69 Avenue Road

LONDON BOROUGH OF CAMDEN

SURFACE WATER FLOW AND FLOOD RISK ASSESSMENT

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WATER | ENVIRONMENT

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This Surface Flow and Flood Risk Assessment was commissioned by HGH Consulting in December 2019 to investigate the risks and assess the consequences of flooding of the proposed development at 69 Avenue Road, Camden.

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GLOSSARY

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BIA	Basement Impact Assessment
BGL	Below Ground Level
BGS	British Geological Survey
CC	Climate Change
CDA	Critical Drainage Area
CPG	Camden Planning Guidance
DEFRA	Department for Environment Food and Rural Affairs
EA	Environment Agency
FFL	Finished Floor Level
FRA	Flood Risk Assessment
LBC	London Borough of Camden
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
NPPF	National Planning Policy Framework
PFRA	Preliminary Flood Risk Assessment
PPG	Planning Practice Guidance
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

EXECUTIVE SUMMARY

The site discussed in this report is located at 69 Avenue Road within the London Borough of Camden. The site is less than 1 hectare (ha) in size and currently comprises of the building footprint and gardens. Proposals are to refurbish the building and construct a rear extension and basement to the existing development. The proposed basement extension will extend past the footprint of the existing building. Local planning policy requires the proposed basement extension to undertake the Surface Water and Flooding Screening Flowchart. As a result of this initial screening assessment, a flood risk assessment has been undertaken for the proposed development.

The Environment Agency flood zone maps indicate that the site is located within Flood Zone 1 (Low Risk). In accordance with the technical guidance document to the National Planning Policy Framework (NPPF), this zone comprises land assessed as having a less than 1 in 1000 annual probability of fluvial or tidal flooding (<0.1%). The risk of flooding from rivers and the sea is therefore low.

The GOV.UK Long Term Flood Risk maps for surface water indicate that there is a natural flow path draining down Avenue Road and that the rear garden is affected by surface water flooding. The rear garden is sunken and approximately 1m lower than the existing development on the site. Therefore, surface water collects in the rear garden. This surface water is not part of a flow route and is isolated. The proposed extension to the existing development is lower than the existing ground floor levels, however, is higher than any the 1 in 1000 year surface water flood level in the rear garden. The FFL are shy of a 300mm freeboard due to level access requirements and such the development will implement flood mitigation measures to ensure there is at least a 300mm freeboard above the 1 in 1000 year surface water event. Therefore, the existing building and proposed extension are said to be at low risk of surface water flooding. As part of the basement design there is a proposed lightwell located on the side of the existing development. To mitigate against the risk of surface water flooding to the basement the lightwell is to be surrounded by retaining walls. This will ensure surface water does not enter the basement via the lightwell.

To mitigate against flood risk further, the proposed development should implement non-return valves on all foul outlets or a positive pumped system within the basement. This will reduce the risk of internal flooding in the event of any surcharge of the public sewer system in the road. With these two measures incorporated, the risks of surface water and sewer flooding to the site are considered to be low.

The onsite ground investigation concluded that a typical succession of Made Ground which was underlain with Claystones and London Clay Formation. Groundwater monitoring was undertaken but no groundwater was found in the location of the basement. However, groundwater was recorded in the monitoring boreholes at the front of the house. It is therefore recommended that the basement extension includes an appropriate tanked system or equivalent to prevent groundwater ingress into the basement. In addition, we advised that de-watering methods may be required during construction of the basement extension. With these mitigation measures in place, the risk of groundwater ingress to the basement is low.

Impermeable areas on the site will be increasing post development and subsequently there will be an increase in surface water runoff (ignoring the effects of climate change) from the site. The development will therefore be required to implement a sustainable urban drainage system (SuDS) to ensure the surface water rates do not increase post development. It is proposed to implement a green roof with 10-15cm subbase which is underlain with a blue roof. This is sufficient for the development to comply to local planning requirements and the London Plan.

The proposed rear and basement extension has been shown to be at a low risk of flooding from all sources when implementing the mitigation measures proposed in this report and is considered acceptable in the context of flood risk, provided the mitigation measures detailed within this report are incorporated into the design. The proposed development does not result in any increase in the risk of flooding to the site or elsewhere due to the SuDS features proposed in this report.

1 INTRODUCTION

General Information

1.1 The site is located at 69 Avenue Road in the London Borough of Camden. The site is less than 1 hectare (ha) in size and currently comprises the residential house and gardens.

1.2 The Environment Agency flood zone maps indicate that the site is located in Flood Zone 1. This zone comprises of land assessed as having a less than 1 in 1000 annual probability of fluvial or tidal flooding (<0.1%). The site is also less than 1 ha and therefore a full Flood Risk Assessment is not normally required.

1.3 However, London Borough of Camden policy dictates that surface water flow and flooding is considered in this case, primarily due to the basement construction. This report has therefore been prepared to assess the risks of flooding from all potential sources including; overland flow, groundwater, artificial water bodies and underground sewers. The impact of the proposed development on surface water infrastructure is also considered, and this report will form part of the Basement Impact Assessment for submission with the planning application.

Scope of Study

1.4 The main objectives of this study are to:

- Provide a surface water flow and flood risk assessment of the site, compliant with the guidelines set out in the National Planning Policy Framework (NPPF) and Camden Planning Guidance (CPG) to accompany any application for planning permission;

- Complete the Stage 1 Surface Flow and Flooding screening assessment, using the flow chart included within CPG and carry forward to scoping stage if required;

- Provide advice and guidance on the management of surface water runoff at the site to ensure the risk of surface water flooding on the site and on nearby sites does not increase following development; and,

- Consider the potential future impacts of climate change over the lifetime of the proposed development.

2 SITE DESCRIPTION

Location

2.1 The site is situated on Avenue Road in the London Borough of Camden as shown in

2.2 Figure 1.

2.3 Primrose Hill is located to the east of the site and Hampstead Heath is located to the north of the site.

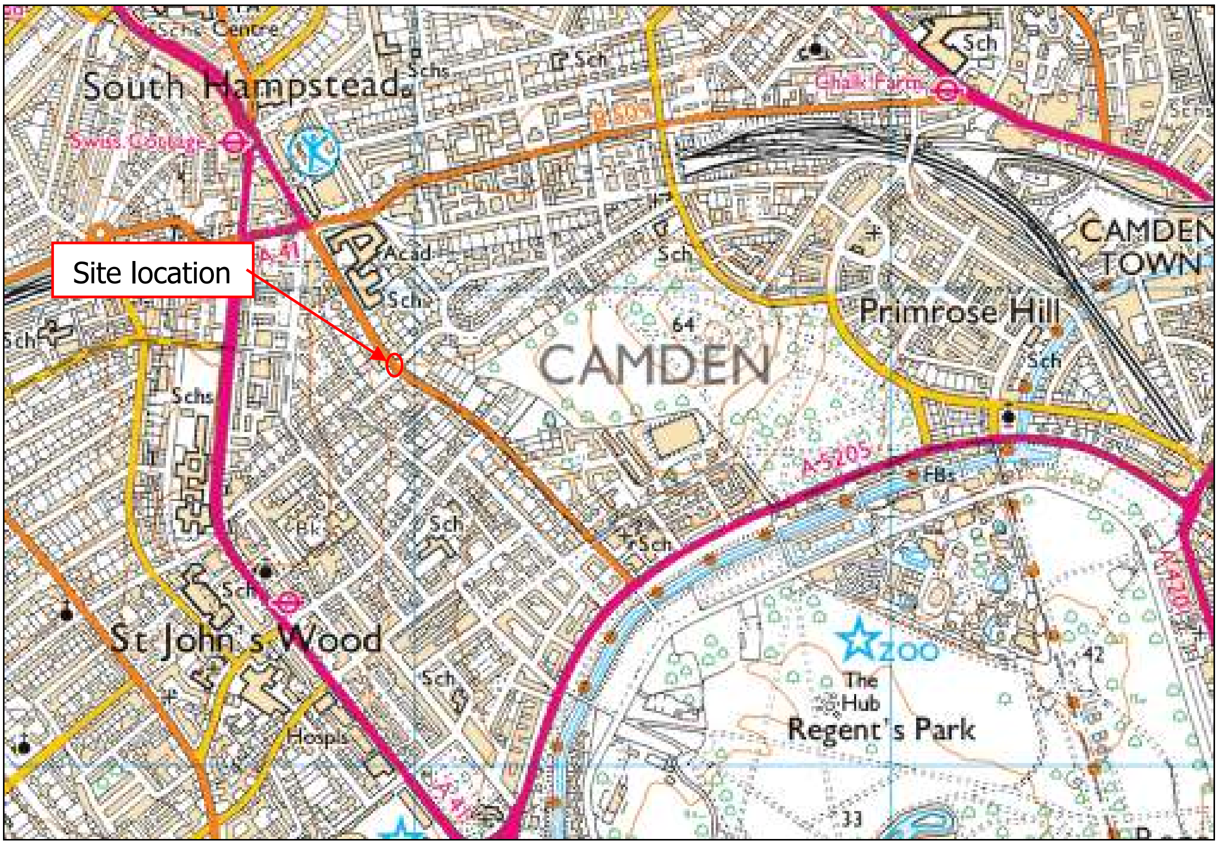

Figure 1[1] - Location of proposed development site

Existing Development

2.4 The existing site comprises of the existing residential building, driveway and gardens. The site is a mixture of hard and soft standing.

2.5 A topographic survey of the site has been carried out. It shows the finished floor levels of the property to be approximately 44.50m AOD. The driveway rises from Avenue Road to the property.

[1] © Crown copyright and database rights 2020 Ordnance Survey 100049945

2.6 The rear garden is sunken compared to the driveway and the property levels. The rear garden has ground levels ranging from 43.53m-44.6m AOD.

Proposed Development

2.7 Proposals are to extend the existing dwelling on the site and to construct a basement under the existing development and part of the proposed extension.

2.8 All rooms situated within the basement level have internal access to higher floors. The basement includes one habitable room in the form of a staff living space.

2.9 The new extension to the property will increase the percentage of hard standing are on the site post development.

2.10 The proposals also include a green roof across the extension to mitigate against the increase of surface water runoff caused by the extension.

3 PLANNING POLICY AND GUIDANCE

National Planning Policy

NPPF

3.1 The revised National Planning Policy Framework (NPPF) was published in February 2019 and sets out the Governments' planning policies for England and how these are expected to be applied. In terms of flooding, the NPPF states that:

> *"Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere."*

3.2 In accordance with the NPPF, run-off rates and volumes should not increase from any site following development, to prevent an increase in surface water flood risk elsewhere.

3.3 In addition, to the NPPF, online Planning Practice Guidance (PPG) was released in March 2014 to clarify planning aspects of flood risk management. The PPG supersedes the Technical Guidance to the NPPF and clarifies which development types are considered appropriate within each flood zone.

3.4 The proposed residential development, according to Table 2 of the Flood Risk and Coastal Change section of the Planning Practice Guidance, is considered to be 'Highly Vulnerable' due to its inclusion of a basement dwelling on the site. The existing development is residential and therefore classified as 'More Vulnerable'. Therefore, there will be an increase in the vulnerability classification of the site as a result of the proposed development.

Sequential and Exception Test

3.5 Table 3 of PPG on Flood Risk and Coastal Changes states that 'Highly Vulnerable' uses are compatible with Flood Zone 1. Therefore, the sequential test is deemed to be passed and the exception test is not required.

Regional Planning Policy – London Plan

3.6 Being within a London borough, the development is subject to the requirements of the Mayor of London's strategic plan, "The London Plan[2]". The London Plan is the overarching spatial strategy for the Greater London Area, and provides the basic foundation for planning policy in London.

3.7 A draft "new London Plan" was published by the Mayor for consultation in December 2017, followed by a version of the draft Plan that includes minor suggested changes

[2] Mayor of London, The London Plan, The spatial development strategy for London consolidated with alterations since 2011, March 2016.

(August 2018), and the latest "Intend to Publish" version in December 2019[3]. These have been considered and there are no significant differences with the adopted London Plan from a drainage perspective, with the exception of requiring permeable surfacing unless it is shown that impermeable surfaces are unavoidable. The new London Plan is projected to be adopted in March 2020.

3.8 Policy 5.13 requires implementation of the drainage hierarchy, as well as a consideration of "*water use efficiency, water quality, biodiversity, amenity and recreation*". Priority is given to preventing water leaving the site, through re-use, then infiltration, followed by open water attenuation, below ground attenuation, and finally, as a last resort, uncontrolled discharge, applying the surface discharge hierarchy.

3.9 The promotion of SuDS is also mentioned in Policy 2.18, Green infrastructure, and it is stated that drainage should be designed in such a way as to deliver other policy objectives of the London Plan, including water efficiency, water quality, biodiversity and recreation.

3.10 The implementation of green roofs does not appear in the hierarchy, but has been considered in a specific Policy (Policy 5.11 "Green Roofs and Development Site Environs"). It is suggested that all major development proposals should include green roofs, green walls and site planting.

3.11 The London Plan Supplementary Planning Guidance[4] states that the 'Mayor's Priority' is that *"developers should maximise all opportunities to achieve greenfield runoff rates in their developments*", with a minimum expectation to "achieve at least 50% attenuation of the site's (prior to re-development) surface water runoff at peak times."

3.12 Flood risk and drainage are considered in the London Plan under Chapter 5 "London's response to Climate Change", within the Climate change adaptation section, Policies 5.11 through to 5.15. Policy 5.12 sets out detailed policy regarding flood risk management and requires compliance with the NPPF and associated PPG. Policy 5.13; Sustainable Drainage states that:

> *"Development proposals must comply with the flood risk assessment and management requirements set out in the NPPF and the associated technical Guidance on flood risk over the lifetime of the development."*

[3] Mayor of London (December 2019), The London Plan – Intend to Publish version, Spatial Development Strategy for Greater London

[4] Mayor of London (April 2014), *Sustainable Design and Construction Supplementary Planning Guidance*.

Local Planning Policy – London Borough of Camden

3.13 The London Borough of Camden has a Local Plan[5] which was adopted in 2017. Relevant polices are CC3 Water and Flooding and A5 Basement. Key points are listed below:

CC3 Water and Flooding

'The Council will seek to ensure that development does not increase flood risk and reduces the risk of flooding where possible. We will require development to:

a. incorporate water efficiency measures;
b. avoid harm to the water environment and improve water quality;
c. consider the impact of development in areas at risk of flooding (including drainage);
d. incorporate flood resilient measures in areas prone to flooding;
e. utilise Sustainable Drainage Systems (SuDS) in line with the drainage hierarchy to achieve a greenfield run-off rate where feasible; and
f. not locate vulnerable development in flood-prone areas.

Where an assessment of flood risk is required, developments should consider surface water flooding in detail and groundwater flooding where applicable.'

A5 Basement
…'The Council will require applicant to demonstrate that proposals for basements: O. avoid adversely affecting drainage and run-off or causing other damage to the water environment.'…

'The Council will not permit basement schemes which include habitable rooms and other sensitive uses in areas prone to flooding.'

3.14 The London Borough of Camden has strict policies with regards to basement development within the Borough, therefore they have provided guidelines for new basement developments and extensions to existing basement accommodation. Formal planning guidance has also been released, in the form of CPG Basements[6], setting out specific criteria for assessing the impact of basement construction. As part of the Basement Impact Assessment (BIA), it is necessary to consider "*surface flow and flooding*" and "subterranean (groundwater) flow". Screening flowcharts (Drawing 3) are used to address individual sources of potential flooding, and where a risk of flooding is present; a scoping and impact assessment will need to be undertaken as appropriate. This report covers this component of the BIA.

3.15 In conjunction with ARUP, the London Borough of Camden produced a "*Geological, Hydrogeological and Hydrological Study*" for guidance on subterranean development[7].

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[5] London Borough of Camden, 2017, Camden Local Plan

[6] London Borough of Camden, March 2018, Camden Planning Guidance Basements.

[7] ARUP Geological, Hydrogeological and Hydrological Study – Guidance for Subterranean Development, November 2010

4 SURFACE FLOW AND FLOODING ASSESSMENT

Stage 1: Screening

4.1 Camden Geological, Hydrogeological and Hydrological Study includes a surface flow and flooding screening flowchart, included in CPG Basements, for assessing the impact of potential sources of flooding, as well as the impact of the development on flood risk elsewhere.

4.2 The flow chart is set out with six questions, which are addressed with reference to the site and proposed development at 69 Avenue Road as follows:

- **Question 1**: Is the site within the catchment of the pond chains on Hampstead Heath?

  Answer: No – The site is not located within the catchment area as shown on Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study. The site is approximately 2km from Hampstead Heath.

- **Question 2**: As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak runoff) be materially changed from the existing route?

  Answer: No – The current proposal is for surface water flows to re-use the existing connections to the Thames Water combined public sewer located in Avenue Road.

- **Question 3**: Will the proposed basement development result in a change in the proportion of hard surfaced/paved external areas?

  Answer: YES – The proposed development will increase the impermeable area post-development. **Developer is required undertake a scoping stage of the Basement Impact Assessment.**

- **Question 4**: Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourse?

  Answer: No – The proposed development is deemed not to affect the profile of inflows to adjacent properties.

- **Question 5**: Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?

  Answer: No – The proposed basement will not result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses.

4.3 According to the Camden Geological, Hydrogeological and Hydrological Study, it is necessary to carry forward to the scoping stage of the Basement Impact Assessment those matters of concern where the response is "Yes".

4.4 In addition:

- **Question 6:** Is the site in an area known to be at risk from surface water flooding, such as South Hampstead, West Hampstead, Gospel Oak and King's Cross, or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?

Reference: The principles outlined in the NPPF should be followed to ensure that flood risk is not increased.

Answer: Yes – The site is shown to experience surface water flooding on the GOV.UK Long Term Flood Risk Maps. . **Developer is required undertake a Flood Risk Assessment in accordance with the NPPF.**

5 POTENTIAL FLOODING ON SITE

5.1 As the Surface Flow and Flooding Screening Flowchart answers "Yes" to Question 6, the development is required to undertake a Flood Risk Assessment in accordance with the NPPF. This chapter contains the Flood Risk Assessment for the site known as 69 Avenue Road for the proposed rear and basement extension.

Historic Information

5.2 No records have been found of the site flooding in the past from any of the sources identified in the NPPF.

5.3 It is noted in the North London Strategic Flood Risk Assessment (SFRA)[8] and the Camden SFRA[9] that a large area in the north of Camden was affected by surface water flooding in August 2002, which was the result of heavy rainfall inundating the public sewer system. A similar region of Camden was affected by surface water/sewer flooding in 1975. In both instances, the floods that occurred are understood to have been the result of high intensity rainfall inundating the main sewer and causing manholes and gullies to surcharge. Avenue Road is recorded of being flooded in the 2002 event. There is no record of the site being affected by this flooding event.

5.4 The Camden SFRA shows that the site is located in the postcode area of NW8 6 which has experienced 1 internal and no external sewer flooding events up to 2014.

5.5 The Camden SFRA maps indicate that the site is located within the Critical drainage area (CDA) Group3_005. Critical drainage areas are defined within the London Borough of Camden Surface Water Management Plan (SWMP)[10] as "a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one of more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure." The majority of the borough is located within a CDA and therefore, whilst a specific area is not necessarily at higher risk of surface water flooding, the location of an area within a CDA indicates that it is within a catchment area that contributes to a flooding hot spot. As a result, surface water management is a particular focus for new developments in these areas.

[8] North London Strategic Flood Risk Assessment, (August 2008)

[9]URS (July 2014) London Borough of Camden Strategic Flood Risk Assessment

[10] Drain London, Surface Water Management Plan for London Borough of Camden, (June 2013)

Tidal and Fluvial Flooding

5.6 The latest online Environment Agency flood zone map is presented in Figure 2. This shows the risk to the site of Tidal and Fluvial flooding only.

5.7 The site is located in Flood Zone 1 and is approximately 6km north of the River Thames at its nearest location. As stated in the NPPF, "this zone comprises land assessed as having a less than 1 in 1000 annual probability of fluvial and tidal flooding (<0.1%)". Therefore the risk of flooding from tidal and fluvial sources is considered low.

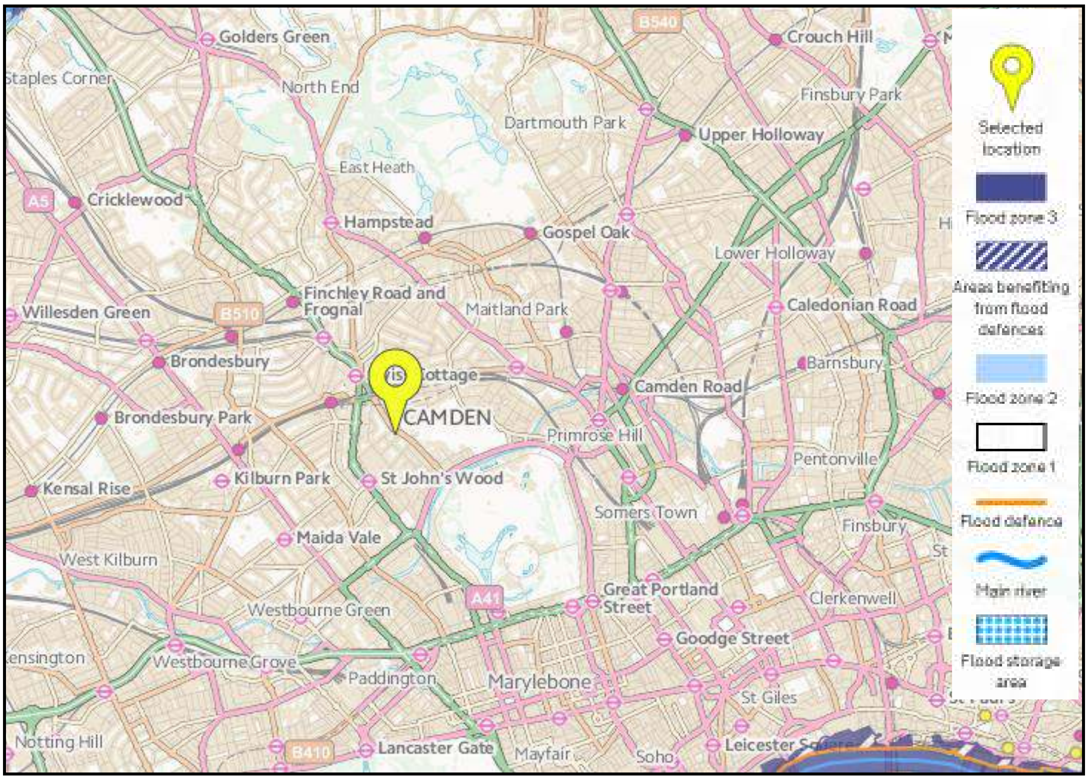

Figure 2[11] - GOV.UK flood zone map

Flooding from Surface Water and Sewers

5.8 Surface water flooding is typically the result of high intensity rainfall that is unable to infiltrate into the ground or enter the drainage system, ultimately following overland flow paths. In an urban environment such as Camden, surface water runoff is disposed of almost entirely via formal drainage systems, and consequently sewer flooding and surface water flooding (overland flow) need to be considered in tandem in this instance.

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[11] © Crown Copyright and database right 2020 OS 100024198. Retrieved 07/01/2020

5.9 It is reasonable to assume that adopted sewers have been designed to the 1 in 30 year return period (in accordance with Sewers for Adoption[12]). Therefore, it is not expected for there to be any sewer flooding up to and including the 30-year event.

5.10 The North London SFRA has collected data from flooding events in 1975 and 2002 which have been used by Camden to map areas of the borough that are more susceptible to surface water flooding. The Camden SFRA shows that Avenue Road is recorded as having flooded in the 2002 event

Surface Water

5.11 The GOV.UK website has online mapping covering the risks of surface water flooding. These maps are a useful tool in assessing the extent and frequency of flooding in a general area but do come with a caveat that they should not be relied upon for site specific development or property level assessment. Engineering judgement is therefore required when considering the flood risk information presented.

5.12 The most up-to-date data available on rainfall flooding modelling is presented in Figure 3.

Figure 3 - GOV.UK Surface Water Extent Map

5.13 The dark blue shaded areas are areas of high surface water flood risk which have a 3.3% (1 in 30) chance of flooding. While the lighter blue areas are of medium risk of surface water flooding which have a 1% (1 in 100) chance and the pale blue areas are of low risk of surface water flooding has a 0.1% (1 in 1000) chance of occurring. Areas not highlighted in blue are classed at very low risk of surface water flooding with a less than 0.1% (1 in 1000) chance of occurring. The site is shown to be a 'Medium' risk of surface water flooding.

[12] WRc7 plc (August 2018) Sewers for Adoption – A Design and Construction Guide for Developers. 8th Edition.

5.14 Surface water flooding is generally associated with topographic depressions and natural valleys. The mapping shows that the site does experience surface water flooding in the rear garden. This flooding is shown to be isolated and not connected to any flow routes. The topographic survey shows that the rear garden to be lower than the existing property and surrounding ground levels.

5.15 The modelled surface water flood map indicates that there is a natural flow path draining down Avenue Road, past the site is in a south-easterly direction. The mapping indicates flooding along the length of Avenue Road.

5.16 A more detailed configuration of the GOV.UK surface water map shows, in Figure 4, the risk of surface water flooding up to the 1 in 100 year storm event, the medium occurrence. This mapping shows the site to experience up to 300mm of flooding in the 1 in 100 year storm event.

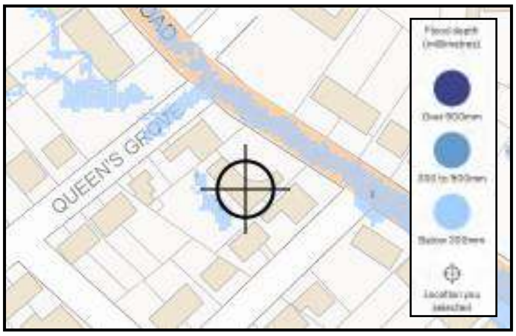

Figure 4 - GOV.UK Medium Occurrence Risk of Flooding from Surface Water

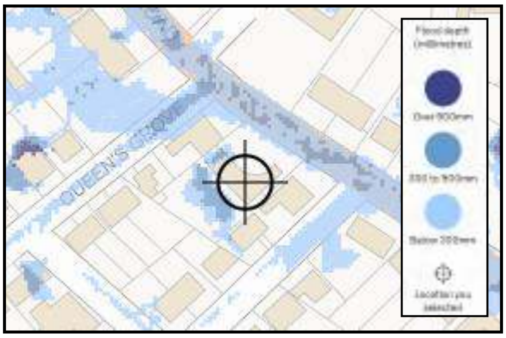

Figure 5 - GOV.UK Low Occurrence Risk of Flooding from Surface Water

5.17 While Figure 5, shows the low occurrence surface water flood event. This is up to the 1 in 1000-year flood event and the surface water is shown to collect in the rear garden which is a sunken garden.

5.18 The design flood event is the 1 in 100 year plus climate change event. It is important to note that surface water maps do not allow for climate change adaption, therefore it is common practice to also evaluate the 1000-year event as sensitivity test for what might happen in the future over the lifetime of the development. In this way it is possible to draw a parallel between the worst-case scenario (1000-year event) and the design 100-year plus climate change event.

5.19 By comparing the extent of the 1000-year surface water flooding event with the topography of the rear garden it is clear that the surface water level does not reach higher than 44.0m AOD. Therefore, 44.0m AOD is taken as a conservative estimate for the maximum surface water level depth for the 1000-year flooding event.

5.20 The proposed extension has set its finished floor levels (FFL) at 44.228m AOD which is 228mm above the 1000 year surface water flood level. A freeboard of 300mm is encouraged above the floodwater level by LBC and EA, however due to the development requiring level access from the front driveway, the FFL of 44.228m AOD was the highest level the extension could be set at.

5.21 As such, the extension will implement flood boards and other flood mitigation measures as outline in the Flood Resilient Construction of New Developments document to provide at least a 300mm freeboard.

5.22 The proposed lightwell, in absence of any mitigation measures, would be set below the garden surface water level for the 1000-year event. To mitigate against this the lightwell is to be contained within a retaining wall which is set above the maximum surface water flooding depth of 44.0m. This will prevent surface flood water entering the basement via the lightwell, the only exterior opening to the basement.

5.23 The site is also located within close proximity to the original route of a tributary of the River Tyburn, one of London's "lost rivers". The precise location of the original watercourse is unknown, and the route differs slightly between historical sources, however an excerpt from "Lost Rivers of London" (Figure 6) indicates that the natural route of the river within Camden.

5.24 The site is shown to be located between the two tributaries of the predicted natural flow of the River Tyburn but as mentioned the exact location of the original flow path is unknown. Nearly all lost rivers within London are now incorporated into the local underground sewer network and no longer flow at the surface. Overland flow may still be following the original course of the river and its tributaries as shown in Figure 6. Based on available information it appears that the site is located outside of the area at high risk of surface water flooding. Overland flow is shown to drain along Avenue Road past the site.

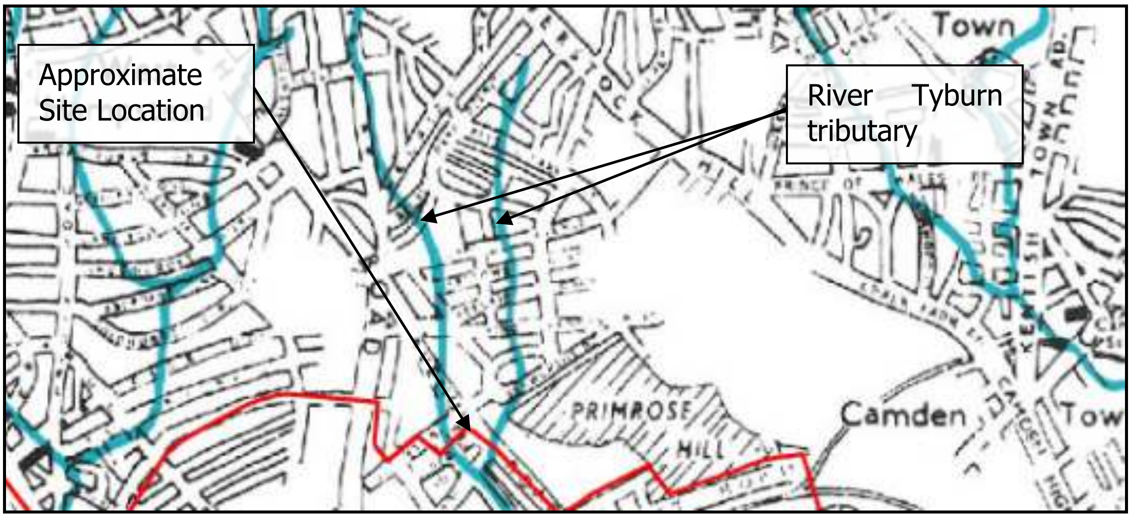

Figure 6 - Excerpt from Figure 11, Camden Geological, Hydrogeological and Hydrological Study. Source – Barton, Lost Rivers of London.

5.25 The existing house and the proposed extension are at low risk of surface water flooding due to FFL being set above the design flood water level. With the mitigation measure of retaining walls for the proposed lightwell in place, the basement is also at a low risk of surface water flooding.

Sewers

5.26 Sewer flooding typically occurs where there is incapacity or a blockage within the surface water or combined drainage system. The SFRA records indicate that there has been one incident of a property flooding from an internal sewer within the NW8 6 postcode area. The location of this property is unknown and is not disclosed within the SFRA. No records of exterior sewer flooding were recorded for postcode NW8 6.

5.27 Thames Water asset plans have been obtained for the area and these confirm that the site is connected directly to the combined public sewer located in Avenue Road. This sewer is a main truck sewer (1372 x 914mm) which is brick lined and egg shaped. This sewer drains combined flows from the area in a south-easterly direction along Avenue Road.

5.28 There are no separate surface water sewers shown on the Thames Water asset plans. In addition, there is no separate sewer identified for the River Tyburn tributary, and therefore it is assumed that this is incorporated into the main combined sewer network. Any excess overland flow is likely to be intercepted by the combined sewer system, reducing the likely risk of surface water flooding to the site. The asset plan for the area is shown in the Appendix.

5.29 The nearest public manhole to the site is no. 0702; however, there is no recorded cover or invert levels within the Thames Water asset information. Ground levels from the Thames Water asset plans show that Avenue Road in a south-easterly direction (approximately 44.5m AOD to the north west of the site) to the east (approximately 42.8m AOD).

5.30 Following the extension of the property, the site will continue to drain to Avenue Road as per the existing connection and with a similar drainage system to the existing site. No CCTV survey of the existing drainage system has been undertaken.

5.31 Flows off the site without any mitigation will increase post development (ignoring climate change), as there is an increase in hard standing on the site. The site will be implementing mitigation measures to reduce surface water flows off the site post development. These mitigation measures should not change the risk of flooding from sewers.

5.32 Levels on site are higher than Avenue Road carriageway, and as a result, any flow which does surcharge the local drainage system is likely to be retained within the road and drain to the south-east away from the site. It is recommended that non-return valves or a positive pumped system are implemented within the proposed basement to reduce the risk of sewers surcharging into the property. However, the residual risk of a blockage in the system cannot be categorically ruled out.

5.33 Finished floor levels are raised above the surrounding levels. This is in accordance with CIRIA guidance[13] where it is recommended that finished floor levels and entrance thresholds are set a minimum of 150mm above surrounding ground levels.

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[13] CIRIA (C635), Designing for Exceedance in Urban Drainage – Good Practice, London 2006

5.34 In summary, provided that the mitigation measures are included within the design in the form of raised thresholds and non-return valves, the risk of flooding from sewers and overland flow is considered to be low.

Flooding from Groundwater

5.35 The online 1:50,000 BGS map indicates the site and wider area to be underlain by the London Clay formation. The mapping indicates that there are no superficial head deposits present within this area. The Environment Agency's online groundwater mapping indicates that the site is not located within a groundwater vulnerability zone. This map confirms that there are no aquifers, bedrock or superficial beneath the site.

5.36 DEFRA online maps show that the site is within a Source Protection Zone (SPZ). The site is shown to be Zone II, the Outer Protection Zone. This is shown in Figure 7. Source Protection Zones were defined by the Environment Agency in order to protect wells, boreholes and springs used for public drinking water supply. These zones indicate areas from which pollutants could reach the water supply, and the outer zone is defined by a 400 day travel time.

5.37 The SFRA shows that there have been two historical groundwater flooding events to the south of the site. These were recorded by the Environment Agency. There are no records of these events affecting property on Avenue Road.

5.38 Water supply for London is obtained from deep aquifers, via boreholes into the Chalk. These bedrock aquifers are found deep beneath the surface across most of London, confined beneath impermeable rock types, including the London Clay. The London Clay is an extensive layer, which the Environment Agency's "Management of the London Basin Chalk Aquifer" 2018 status report confirms is approximately 30-90m thick. The report states that "the low permeability nature of the London Clay overlying these aquifer units prevents the water table reaching the surface". It is noted that this can cause artesian pressure to build up; however, groundwater beneath London is actively managed to ensure that levels are stable.

Figure 7[14] - Magic Maps Source Protection Zone Map

5.39 A site investigation[15] was undertaken in December 2016. Three borehole and eight trial pits were tested, which revealed ground conditions to be generally consistent with geological records. The boreholes revealed a typical succession of Made Ground, ranging from 0.90m to 1.5m thickness below the existing basement level, with the Claystones and London Clay Formation found until the end of the boreholes (20m below existing ground level (BGL)).

5.40 The site investigation notes that seepage was encountered at depths of 9.5m and 8.6m BGL in the boreholes. Seepage was located within the claystone formation.

5.41 Groundwater monitoring was undertaken in standpipes which measured groundwater at depths of between 2.85m BGL and 11.75m BGL. These were in Borehole 2 and 3, located in the middle of the driveway and at the proposed extension location, respectively.

5.42 The site investigation states that '*the London Clay comprises predominantly clay soils, they cannot support groundwater flow and as such do not support a "water table" or continuous piezometric surface. Boreholes constructed within clays do fill with water, due to the often high water content of shallow clays or by the collection of surface water drainage, which is unable to drain through the clay; however, this is not reflective of the type of groundwater flow that would occur in a porous and permeable saturated stratum*'.

5.43 The basement extension is to be constructed wholly within the London Clay, a typically low permeability strata with no continuous water table expected.

5.44 Based on available information and the results of the ground investigation, the risk of flooding as a result of groundwater emerging at the surface is considered to be low. In addition, the wider area is predominantly hard paved and therefore groundwater emerging at the surface is unlikely. Any groundwater which does emerge would drain overland and be collected by the local drainage network with surface water flows.

5.45 Nevertheless, it is assumed that the basement will be constructed within the London Clay. It is therefore required that the proposed basement is built and constructed using appropriate tanked construction to prevent groundwater seepage or ingress into the proposed basement. With the proposed mitigation measures to prevent the ingress of groundwater into the basement, the risk of internal groundwater flooding is low.

[14] Magic Map by DEFRA http://magic.defra.gov.uk/MagicMap.aspx retrieved 08/01/2020

[15] Site Investigation and Basement Impact Assessment Report, 69 Avenue Road London NW8, Geotechnical and Environmental Associates Reference:J16224, December 2016

Flooding from Reservoirs, Canals and Other Artificial Sources

5.46 The Regent's Canal and Regent's Park Lake are the nearest artificial water bodies to the site (reference Figure 12 of the ARUP Study). However at both locations water is not retained above natural ground level and flooding as a result of infrastructure failure is therefore not possible.

5.47 Figure 14 of the ARUP study shows the Hampstead Heath Surface Water Catchments and Drainage including the pond chains, in greater detail. The site is not located within the catchment of the pond chains on Hampstead Heath.

5.48 The risk of flooding from artificial water bodies is therefore considered low.

Climate change

5.49 The current best practice for climate change allowance is the National Planning Policy Framework (NPPF), which defers to the PPG[16] to specify climate change allowances. The Environment Agency recommends an increase in river flows and rainfall intensity depending on which river basin district the site lies in and the type of development.

5.50 The range of allowances is based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it. The central allowance is based on the 50th percentile, the higher central is based on the 70th percentile and the upper end is based on the 90th percentile.

5.51 In this context, the Environment Agency anticipated changes in extreme rainfall intensity in small and urban catchments, which are shown in:

Table 1 – Allowances for Climate Change: Peak Rainfall intensity in small and urban catchments

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

[16] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

5.52 The planned lifetime for the proposed development is assumed to be 100 years, in accordance with the PPG[17] for Flood Risk and Coastal Change.

5.53 The proposed development is classified as 'Highly vulnerable' and therefore it is recommended that the 'Upper End' allowance should be used to assess the future impacts of climate change on peak rainfall intensity. A 40% increase in peak rainfall intensities has been adopted as the allowance for climate change in the design calculations, which is considered to be a precautionary approach.

Flood Risk to Others/SuDS

5.54 In accordance with the NPPF, surface water runoff rates and volumes should not increase as a result of development. The London Plan and associated guidance documents require sites in London to reduce surface water rates by 50%.

5.55 The existing site is mostly impermeable with about 1000m^2 of permeable surfaces. There are no formal SuDS on the site.

5.56 Post development, the site will be increasing the development footprint by approximately 200m^2. This will increase surface water runoff post development and therefore surface water will be managed through the implementation of SuDS.

5.57 Design rainfall intensities have been calculated using the Wallingford Procedure[18] and the resulting runoff was calculated using the Modified Rational Method. Calculation sheets are provided in the Appendix.

5.58 A 100-year, 5.0 minute critical storm (M5-60 of 20mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity of 169.1 mm/h. The resulting runoff rate from the existing site prior to redevelopment has been calculated to be 58.06 l/s for the 1 in 100 annual probability rainfall event.

5.59 Post development, considering the increase of inpermeable areas on the site, a 1% AEP, 5-minute critical storm (M5-60 of 20mm and an 'R' value of 0.4) has been applied to arrive at a rainfall intensity 169.1 mm/h. The resulting runoff rate from the post development case has been calculated to be 67.0 l/s for the 1 in 100 year annual probability rainfall event.

5.60 An increase of 40% in the rainfall intensity to make allowance for climate change has been applied to the post-development state, this results in a runoff rate of 93.78 l/s.

5.61 To mitigate against this increase of surface water runoff, the development proposes to implement greens roofs on the proposed extension. Adding a green roof with a subbase of 10-15cm with 100% runoff reduces the runoff rate to 86.54/s for the 1 in 100 year plus climate change storm event.

---

[17] http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/the-exception-test/what-is-considered-to-be-the-lifetime-of-development-in-terms-of-flood-risk-and-coastal-change/ Retrieved 08/02/2019

[18] HR Wallingford (2000) The Wallingford Procedure for Europe – Best Practice Guide to urban drainage modelling (CD)

5.62 The additional permeability of the green roof does reduce rates however it is not sufficient to comply to the NPPF or London Plan. In order to reduce existing runoff rates by 50% in the post-developed state including an allowance for climate change (in accordance with the London Plan) a minimum of 15.0m^3 of storage will be required.

5.63 A blue roof of at least 7.5cm across the proposed extension is sufficient to ensure that surface water rates can be restricted to 50% of the existing site. A blue-green roof configuration is shown in Appendix A

5.64 Calculations undertaken in this assessment are located within the Appendix B of this FRA.

5.65 It is recommended that any proposed new hard standing utilises permeable pavers and tarmac to further reduce surface water runoff.

5.66 The detailed surface water system should be designed in accordance with local planning policy and will be designed such that runoff from the 1% AEP rainfall event plus climate change allowance is fully retained on the site and discharged at the controlled rate. Full drainage design will be undertaken at the detailed design stage.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 The site is located at 69 Avenue Road in the London Borough of Camden and is currently occupied by the development on the site. Proposals are to extend the building above ground and create a basement. The basement will be extended downwards and extend a small amount outside the existing footprint of the building to the rear.

6.2 In accordance with local planning policy and following the London Borough of Camden Surface Flow and Flooding flowchart, a screening assessment has been undertaken. As a result, the site was required to undertake a flood risk assessment in accordance with the NPPF.

6.3 The Environment Agency flood zone maps indicate that the site is located in Flood Zone 1 (Low Risk). In accordance with the technical guidance document to the National Planning Policy Framework (NPPF), this zone comprises land assessed as having a less than 1 in 1000 annual probability of fluvial or tidal flooding (<0.1%). There is therefore no risk of flooding to the site from rivers or the sea.

6.4 The site is located close to the original route of a tributary of the River Tyburn; one of London's "lost rivers". This watercourse is now incorporated into the local sewer network and any overland flow will follow natural drainage routes. No evidence of any open channel or specific drainage infrastructure associated with this lost river was found onsite during site investigation. It is therefore considered unlikely that there is any additional risk to the site.

6.5 The GOV.UK Long Term Flood Risk maps for surface water indicate that there is a natural flow path draining down Avenue Road and that the rear garden is affected by surface water. The site and development are located sufficiently high enough to not be affected by this flow within Avenue Road. The rear garden is approximately 1m lower than the existing dwelling and therefore collects surface water in high return periods. As the existing house and proposed extension are setting FFL higher than the surface water flood level and will include flood mitigation measures to at least 300mm above the 1 in 1000 year surface water flood event, the risk of surface water ingress to the development is low.

6.6 The proposed new basement has an exterior opening, in the form of a lightwell, which puts the basement at risk of surface water flooding. To mitigate against this risk the development is implementing retaining walls to stop the ingress of surface water into the proposed basement via the lightwell.

6.7 An on-site ground investigation concluded that the geology below the existing basement comprised of made ground over the London Clay Formation. The site investigation notes that seepage was encountered at depths of 9.5m and 8.6m bgl in the boreholes. Groundwater monitoring was also undertaken which measured groundwater at a depth of 2.85m bgl and 11.75m bgl. The site investigation concluded that '*due to the often high water content of shallow clays or by the collection of surface water drainage, which is unable to drain through the clay; however, this is not reflective of the type of groundwater flow that would occur in a porous and permeable saturated stratum*'.

6.8 It is recommended that the basement extension is designed and constructed with appropriate tanked system to prevent groundwater ingress into the proposed basement. With these proposed mitigation measures the risk of groundwater ingress is low. In addition, it is recommended that the basement foul outlets have a non-return valves incorporated into the system to prevent internal flooding of the basement in the event of a blockage in the public sewer system. Therefore the risk of surface water and sewer flooding to the site are considered to be low.

6.9 There is an increase in impermeable area on site following development, which subsequently means there is an increase in the rate of runoff from the site (ignoring any increases as a result of climate change). The development will mitigate this increased runoff by implementing a green and blue roof to ensure a 50% decrease in surface water runoff rates.

6.10 All other sources of flooding have been assessed in accordance with the NPPF and are considered, with the mitigation measures proposed, to pose a low risk to the site.

APPENDIX A - DRAWINGS

Drawing 1 – Topographical Survey

Foundation Architecture Ltd Job Number 522 Drawing 001

Drawing 2 - Proposed Drawings Ground Floor

KSR Architects and Interior Designers Drawing Num: 18030-P100 REV A

Drawing 3- Proposed Drawings Basement Floor

KSR Architects and Interior Designers Drawing Num: 18030-P090

Drawing 4- Proposed Drawings Roof Plan

KSR Architects and Interior Designers Drawing Num: 18030-P130

Drawing 5- Proposed Drawings Elevation

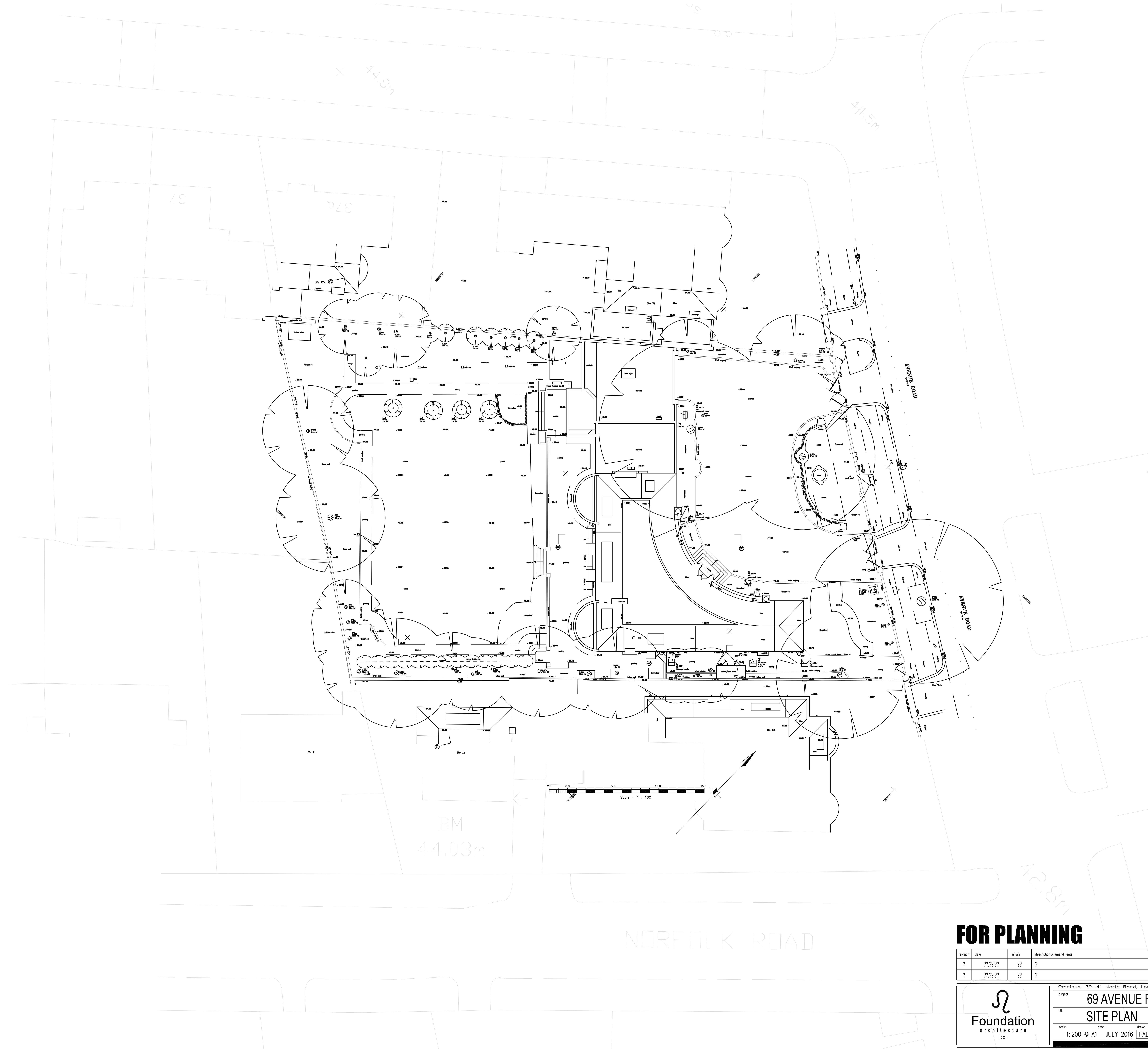
KSR Architects and Interior Designers Drawing Num: 18030-P202 REV A

Drawing 6- Proposed Drawings Elevation

KSR Architects and Interior Designers Drawing Num: 18030-P203 REV A

Drawing 7- Proposed Drawings Elevation

KSR Architects and Interior Designers Drawing Num: 18030-P201 REV A



FOR PLANNING

revision	date	initials	description of amendments
?	??.??.??	??	?
?	??.??.??	??	?

Foundation architecture ltd.

Omnibus, 39–41 North Road, London, N7 9DP Email: info@foundation–architecture.com

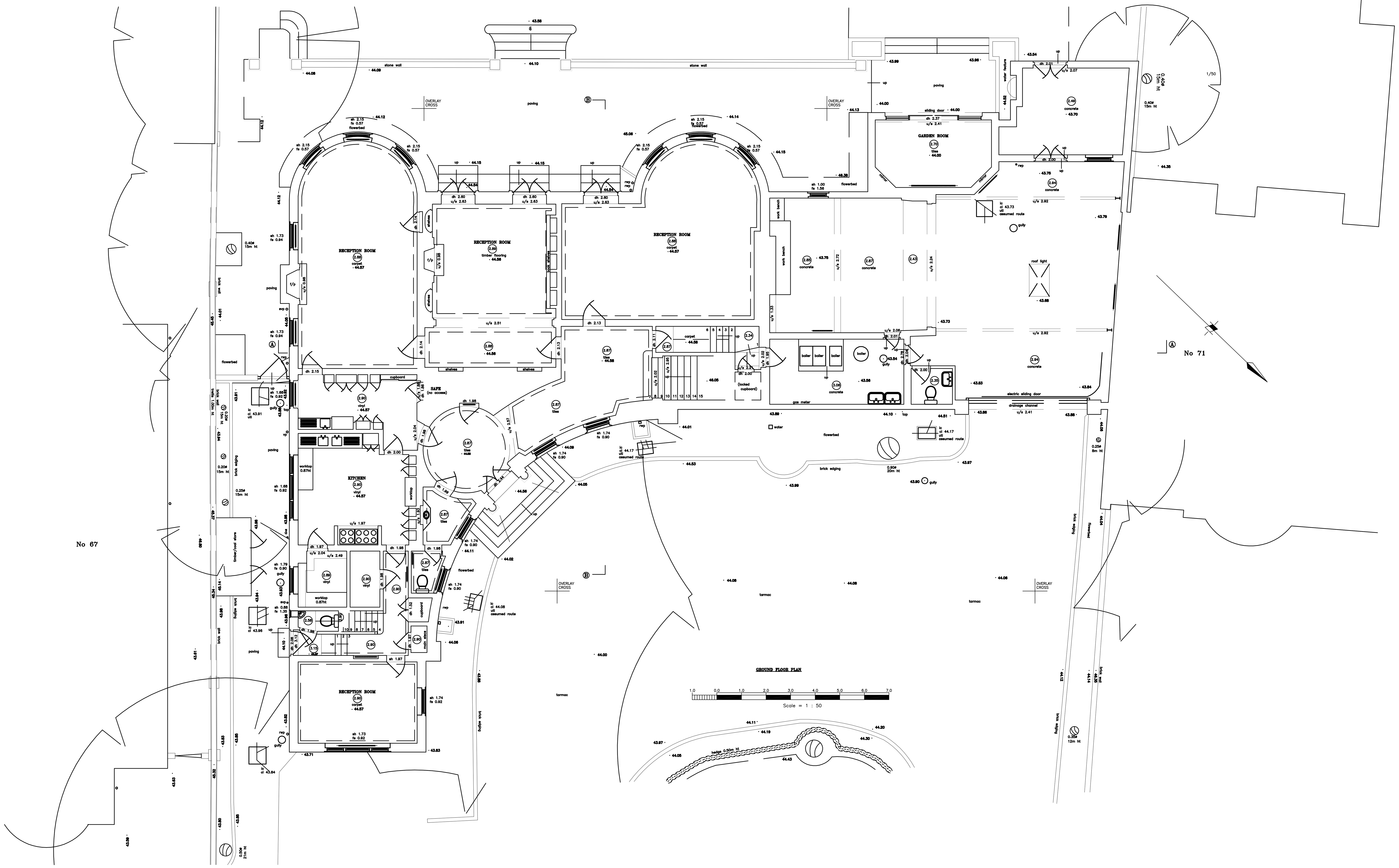
project: 69 AVENUE ROAD NW8 6HP

title: SITE PLAN

scale	date	drawn	checked	job no.	dwg no.	rev.
1:200 @ A1	JULY 2016	FAL		522	**001**	

All dimensions to be verified on site.

*Scale is 1:? at A3



FOR PLANNING

revision	date	initials	description of amendments
?	??.??.??	??	?
?	??.??.??	??	?

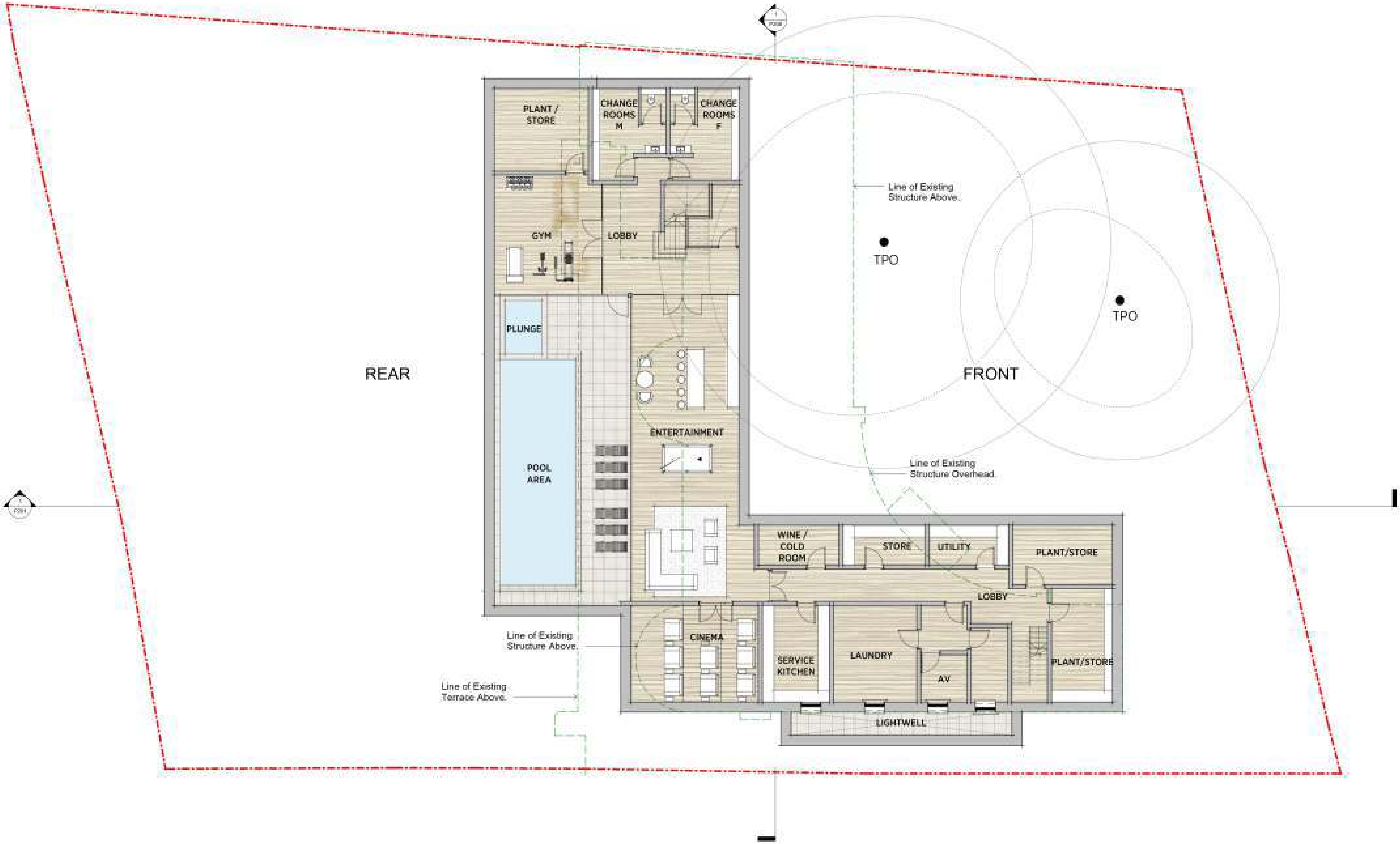
Omnibus, 39-41 North Road, London, N7 9DP Email:info@foundation-architecture.com

Foundation architecture ltd.

project	69 AVENUE ROAD NW8 6HP				
title	GROUND FLOOR PLAN				
scale	date	drawn	checked	job no.	dwg no. / rev.
1:100 @ A1	JULY 2016	FAL		522	100

All dimensions to be verified on site.

*Scale is 1:? at A3



Planning

KSR ARCHITECTS & INTERIOR DESIGNERS

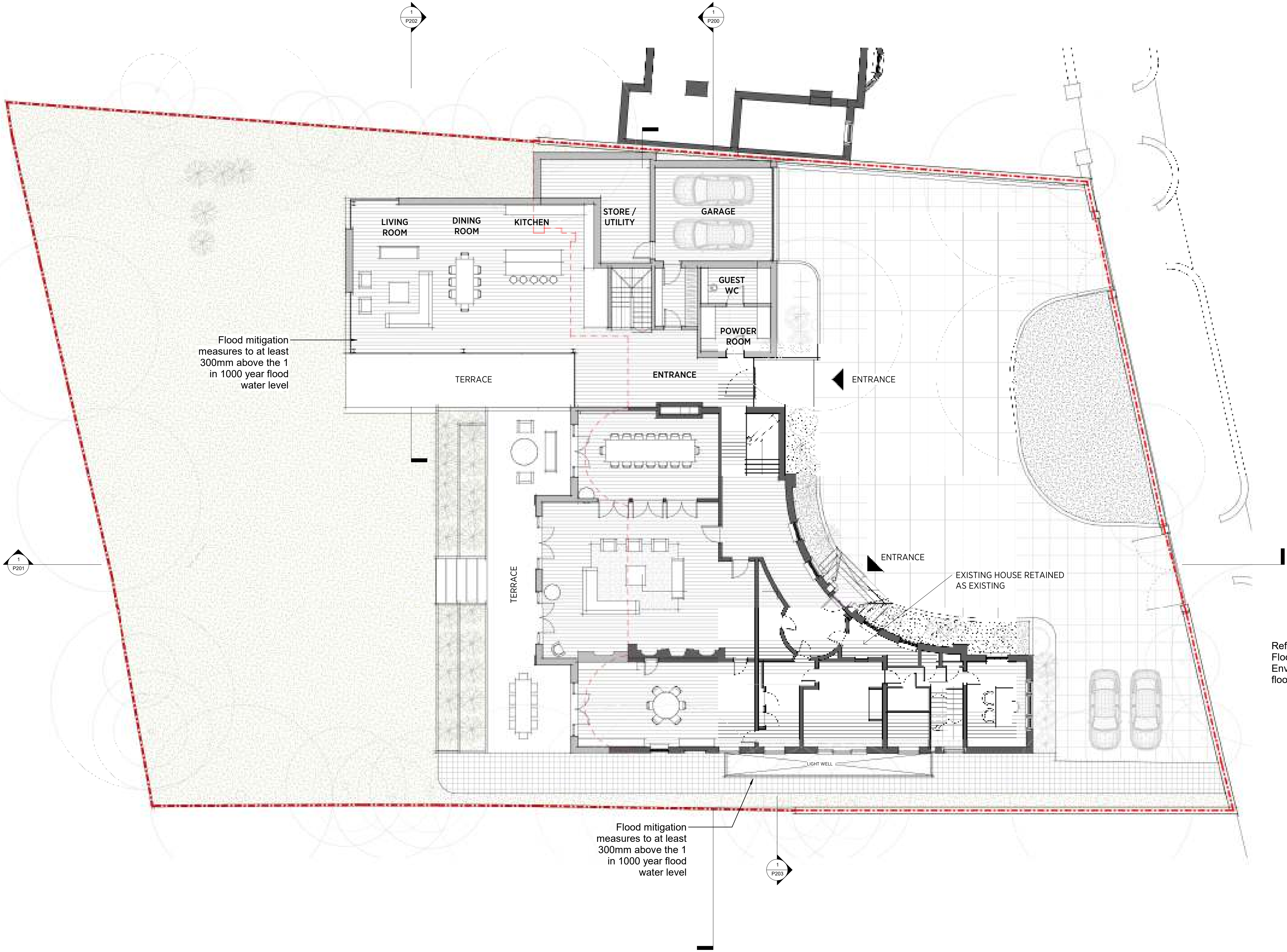
Project: 99 Avenue Road

Basement

31/01/20 — 1:100 @A1 / 1:200 @A3

MF — DC

18030-P090



Reference should be made to the Flood Risk Assessment by Water Environment for more information on flood water levels

Rev	Description	Date	By
A	FRA notes added	30/11/20	DC

Status:

Planning

Key Plan:

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Project:

69 Avenue Road

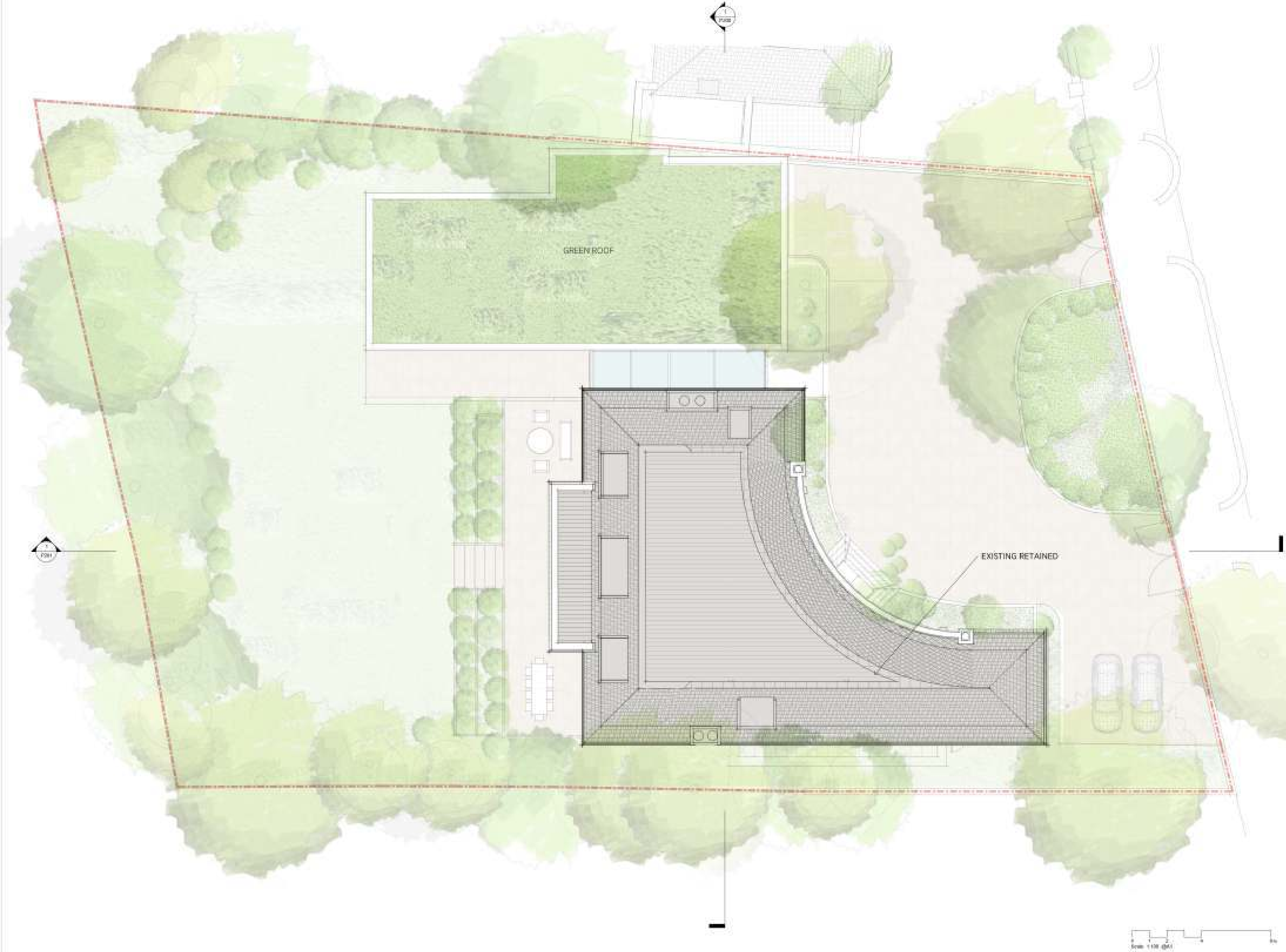
Drawing Title:

Ground Floor Plan

Date of first issue: 31/01/20
Scale: 1:100 @A1 / 1:200 @A3

Drawn By: MF
Checked By: DC

Drawing No: **18030-P100**
Rev: **A**



Planning

KSR ARCHITECTS & INTERIOR DESIGNERS

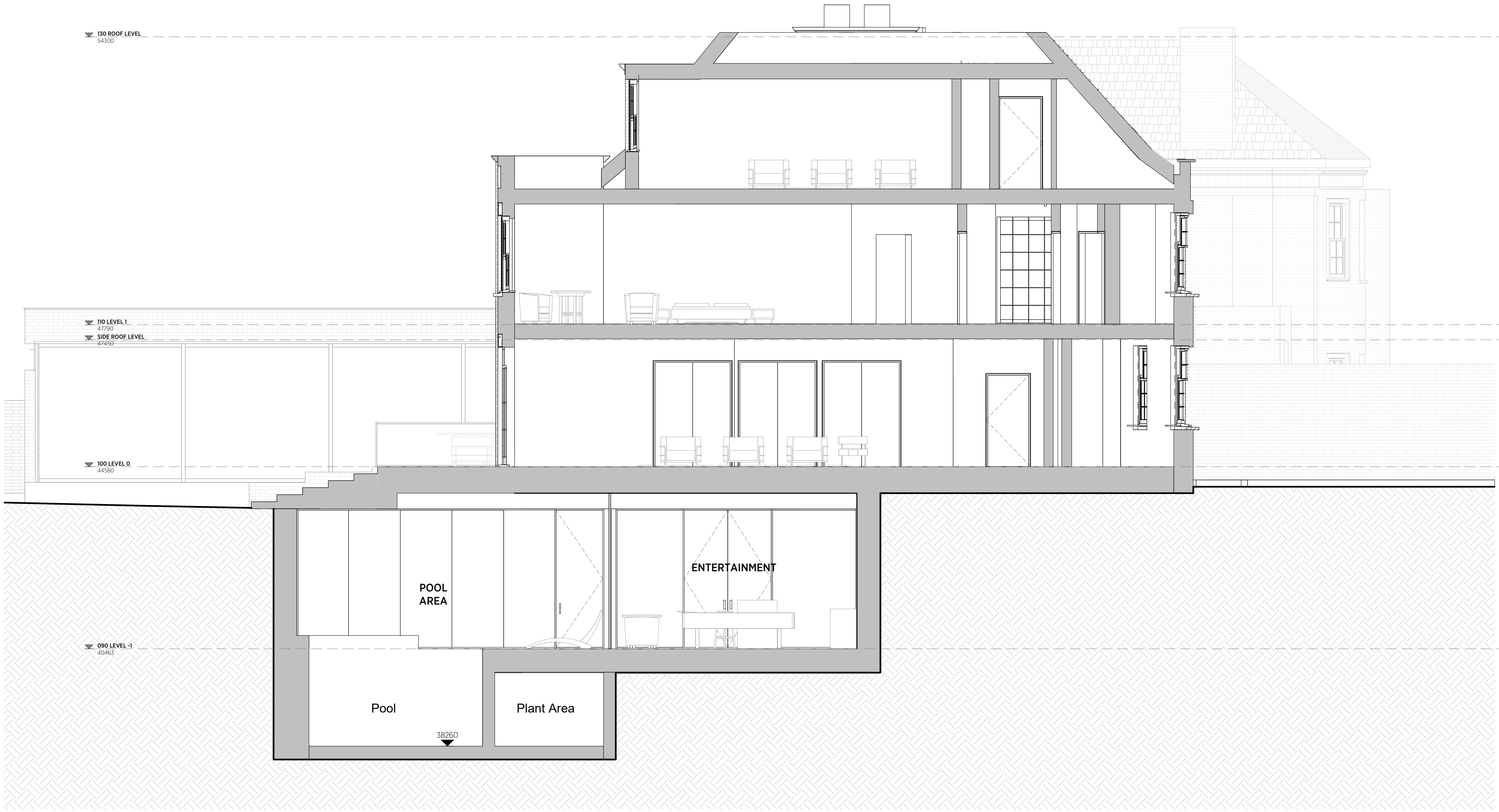
Project: 80 Avenue Road

Drawing Title: Roof Plan

31/01/20 — 1:100 @A1 / 1:50 @A3

MF — DC

18030-P130



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Scale 1:50 @A1

Rev	Description	Date	By

Status:

Scale:

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Project:

69 Avenue Road

Drawing Title:

Section B

Date of first issue: 01/09/20

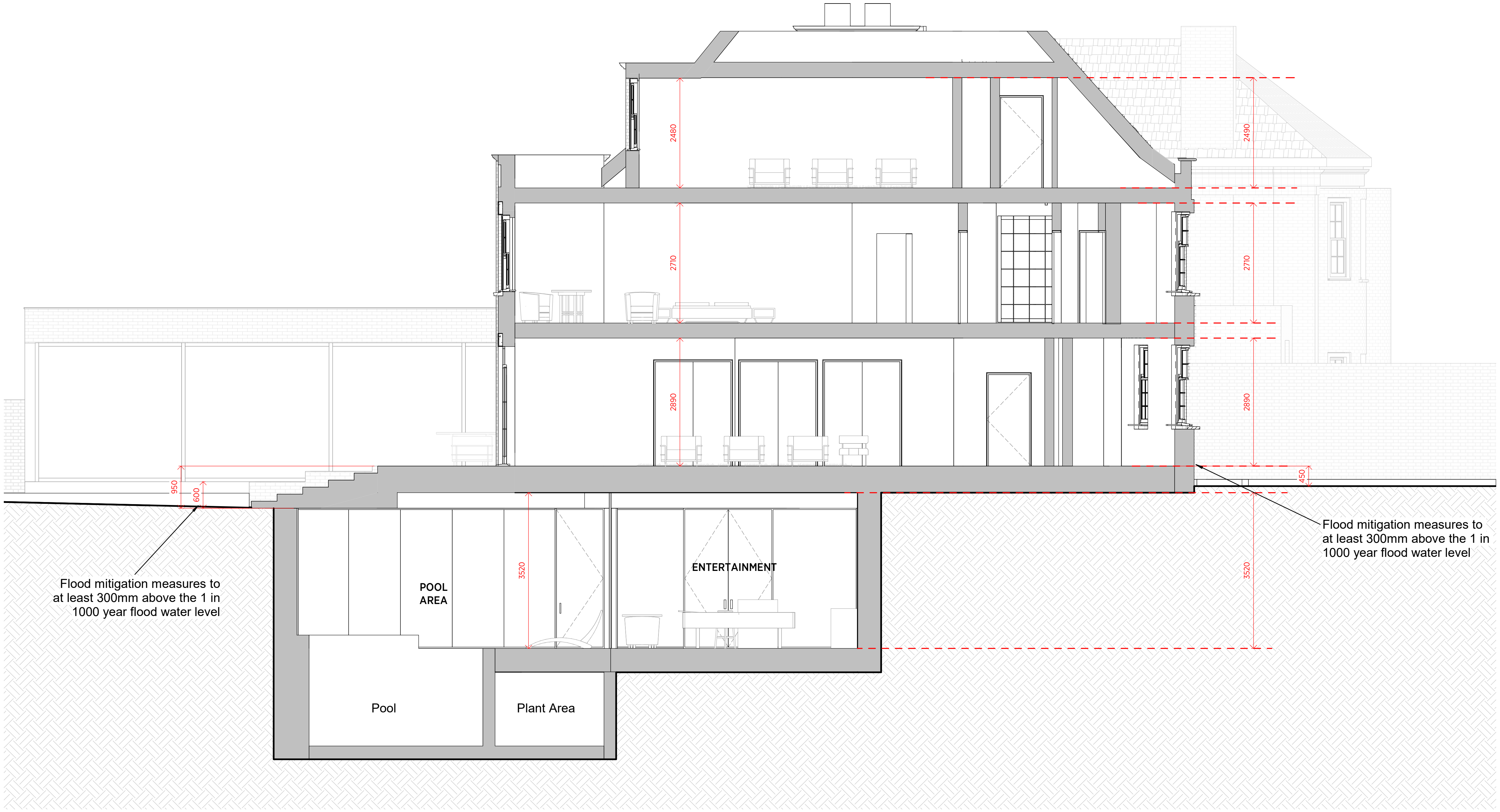
Drawn By: Author

Checked By: Checker

Drawing No: **18030-P201**

Rev:

DRAFT 20/01/2020 14:14:44



Reference should be made to the Flood Risk Assessment by Water Environment for more information on flood water levels

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Scale 1:50 @A1

Rev	Description	Date	By
A	FRA notes added	30/11/20	DC

Status:

Scale:

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Project: **69 Avenue Road**

Drawing Title: Section B

Date of first issue: 05/18/20

Drawn By: Author

Checked By: Checker

Drawing No: **18030-P201**

Rev: **A**

Flood mitigation measures to at least 300mm above the 1 in 1000 year flood water level

Flood mitigation measures to at least 300mm above the 1 in 1000 year flood water level

1 Section C
1 : 50

Reference should be made to the Flood Risk Assessment by Water Environment for more information on flood water levels

GENERAL NOTES:

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Scale 1:50 @A1

Rev	Description	Date	By
A	FRA notes added	30/11/20	DC

Status:

Scale:

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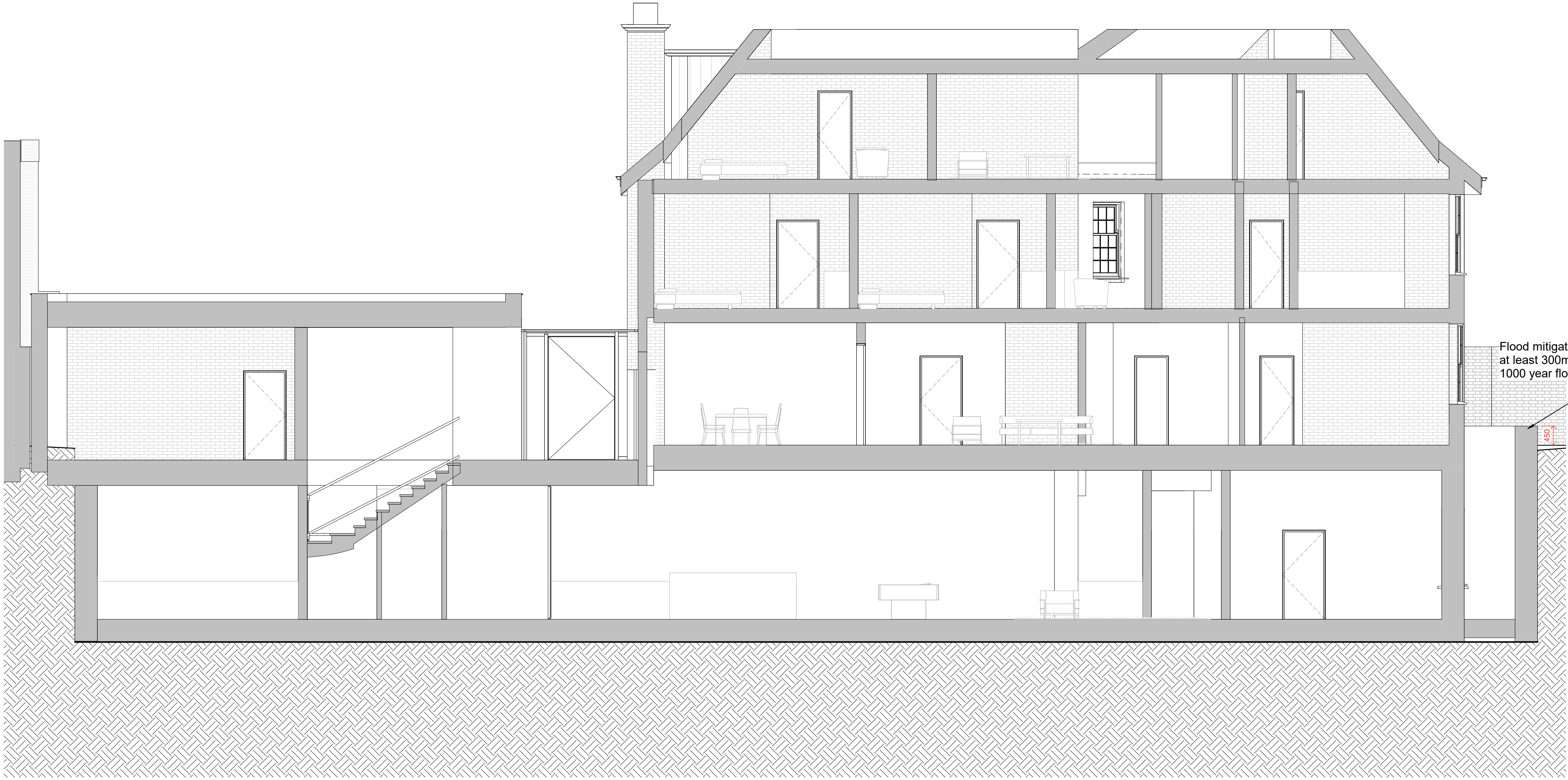
Drawing Title:
Section C

Date of first issue:	Drawn By:	Checked By:	Drawing No:	Rev:
11/30/20	Author	Checker	**18030-P202**	**A**



1 Section D
1 : 50

Reference should be made to the Flood Risk Assessment by Water Environment for more information on flood water levels

GENERAL NOTES:

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Rev	Description	Date	By
A	FRA notes added	30/11/20	DC

Status:

Scale:
1:100 @A3

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Project:
69 Avenue Road

Drawing Title:
Section D

Date of first issue: 11/30/20
Drawn By: Author
Checked By: Checker
Drawing No: **18030-P203**
Rev: **A**

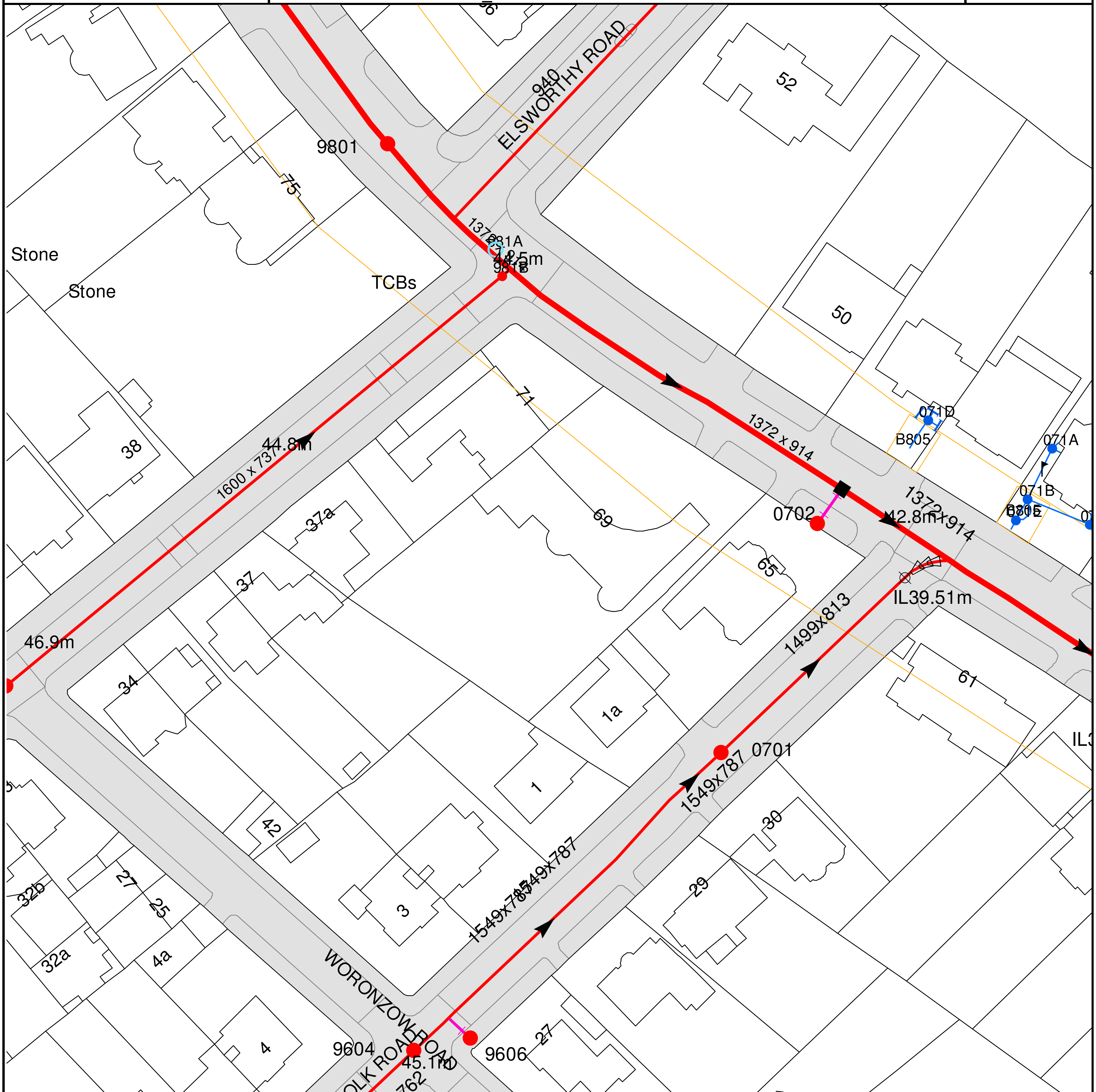
APPENDIX B –TW ASSET SEARCH

Drawing 8- Asset Location Map

Thames Water, Ref No. 2018_3807954

This map shows the Thames Water asset locations near the site.

Asset Location Search Sewer Map - ALS/ALS Standard/2018_3807954



The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 526978,183775

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

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
071C	42.76	40.86
071E	42.69	39.54
071B	42.78	n/a
071A	42.73	40.86
071D	43.64	41.23
9801	44.68	39.4
981A	n/a	n/a
981B	n/a	n/a
9604	45.06	42.3
9606	n/a	n/a
0701	43.42	40.37
0702	n/a	n/a

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

ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.

Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.

- Trunk Surface Water
- Trunk Foul
- Storm Relief
- Trunk Combined
- Vent Pipe
- Bio-solids (Sludge)
- Proposed Thames Surface Water Sewer
- Proposed Thames Water Foul Sewer
- Gallery
- Foul Rising Main
- Surface Water Rising Main
- Combined Rising Main
- Sludge Rising Main
- Proposed Thames Water Rising Main
- Vacuum

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

- Air Valve
- Dam Chase
- Fitting
- Meter
- Vent Column

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

- Control Valve
- Drop Pipe
- Ancillary
- Weir

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

- Outfall
- Undefined End
- Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

- Public/Private Pumping Station
- Change of characteristic indicator (C.O.C.I.)
- Invert Level
- Summit

Areas

Lines denoting areas of underground surveys, etc.

- Agreement
- Operational Site
- Chamber
- Tunnel
- Conduit Bridge

Other Sewer Types (Not Operated or Maintained by Thames Water)

- Foul Sewer
- Surface Water Sewer
- Combined Sewer
- Gulley
- Culverted Watercourse
- Proposed
- Abandoned Sewer

Notes:

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plans are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
5) 'na' or '0' on a manhole level indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in milimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

APPENDIX C – SURFACE WATER CALCULATIONS

Surface Water Calculations

D21 RUNOFF CALCULATIONS — COVER SHEET

Job No.	18024
Job Name	69 Avenue Road
Engineer	Noah Bennett NB
Checked By	Claire Burroughs CB
Date	21/02/2020

Site Characteristics

Site Area (ha) 0.23

	Overall		Discharging from site		
Existing Pervious Surfaces (ha)	0.1	43%	0	β	0%
Existing Impervious Surfaces (ha)	0.13	57%	0.13	α	100%
Total:	0.23	Total:	0.13		

	Overall		Discharging from site		
Proposed Pervious Surfaces (ha)	0.08	35%	0	β	0%
Proposed Impervious Surfaces (ha)	0.13	57%	0.13	α	100%
Proposed Green Roof	0.02	9%	0.02	γ	100%
Total:	0.23	Total:	0.15		

Green Roof Type: sedum-herbaceius-grass plants >10-15 cm Course Depth
Construction Depth: 100-150mm Gradient: of up to 15°,

Peak Rate of Runoff

Existing Site	BROWNFIELD	
Detailed Modelling Used?	No	e.g. Microdrainage, HydroCAD, Multiple Catchments
Runoff Calculation Method (Existing)	Wallingford/Modified Rational	Calculation Sheets Attached
Runoff Calculation Method (Proposed)	Wallingford/Modified Rational	Calculation Sheets Attached
Allowance for Future Climate Change	To 2115 UE 40%	
Surface Water Management Strategy	Attenuated on Site	

	1yr	30yr	100yr		
Existing Discharge Rate	**19.5**	**45.9**	**58.1**	l/s	
IoH Greenfield Discharge Rate (full site)	**0.8**	**2.1**	**2.9**	l/s	
Detailed modelling output/FEH:				l/s	
Limiting Discharge Rate	19.5	45.9	58.1	l/s	
Post-Development Discharge Rate	20.7	48.8	61.8	l/s	
Detailed modelling output:				l/s	
including allowance for climate change	**29.0**	**68.4**	**86.5**	l/s	
Proposed Discharge Rate	19.5	45.9	58.1	l/s	
Bespoke Limiting Discharge Rate	9.7	22.9	29.0		
Design discharge rate:	**9.7**	**22.9**	**29.0**	l/s	Bespoke Rate
Minimum Storage Required	**4.5**	**11.5**	**15.0**	m^3	

Volume of Runoff

Additional Volume (above Greenfield) of Runoff Generated

Existing Site	-2.5	m^3
Proposed Site (unmitigated)	10.2	m^3
Rainwater retained on-site for re-use (where limited)	0.0	m^3
Long Term Storage Required	12.7	m^3
Proposed Site (including soakaways/infiltration SUDS)	4.2	m^3

Off-site discharge must be restricted and storage provided

Justification for not using infiltration or preventing discharge: Ground conditions not suitable

	1yr	Qbar	2 l/s/ha	Min Flow*
Limiting discharge rates:	19.5	0.92	0.46	2 (l/s)

Preferred Limiting Discharge Rate: 2.0 l/s — Design and model outputs attached

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IH124 : Greenfield Peak Runoff	18024	69 Avenue Road	
	Calculations By: NB	Checked By: CB	Date: 21/02/2020

Catchment Area	AREA	ha	0.23
Drained Area	AREA	ha	0.13
Standard average annual rainfall 1941 - 1970	SAAR	mm	597
Soil Index (from FSR or Wallingford Procedure WRAP maps)*	SOIL		0.47

*SOIL is the SPR for the soil type, and for larger sites is a weighted sum of the individual soil classes for the site, where:

$$SOIL = \frac{0.1ASOIL1 + 0.3ASOIL2 + 0.37ASOIL3 + 0.47ASOIL5 + 0.53ASOIL5}{AREA}$$

For smaller sites, use the SPR for the local soil type, as follows:

SOIL TYPE	1	2	3	4	5	
AREA	0	0	0	0.23	0	**SOIL:**
SPR	0.1	0.3	0.37	0.47	0.53	**0.47**

QBAR = 0.00108 . (0.01AREA)$^{0.89}$. SAAR$^{1.17}$. SOIL$^{2.17}$

* The site area is less than 50ha. Since the IoH124 methodology is not calibrated for sites less than 50ha in area, the calculation should be undertaken based on a 50ha site area and proportionately adjusted based on the ratio of the site size to 50ha.

$QBAR_{50ha}$	l/s	200.38
QBAR/ha	l/s/ha	4.01
$QBAR_{site}$	l/s	**0.52**

Hydrological Area	fig 4.2	6

Return Period (years)	Growth Factor (table 4.3)	Discharge rate l/s
1	0.85	**0.44**
2	0.88	0.46
10	1.62	0.84
30	2.3	**1.20**
50	2.62	1.36
100	3.19	**1.66**

Figures and table references from CIRIA C753 The SUDS Manual © CIRIA 2015

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Wallingford Procedure : Existing Peak Runoff

18024	69 Avenue Road	
Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Characteristics

Site Area	AREA	ha	0.23
Drained Catchment Area	AREA	ha	0.13
Approximate Longest Drainage Path	L	m	35
Difference in Ground Levels	ΔH	m	0.3
Slope	Slope (S)		1: 117
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	0%
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	100%
Area Weighted Rational Method Runoff Coefficient			0.950

Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40

Time of Concentration

Recommended Tc Method: SCS: Sheet Flow

Tc Method Choice: SCS: Sheet Flow

Sheet Flow

Surface Description			Concrete (smooth)
Slope			Shallow
Roughness Coefficient	(Manning's n)		0.017
Flow Length, L		m	35
M2-24hr		mm	37.70
Land Slope		m/m	0.00857
Tc		hr	0.07

Time of Concentration	T_c	min	4.0
Critical Storm Duration (minimum 5min)	T_{crit}	min	5.0

Critical Storm Rainfall and Runoff

$Z1_{TC}$ 0.38 *Wallingford Procedure Figure 3.6

$M5\text{-}T_{crit}$ 7.7

C 0.950

Discharge Rate
Q = 2.78CiA

Return Period (years)	Z2*	Depth (mm)	Intensity (mm/hr)	Discharge Rate l/s
1	0.62	4.7	56.7	**19.46**
2	0.79	6.1	72.7	24.95
10	1.20	9.2	110.6	37.97
30	1.45	11.1	133.6	**45.86**
50	1.60	12.2	146.8	50.41
100	1.84	14.1	169.1	**58.06**

*Wallingford Procedure Table 3.2

Wallingford Procedure : Developed Peak Runoff

18024	69 Avenue Road	
Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Characteristics

Site Area	AREA	ha	0.23
Drained Catchment Area	AREA	ha	0.15
Approximate Longest Drainage Path	L	m	35
Difference in Ground Levels	ΔH	m	0.3
Slope	Slope (S)		1: 117
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	0%
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	87%
Green Roof of gradient of up to 15°, and depth of 100-150mm , c=		0.4 *	13%
Area Weighted Rational Method Runoff Coefficient			0.88

*in line with Table 10.1 of CIRIA C644

Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40

Time of Concentration

Recommended Tc Method: SCS: Sheet Flow

Tc Method Choice: SCS: Sheet Flow

Sheet Flow

Surface Description			Concrete (smooth)
Slope			Shallow
Roughness Coefficient	(Manning's n)		0.017
Flow Length, L		m	35
M2-24hr		mm	37.70
Land Slope		m/m	0.00857
Tc		hr	0.07

Time of Concentration	T_c	min	4.0
Critical Storm Duration (minimum 5min)	T_{crit}	min	5.0

Critical Storm Rainfall and Runoff

$Z1_{TC}$ 0.38 *Wallingford Procedure Figure 3.6

$M5\text{-}T_{crit}$ 7.7

C 0.877

Discharge Rate

Q = 2.78CiA

Return Period (years)	Z2*	Depth (mm)	Intensity (mm/hr)	Discharge Rate l/s	Future Rate l/s
1	0.62	4.7	56.7	**20.72**	**29.00**
2	0.79	6.1	72.7	**26.57**	37.20
10	1.20	9.2	110.6	**40.43**	56.60
30	1.45	11.1	133.6	**48.83**	**68.37**
50	1.60	12.2	146.8	**53.68**	75.15
100	1.84	14.1	169.1	**61.82**	**86.54**

*Wallingford Procedure Table 3.2

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MRM 100 year Event Storage Calculator	18024	69 Avenue Road	
	Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Parameters

Drained Catchment Area	AREA	ha	0.15
Approximate Longest Drainage Path	L	m	35
Difference in Ground Levels	ΔH	m	0.3
Slope	Slope (S)		1: 117
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	0%
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	87%
Green Roof of gradient of up to 15°, and depth of 100-150mm , c=		0.4 *	13%
Area Weighted Rational Method Runoff Coefficient			0.88

*in line with the FLL Guidelines on Planning, Execution and Upkeep of Green Roof Sites, 2002

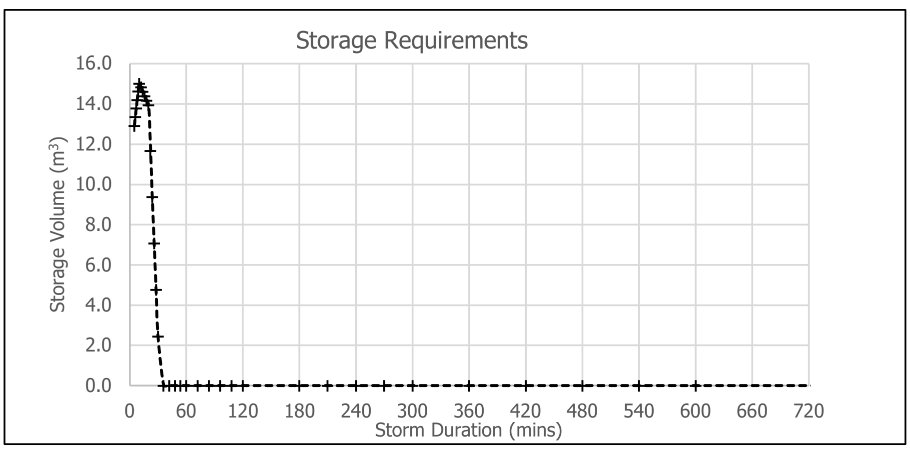
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40
Time of Concentration	T_c	min	4.0

Maximum Storm Runoff Storage Volume (modified rational method)

	5	
T_d	10.0	min
$Z1_{TD}$	0.51	*Wallingford Procedure Figure 3.6
$M5\text{-}T_d$	10.2	mm
C	0.88	
$Z2_{100}$	1.91	*Wallingford Procedure Table 3.2
$M100\text{-}T_d$	19.5	mm
Intensity	117.1	mm/hr
Q_d	42.8	l/s
$Q_{d,climate\ change}$	59.9	l/s
$Q_{limiting\ discharge}$	29.0	l/s

Maximum storage required	m^3	15.0



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MRM 30 year Event Storage Calculator	18024	69 Avenue Road	
	Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Parameters

Drained Catchment Area	AREA	ha	0.15
Approximate Longest Drainage Path	L	m	35
Difference in Ground Levels	ΔH	m	0.3
Slope	Slope (S)		1: 117
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	0%
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	87%
Green Roof of gradient of up to 15°, and depth of 100-150mm , c=		0.4 *	13%
Area Weighted Rational Method Runoff Coefficient			0.88

*in line with the FLL Guidelines on Planning, Execution and Upkeep of Green Roof Sites, 2002

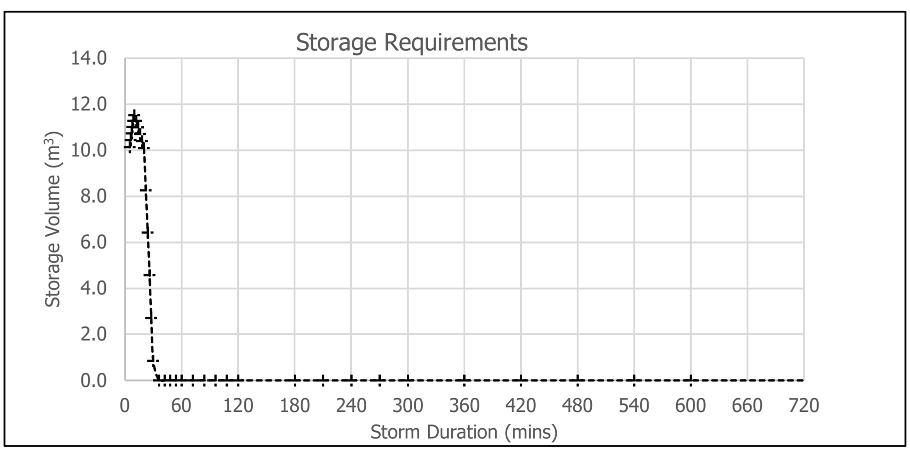
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40
Time of Concentration	T_c	min	4.0

Maximum Storm Runoff Storage Volume (modified rational method)

T_d	10.0	min
$Z1_{TD}$	0.51	*Wallingford Procedure Figure 3.6
$M5\text{-}T_d$	10.2	mm
C	0.88	
$Z2_{30}$	1.49	*Wallingford Procedure Table 3.2
$M30\text{-}T_d$	15.2	mm
Intensity	91.3	mm/hr
Q_d	33.4	l/s
$Q_{d,climate\ change}$	46.7	l/s
$Q_{limiting\ discharge}$	22.9	l/s

Maximum storage required	m^3	11.5



Date Printed: 21/02/2020

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MRM 1 year Event Storage Calculator	18024	69 Avenue Road	
	Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Parameters

Drained Catchment Area	AREA	ha	0.15
Approximate Longest Drainage Path	L	m	35
Difference in Ground Levels	ΔH	m	0.3
Slope	Slope (S)		1: 117
Permeable Surfaces (Rational Method runoff coefficient = 0.4)		ha	0%
Impermeable Surfaces (Rational Method runoff coefficient = 0.95)		ha	87%
Green Roof of gradient of up to 15°, and depth of 100-150mm , c=		0.4 *	13%
Area Weighted Rational Method Runoff Coefficient			0.88

*in line with the FLL Guidelines on Planning, Execution and Upkeep of Green Roof Sites, 2002

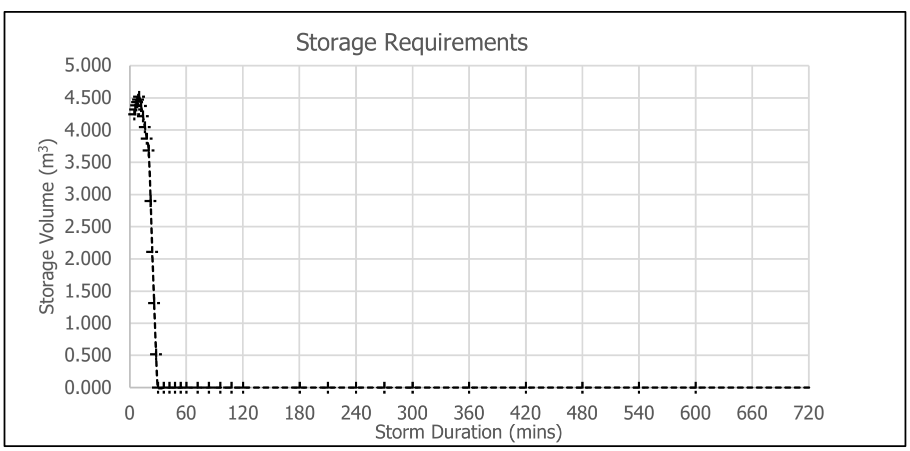
Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40
Time of Concentration	T_c	min	4.0

Maximum Storm Runoff Storage Volume (modified rational method)

T_d	10.0	min
$Z1_{TD}$	0.51	*Wallingford Procedure Figure 3.6
$M5\text{-}T_d$	10.2	mm
C	0.88	
$Z2_1$	0.61	*Wallingford Procedure Table 3.2
$M1\text{-}T_d$	6.2	mm
Intensity	37.4	mm/hr
Q_d	13.7	l/s
$Q_{d,climate\ change}$	19.1	l/s
$Q_{limiting\ discharge}$	9.7	l/s

Maximum storage required m^3 4.5



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SUDS Manual Volume Calculation (Existing)

18024	69 Avenue Road	
Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Characteristics

Site Area	AREA	ha	0.23
Permeable Surfaces (Existing Case)			43%
Proportion discharging to sewer network or local watercourses	β		0%
*zero if all runoff collected from unpaved surfaces is retained on site or discharged to ground			
Impermeable Surfaces (Existing Case)	PIMP		57%
Proportion discharging to sewer network or local watercourses	α		100%
*zero if all runoff from paved surfaces remains on site or is collected and discharged to ground			
Soil Index (from FSR or Wallingford Procedure WRAP maps)*	SOIL		0.47

*SOIL is the SPR for the soil type, and for larger sites is a weighted sum of the individual soil classes for the site, where:

$$SOIL = \frac{0.1A_{SOIL1} + 0.3A_{SOIL2} + 0.37A_{SOIL3} + 0.47A_{SOIL4} + 0.53A_{SOIL5}}{AREA}$$

For smaller sites, use the SPR for the local soil type, as follows:

SOIL TYPE	1	2	3	4	5
AREA	0	0	0	0.23	0
SPR	0.1	0.3	0.37	0.47	0.53

SOIL: 0.47

Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40

Volume Calculation for the 100 year return period 6hr storm

$Z1_{6hr}$	1.55	*Wallingford Procedure Figure 3.6
M5-6hr	31.1	
$Z2_{100yr}$	1.97	*Wallingford Procedure Table 3.2
M100-6hr	61.2	

Additional volume (m^3) of existing site runoff over Greenfield runoff:

$$Vol = \text{"M100-6hr"}.AREA.10[PIMP/100\ (0.8\alpha)+(1-PIMP/100)SOIL\ .\ \beta-SOIL]$$

* EQ24.10 CIRIA C753 The SUDS Manual © CIRIA 2015

Additional Volume of Runoff (above Greenfield state): m^3 **-2.5**

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SUDS Manual Volume Calculation (Proposed)

18024	69 Avenue Road		
Calculations By: NB	Checked By: CB	Date: 21/02/2020	

Site Characteristics

Site Area	AREA	ha	0.23
Permeable Surfaces (Proposed Case)			35%
Proportion discharging to sewer network or local watercourses	β		0%
*zero if all runoff collected from unpaved surfaces is retained on site or discharged to ground			
Impermeable Surfaces (Proposed Case)	PIMP		65%
Proportion discharging to sewer network or local watercourses	α		100%
*zero if all runoff from paved surfaces remains on site or is collected and discharged to ground			
Soil Index (from FSR or Wallingford Procedure WRAP maps)*	SOIL		0.47

*SOIL is the SPR for the soil type, and for larger sites is a weighted sum of the individual soil classes for the site, where:

$$SOIL = \frac{0.1A_{SOIL1} + 0.3A_{SOIL2} + 0.37A_{SOIL3} + 0.47A_{SOIL4} + 0.53A_{SOIL5}}{AREA}$$

For smaller sites, use the SPR for the local soil type, as follows:

SOIL TYPE	1	2	3	4	5	
AREA	0	0	0	0.23	0	**SOIL:**
SPR	0.1	0.3	0.37	0.47	0.53	**0.47**

Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40

Volume Calculation for the 100 year return period 6hr storm

$Z1_{6hr}$	1.55	*Wallingford Procedure Figure 3.6
M5-6hr	31.1	
$Z2_{100yr}$	1.97	*Wallingford Procedure Table 3.2
M100-6hr	61.2	
With Climate Change	85.7	40%

Additional volume (m^3) of development runoff over Greenfield runoff:

$$Vol = \text{M100−6hr}.AREA.10\left[\frac{PIMP}{100}(0.8\alpha) + \left(1 - \frac{PIMP}{100}\right)SOIL.\beta - SOIL\right]$$

* EQ24.10 CIRIA C753 The SUDS Manual © CIRIA 2015

Additional Rainfall Volume (above Greenfield state) for the developed site: m^3 **10.2**

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SUDS Manual Volume Calculation (Developed)	18024	69 Avenue Road	
	Calculations By: NB	Checked By: CB	Date: 21/02/2020

Site Characteristics

Catchment Area	AREA	ha	0.23
Permeable Surfaces (Proposed Case)	PGF		35%
Areas discharging to soakaway or prevented from leaving site via mitigation		ha	0
	β		0%
Impermeable Surfaces (Proposed Case)	PIMP		57%
Areas discharging to soakaway or prevented from leaving site via mitigation		ha	0
	α		100%
Green Roof Area (Proposed Case)	PGR	Depth of Green Roof	9%
Annual coefficient of discharge*	ψ_a	>10-15 cm	0.45

**Inline with Table 3 of the FLL Planning, Execution and Upkeep of Green-roof sites, 2002*

Soil Index (from FSR or Wallingford Procedure WRAP maps)*	SOIL		0.47

*SOIL is the SPR for the soil type, and for larger sites is a weighted sum of the individual soil classes for the site, where:

$$SOIL = \frac{0.1A_{SOIL1} + 0.3A_{SOIL2} + 0.37A_{SOIL3} + 0.47A_{SOIL4} + 0.53A_{SOIL5}}{AREA}$$

For smaller sites, use the SPR for the local soil type, as follows:

SOIL TYPE	1	2	3	4	5
AREA	0	0	0	0.23	0
SPR	0.1	0.3	0.37	0.47	0.53

SOIL:
0.47

Site parameters from The Wallingford Procedure for Europe: Best Practice Guide to urban drainage modelling, HR Wallingford, July 2000 (CD)

60minute, 5 year return period rainfall	M5-60	mm	20
Ratio of M5-60 to 2day, 5 year return period rainfall	r	-	0.40

Volume Calculation for the 100 year return period 6hr storm

$Z1_{6hr}$	1.55	*Wallingford Procedure Figure 3.6
M5-6hr	31.1	
$Z2_{100yr}$	1.97	*Wallingford Procedure Table 3.2
M100-6hr	61.2	
With Climate Change	85.7	40%

Additional volume (m^3) of development runoff over Greenfield runoff:

$$Vol = \text{"M100-6hr"}.AREA.10[PIMP/100\ (0.8\alpha) + (\text{PGF}/100) SOIL\,.\,\beta + (\text{PGR}/100)\,.\,\Psi\text{a} - SOIL]$$

* Modified from EQ24.10 CIRIA C753 The SUDS Manual © CIRIA 2015

Additional Volume of Runoff (above Greenfield state) leaving the site:	m^3	4.2
Rainwater harvesting or other re-use scheme committed volumes:	m^3	0
Additional Volume of Runoff (above Greenfield state) leaving the site:	$\mathbf{m^3}$	**4.2**