore at least 3 m below basement level, and below 65.5 m aOD.[13]

It is understood that during excavation of the site to its full depth, between January and March 2022, no seepage was encountered.

[13] Assuming the ground level of the borehole is 68.5m aOD

3.3.2 Interpretation

Groundwater was only identified in two of the seven shallow boreholes (DIS1 and DIS2), which were drilled into Clay. Groundwater was not identified in deep borehole BH1, which penetrated a 2 m band of gravel, and the Chalk aquifer. It is therefore considered likely that the groundwater in DIS1 and DIS2 is perched groundwater and that the groundwater level was below 20 m depth, (c.52.0 m aOD), in May 2019 when BH1 was drilled.

3.4 Permeability test

A falling head permeability Test (SA1) was carried out at 1.24m depth within the standpipe installed in borehole DIS2 in order to help assess the drainage potential of the ground for proposed soakaways. The permeability test was undertaken in accordance with B.S. 5930:1999 Part 25.4.3 Variable Head Test. Results are shown in Figure 3-2.

Risk Management

FALLING HEAD PERMEABILITY TEST

Risk Management Limited
Tel : 01883 343572

Project Name : London School of Theology, Green Lane, Northwood, London HA6 2UW

SOAKAWAY TEST SA1 (DIS2)

Job No. RML 6980
Date : June 2019

Test Depth		H_0 =	
1.24		1.24	
Depth (m)	Time (mins)	H	H/H_0
0.120	0	1.12	0.90
0.160	1	1.08	0.87
0.180	2	1.06	0.85
0.200	3	1.04	0.84
0.240	4	1.00	0.81
0.260	5	0.98	0.79
0.520	10	0.72	0.58
0.700	15	0.54	0.44
0.820	20	0.42	0.34
0.910	25	0.33	0.27
0.980	30	0.26	0.21
1.100	45	0.14	0.11
1.180	60	0.06	0.05
1.210	75	0.03	0.02
1.230	90	0.01	0.01

Diameter of pipe =	0.019	(m)
Area (A) =	0.0003	(m^2)
Intake factor (F) =	0.05	
Basic Time Factor (T) =	18.5	(min)
Permeability (k) =	4.89E-06	m/sec

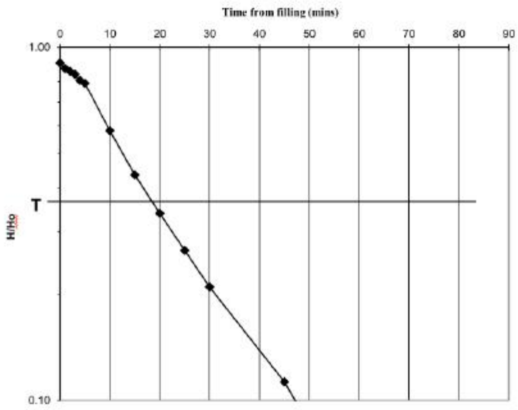


Figure 3-2 Permeability test results (from RML, 2019)

RML calculated the permeability at DIS2 to be 4.89 x 10^{-6} m/s, equivalent to 0.42 m/day.

4 SCREENING

Results of a groundwater screening assessment are presented in Table 4-1.

Table 4-1 Groundwater screening assessment

Question	Response	Details
Does the recorded water table extend above the base of the proposed subsurface structure?	No	A winter groundwater level was measured at shallow borehole DIS7 on 22 March 2022. The 3 m deep borehole, which was installed at basement level, was found to be dry, suggesting that the groundwater level is at least 3 m below basement level. The water table is thought to be at least 16 m below basement level. 20 m deep BH1 was dry upon drilling in May 2019, meaning that groundwater was lower than c.52 m aOD, compared to a basement level of 68.5 m aOD. Groundwater identified in two of seven shallow boreholes (DIS1 and DIS2), drilled into Clay, is thought to be isolated perched groundwater.
Is the proposed subsurface development structure within 100m of a watercourse or spring line?	No	There are no springs mapped within 500 m of the property. The nearest watercourse is a small river c.150 m south of the site.
Are infiltration methods proposed as part of the site's drainage strategy?	Unknown	A Surface Water Drainage Strategy from 2017 recommended drainage discharge to the sewer, subject to the results of infiltration testing. A permeability of 4.89 x 10^{-6} m/s was derived in 2019 using falling head permeability test at the site, but this is considered unusually high, and additional infiltration testing is recommended.
Does the proposed excavation during the construction phase extend below the local water table level or spring line (if applicable)?	No	There is no known local spring line. The water table is thought to be at least 16 m below basement level. During excavation of the site to its full depth, between January and March 2022, no seepage was encountered.
Is the most shallow geological strata at the site London Clay?	Mostly	London Clay is mapped as being the shallowest geological strata across the majority of the site, although the access Road in the south of the site is mapped as having the underlying Lambeth Group at the surface.
Is the site underlain by an aquifer and/or permeable geology?	Yes	Yes, the Lambeth Group is classed as a Secondary A aquifer.

5 SCOPING AND DISCUSSION

The following issues were identified during the screening process:

5.1 Existence of aquifer

The site is partially underlain by a Secondary A aquifer (corresponding with the mapped outcrop of the Lambeth Group). Furthermore, the site lies in Zone 2 of a SPZ.

However, the proven site geology comprises silty Clay to 11.6 m (c.60.4 m aOD; at least 8 m below the proposed basement level of 68.5 m aOD), underlain by Gravel to 13.6 and Chalk to 20 m. Perched, groundwater was identified in two of seven shallow boreholes, but no groundwater was identified during drilling of the deep borehole (BH1), which penetrated the underlying Chalk aquifer, nor during excavation of the site.

Although the Lambeth Group is classed as a Secondary A aquifer, it has been proven as 8 metres of Clay beneath the proposed development, therefore the proposed development is not considered to pose any risk to the underlying Chalk aquifer. Should groundwater level within the Chalk rise, this would not cause flooding at the development due to the presence of 8 m of Clay beneath the proposed basement.

The proposed development will be constructed in low permeability Clay, with only occasional perched groundwater identified. During excavation of the site to its full depth, between January and March 2022, no seepage was encountered.

5.1.1 Mitigation measures

The basement should be appropriately waterproofed in accordance with British Standard BS 8102 in order to mitigate against any seepage. NHBC requirements should be included in the detailed design.

The excavation should be kept dry from groundwater seepage and rainwater. It is expected that groundwater seepage can be dealt with using the methods used for removal of rainwater. Residual hydrogeological impacts on the proposed development would then be negligible.

No significant groundwater flow is predicted around the building, and the proposed development is not considered to cause any adverse hydrogeological impacts. No mitigation measures are considered necessary in order to maintain groundwater flow around the building.

5.2 Site drainage

The Surface Water Drainage Strategy proposed drainage via the sewer, due the likely poor infiltration potential of the soil and the unviability of discharging to a watercourse. The report recommended that the infiltration rate must be confirmed through trial pit infiltration tests on site prior to the final detailed drainage design stage being carried out.

RML calculated a permeability of 4.89×10^{-6} m/s using falling head permeability testing at DIS2 (a borehole within the Clay). This value is equivalent to 0.42 m/day which seems unusually high for a clay.

5.2.1 Mitigation measures

It is recommended that infiltration testing is undertaken prior to the final detailed drainage design stage being carried out.

6 CONCEPTUAL SITE MODEL

The land to the east of the London School of Theology, Green Lane, Northwood, HA6 2UW was levelled in early 2022 but previously comprised a two-storey student accommodation block and a pair of semi-detached houses set in grounds. There is no evidence of existing or approved nearby basements.

The proposed development involves construction of a residential building comprising 15 No. flats, including a basement level housing two flats with patios, 12 No. car parking spaces, cycle storage, motorcycle parking, and bin storage. The original site elevation lay at between 73.9 m aOD in the north and 70.5 m aOD in the south of the main part of the site (i.e. not including the access road), with a gentle slope down towards the south, but excavation to the proposed levels has been undertaken. Excavation of up to at least 4.64 m was required across the footprint of the proposed building and in the proposed parking area to the south/east of the building to achieve a basement floor level of 68.5 m aOD.

The mapped bedrock geology comprises Lambeth Group, overlain in the north of the site (i.e. across all but the access road) by a layer of London Clay, with no superficial sediments present. Site investigation recorded up to 1.4 m of Topsoil / Made Ground underlain by silty Clay to 11.6 m (c.60.4 m aOD, at least 8 m below the proposed basement level). It is considered likely that the silty Clay comprises the Lambeth Group, and that London Clay is not present at the site.

The nearest watercourse is located c.150 m south of the site, in Northwood Golf Course. The site is in flood zone 1. There is a low risk of surface water flooding within 20 m of the site.

The majority of the site (i.e. all but the access road) is designated by the Environment Agency as unproductive strata, with the access road underlain by a Secondary A aquifer (bedrock). The site lies in Zone 2 of a SPZ. The site is in an area which the Environment Agency classifies as having no potential for groundwater flooding to occur.

The water table is thought to be at least 16 m below basement level. Groundwater identified in two of seven shallow boreholes (DIS1 and DIS2), drilled into Clay, is thought to be isolated perched groundwater. During excavation of the site to its full depth, between January and March 2022, no seepage was encountered.

RML calculated a permeability of 4.89×10^{-6} m/s, equivalent to 0.42 m/day, which seems unusually high for a clay.

7 BASEMENT IMPACT ASSESSMENT

The water table is thought to be at least 16 m below basement level, but perched groundwater could cause seepage. Provided the following mitigation measures are adopted, hydrogeological impacts on the proposed development would be negligible:

- The basement should be appropriately waterproofed to British Standard BS 8102 in order to mitigate against any seepage. NHBC requirements should be included in the detailed design.
- The excavation should be kept dry. Any seepage from the open sides of the excavation is likely to be minimal and would be dealt with using provisions made for removal of rainwater.

No significant groundwater flow is predicted around the building, and the proposed development is not considered to cause any adverse hydrogeological impacts. No mitigation measures are considered necessary in order to maintain groundwater flow around the building.

In order to inform the SuDS design, it is recommended that additional infiltration testing be undertaken in the area where a soakaway would potentially be located, in accordance with BS EN ISO 22282-5:2012.

APPENDIX A

Existing and proposed plans

Rev	Date	Description

FLUENT
ARCHITECURAL DESIGN SERVICES
221 Clare Road, Staines,
Middlesex, TW19 7EF
Tel: 01784 391674 Mob: 07841 848473
E-mail: tommillin@fluent-ads.co.uk
Web: fluent-ads.co.uk

Client :
Westcombe Homes Ltd

LST Site C, Green Lane, Northwood

Location Plan

1 : 1250 @ A3 0 10 20

Scale	Dwg No.
1:1250 @ A3	FLU.249.4.01
Date 24.02.19	Rev B
Drawn N.Millin	

proposed levels

Existing levels

Rev	Date	Description

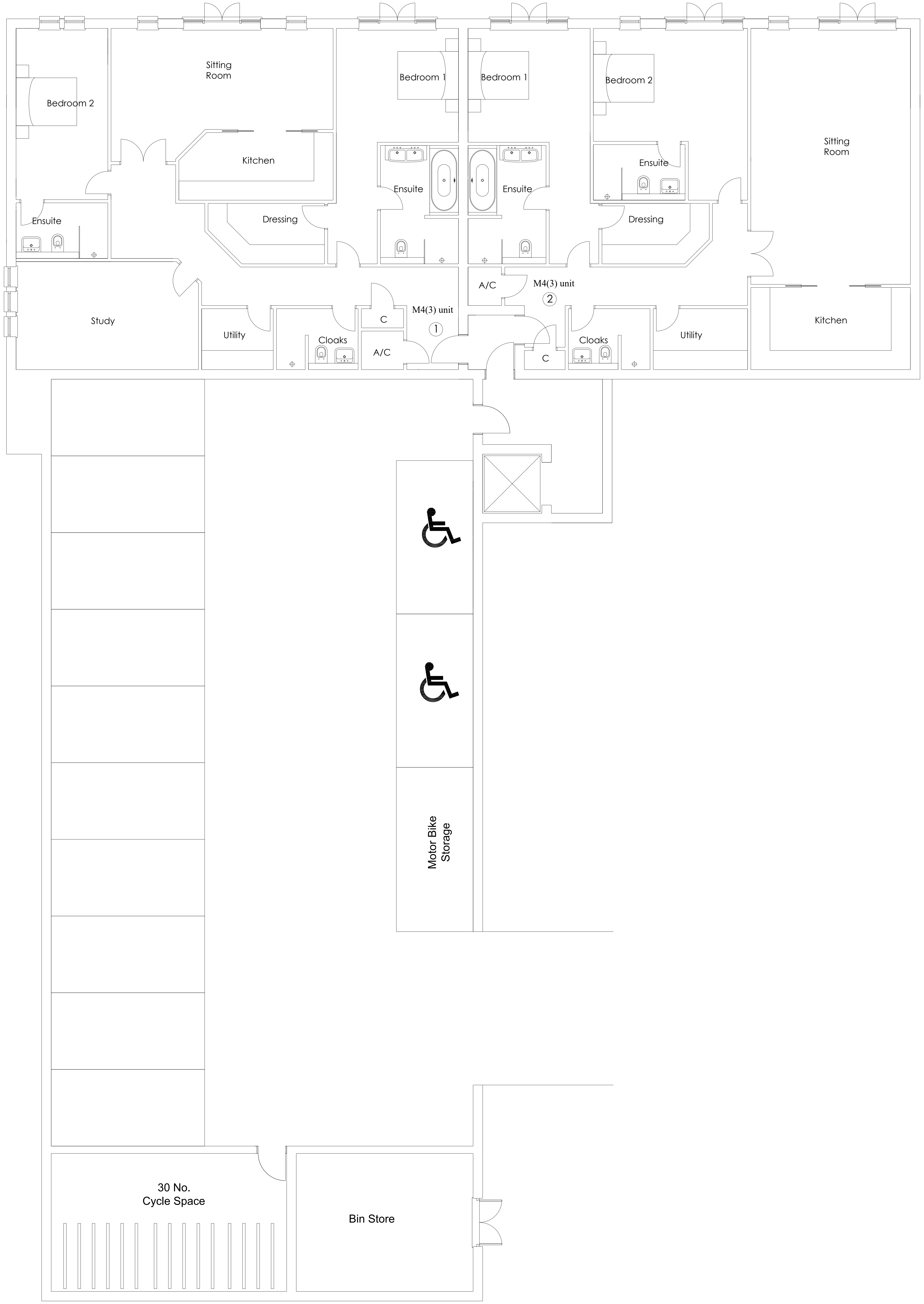
FLUENT
ARCHITECTURAL DESIGN SERVICES
221 Clare Road, Staines, Middlesex, TW19 7EF
Tel: 01784 391674 Mob: 07841 848473
E-mail: tommillin@fluent-ads.co.uk
Web: fluent-ads.co.uk

Client :
Westcombe Homes Ltd

LST Site C, Green Lane, Northwood

Levels Plan

Scale: 1:200 @ A2	Dwg No.: FLU.249.LP.01
Date: 25.03.20	Rev
Drawn: N.Millin	



Rev	Date	Description

FLUENT
ARCHITECURAL DESIGN SERVICES

221 Clare Road, Staines,
Middlesex, Tw19 7EF
Tel: 01784 391674 Mob: 07841 848473
E-mail: tommillin@fluent-ads.co.uk
Web: fluent-ads.co.uk

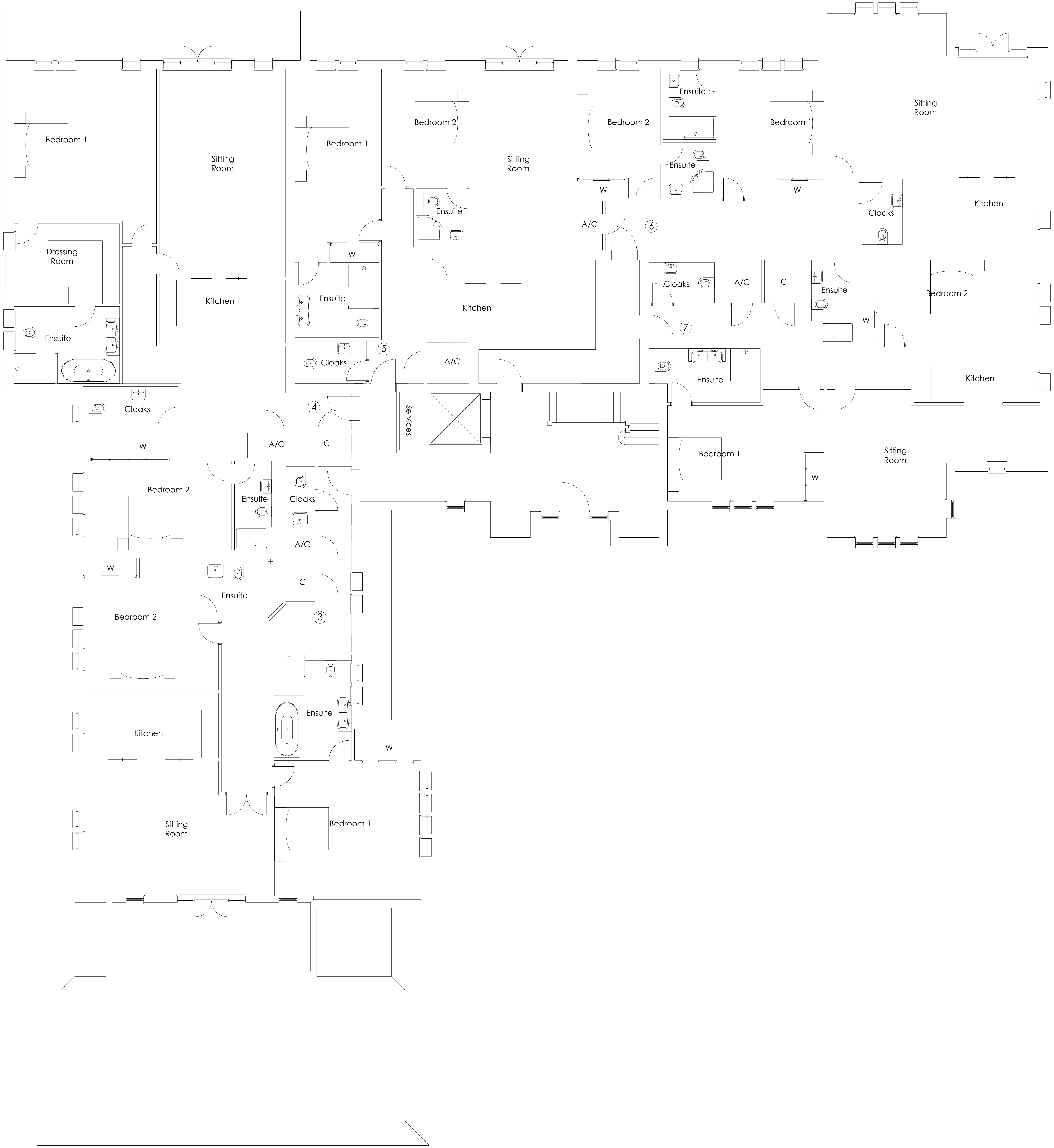
Client :
Westcombe Homes Ltd

LST Site C, Green Lane, Northwood

Basement Floor Plan

1 : 100 @ A2 0 1 2 3

Scale	Dwg No.
1:100 @ A2	FLU.249.4.03
Date	Rev
24.02.19	B
Drawn	
N.Millin	



Rev	Date	Description

FLUENT
ARCHITECURAL DESIGN SERVICES
221 Clare Road, Staines,
Middlesex, Tw19 7EF
Tel: 01784 391674 Mob: 07841 848473
E-mail: tommillin@fluent-ads.co.uk
Web: fluent-ads.co.uk

Client :
Westcombe Homes Ltd

LST Site C, Green Lane, Northwood

Ground Floor Plan

1 : 100 @ A2 0 1 2 3

Scale
1:100 @ A2

Dwg No.
FLU.249.4.04

Date
24.02.19

Rev
A

Drawn
N.Millin

Rev	Date	Description

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ARCHITECURAL DESIGN SERVICES
221 Clare Road, Staines,
Middlesex, Tw19 7EF
Tel: 01784 391674 Mob: 07841 848473
E-mail: tommillin@fluent-ads.co.uk
Web: fluent-ads.co.uk

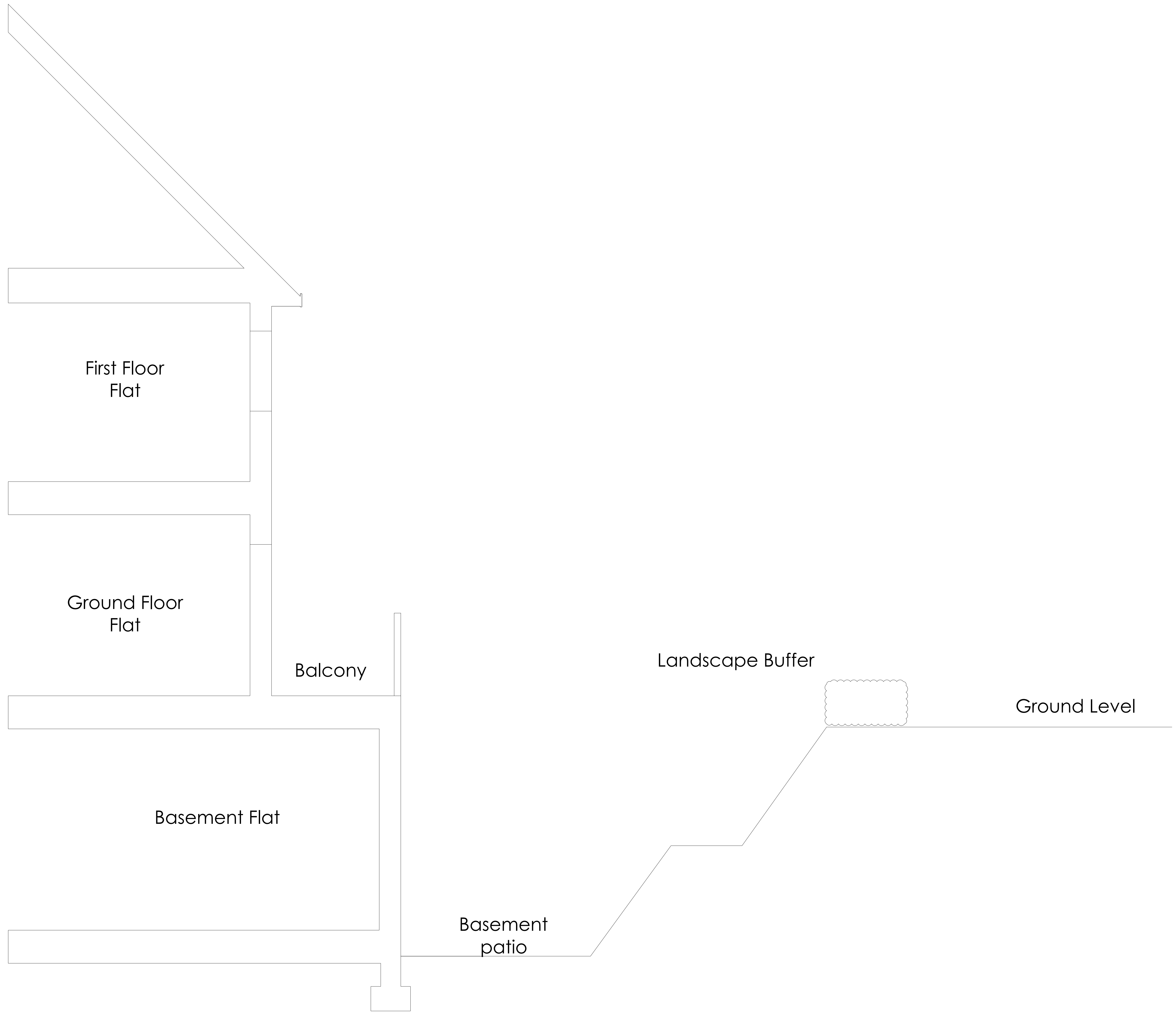
Client :
Westcombe Homes Ltd

LST Site C, Green Lane, Northwood

Front & Side Elevations

1 : 100 @ A2 0 1 2 3

Scale	Dwg No.
1:100 @ A2	FLU.249.4.07
Date 24.02.19	Rev
Drawn N.Millin	



Rev	Date	Description

FLUENT
ARCHITECURAL DESIGN SERVICES
221 Clare Road, Staines,
Middlesex, Tw19 7EF
Tel: 01784 391674 Mob: 07841 848473
E-mail: tommillin@fluent-ads.co.uk
Web: fluent-ads.co.uk

Client :
Westcombe Homes Ltd

LST Site C, Green Lane, Northwood

Basement Section

1 : 100 @ A2 0 1 2 3

Scale 1:50 @ A2	Dwg No. FLU.249.4.10
Date 24.02.19	Rev
Drawn N.Millin	

APPENDIX B

Surface Water Drainage Strategy

Ambiental Technical Solutions, May 2017

ambiental

predicting · preventing · protecting

Project:	Surface Water Drainage Strategy (SWDS)
Prepared for:	Fluent Ads
Reference:	SWDS 3110
Date:	May, 2017
Version:	Final v1.0

Document Issue Record

Project: Surface Water Drainage Strategy (SWDS)

Prepared for: Fluent Ads

Reference: SWDS 3110

Site Location: London School of Theology, Green Lane, Northwood, Middlesex, HA6 2UW

Proposed Development: It is understood that the development is for the removal of two existing 2 storey buildings and the construction of a new 2.5 storey apartment block with basement. The development will provide 12 residential units.

Consultant		Date	Signature
Author	Jose Tenedor	20/06/2016	
Document Check	Natalie James	20/06/2016	
Authorisation	Natalie James	20/06/2016	
Amendments	Jose Tenedor	21/03/2017	
Amendments	Jose Tenedor	16/05/2017	

Please Note:

Contact Us:

Ambiental Technical Solutions Ltd.
Science Park Square
Brighton, BN1 9SB
www.ambiental.co.uk
UK Office: +44 (0) 20 3857 8530 or +44 (0) 20 3857 8540

Contents

1. Summary

SITE DETAILS			
Site Name	London School of Theology, Green lane, Northwood, HA6 2UW		
Total Site Area	0.28 ha		
Site Area which is positively drained	0.28 ha		
Developed Area	0.15 ha		
Predevelopment Use	Site already developed for residential purposes.		
Site Constraints	Residential Site		
	Groundwater Source Protection Zone: YES. Outer zone (Zone 2).		
	Groundwater Vulnerability Zone: Minor Aquifer High		
	- Poor Infiltration Soils		
	- Unknown Groundwater Table		
IMPERMEABLE AREAS			
	Existing	Proposed	Difference (Proposed - Existing)
Impermeable Area (Ha)	0.13 ha	0.16 ha	0.03 ha
Drainage Method (Infiltration/Sewer/Watercourse)	Sewer	Sewer	N/A
PROPOSED TO DISCHARGE SURFACE WATER VIA			
	YES	NO	Evidence
Infiltration		X	Soils with Poor Infiltration Media.
To Watercourse		X	Discharge to watercourse is not viable.
To Surface water sewer	X		
Combination of above		X	
PEAK DISCHARGE RATES			
	Greenfield Rates (l/s)	Proposed Pre-development Rates (l/s)	Proposed Discharge Rates (l/s)
Greenfield Q_{BAR}	**1.28 l/s**	N/A	N/A
1 in 1	1.09 l/s	18.80 l/s	3.80
1 in 20	N/A	22.80 l/s	-
1 in 30	3.15 l/s	22.80 l/s	3.80
1 in 100	4.08 l/s	22.90 l/s	3.80
1 in 100 plus climate change	N/A	N/A	3.80

SITE STORAGE VOLUME		
Source Control Provided	Yes	
Interception Volume Storage (Daily Storms)	7m^3	
Attenuation Volume Storage (1 in 100 year + CC storm, critical duration)	95m^3	
Approach used for Long Term storage (LTS) Either Use Long Term Storage or Discharge at very low rate	Discharge at very Low Rate, thus LTS is not taken into account.	
LTS (1 in 100 years, 6 hours event)	0.00 m^3	
Total Site Storage	102m^3	

INFILTRATION FEASIBILITY ANALYSIS		
Geology	Pre-quaternary Marine/Estuarine Sand and Silt Clay to Silt	
Infiltration Rates	Less than 3x10^{-8} m/s	This value must be confirmed through trial pit infiltration tests on site prior to the final detailed drainage design stage being carried out.
Infiltration Rates Suitability	Unsuitable	
Ground Water Level	Unknown	It is recommended that a groundwater level check be undertaken at the later detailed design stage in order to accurately identify the depth of the water table at the site.
Is the site within a known Source Protection Zones (SPZ)?	Yes	Outer Zone (Zone 2)
Site's Contamination	Site already developed, thus there is a potential contamination due to petrochemical pollutants of the cars.	
Infiltration Feasibility	NO	
If Infiltration is not feasible, how is the Storage Requirements Approach?	Simple Approach. Discharge Long Term Storage and Attenuation Volume at very low discharge rate.	

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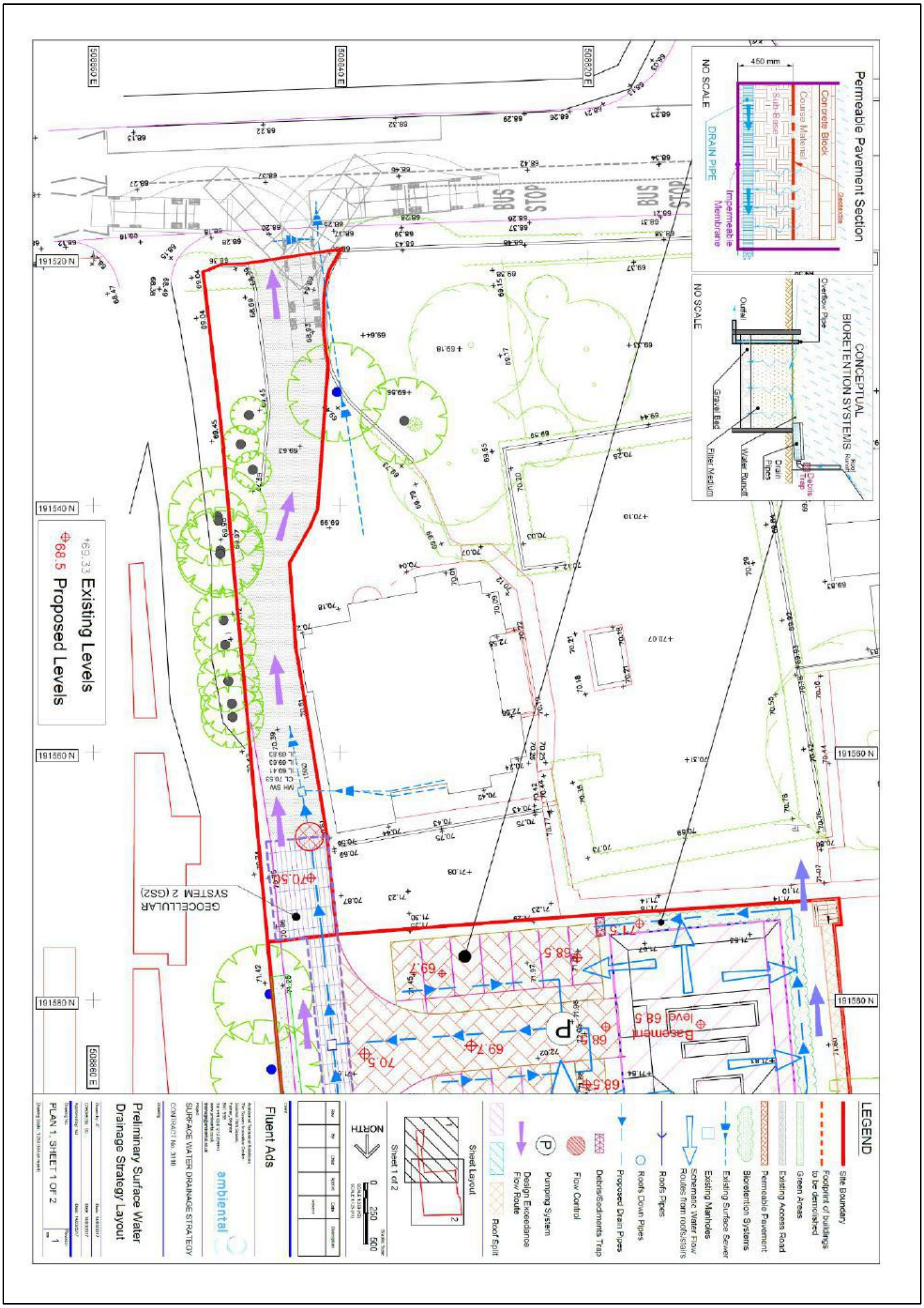
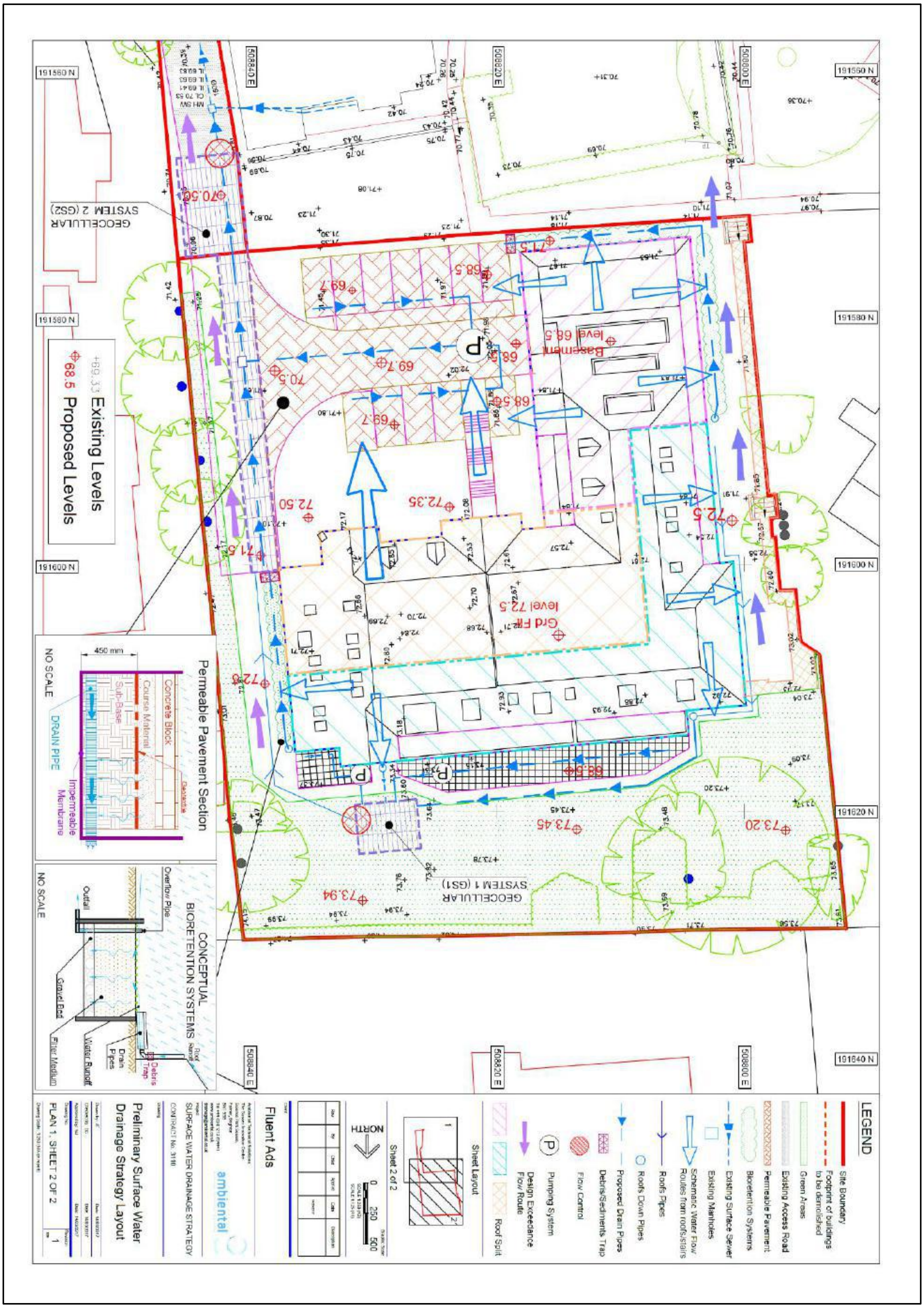
PROPOSED DRAINAGE COMPONENTS	
Permeable Pavement	Pervious surfaces provide a surface suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into underlying layers.
Bioretention Systems	Bioretention areas are shallow landscaped depressions which are typically under drained and rely on engineered soils, enhanced vegetation and filtration to remove pollution and reduce runoff downstream. They are aimed at managing and treating runoff from day-to-day rainfall events.
Geocellular System	Geocellular systems can be used to control and manage rainwater surface water runoff as a storage tank. The modular/honeycomb nature of geocellular systems means that they can be tailored to suit the specific requirements of any site.
Rills/Channels	Canals and rills are open surface water channels with hard edges. They are simply channels that water flows along whereby they can have a variety of cross sections to suit the urban landscape, including the use of planting to provide both enhanced visual appeal and water treatment.
Flow Control	A self-activating device that provides improved hydraulic performance over conventional flow controls such as orifice plates and throttle pipes and reduced maintenance requirements.

DESIGN CHECKS		
Drainage Systems Measures	Permeable Pavement, Geocellular System, Bioretention Systems, Flow Control (Hydrobrake or Vortex Control), Pumping System	
How are rates being restricted	Hydrobrake	
Key Drainage component	Geocellular Systems and Pumping Systems	
Drainage Systems Maintenance	Supplier must provide appropriate guidance for maintenance	
All SuDS storage located outside Q100 floodplain	Yes	
Provision for blockage / Design Exceedance	Yes	Exceedance routes are provided
Time taken for 50% of storage to drain down	2.34 hours	

Proposed Surface Water Drainage Strategy Layout





LEGEND
Site Boundary
Footprint of buildings to be demolished
Green Areas
Existing Access Road
Permeable Pavement
Bioretention Systems
Existing Surface Sewer
Existing Manholes
Schematic Water Flow Routes from roofs/stairs
Roofs Pipes
Roofs Down Pipes
Proposed Drain Pipes
Debris/Sediments Trap
Flow Control
Pumping System
Design Exceedance Flow Route
Roof Split
Sheet Layout
Sheet 2 of 2
NORTH
Fluent Ads
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SURFACE WATER DRAINAGE STRATEGY
CONTRACT No. 3110
Preliminary Surface Water Drainage Strategy Layout
PLAN 1, SHEET 2 OF 2
+69.33 Existing Levels
68.5 Proposed Levels
Basement level 68.5
Grd Flr level 72.5
GEOCELLULAR SYSTEM 1 (GS1)
GEOCELLULAR SYSTEM 2 (GS2)
Permeable Pavement Section
Concrete Block
Course Material
Sub-Base
Impermeable Membrane
DRAIN PIPE
450 mm
NO SCALE
CONCEPTUAL BIORETENTION SYSTEMS
Overflow Pipe
Outfall
Gravel Bed
Filter Medium
Water Runoff
Drain Pipes
Debris Trap
NO SCALE

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2. Introduction

2.1 This Surface Water Drainage Strategy has been prepared by Ambiental Technical Solutions, in respect of a planning application for the redevelopment of two existing storey buildings at the London School of Theology, Green Lane, Northwood, Middlesex, HA6 2UW (X:508808; Y:191602). See Appendix 1, Plan 1 – Site Location, Plan 2 – Plan Location and an extract of the Plan 1 on the Figure 1 below.

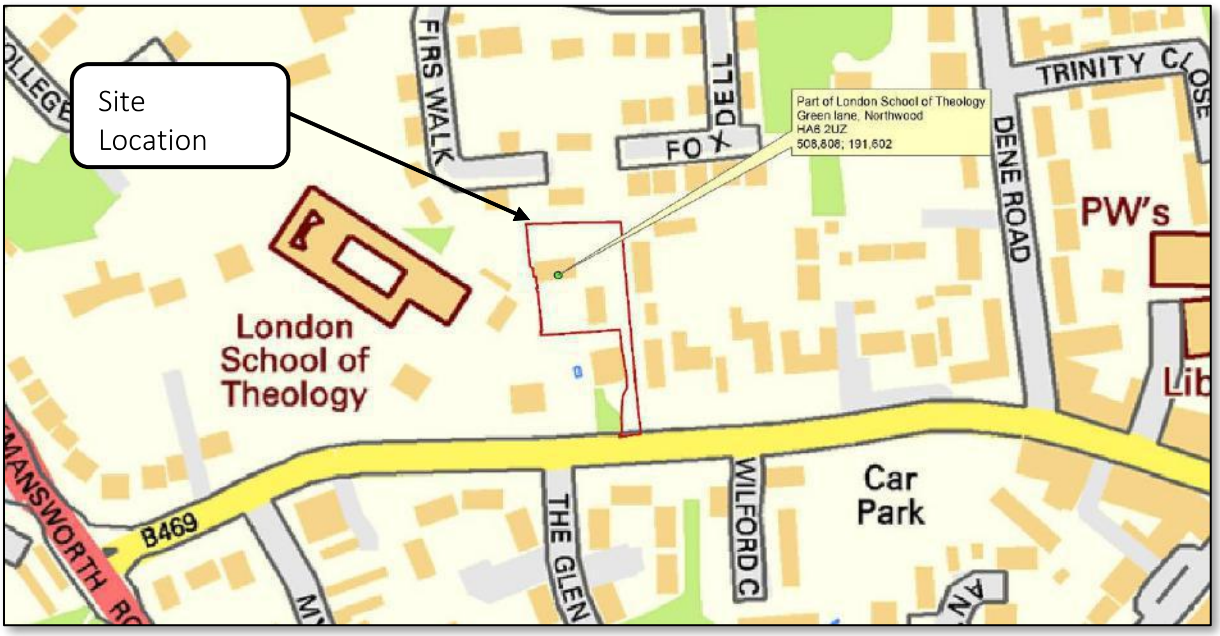

Figure 1 - Extract of Appendix 1, Plan 1 - Site Location (Source: OS-Street View). Site boundary shown in red.

Development Proposal

2.2 It is understood that the development is for the removal of two existing 2 storey buildings to build a new 2.5 storey apartment block with basement, providing 12 residential units.

2.3 This study is based on the plans in Appendix 1 (refer to Plans 1 to 12. Plans 1 and 4 were made in-house, while the remaining plans were provided by the client).

Need for Study

2.4 The purpose of this assessment is to demonstrate that the development proposal outlined above can be satisfactorily accommodated without worsening flood risk for the area and without placing the development itself at risk of flooding, as per National guidance provided within the National Planning Policy Framework (NPPF).

3. Development Description and Site Area

3.1 The site forms part of the London School of Theology which is located within Northwood to the north of the London Borough of Hillingdon. Specifically, it is bounded by Green Lane to the south, several dwellings to the north and the east, while the main building of the London School of Theology is to the west. The site is currently formed of two 2-storey buildings, a square grass area as well as access from Green Lane. Refer to Appendix 1, Plan 1 – Site Location, Plan 2 – Plan Location, Plan 3 – Topographical Survey of the Site as well as the Figures 1 (above) and 2 (below).

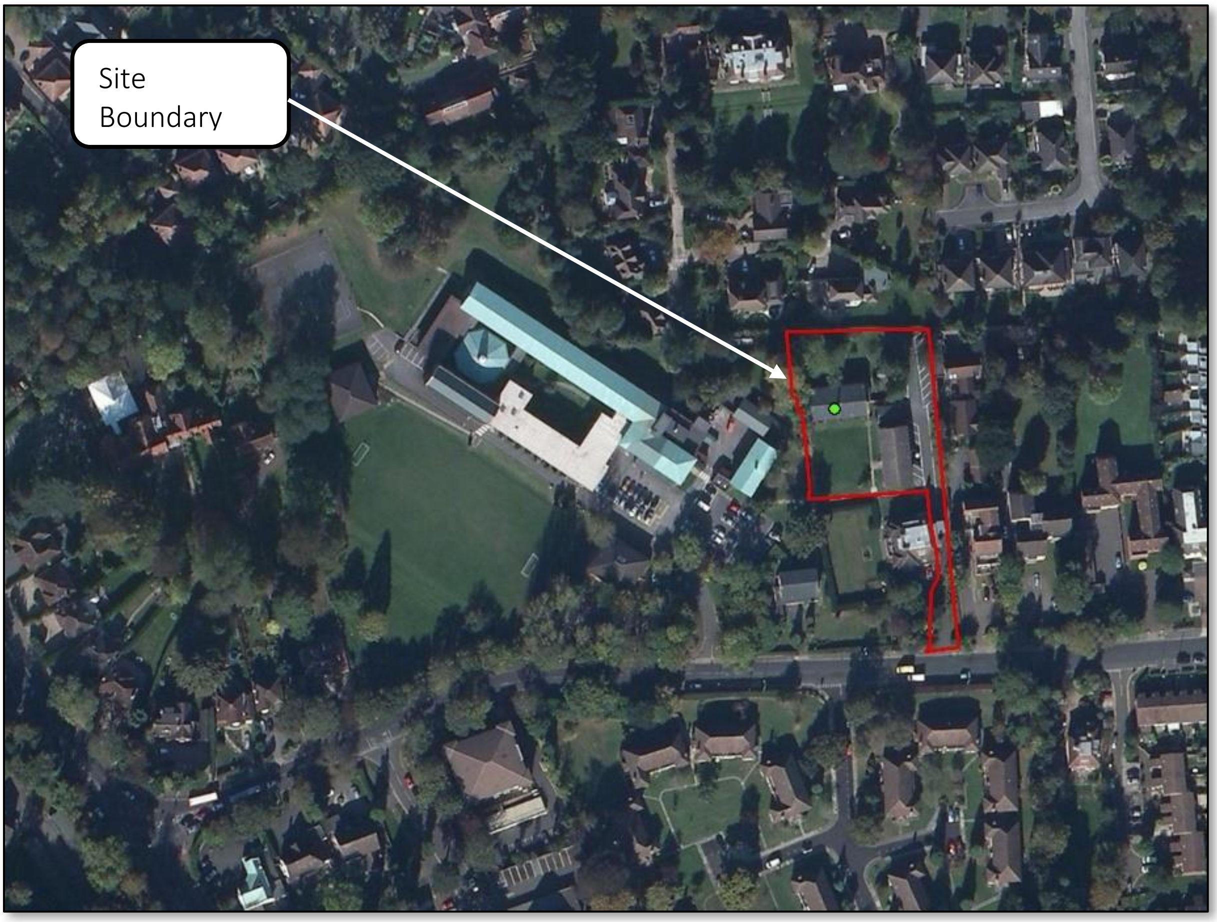

Figure 2 - Aerial View of Development Site (Source: ESRI). Site boundary shown in red.

3.2 It is understood that the development is for the removal of two existing 2 storey buildings to build a new 2.5 storey apartment block with basement, providing 12 residential units. See Appendix 1, Plan 5 – Proposed Site Layout and Figure 3 overleaf.

Figure 3 - Extract of Appendix 1, Plan 5 – Proposed Site Layout.

3.3 As the existing site is already developed, it is considered **brownfield**.

3.4 The total area of the site is approximately 3030.2m^2 (0.3 Ha), based on plans the provided by the client. However road access is subtracted as it is not to be modified. Hence, the area on the Site to be taken into account is approximately 2766.6m^2 (approximately 0.28Ha).

3.5 Having said that, the existing site to be modified is considered partly pervious (1492.75m^2, approx. 0.15Ha), due to the existing green areas, thus there is an existing impervious area of 1273.86m^2 (approximately 0.13 Ha). Following development, the pervious areas on site will be reduced to approximately 1166m^2 (approximately 0.12 Ha), while the impervious areas will be increased to approximately 1601m^2 (0.16 Ha).

3.6 According to the topographical survey provided by the client, the topography of the site ranges from 68.33mAOD[1] to 74.26mAOD. Hence the site can be considered to slope to the south with likelihood of rapid runoff within the property boundary. Refer to Appendix 1, Plan 3 – Topographical Survey of the Site, Plan 4 – Existing Surface Water Flow Pathways and an extract of the Plan 4 on the Figure 4 below.

Figure 4 – Extract of Appendix 1, Plan 4 – Existing Surface Water Flow Pathways.

[1] mAOD: meters Above Ordnance Datum.

Existing Drainage Infrastructure

3.7 The existing site is currently developed, thus it is considered that there is a drainage infrastructure associated to it. This is confirmed by the topographical survey provided by the client. Refer to Appendix 1, Plan 3 – Topographical Survey of the Site and an extract of it on the Figure 5 below. Based on this plan, the surface water of the Site is drained by a 100mm of diameter pipe. See Figure 5 below:

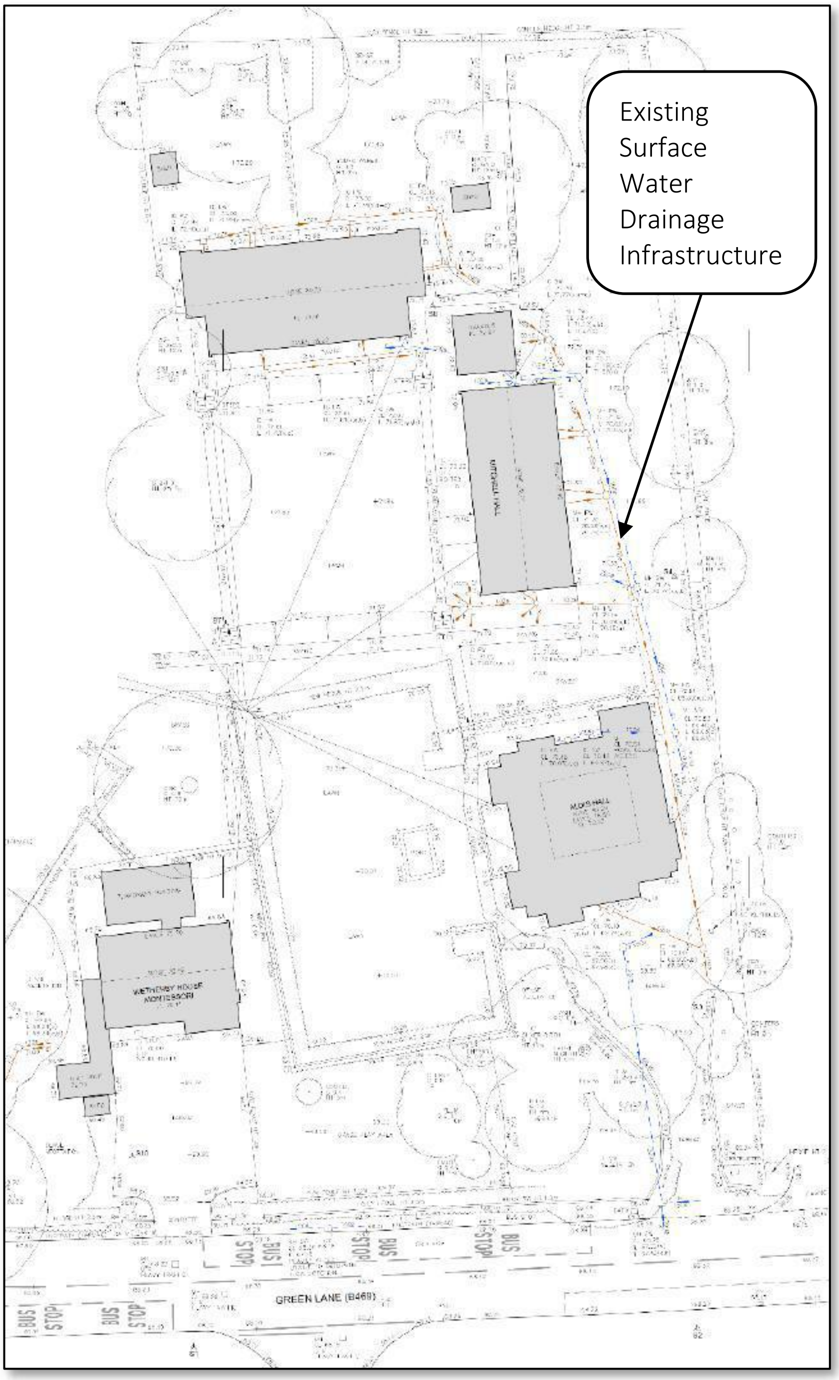

Figure 5 – Extract of Appendix 1, Plan 3 – Topographical Survey of the Site.

3.8 Although public sewer records were not provided by the client, **there is a potential opportunity of utilising the public sewer network for surface water discharging purposes.**

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Existing Ground Conditions

3.9 The British Geological Survey (BGS) Map indicates that the bedrock underlying the site is the *London Clay Formation – Clay, Silt and Sand* and the *Lambeth Group – Clay, Silt and Sand*. (See an extract from the BGS Geology map in Appendix 2, Figure 1.A – Bedrock Geology, London Clay Formation and Figure 1.B – Bedrock Geology, Lambeth Group).

3.10 The *London Clay Formation* is a sedimentary bedrock formed approximately 34 to 56 million years ago in the Palaeogene Period. The local environment of the origin of these rocks was previously dominated by deep seas, being formed from infrequent slurries of shallow water sediments which were then redeposited as graded beds. The Lambeth Group, however is a sedimentary bedrock formed approximately 56 to 66 million years ago in the Palaeogene Period as well. The local environment was previously dominated by swamps, estuaries and deltas, thus these rocks were formed in marginal coastal plains with lakes and swamps.

3.11 There are no records in relation to the Superficial Deposits in the BGS database. (See the extract from BGS Geology Map in Appendix 2, Figure 2 – Superficial Deposits).

3.12 The Soil Parental Material in the area taken from the UK Soil Observatory (UKSO) website is classified as *Pre-quaternary Marine/Estuarine Sand and Silt* while the Soil Texture is *Clay to Silt* to the north of the site and *Loam to Silty Loam* to the south. See Appendix 2, Figure 3 – Soil Parental Material as well as the Appendix 2, Figure 4.A – Soil Texture-North, Clay to Silt and the Figure 4.B – Soil Texture, South, Loam to Silty Loam.

3.13 Standard values from the specialized literature *CIRIA 753 'The SUDS Manual'* suggest the infiltration coefficient of these types of soils is less than $1.08\text{x}10^{-4}$ m/h ($3\text{x}10^{-8}$ m/s) for clayey soils, the range for loam soils is between 0.00036 m/h ($1\text{x}10^{-7}$ m/s) and 0.018 m/h ($5\text{x}10^{-6}$ m/s), while the range for silty loam soils is between 0.00036 m/h ($1\text{x}10^{-7}$ m/s) and 0.036 m/h ($1\text{x}10^{-5}$ m/s). See Table 1 – Typical Infiltration Coefficients based on Soil Texture below. It is recommended that these values are checked through trial pit infiltration tests on site prior to the final detailed drainage design being carried out.

SOIL TYPE	Typical infiltration Coefficients (m/h)
Poor Infiltration media	
Loam	0.00036 - 0.018
Silt Loam	0.00036 - 0.036
Very Poor Infiltration media	
Clay	$< 1.08\text{x}10^{-6}$

Table 1 – Typical Infiltration Coefficients based on Soil Texture

3.14 There are three boreholes from the BGS database, very close to the site to the east. The borehole's reference are TQ09SE50, TQ09SE103 and TQ09SE104 located at approximately 120, 90 and 80 metres respectively. See Appendix 2, Figure 5 – Boreholes Map and an extract of it on the Figure 6 below as well as the boreholes data on the Appendix 2, Figures 5.2.1, 5.2.2, 5.3.1 and 5.4.1. Based on the description of the Boreholes TQ09SE103 and TQ09SE104, the site is underlain by clayey layers.

Figure 6 - Extract of Appendix 2, Figure 5.1 – Boreholes Location Map

3.15 It is recommended that a groundwater level check be undertaken later at the detailed design stage, in order to accurately identify the depth of the water table at the site.

3.16 Additionally, it is important to note for the infiltration devices they should follow the guidance of the specialized literature the *CIRIA 753 – 'The SuDS Manual'*, section 25.2.2:

> *"Groundwater levels should be investigated to ensure that the base of a proposed infiltration component is at least 1 m above the maximum anticipated groundwater level (taking account of seasonal variations in levels and any underlying trends)"*.

3.17 Thus, in compliance with the *CIRIA 753 – 'The SuDS Manual'*, if an infiltration device was proposed, the groundwater table must be always at least 1m below of the bottom of the device. This measure could be loose to fix the groundwater table just below the bottom of the device, under the consent of the corresponding environmental regulator or drainage approval body.

3.18 The site lies in within aquifers with significant intergranular flow and considered as a *Low Productive Aquifer* according to the BGS hydrogeological database (see Appendix 2, Figure 6 – Hydrogeology).

3.19 The EA's[2] *Groundwater Source Protection Zone Map* confirms that the site lies within a Source Protection Zone considered as *Outer Zone (Zone 2)*, as well as within a Groundwater Vulnerability Zone classified as *Minor Aquifer High*. See Appendix 2, Figure 7 - Groundwater Source Protection Zones and Figure 8 – Groundwater Vulnerability Zones.

Nearby Watercourses and Drainage

3.20 In general terms, the runoff from the existing site flows to south of the site where the lowest point is located, according to the topographical survey data provided by the client.

3.21 A watercourse, considered as a main river by the Environmental Agency is located approximately 630m to north-east of the red line application boundary. See Figure 7 below.

3.22 **Thus, it is considered that there is no watercourse close enough to the site for discharging purposes.**

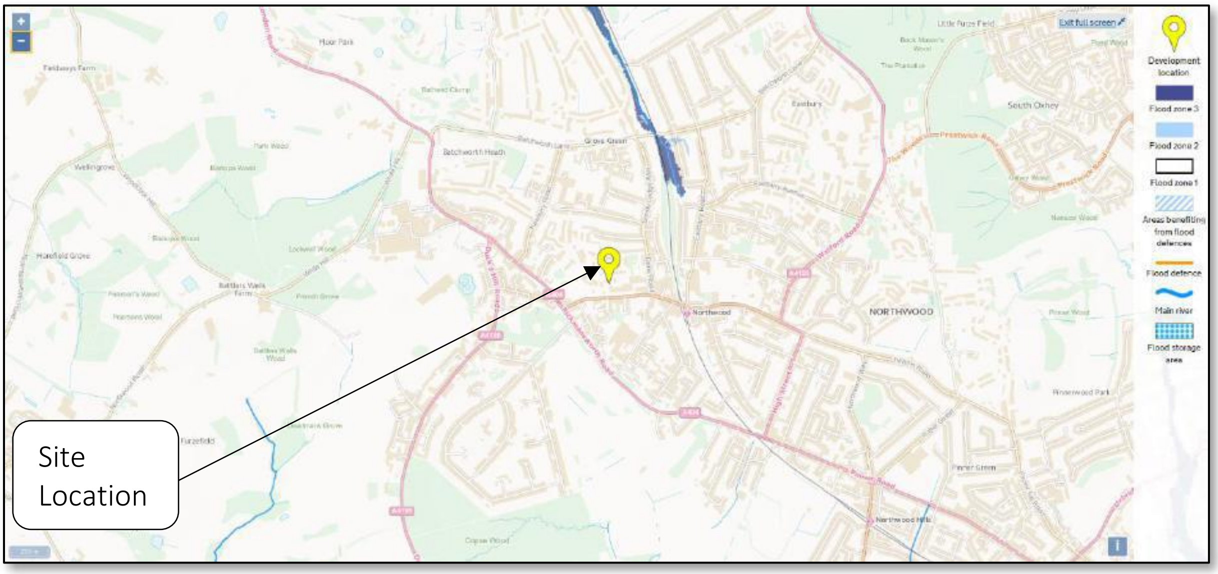

Figure 7 – Extract of EA Flood Map for Planning (Source: EA).

[2] EA: Environmental Agency

4. Surface Water Drainage

4.1 In order to mitigate flood risk posed by the proposed development, adequate control measures are required to be considered. This will ensure that surface water runoff is dealt with at source and the flood risk off site is not increased.

4.2 The existing site is already developed, being considered brownfield, and it is comprised of impervious surfaces areas; thus there is an existing drainage infrastructure which is confirmed by the Topographical Survey provided by the client. In accordance with the proposed development plans, the proposed development will increase the impermeable surface cover to the site by approximately 327m².

4.3 Based on the Policy 5.13 of the London Plan 2016:

"Development should utilise sustainable urban drainage systems (SUDS[3]) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:

1. *Store rainwater for later use;*
2. *Use infiltration techniques, such as porous surfaces in non-clay areas;*
3. *Attenuate rainwater in ponds or open water features for gradual release;*
4. *Attenuate rainwater by storing in tanks or sealed water features for gradual release;*
5. *Discharge rainwater direct to a watercourse;*
6. *Discharge rainwater to a surface water sewer/drain;*
7. *Discharge rainwater to the combined sewer.*

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

4.4 Therefore, the runoff arising from the redevelopment will need to be managed in accordance with sustainable drainage principles.

Infiltration Potential

4.5 The BGS database and the UK Soil Observatory records indicate the site is predominantly underlain by clayey soils which are unlikely to be suitable for infiltration drainage. Furthermore, the local Surface Water Management Plan, London Borough of Hillingdon, indicates that the area is unsuitable for infiltration drainage. See Appendix 2, Figure 9 – Infiltration SUDS Suitability Map.

4.6 Therefore it is proposed that surface water will be discharged post development via attenuation SuDS.

[3] SuDS: Sustainable Drainage Systems which are able to manage surface water that take account of water quantity (flooding), water quality (pollution) biodiversity (wildlife and plants) and amenity.

Runoff rates

4.7 The specialised literature *CIRIA 753 'The SUDS Manual'* provides two approaches guidance for the rates of discharge in relation to the Long-Tem Storage:

- Approach A

  "Where there is extra volume generated by the development that has to be discharged (because there are no opportunities for it to be infiltrated and/or used on site), this volume should be released at a very low rate (eg < 2 l/s/ha or as agreed with the local drainage approving body and/or environmental regulator) and the 1:100 year greenfield allowable runoff rate reduced to take account of this extra discharge." (Kellagher, 2002).

- Approach B

  "An alternative approach to managing the extra runoff volumes from extreme events separately from the main drainage system is to release all runoff (above the 1 year event) from the site at a maximum rate of 2 l/s/ha or QBAR, whichever is the higher value (or as agreed with the drainage approving body and/or environmental regulator). This avoids the need to undertake more detailed calculations and modelling."

4.8 As Infiltration techniques are not viable, it is proposed to discharge all runoff due to any storm events above than 1 in 1 year event at a low rate such as Q_{BAR} or as agreed with the drainage approving body in compliance with the **Approach B** above.

4.9 Greenfield runoff rates have been calculated using the *Institute of Hydrology Report 124 (*Marshall and Bayliss, 1994*)*, as recommended in the *CIRIA 753 'The SUDS Manual'* (See calculations in Appendix 3, Table 1 – Greenfield Runoff Rates Calculation Summary).

4.10 The Greenfield runoff rates for several storm durations for various return periods have been calculated based on the following equation:

$$QBAR_{rural} = 0.00108 * AREA^{0.89} * SAAR^{1.179} * SOIL^{2.17}$$

Where,

$Q_{BAR,rural}$: Mean Annual Flood (m^3/s).

AREA: Catchment Area (km^2).

SAAR: Standard Average Annual Rainfall for the 1941 to 1970 (mm).

SOIL: Soil Index of the catchment from Wallingford Procedure Volume 3.

Equation 1 – IH 124 Mean Annual flood flow Rate Equation.

4.11 Preliminary calculations based on Equation 1 show that the *Greenfield Runoff Rate* ($Q_{BAR,rural}$) from 50Ha is 231.34l/s. According to the size area positively drained (0.28ha), **the *Greenfield Runoff Rate* from the area of the site is 1.28l/s (4.63l/s/ha)**. Other results properly factored for each return period and area of the site are shown in Appendix 3, Table 1 – Greenfield Runoff Rates Calculation Summary.

4.12 The CIRIA 753 'The SUDS Manual', Section 24.5, specifies that the runoff rate and runoff volume estimation to previously developed sites can be carried out as per the paragraph below:

"(…)

Runoff characteristics for a previously developed site can be estimated in a number of ways:

1 Any land that has been previously developed is likely to have had a system in place to drain surface water runoff from the site. This drainage system may or may not have included storage and flow control systems. Where any drainage system is still operational, peak flow rates at the outfall for the relevant return periods (usually 1:1 year, 1:30 year and 1:100 year) can be demonstrated by producing a simulation model that includes an accurate representation of the drainage system and site area contributions – thus allowing derivation of an appropriate head-discharge relationship at the outfall.

It is recognised that existing drainage systems will probably be overwhelmed for the 1:30 and 1:100 year events and therefore the actual rate of discharge from the site in such scenarios is likely to be increased by overland flow contributions or surcharging. However, these effects should not be accounted for, and the discharge limit should be based solely on the flow rate from the piped system (thus providing a conservative estimate).

(…)".

4.13 Therefore in view of the above, a minimum flow based on the 1 in 20 year pre development runoff rate will be utilised as the limiting discharge rate from the site. In order to look into the existing runoff rates of the existing site, a storm sewer design simulation has been carried out using the industry standard software, Microdrainage v2016.1. The results from a variety of rainfall events are shown on the Appendix 3 – Calculations, Existing Runoff Rates and a summary of them on the Table 2.

4.14 Additionally, and following the guidance of the Sustainable Design and Construction SPG, Mayor of London:

"(…)

3.4.8 Most developments referred to the Mayor have been able to achieve at least 50% attenuation of the site's (prior to re-development) surface water runoff at peak times. This is the minimum expectation from development proposals.

3.4.9 There may be situations where it is not appropriate to discharge at greenfield runoff rates. These include, for example, sites where the calculated greenfield runoff rate is extremely low and the final outfall of a piped system required to achieve this would be prone to blockage. An appropriate minimum discharge rate would be ***5 litres*** *per second per outfall.*

3.4.10 All developments on greenfield sites must maintain greenfield runoff rates. ***On previously developed sites, runoff rates should not be more than three times the calculated greenfield rate****. The only exceptions to this, where greater discharge rates may be acceptable, are where a pumped discharge would be required to meet the standards or where surface water drainage is to tidal waters and therefore would be able to discharge at unrestricted rates provided unacceptable scour would not result.*

(…)".

4.15 It should be noted that although a rate of 5l/s has been historically considered as a limiting discharge when Q_{BAR} was lower than that (this is due to the fact that most of devices would require an outlet orifice size smaller than 50mm which would increase the susceptibility of blockage and failure); currently there are flow control devices that can be designed up to a limiting discharge rate of 1.0l/s.

4.16 Therefore, taking into consideration the discharge restrictions exposed above, and according to the guidance of the Sustainable Design and Construction SPG, Mayor of London, if the Greenfield Runoff Rate is 1.28l/s, a limiting discharge of 3 times greenfield runoff rate could be proposed, 3.84l/s. Additionally, the proposed rate is lower than the 50% of the existing 1 in 100 year pre-development runoff rate as required by the Sustainable Design and Construction SPG of the Mayor of London.

4.17 **Hence, a limiting discharge of 3.8l/s will be utilised as the design runoff rate**. See Table 2 – Surface Water Discharge Rates Summary below:

SURFACE WATER DISCHARGE RATES SUMMARY						
	Impermeable Area (m²)	Discharge Rates (l/s)				
		Q_{BAR}	1 year	20 years	30 years	100 years
Greenfield Site	0	**1.28**	1.09	-	3.15	1.08
Existing Site (Using Microdrainage)	1274	-	18.8	22.8	22.8	22.9
Reduction of 50% for the Existing Site	1274	-	9.4	11.4	11.4	11.45
Limiting Discharge for Proposed Site	1600	-	3.8	-	3.8	3.8
Designed Discharge for Proposed Site (from calculations in Appendix 3)	**1761 (Urban Creep Factor applied)**	**-**	**3.6**	**-**	**3.8**	**3.8**

Table 2 – Surface Water Discharge Rates Summary

4.18 It can be seen from the Table 2 that the proposed limiting discharge rates are lower than the existing runoff rates for the 1 in 1, 1 in 30 and 1 in 100 years rainfall events. Proposed limiting discharge rates will reduce the outflow capacity of the existing drainage infrastructure network within the site and improving the existing discharge conditions.

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Interception Storage

4.19 Preliminary calculations have been carried out for a typical rainfall depth of $5mm/m^2$ to store the volume owing to these very frequent storms.

4.20 Urban Creep Factor (UCF) is defined as any increase in the impervious area that is drained to an existing drainage system without planning permission being required, such as the construction of patios, conservatories, small extensions, etc. Hence, an increase in paved surface area of 10% is often suggested by the *CIRIA 753 'The SUDS Manual'*. Also, a typical Runoff Percentage of 80% has been taken into account.

4.21 **Based on the size of the whole area of the site, the UCF and the Runoff Percentage, the Interception Storage is 7.04m^3.**

Long Term Storage

4.22 **Long-Term Storage is not taken into account, as defined by *Approach B* in Paragraph 4.7.**

Attenuation Storage

4.23 Attenuation storage is needed to temporarily store water during periods when the runoff rates from the development site exceed the allowable discharge rates from the site.

4.24 Rainfall depths for the 1 in 100 years Return Period plus 40% of climate change were produced using the *Microdrainage* software in order to estimate the largest volume, *critical storm*, for typical storm durations up to and including 48 hours for the proposed site limiting the discharge rate up to **3.8 l/s**. In addition to this, the Urban Creep Factor, 10%, is applied for the impervious surface. See summary calculations in Appendix 3, Calculations, Summary of Results for Proposed SuDS.

4.25 Thus, it meets with the minimum standards required by the DEFRA - Non-statutory technical standards for sustainable drainage systems (March 2015), to avoid the flood risk within the development in a 1 in 100 year rainfall event.

4.26 In terms of storage, for a 100 years storm event with an allowance for climate change **therefore the Attenuation Storage Volume required is 95m^3**. See summary calculations in Appendix 3, Calculations, Summary of Results for Proposed SuDS.

Storage Volumes

4.27 Preliminary calculations indicate that 95m^3 of storage will be required to attenuate all runoff above the 1:1 year storm events up to a 1 in 100 years return period storm event - with a 40% climate change allowance and including a 10% of Urban Creep Factor. Approximately 7m^3 of storage are required for the day-to-day rainfall as Interception Volume. Long-Term Storage Volume (6 hours, 100 year Return Period event) is not taken into account.

4.28 **Thus a Total Storage of 102m^3 is required to be managed through SuDS techniques.**

5. SuDS Assessment

5.1 In accordance with a SuDS management train approach, the use of various SuDS measures to reduce and control surface water flows have been considered in details for the development. Based on the hierarchy line of discharge provided by the Policy 5.13 of the London Plan 2016:

Drainage Hierarchy			
		Suitability	Comment
1.	Store rainwater for later use.	✓	The use of rainwater for a potential non-potable use such as gardening might be suitable.
2.	Use infiltration techniques, such as porous surfaces in non-clay areas.	×	Due to the geology at the site, infiltration is considered unsuitable.
3.	Attenuate rainwater in ponds or open water features for gradual release.	×	There is no ponds or open water features within the site. Besides that, space and topographical constraints would make too complicate to incorporate this type of storage water to the development.
4.	Attenuate rainwater by storing in tanks or sealed water features for gradual release.	✓	Due to the proposed layout, sealed water features for gradual release is considered suitable.
5.	Discharge rainwater direct to a watercourse.	×	There is no watercourses close enough to the site.
6.	Discharge rainwater to a surface water sewer/drain.	✓	There is an existing surface water drainage infrastructure within the site, thus it is taking into consideration.
7.	Discharge rainwater to the combined sewer.	-	Not taken into account.

Table 3 – Drainage Hierarchy

5.2 At this stage the practicality and viability of certain SuDS options have been ruled out on the basis of ground conditions and constraints presented by the site layout:

Suitability of SuDS Components		
SuDS Component	Description	Suitability
Infiltrating SuDS	Infiltration can contribute to reducing runoff rates and volumes while supporting baseflow and groundwater recharge processes. The suitability and infiltration rate depends on the permeability of the surrounding soils	×
Permeable Pavement	Pervious surfaces can be used in combination with aggregate sub-base and/or geocellular/modular storage to attenuate and/or infiltrate runoff from surrounding surfaces and roofs. Liners can be used where ground conditions are not suitable for infiltration	✓
Green Roofs	Green Roofs provide areas of visual benefit, ecological value, enhanced building performance and the reduction of surface water runoff. They are generally more costly to install and maintain than conventional roofs but can provide many long-term benefits and reduce the on-site storage volumes	×
Rainwater Harvesting	Rainwater Harvesting is the collection of rainwater runoff for use. It can be collected form roofs or other impermeable area, stored, treated (where required) and then used as a supply of water for domestic, commercial and industrial properties. Rainwater butts are likely to be installed in accordance with best practice and harvesting could be utilised on this development but would be subject to detailed design. Thus, water butts are considered **suitable**.	✓
Swales	Swales are designed to convey, treat and attenuate surface water runoff and provide aesthetic and biodiversity benefits. They can replace conventional pipework as a means of conveying runoff, however space constraints of some sites can make it difficult incorporating them into the design.	×
Rills and Channels	This SuDS technique is an excellent choice as part of the SuDS train management to convey the runoff water into further SuDS features due to its appealing visual features in urban landscapes, amenity value and effectiveness to treat pollution in water, acting as pre-treatment to remove silt. As such they are considered **suitable**.	✓
Bioretention Systems	Bioretention systems can reduce runoff rates and volumes and treat pollution through the use of engineer soils and vegetation. They are particularly effective in delivering interception, but can also be an attractive landscape feature whilst providing habitat and biodiversity.	✓
Retention Ponds and Wetlands	Ponds and Wetlands are features with a permanent pool of water that provide both attenuation and treatment of surface water runoff. They enhance treatment processes and have great amenity and biodiversity benefits. Often a flow control system at the outfall controls the rates of discharge for a range of water levels during storm events. Nevertheless, they are dismissed as they are recommended to manage high volumes runoff due to large developments such as a neighbourhood.	×
Detention Basins	Detention Basins are landscaped depressions that are usually dry except during and immediately following storm events, and can be used as a recreational or other amenity facility. They generally appropriate to manage high volumes of surface water from larger sites such as a neighbourhood.	×
Geocellular Systems	Attenuation storage tanks are used to create a below-ground void space for the temporary storage of surface water before infiltration, controlled release or use. The inherent flexibility in size and shape means they can be tailored to suit the specific characteristics and requirements of any site.	✓
Proprietary Treatment Systems	Proprietary treatment systems are manufactured products that remove specific pollutants from surface water runoff. They are especially useful where site constraints preclude the use of other methods and can be useful in reducing the maintenance requirements of downstream SuDS.	×
Filter Drains and Filter Strips	Filter drains are shallow trenches filled with stone, gravel that cerate temporary subsurface storage for the attenuation, conveyance and filtration of surface water runoff. Filter strips are uniformly graded and gently sloping strips of grass or dense vegetation, designed to treat runoff from adjacent impermeable areas by promoting sedimentation, filtration and infiltration	×

Table 4 – Suitability of SuDS Components.

5.3 As such, several SuDS components are deemed appropriate. It is suggested to use a SuDS train management composed by **Bioretention Systems, lined Permeable Pavements** with No Infiltration (Type C) and **Geocellular Systems**. Rills/Channels could be used to convey water runoff from the hardstanding areas as long as the gradient and slope is adequate. A **throttle device** such as a hydrobrake must be set up to control the flow rates up to a maximum of 3.8l/s. And, finally, **pumping systems** would be required to convey water runoff from low points and proposed basements. See Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout, Sheets 1 & 2.

5.4 The combined action of the proposed SuDS train will be able to manage the arising runoff volume from hardstanding areas and roofs due to the day-to-day storms, Interception Volume, as well as the Attenuation Volume, being progressively stored and gradually discharged while also providing enough water quality treatment.

5.5 The Bioretention Systems, which are formed by shallow depressions with vegetation within them, will provide ecological benefits such as biodiversity and cool the local microclimate due to the evapotranspiration. They are very flexible and can be integrated into a wide variety of developments, thus these are proposed to the sides of the building pedestrian accesses. Refer to Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout, Sheets 1 & 2.

5.6 The Bioretention System must be lined and incorporate a layer of gravel as bed, and filled with engineered soil. The Bioretention Systems should be finalised at the later detailed design by a specialist. Guidance about proper use and maintenance must also be provided. See conceptual design of this SuDS technique on Figure 8 below.

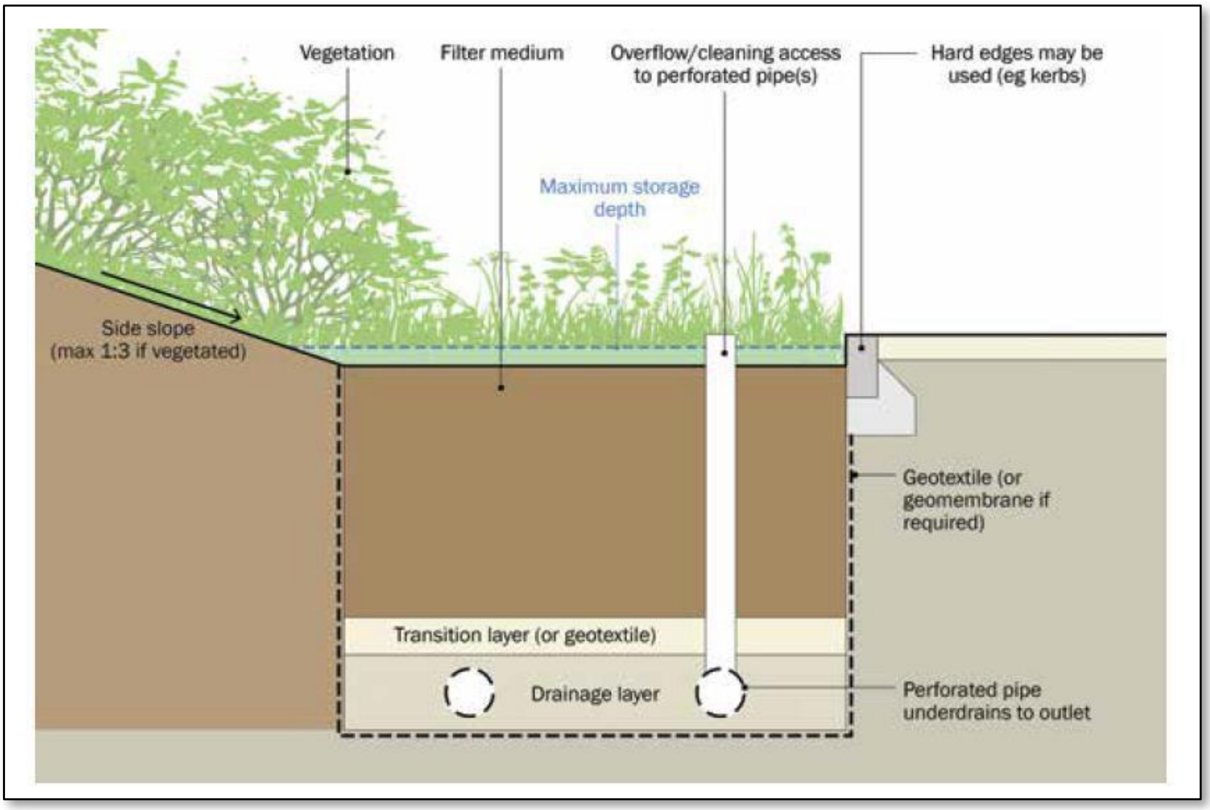

Figure 8 – Conceptual Design of the Components of a Bioretention System.

5.7 The Permeable Paving will be Type C (NO infiltration), with Geotextile to retain pollutants. It would be formed by 3 layers:

- Permeable Concrete blocks.
- Laying Course Material.
- Geotextile filter.
- Sub-Base: Clean Stone (Depth: 450 mm).
- Impermeable membrane.

Refer to Appendix 4, Plan 1 – Preliminary Surface Water Drainage Strategy Layout, Sheets 1 & 2.

5.8 It is proposed to utilise two Geocellular Systems with a depth of 1m to manage water runoff due to extreme storm events up to a 1 in 100 years storm event with a 40% climate change allowance.

5.9 For a reference, the geocellular system located to the north of the site is named 'Geocellular System 1' (GS1), while the Geocellular System located to the east of the site (under the car access) is named 'Geocellular System 2' (GS2). Refer to Appendix 4, Plan 1 – Preliminary Surface Water Drainage Strategy Layout, Sheets 1 & 2. The areas of the Geocellular System 1 and 2 would be $20m^2$ and $105m^2$ respectively. While the capacity of them with a typical porosity of 0.95 would be $19m^3$ and $99.75m^3$.

5.10 Throttle devices such as a Crown Vortex Valves and/or Hydrobrakes must be set up to control the flow rates among the SuDS devices. Besides that, a flow control should limit the discharge to the existing drainage infrastructure within the site, up to a maximum rate of 3.8 l/s. See Appendix 4, Plan 1 – Preliminary Surface Water Drainage Strategy Layout, Sheets 1 & 2.

5.11 Finally, pumping systems would likely be required to drain water runoff from low points and basements. Guidance about proper use, installation and maintenance of any proprietary system should be provided by the supplier and incorporated into the site proposals at detailed design stage.

5.12 Sediment Traps should be installed on the storm drainage pipework at incoming connections to SuDS features to reduce the incidence of blockage or silting up.

5.13 Guidance about proper use, installation and maintenance of any proprietary system must be provided by the supplier and incorporated into the site proposals at detailed design stage.

6. Drainage Strategy

6.1 Following the hierarchy line provided by the Policy 5.13 of the London Plan 2016, it is proposed to store rainwater for later use where this is feasible, while the excess of water runoff should be stored to be gradually discharged to the existing surface water sewer within the site.

6.2 The proposed storm water management regime for the site is to store runoff in Permeable Paving - located under parking bays and the car access to the basement, as well as in two Geocellular Systems strategically located to store and adequately release the water runoff to the existing sewer network within the site.

Interception Volume

6.3 It is proposed to contain rainwater from the roof due to the day-to-day storms (Interception Volume) through the proposed Bioretention Systems and the Permeable Pavement. The exceedance of runoff from the Bioretention Systems would be conveyed to the sub-base of the Permeable Paving and to the Geocellular Systems to be properly stored and gradually discharged.

6.4 Debris traps must be installed in the connection to the sub-base of the Permeable Paving to avoid any blockage. For a better understanding, the roof has been split into 3 zones to show how the runoff would be discharged. Refer to Appendix 4, Plan 1 – Preliminary Surface Water Drainage Strategy Layout, Sheets 1 & 2.

6.5 It is proposed to utilise the water stored in the Geocellular System 1 for non-potable purposes such as gardening as the water runoff to be stored in it would derive from roofs and other free petrochemical pollutants hardstanding surfaces such as pedestrian accesses, thus the water quality treatment would be very low.

6.6 It is important to point out that there are two basements located to the north of the site. Refer to Appendix 4, Plan 1 – Preliminary Surface Water Drainage Strategy Layout, Sheet 2. Water runoff from there would be raised through the proposed Pumping Systems to the Geocellular System 1.

6.7 Water runoff from hardstanding surfaces for pedestrian facilities purposes such as stairs, accesses, etc. would be conveyed to the proposed Bioretention Systems and to the Permeable Paving through appropriate landscaping and/or Rills/Channels.

Attenuation Volume

6.8 Surface water runoff due to storm events above 1 in 1 year return period and up to a 1 in 100 years event with a 40% climate change allowance would be stored in the Sub-base of the Permeable Paving, the Geocellular System 1 and the Geocellular System 2, to be gradually released.

6.9 It should be noted that as the Permeable Paving is sloped, the water runoff should be drained through the proposed Pumping System to the Geocellular System 2 up to a rate of 25l/s.

6.10 The outflow from Geocellular System 1 would be controlled up to a rate of 5l/s, while the limiting discharge rate from Geocellular System 2 would be 3.8l/s as it is connected to the existing surface water sewer within the site.

6.11 In order to connect and coordinate all the proposed SuDS, a model in cascade has been carried out using the industry standard software, Microdrainage v2016. See Figure 9 below. The results for a variety of rainfall events are shown on the Appendix 3 – Calculations, Summary of Results.

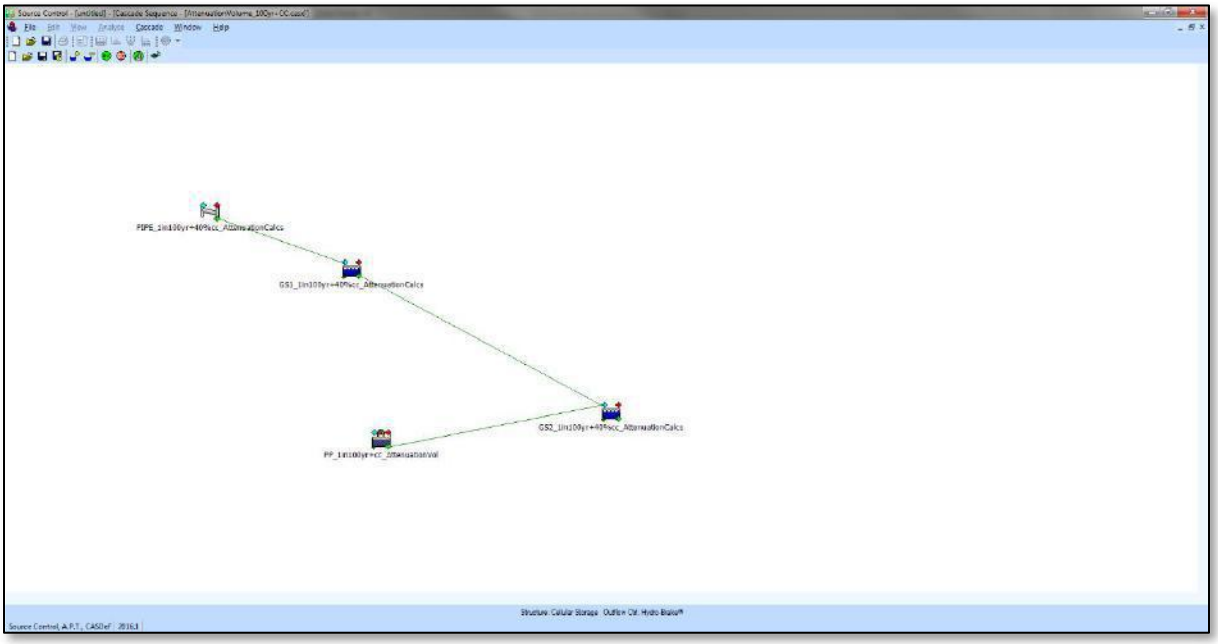

Figure 9 – Model in Cascade using Microdrainage.

6.12 Table 5 summarizes the attenuation volumes and the SuDS devices to be used to manage them:

	ATTENUATION VOLUMES SUMMARY Attenuation Volumes for each of the sub-catchments	
SuDS Device	Limiting Discharge Rate (l/s)	Required total 1:100 year Attenuation storage volume (m^3)
Pumping System for Basement ('PIPE' on Figure 9).	2l/s	0.5m^3
Pervious Pavement ('PP' on Figure 9).	25l/s	0.3m^3
Geocellular System 1 ('GS1' on Figure 9).	5l/s	14.6m^3
Geocellular System 2 ('GS2' on Figure 9).	3.8l/s	79.6m^3
TOTAL	-	95m^3

Table 5 – Attenuation Volume Summary.

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6.13 Preliminary calculations show that the storage capacity of the Geocellular Systems (with typical features such as porosity, n=0.95, and depth, d=1000mm) is approximately 118.75m^3. Hence, the storage capacity of this SuDS train (under a conservative point of view Permeable Paving is not taken into account) is higher than the total required volume, 102m^3.

6.14 A throttle device such as a Hydrobrake at the Geocellular System 1 will control the flow rates up to a maximum of 5 l/s before the runoff is conveyed and discharged to the Geocellular System 2. A Pumping System would raise the water runoff from the Permeable Pavement to the Geocellular System 2 up to a maximum Rates of 25l/s, while another flow control (Hydrobrake or Vortex Control) would limit the discharge rate from the Geocellular System 2 to the sewer network through drain pipes up to 3.8l/s. Refer to Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout, Sheets 1 & 2.

6.15 In the case of a rainfall event that exceeds the storage capacity of these SuDS techniques, overland conveyance routes should be established that direct water away from property to landscaped areas or off site. Design of external ground levels will need to be undertaken at detailed design stage to finalise these routes, but some indicative flow paths have been indicated on the outline strategy drawings. See Appendix 4, Plan 1 – Preliminary Surface Water Drainage Strategy, Sheets 1 & 2.

6.16 It may be necessary to update or alter the drainage strategy at detailed design stage following confirmation of site constraints or alterations to the overall layout. Calculations for, and the design of the SuDS devices, should be reviewed at detailed design stage to ensure a robust drainage strategy is maintained.

Water Quality

6.17 Adequate treatment must be delivered to the water runoff to remove pollutants through SuDS devices which are able to provide pollution mitigation. Pollution Hazards and the SuDS Mitigation have been indexed in the specialized literature *CIRIA 753 'The SUDS Manual'*. This is determined by the following restriction:

POLLUTION HAZARD INDICES FOR DIFFERENT LAND USE CLASSIFICATIONS				
LAND USE	Pollution Hazard Level	Total suspended Solids (TSS)	Metals	Hydrocarbons
Residential Roofs	Very Low	0.2	0.2	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4

Table 6 – Summary of Pollution Hazard Indices for different Land Use.

6.18 The Mitigation Indices of the proposed SuDS techniques are summarized in the Table 7 - Indicative SuDS Mitigation Indices, below:

INDICATIVE SuDS MITIGATION INDICES FOR DISCHARGES TO SURFACE WATER			
SuDS Component	**Total suspended Solids (TSS)**	**Metals**	**Hydrocarbons**
Bioretention Systems	0.8	0.8	0.8
Permeable Pavement	0.7	0.6	0.7

Table 7 – Indicative SuDS Mitigation Indices

6.19 Table 8 – Pollution Treatment below, summarizes the water treatment for each zone:

POLLUTION HAZARD TREATMENT					
LAND USE	**Treatment**	**Pollution Hazard Level**	**Total suspended Solids (TSS)**	**Metals**	**Hydrocarbons**
Roofs	Permeable Pavement	Very Low	0.2<0.7	0.2<0.6	0.05<0.7
Roofs	Bioretention Systems	Very Low	0.2<0.8	0.2<0.8	0.05<0.8
Car Facilities / Pedestrian Accesses	Permeable Pavement	Low	0.5<0.7	0.4<0.6	0.4<0.7
Pedestrian Accesses	Bioretention Systems	Low	0.5<0.8	0.4<0.8	0.4<0.8

Table 8 – Pollution Treatment

6.20 **Thus, the water treatment provided by this SuDS train is enough to remove the pollutants.**

Design Exceedance

6.21 In the event of drainage system failure under extreme rainfall events or blockage, flooding may occur within the site. In the event of the drainage system failure, the runoff flow will be dictated by topography on site. This will not impact on the site or nearby dwellings.

6.22 It is advised that the finished floor level of the proposed building should be 300mm above surrounding finished ground levels to mitigate against any potential surface water flows. External ground levels should be designed to direct water away from thresholds where feasible. See plans on Appendix 4, Plan 1 - Preliminary Surface Water Drainage Strategy Layout, Sheets 1 & 2.

Adoption and Maintenance

6.23 All onsite SuDS and drainage systems will be privately maintained. A long term maintenance regime should be agreed with the site owners before adoption. In addition to a long term maintenance regime it is recommended that all drainage elements implemented on site should be inspected following the first rainfall event post construction and monthly for the first quarter following construction.

Proposed Schedule of Maintenance for Below Ground Drainage				
Item	Visual Inspection	Cleanse / De-sludge	CCTV Survey	Comments
Surface Water Drainage System (pipework, chambers etc.)	5 years	10 years	10 years	Cleansing to be carried as necessary
Gullies/Channels	1 year	1 year	N/A	Cleansing to be carried as necessary
Permeable Block Paving	1 year	'Swept' clean of debris every 2 years.	N/A	Lift blocks and remove sand bedding and replace and re-bed paving – refer to individual manufacturers recommendations.
Catchpits	1 year	-	N/A	Cleansing to be carried as necessary.

Table 9 – Proposed Schedule of Maintenance for Below Ground Drainage.

7. Conclusions

7.1 The existing site is already developed, runoff from the proposed development is to be managed in accordance with the sustainable drainage principles.

7.2 The drainage strategy for this site is to discharge to the existing surface water sewer within the Site utilising Bioretention Systems, Permeable Pavement and Geocellular Systems with managed offsite flows controlled by hydrobrake, or similar flow control, as necessary.

7.3 Initial calculations indicate a storage requirement of approximately $102m^3$, being properly managed by the proposed SuDS train. This can be accommodated in the Geocellular Systems proposed on site.

7.4 The Treatment train of Bioretention Systems and Permeable Paving is suitable to offer acceptable contamination treatment to runoff from parking bays and trafficked areas prior to being discharged to local sewer network.

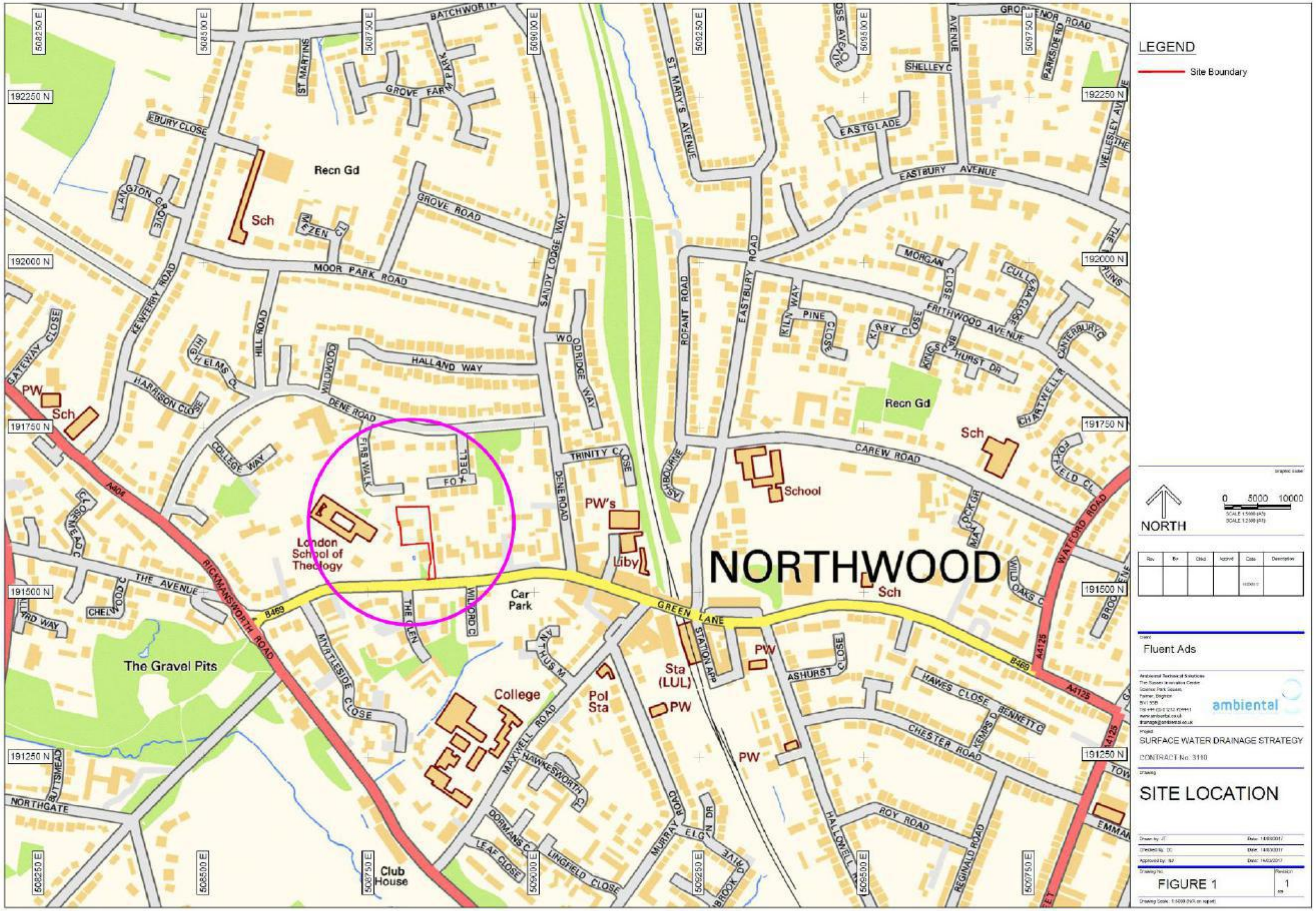
7.5 It is advised that the finished floor level of the proposed building should be 300mm above surrounding finished ground levels to mitigate against any potential surface water flows. Ground levels should be designed to convey water away from the proposed development where feasible.

The findings and recommendations of this report are for the use of the client who commissioned the assessment, and no responsibility or liability can be accepted for the use of the report or its findings by any other person or for any other purpose.

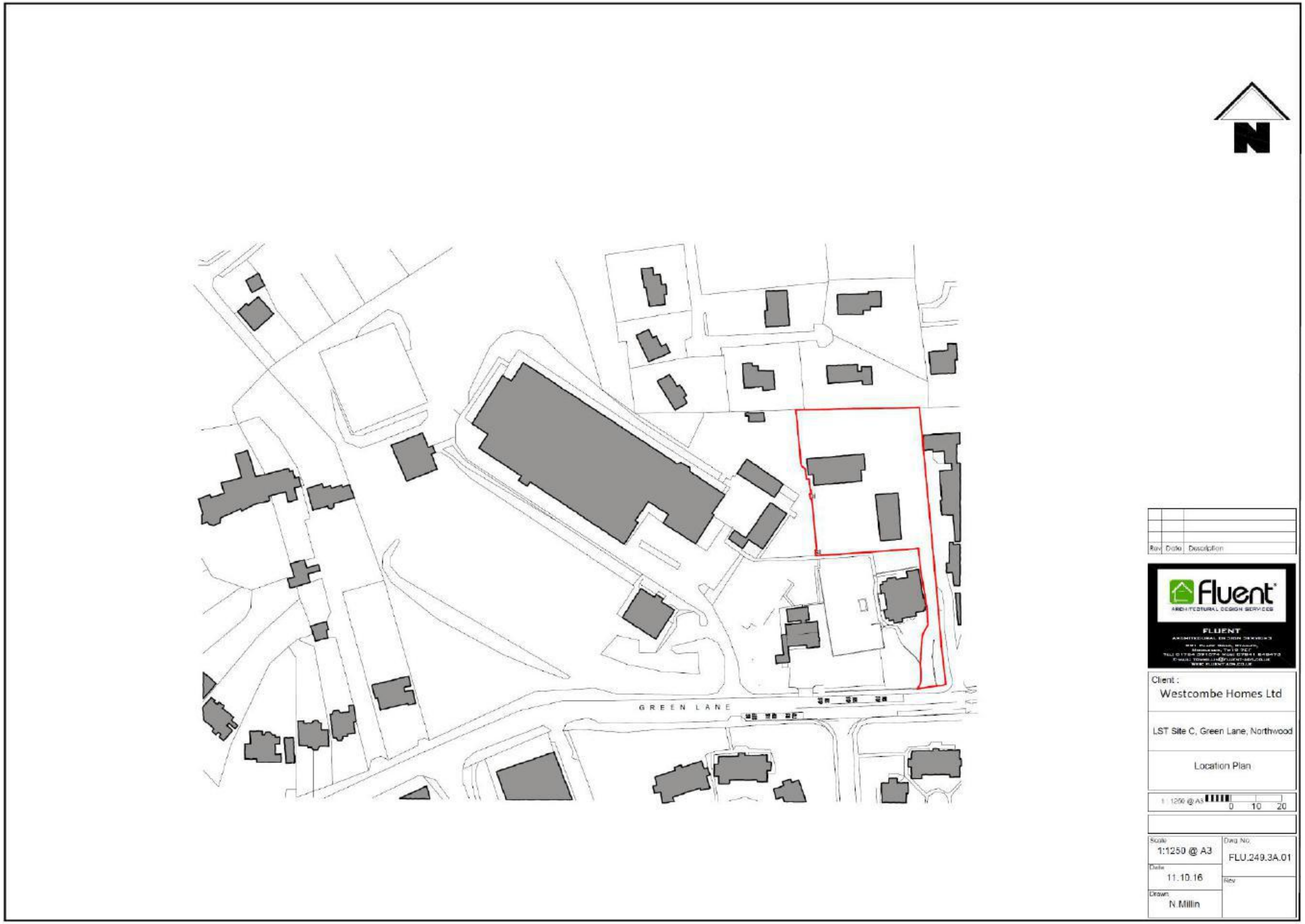
Dr. J. B. Butler
B.Sc., M.Phil., PhD.
Ambiental Technical Solutions Ltd. May 2017

Appendix 1 – Plans

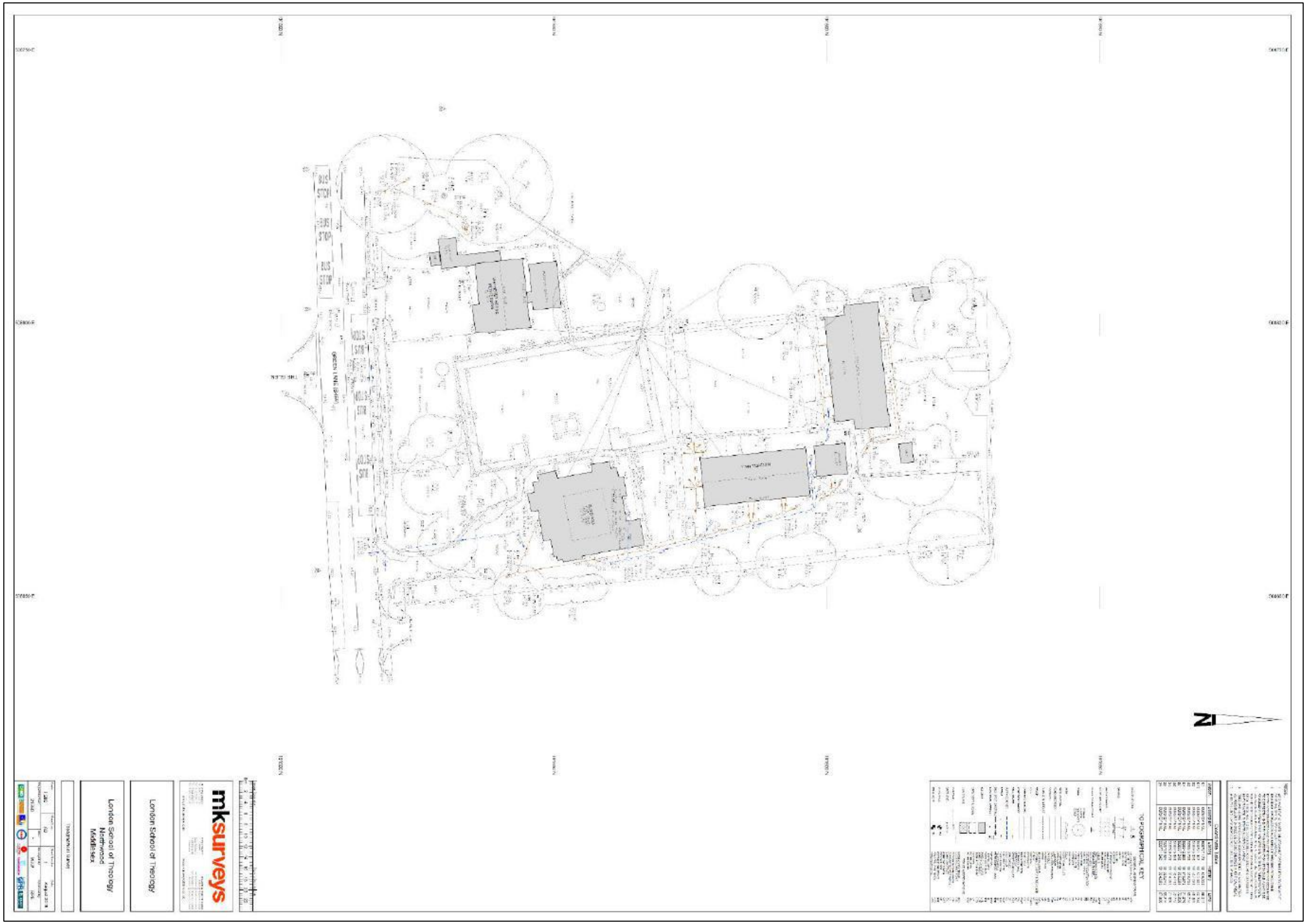
- *Plan 1 – Site Location*
- *Plan 2 – Plan Location*
- *Plan 3 – Topographical Survey of the Site*
- *Plan 4 – Existing Surface Water Flow Pathways*
- *Plan 5 – Proposed Site Layout*
- *Plan 6 – Basement Floor Plan*
- *Plan 7 – Ground Floor Plan*
- *Plan 8 – First Floor Plan*
- *Plan 9 – Second Floor Plan*
- *Plan 10 – Front & Side Elevations*
- *Plan 11 – Rear & Side Elevations*
- *Plan 12 – BRE 25^{o} Test*



Appendix 1, Plan 1 – Site Location

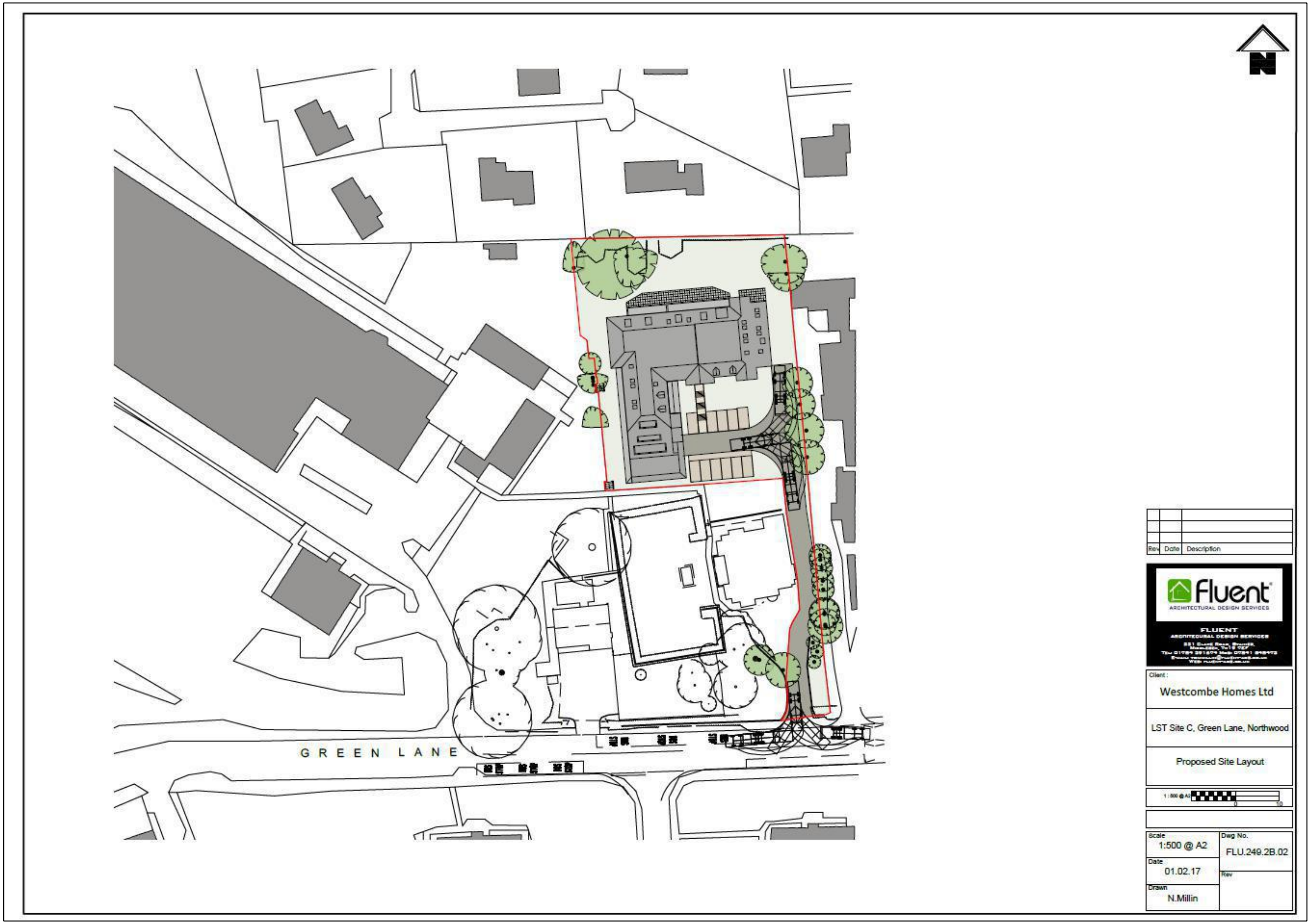


Appendix 1, Plan 2 – Plan Location

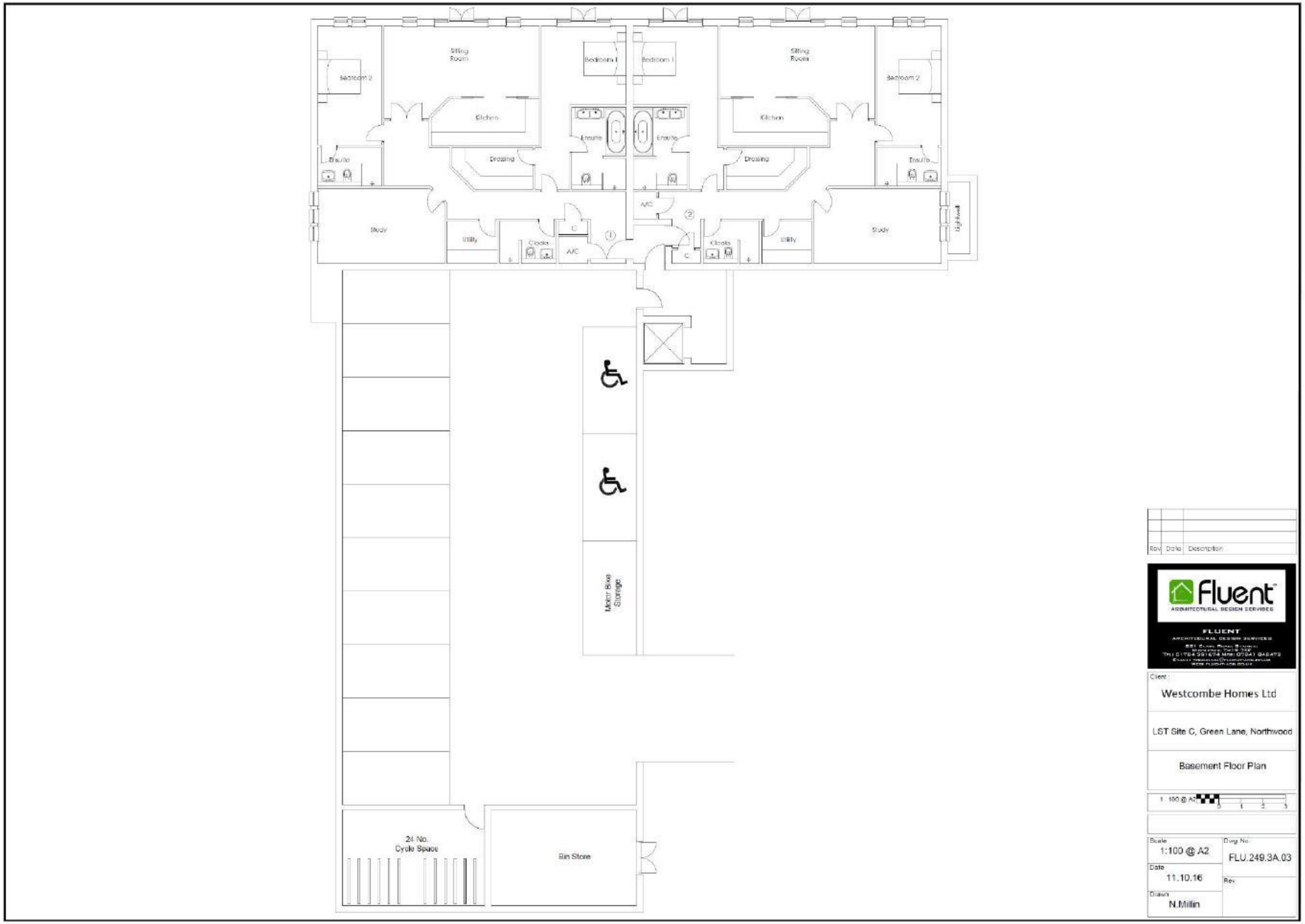


Appendix 1, Plan 3 – Topographical Survey of the Site

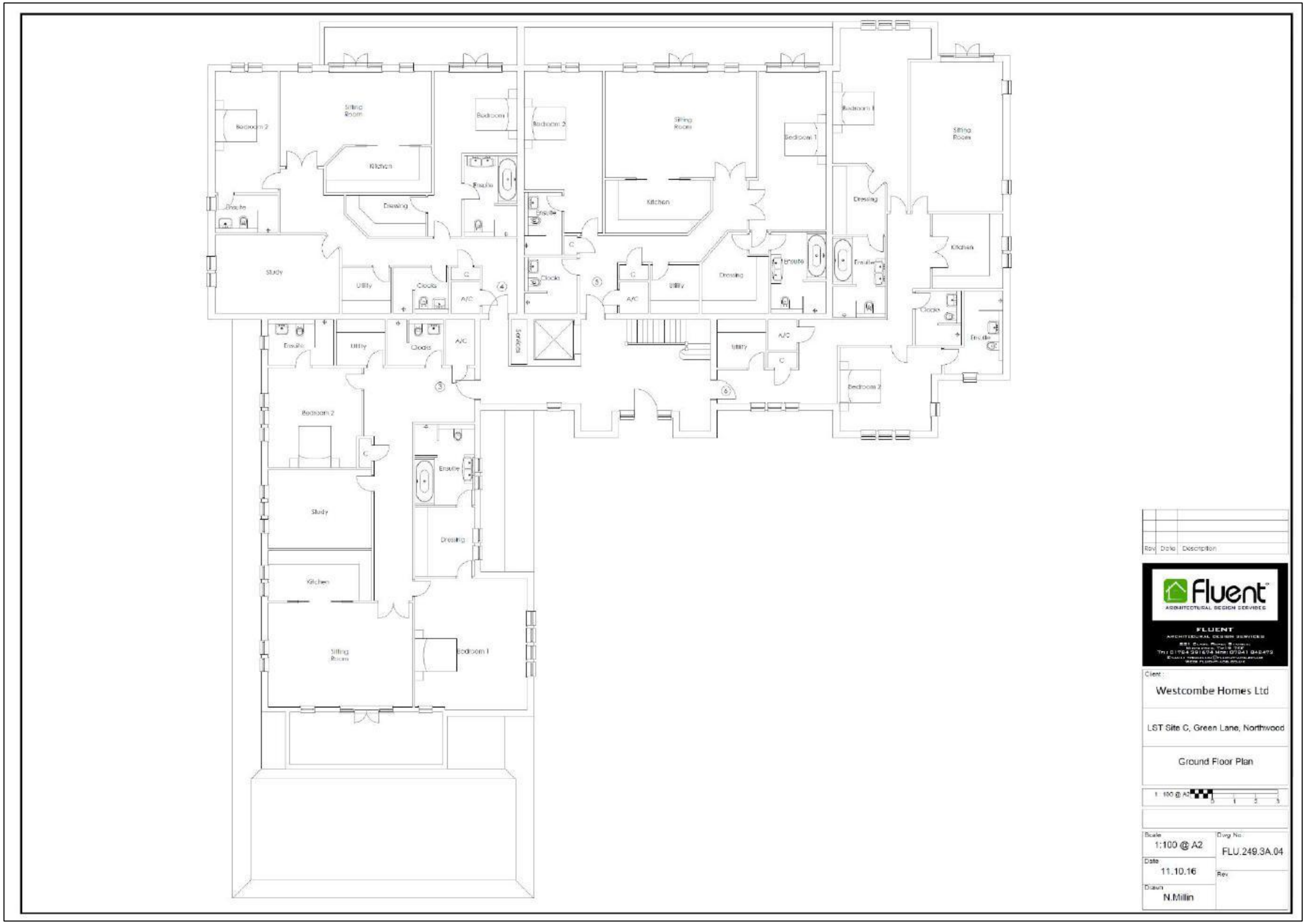
Appendix 1, Plan 4 – Existing Surface Water Flow Pathways



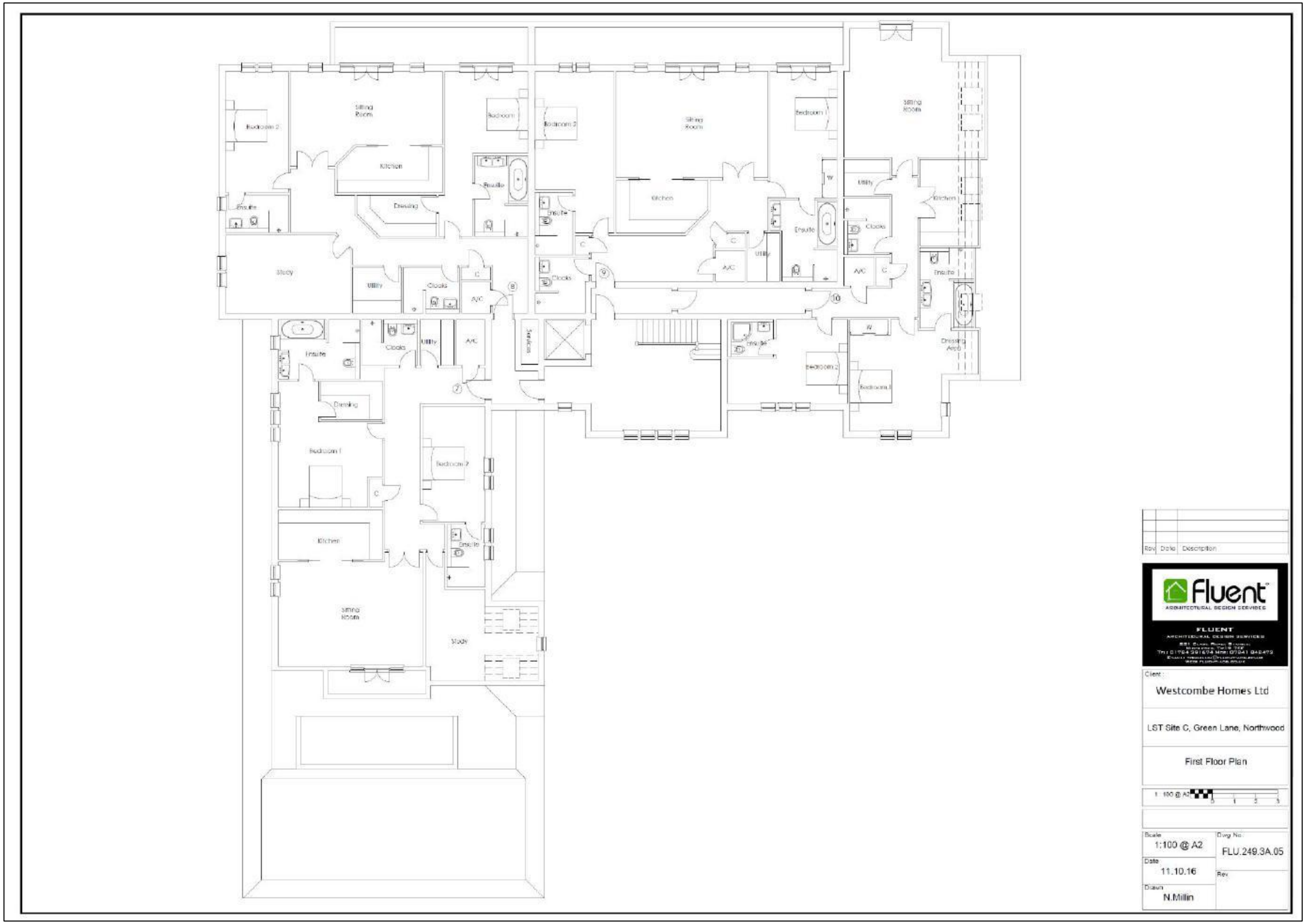
Appendix 1, Plan 5 – Proposed Site Layout



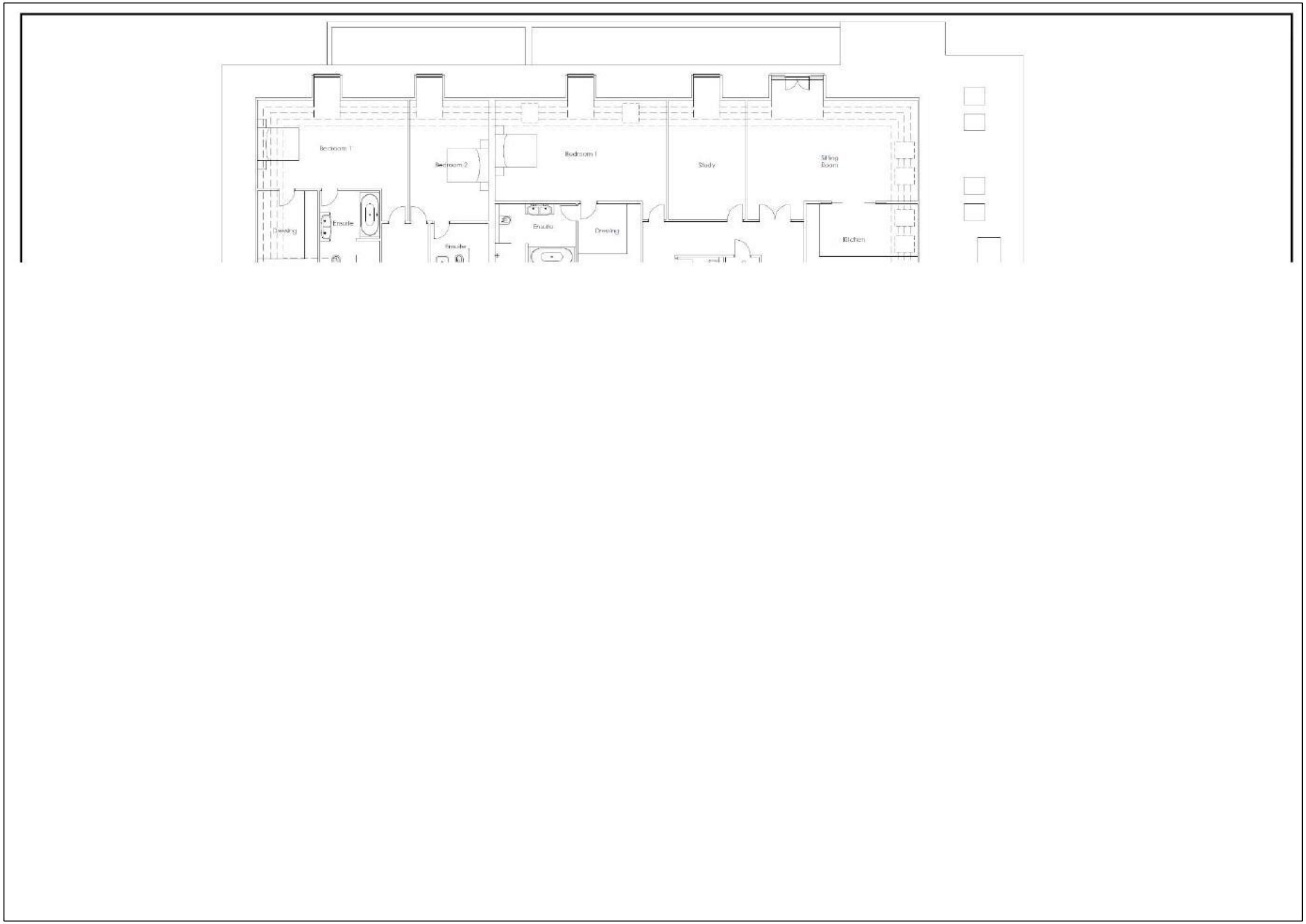
Appendix 1, Plan 6 – Basement Floor Plan



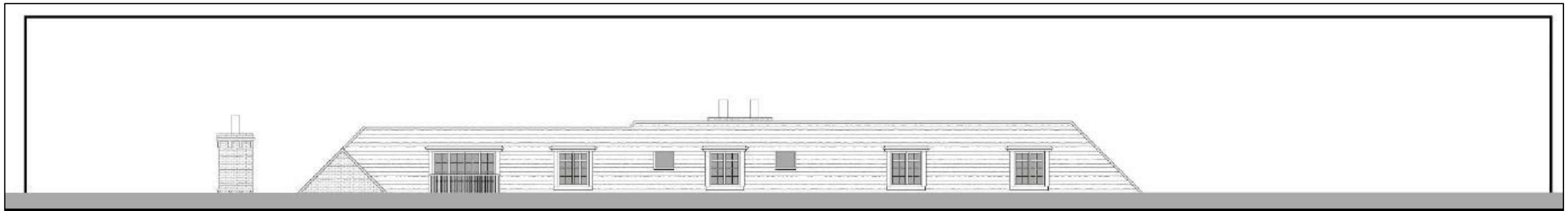
Appendix 1, Plan 7 – Ground Floor Plan,



Appendix 1, Plan 8 – First Floor Plan



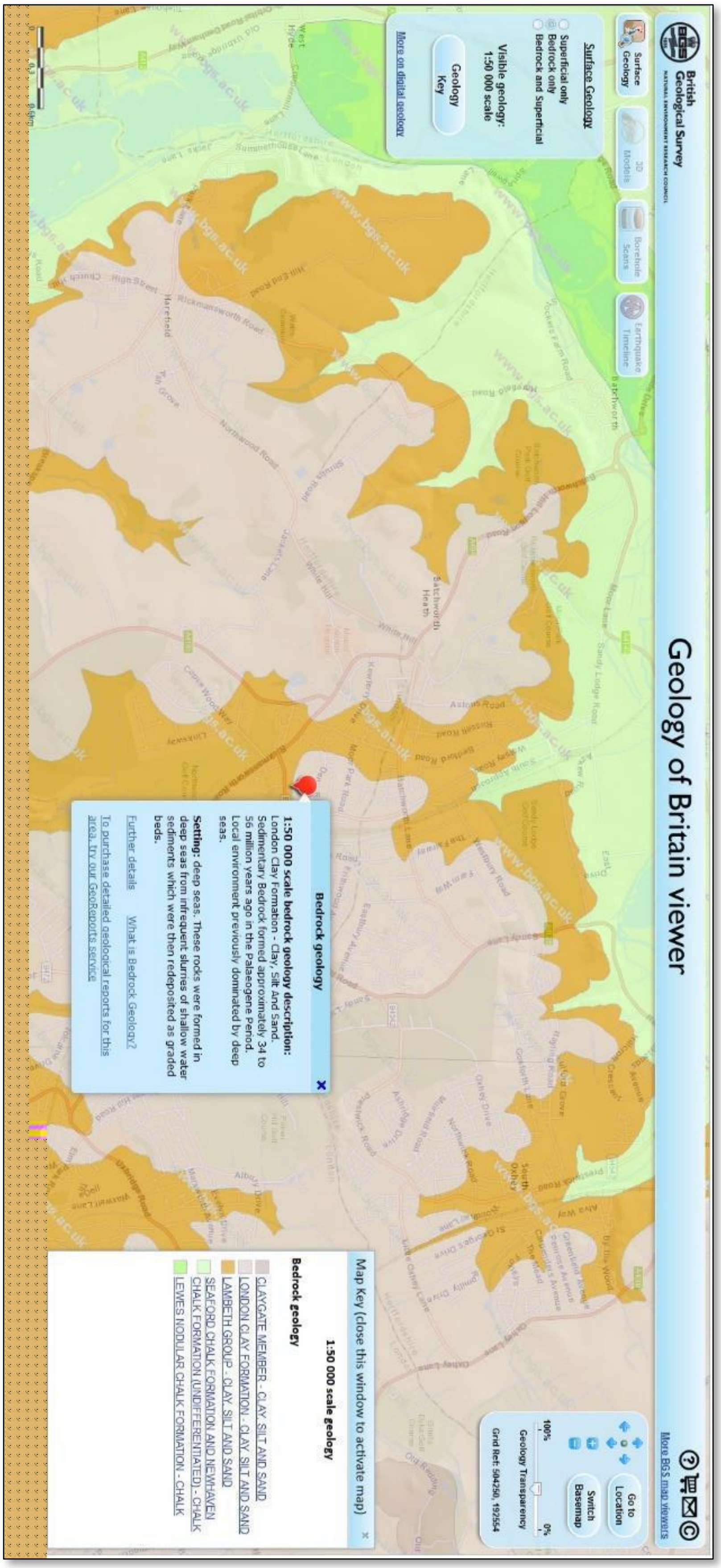
Appendix 1, Plan 9 – Second Floor Plan



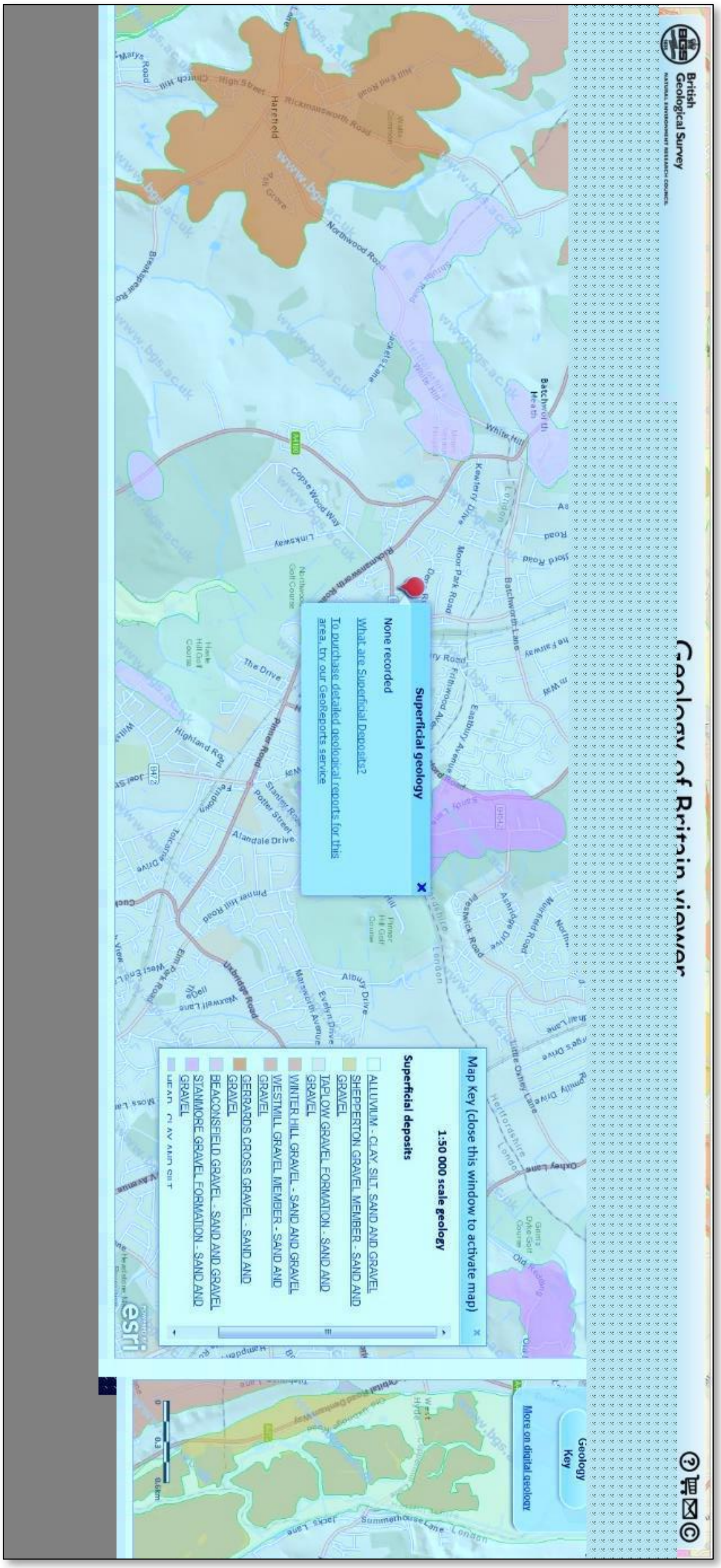
[redacted]

Appendix 1, Plan 11 – Rear & Side Elevations

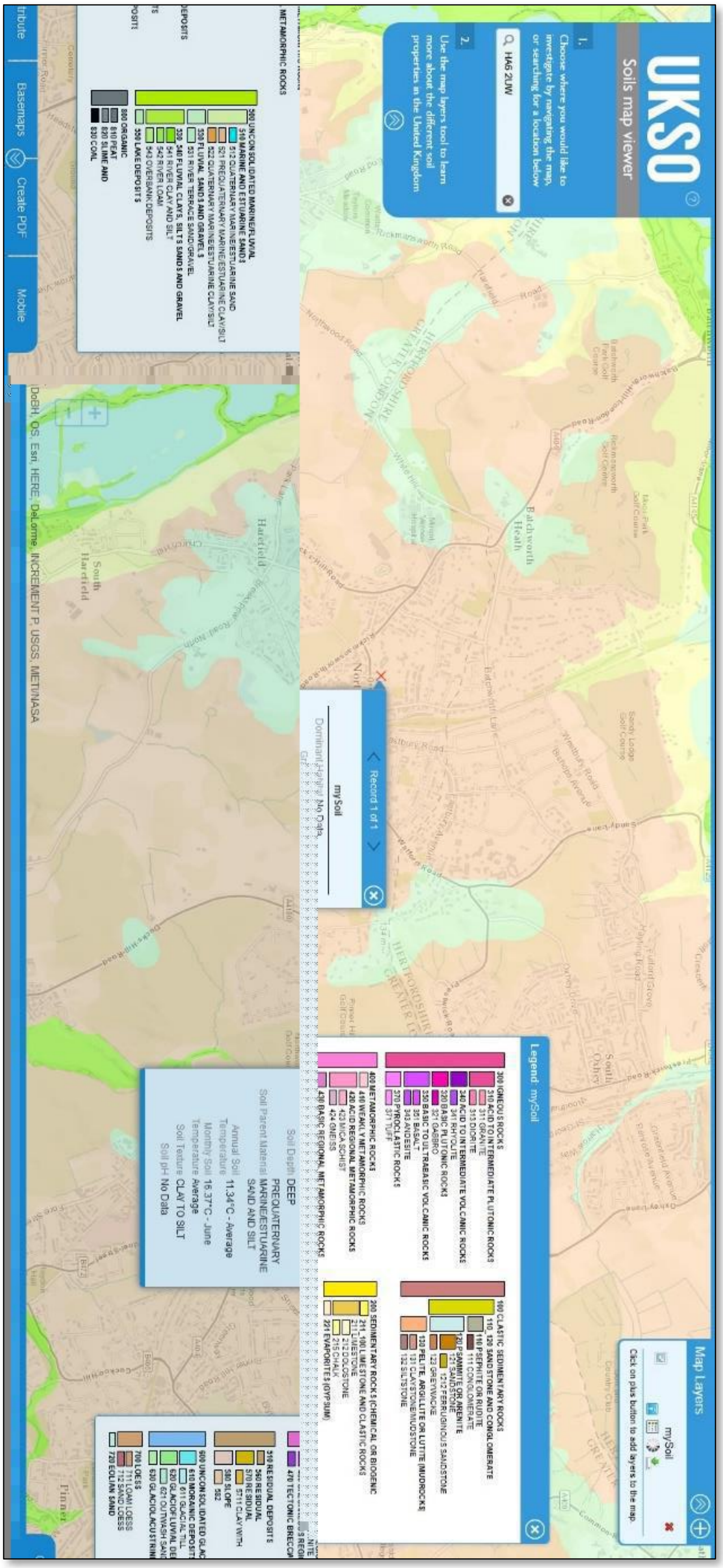
Appendix 2 – Site Geology Maps



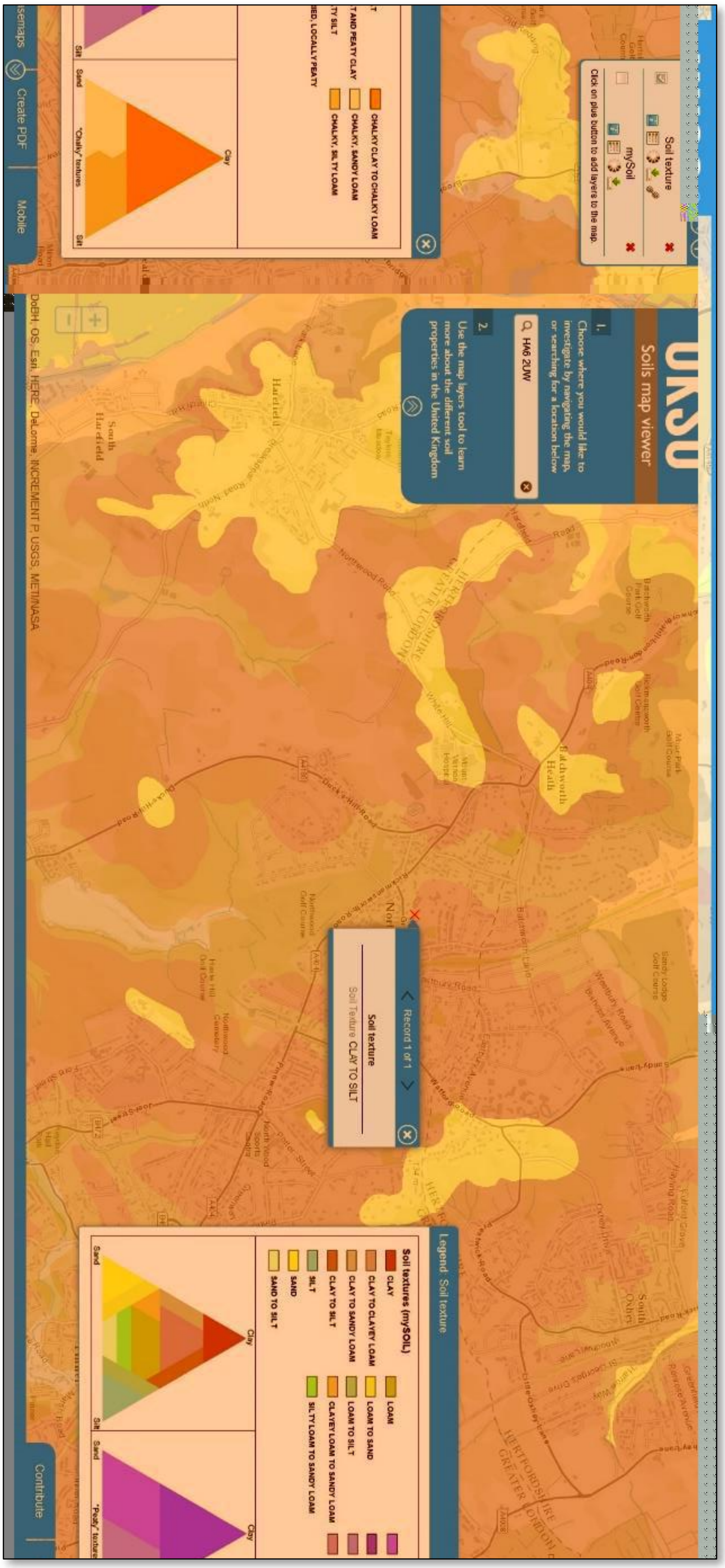
Appendix 2, Figure 1.A – Bedrock Geology, London Clay Formation



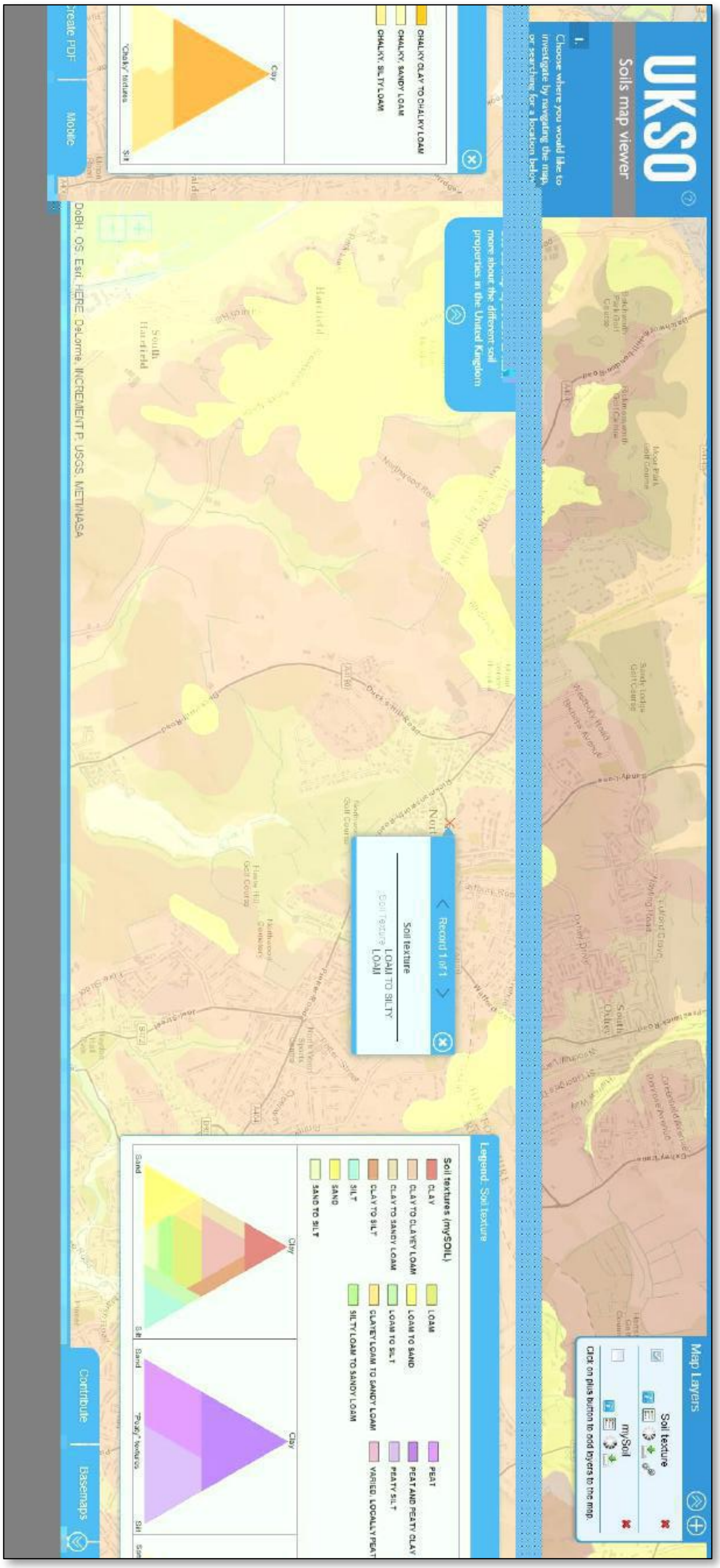
Appendix 2, Figure 2 – Superficial Deposits



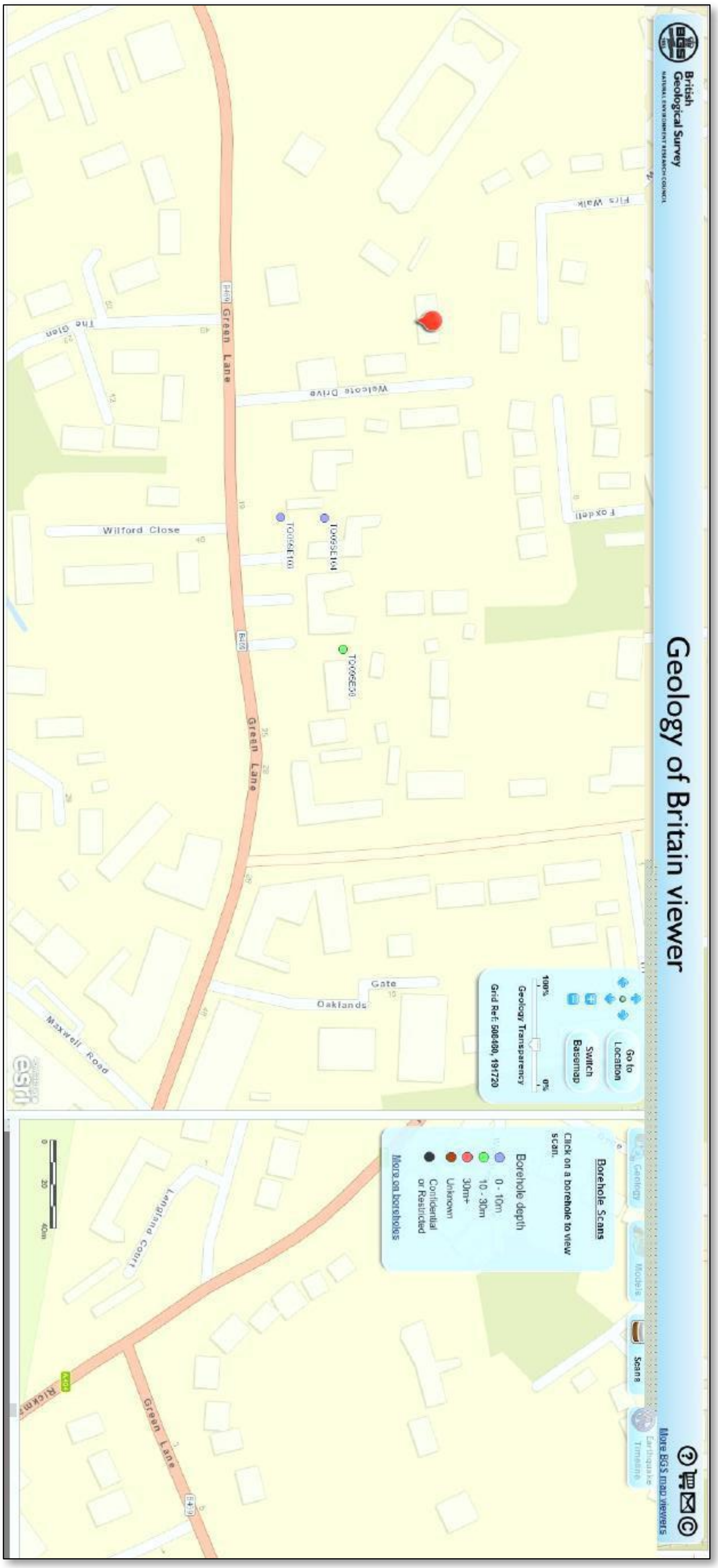
Appendix 2, Figure 3 – Soil Parental Material



Appendix 2, Figure 4.A – Soil Texture-North, Clay to Silt



Appendix 2, Figure 4.B – Soil Texture, South, Loam to Silty Loam



Appendix 2, Figure 5.1 – Boreholes Location Map

TQ 09 SE / 50

TQ09/116

TQ 0896 9157

255 TQ09/116 374

GROUND EXPLORATIONS LIMITED

BOREHOLE SECTION SHEET

Date........November........19...

CONTRACT NAME 25, GREEN LANE, NORTHWOOD.

ORDER NO.

Bored for: Messrs. Clifford & Clifford Ltd.,

Address: 28, Ealing Road, Wembley, Middx.

Address of Site: 25, Green Lane, 1/5 m. NW of Northwood Ry. Sta., Middlesex 5 SW

District or Town: Northwood.

County: Middlesex.

Standing Water Level: below surface

Dia. of Borehole: 6 Inches.

Water Struck (1) None. (2) (3)

Boring Commenced: 1.11.60.

Boring Completed: 4.11.60.

Special Remarks: Borehole made to test ground before erecting a block of flats. Shaft (c.65ft) with galleries from which chalk has been extracted on site (Report by Sir Harold Harding to contractors 1961).

Jar Samples: 8648 3'0"; 8651 9'0"; 8652 13'0"; 8653 17'0"; 8654 21'0"; 8656 26'0"; 8658 30'0"; 8659 31'0"; 8662 36'0"; 8663 38'0";

DESCRIPTION OF STRATA

The descriptions are given in accordance with the British Standard Code of Practice CP2001 (1957) "Site Investigations." No responsibility is accepted for these descriptions and clients should examine the samples submitted.

No. I Boring OD + ca 230', 70.0 m.

Description	Thickness Feet	Thickness Inches	Depth below Surface Feet	Depth below Surface Inches
Made ground (brick, clay etc.,)	1 (0.45m)	6	1 (0.45m)	6
Firm mottled brown/blue clay.	5 (1.52m)	0		

Thickness	Depth	Description
1 (0.30m) 0	33 (10.20m) 6	
2 (0.60m) 0	35 (10.81m) 6	Firm blue sandy clay.
(0.15m) 6	36 (10.97m) 0	Coarse gravel containing sand at lower levels
9 (2.74m) 0	45 (13.71m) 0	Upper Chalk: Chalk with flints.
9 (2.74m) 0	54 (16.46m) 0	Chalk.
6 (1.82m) 0	60 (18.28m) 0	
60 (18.28m) 0	60 (18.28m) 0	TOTAL FROM SURFACE

Data Bank • Dec 1979

Made by Ground Explorations Ltd.

Appendix 2, Figure 5.2.1 – Borehole TQ09SE50, Sheet 1

TQ 0892 9157

255/374 TQ09/116

GROUND EXPLORATIONS LIMITED

BOREHOLE SECTION SHEET

Date: November 19 60

CONTRACT NAME	25, GREEN LANE, NORTHWOOD.
ORDER NO.	
Bored for:	Messrs. Clifford & Clifford Ltd.,
Address:	28, Ealing Road, Wembley, Middx.
Address of Site:	25, Green Lane, 1/5 m. NW of Northwood Ry. Sta, Middlesex 5 SW
District or Town:	Northwood.
County:	Middlesex.
Standing Water Level:	below surface
Dia. of Borehole:	6 Inches.
Water Struck (1)	None. (2) (3)
Boring Commenced:	1.11.60.
Boring Completed:	4.11.60.
Special Remarks:	Borehole made to test ground before erecting a block of flats. Shaft (c.65ft) with galleries from which chalk has been extracted on same site. (Report by Sir Harold Harding to contractors 1961).
Jar Samples:	8648 2'0"; 8651 9'0"; 8652 12'0"; 8653 17'0"; 8654 21'0"; 8656 26'0"; 8658 30'0"; 8659 32'6"; 8662 36'0"; 8663 38'0"; 8666 46'0"; 8667 50'0"; 8668 55'0"; 8669 60'0"
Core Samples:	8649 3'6"-5'0", 8650 6'0"-7'0"
Large Disturbed Samples:	8655 24'0"; 8657 28'0"; 8660 33'6"; 8661 34'0"; 8664 40'0"; 8665 44'0"

c 220

The descriptions are given in accordance with the British Standard Code of Practice CP2001 (1957) "Site Investigations." No responsibility is accepted for these descriptions and clients should examine the samples submitted.

No. I Boring

	DESCRIPTION OF STRATA	Thickness Feet	Thickness Inches	Depth below Surface Feet	Depth below Surface Inches
	Made ground (brick, clay etc.,)	1 (0.45m)	6	1 (0.46m)	6
Woolwich + Reading Beds	Firm mottled brown/blue clay.	5 (1.52m)	0	6 (1.97m)	6
	Firm mottled green/brown chalky clay.	1 (0.30m)	0	7 (2.28m)	6
	Stiff mottled red/green/brown chalky clay.	5 (1.67m)	6	13 (3.96)	0
	Brown sand with pockets of grey clayey sand.	10 (3.04m)	0	23 (7.01m)	0
	Brown sand.	7 (2.13m)	0	30 (9.14m)	0
(Reading Type) 45ft +	Light brown sand.	2 (0.60m)	0	32 (9.75m)	0
	Firm brown silty clay with thin layers of sand.	(0.15m)	6	32 (9.90m)	6
	Grey clayey sand.	1 (0.30m)	0	33 (10.20m)	6
	Gravel.	2 (0.60m)	0	35 (10.81m)	6
	Firm blue sandy clay.	(0.15m)	6	36 (10.97m)	0
	Coarse gravel containing sand at lower levels.	9 (2.74m)	0	45 (13.71m)	0
Upper Chalk	Chalk with flints.	9 (2.74m)	0	54 (16.46m)	0
	Chalk.	6 (1.82m)	0	60 (18.28m)	0
	TOTAL FROM SURFACE ..	60 (18.28m)	0	60 (18.28m)	0

Data Bank · Dec 1979

Made by Ground Explorations Ltd.

per S.W. Hester

Signed

Trial for foundations.
Site visited.

Date

PR10359 Data Bank · Dec 1979

OD to 230 ft OD

Received March 1975.

31.10.77 RMJ/MA.

Appendix 2, Figure 5.2.2 – Borehole TQ09SE50, Sheet 2

Contract Name GREEN LANE, NORTHWOOD

Borehole No. HA1
Sheet 1 **of** 1

Method of boring Hand auger
Diameter 100 mm nominal

Ground level about 70.0 m O.D
Start 10.9.76 0890
Finish 10.9.76 9154

Daily progress	Water levels	In-situ tests	Samples	Depth (m)	Reduced level (m O.D.)	Thickness (m)	Description of Strata
				0.15	69.85	0.15	Topsoil
				0.70	69.30	0.55	Soft mottled reddish brown silty clay with traces of organic material, root fibres and some fine sand partings
			U* U* U*	2.00	68.00	1.30	Stiff to very stiff mottled reddish brown silty clay with traces of organic material, root fibres and some fine sand partings
			U*	2.43	67.57	0.43	Very stiff mottled greyish brown silty sandy clay with some traces of fine gravel
10/9							Bottom of Borehole

Notes

Terresearch Limited **Report No.** S.26/875 **Appendix 1 Sheet** 3

Appendix 2, Figure 5.3.1 – Borehole TQ09SE103, Sheet 1

Contract Name GREEN LANE, NORTHWOOD

Borehole No. HA2

Sheet 1 **of** 1

Method of boring Hand auger

Diameter 100 mm nominal

Ground level 71.0 m O.D. 0890 9186

Start 10.9.76

Finish 10.9.76

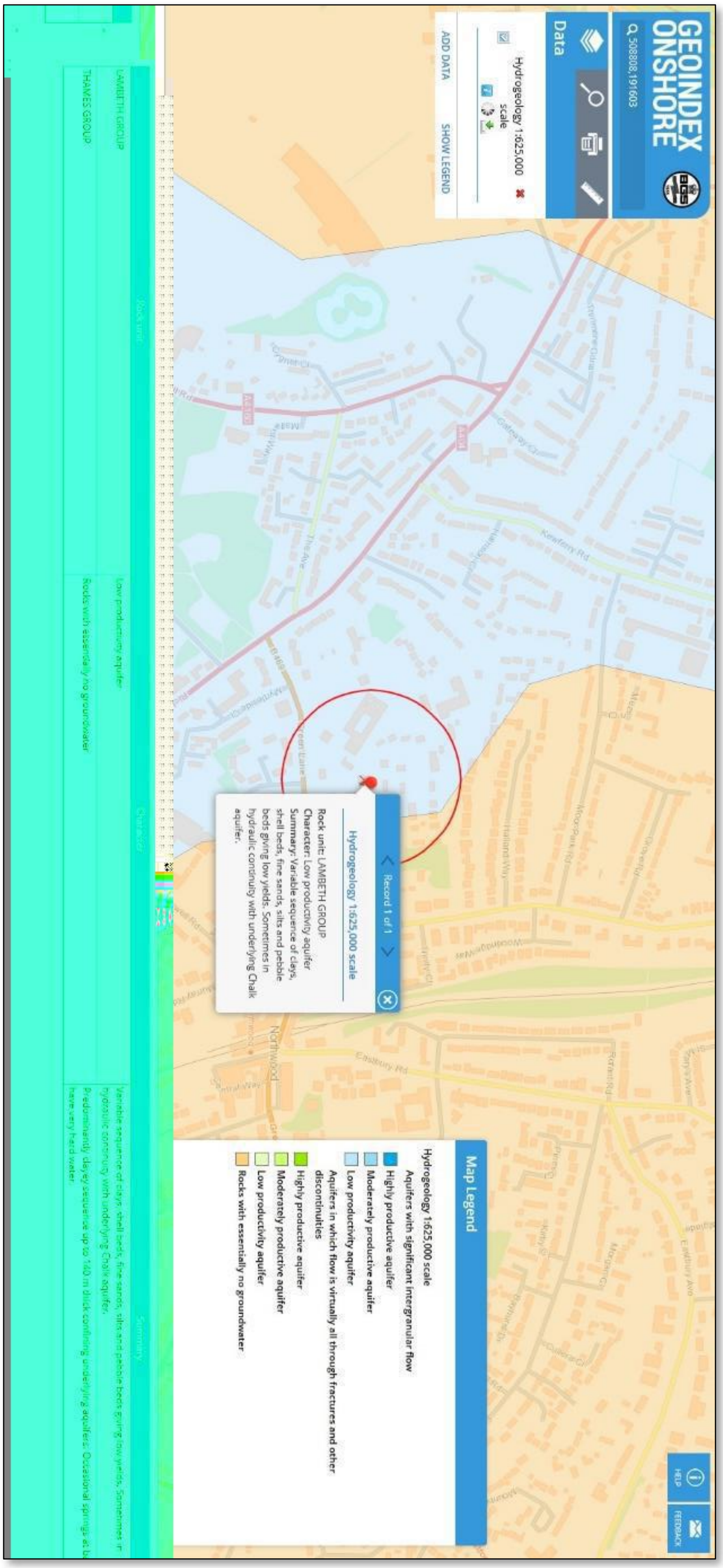
Daily progress	Water levels	In-situ tests	Samples	Depth (m)	Reduced level (m O.D.)	Thickness (m)	Description of Strata
				0.15	70.95	0.15	Topsoil
			U* U*	1.00	70.10	0.85	Soft mottled light brown grey silty clay with numerous traces of organic material and some root fibres
			U* U* U* U*	2.73	68.37	1.73	Firm to very stiff light brown grey silty clay with traces of organic material
10/9							Bottom of Borehole

Notes

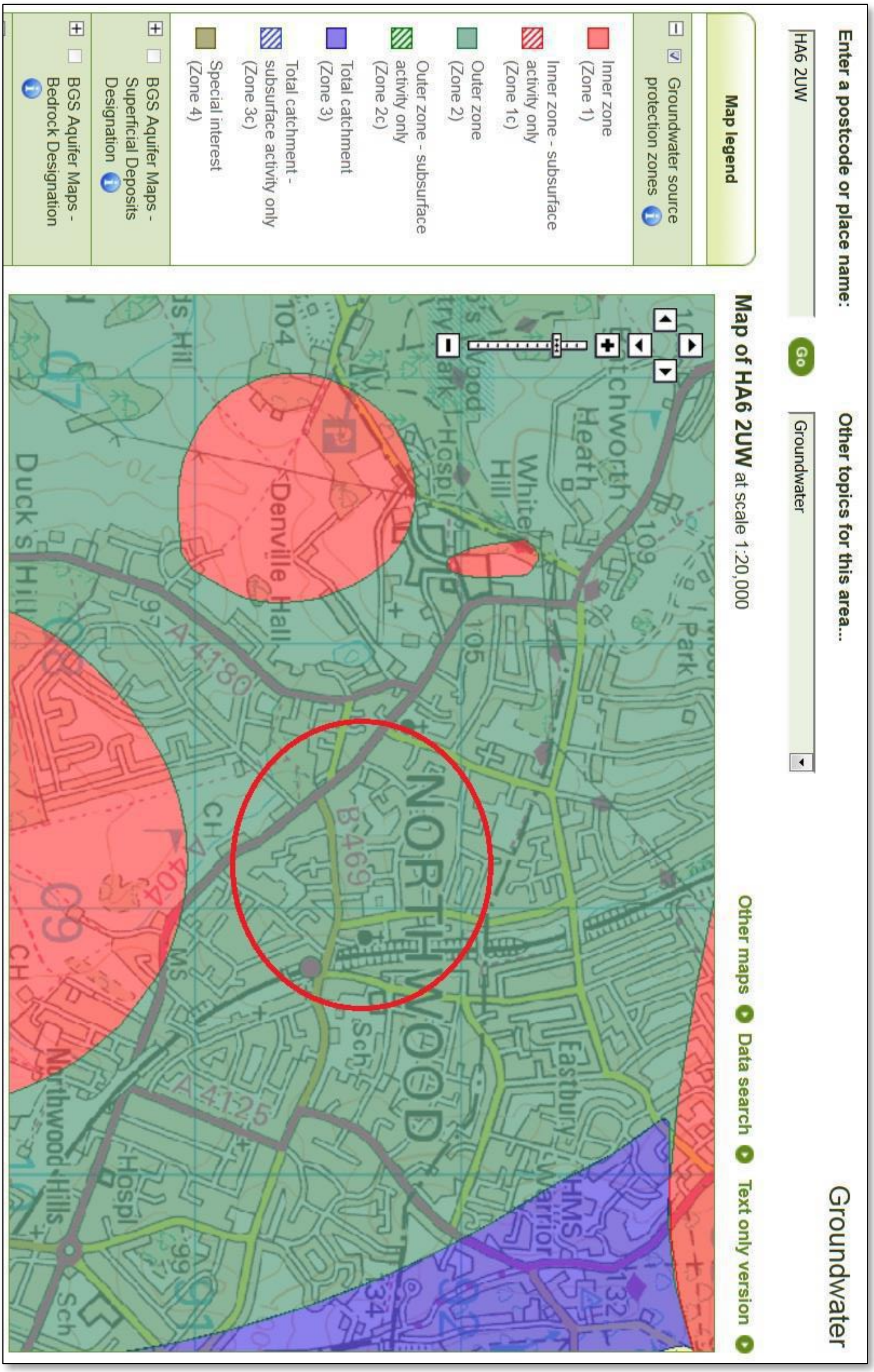
d **Report No.** S.26/875 **Appendix 1 Sheet** 4

Terresearch Limite

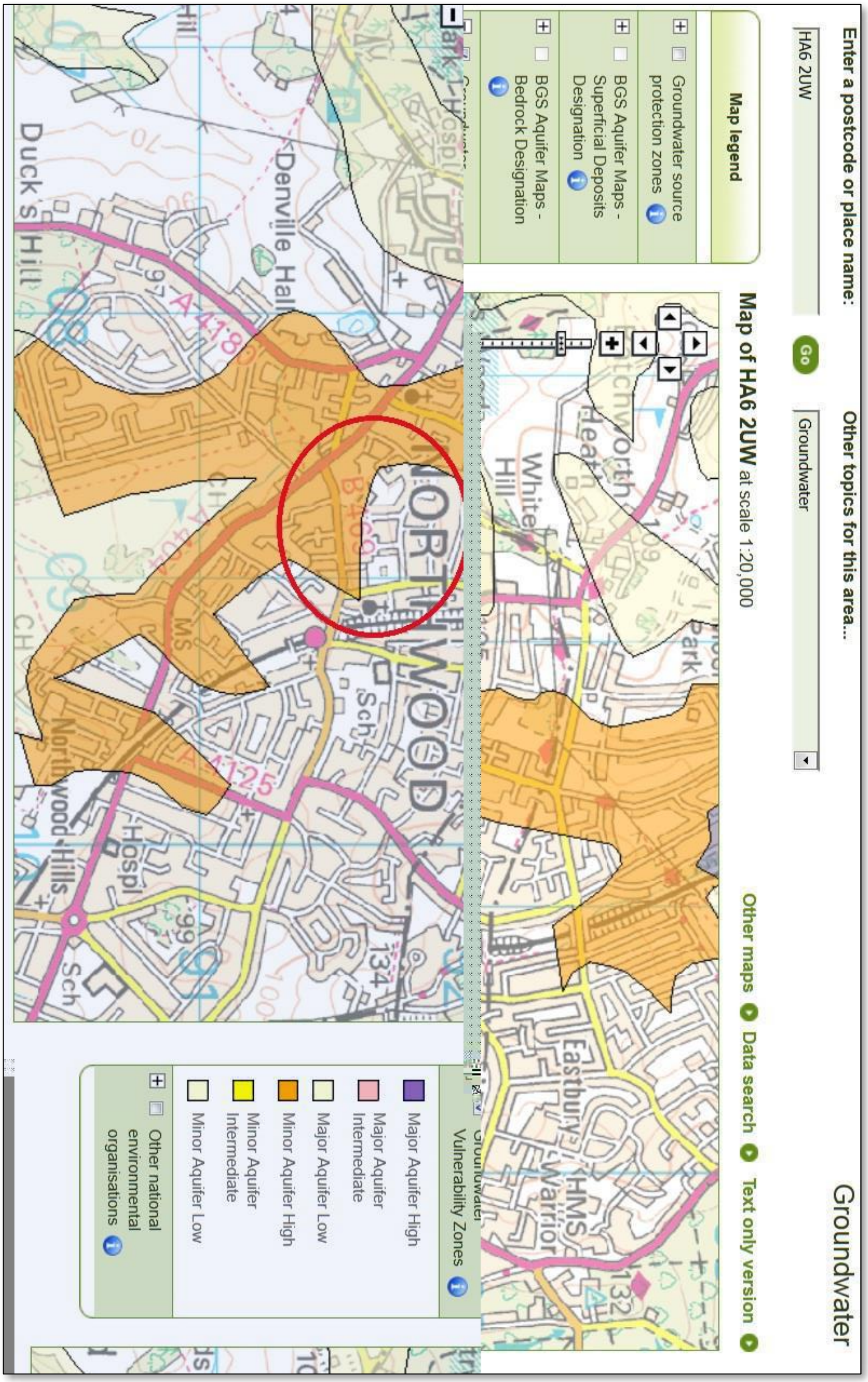
Appendix 2, Figure 5.4.1 – TQ09SE104, Sheet 1



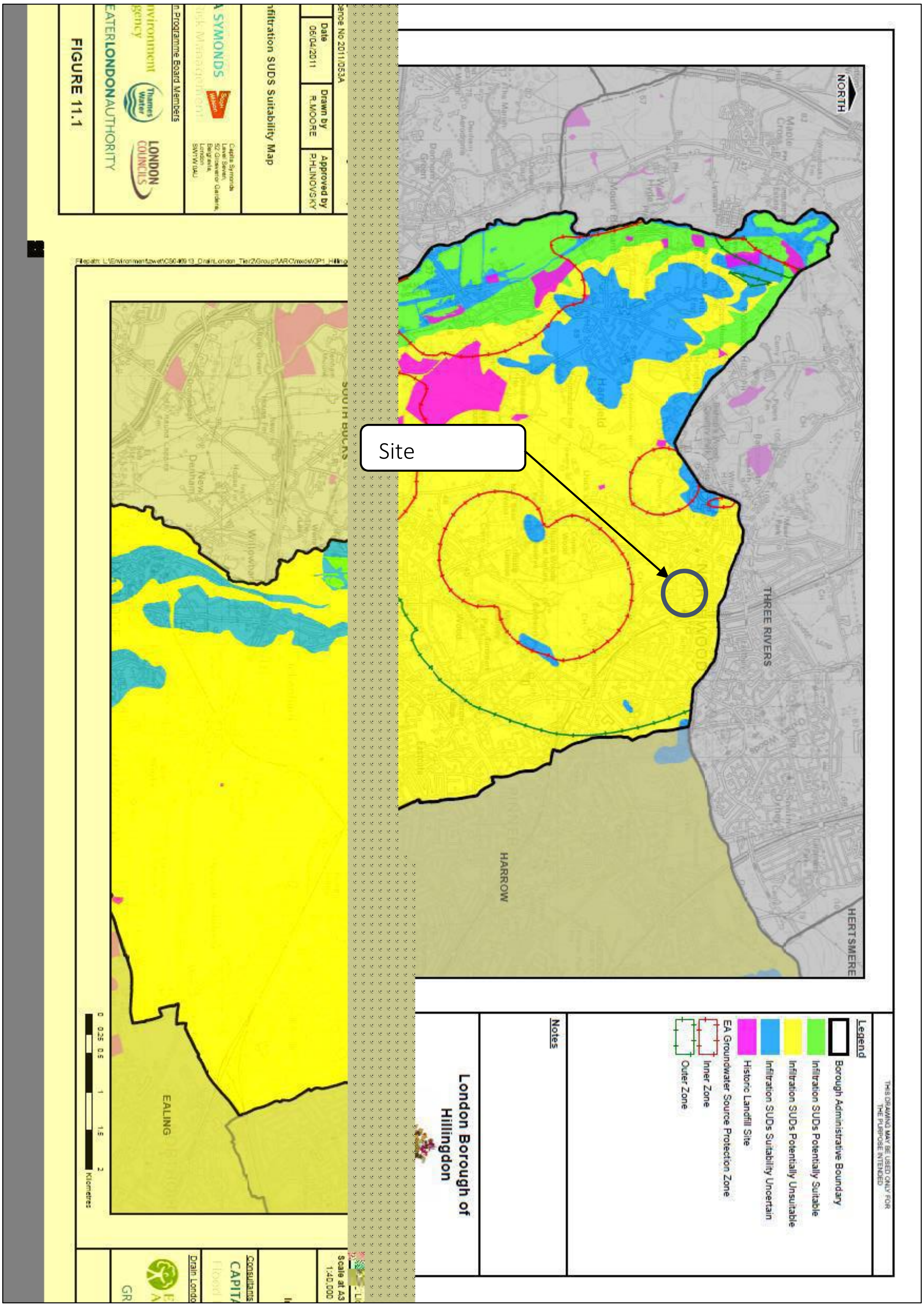
Appendix 2, Figure 6 – Hydrogeology



Appendix 2, Figure 7 - Groundwater Source Protection Zones



Appendix 2, Figure 8 - Groundwater Vulnerability Zones



Appendix 2, Figure 9 – Infiltration SUDS Suitability Map

Appendix 3 – Calculations

- *Greenfield Runoff Rates Calculation Summary*
- *Existing Runoff Rates*
- *Summary of Results for Proposed SuDS – Basement Pump*
- *Summary of Results for Proposed SuDS – Geocellular System No 1*
- *Summary of Results for Proposed SuDS – Permeable Pavement*
- *Summary of Results for Proposed SuDS – Geocellular System No 2*

Greenfield Runoff Rates Calculation Summary

GREENFIELD RUNOFF RATES CALCULATION SUMMARY		
PARAMETERS		
Catchment Area	2766.61 m^2	0.28 ha
Open Public Space	0.00 m^2	0.00 ha
Area Positively Drained	2766.61 m^2	0.28 ha
SAAR (mm)	675 mm	
SOIL	4	
SPR	0.47	
$Q_{BAR,rural}$ (l/s) for 50 Ha	**231.34 l/s**	
Hydrological Region	6	
Growth Curve Factor 1 year	0.85	
Growth Curve Factor 30 year	2.46	
Growth Curve Factor 100 year	3.19	
Return Period	**Greenfield Runoff per Hectare (l/s/ha)**	
Q_{BAR}	4.63	
1	3.93	
30	11.38	
100	14.76	
Return Period	**Greenfield Runoff (l/s)**	
Q_{BAR}	1.28	
1	1.09	
30	3.15	
100	**4.08**	

Appendix 3, Table 1 - Greenfield Runoff Rates Calculation Summary

Existing Runoff Rates

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Existing Storm Sewer Design London School of Theology Contract No 3110	
Date 14/03/2017 12:50 File Existing Runoff Rates#3...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Network 2016.1	

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	100	Add Flow / Climate Change (%)	0
M5-60 (mm)	20.100	Minimum Backdrop Height (m)	0.200
Ratio R	0.412	Maximum Backdrop Height (m)	1.500
Maximum Rainfall (mm/hr)	50	Min Design Depth for Optimisation (m)	1.200
Maximum Time of Concentration (mins)	30	Min Vel for Auto Design only (m/s)	1.00
Foul Sewage (l/s/ha)	0.000	Min Slope for Optimisation (1:X)	500
Volumetric Runoff Coeff.	0.750		

Designed with Level Soffits

Time Area Diagram for Storm

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.105	4-8	0.022

Total Area Contributing (ha) = 0.127

Total Pipe Volume (m³) = 0.837

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
S1.000	20.000	3.040	6.6	0.127	4.00	0.0	0.600	o	100	Pipe/Conduit	
S1.001	38.465	0.481	80.0	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
S1.000	50.00	4.11	71.000	0.127	0.0	0.0	0.0	3.03	23.8	17.2
S1.001	50.00	4.68	67.910	0.127	0.0	0.0	0.0	1.13	19.9	17.2

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
S1.001	S	70.000	67.429	0.000	0	0

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Existing Storm Sewer Design London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 12:50 File Existing Runoff Rates#3...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Network 2016.1	

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

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Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Existing Storm Sewer Design London School of Theology Contract No 3110	
Date 14/03/2017 12:50 File Existing Runoff Rates#3...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Network 2016.1	

1 year Return Period Summary of Critical Results by Maximum Outflow (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Storage Structures 0
Number of Online Controls 0 Number of Time/Area Diagrams 0
Number of Offline Controls 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.412
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 20.100 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years) 1, 20, 30, 100
Climate Change (%) 0, 0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
S1.000	S1	15 Winter	1	+0%	20/15 Summer	20/15 Summer			71.070
S1.001	S2	15 Winter	1	+0%	20/15 Summer				68.029

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
S1.000	S1	-0.030	0.000	0.82		18.8	FLOOD RISK	14
S1.001	S2	-0.031	0.000	0.97		18.6	OK	

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Existing Storm Sewer Design London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 12:50 File Existing Runoff Rates#3...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Network 2016.1	

20 year Return Period Summary of Critical Results by Maximum Outflow (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Storage Structures 0
Number of Online Controls 0 Number of Time/Area Diagrams 0
Number of Offline Controls 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.412
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 20.100 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years) 1, 20, 30, 100
Climate Change (%) 0, 0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
S1.000	S1	15 Summer	20	+0%	20/15 Summer	20/15 Summer			71.232
S1.001	S2	15 Winter	20	+0%	20/15 Summer				68.244

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
S1.000	S1	0.132	1.620	0.99		22.8	FLOOD	14
S1.001	S2	0.184	0.000	1.18		22.8	SURCHARGED	

Ambiental		Page 5
Science Park Square Brighton BN1 9SB	Existing Storm Sewer Design London School of Theology Contract No 3110	
Date 14/03/2017 12:50	Designed by Jose Tenedor	

Ambiental		Page 6
Science Park Square	Existing Storm Sewer Design	
Brighton	London School of Theology	
BN1 9SB	Contract No 3110	
Date 14/03/2017 12:50	Designed by Jose Tenedor	
File Existing Runoff Rates#3...	Checked by Mark Naumann	
XP Solutions	Network 2016.1	

100 year Return Period Summary of Critical Results by Maximum Outflow (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor 1.000 Additional Flow - % of Total Flow 0.000
Hot Start (mins) 0 MADD Factor * 10m³/ha Storage 2.000
Hot Start Level (mm) 0 Inlet Coeffiecient 0.800
Manhole Headloss Coeff (Global) 0.500 Flow per Person per Day (l/per/day) 0.000
Foul Sewage per hectare (l/s) 0.000

Number of Input Hydrographs 0 Number of Storage Structures 0
Number of Online Controls 0 Number of Time/Area Diagrams 0
Number of Offline Controls 0 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model FSR Ratio R 0.412
Region England and Wales Cv (Summer) 0.750
M5-60 (mm) 20.100 Cv (Winter) 0.840

Margin for Flood Risk Warning (mm) 300.0 DVD Status OFF
Analysis Timestep Fine Inertia Status OFF
DTS Status ON

Profile(s) Summer and Winter
Duration(s) (mins) 15, 30, 60, 120, 180, 240, 360, 480, 600, 720, 960, 1440, 2160, 2880, 4320, 5760, 7200, 8640, 10080
Return Period(s) (years) 1, 20, 30, 100
Climate Change (%) 0, 0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
S1.000	S1	15 Summer	100	+0%	20/15 Summer	20/15 Summer			71.236
S1.001	S2	15 Winter	100	+0%	20/15 Summer				68.245

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Pipe Flow (l/s)	Status	Level Exceeded
S1.000	S1	0.136	6.328	1.00		22.9	FLOOD	14
S1.001	S2	0.185	0.000	1.18		22.8	SURCHARGED	

Summary of Results for Proposed SuDS - Basement Pump

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PIPE_1in1yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
(None)	(None)	GS1_1in1yr+40%cc_VolumeCalcs.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	68.000	0.000	0.9	0.0	O K
30 min Summer	68.000	0.000	0.9	0.0	O K
60 min Summer	68.000	0.000	0.8	0.0	O K
120 min Summer	68.000	0.000	0.6	0.0	O K
180 min Summer	68.000	0.000	0.5	0.0	O K
240 min Summer	68.000	0.000	0.4	0.0	O K
360 min Summer	68.000	0.000	0.3	0.0	O K
480 min Summer	68.000	0.000	0.3	0.0	O K
600 min Summer	68.000	0.000	0.2	0.0	O K
720 min Summer	68.000	0.000	0.2	0.0	O K
960 min Summer	68.000	0.000	0.2	0.0	O K
1440 min Summer	68.000	0.000	0.1	0.0	O K
2160 min Summer	68.000	0.000	0.1	0.0	O K
2880 min Summer	68.000	0.000	0.1	0.0	O K
4320 min Summer	68.000	0.000	0.1	0.0	O K
5760 min Summer	68.000	0.000	0.0	0.0	O K
7200 min Summer	68.000	0.000	0.0	0.0	O K
8640 min Summer	68.000	0.000	0.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	44.043	0.0	0.7	0
30 min Summer	28.612	0.0	0.9	0
60 min Summer	18.021	0.0	1.1	0
120 min Summer	11.117	0.0	1.3	0
180 min Summer	8.339	0.0	1.5	0
240 min Summer	6.792	0.0	1.6	0
360 min Summer	5.057	0.0	1.8	0
480 min Summer	4.090	0.0	2.0	0
600 min Summer	3.468	0.0	2.1	0
720 min Summer	3.031	0.0	2.2	0
960 min Summer	2.451	0.0	2.4	0
1440 min Summer	1.817	0.0	2.6	0
2160 min Summer	1.348	0.0	2.9	0
2880 min Summer	1.090	0.0	3.1	0
4320 min Summer	0.808	0.0	3.5	0
5760 min Summer	0.653	0.0	3.8	0
7200 min Summer	0.554	0.0	4.0	0
8640 min Summer	0.485	0.0	4.2	0

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PIPE_1in1yr+40%cc_VolumeCalcs.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	68.000	0.000	0.0	0.0	O K
15 min Winter	68.000	0.000	1.0	0.0	O K
30 min Winter	68.000	0.000	1.0	0.0	O K
60 min Winter	68.000	0.000	0.8	0.0	O K
120 min Winter	68.000	0.000	0.5	0.0	O K
180 min Winter	68.000	0.000	0.4	0.0	O K
240 min Winter	68.000	0.000	0.3	0.0	O K
360 min Winter	68.000	0.000	0.2	0.0	O K
480 min Winter	68.000	0.000	0.2	0.0	O K
600 min Winter	68.000	0.000	0.2	0.0	O K
720 min Winter	68.000	0.000	0.1	0.0	O K
960 min Winter	68.000	0.000	0.1	0.0	O K
1440 min Winter	68.000	0.000	0.1	0.0	O K
2160 min Winter	68.000	0.000	0.1	0.0	O K
2880 min Winter	68.000	0.000	0.1	0.0	O K
4320 min Winter	68.000	0.000	0.0	0.0	O K
5760 min Winter	68.000	0.000	0.0	0.0	O K
7200 min Winter	68.000	0.000	0.0	0.0	O K
8640 min Winter	68.000	0.000	0.0	0.0	O K
10080 min Winter	68.000	0.000	0.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.433	0.0	4.4	0
15 min Winter	44.043	0.0	0.7	0
30 min Winter	28.612	0.0	1.0	0
60 min Winter	18.021	0.0	1.2	0
120 min Winter	11.117	0.0	1.5	0
180 min Winter	8.339	0.0	1.7	0
240 min Winter	6.792	0.0	1.8	0
360 min Winter	5.057	0.0	2.0	0
480 min Winter	4.090	0.0	2.2	0
600 min Winter	3.468	0.0	2.3	0
720 min Winter	3.031	0.0	2.4	0
960 min Winter	2.451	0.0	2.6	0
1440 min Winter	1.817	0.0	2.9	0
2160 min Winter	1.348	0.0	3.3	0
2880 min Winter	1.090	0.0	3.5	0
4320 min Winter	0.808	0.0	3.9	0
5760 min Winter	0.653	0.0	4.2	0
7200 min Winter	0.554	0.0	4.5	0
8640 min Winter	0.485	0.0	4.7	0
10080 min Winter	0.433	0.0	4.9	0

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for PIPE_1in1yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.008

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.003	4	8	0.003	8	12	0.003

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for PIPE_1in1yr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 68.500

Pipe Structure

Diameter (m) Conduit Section Length (m) 27.000
Slope (1:X) 1000.000 Invert Level (m) 68.000

Section Number 41 Minor Dimn (mm) 300 4 * Hyd Radius (mm) 0.299
Conduit Type oo Side Slope (Deg) XSect Area (m²) 0.141
Major Dimn (mm) 600 Corner Splay (mm)

Pump Outflow Control

Invert Level (m) 67.500

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.0000	0.900	2.0000	1.700	2.0000	2.500	2.0000
0.200	2.0000	1.000	2.0000	1.800	2.0000	2.600	2.0000
0.300	2.0000	1.100	2.0000	1.900	2.0000	2.700	2.0000
0.400	2.0000	1.200	2.0000	2.000	2.0000	2.800	2.0000
0.500	2.0000	1.300	2.0000	2.100	2.0000	2.900	2.0000
0.600	2.0000	1.400	2.0000	2.200	2.0000	3.000	2.0000
0.700	2.0000	1.500	2.0000	2.300	2.0000		
0.800	2.0000	1.600	2.0000	2.400	2.0000		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:39 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PIPE_1in30yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
(None)	(None)	GS1_1in30yr+40%cc_VolumeCalcs.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	68.013	0.013	2.0	0.0	O K
30 min Summer	68.021	0.021	2.0	0.0	O K
60 min Summer	68.000	0.000	1.9	0.0	O K
120 min Summer	68.000	0.000	1.4	0.0	O K
180 min Summer	68.000	0.000	1.1	0.0	O K

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:39 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PIPE_1in30yr+40%cc_VolumeCalcs.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	68.000	0.000	0.1	0.0	O K
15 min Winter	68.038	0.038	2.0	0.1	O K
30 min Winter	68.036	0.036	2.0	0.1	O K
60 min Winter	68.000	0.000	1.8	0.0	O K
120 min Winter	68.000	0.000	1.2	0.0	O K
180 min Winter	68.000	0.000	0.9	0.0	O K
240 min Winter	68.000	0.000	0.7	0.0	O K
360 min Winter	68.000	0.000	0.5	0.0	O K
480 min Winter	68.000	0.000	0.4	0.0	O K
600 min Winter	68.000	0.000	0.4	0.0	O K
720 min Winter	68.000	0.000	0.3	0.0	O K
960 min Winter	68.000	0.000	0.2	0.0	O K
1440 min Winter	68.000	0.000	0.2	0.0	O K
2160 min Winter	68.000	0.000	0.1	0.0	O K
2880 min Winter	68.000	0.000	0.1	0.0	O K
4320 min Winter	68.000	0.000	0.1	0.0	O K
5760 min Winter	68.000	0.000	0.1	0.0	O K
7200 min Winter	68.000	0.000	0.0	0.0	O K
8640 min Winter	68.000	0.000	0.0	0.0	O K
10080 min Winter	68.000	0.000	0.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	0.792	0.0	8.0	0
15 min Winter	108.085	0.0	1.8	17
30 min Winter	70.019	0.0	2.3	25
60 min Winter	43.355	0.0	2.9	0
120 min Winter	26.057	0.0	3.5	0
180 min Winter	19.144	0.0	3.9	0
240 min Winter	15.318	0.0	4.1	0
360 min Winter	11.161	0.0	4.5	0
480 min Winter	8.912	0.0	4.8	0
600 min Winter	7.480	0.0	5.0	0
720 min Winter	6.481	0.0	5.2	0
960 min Winter	5.166	0.0	5.6	0
1440 min Winter	3.748	0.0	6.0	0
2160 min Winter	2.716	0.0	6.6	0
2880 min Winter	2.160	0.0	7.0	0
4320 min Winter	1.563	0.0	7.6	0
5760 min Winter	1.242	0.0	8.0	0
7200 min Winter	1.038	0.0	8.4	0
8640 min Winter	0.897	0.0	8.7	0
10080 min Winter	0.792	0.0	8.9	0

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:39 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for PIPE_1in30yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.008

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.003	4	8	0.003	8	12	0.003

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:39 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for PIPE_1in30yr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 68.500

Pipe Structure

Diameter (m) Conduit Section Length (m) 27.000
Slope (1:X) 1000.000 Invert Level (m) 68.000

Section Number 41 Minor Dimn (mm) 300 4 * Hyd Radius (mm) 0.299
Conduit Type oo Side Slope (Deg) XSect Area (m²) 0.141
Major Dimn (mm) 600 Corner Splay (mm)

Pump Outflow Control

Invert Level (m) 67.500

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.0000	0.900	2.0000	1.700	2.0000	2.500	2.0000
0.200	2.0000	1.000	2.0000	1.800	2.0000	2.600	2.0000
0.300	2.0000	1.100	2.0000	1.900	2.0000	2.700	2.0000
0.400	2.0000	1.200	2.0000	2.000	2.0000	2.800	2.0000
0.500	2.0000	1.300	2.0000	2.100	2.0000	2.900	2.0000
0.600	2.0000	1.400	2.0000	2.200	2.0000	3.000	2.0000
0.700	2.0000	1.500	2.0000	2.300	2.0000		
0.800	2.0000	1.600	2.0000	2.400	2.0000		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	
Date 14/03/2017 18:16 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PIPE_1in100yr+40%cc_AttenuationCalcs.srcx

Upstream Structures	Outflow To	Overflow To
(None)	GS1_1in100yr+40%cc_AttenuationCalcs.srcx	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	68.062	0.062	2.0	0.3	O K
30 min Summer	68.068	0.068	2.0	0.4	O K
60 min Summer	68.050	0.050	2.0	0.2	O K
120 min Summer	68.000	0.000	1.9	0.0	O K
180 min Summer	68.000	0.000	1.5	0.0	O K
240 min Summer	68.000	0.000	1.2	0.0	O K
360 min Summer	68.000	0.000	0.9	0.0	O K
480 min Summer	68.000	0.000	0.7	0.0	O K
600 min Summer	68.000	0.000	0.6	0.0	O K
720 min Summer	68.000	0.000	0.5	0.0	O K
960 min Summer	68.000	0.000	0.4	0.0	O K
1440 min Summer	68.000	0.000	0.3	0.0	O K
2160 min Summer	68.000	0.000	0.2	0.0	O K
2880 min Summer	68.000	0.000	0.2	0.0	O K
4320 min Summer	68.000	0.000	0.1	0.0	O K
5760 min Summer	68.000	0.000	0.1	0.0	O K
7200 min Summer	68.000	0.000	0.1	0.0	O K
8640 min Summer	68.000	0.000	0.1	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	140.352	0.0	2.1	19
30 min Summer	91.674	0.0	2.8	26
60 min Summer	57.005	0.0	3.4	40
120 min Summer	34.241	0.0	4.1	0
180 min Summer	25.078	0.0	4.5	0
240 min Summer	19.989	0.0	4.8	0
360 min Summer	14.479	0.0	5.2	0
480 min Summer	11.517	0.0	5.5	0
600 min Summer	9.637	0.0	5.8	0
720 min Summer	8.327	0.0	6.0	0
960 min Summer	6.608	0.0	6.3	0
1440 min Summer	4.764	0.0	6.9	0
2160 min Summer	3.429	0.0	7.4	0
2880 min Summer	2.712	0.0	7.8	0
4320 min Summer	1.947	0.0	8.4	0
5760 min Summer	1.538	0.0	8.9	0
7200 min Summer	1.280	0.0	9.2	0
8640 min Summer	1.101	0.0	9.5	0

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	
Date 14/03/2017 18:16	Designed by Jose Tenedor	

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS - Pump London School of Theology Contract No 3110	

Ambiental		Page 5
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.6	1.200	5.4	3.000	8.4	7.000	12.5
0.200	4.8	1.400	5.8	3.500	9.0	7.500	12.9
0.300	5.0	1.600	6.2	4.000	9.6	8.000	13.3
0.400	4.9	1.800	6.6	4.500	10.1	8.500	13.7
0.500	4.7	2.000	6.9	5.000	10.6	9.000	14.1
0.600	4.3	2.200	7.2	5.500	11.1	9.500	14.5
0.800	4.5	2.400	7.5	6.000	11.6		
1.000	5.0	2.600	7.8	6.500	12.1		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:40 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS1_1in30yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
PIPE_1in30yr+40%cc_VolumeCalcs.srcx	GS2_1in30yr+40%cc_VolumeCalcs.srcx	(None)

Half Drain Time : 14 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	72.555	0.305	0.0	5.0	5.0	5.8	O K
30 min Summer	72.607	0.357	0.0	5.0	5.0	6.8	O K
60 min Summer	72.589	0.339	0.0	5.0	5.0	6.4	O K
120 min Summer	72.511	0.261	0.0	5.0	5.0	5.0	O K
180 min Summer	72.445	0.195	0.0	4.8	4.8	3.7	O K
240 min Summer	72.399	0.149	0.0	4.6	4.6	2.8	O K
360 min Summer	72.360	0.110	0.0	3.9	3.9	2.1	O K
480 min Summer	72.343	0.093	0.0	3.3	3.3	1.8	O K
600 min Summer	72.332	0.082	0.0	2.8	2.8	1.6	O K
720 min Summer	72.325	0.075	0.0	2.5	2.5	1.4	O K
960 min Summer	72.316	0.066	0.0	2.0	2.0	1.2	O K
1440 min Summer	72.305	0.055	0.0	1.5	1.5	1.0	O K
2160 min Summer	72.296	0.046	0.0	1.1	1.1	0.9	O K
2880 min Summer	72.290	0.040	0.0	0.8	0.8	0.8	O K
4320 min Summer	72.284	0.034	0.0	0.6	0.6	0.6	O K
5760 min Summer	72.280	0.030	0.0	0.5	0.5	0.6	O K
7200 min Summer	72.277	0.027	0.0	0.4	0.4	0.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	108.085	0.0	9.7	20
30 min Summer	70.019	0.0	12.6	29
60 min Summer	43.355	0.0	15.6	46
120 min Summer	26.057	0.0	18.8	76
180 min Summer	19.144	0.0	20.7	106
240 min Summer	15.318	0.0	22.0	134
360 min Summer	11.161	0.0	24.1	192
480 min Summer	8.912	0.0	25.7	252
600 min Summer	7.480	0.0	26.9	312
720 min Summer	6.481	0.0	28.0	372
960 min Summer	5.166	0.0	29.7	492
1440 min Summer	3.748	0.0	32.4	730
2160 min Summer	2.716	0.0	35.2	1096
2880 min Summer	2.160	0.0	37.3	1464
4320 min Summer	1.563	0.0	40.5	2200
5760 min Summer	1.242	0.0	42.9	2912
7200 min Summer	1.038	0.0	44.8	3576

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:40 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS1_1in30yr+40%cc_VolumeCalcs.srcx

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
8640 min Summer	72.275	0.025	0.0	0.4	0.4	0.5	O K
10080 min Summer	72.274	0.024	0.0	0.3	0.3	0.4	O K
15 min Winter	72.603	0.353	0.0	5.0	5.0	6.7	O K
30 min Winter	72.661	0.411	0.0	5.0	5.0	7.8	O K
60 min Winter	72.623	0.373	0.0	5.0	5.0	7.1	O K
120 min Winter	72.492	0.242	0.0	4.9	4.9	4.6	O K
180 min Winter	72.403	0.153	0.0	4.6	4.6	2.9	O K
240 min Winter	72.365	0.115	0.0	4.1	4.1	2.2	O K
360 min Winter	72.338	0.088	0.0	3.1	3.1	1.7	O K
480 min Winter	72.326	0.076	0.0	2.5	2.5	1.4	O K
600 min Winter	72.318	0.068	0.0	2.1	2.1	1.3	O K
720 min Winter	72.312	0.062	0.0	1.8	1.8	1.2	O K
960 min Winter	72.305	0.055	0.0	1.5	1.5	1.0	O K
1440 min Winter	72.296	0.046	0.0	1.1	1.1	0.9	O K
2160 min Winter	72.288	0.038	0.0	0.8	0.8	0.7	O K
2880 min Winter	72.284	0.034	0.0	0.6	0.6	0.6	O K
4320 min Winter	72.279	0.029	0.0	0.5	0.5	0.5	O K
5760 min Winter	72.275	0.025	0.0	0.4	0.4	0.5	O K
7200 min Winter	72.273	0.023	0.0	0.3	0.3	0.4	O K
8640 min Winter	72.271	0.021	0.0	0.3	0.3	0.4	O K
10080 min Winter	72.270	0.020	0.0	0.2	0.2	0.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.897	0.0	46.5	4384
10080 min Summer	0.792	0.0	47.9	5072
15 min Winter	108.085	0.0	10.9	21
30 min Winter	70.019	0.0	14.1	30
60 min Winter	43.355	0.0	17.5	48
120 min Winter	26.057	0.0	21.0	80
180 min Winter	19.144	0.0	23.1	108
240 min Winter	15.318	0.0	24.7	134
360 min Winter	11.161	0.0	27.0	192
480 min Winter	8.912	0.0	28.7	252
600 min Winter	7.480	0.0	30.2	314
720 min Winter	6.481	0.0	31.3	370
960 min Winter	5.166	0.0	33.3	488
1440 min Winter	3.748	0.0	36.3	734
2160 min Winter	2.716	0.0	39.4	1088
2880 min Winter	2.160	0.0	41.8	1440
4320 min Winter	1.563	0.0	45.4	2204
5760 min Winter	1.242	0.0	48.1	2920
7200 min Winter	1.038	0.0	50.2	3624
8640 min Winter	0.897	0.0	52.1	4272
10080 min Winter	0.792	0.0	53.7	5072

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	
Date 14/03/2017 18:40 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for GS1_1in30yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.048

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.016	4	8	0.016	8	12	0.016

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:40 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for GS1_1in30yr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 73.450

Cellular Storage Structure

Invert Level (m) 72.250 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	20.0	0.0	1.300	0.0	0.0
0.100	20.0	0.0	1.400	0.0	0.0
0.200	20.0	0.0	1.500	0.0	0.0
0.300	20.0	0.0	1.600	0.0	0.0
0.400	20.0	0.0	1.700	0.0	0.0
0.500	20.0	0.0	1.800	0.0	0.0
0.600	20.0	0.0	1.900	0.0	0.0
0.700	20.0	0.0	2.000	0.0	0.0
0.800	20.0	0.0	2.100	0.0	0.0
0.900	20.0	0.0	2.200	0.0	0.0
1.000	20.0	0.0	2.300	0.0	0.0
1.001	0.0	0.0	2.400	0.0	0.0
1.200	0.0	0.0	2.500	0.0	0.0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0105-5000-1000-5000
Design Head (m)	1.000
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	105
Invert Level (m)	72.250
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	5.0
Flush-Flo™	0.296	5.0
Kick-Flo®	0.637	4.1
Mean Flow over Head Range	-	4.3

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

Ambiental		Page 5
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:40 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.6	1.200	5.4	3.000	8.4	7.000	12.5
0.200	4.8	1.400	5.8	3.500	9.0	7.500	12.9
0.300	5.0	1.600	6.2	4.000	9.6	8.000	13.3
0.400	4.9	1.800	6.6	4.500	10.1	8.500	13.7
0.500	4.7	2.000	6.9	5.000	10.6	9.000	14.1
0.600	4.3	2.200	7.2	5.500	11.1	9.500	14.5
0.800	4.5	2.400	7.5	6.000	11.6		
1.000	5.0	2.600	7.8	6.500	12.1		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:14 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS1_1in100yr+40%cc_AttenuationCalcs.srcx

Upstream Structures	Outflow To	Overflow To
PIPE_1in100yr+40%cc_AttenuationCalcs.srcx	GS2_1in100yr+40%cc_AttenuationCalcs.srcx	(None)

Half Drain Time : 27 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	72.780	0.530	0.0	5.0	5.0	10.1	O K
30 min Summer	72.911	0.661	0.0	5.0	5.0	12.6	O K
60 min Summer	72.920	0.670	0.0	5.0	5.0	12.7	O K
120 min Summer	72.813	0.563	0.0	5.0	5.0	10.7	O K
180 min Summer	72.697	0.447	0.0	5.0	5.0	8.5	O K
240 min Summer	72.597	0.347	0.0	5.0	5.0	6.6	O K
360 min Summer	72.463	0.213	0.0	4.9	4.9	4.0	O K
480 min Summer	72.395	0.145	0.0	4.6	4.6	2.8	O K
600 min Summer	72.367	0.117	0.0	4.2	4.2	2.2	O K
720 min Summer	72.352	0.102	0.0	3.7	3.7	1.9	O K
960 min Summer	72.336	0.086	0.0	3.0	3.0	1.6	O K
1440 min Summer	72.319	0.069	0.0	2.2	2.2	1.3	O K
2160 min Summer	72.307	0.057	0.0	1.6	1.6	1.1	O K
2880 min Summer	72.300	0.050	0.0	1.2	1.2	0.9	O K
4320 min Summer	72.291	0.041	0.0	0.9	0.9	0.8	O K
5760 min Summer	72.287	0.037	0.0	0.7	0.7	0.7	O K
7200 min Summer	72.283	0.033	0.0	0.6	0.6	0.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	140.352	0.0	14.7	22
30 min Summer	91.674	0.0	19.3	33
60 min Summer	57.005	0.0	23.9	50
120 min Summer	34.241	0.0	28.8	82
180 min Summer	25.078	0.0	31.6	114
240 min Summer	19.989	0.0	33.6	144
360 min Summer	14.479	0.0	36.5	200
480 min Summer	11.517	0.0	38.7	256
600 min Summer	9.637	0.0	40.5	312
720 min Summer	8.327	0.0	42.0	372
960 min Summer	6.608	0.0	44.4	492
1440 min Summer	4.764	0.0	48.0	734
2160 min Summer	3.429	0.0	51.8	1100
2880 min Summer	2.712	0.0	54.7	1460
4320 min Summer	1.947	0.0	58.9	2200
5760 min Summer	1.538	0.0	62.0	2920
7200 min Summer	1.280	0.0	64.5	3664

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:14 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS1_1in100yr+40%cc_AttenuationCalcs.srcx

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
8640 min Summer	72.281	0.031	0.0	0.5	0.5	0.6	O K
10080 min Summer	72.279	0.029	0.0	0.5	0.5	0.5	O K
15 min Winter	72.859	0.609	0.0	5.0	5.0	11.6	O K
30 min Winter	73.009	0.759	0.0	5.0	5.0	14.4	O K
60 min Winter	73.019	0.769	0.0	5.0	5.0	14.6	O K
120 min Winter	72.861	0.611	0.0	5.0	5.0	11.6	O K
180 min Winter	72.669	0.419	0.0	5.0	5.0	8.0	O K
240 min Winter	72.527	0.277	0.0	5.0	5.0	5.3	O K
360 min Winter	72.386	0.136	0.0	4.5	4.5	2.6	O K
480 min Winter	72.355	0.105	0.0	3.8	3.8	2.0	O K
600 min Winter	72.340	0.090	0.0	3.2	3.2	1.7	O K
720 min Winter	72.331	0.081	0.0	2.7	2.7	1.5	O K
960 min Winter	72.319	0.069	0.0	2.2	2.2	1.3	O K
1440 min Winter	72.307	0.057	0.0	1.6	1.6	1.1	O K
2160 min Winter	72.297	0.047	0.0	1.1	1.1	0.9	O K
2880 min Winter	72.292	0.042	0.0	0.9	0.9	0.8	O K
4320 min Winter	72.285	0.035	0.0	0.6	0.6	0.7	O K
5760 min Winter	72.281	0.031	0.0	0.5	0.5	0.6	O K
7200 min Winter	72.278	0.028	0.0	0.4	0.4	0.5	O K
8640 min Winter	72.276	0.026	0.0	0.4	0.4	0.5	O K
10080 min Winter	72.274	0.024	0.0	0.3	0.3	0.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.101	0.0	66.6	4320
10080 min Summer	0.969	0.0	68.4	5032
15 min Winter	140.352	0.0	16.5	23
30 min Winter	91.674	0.0	21.6	35
60 min Winter	57.005	0.0	26.8	54
120 min Winter	34.241	0.0	32.2	90
180 min Winter	25.078	0.0	35.4	120
240 min Winter	19.989	0.0	37.6	148
360 min Winter	14.479	0.0	40.9	198
480 min Winter	11.517	0.0	43.3	254
600 min Winter	9.637	0.0	45.3	312
720 min Winter	8.327	0.0	47.0	370
960 min Winter	6.608	0.0	49.7	494
1440 min Winter	4.764	0.0	53.8	740
2160 min Winter	3.429	0.0	58.1	1096
2880 min Winter	2.712	0.0	61.2	1436
4320 min Winter	1.947	0.0	65.9	2152
5760 min Winter	1.538	0.0	69.4	2856
7200 min Winter	1.280	0.0	72.2	3560
8640 min Winter	1.101	0.0	74.6	4376
10080 min Winter	0.969	0.0	76.6	5072

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:14 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for GS1_1in100yr+40%cc_AttenuationCalcs.srcx

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)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.048

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.016	4	8	0.016	8	12	0.016

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	
Date 14/03/2017 18:14 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for GS1_1in100yr+40%cc_AttenuationCalcs.srcx

Storage is Online Cover Level (m) 73.450

Cellular Storage Structure

Invert Level (m) 72.250 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	20.0	0.0	1.300	0.0	0.0
0.100	20.0	0.0	1.400	0.0	0.0
0.200	20.0	0.0	1.500	0.0	0.0
0.300	20.0	0.0	1.600	0.0	0.0
0.400	20.0	0.0	1.700	0.0	0.0
0.500	20.0	0.0	1.800	0.0	0.0
0.600	20.0	0.0	1.900	0.0	0.0
0.700	20.0	0.0	2.000	0.0	0.0
0.800	20.0	0.0	2.100	0.0	0.0
0.900	20.0	0.0	2.200	0.0	0.0
1.000	20.0	0.0	2.300	0.0	0.0
1.001	0.0	0.0	2.400	0.0	0.0
1.200	0.0	0.0	2.500	0.0	0.0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0105-5000-1000-5000
Design Head (m)	1.000
Design Flow (l/s)	5.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	105
Invert Level (m)	72.250
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	5.0
Flush-Flo™	0.296	5.0
Kick-Flo®	0.637	4.1
Mean Flow over Head Range	-	4.3

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

Ambiental		Page 5
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#1 London School of Theology Contract No 3110	
Date 14/03/2017 18:14 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.6	1.200	5.4	3.000	8.4	7.000	12.5
0.200	4.8	1.400	5.8	3.500	9.0	7.500	12.9
0.300	5.0	1.600	6.2	4.000	9.6	8.000	13.3
0.400	4.9	1.800	6.6	4.500	10.1	8.500	13.7
0.500	4.7	2.000	6.9	5.000	10.6	9.000	14.1
0.600	4.3	2.200	7.2	5.500	11.1	9.500	14.5
0.800	4.5	2.400	7.5	6.000	11.6		
1.000	5.0	2.600	7.8	6.500	12.1		

Summary of Results for Proposed SuDS - Permeable Paving

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PP_1in1yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
(None)	GS2_1in1yr+40%cc_VolumeCalcs.srcx	(None)

Half Drain Time : 0 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	68.080	0.030	0.0	7.4	7.4	0.0	O K
30 min Summer	68.080	0.030	0.0	7.4	7.4	0.0	O K
60 min Summer	68.077	0.027	0.0	6.8	6.8	0.0	O K
120 min Summer	68.070	0.020	0.0	5.1	5.1	0.0	O K
180 min Summer	68.067	0.017	0.0	4.2	4.2	0.0	O K
240 min Summer	68.065	0.015	0.0	3.7	3.7	0.0	O K
360 min Summer	68.061	0.011	0.0	2.8	2.8	0.0	O K
480 min Summer	68.059	0.009	0.0	2.2	2.2	0.0	O K
600 min Summer	68.058	0.008	0.0	1.9	1.9	0.0	O K
720 min Summer	68.057	0.007	0.0	1.7	1.7	0.0	O K
960 min Summer	68.055	0.005	0.0	1.3	1.3	0.0	O K
1440 min Summer	68.054	0.004	0.0	1.1	1.1	0.0	O K
2160 min Summer	68.053	0.003	0.0	0.7	0.7	0.0	O K
2880 min Summer	68.052	0.002	0.0	0.6	0.6	0.0	O K
4320 min Summer	68.052	0.002	0.0	0.4	0.4	0.0	O K
5760 min Summer	68.051	0.001	0.0	0.3	0.3	0.0	O K
7200 min Summer	68.051	0.001	0.0	0.3	0.3	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	44.043	0.0	4.1	12
30 min Summer	28.612	0.0	5.8	19
60 min Summer	18.021	0.0	7.6	36
120 min Summer	11.117	0.0	9.7	66
180 min Summer	8.339	0.0	11.0	98
240 min Summer	6.792	0.0	12.1	122
360 min Summer	5.057	0.0	13.6	184
480 min Summer	4.090	0.0	14.6	238
600 min Summer	3.468	0.0	15.6	322
720 min Summer	3.031	0.0	16.3	380
960 min Summer	2.451	0.0	17.7	492
1440 min Summer	1.817	0.0	19.4	752
2160 min Summer	1.348	0.0	21.2	1328
2880 min Summer	1.090	0.0	22.7	836
4320 min Summer	0.808	0.0	24.8	2972
5760 min Summer	0.653	0.0	26.1	2312
7200 min Summer	0.554	0.0	27.3	4544

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PP_1inlyr+40%cc_VolumeCalcs.srcx

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
8640 min Summer	68.051	0.001	0.0	0.3	0.3	0.0	O K
10080 min Summer	68.051	0.001	0.0	0.2	0.2	0.0	O K
15 min Winter	68.083	0.033	0.0	8.3	8.3	0.0	O K
30 min Winter	68.082	0.032	0.0	8.1	8.1	0.0	O K
60 min Winter	68.075	0.025	0.0	6.3	6.3	0.0	O K
120 min Winter	68.068	0.018	0.0	4.4	4.4	0.0	O K
180 min Winter	68.063	0.013	0.0	3.3	3.3	0.0	O K
240 min Winter	68.061	0.011	0.0	2.7	2.7	0.0	O K
360 min Winter	68.058	0.008	0.0	2.0	2.0	0.0	O K
480 min Winter	68.056	0.006	0.0	1.6	1.6	0.0	O K
600 min Winter	68.056	0.006	0.0	1.4	1.4	0.0	O K
720 min Winter	68.055	0.005	0.0	1.2	1.2	0.0	O K
960 min Winter	68.054	0.004	0.0	1.0	1.0	0.0	O K
1440 min Winter	68.053	0.003	0.0	0.7	0.7	0.0	O K
2160 min Winter	68.052	0.002	0.0	0.6	0.6	0.0	O K
2880 min Winter	68.052	0.002	0.0	0.4	0.4	0.0	O K
4320 min Winter	68.051	0.001	0.0	0.3	0.3	0.0	O K
5760 min Winter	68.051	0.001	0.0	0.3	0.3	0.0	O K
7200 min Winter	68.051	0.001	0.0	0.2	0.2	0.0	O K
8640 min Winter	68.051	0.001	0.0	0.2	0.2	0.0	O K
10080 min Winter	68.051	0.001	0.0	0.2	0.2	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.485	0.0	28.3	4280
10080 min Summer	0.433	0.0	28.1	4368
15 min Winter	44.043	0.0	4.8	14
30 min Winter	28.612	0.0	6.6	20
60 min Winter	18.021	0.0	8.7	38
120 min Winter	11.117	0.0	11.0	70
180 min Winter	8.339	0.0	12.6	104
240 min Winter	6.792	0.0	13.7	134
360 min Winter	5.057	0.0	15.4	194
480 min Winter	4.090	0.0	16.6	196
600 min Winter	3.468	0.0	17.7	328
720 min Winter	3.031	0.0	18.5	414
960 min Winter	2.451	0.0	20.0	486
1440 min Winter	1.817	0.0	22.1	710
2160 min Winter	1.348	0.0	24.1	1952
2880 min Winter	1.090	0.0	25.9	2516
4320 min Winter	0.808	0.0	28.3	2720
5760 min Winter	0.653	0.0	29.8	4112
7200 min Winter	0.554	0.0	30.9	2720
8640 min Winter	0.485	0.0	32.3	5912
10080 min Winter	0.433	0.0	33.0	4264

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for PP_1in1yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.067

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.022	4	8	0.022	8	12	0.022

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	
Date 14/03/2017 18:44 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for PP_1inlyr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 68.500

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	15.0
Membrane Percolation (mm/hr)	1000	Length (m)	18.7
Max Percolation (l/s)	77.9	Slope (1:X)	10.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	68.050	Membrane Depth (m)	130

Pump Outflow Control

Invert Level (m) 68.050

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	25.0000	0.900	25.0000	1.700	25.0000	2.500	25.0000
0.200	25.0000	1.000	25.0000	1.800	25.0000	2.600	25.0000
0.300	25.0000	1.100	25.0000	1.900	25.0000	2.700	25.0000
0.400	25.0000	1.200	25.0000	2.000	25.0000	2.800	25.0000
0.500	25.0000	1.300	25.0000	2.100	25.0000	2.900	25.0000
0.600	25.0000	1.400	25.0000	2.200	25.0000	3.000	25.0000
0.700	25.0000	1.500	25.0000	2.300	25.0000		
0.800	25.0000	1.600	25.0000	2.400	25.0000		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	
Date 14/03/2017 18:41 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PP_1in30yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
(None)	GS2_1in30yr+40%cc_VolumeCalcs.srcx	(None)

Half Drain Time : 0 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	68.121	0.071	0.0	17.7	17.7	0.1	O K
30 min Summer	68.122	0.072	0.0	18.1	18.1	0.1	O K
60 min Summer	68.115	0.065	0.0	16.3	16.3	0.1	O K
120 min Summer	68.099	0.049	0.0	12.2	12.2	0.0	O K
180 min Summer	68.088	0.038	0.0	9.6	9.6	0.0	O K
240 min Summer	68.081	0.031	0.0	7.8	7.8	0.0	O K
360 min Summer	68.074	0.024	0.0	5.9	5.9	0.0	O K
480 min Summer	68.070	0.020	0.0	4.9	4.9	0.0	O K
600 min Summer	68.066	0.016	0.0	4.1	4.1	0.0	O K
720 min Summer	68.065	0.015	0.0	3.7	3.7	0.0	O K
960 min Summer	68.062	0.012	0.0	2.9	2.9	0.0	O K
1440 min Summer	68.059	0.009	0.0	2.2	2.2	0.0	O K
2160 min Summer	68.056	0.006	0.0	1.6	1.6	0.0	O K
2880 min Summer	68.055	0.005	0.0	1.2	1.2	0.0	O K
4320 min Summer	68.053	0.003	0.0	0.8	0.8	0.0	O K
5760 min Summer	68.053	0.003	0.0	0.7	0.7	0.0	O K
7200 min Summer	68.052	0.002	0.0	0.6	0.6	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	108.085	0.0	12.2	13
30 min Summer	70.019	0.0	16.2	20
60 min Summer	43.355	0.0	20.3	36
120 min Summer	26.057	0.0	24.7	68
180 min Summer	19.144	0.0	27.3	94
240 min Summer	15.318	0.0	29.2	124
360 min Summer	11.161	0.0	32.0	182
480 min Summer	8.912	0.0	34.0	244
600 min Summer	7.480	0.0	35.7	308
720 min Summer	6.481	0.0	37.1	372
960 min Summer	5.166	0.0	39.5	492
1440 min Summer	3.748	0.0	42.6	738
2160 min Summer	2.716	0.0	46.2	1072
2880 min Summer	2.160	0.0	48.6	1584
4320 min Summer	1.563	0.0	51.4	2428
5760 min Summer	1.242	0.0	53.9	1872
7200 min Summer	1.038	0.0	55.9	1920

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:41 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PP_1in30yr+40%cc_VolumeCalcs.srcx

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
8640 min Summer	68.052	0.002	0.0	0.6	0.6	0.0	O K
10080 min Summer	68.052	0.002	0.0	0.4	0.4	0.0	O K
15 min Winter	68.129	0.079	0.0	19.8	19.8	0.1	O K
30 min Winter	68.129	0.079	0.0	19.7	19.7	0.1	O K
60 min Winter	68.111	0.061	0.0	15.3	15.3	0.1	O K
120 min Winter	68.090	0.040	0.0	9.9	9.9	0.0	O K
180 min Winter	68.080	0.030	0.0	7.4	7.4	0.0	O K
240 min Winter	68.074	0.024	0.0	5.9	5.9	0.0	O K
360 min Winter	68.069	0.019	0.0	4.7	4.7	0.0	O K
480 min Winter	68.065	0.015	0.0	3.7	3.7	0.0	O K
600 min Winter	68.064	0.014	0.0	3.4	3.4	0.0	O K
720 min Winter	68.061	0.011	0.0	2.7	2.7	0.0	O K
960 min Winter	68.060	0.010	0.0	2.6	2.6	0.0	O K
1440 min Winter	68.056	0.006	0.0	1.5	1.5	0.0	O K
2160 min Winter	68.054	0.004	0.0	1.1	1.1	0.0	O K
2880 min Winter	68.053	0.003	0.0	0.8	0.8	0.0	O K
4320 min Winter	68.053	0.003	0.0	0.7	0.7	0.0	O K
5760 min Winter	68.052	0.002	0.0	0.6	0.6	0.0	O K
7200 min Winter	68.052	0.002	0.0	0.4	0.4	0.0	O K
8640 min Winter	68.051	0.001	0.0	0.3	0.3	0.0	O K
10080 min Winter	68.051	0.001	0.0	0.3	0.3	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.897	0.0	57.6	3928
10080 min Summer	0.792	0.0	58.5	3400
15 min Winter	108.085	0.0	13.8	14
30 min Winter	70.019	0.0	18.3	22
60 min Winter	43.355	0.0	22.9	34
120 min Winter	26.057	0.0	27.9	66
180 min Winter	19.144	0.0	30.8	98
240 min Winter	15.318	0.0	32.9	128
360 min Winter	11.161	0.0	36.0	176
480 min Winter	8.912	0.0	38.4	256
600 min Winter	7.480	0.0	40.3	286
720 min Winter	6.481	0.0	41.8	360
960 min Winter	5.166	0.0	44.3	496
1440 min Winter	3.748	0.0	48.1	782
2160 min Winter	2.716	0.0	52.1	1444
2880 min Winter	2.160	0.0	54.8	1860
4320 min Winter	1.563	0.0	57.9	2296
5760 min Winter	1.242	0.0	60.6	3152
7200 min Winter	1.038	0.0	63.6	2504
8640 min Winter	0.897	0.0	64.7	4520
10080 min Winter	0.792	0.0	66.7	7360

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:41 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for PP_1in30yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.067

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.022	4	8	0.022	8	12	0.022

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	
Date 14/03/2017 18:41 File VolumeCalcs_30yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for PP_1in30yr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 68.500

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	15.0
Membrane Percolation (mm/hr)	1000	Length (m)	18.7
Max Percolation (l/s)	77.9	Slope (1:X)	10.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	68.050	Membrane Depth (m)	130

Pump Outflow Control

Invert Level (m) 68.050

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	25.0000	0.900	25.0000	1.700	25.0000	2.500	25.0000
0.200	25.0000	1.000	25.0000	1.800	25.0000	2.600	25.0000
0.300	25.0000	1.100	25.0000	1.900	25.0000	2.700	25.0000
0.400	25.0000	1.200	25.0000	2.000	25.0000	2.800	25.0000
0.500	25.0000	1.300	25.0000	2.100	25.0000	2.900	25.0000
0.600	25.0000	1.400	25.0000	2.200	25.0000	3.000	25.0000
0.700	25.0000	1.500	25.0000	2.300	25.0000		
0.800	25.0000	1.600	25.0000	2.400	25.0000		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:09 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PP_1in100yr+cc_AttenuationVol.srcx

Upstream Structures	Outflow To	Overflow To
(None)	GS2_1in100yr+40%cc_AttenuationCalcs.srcx	(None)

Half Drain Time : 0 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	68.141	0.091	0.0	22.8	22.8	0.2	O K
30 min Summer	68.145	0.095	0.0	23.7	23.7	0.2	O K
60 min Summer	68.136	0.086	0.0	21.4	21.4	0.2	O K
120 min Summer	68.113	0.063	0.0	15.7	15.7	0.1	O K
180 min Summer	68.099	0.049	0.0	12.3	12.3	0.1	O K
240 min Summer	68.091	0.041	0.0	10.3	10.3	0.0	O K
360 min Summer	68.081	0.031	0.0	7.7	7.7	0.0	O K
480 min Summer	68.075	0.025	0.0	6.2	6.2	0.0	O K
600 min Summer	68.073	0.023	0.0	5.7	5.7	0.0	O K
720 min Summer	68.069	0.019	0.0	4.7	4.7	0.0	O K
960 min Summer	68.065	0.015	0.0	3.8	3.8	0.0	O K
1440 min Summer	68.061	0.011	0.0	2.7	2.7	0.0	O K
2160 min Summer	68.058	0.008	0.0	1.9	1.9	0.0	O K
2880 min Summer	68.056	0.006	0.0	1.5	1.5	0.0	O K
4320 min Summer	68.054	0.004	0.0	1.1	1.1	0.0	O K
5760 min Summer	68.053	0.003	0.0	0.8	0.8	0.0	O K
7200 min Summer	68.053	0.003	0.0	0.7	0.7	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	140.352	0.0	16.2	13
30 min Summer	91.674	0.0	21.6	21
60 min Summer	57.005	0.0	27.2	36
120 min Summer	34.241	0.0	32.9	66
180 min Summer	25.078	0.0	36.3	98
240 min Summer	19.989	0.0	38.6	126
360 min Summer	14.479	0.0	41.9	192
480 min Summer	11.517	0.0	44.5	244
600 min Summer	9.637	0.0	46.5	312
720 min Summer	8.327	0.0	48.3	372
960 min Summer	6.608	0.0	51.0	498
1440 min Summer	4.764	0.0	55.0	720
2160 min Summer	3.429	0.0	59.0	976
2880 min Summer	2.712	0.0	61.8	1344
4320 min Summer	1.947	0.0	65.4	2428
5760 min Summer	1.538	0.0	67.9	2784
7200 min Summer	1.280	0.0	70.4	5456

Ambiental		Page 2
Science Park Square	Proposed SuDS-Permeable Paving	
Brighton	London School of Theology	
BN1 9SB	Contract No 3110	
Date 14/03/2017 18:09	Designed by Jose Tenedor	
File AttenuationVolume_100yr...	Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for PP_1in100yr+cc_AttenuationVol.srcx

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
8640 min Summer	68.052	0.002	0.0	0.6	0.6	0.0	O K
10080 min Summer	68.052	0.002	0.0	0.6	0.6	0.0	O K
15 min Winter	68.173	0.123	0.0	25.0	25.0	0.3	O K
30 min Winter	68.170	0.120	0.0	25.0	25.0	0.3	O K
60 min Winter	68.130	0.080	0.0	20.1	20.1	0.1	O K
120 min Winter	68.102	0.052	0.0	13.1	13.1	0.1	O K
180 min Winter	68.089	0.039	0.0	9.8	9.8	0.0	O K
240 min Winter	68.081	0.031	0.0	7.8	7.8	0.0	O K
360 min Winter	68.073	0.023	0.0	5.7	5.7	0.0	O K
480 min Winter	68.069	0.019	0.0	4.7	4.7	0.0	O K
600 min Winter	68.066	0.016	0.0	3.9	3.9	0.0	O K
720 min Winter	68.065	0.015	0.0	3.7	3.7	0.0	O K
960 min Winter	68.061	0.011	0.0	2.8	2.8	0.0	O K
1440 min Winter	68.058	0.008	0.0	1.9	1.9	0.0	O K
2160 min Winter	68.055	0.005	0.0	1.3	1.3	0.0	O K
2880 min Winter	68.054	0.004	0.0	1.1	1.1	0.0	O K
4320 min Winter	68.053	0.003	0.0	0.8	0.8	0.0	O K
5760 min Winter	68.052	0.002	0.0	0.6	0.6	0.0	O K
7200 min Winter	68.052	0.002	0.0	0.6	0.6	0.0	O K
8640 min Winter	68.052	0.002	0.0	0.4	0.4	0.0	O K
10080 min Winter	68.052	0.002	0.0	0.4	0.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.101	0.0	71.7	4768
10080 min Summer	0.969	0.0	72.9	4952
15 min Winter	140.352	0.0	18.3	15
30 min Winter	91.674	0.0	24.4	23
60 min Winter	57.005	0.0	30.6	36
120 min Winter	34.241	0.0	37.0	64
180 min Winter	25.078	0.0	40.8	96
240 min Winter	19.989	0.0	43.4	120
360 min Winter	14.479	0.0	47.2	184
480 min Winter	11.517	0.0	50.2	250
600 min Winter	9.637	0.0	52.4	296
720 min Winter	8.327	0.0	54.2	376
960 min Winter	6.608	0.0	57.3	522
1440 min Winter	4.764	0.0	61.7	676
2160 min Winter	3.429	0.0	66.3	1172
2880 min Winter	2.712	0.0	69.7	1540
4320 min Winter	1.947	0.0	74.5	2348
5760 min Winter	1.538	0.0	75.9	4440
7200 min Winter	1.280	0.0	78.5	2968
8640 min Winter	1.101	0.0	81.0	1824
10080 min Winter	0.969	0.0	82.9	7824

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	
Date 14/03/2017 18:09 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for PP_1in100yr+cc_AttenuationVol.srcx

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)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.067

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.022	4	8	0.022	8	12	0.022

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Permeable Paving London School of Theology Contract No 3110	Micro Drainage
Date 14/03/2017 18:09 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for PP_1in100yr+cc_AttenuationVol.srcx

Storage is Online Cover Level (m) 68.500

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	15.0
Membrane Percolation (mm/hr)	1000	Length (m)	18.7
Max Percolation (l/s)	77.9	Slope (1:X)	10.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	68.050	Membrane Depth (m)	130

Pump Outflow Control

Invert Level (m) 68.050

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	25.0000	0.900	25.0000	1.700	25.0000	2.500	25.0000
0.200	25.0000	1.000	25.0000	1.800	25.0000	2.600	25.0000
0.300	25.0000	1.100	25.0000	1.900	25.0000	2.700	25.0000
0.400	25.0000	1.200	25.0000	2.000	25.0000	2.800	25.0000
0.500	25.0000	1.300	25.0000	2.100	25.0000	2.900	25.0000
0.600	25.0000	1.400	25.0000	2.200	25.0000	3.000	25.0000
0.700	25.0000	1.500	25.0000	2.300	25.0000		
0.800	25.0000	1.600	25.0000	2.400	25.0000		

Summary of Results for Proposed SuDS - Geocellular System No 2

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in1yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
GS1_1in1yr+40%cc_VolumeCalcs.srcx PIPE_1in1yr+40%cc_VolumeCalcs.srcx PP_1in1yr+40%cc_VolumeCalcs.srcx	(None)	(None)

Half Drain Time : 51 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	69.495	0.095	0.0	2.8	2.8	9.4	O K
30 min Summer	69.521	0.121	0.0	3.4	3.4	12.1	O K
60 min Summer	69.542	0.142	0.0	3.5	3.5	14.2	O K
120 min Summer	69.553	0.153	0.0	3.6	3.6	15.3	O K
180 min Summer	69.553	0.153	0.0	3.6	3.6	15.3	O K
240 min Summer	69.549	0.149	0.0	3.5	3.5	14.9	O K
360 min Summer	69.535	0.135	0.0	3.5	3.5	13.5	O K
480 min Summer	69.521	0.121	0.0	3.4	3.4	12.1	O K
600 min Summer	69.511	0.111	0.0	3.2	3.2	11.0	O K
720 min Summer	69.503	0.103	0.0	3.0	3.0	10.2	O K
960 min Summer	69.491	0.091	0.0	2.7	2.7	9.0	O K
1440 min Summer	69.476	0.076	0.0	2.2	2.2	7.6	O K
2160 min Summer	69.464	0.064	0.0	1.7	1.7	6.3	O K
2880 min Summer	69.457	0.057	0.0	1.4	1.4	5.6	O K
4320 min Summer	69.448	0.048	0.0	1.1	1.1	4.8	O K
5760 min Summer	69.442	0.042	0.0	0.8	0.8	4.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	44.043	0.0	12.1	25
30 min Summer	28.612	0.0	16.3	36
60 min Summer	18.021	0.0	21.0	56
120 min Summer	11.117	0.0	26.2	88
180 min Summer	8.339	0.0	29.7	122
240 min Summer	6.792	0.0	32.3	154
360 min Summer	5.057	0.0	36.2	218
480 min Summer	4.090	0.0	39.1	278
600 min Summer	3.468	0.0	41.4	336
720 min Summer	3.031	0.0	43.5	398
960 min Summer	2.451	0.0	46.9	518
1440 min Summer	1.817	0.0	51.9	756
2160 min Summer	1.348	0.0	57.5	1116
2880 min Summer	1.090	0.0	61.9	1476
4320 min Summer	0.808	0.0	68.2	2208
5760 min Summer	0.653	0.0	73.0	2944

Ambiental		Page 2
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in1yr+40%cc_VolumeCalcs.srcx

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
7200 min Summer	69.439	0.039	0.0	0.7	0.7	3.9	O K
8640 min Summer	69.436	0.036	0.0	0.6	0.6	3.6	O K
10080 min Summer	69.434	0.034	0.0	0.6	0.6	3.3	O K
15 min Winter	69.507	0.107	0.0	3.1	3.1	10.7	O K
30 min Winter	69.539	0.139	0.0	3.5	3.5	13.9	O K
60 min Winter	69.563	0.163	0.0	3.6	3.6	16.2	O K
120 min Winter	69.570	0.170	0.0	3.6	3.6	17.0	O K
180 min Winter	69.564	0.164	0.0	3.6	3.6	16.3	O K
240 min Winter	69.553	0.153	0.0	3.6	3.6	15.3	O K
360 min Winter	69.529	0.129	0.0	3.4	3.4	12.9	O K
480 min Winter	69.511	0.111	0.0	3.3	3.3	11.1	O K
600 min Winter	69.499	0.099	0.0	2.9	2.9	9.9	O K
720 min Winter	69.490	0.090	0.0	2.7	2.7	9.0	O K
960 min Winter	69.478	0.078	0.0	2.2	2.2	7.8	O K
1440 min Winter	69.464	0.064	0.0	1.7	1.7	6.4	O K
2160 min Winter	69.454	0.054	0.0	1.3	1.3	5.4	O K
2880 min Winter	69.448	0.048	0.0	1.1	1.1	4.8	O K
4320 min Winter	69.440	0.040	0.0	0.8	0.8	4.0	O K
5760 min Winter	69.436	0.036	0.0	0.6	0.6	3.6	O K
7200 min Winter	69.433	0.033	0.0	0.5	0.5	3.2	O K
8640 min Winter	69.431	0.031	0.0	0.5	0.5	3.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Summer	0.554	0.0	77.1	3672
8640 min Summer	0.485	0.0	80.6	4408
10080 min Summer	0.433	0.0	82.5	5136
15 min Winter	44.043	0.0	13.8	25
30 min Winter	28.612	0.0	18.4	37
60 min Winter	18.021	0.0	23.7	58
120 min Winter	11.117	0.0	29.6	94
180 min Winter	8.339	0.0	33.4	130
240 min Winter	6.792	0.0	36.4	164
360 min Winter	5.057	0.0	40.8	226
480 min Winter	4.090	0.0	44.0	284
600 min Winter	3.468	0.0	46.7	346
720 min Winter	3.031	0.0	48.9	406
960 min Winter	2.451	0.0	52.8	526
1440 min Winter	1.817	0.0	58.6	770
2160 min Winter	1.348	0.0	64.8	1124
2880 min Winter	1.090	0.0	69.7	1496
4320 min Winter	0.808	0.0	77.0	2216
5760 min Winter	0.653	0.0	82.4	2960
7200 min Winter	0.554	0.0	86.7	3640
8640 min Winter	0.485	0.0	90.8	4384

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in1yr+40%cc_VolumeCalcs.srcx

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
10080 min Winter	69.429	0.029	0.0	0.4	0.4	2.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.433	0.0	93.9	5000

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for GS2_1in1yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.052

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.017	4	8	0.017	8	12	0.017

Ambiental		Page 5
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for GS2_1in1yr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 70.500

Cellular Storage Structure

Invert Level (m) 69.400 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	105.0	0.0	1.300	0.0	0.0
0.100	105.0	0.0	1.400	0.0	0.0
0.200	105.0	0.0	1.500	0.0	0.0
0.300	105.0	0.0	1.600	0.0	0.0
0.400	105.0	0.0	1.700	0.0	0.0
0.500	105.0	0.0	1.800	0.0	0.0
0.600	105.0	0.0	1.900	0.0	0.0
0.700	105.0	0.0	2.000	0.0	0.0
0.800	105.0	0.0	2.100	0.0	0.0
0.900	105.0	0.0	2.200	0.0	0.0
1.000	105.0	0.0	2.300	0.0	0.0
1.001	0.0	0.0	2.400	0.0	0.0
1.200	0.0	0.0	2.500	0.0	0.0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0093-3840-1000-3840
Design Head (m)	1.000
Design Flow (l/s)	3.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	93
Invert Level (m)	69.400
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	3.8
Flush-Flo™	0.299	3.8
Kick-Flo®	0.632	3.1
Mean Flow over Head Range	-	3.3

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

Ambiental		Page 6
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.0	1.200	4.2	3.000	6.4	7.000	9.6
0.200	3.7	1.400	4.5	3.500	6.9	7.500	9.9
0.300	3.8	1.600	4.8	4.000	7.3	8.000	10.2
0.400	3.8	1.800	5.0	4.500	7.8	8.500	10.5
0.500	3.6	2.000	5.3	5.000	8.1	9.000	10.8
0.600	3.3	2.200	5.5	5.500	8.5	9.500	11.1
0.800	3.5	2.400	5.8	6.000	8.9		
1.000	3.8	2.600	6.0	6.500	9.2		

Ambiental		Page 1
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in1yr+40%cc_VolumeCalcs.srcx

Upstream Structures	Outflow To	Overflow To
GS1_1in1yr+40%cc_VolumeCalcs.srcx PIPE_1in1yr+40%cc_VolumeCalcs.srcx PP_1in1yr+40%cc_VolumeCalcs.srcx	(None)	(None)

Half Drain Time : 51 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	69.495	0.095	0.0	2.8	2.8	9.4	O K
30 min Summer	69.521	0.121	0.0	3.4	3.4	12.1	O K
60 min Summer	69.542	0.142	0.0	3.5	3.5	14.2	O K
120 min Summer	69.553	0.153	0.0	3.6	3.6	15.3	O K
180 min Summer	69.553	0.153	0.0	3.6	3.6	15.3	O K
240 min Summer	69.549	0.149	0.0	3.5	3.5	14.9	O K
360 min Summer	69.535	0.135	0.0	3.5	3.5	13.5	O K
480 min Summer	69.521	0.121	0.0	3.4	3.4	12.1	O K
600 min Summer	69.511	0.111	0.0	3.2	3.2	11.0	O K
720 min Summer	69.503	0.103	0.0	3.0	3.0	10.2	O K
960 min Summer	69.491	0.091	0.0	2.7	2.7	9.0	O K
1440 min Summer	69.476	0.076	0.0	2.2	2.2	7.6	O K
2160 min Summer	69.464	0.064	0.0	1.7	1.7	6.3	O K
2880 min Summer	69.457	0.057	0.0	1.4	1.4	5.6	O K
4320 min Summer	69.448	0.048	0.0	1.1	1.1	4.8	O K
5760 min Summer	69.442	0.042	0.0	0.8	0.8	4.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	44.043	0.0	12.1	25
30 min Summer	28.612	0.0	16.3	36
60 min Summer	18.021	0.0	21.0	56
120 min Summer	11.117	0.0	26.2	88
180 min Summer	8.339	0.0	29.7	122
240 min Summer	6.792	0.0	32.3	154
360 min Summer	5.057	0.0	36.2	218
480 min Summer	4.090	0.0	39.1	278
600 min Summer	3.468	0.0	41.4	336
720 min Summer	3.031	0.0	43.5	398
960 min Summer	2.451	0.0	46.9	518
1440 min Summer	1.817	0.0	51.9	756
2160 min Summer	1.348	0.0	57.5	1116
2880 min Summer	1.090	0.0	61.9	1476
4320 min Summer	0.808	0.0	68.2	2208
5760 min Summer	0.653	0.0	73.0	2944

Ambiental		Page 2
Science Park Square	Proposed SuDS-Geocellular S.#2	
Brighton	London School of Theology	
BN1 9SB	Contract No 3110	
Date 15/03/2017 19:42	Designed by Jose Tenedor	
File VolumeCalcs_1yr+CC.casx	Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in1yr+40%cc_VolumeCalcs.srcx

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
7200 min Summer	69.439	0.039	0.0	0.7	0.7	3.9	O K
8640 min Summer	69.436	0.036	0.0	0.6	0.6	3.6	O K
10080 min Summer	69.434	0.034	0.0	0.6	0.6	3.3	O K
15 min Winter	69.507	0.107	0.0	3.1	3.1	10.7	O K
30 min Winter	69.539	0.139	0.0	3.5	3.5	13.9	O K
60 min Winter	69.563	0.163	0.0	3.6	3.6	16.2	O K
120 min Winter	69.570	0.170	0.0	3.6	3.6	17.0	O K
180 min Winter	69.564	0.164	0.0	3.6	3.6	16.3	O K
240 min Winter	69.553	0.153	0.0	3.6	3.6	15.3	O K
360 min Winter	69.529	0.129	0.0	3.4	3.4	12.9	O K
480 min Winter	69.511	0.111	0.0	3.3	3.3	11.1	O K
600 min Winter	69.499	0.099	0.0	2.9	2.9	9.9	O K
720 min Winter	69.490	0.090	0.0	2.7	2.7	9.0	O K
960 min Winter	69.478	0.078	0.0	2.2	2.2	7.8	O K
1440 min Winter	69.464	0.064	0.0	1.7	1.7	6.4	O K
2160 min Winter	69.454	0.054	0.0	1.3	1.3	5.4	O K
2880 min Winter	69.448	0.048	0.0	1.1	1.1	4.8	O K
4320 min Winter	69.440	0.040	0.0	0.8	0.8	4.0	O K
5760 min Winter	69.436	0.036	0.0	0.6	0.6	3.6	O K
7200 min Winter	69.433	0.033	0.0	0.5	0.5	3.2	O K
8640 min Winter	69.431	0.031	0.0	0.5	0.5	3.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Summer	0.554	0.0	77.1	3672
8640 min Summer	0.485	0.0	80.6	4408
10080 min Summer	0.433	0.0	82.5	5136
15 min Winter	44.043	0.0	13.8	25
30 min Winter	28.612	0.0	18.4	37
60 min Winter	18.021	0.0	23.7	58
120 min Winter	11.117	0.0	29.6	94
180 min Winter	8.339	0.0	33.4	130
240 min Winter	6.792	0.0	36.4	164
360 min Winter	5.057	0.0	40.8	226
480 min Winter	4.090	0.0	44.0	284
600 min Winter	3.468	0.0	46.7	346
720 min Winter	3.031	0.0	48.9	406
960 min Winter	2.451	0.0	52.8	526
1440 min Winter	1.817	0.0	58.6	770
2160 min Winter	1.348	0.0	64.8	1124
2880 min Winter	1.090	0.0	69.7	1496
4320 min Winter	0.808	0.0	77.0	2216
5760 min Winter	0.653	0.0	82.4	2960
7200 min Winter	0.554	0.0	86.7	3640
8640 min Winter	0.485	0.0	90.8	4384

Ambiental		Page 3
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
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XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in1yr+40%cc_VolumeCalcs.srcx

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
10080 min Winter	69.429	0.029	0.0	0.4	0.4	2.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.433	0.0	93.9	5000

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for GS2_1in1yr+40%cc_VolumeCalcs.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.052

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.017	4	8	0.017	8	12	0.017

Ambiental		Page 5
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for GS2_1in1yr+40%cc_VolumeCalcs.srcx

Storage is Online Cover Level (m) 70.500

Cellular Storage Structure

Invert Level (m) 69.400 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	105.0	0.0	1.300	0.0	0.0
0.100	105.0	0.0	1.400	0.0	0.0
0.200	105.0	0.0	1.500	0.0	0.0
0.300	105.0	0.0	1.600	0.0	0.0
0.400	105.0	0.0	1.700	0.0	0.0
0.500	105.0	0.0	1.800	0.0	0.0
0.600	105.0	0.0	1.900	0.0	0.0
0.700	105.0	0.0	2.000	0.0	0.0
0.800	105.0	0.0	2.100	0.0	0.0
0.900	105.0	0.0	2.200	0.0	0.0
1.000	105.0	0.0	2.300	0.0	0.0
1.001	0.0	0.0	2.400	0.0	0.0
1.200	0.0	0.0	2.500	0.0	0.0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0093-3840-1000-3840
Design Head (m)	1.000
Design Flow (l/s)	3.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	93
Invert Level (m)	69.400
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	3.8
Flush-Flo™	0.299	3.8
Kick-Flo®	0.632	3.1
Mean Flow over Head Range	-	3.3

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

Ambiental		Page 6
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	
Date 15/03/2017 19:42 File VolumeCalcs_1yr+CC.casx	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Hydro-Brake Optimum® Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.0	1.200	4.2	3.000	6.4	7.000	9.6
0.200	3.7	1.400	4.5	3.500	6.9	7.500	9.9
0.300	3.8	1.600	4.8	4.000	7.3	8.000	10.2
0.400	3.8	1.800	5.0	4.500	7.8	8.500	10.5
0.500	3.6	2.000	5.3	5.000	8.1	9.000	10.8
0.600	3.3	2.200	5.5	5.500	8.5	9.500	11.1
0.800	3.5	2.400	5.8	6.000	8.9		
1.000	3.8	2.600	6.0	6.500	9.2		

Ambiental		Page 1
Science Park Square	Proposed SuDS-Geocellular S.#2	
Brighton	London School of Theology	
BN1 9SB	Contract No 3110	
Date 15/03/2017 19:39	Designed by Jose Tenedor	
File AttenuationVolume_100yr...	Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in100yr+40%cc_AttenuationCalcs.srcx

Upstream Structures	Outflow To	Overflow To
PP_1in100yr+cc_AttenuationVol.srcx GS1_1in100yr+40%cc_AttenuationCalcs.srcx PIPE_1in100yr+40%cc_AttenuationCalcs.srcx	(None)	(None)

Half Drain Time : 182 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	69.732	0.332	0.0	3.8	3.8	33.1	O K
30 min Summer	69.836	0.436	0.0	3.8	3.8	43.5	O K
60 min Summer	69.950	0.550	0.0	3.8	3.8	54.9	O K
120 min Summer	70.070	0.670	0.0	3.8	3.8	66.9	O K
180 min Summer	70.089	0.689	0.0	3.8	3.8	68.7	O K
240 min Summer	70.073	0.673	0.0	3.8	3.8	67.1	O K
360 min Summer	70.032	0.632	0.0	3.8	3.8	63.1	O K
480 min Summer	69.985	0.585	0.0	3.8	3.8	58.4	O K
600 min Summer	69.940	0.540	0.0	3.8	3.8	53.8	O K
720 min Summer	69.897	0.497	0.0	3.8	3.8	49.6	O K
960 min Summer	69.819	0.419	0.0	3.8	3.8	41.8	O K
1440 min Summer	69.696	0.296	0.0	3.8	3.8	29.5	O K
2160 min Summer	69.583	0.183	0.0	3.7	3.7	18.3	O K
2880 min Summer	69.527	0.127	0.0	3.4	3.4	12.6	O K
4320 min Summer	69.491	0.091	0.0	2.7	2.7	9.1	O K
5760 min Summer	69.475	0.075	0.0	2.2	2.2	7.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	140.352	0.0	44.4	52
30 min Summer	91.674	0.0	58.5	74
60 min Summer	57.005	0.0	73.3	100
120 min Summer	34.241	0.0	88.3	134
180 min Summer	25.078	0.0	97.1	178
240 min Summer	19.989	0.0	103.3	208
360 min Summer	14.479	0.0	112.2	268
480 min Summer	11.517	0.0	119.0	332
600 min Summer	9.637	0.0	124.4	396
720 min Summer	8.327	0.0	129.1	460
960 min Summer	6.608	0.0	136.5	586
1440 min Summer	4.764	0.0	147.4	828
2160 min Summer	3.429	0.0	158.9	1168
2880 min Summer	2.712	0.0	167.2	1504
4320 min Summer	1.947	0.0	178.8	2208
5760 min Summer	1.538	0.0	187.4	2936

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Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	
Date 15/03/2017 19:39 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in100yr+40%cc_AttenuationCalcs.srcx

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
7200 min Summer	69.467	0.067	0.0	1.8	1.8	6.6	O K
8640 min Summer	69.460	0.060	0.0	1.5	1.5	6.0	O K
10080 min Summer	69.456	0.056	0.0	1.4	1.4	5.6	O K
15 min Winter	69.771	0.371	0.0	3.8	3.8	37.0	O K
30 min Winter	69.891	0.491	0.0	3.8	3.8	48.9	O K
60 min Winter	70.028	0.628	0.0	3.8	3.8	62.6	O K
120 min Winter	70.154	0.754	0.0	3.8	3.8	75.2	O K
180 min Winter	70.198	0.798	0.0	3.8	3.8	79.6	O K
240 min Winter	70.176	0.776	0.0	3.8	3.8	77.4	O K
360 min Winter	70.125	0.725	0.0	3.8	3.8	72.3	O K
480 min Winter	70.068	0.668	0.0	3.8	3.8	66.6	O K
600 min Winter	69.996	0.596	0.0	3.8	3.8	59.4	O K
720 min Winter	69.925	0.525	0.0	3.8	3.8	52.4	O K
960 min Winter	69.806	0.406	0.0	3.8	3.8	40.5	O K
1440 min Winter	69.634	0.234	0.0	3.8	3.8	23.4	O K
2160 min Winter	69.519	0.119	0.0	3.4	3.4	11.9	O K
2880 min Winter	69.493	0.093	0.0	2.8	2.8	9.3	O K
4320 min Winter	69.471	0.071	0.0	2.0	2.0	7.1	O K
5760 min Winter	69.461	0.061	0.0	1.6	1.6	6.0	O K
7200 min Winter	69.455	0.055	0.0	1.3	1.3	5.5	O K
8640 min Winter	69.450	0.050	0.0	1.1	1.1	4.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Summer	1.280	0.0	194.7	3656
8640 min Summer	1.101	0.0	200.0	4360
10080 min Summer	0.969	0.0	204.6	5120
15 min Winter	140.352	0.0	49.9	59
30 min Winter	91.674	0.0	65.7	82
60 min Winter	57.005	0.0	82.2	110
120 min Winter	34.241	0.0	99.0	142
180 min Winter	25.078	0.0	109.0	178
240 min Winter	19.989	0.0	115.8	228
360 min Winter	14.479	0.0	125.9	284
480 min Winter	11.517	0.0	133.6	364
600 min Winter	9.637	0.0	139.6	434
720 min Winter	8.327	0.0	144.7	500
960 min Winter	6.608	0.0	153.1	626
1440 min Winter	4.764	0.0	165.2	854
2160 min Winter	3.429	0.0	178.2	1160
2880 min Winter	2.712	0.0	187.7	1496
4320 min Winter	1.947	0.0	201.4	2200
5760 min Winter	1.538	0.0	209.7	2920
7200 min Winter	1.280	0.0	217.8	3672
8640 min Winter	1.101	0.0	224.7	4312

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Science Park Square	Proposed SuDS-Geocellular S.#2	
Brighton	London School of Theology	
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File AttenuationVolume_100yr...	Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Summary of Results for GS2_1in100yr+40%cc_AttenuationCalcs.srcx

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
10080 min Winter	69.446	0.046	0.0	1.0	1.0	4.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	0.969	0.0	230.5	5152

Ambiental		Page 4
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	Micro Drainage
Date 15/03/2017 19:39 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Rainfall Details for GS2_1in100yr+40%cc_AttenuationCalcs.srcx

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)	20.100	Shortest Storm (mins)	15
Ratio R	0.412	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.052

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.017	4	8	0.017	8	12	0.017

Ambiental		Page 5
Science Park Square	Proposed SuDS-Geocellular S.#2	
Brighton	London School of Theology	
BN1 9SB	Contract No 3110	
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File AttenuationVolume_100yr...	Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Cascade Model Details for GS2_1in100yr+40%cc_AttenuationCalcs.srcx

Storage is Online Cover Level (m) 70.500

Cellular Storage Structure

Invert Level (m) 69.400 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	105.0	0.0	1.300	0.0	0.0
0.100	105.0	0.0	1.400	0.0	0.0
0.200	105.0	0.0	1.500	0.0	0.0
0.300	105.0	0.0	1.600	0.0	0.0
0.400	105.0	0.0	1.700	0.0	0.0
0.500	105.0	0.0	1.800	0.0	0.0
0.600	105.0	0.0	1.900	0.0	0.0
0.700	105.0	0.0	2.000	0.0	0.0
0.800	105.0	0.0	2.100	0.0	0.0
0.900	105.0	0.0	2.200	0.0	0.0
1.000	105.0	0.0	2.300	0.0	0.0
1.001	0.0	0.0	2.400	0.0	0.0
1.200	0.0	0.0	2.500	0.0	0.0

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0093-3840-1000-3840
Design Head (m)	1.000
Design Flow (l/s)	3.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	93
Invert Level (m)	69.400
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	3.8
Flush-Flo™	0.299	3.8
Kick-Flo®	0.632	3.1
Mean Flow over Head Range	-	3.3

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

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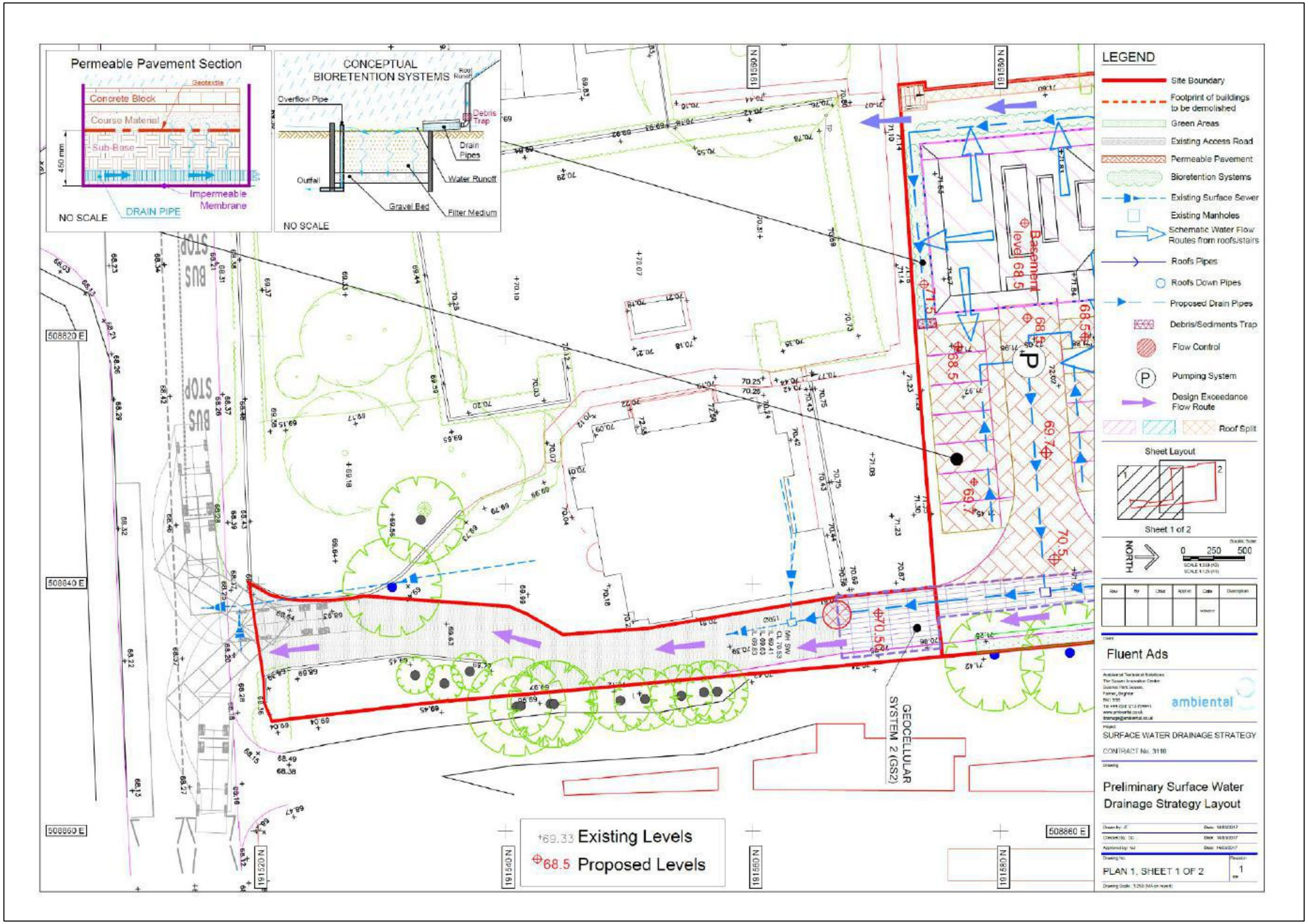
Science Park Square Brighton BN1 9SB	Proposed SuDS-Geocellular S.#2 London School of Theology Contract No 3110	
Date 15/03/2017 19:39 File AttenuationVolume_100yr...	Designed by Jose Tenedor Checked by Mark Naumann	
XP Solutions	Source Control 2016.1	

Hydro-Brake Optimum® Outflow Control

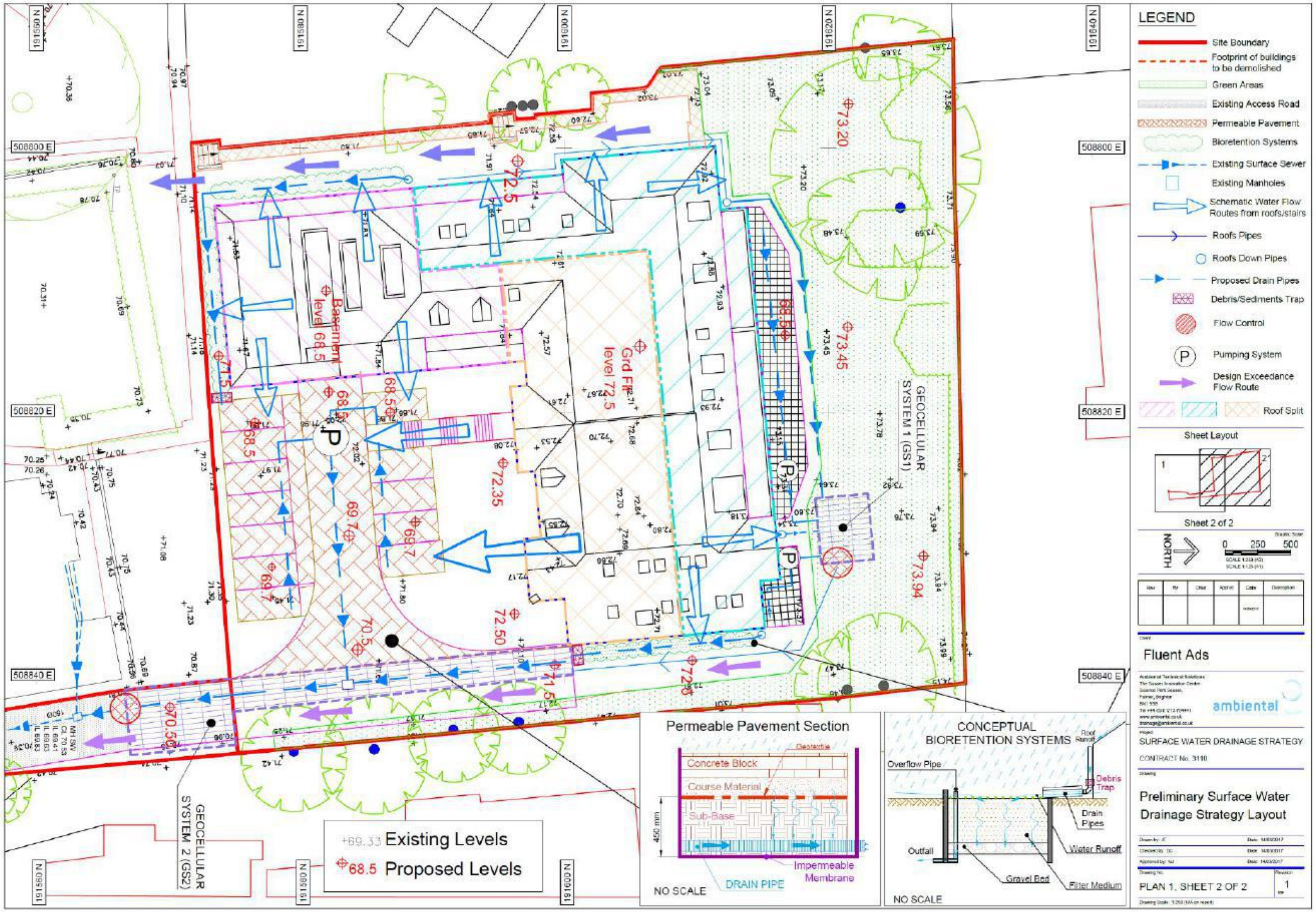
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.9	1.200	4.1	3.000	6.3	7.000	9.5
0.200	3.7	1.400	4.4	3.500	6.8	7.500	9.8
0.300	3.8	1.600	4.7	4.000	7.3	8.000	10.1
0.400	3.7	1.800	5.0	4.500	7.7	8.500	10.4
0.500	3.6	2.000	5.2	5.000	8.1	9.000	10.7
0.600	3.3	2.200	5.5	5.500	8.4	9.500	10.9
0.800	3.4	2.400	5.7	6.000	8.8		
1.000	3.8	2.600	5.9	6.500	9.1		

Appendix 4 – Proposed Surface Water Drainage Strategy

- *Plan 1 – Preliminary Drainage Strategy Layout, Sheet 1 of 2*
- *Plan 1 – Preliminary Drainage Strategy Layout, Sheet 2 of 2*



Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout, Sheet 1 of 2



Appendix 4, Plan 2 – Preliminary Drainage Strategy Layout, Sheet 2 of 2

Appendix 5 – Information

Rainfall data has been extracted from the FEH CD-ROM for several storm duration events for a number of return periods, including 1:1.01 year, 1:10 year and 1:100 year storm events. These return periods are industry standard, however it is important to be aware that return periods less than 1:2 years are not considered reliable and should not be used in detailed design calculations.

The 1:100 year with an allowance for climate change has `been based on a 40% increase to the 1:100 year rainfall intensity and not the rainfall depth. This is to provide the most conservative runoff rates for the site possible.

Greenfield runoff rates have been calculated using The Institute of Hydrology Report 124 Marshall and Bayliss, 1994 method, as recommended in the SuDS Manual CIRIA (C753). In keeping with standard practice, the calculations are based on calculating the Greenfield runoff rates for a 50 Ha site and then factored to account for the actual site size.

APPENDIX C

Site investigation report

Risk Management Limited, June 2019

Unit 10 Coopers Place
Combe Lane, Godalming
Surrey GU8 5SZ
Tel: 01883 343572
Fax: 01883 344060
email: enquiries@riskmanagementltd.co.uk
Web: www.riskmanagementltd.co.uk

PROJECT No. RML 6980

PHASE I, *NON-INTRUSIVE* & PHASE II, *INTRUSIVE*, SITE INVESTIGATION

AT
LONDON SCHOOL OF THEOLOGY, NORTHWOOD

ON BEHALF OF
WESTCOMBE HOMES LIMITED

June 2019

CONTENTS

APPENDICES

1.0 INTRODUCTION & SCOPE OF WORKS

1.1 This report has been prepared by Risk Management Limited under cover of the Client, Westcombe Homes Limited's, signed Instructions to Proceed, dated 12th May 2019.

1.2 The Architects for the project are Messrs. Fluent Architectural Design Services.

1.3 The site under consideration is located within the grounds of the London School of Theology, Green Lane, Northwood, London, HA6 2UW.

1.4 The approximate six-figure grid reference for the centre of the site is 508830E,191580N.

1.5 It is understood that the proposed development will comprise demolition of the existing two blocks of flats and erection of 12 new apartments with associated parking, cycle storage, motorcycle parking, disabled parking and bin storage. Further details of the proposed development can be found on the appended Messrs. Fluent Architectural Design Services, Drawing Nos. FLU.249.3A.02

1.6 Risk Management Limited have now been commissioned to carry out an investigation into the site comprising both a Phase I, *Non-Intrusive,* Desk Study and a Phase II, *Intrusive*, Site Investigation.

1.7 The Desk Study comprises a Walkover Survey, an Environmental Disclosure Report, Historical Map Search and a Preliminary Unexploded Ordnance Assessment and covers the whole of the site.

1.8 It should be noted that the current Desk Study is designed for geo-environmental purposes only and does not include a Structural Survey, Ecological Survey, above ground or building Asbestos Survey or an Invasive Plant Survey for Japanese Knotweed, Giant Hogweed etc.

1.9 The *Intrusive* site investigation provides information on the sub-soil conditions at this site, together with laboratory testing and includes a land-borne gas monitoring survey.

1.10 This report presents the work carried out and discusses the findings.

2.0 WALKOVER SURVEY

2.1 A Walkover Survey of the site under investigation, and that of the immediate surrounding area, was carried out by Risk Management Limited on Monday 3rd June 2019.

2.2 The site is an irregular shape in plan, covers an area of approximately 0.31ha and has a downward slope from north to south. The local topography appears to fall generally from north-east to south-west. Access to the site is gained directly from Green Lane via a shared access road and pavement crossover.

2.3 The site is currently occupied by 2 No. two-storey blocks of flats both constructed in masonry with one having a copper sheet roof and the other a tiled roof. Between the two buildings is a double garage constructed in brickwork under a corrugated cement sheet roof. The northern part of the site provides private gardens mainly laid to lawn and with mature shrubs and bushes to the borders. The eastern part of the site provides a blacktop surfaced car parking area and access road. In the north-east corner of the site is a fenced enclosure containing building equipment and materials. The south-west part of the site provides a level communal garden area mainly laid to lawn with paved footpaths and access steps to the perimeter. There are several mature and semi-mature trees within the site and along the site boundaries.

2.4 The northern boundary to the current site is formed mainly by wire chain link fencing with some timber panel fencing at the western end. Beyond the boundary there are residential properties with private gardens.

2.5 The eastern boundary to the current site is formed by timber panel fencing. Beyond the boundary there are residential apartments with landscaped areas and communal gardens.

2.6 The southern boundary to the current site is formed in part by a Yew Hedge and in part is undefined where it crosses the grassed area at the western end of the boundary and the grassed area and access road at the east end of the boundary. Beyond the boundary are the buildings, gardens and parking areas associated with Aldis House. Further beyond are the footways and roadway and footway of Green Lane and then residential apartments with landscaped areas and communal gardens.

2.7 The western boundary to the current site is formed in part by a wire chain link fence and a timber panel fence. Beyond the boundary are the communal grounds, parking areas and buildings of The London School of Theology.

2.8 Within the site several drainage manholes were noted and a water supply stopcock was also noted in the footpath in the southern part of the site. In the nearside footway of Green Lane, the presence of telecommunications, water, street lighting, drainage and CATV services was noted. In the roadway, the presence of drainage gulleys, manholes and gas and water services were noted. In the far side footway, the presence of telecommunications (including green exchange boxes), water, street lighting, drainage, fire hydrant and CATV services was noted. There is also an electricity sub-station on the far side of Green Lane.

2.9 The site lies in a mainly residential area of Northwood with local shops, educational facilities, public open space and recreational facilities in evidence close by.

2.10 No visual or olfactory evidence of contamination was noted during the Walkover Survey.

2.11 Plates 1 to 3, appended, show general photographs of the site at the time of the current Walkover Survey.

3.0 PHASE 1 ENVIRONMENTAL RISK ASSESSMENT

3.1 An EnviroCheck Report was commissioned for the current site covering an area of up to 1000m from the centre of the site.

3.2 Only criteria within 250m of the centre of the site are discussed in detail below but full results of all the search criteria up to 1000m from the centre of the site are summarised within the relevant pages of the appended EnviroCheck Report.

Geo-Environmental Hazards

3.3 The following table summarises the potential geo-environmental hazards and mitigation measures for this site.

Data Type	Hazard	Mitigation Measures for currently proposed development
Landfill & Waste Management Facilities	The Local Authorities responsible for Landfill Coverage are designated as the London Borough of Hillingdon which has not been able to supply data and Hertfordshire County Council & Three Rivers District Council both of which have supplied data. There are no Recorded, Historical or Registered Landfill Sites, Licensed Waste Management Facilities, Waste Transfer Treatment or Disposal Site entries within the 0-250m search band. There is one local authority recorded landfill site in the 501-1000m search band. There are 2 Potentially infilled land (non-water) and 3 (water) entries in the 0-250m search band. The nearest non-water entry relates to unknown filled ground (pit, quarry, etc) 141m to the south-west and the nearest water entry relates to unknown filled ground (pond, marsh. river, etc.) 36m to the south.	Gas-monitoring will be undertaken as part of the current Phase II *intrusive* site investigation.
Local Authority Pollution Prevention and Controls	There is one Local Authority Pollution Prevention and Control entry within the 0-250m search band. This relates to a dry cleaners some 213m to the east of the site. There are four entries in the 251-1000m search band.	None required.
Hazardous Substances	There are no Hazardous Substances entries within the 0-1000m search band.	None required.
Coal Mining	The site lies in an area which would not normally be affected by coal mining activity	None required

Mining Instability	There is one Mining Instability entry within the 0-250m search band, which refers to rock mining at the site.	This will be addressed by the current Phase II *intrusive* site investigation.
Non-Coal Mining Areas of Great Britain	There are three Non-Coal mining areas entries within the 0-250m search band. The nearest is at the site and has an "unlikely" risk. The other two are 31m and 81m to the east and have "likely" and "highly likely" risks respectively.	This will be addressed by the current Phase II *intrusive* site investigation.
Collapsible Ground Stability	There is a "Very Low" Hazard potential on site from Collapsible Ground Stability	None required.
Compressible Ground Stability	There is "No" Hazard potential on site from Compressible Ground Stability	None required.
Ground Dissolution Stability	There is "No" Hazard potential on the site from Ground Dissolution Stability.	None required.
Landslide Stability	There is "Very Low" Hazard potential on site from Landslide stability.	None required.
Running Sand Stability	There is "Very Low" Hazard potential on site from Running Sand stability.	None required.
Shrinking or Swelling Clay Stability.	There is "Moderate" Hazard potential on site from Shrinking or Swelling Clay Stability.	This will be addressed by the current Phase II *intrusive* site investigation.
Radon	The site does not fall within shaded sections of Annexe A of BRE Report 211 (2007) "Radon: guidance on protective measures for new dwellings". Therefore, ***No Radon Protective Measures will be necessary in the construction of new buildings at this location***	None required.
Contemporary Trade Directory Entries	There are no 'active' Contemporary Trade Directory entries within the 0-250m search band. There are five entries in the 251-500m search band the nearest of which is a Frozen Food Processors & Distributors some 281m to the east.	None required
Historic Contemporary Trade Directory Entries	There are two Historic Trade Directory entries within the 0-250m search band, these are 151m to the north and 211m to the east and relate to a Children & Baby Wear manufacturer and a Dry Cleaners respectively.	Non-targeted Contamination testing will be undertaken as part of the current Phase II *intrusive* site investigation.
Fuel Station Entries	There are no Fuel Station entries within the 0-250m search band and one obsolete entry within the 251-500m search band.	None required. Nearest hazards are in excess of 250m from site.
Sensitive Land Use	There is one Sensitive Land Use entry within the 0-250m search band. This relates to surface water run-off in the Colne and GUC (Grand Union Canal) Nitrate Vulnerable Zone within which the site is situated. These zones can be influenced by both the site and the surrounding area.	Ensure no significant pathway is created between the site surface and any underlying aquifer formation.

Hydrology and Hydrogeology

3.4 The following table summarises the potential **Hydrology and Hydrogeology** aspects for this site.

	Hazard	Mitigation Measures for currently proposed development
Discharge Consents	There are two Discharge Consent entries within the 0-250m search band. These relate to a surrendered and a temporary consent for Thames Water Utilities to discharge sewage from a pumping station to Cannon Brook 127m to the South. There are entries for two surrendered consents and two temporary consents within the 251 - 1000m search band.	None required.
Nearest Surface Water Feature	The nearest surface water feature entry is 133m to the south of the current site. This appears to be a watercourse or drainage channel running along the north-west boundary of Northwood College.	None required
Water Abstractions	No Water Abstractions are noted within the 0-1000m search band.	None required.
Pollution Incidents to Controlled Waters	There are no Pollution Incidents to Controlled Water entries within the 0-250m search band and two entries within the 251-500m search band. The nearest entry relates to a Category 3-minor incident where oils were discharged to an unnamed water 326m to the south-west.	None required
Groundwater Vulnerability	The appended Groundwater Vulnerability Map indicates that the northern part of the site lies in an area of Unproductive aquifer. The southern part, mainly the access road, lies an area of 'Secondary Aquifer' with soils of medium leaching potential in both the Bedrock and Superficial strata.	Some Contamination testing will be undertaken as part of the current Phase II *intrusive* site investigation.
Bedrock Aquifer Designations	The Bedrock Aquifer Designation is given as 'Unproductive Strata' for the northern part of the site and 'Secondary-A Aquifer' for the southern part.	
Superficial Aquifer Designations	The Superficial Aquifer does not have a designation as there is no Data Available.	
Source Protection Zones	The appended Source Protection Zone Map indicates that the site lies within the outer zone (Zone 2) of an Environment Agency Source Protection Zone (SPZ).	
Flood Risk	The site lies over the outer zone (Zone 2) of an Environment Agency Source Protection Zone (SPZ). however, there is no potential for groundwater flooding to occur. There is a low risk of surface water flooding both on the site and in the roadway outside the site entrance.	A full Flood Risk Assessment is outside the scope of the current Report.

3.5 From reference to Ordnance Survey mapping the nearest watercourse would appear to be approximately 135m to the south-east of the current site. The watercourse flows southwards towards Ruislip Lido and then into the River Pinn just to the north of Ruislip Golf Course. The River Pinn flows in a south-westerly direction towards the River Colne, which then flows south and discharges to the River Thames at Staines.

3.6 The general hydraulic gradient for the catchment is assumed to be in a westerly or south-westerly direction towards the River Colne and the Colne Valley. The local hydraulic gradient is assumed to be in a southerly direction towards the unnamed watercourse. Therefore, only potential sources of contamination to the north of the site are considered likely to have any significant impact.

4.0 HISTORICAL MAPS

4.1 The following ten historical maps covering the site are discussed below.

4.1.1 1883 (1:2,500)

The map of 1883 shows the site situated in an area of fields and some tree planting. An un-named building is situated in the southern part of the site.

The surrounding area to the north is open fields with some tree planting. To the north-east there are fields with tree planting to the margins leading to Greenhill Farm. To the east and south east there are fields with tree planting to the margins leading to Green Lane Farm. To the south is an un-named building. Beyond that Green Lane has been established and beyond Green Lane is an area of woodland with a well and ponds. To the south-west there are open fields leading to an un-named pit or quarry and beyond that an un-named road is shown. Beyond the road is a public house and an area with rough grassland and marshland. To the west there are open fields with tree planting at the margins leading to Northwood House and a farm set in mixed woodland. To the north-west there are open fields with tree planting at the margins leading to a Farm.

4.1.2 1896 (1:2,500)

The map of 1896 shows the site situated in an area laid out with building plots. Two un-named buildings occupy the southern part of the site and there is some tree planting in the south-west corner of the site.

To the north the open fields and tree planting are no longer shown. Buildings plots have been established and Dene Road is laid out. Beyond Dene Road more building plots have been established. To the north-east the fields and tree planting are no longer shown. Building plots have been established alongside Dene Road and some residential development has taken place. The buildings at Greenhill Farm can still be seen. Further beyond are more building plots leading to railway tracks set in cutting. To the east the fields and tree planting are no longer shown, and more building plots have been established. Beyond that Dene Road is laid out and further beyond some residential development has taken place. To the south-east the fields and tree planting are no longer shown. Green Lane has been widened and beyond that is an area of open land.

Further beyond, more building plots have been established and new roads laid out. The areas to the south remains generally unchanged with the previous area of woodland now open land and beyond that more building plots have been established and some residential development has taken place. To the south-west the open fields and un-named pit or quarry are no longer shown. Some un-named buildings and a public house have been established alongside the un-named road and some residential development has taken place. The un-named road is now shown as Rickmansworth Road and beyond that the area appears generally unchanged. To the west the area appears generally unchanged. Northwood House is now named Northwood Grange. To the north-west the area appears generally unchanged. Dene Road is laid out and beyond that some residential development has taken place.

4.1.3 1913 (1:2,500)

The map of 1913 shows the current site still situated in an area laid out with building plots. The trees and the previous two un-named buildings in the southern part of the site are no longer shown and part of another un-named building now occupies the south-eastern part of the current site.

To the north, north-east and east residential properties with private gardens have been constructed on the building plots to both sides of Dene Road. The pond at Greenhill Farm is no longer shown. To the south-east residential properties with private gardens have been constructed and further beyond more residential development has taken place. To the south the area of open land has been laid out with building plots and some residential properties with private gardens have been constructed. An un-named watercourse is shown at the boundary of the new building plots. Further beyond, Northwood College has been established and more residential development has taken place. The areas to the south-west, west and north-west appear generally unchanged.

4.1.4 1935 (1:2,500)

The map of 1935 shows the site still situated in an area laid out with building plots. The south-eastern part of the current site is occupied by two unnamed buildings.

To the north, north-east, east and south-east the area appears generally unchanged. Some new residential development has taken place on the far side of Dene Road. To the south the area appears generally unchanged. Some new residential development has taken place on the far side of Green Lane. The un-named watercourse has been extended and a playing field has been established at Northwood College. To the south-west and west the area appears generally unchanged. Some new residential development has taken place at the junction of Green Lane and Rickmansworth Road. To the north-west the area appears generally unchanged.

4.1.5 1960 (1:2,500)

The map of 1960 shows the site now situated in the grounds of St. Johns Hall. The south eastern part of the site is occupied by three un-named buildings. The northern and eastern part of the site are occupied by an orchard and mixed woodland.

To the north, north-east, east and south-east the areas appear generally unchanged. To the north a private garden with orchards and mixed woodlands has now been laid out and to the south-east, beyond Green Lane, a car park has been established. To the south and south-west beyond Green Lane residential properties with private gardens have been constructed. To the west the open fields are no longer shown and has been developed with St Johns Hall, playing fields and a tennis court. To the north-west the area appears generally unchanged. Some new development has taken place alongside Dene Road.

4.1.6 1970 -1976 (1:1,250)

The map of 1970-1976 shows the site located in the 1970 part of the mapping. The un-named buildings, orchard and mixed woodlands are no longer shown, and the main part of the site is now occupied by two un-named buildings, assumed to be the blocks of flats currently occupying the site.

To the north the private garden is no longer shown, and a new road has been laid out and Residential properties with private gardens constructed. Beyond Dene Road more new roads have been laid out and residential properties constructed. To the north-east new roads have been laid out and residential properties with private gardens constructed.

To the east properties have been demolished, new roads laid out and residential properties with communal grounds and private gardens have been constructed. To the south and south-east the areas appear generally unchanged. To the south-west new roads have been laid out and residential properties with communal grounds constructed. Beyond Rickmansworth Road, The Gravel Pits public open space has been established. To the west the area appears generally unchanged. To the north-west an electricity sub-station is shown. Residential properties with private gardens have been constructed alongside Dene Road and beyond that a new road laid out and residential properties constructed.

4.1.7 1992 (1:1,250)

The map of 1992 shows the current site generally unchanged and St. Johns Hall now renamed as the London Bible College.

To the north properties have been demolished, existing roads extended and residential properties with private gardens constructed. To the north-east beyond Dene Road existing roads have been extended and residential properties with private gardens constructed. To the east properties have been demolished and residential properties with communal grounds constructed. To the south-east beyond the car park and an un-named watercourse a new road is laid out and residential properties with communal grounds have been constructed. To the south the area appears generally unchanged. To the south-west properties have been demolished new roads laid out and residential properties with private gardens constructed. To the west the area appears generally unchanged. To the north-west new roads have been laid out and residential properties with private gardens constructed.

4.1.8 1999 (Aerial Photograph)

The aerial photograph of 1999 shows the site still occupied by two buildings.

The immediate surrounding area appears generally unchanged.

4.1.9 2006 (1:10,000)

The map of 2006 shows the shows the site still occupied by two un-named buildings.

The immediate surrounding area appears generally unchanged.

4.1.10 2019 (1:10,000)

The map of 2019 shows the current buildings occupying the site.

The immediate surrounding area appears generally unchanged and as found during the current site walkover survey.

5.0 FIELDWORK

5.1 Fieldwork was generally executed in accordance with the recommendations given in British Standard BS 5930:2015, “Code of Practice for Ground Investigations”. Contamination sampling was undertaken in accordance with BS 10175:2011, “Code of Practice for the Investigation of Potentially Contaminated Sites”.

5.2 Borehole locations are shown on the appended Sketch Fieldwork Location Plan, Drawing No. RML 6980/1.

5.3 Fieldwork was undertaken between the 20th and 24th May 2019 and comprised the following:-

Cable Percussion Borehole

5.4 One cable percussion borehole (BH1) was drilled at this site, to a depth of 20.00m below existing ground level.

5.5 Small disturbed samples together with nominally undisturbed U100 samples were taken from the borehole at regular depth intervals within each stratum and when a change of strata was encountered.

5.6 In addition, Standard Penetration Tests (SPT’s) were carried out within the borehole in order to provide additional information on the consistency of the material encountered. The appended SPT versus Depth Profile plots SPT ‘N’ values against depth for borehole BH1.

5.7 Full details of the cable percussion borehole findings are given on the appended borehole record sheets.

Drive-in-Sampler Boreholes

5.8 Owing to access restrictions, and in addition to the above noted cable percussion borehole, six drive-in-sampler boreholes (DIS1-DIS6) were drilled across the site. Borehole DIS2 was drilled to a depth of 5.00m below existing ground level and boreholes DIS1 and DIS3-DIS6 were drilled to a depth of 3.00m below existing ground level.

5.9 The drive-in-sampler comprises a series of 1 and 2 metre long metal tubes, varying in diameter from 80mm down to 35mm, driven into the ground using a mini-hydraulic breaker unit. The tubes are subsequently jacked out of the ground and side windows enable the tubes to be cleaned and small disturbed samples to be taken at regular intervals within each stratum.

5.10 Small disturbed samples were taken at regular depth intervals down the boreholes.

5.11 Upon completion of borehole DIS2 a combined groundwater/gas monitoring standpipe was installed to a depth of 5.00m below existing ground level. The monitoring installation comprised a 1 metre length of plain 19mm diameter HDPE pipe followed by slotted geotextile wrapped HDPE pipe, capped at the base. A cement/bentonite seal was installed from 1.00m to ground level and the installation finished with a gas valve on top of the pipe and a lockable stopcock cover concreted in flush with ground level.

5.12 Full details of the drive-in-sampler borehole findings are given on the appended borehole record sheets.

MEXE Probe (CBR) Tests

5.13 Six MEXE Probe tests (CBR1-CBR6) were undertaken at 0.50m depth across the site in order to provide California Bearing Ratio (CBR) information for road pavement design.

5.14 The MEXE Probe consists of a cast aluminium housing containing a calibrated compression spring, operating shafts and dials with a CBR cone. The instrument is forced into the ground and an average of the readings obtained is considered the CBR value.

5.15 The following CBR test values were obtained at 0.50m below existing ground level.

CBR1 (DIS1)	-	2.5%
CBR2 (DIS2)	-	3%
CBR3 (DIS3)	-	2.5%
CBR4 (DIS4)	-	2%
CBR3 (DIS5)	-	2.5%
CBR3 (DIS6)	-	2.5%

Falling Head Permeability Test

5.16 A Falling Head Permeability Test (SA1) was carried out at 1.24m depth within the standpipe installed in borehole DIS2.

5.17 The permeability test was undertaken in accordance with B.S. 5930:1999 Part 25.4.3 Variable Head Test.

5.18 Full details are given on the attached summary sheet together with any assumptions made to obtain the permeability of the material tested and to help assess the drainage potential of the ground for proposed soakaways.

Land-Borne Gas Monitoring

5.19 Following the initial site work, three return gas/groundwater monitoring visits have been undertaken to the installation fitted within borehole DIS2 on the 3rd, 11th & 20th June 2019.

5.20 On each visit the barometric pressure was recorded together with the level of Carbon Dioxide, Oxygen and Methane. In addition, gas flow measurements were taken and the depth to groundwater recorded.

5.21 Full details of the readings are included on the appended Gas/Groundwater Monitoring Record Sheet.

6.0 GROUND CONDITIONS

6.1 According to information published by the British Geological Survey (Sheet 255, Beaconsfield) the underlying geology at this site is shown as being Reading Beds (Lambeth Group) of the Eocene Period overlying Upper Chalk of the Cretaceous Period.

6.2 The Lambeth Group is the new name for the previous Woolwich and Reading Beds and includes the Thanet Sand formation.

6.3 The Woolwich and Reading Beds can be up to 10m thick near Lewisham and the formation includes a variety of lithologies laid down in a lagoonal or estuarine environment. The beds contain multi-coloured silty sandy clays interbedded in parts with sands and silts and sometimes gravel.

6.4 The Thanet Sand is often between 5 and 6 metres thick but beneath the Thames Estuary can be in the order of 30m thick. The bulk of the Thanet Sand consists of silty fine-grained sand which tends to be clayey and more silty with depth. The colour varies between greenish-grey and brownish-grey. In south-east London the sand is often patchily cemented by calcium carbonate into large irregular sandstone masses. The beds often contain glauconite and there is a basal conglomerate layer containing rounded flint pebbles. The Thanet Sand would be expected to rest directly onto Chalk.

6.5 The Lambeth Group is complex but generally comprises a clay mottled in part with beds of sand, pebbles and shells and can be summarised as follows:

Reading Beds	-	"upper mottled clay"
Woolwich Formation	-	"laminated clay, silt and sand beds" "shelly clay"
Reading Formation	-	"Lower mottled clay and sand beds"
Upnor Formation	-	"Sand and flint Gravel"
Thanet Sand Formation	-	"Silty fine Sand"

6.6 The Chalk Group is composed predominantly of chalk, a very fine grained pure limestone. Up to 90% of the carbonate sediment is composed of minute calcite crystals a few microns across, derived from the disintegration of coccoliths which are the skeletons of algae that thrived in the Late Cretaceous seas.

6.7 The Upper Chalk succession in the South-East is relatively thin because it is condensed over the London Platform and also because the youngest beds have been removed by post-Cretaceous erosion.

6.8 Full details of the ground conditions encountered are presented on the borehole records appended to this report and can be summarised., from borehole BH1 only, as follows:-

Borehole BH1

Depth From (m)	Depth To (m)	Description
0.00	0.20	Grass over Topsoil
0.20	1.40	MADE GROUND
1.40	11.60	Silty CLAY
11.60	13.60	Rounded GRAVEL
13.60	20.00 +	CHALK

6.9 Groundwater was only noted in boreholes DIS1 and DIS2 during boring at 1.80m and 2.00m depth respectively.

6.10 Groundwater was also noted during the return monitoring visits to the installation within borehole DIS2 at between 1.24m and 1.57m below existing ground level. This is considered to be related to superficial water "perched" over the relatively impermeable silty clay which has seeped down into the standpipe and not an actual groundwater table.

6.11 Roots were noted within six of the seven boreholes, up to a maximum depth of at least 1.40m below existing ground level.

7.0 LABORATORY TESTING

7.1 The following geotechnical and chemical laboratory tests have been carried out on samples recovered from the boreholes at this site.

7.2 Unless otherwise stated, the geotechnical tests have generally been carried out in accordance with the recommendations given in British Standard 1377:1990, "Methods of Test for Soils for Civil Engineering Purposes".

7.3 The chemical testing was carried out in accordance with standard industry methods in a UKAS approved laboratory which is also currently accredited in accordance with MCERTS for the majority of its testing. Further information regarding this accreditation is available on request together with a full list of test methods if required.

7.4 *Natural Moisture Content Tests*

The natural moisture content has been determined for a total of five samples from borehole BH1. The natural moisture content was found to range between 13% and 23%.

7.5 *Atterberg Limits*

The Atterberg Limits have been determined for two samples of the silty Clay from borehole BH1 at 1.50m and 2.50m depth.

The liquid limits (LL) were found to be 77% and 63%, the plastic limits (PL) 24% and 18%, and the plasticity index (PI) 53 and 45.

These results indicate that the sample tested from 1.50m depth can be classified as being a clay of 'very high' plasticity (CV) and the sample tested from 2.50m depth can be classified as being a clay of 'high' plasticity (CH), both in accordance with the Casagrande Geotechnical classification system.

In addition, the samples tested would be classified as having a 'high' potential for swelling/shrinking in accordance with the National House Building Councils (NHBC) classification system given in Part 4 of their Standards.

7.6 *Quick Undrained Triaxial Compression Tests.*

The undrained shear strength has been determined in single-stage triaxial compression for two remoulded, 38mm diameter samples and three undisturbed 104mm diameter samples.

The resulting mean shear stress (undrained cohesion) C_u values varied between 98 kN/m^2 and 188 kN/m^2 indicating that the samples tested were 'stiff' to 'very stiff' in consistency.

Full results are plotted on the appended C_u versus Depth Profile.

7.7 *Particle Size Distribution*

The particle size distribution has been determined for one sample of the more granular soil encountered.

The results are presented as a grading curve in the appendix to this report.

7.8 *pH and Sulphate Tests*

The pH has been determined for a total of eight samples from across the site. The pH was found to range between 7.1 and 9.1.

The sulphate content has been determined for two samples from 1.00m and 2.00m depth and, on a 2:1 water:soil extract, was found to be < 0.02 g/l and 0.05 g/l.

7.9 *Chemical Analysis*

Four shallow samples of MADE GROUND from across the site were selected and tested for a range of commonly occurring contaminants and indicators of contamination including those given by the Contaminated Land Exposure Assessment (CLEA).

The contamination suite undertaken at this site includes speciated **P**oly**A**romatic **H**ydrocarbon (**PAH**) and speciated **T**otal **P**etroleum **H**ydrocarbon (**TPH**), together with **BTEX**, **B**enzene, **T**oluene, **E**thylbenzene and **X**ylenes.

7.10 *Asbestos Identifications*

The same four samples, as discussed above, were submitted to a UKAS accredited laboratory for asbestos identification and full details of the results are appended.

7.11 *Waste Classification Tests*

Two shallow samples, at a depth of 0.50m and 1.00m from boreholes DIS5 and DIS6, were selected and tested for Waste Acceptance Criteria (WAC) testing in accordance with BS EN 12457 Part 3.

Full details of the results are given on the appended result sheets.

8.0 DISCUSSION

PROPOSED DEVELOPMENT & SCOPE OF WORKS

8.1 As discussed in Section 1 above, it is understood that the proposed development will comprise demolition of the existing two blocks of flats and erection of 12 apartments with associated parking, cycle storage, motorcycle parking, disabled parking and bin storage. Further details of the proposed development can be found on the appended Messrs. Fluent Architectural Design Services, Drawing Nos. FLU.249.3A.02.

8.2 The current report comprises a Phase I, *Non-Intrusive,* Desk Study and a Phase II, *Intrusive*, Site Investigation.

DESK STUDY

8.3 The current Walkover Survey found the site to be occupied by two blocks of flats with a double garage constructed between. The northern part of the site provides private gardens mainly laid to lawn and with mature shrubs and bushes to the borders. The eastern part of the site provides a blacktop surfaced car parking area and access road. In the north-east corner of the site is a fenced enclosure containing building equipment and materials. The south-west part of the site provides a level communal garden area mainly laid to lawn with paved footpaths and access steps to the perimeter. There are several mature and semi-mature trees within the site and along the site boundaries. The site lies in a mainly residential area of Northwood. No visual or olfactory evidence of contamination was noted during the walkover survey.

8.4 The historical mapping shows that circa 1883 the site was situated in an area of fields with some tree planting and an un-named building occupied part of the site. From Circa 1896 to 1960 un-named buildings occupy the site and the surrounding area is laid out with new roads and building plots and some residential development has taken place. Circa 1960 St Johns Hall (now London School of Theology) is constructed and the site lies within the school grounds. Circa 1970 the current two blocks of flats on site are shown and the surrounding area is developed with residential properties. Circa 1992 to current date the site and immediate surrounding area remain generally unchanged.

8.5 There are no landfill or waste management facilities, infilled land, local authority pollution prevention and controls, ground stability hazards or sensitive land uses that are considered likely to have a detrimental effect on the site. There are some non-coal mining activities close to the site. There are some historical trade activities in the area surrounding the site, which include a baby wear manufactures and a dry cleaners. The site lies in an area unaffected by Radon and no protective measures are necessary in the construction of new buildings.

8.6 There are no discharge consents, pollution incidents or water abstractions that are considered likely to have a detrimental effect on the site. In the Bedrock Strata the southern part of the site lies over 'Secondary Aquifer' and the northern part of the site lies over 'Unproductive Aquifer'. The Superficial Strata is not designated. The site lies over the outer zone (Zone 2) of an Environment Agency Source Protection Zone (SPZ). The site lies within an Environment Agency indicative flood zone 1 and is not at risk from groundwater flooding but has a low risk of surface water flooding in the roadway outside the site.

8.7 Provided the above noted points are taken into account, the environmental search has not found any reason to preclude any proposed re-development of this site.

FOUNDATION DESIGN

8.8 Based on borehole BH1 only the current work has found, beneath Grass over Topsoil, a band of MADE GROUND to a depth of 1.40m below existing ground level. Beneath the MADE GROUND was silty CLAY to a depth of 11.60m below existing ground level. Beneath silty CLAY, a band of black rounded GRAVEL was encountered up to a depth of 13.60m below existing ground level. Beneath rounded GRAVEL, CHALK was encountered and was not penetrated at the maximum borehole termination depth of 20.00m below existing ground level.

8.9 From the borehole findings, conventional strip or pad foundations would need to be set below any MADE GROUND within the underlying silty CLAY at a depth of some 1.50m to 2.00m below existing ground level where an allowable bearing pressure of 100 kN/m^2 could be adopted. This could be increased to 125 kN/m^2 at 2.50m depth and to 150 kN/m^2 at some 3.00m depth.

8.10 Settlement due to the above noted order of loading would not be expected to exceed 20-25mm, the majority of which would be 'long-term' occurring over a period of some 20-30 years after the construction period.

8.11 Groundwater was only noted in boreholes DIS1 and DIS2 during boring at 1.80m and 2.00m depth respectively. Groundwater was also noted during the return monitoring visits to the installation within borehole DIS2 at between 1.24m and 1.57m below existing ground level. However, this is considered to be related to superficial water “perched” over the relatively impermeable silty clay which has seeped down into the standpipe and not an actual groundwater table. Therefore, should seasonal groundwater or surface water accumulate at the base of service, basement or foundation excavations it is very important that these are kept dry by, for example, pumping from a sump, the foundation base is kept square and that any soft spots are replaced and compacted prior to pouring foundation concrete.

8.12 Further, we recommend that where groundwater or surface water flows into foundation excavations, ‘blinding’ concrete is used at the base of the foundation excavations and that foundation concrete is poured as soon as possible thereafter.

8.13 In addition, from the evidence of the boreholes, any shallow foundation or service excavations, deeper than 1 metre, will require support against collapse of sides in the MADE GROUND and into the underlying silty CLAY, and we recommend that a contingency is made for this at this stage.

8.14 The results of the Atterberg Limit tests indicate that the underlying silty CLAY across the site would have a ‘high’ potential for swelling and/or shrinking in accordance with the National House Building Councils (NHBC) classification system given in Part 4 of their Standards. In addition, roots were in evidence in six of the seven boreholes to a maximum depth of at least 1.40m depth, Therefore, precautions against shallow foundation sides in the form of compressible material <u>will</u> be required at this site where foundations fall within the ‘zone of influence’ of any past, existing or any proposed trees.

8.15 It should be noted that should ground conditions differing significantly from those described in our report be encountered during foundation excavation, then Risk Management Limited should be contacted immediately and that the above noted allowable bearing pressure or recommended foundation type may need to be altered accordingly.

PILED FOUNDATIONS

8.16 Owing to the potential loads from the proposed building, consideration may need to be given to supporting the proposed new building on piled foundations.

8.17 Piled foundations at this site could be bored or driven to support foundation loads to the new building. Given the nature of the ground conditions encountered, and the proximity to adjacent properties, a bored pile solution would appear the most appropriate; particularly those formed by continuous flight auger.

8.18 It is beyond our brief to provide a full and detailed pile design and the advice of a specialist piling contractor should be sought in this respect. However, the following table gives typical working loads for isolated bored piles of varying diameter to 10 metres and 15 metres below existing ground level.

Pile Type	Depth below existing ground level (m)	Diameter (m)	Working Load (tonnes)
Bored	10.00	0.30	20-25
Bored	10.00	0.45	35-40
Bored	10.00	0.60	50-55
Bored	15.00	0.30	60-65
Bored	15.00	0.45	100-105
Bored	15.00	0.60	145-150

8.19 In calculating the above working loads we have assumed a factor of safety of 2.5 on the sum of the skin friction and end bearing. In addition, we have assumed that the top 2 to 3 metres of each pile is 'sleeved' through the upper MADE GROUND to prevent 'down-drag' forces developing on the shaft.

8.20 Again, it is recommended that the advice of competent piling contractors is sought as to the most suitable pile type at this site and for confirmation of the order of working load achievable given the ground conditions encountered and the proprietary pile type selected.

8.21 Settlement of such piles can be expected to be small, typically less than 5 mm.

BURIED CONCRETE

8.22 The results of the chemical analyses indicate that the samples tested from 0.50m and 1.50m depth would fall into Class DS-1 of the Building Research Establishments (BRE) classification system Special Digest Part 1:2005 "Concrete in aggressive ground".

SOAKAWAYS

8.23 The Falling Head Permeability tests gave the following value:-

SA1 (DIS2) - $k = 4.89 \times 10^{-6}$ m/sec.

8.24 Based on these initial results, soakage was 'good'. However the test was undertaken at the depth to groundwater (1.24m b.g.l) and this result is indicative of this upper layer of soil only with approximately 0.40m of the soil tested consisting of MADE GROUND. The presence of standing water at 1.24m coupled with the underlying ground conditions of silty CLAY would likely preclude the use of conventional shallow soakaways at this site.

ROAD PAVEMENT DESIGN

8.25 The results of the current work recorded CBR values at about 0.50m depth varying between 2% and 3% across the site. We would therefore recommend adopting a CBR value of some 2% in the MADE GROUND at this site.

LAND-BORNE GAS

8.26 During the initial return gas/groundwater monitoring visits to the installation fitted within borehole DIS2, no methane and a maximum carbon dioxide level of 3.8% was detected. In addition, no flow was noted.

8.27 The minimum instrument detection flow rate of 0.1 l/hr will therefore be used to calculate the maximum hazardous gas concentration for CO_2.

8.28 With reference to BS 8485:2015 Section 6 and Section 7:

From Clause 6.3.4, the maximum hazardous gas flow rate (in litres per hour) is calculated by:-

$Q_{hg} = q(C_{hg}/100)$ where;

q is the measured flow rate (in litres per hour) of combined gases from the monitoring standpipe.

C_{hg} is the measured hazardous gas concentration (in percentage volume/volume).

Therefore, for the highest CO_2 level recorded in borehole DIS5,

$$Q_{hg} = 0.1(3.8/100) = 0.0038 \text{ l/h}$$

From Clause 6.3.7.4 - The calculated Q_{hg} is adopted as the worst-case Gas Screening Value (GSV) therefore the site characteristic GSV = 0.0038 l/h

From Clause 6.4 - Table 2 the site characteristic situation (CS) is shown to fall under CS1 for the Gas Screening Value which has a **"very low"** hazard potential.

From Table 3 - The building is type A - Private ownership with no building management controls

From Table 4 – The minimum gas protection score (points) required for this site is 0.

Therefore, no land borne gas remedial measures would be required at this site.

PRELIMINARY CONTAMINATION ASSESSMENT

8.29 Part IIA of the Environmental Protection Act 1990 contains the legislative framework for the regulation of contaminated land and this was implemented in the Contaminated Land (England) Regulations 2000. This legislation allows for the identification and remediation of land where contamination is causing unacceptable risks to human health or the wider environment. The approach adopted by the UK contaminated land policy is "suitable for use" which implies that the land should be suitable for its current use and made suitable for any known future use.

8.30 For this ***Preliminary Contamination Assessment*** the site has been modelled using the Source-Pathway-Receptor approach to produce a Conceptual Site Model.

Source	(substances or potential contaminants which may cause harm)
Pathway	(a linkage route between the source and receptor)
Receptor	(something which may be harmed by the source e.g. humans, plant, groundwater

8.31 Source

A total of four shallow samples of MADE GROUND were selected from across site and tested for a range of commonly occurring contaminants and indicators of contamination including those given by the Contaminated Land Exposure Assessment (CLEA).

8.32 Pathways

The pathways needing to be considered, as discussed above, will depend on the land usage, and will include for, example; soil ingestion, inhalation of vapour and dust, and consumption of home-grown vegetables, where this is applicable.

8.33 Receptors

From the results of the Desk Study and the current possible development of part of the site as residential flats, the following potential receptors have been identified.

- Workers on the site likely to come into contact with the soils.
- Future users of new residential building and shared landscaped areas.
- Any proposed additional vegetation.
- Neighbours.

8.34 It should be noted that the CLEA software has limited functionality and contains algorithms, which the EA has publicly expressed its intention to update. As a consequence of this, some of the screening values generated by the CLEA software may not adequately reflect specific site conditions and, in some instances, are unduly conservative. In addition, it should also be noted that the figures given in the appended table are based on a 6% soil organic matter content.

8.35 The DEFRA/EA model has been developed on the basis of many critical assumptions about possible exposure to soil contamination and the development of conceptual exposure models to describe different land uses as follows:

- *Residential with consumption of home-grown fruit and vegetables*
- *Residential without consumption of home-grown fruit and vegetables*
- *Allotments*
- *Commercial*

8.36 The Contaminated Land Exposure Assessment (CLEA) model was originally published in March 2002 as joint DEFRA/EA publications; Contaminated Land Research (CLR) Report CLR 10, with Reports CLR7, 8 and 9 as supporting documents, providing toxicity data and human tolerable daily intake (TDI) data to be used with this model. This model enabled the derivation of more site-specific values for contaminants present on a site, rather than the use of 'generic' values, which were previously used.

8.37 DEFRA/EA previously published a number of Soil Guideline Values (SGVs) for certain determinands, (common toxic metals), which were generic guideline criteria for assessing the risks to human health from chronic exposure to soil contamination for standard land-use functions. However, these were withdrawn in late 2008 and DEFRA/EA have now issued a new set of guidance documents. With regard to the Risk Management Limited standard suite of tests, currently SGV figures have only been issued for Arsenic, Cadmium, Mercury, Nickel, Phenols and Selenium.

8.38 In the absence of currently published SGV values for the remaining contaminants, Messrs. W. S. Atkins have derived ATRISK^{soil} Soil Screening Values (SSVs) which have been updated using CLEA v1.071 to incorporate changes to exposure assessment parameters, methodology, and land uses as set out in the Department for Environment, Food and Rural Affairs (Defra) Category 4 Screening Level (C4SL) Project Methodology Report.

8.39 Full details of how the SSVs have been derived and general notes as to their use are given on the ATRISK website and are available from Risk Management Limited upon request. A few of the PAH levels have not been updated and have been left as per the previous CLEA v1.04 derivation.

8.40 The SGV and SSV levels represent "intervention" levels above which the levels of contamination may pose an unacceptable risk to the health of site-users such that further investigation and/or remediation is required.

8.41 Total Petroleum Hydrocarbons are considered in accordance with the fractions proposed by The Environment Agency, drawing on the TPHCWG methodology. These are contained in Table 4.2 – Petroleum hydrocarbon fractions for use in UK human health risk assessment, based on Equivalent Carbon (EC) number, contained in Science Report P5-080/TR3, *The UK Approach for Evaluating Human Health Risks from Petroleum Hydrocarbons in Soils.*

8.42 The contamination results have been compared with the ***Residential without consumption of home-grown fruit and vegetables*** criteria as shown on the table below. Any exceedences are marked in yellow on the appended laboratory test results sheets.

Determinand (below)		Units	ATRISK Contaminated Land Screening Values (SSV) derived using CLEA v1.071 as set out in DEFRA Category 4 Screening Levels (C4SL) Methodology. 6% SOM Sandy Loam. Residential with consumption of home-grown fruit and vegetables.	Residential without consumption of home-grown fruit and vegetables.	Allotments.	Commercial.
Aliphatic Hydrocarbons	(mg/kg)	C5-C6	369	371	6110	29400
		C6-C8	1240	1240	18300	98200
		C8-C10	204	205	2390	14800
		C10-C12	1180	1190	8960	69500
		C12-C16	4130	2710	16300	139000
		C16-C35	210100	212000	477000	3620000
Aromatic Hydrocarbons	(mg/kg)	C8-C10	232	332	73.9	20800
		C10-C12	468	1550	95.9	53800
		C12-C16	830	2710	176	65400
		C16-C21	1040	1930	321	28400
		C21-C35	1710	1930	1570	28400
TOTAL TPH						
Naphthalene		mg/kg	12.2	13.1	27.4	1050
Acenaphthylene		mg/kg	-	-	-	-
Acenaphthene		mg/kg	2760	6730	680	106000
Fluorene		mg/kg	2610	4860	796	72000
Phenanthrene		mg/kg	-	-	-	-
Anthracene		mg/kg	26200	37700	11300	544000
Fluoranthene		mg/kg	2980	5050	1010	72600
Pyrene		mg/kg	2120	3780	679	54400
Benz(a)anthracene		mg/kg	8.54	9.04	10.3	10.3
Chrysene		mg/kg	2.64	2.64	2.64	2.64
Benzo(b)fluoranthene		mg/kg	7.29	7.29	7.29	7.29
Benzo(k)fluoranthene		mg/kg	4.12	4.12	4.12	4.12
Benzo(a)pyrene		mg/kg	4.95	5.34	5.72	76.3
Indeno(123-cd)pyrene		mg/kg	9.75	10.3	16.6	144
Dibenz(ah)anthracene		mg/kg	1	1.03	2.57	14.4
Benzo(ghi)perylene		mg/kg	103	104	342	1450
TOTAL PAH						
Cyanide (Free)		mg/kg	34	34	34	373
pH		unit	-	-	-	-
Copper (Total)		mg/kg	4790	9060	1450	106000
Lead (Total)		mg/kg	200	313	79.1	2310
Zinc (Total)		mg/kg	20300	47000	5230	1100000
Chromium III		mg/kg	14300	16700	12600	208000
Chromium (Hexavalent)		mg/kg	20.5	20.5	171	49.1
			CLEA Soil Guideline Values (SGV)			
Benzene		mg/kg	0.33	0.998	0.07	95
Toluene		mg/kg	610	2710	120	4400
Ethylbenzene		mg/kg	350	843	90	2800
Xylenes		mg/kg	230	321	160	2600
Arsenic (Total)		mg/kg	32	35	43	640
Cadmium (Total)		mg/kg	10	83.6	1.8	230
Mercury (Total)		mg/kg	170	238	80	3600
Nickel (Total)		mg/kg	130	130	230	1800
Phenols (Total)		mg/kg	420	519	280	3200
Selenium (Total)		mg/kg	350	595	120	13000

ASSESSMENT OF RESULTS

8.43 No samples had determinands exceeding the CLEA Soil Guideline Values (SGV) for ***Residential without consumption of home-grown fruit and vegetables*** usage.

8.44 The samples of MADE GROUND from borehole DIS2 at 0.15m depth and borehole DIS4 at 0.50m depth had elevated levels of Lead. The sample from borehole DIS4 also had elevated levels of the PAH, chrysene, when compared against the ATRISK Contaminated Land Screening Values (SSV) for ***Residential without consumption of home-grown fruit and vegetables*** usage.

8.45 Asbestos was not identified in the four samples tested.

8.46 ***<u>Discussion</u>***

No remedial measures would be required for MADE GROUND beneath the new building or associated hardstanding.

The elevated levels of Lead and PAH encountered within the MADE GROUND would only be relevant to proposed landscaped areas. Therefore, for any new planting areas or shared access landscaped areas, at ground level, we would recommend removal of any MADE GROUND, to a minimum depth of 600mm, and replacement with a separator membrane and some 300mm-400mm of "clean" imported material overlain by 200mm-300mm of "clean" Topsoil as necessary.

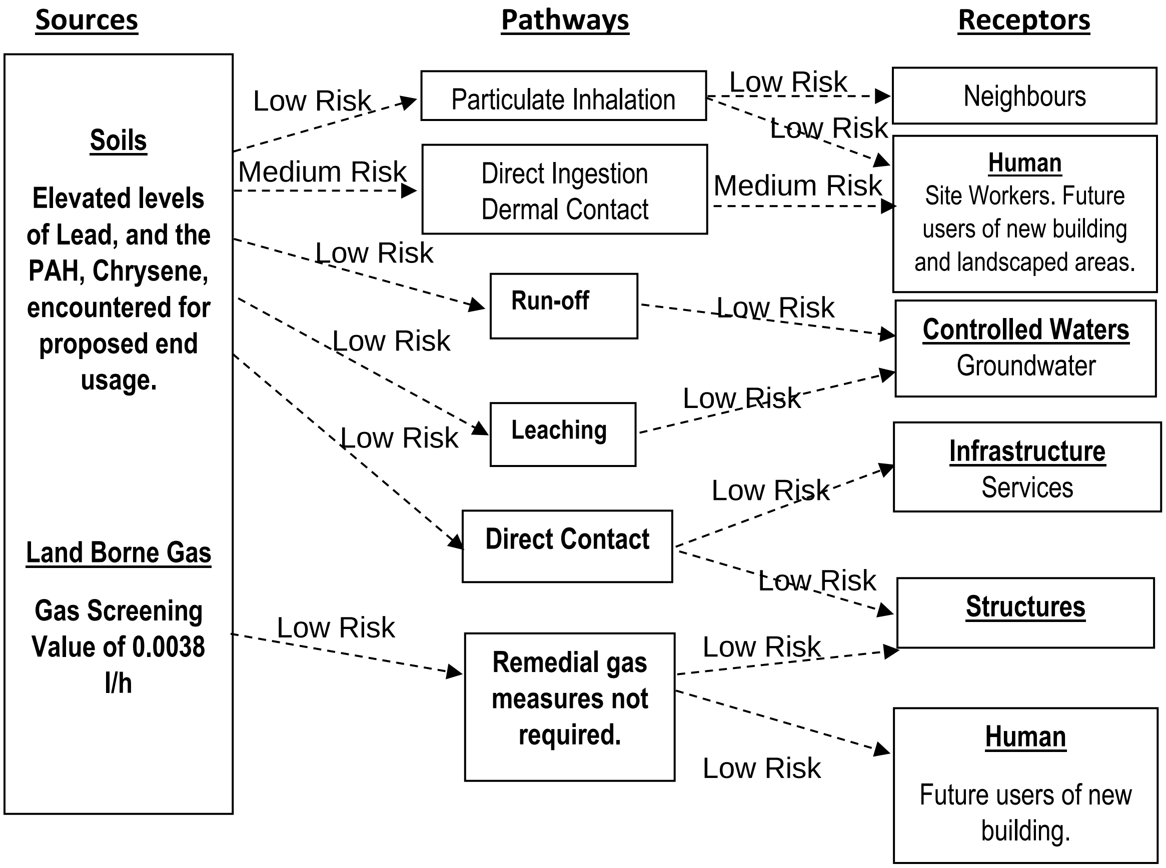
The presence of elevated levels of Lead and PAH in the MADE GROUND should be noted by Groundworkers and included within the main contractors site method statements and risk assessments.

Any material removed from site should be sent to a suitably licensed landfill and waste tickets should be retained. In addition, any imported "clean" material and/or topsoil should be certified as 'clean' and suitable for use. The waste tickets and certification will need to form part of a final Verification Report for the site in due course.

In addition, to any precautions regarding the presence of Lead and PAH's as noted above, we would recommend that standard Health and Safety precautions be taken with regard to ground workers at this site and these should include PPE equipment such as gloves, overalls etc. and normal washing facilities available on-site.

CONCEPTUAL SITE MODEL

8.47 The following diagram summarises the potential pollution linkages identified for this site in the form of a diagrammatic Conceptual Site Model (CSM).



8.48 By employing the measures discussed in paragraph 8.46 above, the above noted 'medium' risks could be reduced to 'low' risks.

8.49 As always, the above recommendations are based on a selected number of representative samples and further testing may be required if any significant contamination is suspected or encountered during ground works.

WASTE ACCEPTANCE CRITERIA (WAC) TESTS

8.50 Two EN 14473/02 Waste Acceptance Criteria (WAC) tests have been undertaken during the current work and the certificates pertaining to this is appended to this report.

8.51 The results tend to indicate that the material tested is likely to be classified as 'Inert'. However, the sample from 1.00m depth in borehole DIS6 had a very slightly elevated level of Fluoride and may be classified as 'Stable Non-reactive Hazardous Waste in non-hazardous Landfill' category.

8.52 However, it should be noted that Risk Management are not a licensed landfill operator and we therefore strongly recommend that the WAC data be presented to potential Waste Management Companies in order for them to confirm the waste classification of surplus soils to be removed from this site and to determine its acceptability at appropriate landfill sites for disposal/treatment.

SOIL SAMPLES

8.53 All soil samples will be kept for a period of 28 days after the date of the invoice for this project unless otherwise notified to Risk Management Limited in writing. Should samples be required to be stored for longer than 28 days then a storage charge may be levied.

Prepared By : Richard Price B.Sc., F.G.S., M.I.Env.Sc.
Project Engineer

Checked By : Malcolm S. Price B.Sc., M.Sc., M.I.C.E., C.Eng. MIEnvSc.
Director

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The recommendations made and the opinions expressed in this report are based on the borehole records, examination of samples and the results of site and laboratory tests.

The report is issued on the condition that Risk Management Limited will under no circumstances be liable for any loss arising directly or indirectly from ground conditions between the boreholes or trial pits which have not been shown by the boreholes, trial pits or other tests carried out during the investigation.

In addition, Risk Management Limited will not be liable for any loss whatsoever arising directly or indirectly from any opinion given on the possible configuration of strata both between the borehole and/or trial pit positions and/or below the maximum depth of the investigation. Such opinions, where given, are for guidance only.

Groundwater levels may also vary with time from those reported during our site investigation due to factors such as tidal conditions, heavy pumping from nearby wells or seasonal changes.

No person other than the client to whom this report is addressed, shall rely on it in any respect and no duty of care shall be owed to any such third party.