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Project: Surface Water Drainage Strategy (SWDS)
Prepared for: Fluent Ads
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Document Issue Record

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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 8 residential units.

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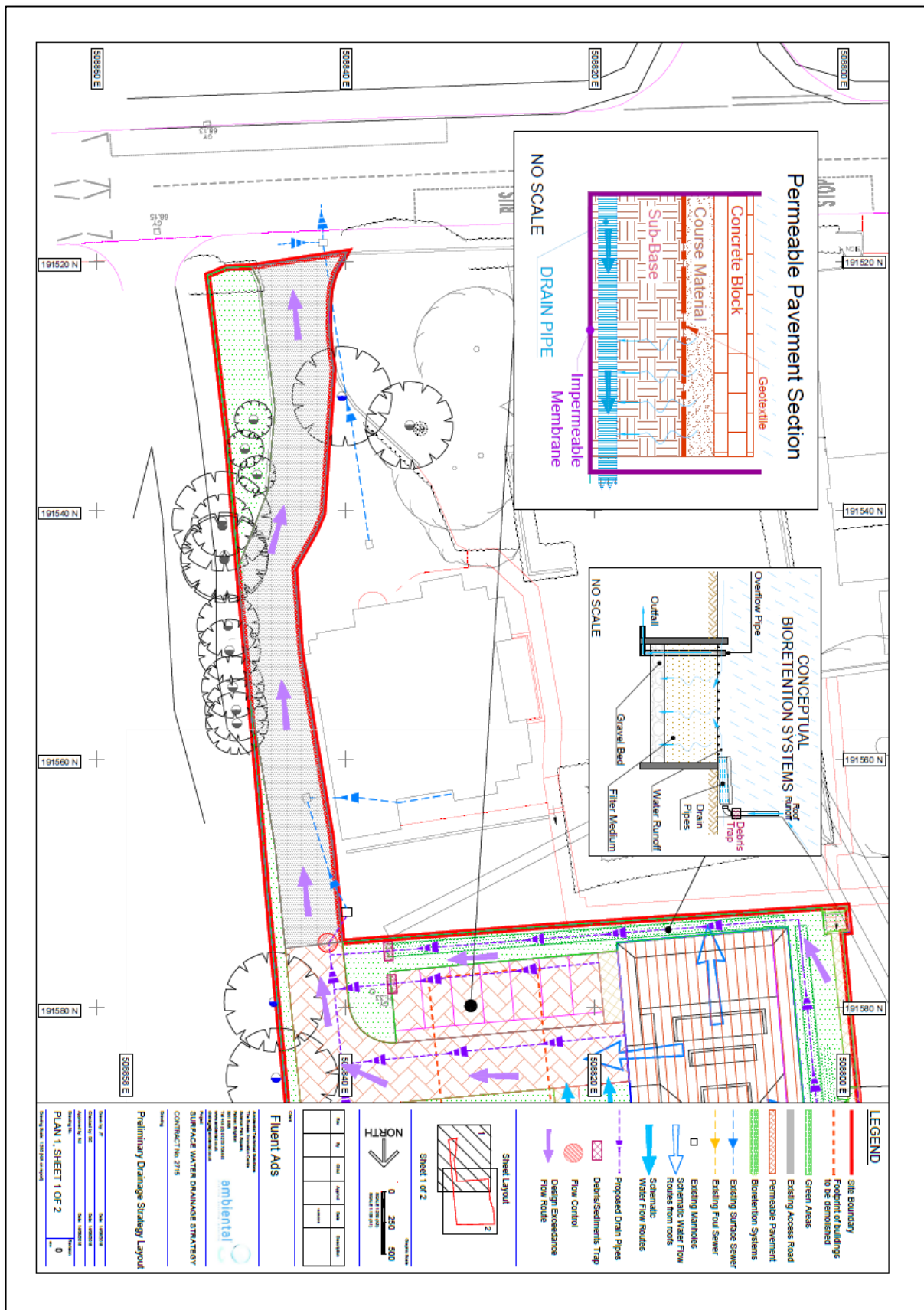
1. Summary

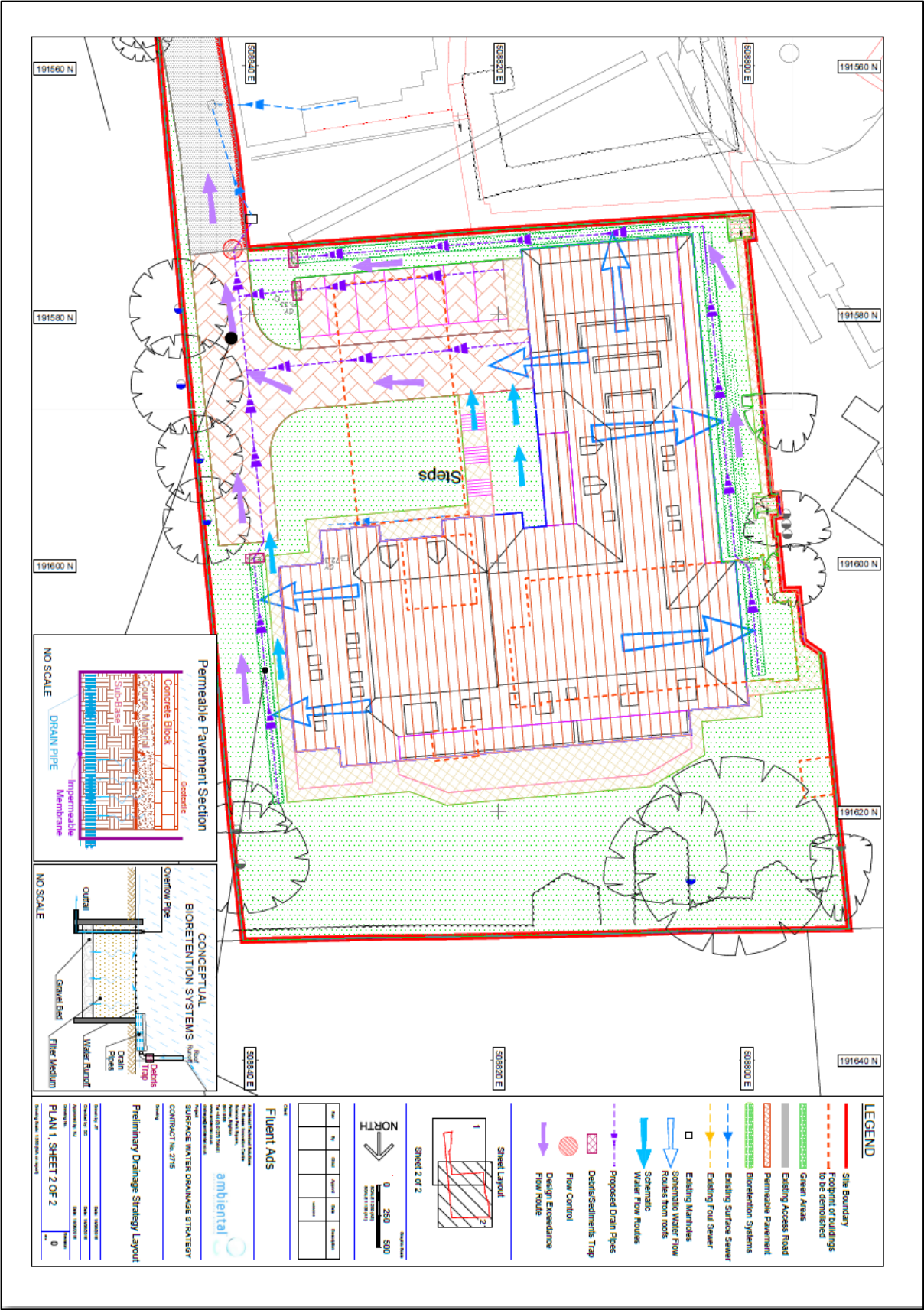
SITE DETAILS			
Site Name	London School of Theology, Green lane, Northwood, HA6 2UW		
Total Site Area	0.28 ha		
Site Area which is positively drained	0.28 ha		
Developed Area	0.15 ha		
Predevelopment Use	Site already developed		
Site Constraints	Residential Site		
	Groundwater Source Protection Zone: 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	0.15 ha	0.02 ha
Drainage Method (Infiltration/Sewer/Watercourse)		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 Rates (l/s)
Greenfield Q _{BAR} (Mean Flow Rate)		1.66 l/s	N/A
1 in 1		1.41 l/s	5.00 l/s
1 in 30		4.09 l/s	5.00 l/s
1 in 100		5.30 l/s	5.30 l/s
1 in 100 plus climate change		N/A	5.30 l/s
FLOW CONTROL			
Flow Control Type	Variable		
Greenfield Flow 1 in 1 (Daily storm event)	18.07 l/s/ha	5.00 l/s	
Greenfield Flow 1 in 100 (Extreme event)	19.16 l/s/ha	5.30 l/s	

SITE STORAGE VOLUME		
Source Control Provided	Yes	
Interception Volume Storage (Daily Storms)	6.65 m ³	
Attenuation Volume Storage (1 in 100 yr + CC storm)	121.57 m ³	
Approach used for Long Term storage (Either <i>Use Long Term Storage</i> or <i>Discharge rate at 2 l/s/ha</i>)	Use Long Term Storage	
LTS (1 in 100 years, 6 hours event)	0.00 m ³	0.00 m ³ /ha
Total Site Storage	128.22 m ³	
INFILTRATION FEASIBILITY ANALYSIS		
Geology	Pre-quaternary Marine/Estuarine Sand and 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	Potential Contamination	
Infiltration Feasibility	No	

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.
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	
All SuDS storage located outside Q ₁₀₀ floodplain	Yes
Provision for blockage / Design Exceedance	Yes

Proposed Strategy Layout





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:191603). See *Appendix 1, Plan 1 – Site Location, Plan 2 – Plan Location, Plan 5 – Proposed Site Layout* and *Figure 1* below.

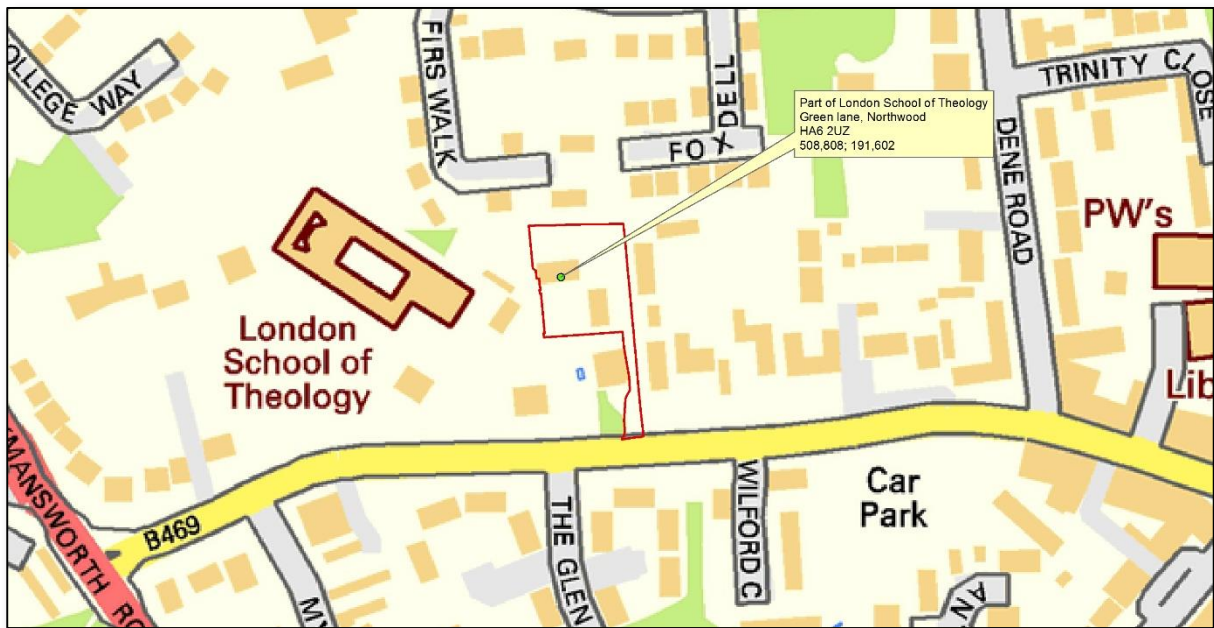


Figure 1 - Extract of Appendix 1, Plan 1 - Site Location (Source: OS-Street View) Site boundary shown in red

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 8 residential units.
- 2.3 This study is based on the plans included in *Appendix 1* (see *Plans 1 to 11*. *Plans 1* and *4* were made in-house, while the rest of the 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 2 2-storey buildings, a squared grass zone as well as the access from Green Lane. See *Appendix 1, Plan 1 – Site Location, Plan 2 – Plan Location, Plan 3 – Topographical Survey of the Site* and *Figure 2* below.

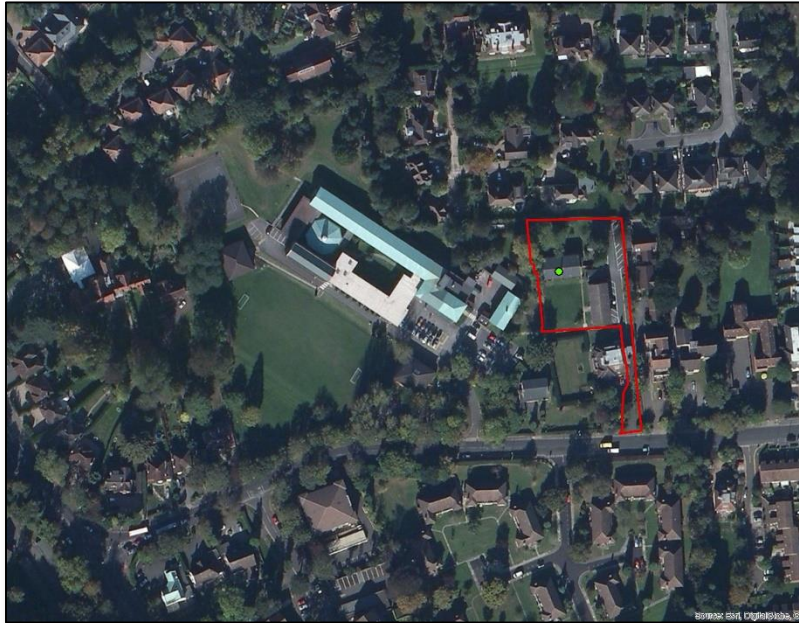


Figure 2 - Aerial View of Development Site (Source: ESRI) Site boundary shown in red.

- 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 8 residential units. See *Appendix 1, Plan 5 – Proposed Site Layout* and *Figure 3* overleaf.

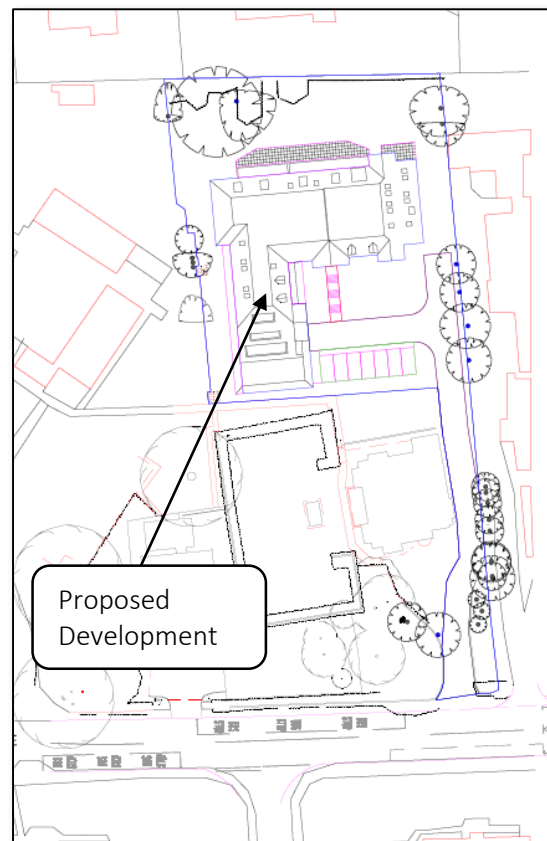


Figure 3 - Extract of Appendix 1, Plan 5 – Proposed Site Layout.

- 3.3 The total area of the site is approximately 2767m² (0.28 Ha), based on plans the provided by the client.
- 3.4 The existing site is considered partly (1492.75m², approx. 0.15Ha) pervious, due to the existing green areas, thus there is an existing impervious area of 1273.86m² (approximately 0.13 Ha). Following development, the pervious areas on site will be reduced to 1255.34m² (approximately 0.13 Ha), while the impervious areas will be increased to 1511.27m² (0.15 Ha).
- 3.5 According to the topographical survey provided by the client, the topography of the site ranges from 68.33mAOD to 74.26mAOD. Hence the site can be considered to slope to the south with likelihood of rapid runoff within the property boundary. See *Appendix 1, Plan 3 – Topographical Survey of the Site, Plan 4 – Existing Surface Water Flow Pathways* and Figure 4 overleaf.

Existing Drainage Infrastructure

- 3.6 Based on the topographical survey provided by the client, there is an existing drainage infrastructure within the site to collect the surface water runoff. See *Appendix 1, Plan 3 – Topographical Survey of the Site, Plan 4 – Existing Surface Water Flow Pathways* and Figure 4 below.

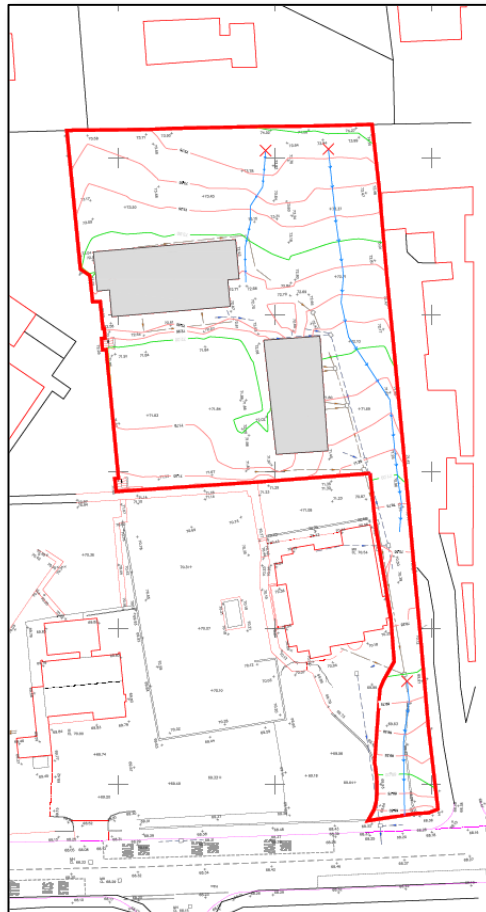


Figure 4 – Extract of Appendix 1, Plan 4 – Existing Surface Water Flow Pathways.

Existing Ground Conditions

- 3.7 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*).
- 3.8 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.

- 3.9 There is 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*).
- 3.10 The Soil Parental Material in the area taken from the *UK Soil Observatory (UKSO)* website is classified as *Prequaternary 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 *Figure 4.A – Soil Texture-North, Clay to Silt* and the *Figure 4.B – Soil Texture, South, Loam to Silty Loam*.
- 3.11 Standard values from the specialized literature *CIRIA 753 'The SUDS Manual'* suggest the infiltration coefficient of these types of soils is less than 1.08×10^{-4} m/h (3×10^{-8} m/s) for *Clay* soils, the range for *Loam* soils is between 0.00036 m/h (1×10^{-7} m/s) and 0.018 m/h (5×10^{-6} m/s), while the range for *Silty Loam* soils is between 0.00036 m/h (1×10^{-7} m/s) and 0.036 m/h (1×10^{-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	$< 1.08 \times 10^{-4}$

Table 1 – Typical Infiltration Coefficients based on Soil Texture

- 3.12 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 5* 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.

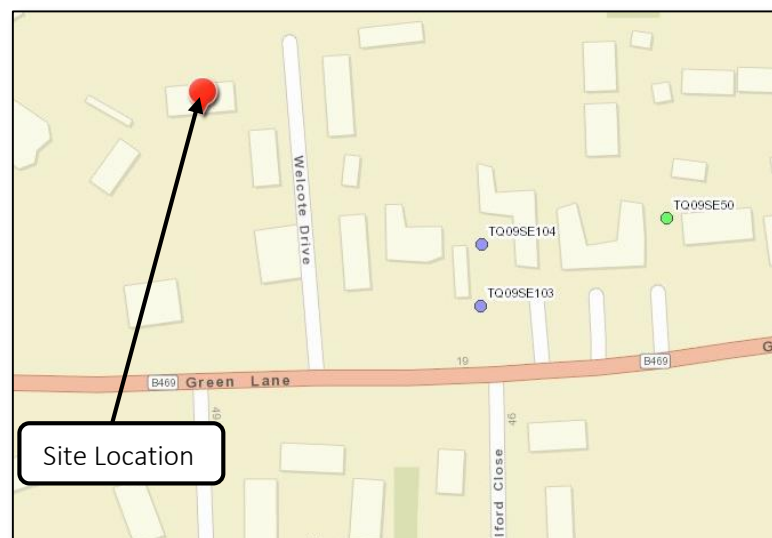


Figure 5 - Extract of Appendix 2, Figure 5.1 – Boreholes Location Map

3.13 Nevertheless, the groundwater table is not shown on these boreholes. Therefore, 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.

3.14 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)”.

3.15 Thus, in compliance with the CIRIA 753 – ‘The SuDS Manual’, if an infiltration device was proposed, the groundwater table must be always, at least, 1 m 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.

3.16 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).

3.17 The Environmental Agency’s Groundwater Source Protection Zone Map confirms that the site lies within a Source Protection Zone, the Groundwater Vulnerability Zone being classified as *Minor Aquifer High*. See Appendix 2, Figure 7 - Groundwater Source Protection Zones and Figure 8 – Groundwater Vulnerability Zones.

Nearby Watercourses and Drainage

3.18 Based on the OS-Street View map, a watercourse is located to the south of the site. A potential discharge to this watercourse is dismissed as it is considered they are not close enough. See Figure 6 below.

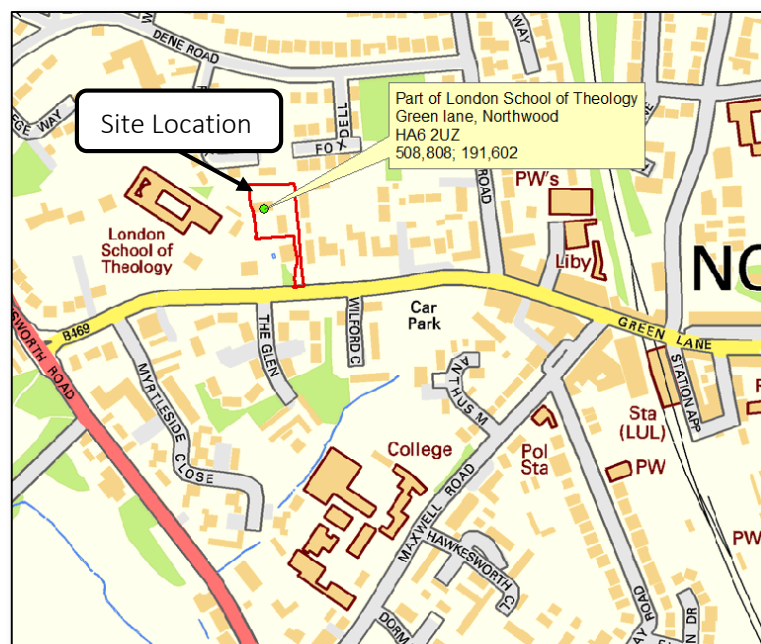


Figure 6 – Extract of Appendix 1, Plan 1 - Site Location (Source: OS-Street View)

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 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 237.41m².

- 4.3 Based on the *Policy 5.13 of the London Plan 2011*:

“Development should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that 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.

Runoff rates

- 4.7 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*).

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

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

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.

- 4.9 In consonance with the guidance of the CIRIA 753 'The SUDS Manual', Section 24.5, it is important to note that a high runoff soil type was considered as it better represents the high levels of runoff that take place from developed surfaces. In this case, a FSR¹ Soil Type 5 was taken into consideration. The Standard Percentage Runoff (SPR) for this type of soils is 0.53.
- 4.10 Preliminary calculations based on Equation 1 show that the *Greenfield Runoff Rate* ($Q_{BAR_{rural}}$) from the site is 300.24 l/s. In keeping with the standard practice this is the value for 50 hectares, therefore the rate per hectare is approximately 6 l/s/ha. According to the size area positively drained (0.28 ha), the *Greenfield Runoff Rate* from the area of the site is 1.66 l/s. 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*.
- 4.11 As DEFRA Report 'Rainfall runoff management for Developments' recommends, the design principle is to limit the runoff for events of similar frequency of occurrence to the same peak rate of run as that which takes place from greenfield sites. However, there are two situations where the greenfield flow rate is not actually applied to define the limiting discharge rates (based on this literature as well):
- The limit of discharges based on Q_{BAR} that are less than 1 l/s/ha for permeable sites as this is seen as being an unreasonable requirement (producing very large storage volumes). Q_{BAR} is then set to 1 l/s/ha;
 - Small sites would require impractically small controls to achieve the required flow rates where these are calculated to be less than 5 l/s and therefore in this case a minimum flow of 5 l/s is used.
- 4.12 Besides this, and following the guidance of the Sustainable Design and Construction SPG, Mayor of London:

"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.

¹ FSR: Flood Studies Report - NERC, 1975

*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**".*

- 4.13 Therefore, a limiting discharge of 5 l/s will be taken into account. See Table 2 – Surface Water Discharge Rates Summary below.

SURFACE WATER DISCHARGE RATES SUMMARY					
Impermeable Area (m²)		Discharge Rates (l/s)			
		1:1 year	Q _{BAR}	1:30 years	1:100 years
Existing Site	1259.85	1.41 l/s	1.66 l/s	4.09 l/s	5.30 l/s
		5.10 l/s/ha	6.00 l/s/ha	14.77 l/s/ha	19.16 l/s/ha
Proposed Site	1511.27	5 l/s	5 l/s	5 l/s	5.30 l/s
		18.07 l/s/ha	18.07 l/s/ha	18.07 l/s/ha	19.16 l/s/ha

Table 2 – Surface Water Discharge Rates Summary

Interception Storage

- 4.14 Preliminary calculations have been carried out for a typical rainfall depth of 5 mm/m² to store the volume owing to these very frequent storms.
- 4.15 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% have been taken into account.
- 4.16 Based on the size of the whole area of the site, the UCF and the Runoff Percentage, the Interception Storage is 6.65 m³.

Long Term Storage

- 4.17 Long-term storage is required to address the additional runoff caused by the development compared to the volume that would be contributed from the site in its Greenfield state. It is based in a 100 year, 6 hours storm event plus climate change (30%) and it must be prevented from leaving the site (via rainwater harvesting and/or infiltration) or, where this is not possible, controlled so that it discharges at very low rates that would have negligible impact on downstream flood risk.

4.18 As recommended in the CIRIA 753 'The SUDS Manual', Long-term Storage Volume has been calculated according to the following formula:

$$Vol_{XS} = 10 \cdot RD \cdot A \left[\frac{PIMP}{100} (\alpha \cdot 0.8) + \left(1 - \frac{PIMP}{100} \right) (\beta \cdot SOIL) - SOIL \right]$$

Where,

Vol_{XS}: Extra runoff volume (m³) of development runoff over Greenfield runoff.

RD: Rainfall Depth for the 100 year, 6 hour event (mm).

PIMP: Impermeable Area as a percentage of the Total Area.

A: Area of the site (ha).

SPR: "SPR" Index for the FSR SOIL type.

α : Proportion of Paved area draining to the network or directly to the river (values from 0 to 1) with 80 per cent runoff.

β : Proportion of Pervious Area draining to the network or directly to the river (values from 0 to 1).

Equation 2 - Long-Term Volume Storage Equation.

4.19 As Interception Storage is provided, RD is reduced 5 mm. See values for each variable in the table 3 below:

LONG-TERM STORAGE VOLUME SUMMARY	
RAINFALL DEPTH (mm)	65.84
AREA (ha)	0.28
PIMP	54.63
SOIL TYPE	5
SPR	0.53
α	1
β	0.16
Long-Term Storage Volume (m ³)	0.00 m³

Table 3 - Values for Long-Term Storage Volume Equation

4.20 Therefore, the Long-Term Storage Volume is 0 m³.

Attenuation Storage

4.21 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.

4.22 Rainfall depths for the 1 in 100 years return period plus 30% for climate change were produced using the FEH CD-ROM DDF (Depth-Duration-Frequency) modelling function. These have been

used as Inflows. Long-Term Storage Volume and Interception Volume were subtracted from the Inflows.

- 4.23 Outflow values have been calculated for several durations based on the Discharge Rate obtained as an average of the Greenfield Runoff Rates of the site for the 100 years and 1 year Return Periods.
- 4.24 Preliminary calculations have been undertaken in compliance with the objective of obtaining the largest volume for typical storm durations up to and including 24 hours for a 100 year Return Period Event with an allowance for climate change (30%) for the proposed site, *Critical Storm*, subtracting the Outflow values from Inflow values for each duration. In addition to this, the Urban Creep Factor, 10%, is applied for the impervious surface.
- 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. Values are increased by 25% to provide a conservative, risk adverse approach. See summary calculations in *Appendix 3, Table 2 – Summary of Attenuation Storage Estimation – 1 in 100 years + cc*.
- 4.26 In terms of storage, for a 100 years storm event with an allowance for climate change, the **Critical Durations is 2 hours**, the largest volume per square metre being 0.0731 m³/m². Therefore the Attenuation Storage Volume required for the whole site is **121.57 m³**. See *Appendix 3, Graph 1 - Attenuation Storage Volume required for site estimated for Critical Duration (m³ per m²)*.

On Site Drainage and Storage Systems

- 4.27 Preliminary calculations indicate that 121.57 m³ of storage will be required to attenuate runoff from the 1:100 year +30% climate change events and a 10% of Urban Creep Factor. 6.65 m³ of storage is required for the day-to-day rainfall as Interception Volume.
- 4.28 A summary to identify these figures and other information regarding to the flow and volume for the following proposed SuDS scheme is showed in the *Appendix 3, Table 3 – Flow and Volume Information Summary*.
- 4.29 In accordance with the 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.
- 4.30 Based on the hierarchy line of the *Policy 5.13* of the *London Plan 2011*, 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.

4.31 Infiltrating SuDS

Infiltration components of SuDS, such as soakaways, are deemed **unsuitable** due to the low rate of permeability of the soils which underlie the site.

4.32 Source Control Components

- *Permeable Pavement.*
Given the nature of the proposed development, including the provision of hardstanding areas to be used as public realm, access, etc. the use of lined permeable paving is deemed **appropriate**.
- *Green Roofs.*
Options for this choice are discounted based on their very limited ability to attenuate runoff for the proposed development roof. Thus, this option is deemed to be **unsuitable**.
- *Rainwater Harvesting.*
Rainwater from roofs can be stored and used in and around properties. The collected water can be used potentially for a range of non-potable purposes. Rainwater systems may be able to provide potable water, but this is likely to require sophisticated and expensive water treatment systems and monitoring to ensure compliance with the Private Water Supplies Regulations 1991. Furthermore, demonstrating satisfactory attenuation through the provision of rainwater harvesting would be difficult due to the need to ensure storage availability during a storm event. Hence, this option is **dismissed**.

4.33 Swales

This type of SuDS technique is well considered to convey and treat water runoff. Nevertheless, the facts such as the slope of the site and the insufficient space within the proposed layout to practicable offer these features as viable SuDS option, and consequently they are deemed **unsuitable**.

4.34 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**.

4.35 Bioretention Systems

Given the proposed development layout and the constraints for the use of infiltration techniques, this SuDS component is deemed to be **appropriate** as long as they are lined.

4.36 Retention and Detention Components

- *Geocellular Systems.*

This SuDS option can be tailored for any place owing to its modular nature to store and it is able to attenuate the water runoff, being used either as a soakaway or as a storage tank. Thus this SuDS technique is deemed to be **appropriate**.

- *Retention Ponds and Detention Basins.*

They cannot be considered as a SuDS option for this site owing to the fact that they are appropriate to manage high volumes of surface water from bigger sites as a neighbourhood or even more. Given the scale of the development, these are deemed **unsuitable**.

4.37 Consequently, given the facts that infiltration techniques are not feasible, there is no a watercourse close enough to the site and following the hierarchy line of the *Policy 5.13* of the *London Plan 2011*:

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.*

4.38 The arising water runoff owing to the proposed redevelopment will be attenuated in the site to be discharged to the sewer at the south of the site, several SuDS components being deemed appropriate.

4.39 As such, it is suggested to use a SuDS train management composed by **Permeable Paving** and **Bioretention Systems**. *Rills/Channels* could be used to convey water runoff from the hardstanding areas as long as the gradient and slope is adequate. Although a Geocellular System could be used as sub-base of the proposed *Permeable Pavement*, it is proposed to use **Uniform Gravel** instead. A **throttle device** such as a *hydrobrake* must be set up between the drains from the Permeable Pavement and the existing drainage infrastructure to control the flow rates up to a maximum of 5.3 l/s. See *Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout*.

4.40 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), being progressively stored and gradually discharged.

4.41 The Attenuation Volume is designed so that the peak runoff rate for an extreme rainfall event (1 in 100 year event) is constrained to the greenfield rate of runoff for the same event. Thus, it is required the **total capacity of the SuDS train must be higher than 121.57m³** due to the fact that

the flow discharge must be controlled up to a maximum rate of 5.3 l/s, being gradually discharged to the sewer network through drain pipes.

- 4.42 As such this SuDS management train has been designed to accommodate and dispose of runoff from storms up to and including the 1:100 year + 30% climate change event without flooding.
- 4.43 The *Bioretention Systems* will be connected to the *Permeable Pavement* through drain pipes as they are only capable of managing low volumes of water. Exceedance pipes must be installed on them to convey the runoff that cannot be managed by this SuDS device to the Sub-Base of the Permeable Paving. It is important to note that **Sediment Traps** must be installed on these drain pipes between the *Bioretention Systems* and the *Permeable Pavement* to avoid any blockage. Finally, appropriate landscaping must be set up so that the arising runoff from the hardstanding areas can be collected and managed by the proposed SuDS train. See *Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout*.
- 4.44 Runoff from the roofs will be piped either to the sub-base of the *Permeable Paving* or to the *Bioretention Systems* to be stored and gradually discharged. It is necessary to set up sediment traps before the water comes into the SuDS devices to avoid any blockage. See *Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout*. Runoff from the hardstanding areas will be conveyed through properly landscaping. Rills/channels would potentially be useful if the gradient is not too steep.
- 4.45 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 will be lined, with a layer of gravel as bed, being filled with engineered soil the rest of the room. They are very flexible and can be integrated into a wide variety of developments, hence design of the *Bioretention Systems* must be undertaken at the later detailed design and to be redesigned if it is required by a specialist. Guidance about proper use and maintenance must also be provided. See *Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout*.
- 4.46 The Permeable Paving will be Type C, with Impermeable Membrane to retain pollutants, avoid infiltration and provide flow attenuation. The permeable paving would be formed by 3 layers:
- Permeable Concrete blocks at the top.
 - Laying Course Material.
 - Sub-Base: Uniform Gravel.
- 4.47 The base area of the Permeable Pavement is approximately 222 m². Although it does not keep the relation 2:1 with rest of the impervious surfaces areas (roofs and hardstanding surfaces), this ratio is not necessary to be applied if the runoff is directed via catch pits. Hence catch pits are required.
- 4.48 Design of the *Permeable Pavement* must be undertaken at the later detailed design and to be redesigned if it is required. Guidance about proper use and maintenance must also be provided.
- 4.49 A throttle device at the *Permeable Pavement* will control the flow rates up to a maximum of 5.3 l/s before the runoff is conveyed and discharged to the sewer network through drain pipes. See

Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout. It is suggested to use *Hydrobrakes*. Installations of these devices must be undertaken at the later detailed design and to be redesigned if it is required.

Design Exceedance

4.50 In the event of drainage system failure under extreme rainfall events or blockage, flooding may occur within the site. In the event of the extension's drainage system failure, the runoff flow will be dictated by direction of flow based on topography. This will not impact on the site or nearby dwellings. The finished floor level of the proposed building should be 300 mm above surrounding finished ground levels.

Water Quality

4.51 Adequate treatment must be delivered to the water runoff to remove pollutants. Based on the guidance of *CIRIA 753 'The SUDS Manual'*, the pollution Hazard Level of Roofs is considered *Very Low* while it is *Low* on the car park. See Table 4 below.

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 4 – Summary of Pollution Hazard Indices for different Land Use.

4.52 The Mitigation Indices of the proposed SuDS techniques are summarized in the *Table 5 - 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 5 – Indicative SuDS Mitigation Indices

4.53 Table 6 – 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 6 – Pollution Treatment

Adoption and Maintenance

4.54 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.

5. Conclusions

- 5.1 The existing site is already developed, runoff from the proposed development is to be managed in accordance with the sustainable drainage principles.
- 5.2 The proposed development will increase the impermeable surface cover on the site by approximately 238 m².
- 5.3 Surface water will be managed as close to the source as possible, in line with the drainage hierarchy based on the *Policy 5.13 of the London Plan 2011*:

“Development should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that 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”.

- 5.4 Existing quantity of water runoff should be managed in accordance with sustainable drainage principles.
- 5.5 The nature of the geology underlying the site surface is not adequate for SuDS infiltration techniques, thus these SuDS techniques are dismissed, instead it is proposed that runoff from the site is to be discharged via attenuation.
- 5.6 Consequently, the arising water runoff owing to the proposed redevelopment will be attenuated in the site to be discharged to the sewer at the south of the site. As such, it is suggested to use a SuDS train management composed by **Permeable Paving** and **Bioretention 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 to **control the flow rates up to a maximum of 5.3 l/s**. See *Appendix 4, Plan 1 – Preliminary Drainage Strategy Layout*.

- 5.7 The devices will be designed for a Critical Duration Storm, 100 year rainfall event plus 30% climate change allowance. Hence, they meet 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.
- 5.8 As part of this surface water drainage strategy existing public sewers that may affect the site have not been considered. Nor has consultation been sort from the local water authorities with regards to the existing sewer system, nor has consultation been sort with regards to connection of site drainage to the existing sewer system. The developer should obtain this information and consent as part of a detailed site drainage design. Location of existing sewer lines across the site boundary should be obtained prior to any land cutting to inform any need for sewer protection on the site.

Design Exceedance

- 5.9 In the event of drainage system failure under extreme rainfall events or blockage, flooding may occur within the site. In the event of drainage system failure, runoff flow will be dictated by direction of flow based on topography. This will not impact on the site or nearby dwellings. The finished floor level of the proposed building should be 300mm above surrounding finished ground levels.

Water Quality

- 5.10 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:

$$\text{Total SuDS Mitigation Index} \geq \text{Pollution Hazard Index}$$

- 5.11 The Table 6 – 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 6 – Pollution Treatment

Adoption and Maintenance

- 5.12 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.
- 5.13 This study has been undertaken in accordance with the principles set out in NPPF. We can conclude that providing the development adheres to the conditions advised in the conclusions of this report, the said development proposals can be accommodated without increasing flood risk within the locality in accordance with objectives set by Central Government and the EA.

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.

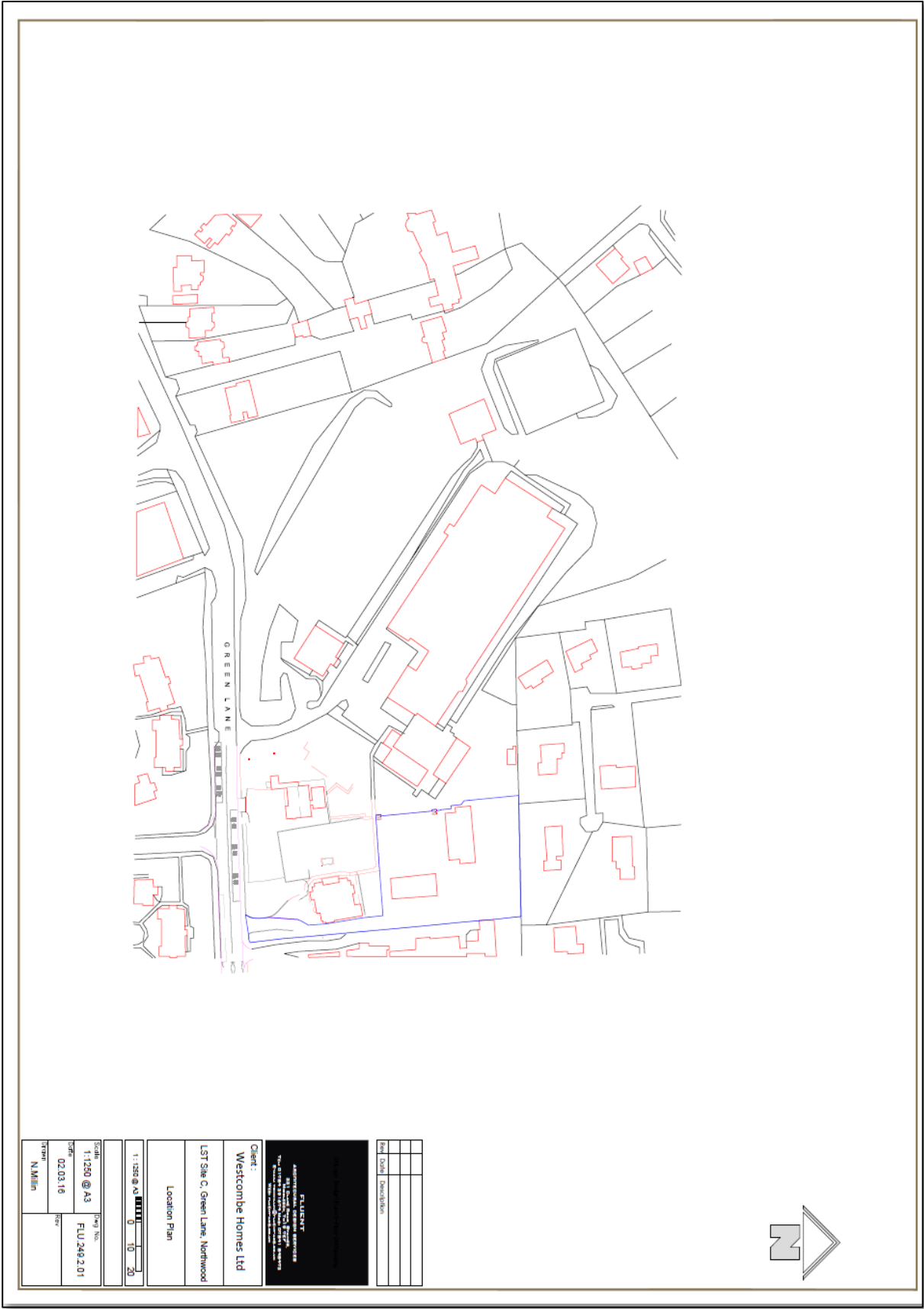
Dr. J. B. Butler
B.Sc., M.Phil., PhD.
Ambiental Technical Solutions Ltd.

June 2016

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*



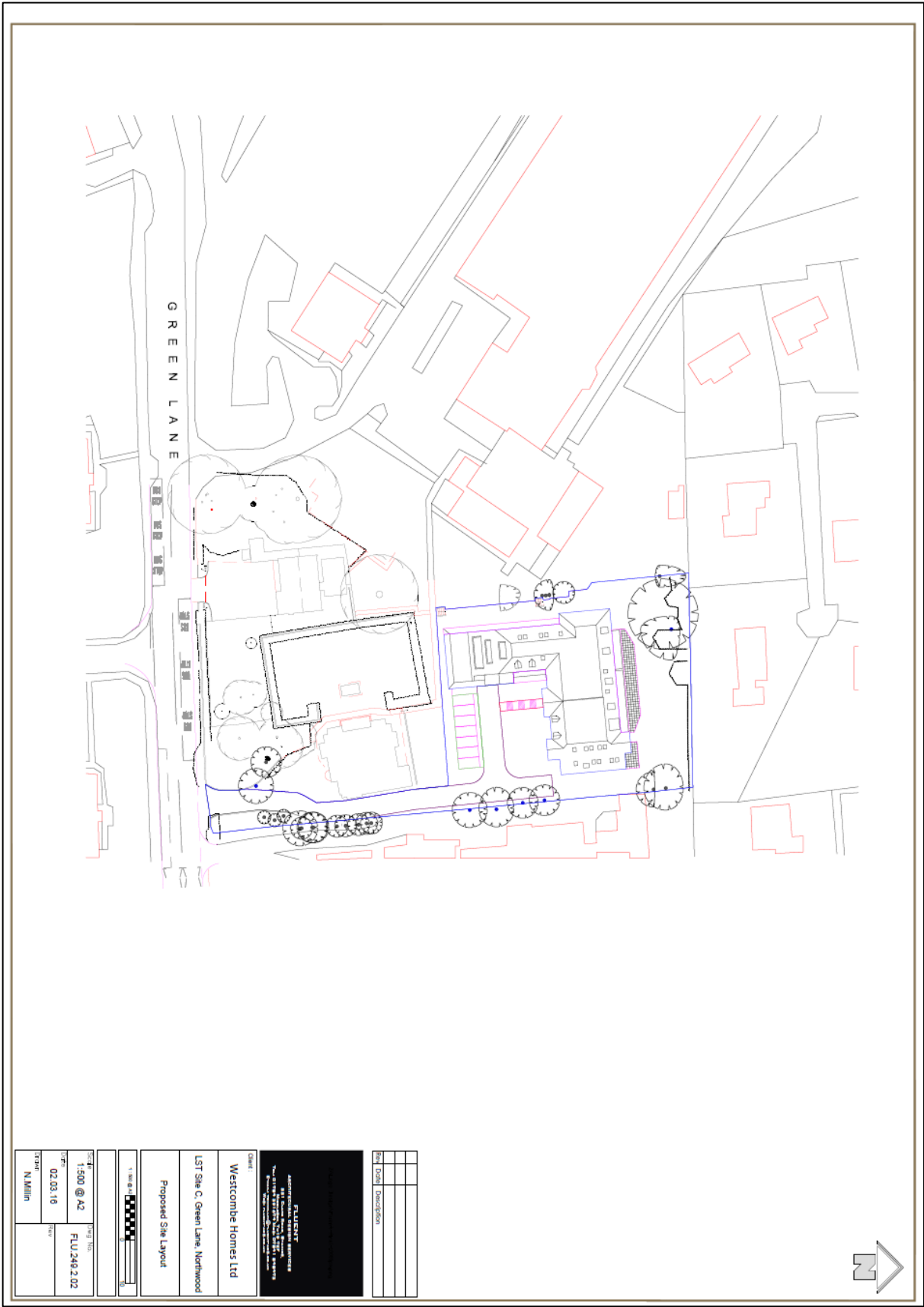


Appendix 1, Plan 2 – Plan Location

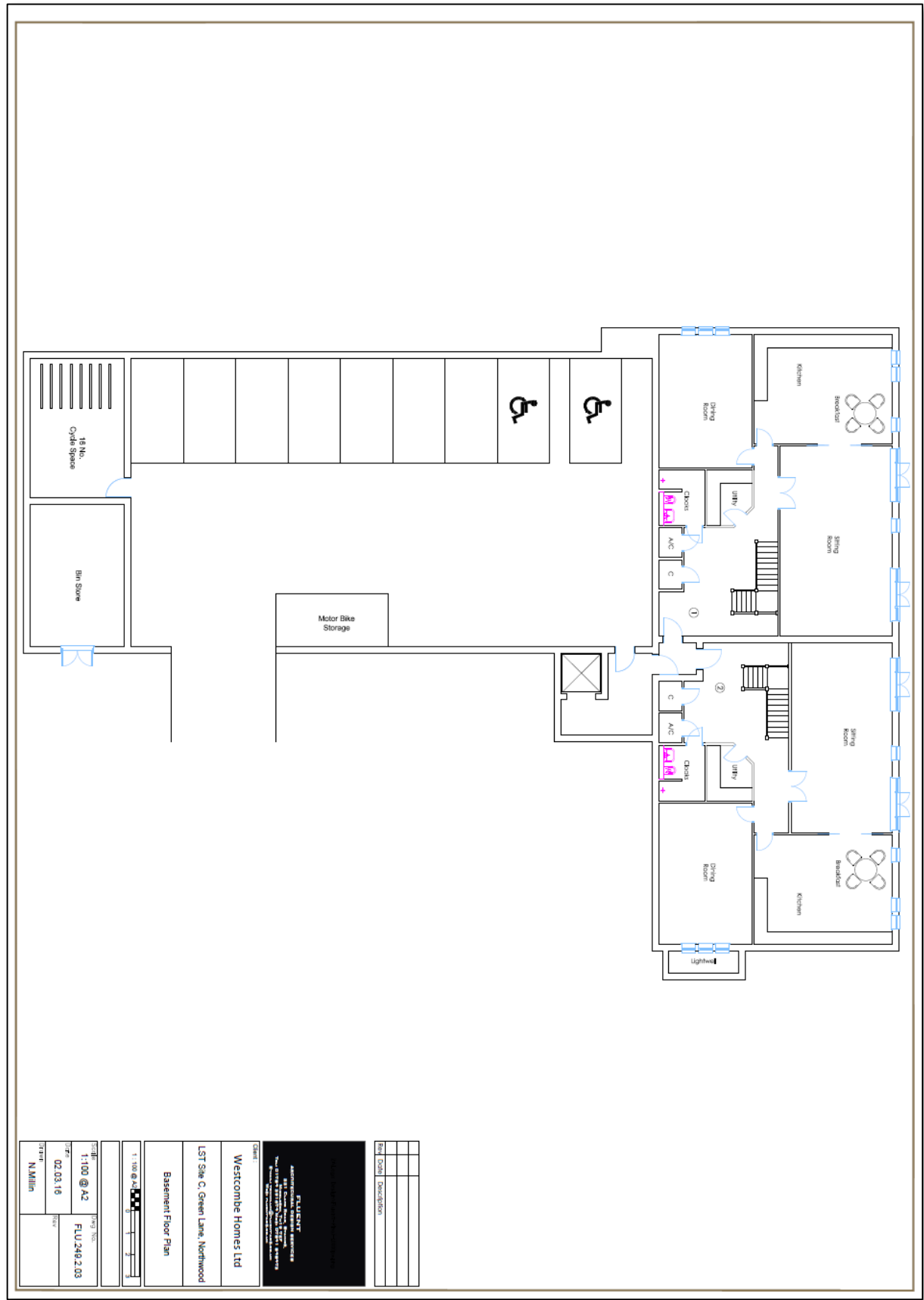


Appendix 1, Plan 3 – Topographical Survey of the Site





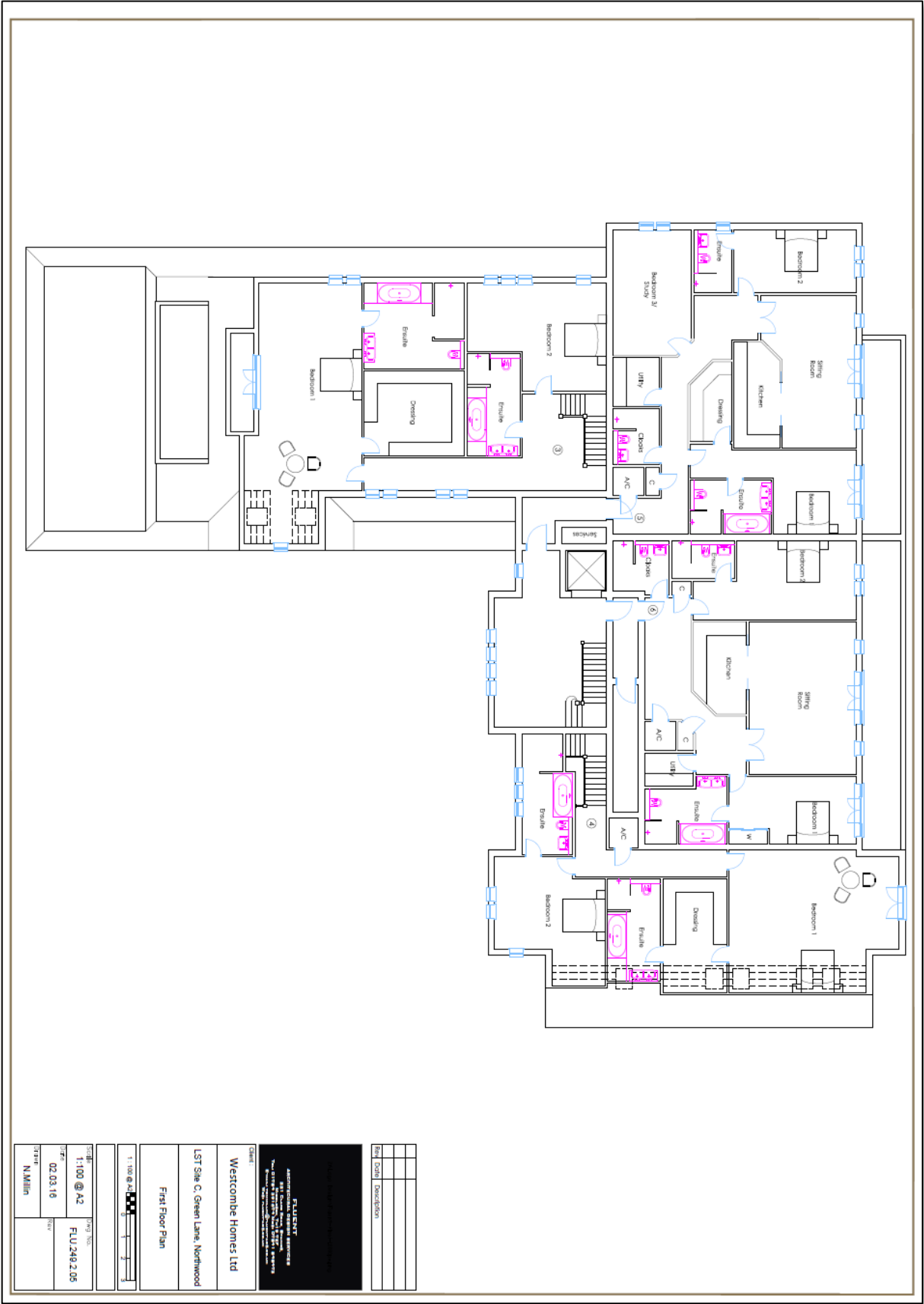
Appendix 1, Plan 5 – Proposed Site Layout



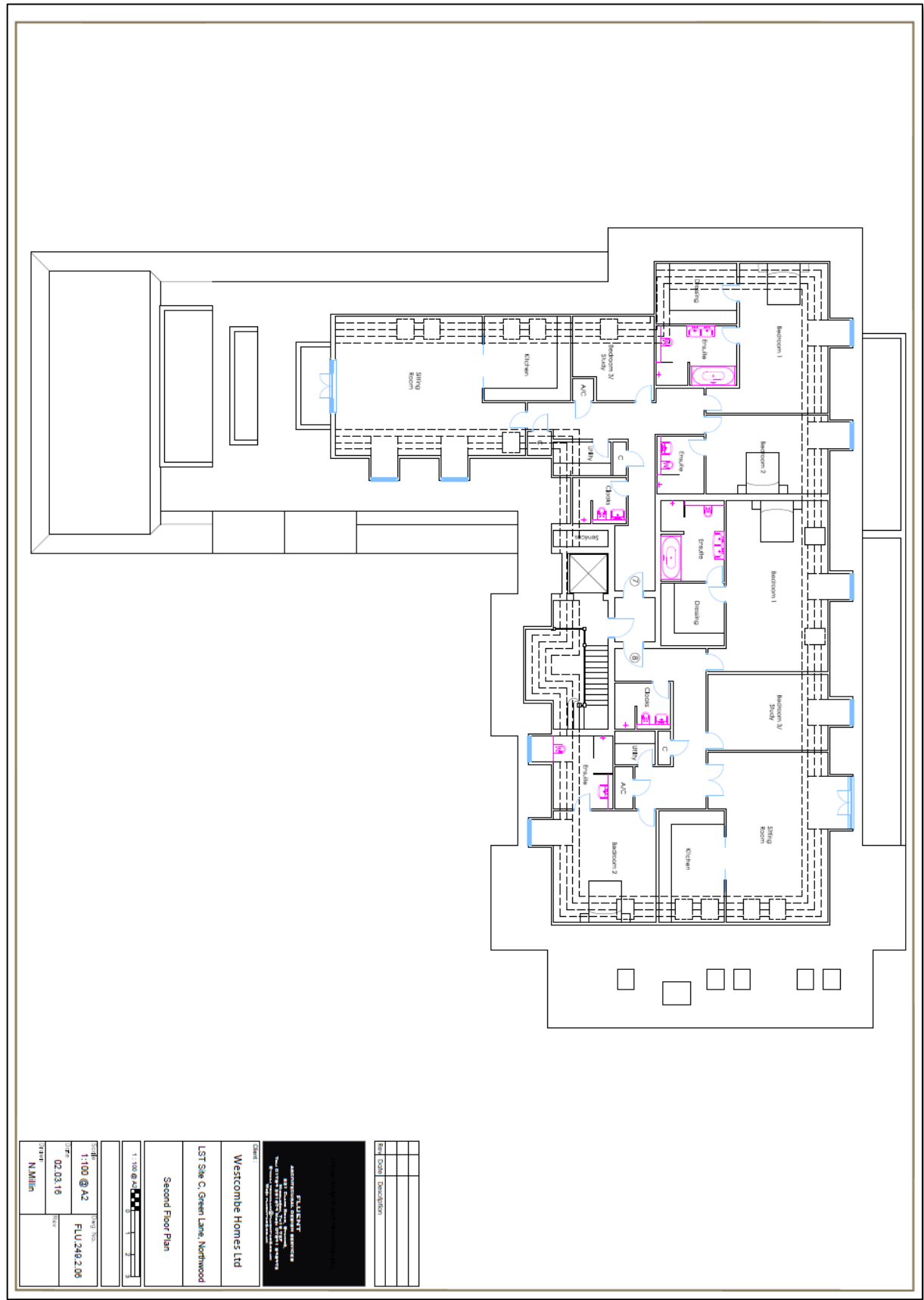
Appendix 1, Plan 6 – Basement Floor Plan



Appendix 1, Plan 7 – Ground Floor Plan



Appendix 1, Plan 8 – First Floor Plan



Appendix 1, Plan 9 – Second Floor Plan



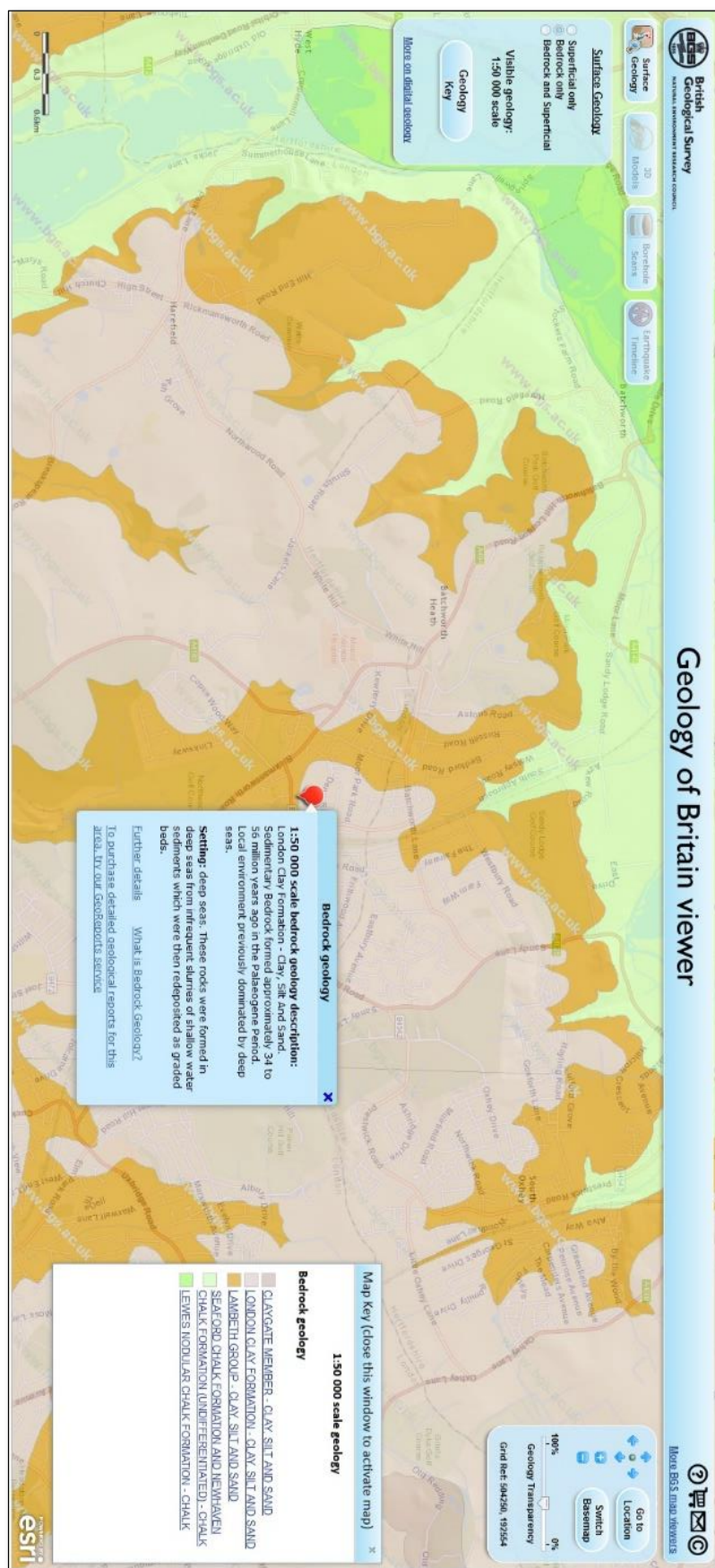
Appendix 1, Plan 10 – Front & Side Elevations



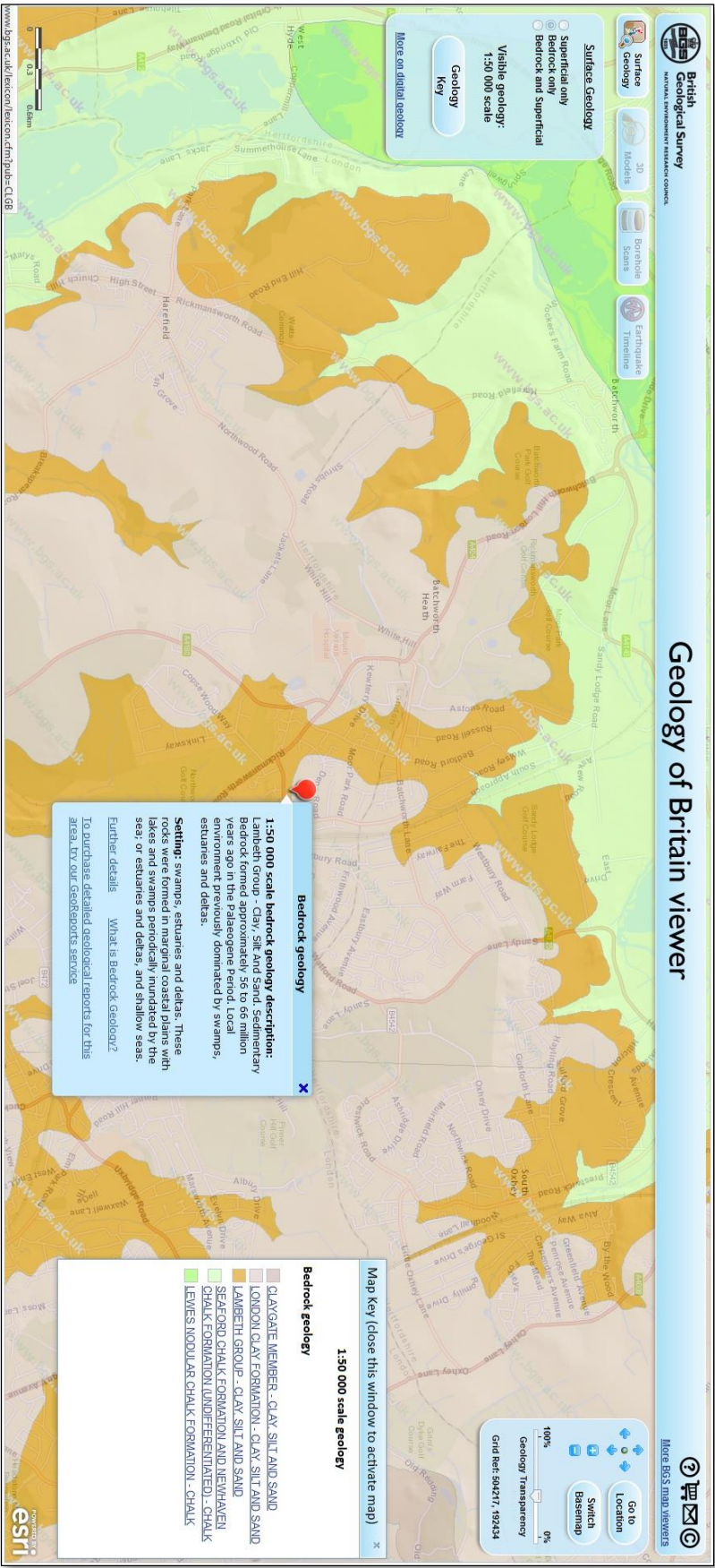
Appendix 1, Plan 11 – Rear & Side Elevations

Appendix 2 – Site Geology Maps

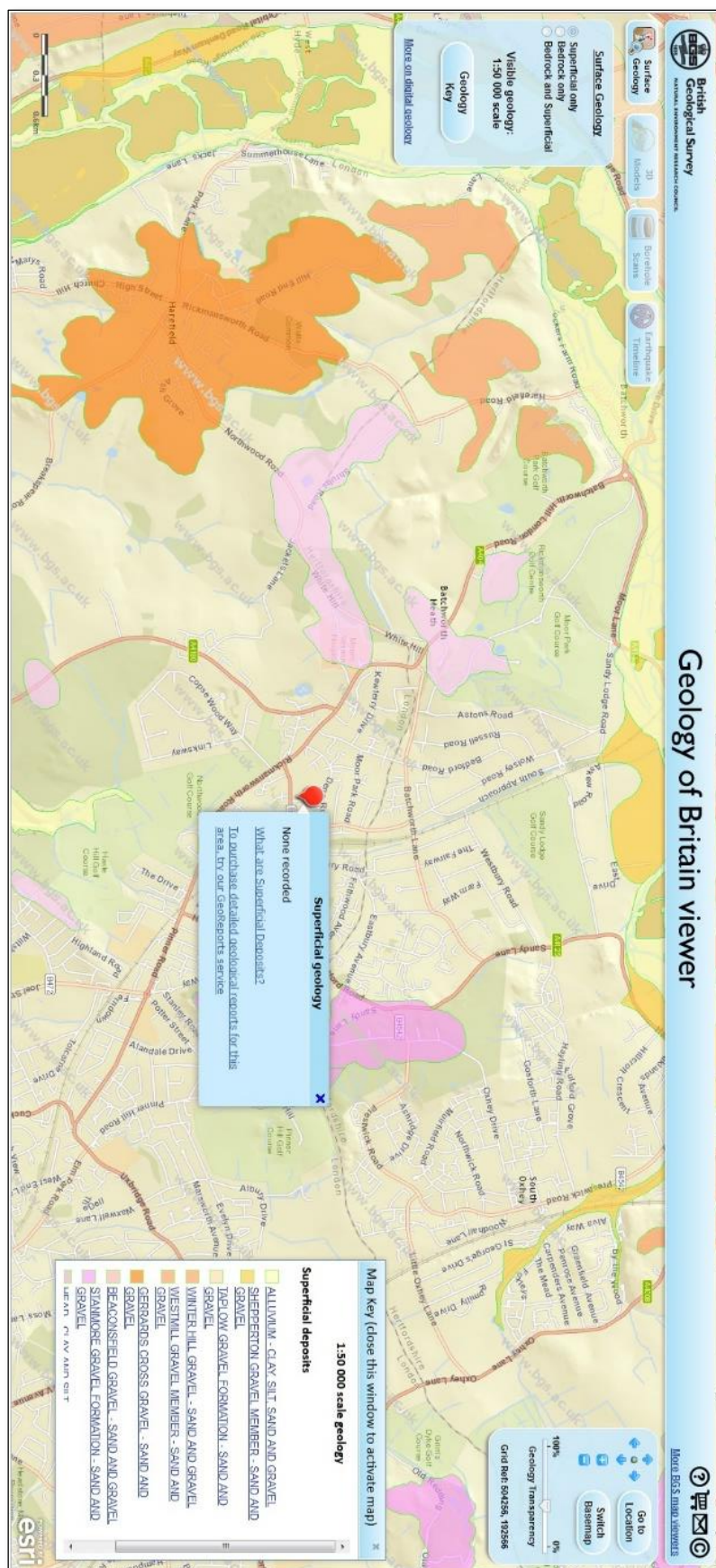
- *Figure 1.A – Bedrock Geology, London Clay Formation*
- *Figure 1.B – Bedrock Geology, Lambeth Group*
- *Figure 2 – Superficial Deposits*
- *Figure 3 – Soil Parental Material*
- *Figure 4.A – Soil Texture-North, Clay to Silt*
- *Figure 4.B – Soil Texture, South, Loam to Silty Loam*
- *Figure 5.1 – Boreholes Location Map*
- *Figure 5.2.1 – Borehole TQ09SE50, Sheet 1*
- *Figure 5.2.2 – Borehole TQ09SE50, Sheet 2*
- *Figure 5.3.1 – Borehole TQ09SE103, Sheet 1*
- *Figure 5.4.1 – TQ09SE104, Sheet 1*
- *Figure 6 – Hydrogeology*
- *Figure 7 – Groundwater Source Protection Zones*
- *Figure 8 – Groundwater Vulnerability Zones*
- *Figure 9 – Infiltration SUDS Suitability Map*



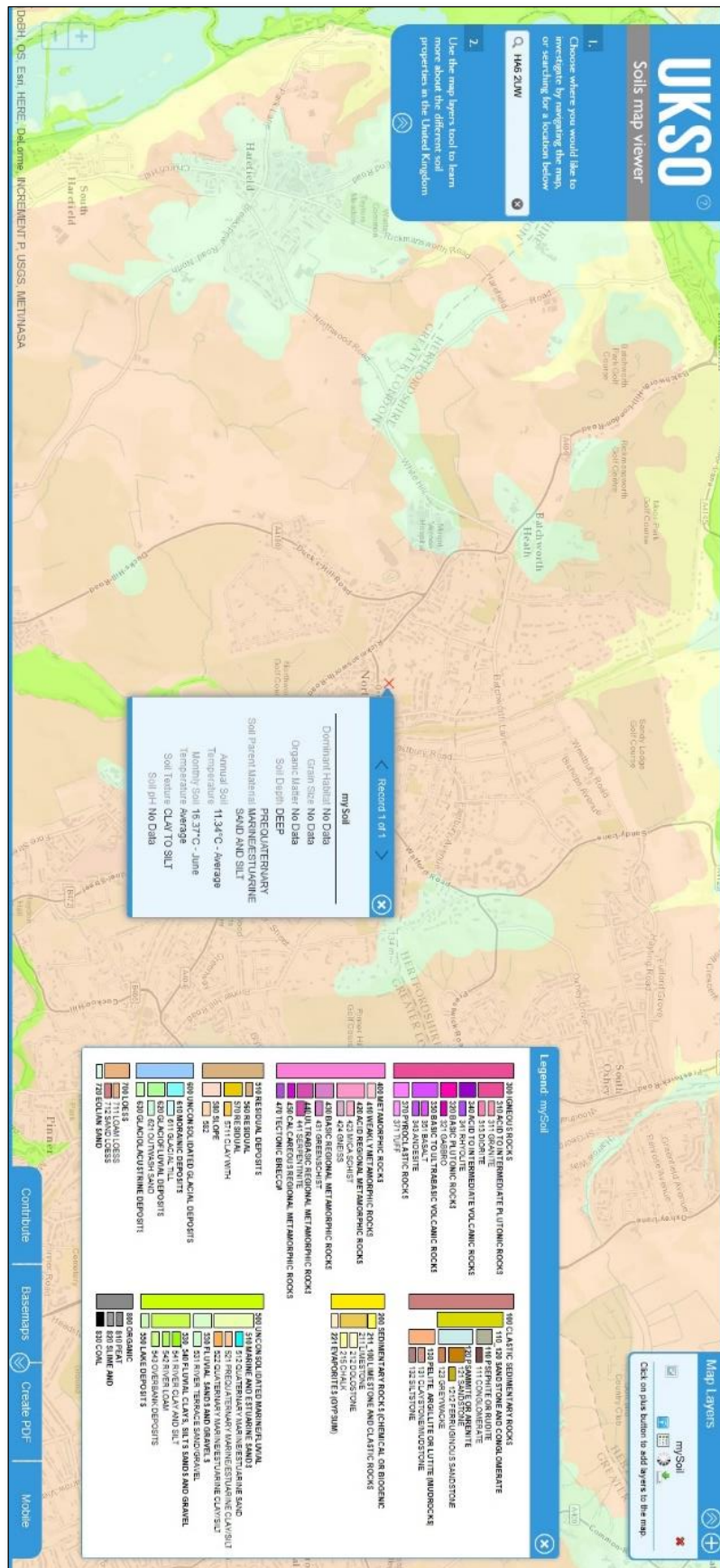
Appendix 2, Figure 1.A – Bedrock Geology, London Clay Formation

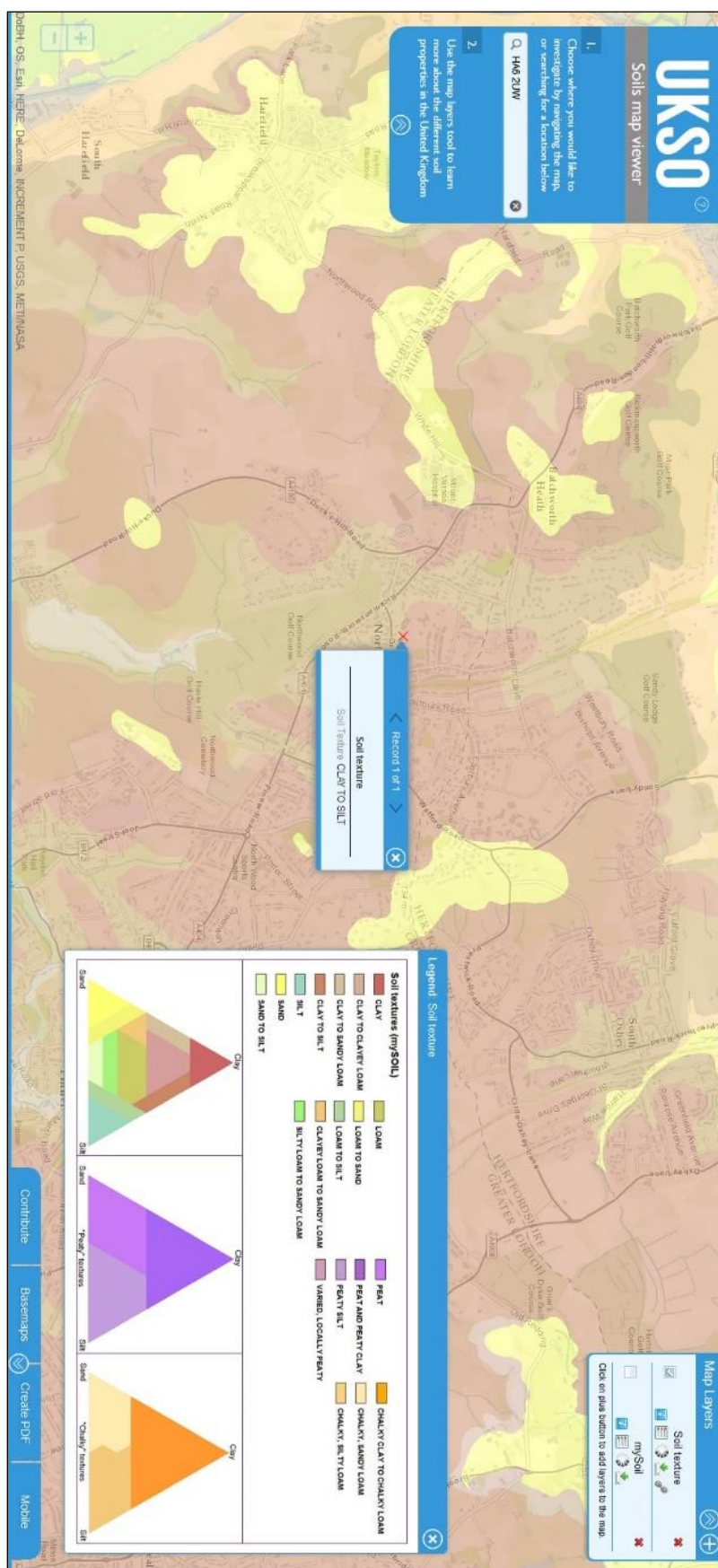


Appendix 2, Figure 1.B – Bedrock Geology, Lambeth Group

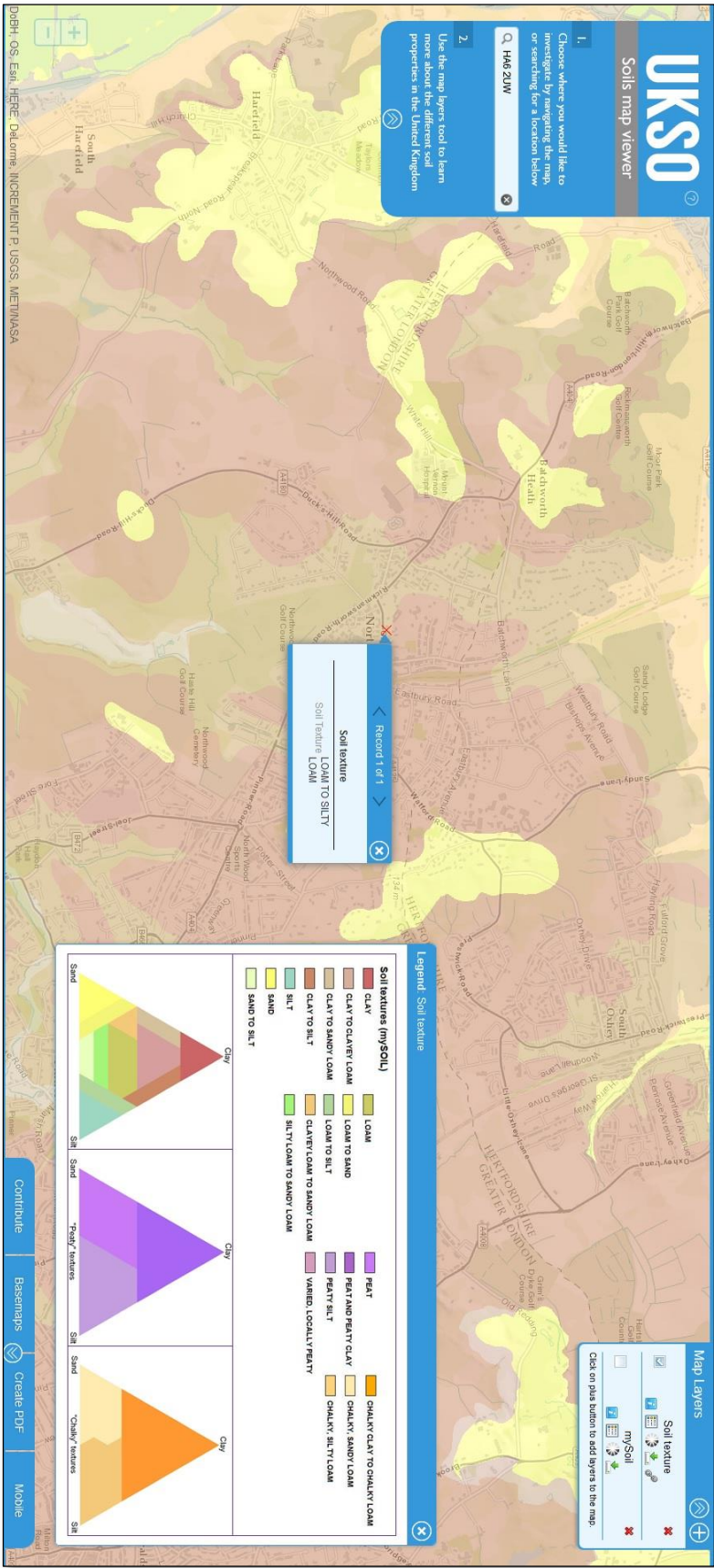


Appendix 2, Figure 2 – Superficial Deposits

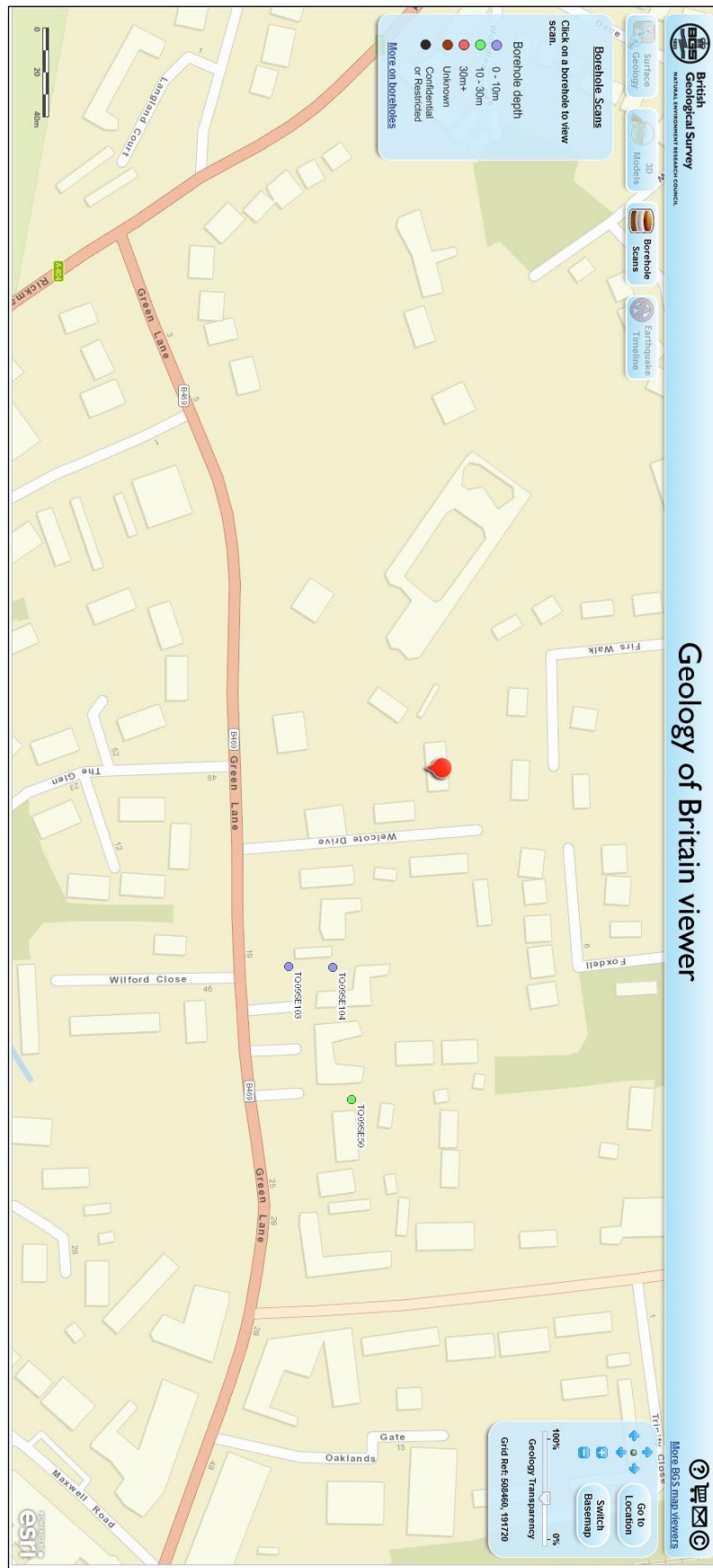




Appendix 2, Figure 4.A – Soil Texture-North, Clay to Silt



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



Appendix 2, Figure 5.1 – Boreholes Location Map

TQ09SE/50

TQ09/116

255 **374**

TQ 0896 9157

GROUND EXPLORATIONS LIMITED
BOREHOLE SECTION SHEET

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

CONTRACT NAME **25, GREEN LANE, NORTHWOOD.**

Bored for: **Messrs. Clifford & Clifford Ltd.,**

Address: **28, Ealing Road, Wembley, Middx.**

Address of Site: **25, Green Lane, $\frac{1}{2}$ m. NW of Northwood Ry. Sta., Middlesex & South**

District or Town: **Northwood.**

County: **Middlesex.**

Standing Water Level: **below surface**

Dia. of Borehole: **6** Inches.

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

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. 65 ft) with galleries from which chalk has been extracted on site (Report by Sir Harold Harding to Contractor 1961).**

Jar Samples: **8648 3'0"; 8651 5'0"; 8652 13'0"; 8653 17'0"; 8654 21'0"; 8656 26'0"; 8658 31'0"; 8659 35'0"; 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 5'0"-7'0"**

Large Disturbed Samples: **8655 24'0"; 8657 33'0"; 8658 33'6"; 8661 34'0"; 8664 40'0"; 8665 44'0"**

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', $\pm$ 0.0 m.**

	Thickness		Depth below Surface	
	Feet	Inches	Feet	Inches
Made ground (brick, clay etc.,)	1 (0.45m)	6	1 (0.45m)	6
Firm mottled brown/blue clay.	5 (1.52m)	0	6 (1.97m)	6
Firm mottled green/brown chalky clay.	1 (0.30m)	0	7 (2.23m)	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
Light brown sand.	2 (0.60m)	0	32 (9.75m)	0
Firm brown silty clay with thin layers of sand.	1 (0.30m)	0	33 (10.20m)	6
Grey clayey sand.	2 (0.60m)	0	35 (10.81m)	6
Gravel.	1 (0.30m)	0	36 (10.97m)	0
Firm blue sandy clay.	9 (2.74m)	0	45 (13.71m)	0
Coarse gravel containing sand at lower levels.	9 (2.74m)	0	54 (16.46m)	0
Chalk with flints.	6 (1.82m)	0	60 (18.28m)	0
Chalk.				
TOTAL FROM SURFACE	60 (18.28m)	0	60 (18.28m)	0

Made by **Ground Explorations Ltd.**

Data Bank - Dec 1979

Appendix 2, Figure 5.2.1 – Borehole TQ09SE50, Sheet 1

255 TQ09/116
374

British Geological Survey
GROUND EXPLORATIONS LIMITED
BOREHOLE SECTION SHEET

Date November 1960

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, 1/2 m. NW of Northwood Ry. Sta., Middlesex 5 SW N

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. 65 ft) with galleries from which chalk has been extracted on some (Report by Sir Harold Harding & contractors 1961).

Jar Samples: 8648 1'0"; 8651 5'0"; 8652 11'0"; 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"; 8649 3'0"-5'0"; 8650 6'0"-7'0"

Core Samples: _____

Large Disturbed Samples: 8655 24'0"; 8657 29'0"; 8660 33'6"; 8661 34'0"; 8664 40'0"; 8665 44'0"

DESCRIPTION OF STRATA		Thickness Feet Inches	Depth below Surface Feet Inches
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. <u>I</u> Boring			
Made ground (brick, clay etc.,)	1 (0.45m) 6	1 (0.45m) 6	
Firm mottled brown/blue clay.	5 (1.52m) 0	6 (1.97m) 6	
Firm mottled green/brown chalky clay.	1 (0.30m) 0	7 (2.27m) 6	
Stiff mottled red/green/brown chalky clay.	5 (1.67m) 6	13 (3.94) 0	
Brown sand with pockets of grey clayey sand.	10 (3.04m) 0	23 (7.01m) 0	
Brown sand.	7 (2.13 m) 0	30 (8.44m) 0	
Light brown sand.	2 (0.60m) 0	32 (9.75m) 0	
Firm brown silty clay with thin layers of sand.	1 (0.30m) 0	32 (9.90) 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	
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	

Made by Ground Explorations Ltd. per SWH

Signed Data Bank Dec 1979 Date 01.10.77

Received march 1975.

Use for foundations.
Site visited.
Date 01.10.77 Rm JJA

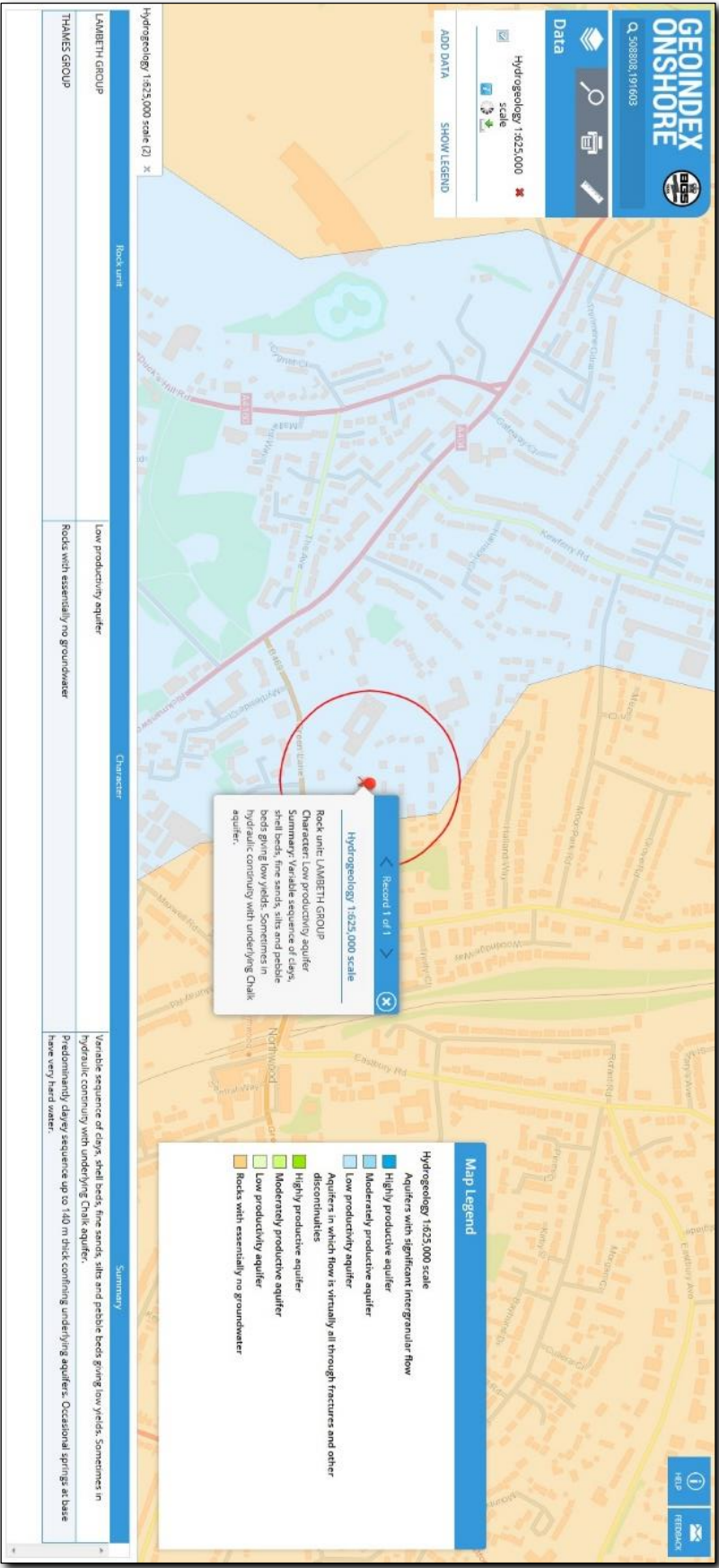
Appendix 2, Figure 5.2.2 – Borehole TQ09SE50, Sheet 2

Contract Name GREEN LANE, NORTHWOOD						Borehole No. HA1	
						Sheet 1 of 1	
Method of boring Hand auger				Ground level about 70.0 m O.D			
Diameter 100 mm nominal				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
10/9				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*			1.30	Stiff to very stiff mottled reddish brown silty clay with traces of organic material, root fibres and some fine sand partings
			U*	2.00	68.00	0.43	Very stiff mottled greyish brown silty sandy clay with some traces of fine gravel
			U*	2.43	67.57		Bottom of Borehole
Notes							
Terresearch Limited				Report No. S.26/875		Appendix 1 Sheet 3	

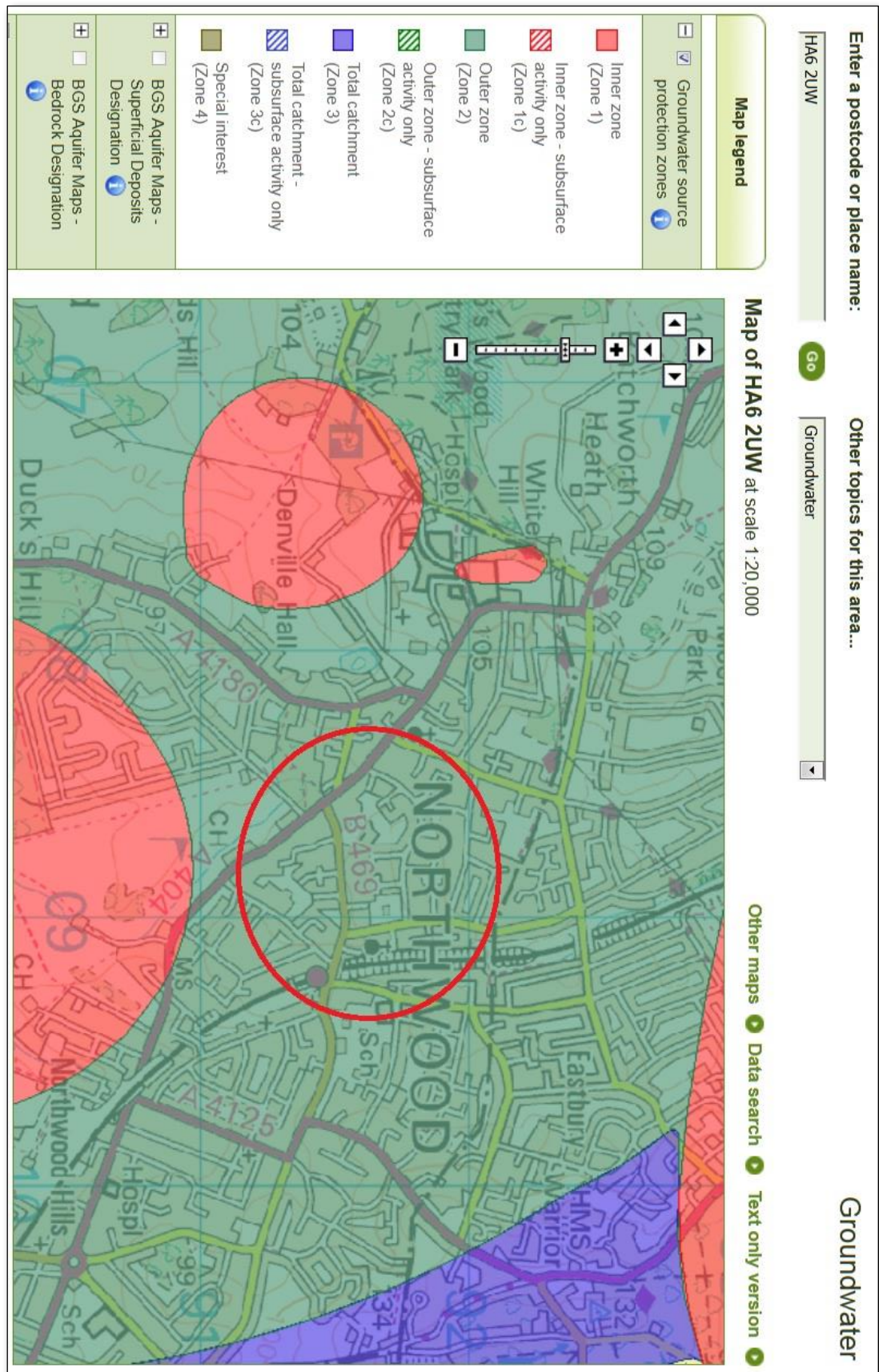
Appendix 2, Figure 5.3.1 – Borehole TQ09SE103, Sheet 1

Contract Name GREEN LANE, NORTHWOOD						Borehole No. HA2	
						Sheet 1 of 1	
Method of boring Hand auger				Ground level 71.0 m O.D. 0890			
Diameter 100 mm nominal				Start 10.9.76 9186			
				Finish 10.9.76			
Daily progress	Water levels	In-situ tests	Samples	Depth (m)	Reduced level (m O.D.)	Thickness (m)	Description of Strata
			U*	0.15	70.95	0.15	Topsoil
			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*			1.73	Firm to very stiff light brown grey silty clay with traces of organic material
			U*				
			U*	2.73	68.37		
10/9							Bottom of Borehole
Notes 							
Terresearch Limited				Report No. S.26/875		Appendix 1 Sheet 4	

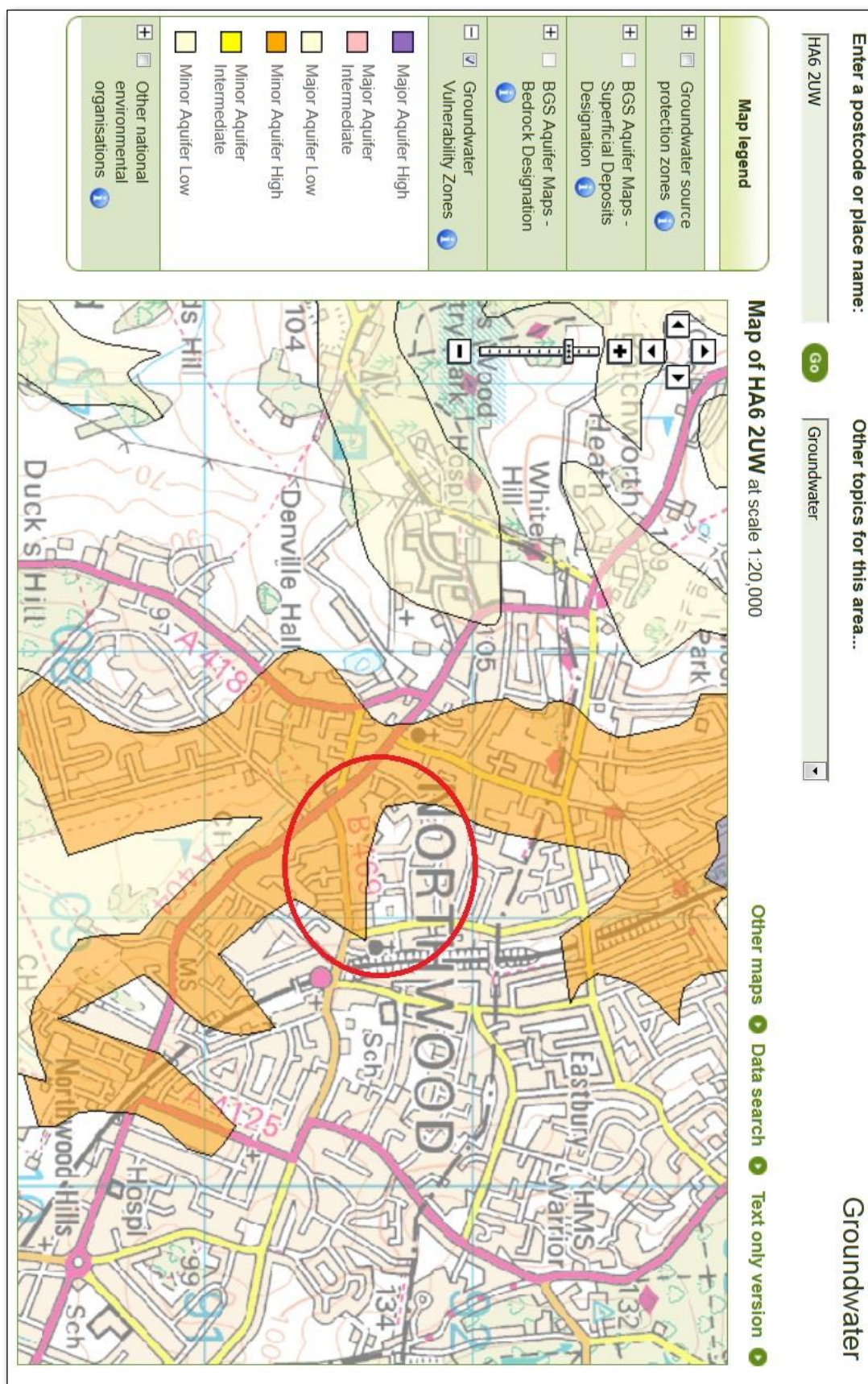
Appendix 2, Figure 5.4.1 – TQ09SE104, Sheet 1



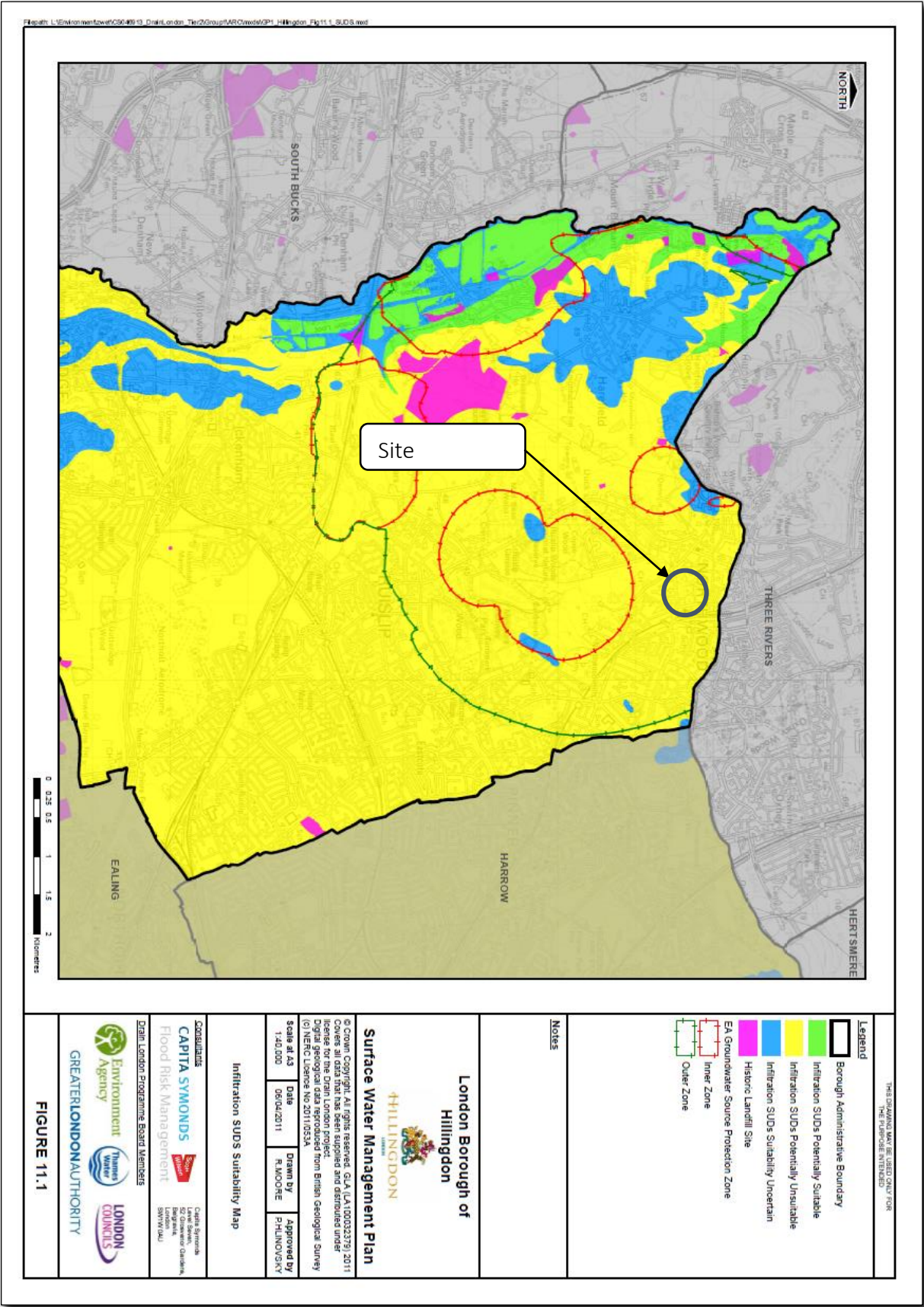
Appendix 2, Figure 6 – Hydrogeology



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

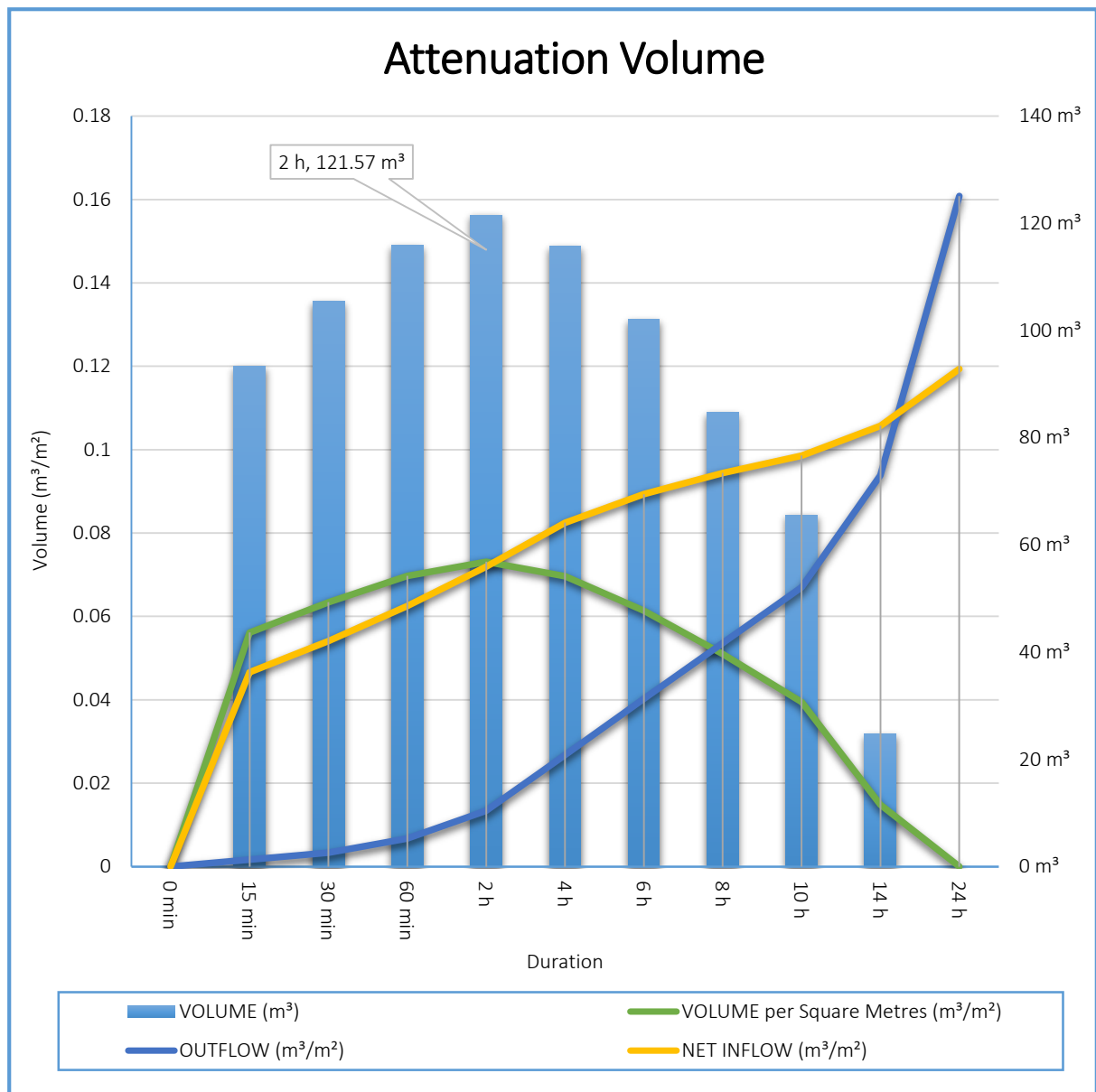
- *Table 1 – Greenfield Runoff Rates Calculation Summary*
- *Table 2 – Summary of Attenuation Storage Estimation – 1 in 100 years + cc*
- *Graph 1 – Attenuation Storage Volume required for site estimated for Critical Duration (m^3 per m^2)*
- *Table 3 – Flow and Volume Information Summary*

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	5	
SPR	0.53	
QBAR _{rural} (l/s) for 50 Ha	300.24 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)	
QBAR	5.28	
1	5.10	
30	14.77	
100	19.16	
Return Period	Greenfield Runoff (l/s)	
QBAR	1.66	
1	1.41	
30	4.09	
100	5.30	

Appendix 3, Table 1 - Greenfield Runoff Rates Calculation Summary

Storm Duration	RAINFALL DEPTH (mm)		NET INFLOW (l/m²)		OUTFLOW (l/m²)	VOLUME (m³/m²)	
	RETURN PERIOD		RETURN PERIOD			RETURN PERIOD	
	100 years	100 yr + CC (30%)	100 years	100 yr + CC (30%)		100 yr + CC (30%)	100 yr + CC (30%) Adjustment (+25%)
0					0.00		
15 min	37.98	49.37	35.19	46.58	1.68	0.0449	0.0561
30 min	43.75	56.88	40.96	54.08	3.35	0.0507	0.0634
60 min	50.21	65.27	47.42	62.48	6.70	0.0558	0.0697
2 h	57.46	74.70	54.67	71.91	13.40	0.0585	0.0731
4 h	65.6	85.28	62.81	82.49	26.80	0.0557	0.0696
6 h	70.84	92.09	68.05	89.30	40.21	0.0491	0.0614
8 h	74.77	97.20	71.98	94.41	53.61	0.0408	0.0510
10 h	77.97	101.36	75.18	98.57	67.01	0.0316	0.0394
14 h	83.47	108.51	80.68	105.72	93.81	0.0119	0.0149
24 h	93.98	122.17	91.19	119.38	160.83	-0.0414	No storage required

Appendix 3, Table 2 – Summary of Attenuation Storage Estimation – 1 in 100 years + cc



Appendix 3, Graph 1 - Attenuation Storage Volume required for site estimated for Critical Duration (m^3 per m^2)

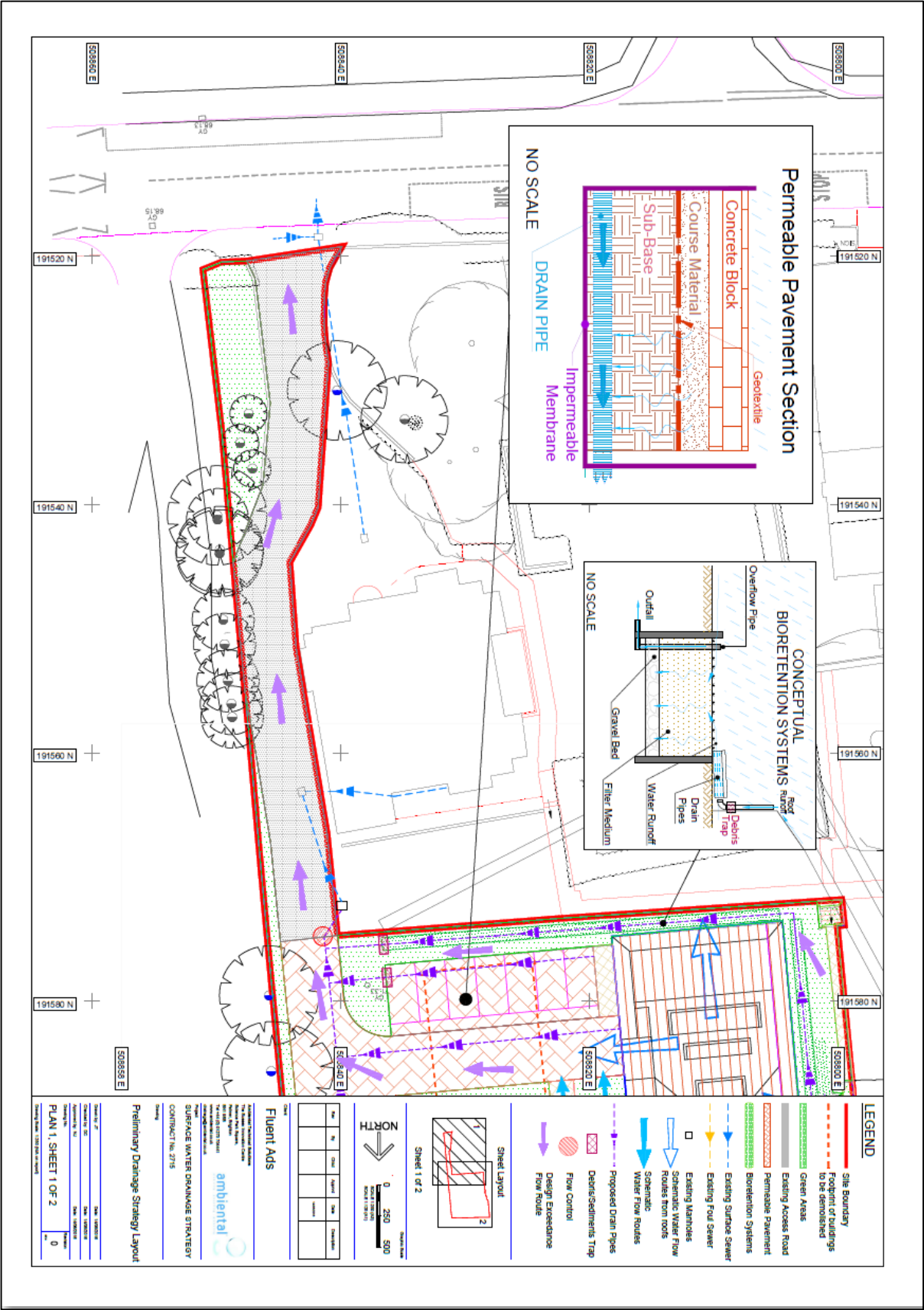
FLOW & VOLUME INFORMATION			
SITE DETAILS			
Site Name	London School of Theology, Green lane, Northwood, HA6 2UW		
Total Site Area	0.28 ha		
Site Area which is positively drained	0.28 ha		
Developed Area	0.15 ha		
Predevelopment Use	Site already developed		
Site Constraints	Residential Site		
	Groundwater Source Protection Zone: Outer zone (Zone 2)		
	Groundwater Vulnerability Zone: Minor Aquifer High		
	- Poor Infiltration Soils		
	- Unknown Groundwater Table		
IMPERMEABLE AREA			
	EXISTING	PROPOSED	DIFFERENCE (Proposed - Existing)
Impermeable Area (Ha)	0.13 ha	0.15 ha	0.02 ha
Drainage Method (Infiltration/Sewer/Watercourse)		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 Rates (l/s)	
Greenfield Q _{BAR} (Mean Flow Rate)	1.66 l/s	N/A	
1 in 1	1.41 l/s	5.00 l/s	
1 in 30	4.09 l/s	5.00 l/s	
1 in 100	5.30 l/s	5.30 l/s	
1 in 100 plus climate change	N/A	5.30 l/s	
FLOW CONTROL			
Flow Control Type	Variable		
Greenfield Flow Q ₁ (Daily storm event)	18.07 l/s*ha	5.00 l/s	
Greenfield Flow Q ₁₀₀ (Extreme event)	19.16 l/s*ha	5.30 l/s	
SITE STORAGE VOLUME			
Source Control Provided	Yes		
Interception Volume (Daily Storms)	6.65 m³		
Storage - 1 in 100 year + CC (Attenuation Volume)	0.0731 m³/m²	121.57 m³	
Approach used to calculate storage	Use Long Term Storage		
Long Term Storage	0.00 m³	0.00 m³/ha	
Total site Storage	128.22 m³		
Infiltration	Site's Geology	Prequaternary Marine/Estuarine Sand and 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/No?	YES	Outer zone (Zone 2)
	Site's Contamination	Potential Contamination	
Infiltration Feasibility	NO		

FLOW & VOLUME INFORMATION		
Drainage provided by:	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.
	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		
All SuDS storage located outside Q100 floodplain		Yes
Provision for blockage / Design Exceedance		Yes

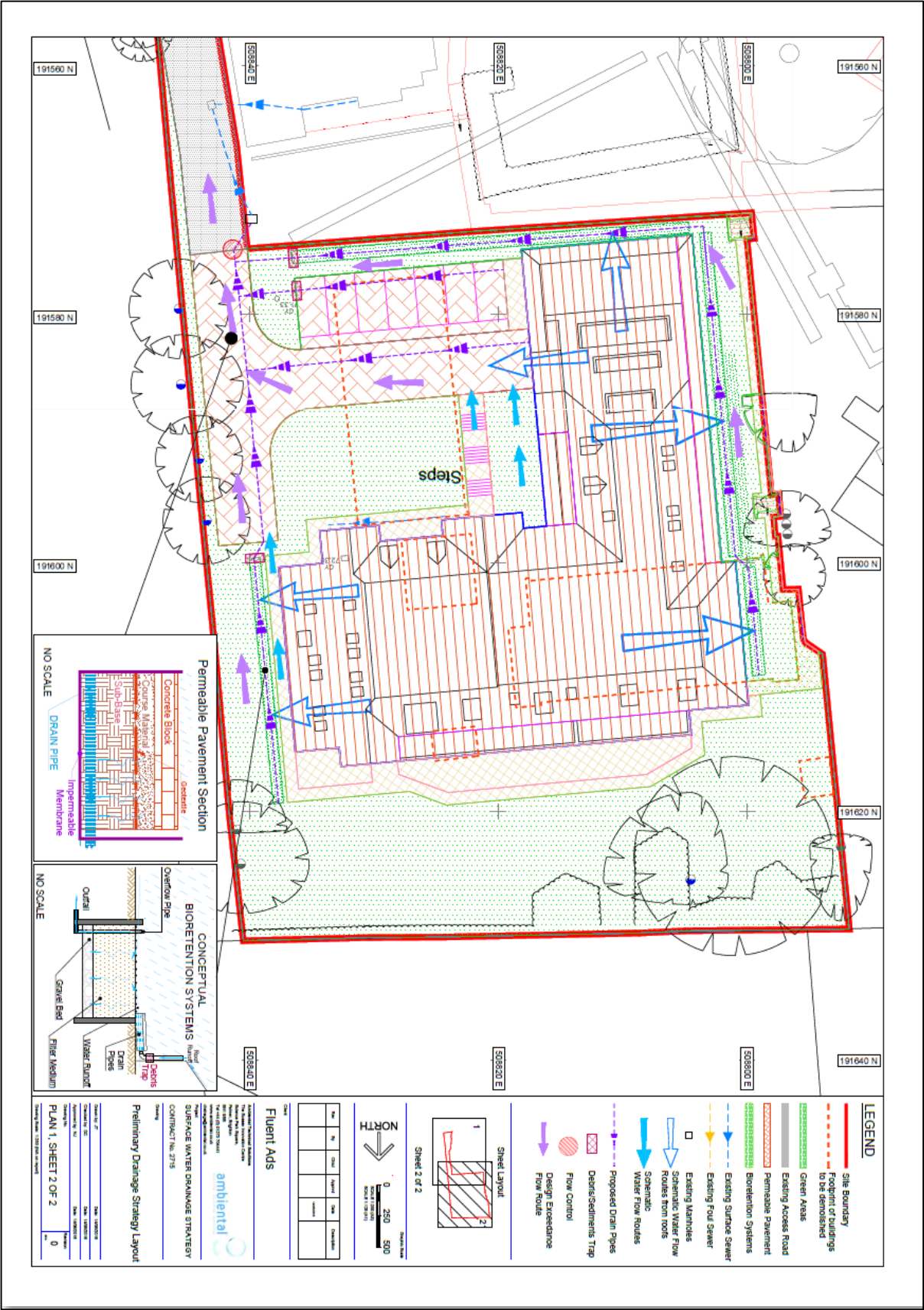
Appendix 3, Table 3 - Flow and Volume Information Summary

Appendix 4 – Proposed 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

Surface Water Runoff Calculation Method

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 30% 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.

Impermeable runoff rates have been calculated using the Modified Rational Method for the impermeable surfaces on site only.

Throughout the calculations a weighted co-efficient has been used, allowing different materials of surface covering on site to be taken into account.

These runoff rates have then been combined to provide the most accurate runoff rate possible for both the existing and proposed site.