Flo

Consulting Engineers

Project_

Residential Development at
2 Sandy Lodge Way
Northwood, HA6 2AJ

Title_

Surface Water Management Report

Project No_

998

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Contents

Appendices

1. Introduction

Flo Consult UK Ltd have prepared this surface water management report, on behalf of Gavacan Homes, in support of an application for a new residential development at 2 Sandy Lodge Way, Northwood, HA6 2AJ (hereafter referred to as 'the Site').

The report describes and demonstrates how the surface water run-off rate and volume from the Site will be managed to adhere to National planning policies, regulations, and relevant design guidance, which include:

- National Planning Policy Framework (NPPF), December 2023, Paragraphs 152-158;
- National Planning Practice Guidance (NPPG), released in March 2014 and updated in August 2022;
- National Standards for Sustainable Drainage Systems (SuDS) set out by the Department for Environment, Food & Rural Affairs (DEFRA) (2011);
- CIRIA (2010) Planning for SuDS – Making it Happen C687;
- CIRIA SuDS Manual C753 (2015).

And local policies including:

- The London Plan (2021) SI 13 (Sustainable Drainage) (see summary of policies in Section 2.0 of this report);
- London Borough of Hillingdon Local Planning Policy Part 1 (LPP1) (2012) Policy EM6;
- London Borough of Hillingdon Local Planning Policy Part 2 (LPP2) (Adopted 16th January 2020) Policy DMEI 10.

Subsequently, Londin Borough of Hillingdon Council (LBHC), acting as Lead Local Flood Authority (LLFA), need to be satisfied that the design and drainage principles of the proposed development:

- will address the surface water management and risk of flooding within the site;
- will ensure that the drainage is managed and maintained for its lifetime to prevent flooding;
- and will ensure that the development will not increase the risk of flooding to neighbouring land and property.

2. National / Local Policies and Water Management Guidance

2.1. National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG)

The NPPF (December 2023) sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally prepared plans for housing and other development can be produced. This document is used to form this surface water management report, with particular attention to Paragraphs 153 to 158 Planning for Climate Change.

NPPG, Paragraph 055 (Reference ID:7-055-20220825) states that sustainable drainage systems (SuDS) are designed to control surface water run off close to where it falls and mimic natural drainage as closely as possible, where they provide opportunities to reduce the causes and impacts of flooding; remove pollutants from urban run-off at source; and to combine water management with green space with benefits for amenity, recreation, and wildlife.

Further to this NPPG, Paragraph 056 (Reference ID:7-056-20220825) states that the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable which (in order) are into the ground (infiltration); to a surface water body; to a surface water sewer, highway drain, or another drainage system; to a combined sewer.

2.2. Flood and Water Management Act

The Flood and Water Management Act (FWMA) received royal assent in April 2010, aiming to create a simpler and more effective means of managing flood risk and coastal erosion. The FWMA incorporates and implements some of the recommendations from the Pitt Review (2008), following the severe flooding that affected a large area of the UK in 2007. The FWMA also places several new duties and responsibilities on LLFAs regarding the management of local flood risk, to:

- Develop, maintain, apply, and monitor a Local Flood Risk Management Strategy.
- Approve, adopt, and maintain Sustainable Drainage Systems (SuDS) (yet to be implemented).
- Establish and maintain a flood risk Asset Register.
- Investigate incidents of flooding (where appropriate) and publish the findings in a report.
- Ensure delivery of effective and joined up management of flood risk.

2.3. London Plan (March 2021)

Policy SI 13 (Sustainable Drainage) states:

A. *Lead Local Flood Authorities should identify – through their Local Flood Risk Management Strategies and Surface Water Management Plans – areas where there are particular surface water management issues and aim to reduce these risks. Increases in surface water run-off outside these areas also need to be identified and addressed.*

B. *Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible. There should also be a preference for green over grey features, in line with the following drainage hierarchy:*

   1) *rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)*
   2) *rainwater infiltration to ground at or close to source*
   3) *rainwater attenuation in green infrastructure features for gradual release*
   4) *rainwater discharge direct to a watercourse (unless not appropriate)*
   5) *controlled rainwater discharge to a surface water sewer or drain*
   6) *controlled rainwater discharge to a combined sewer.*

C. *Development proposals for impermeable surfacing should normally be resisted unless they can be shown to be unavoidable, including on small surfaces such as front gardens and driveways.*

D. *Drainage should be designed and implemented in ways that promote multiple benefits including increased water use efficiency, improved water quality, and enhanced biodiversity, urban greening, amenity, and recreation.*

2.4. LBH LPP2

Relevant section of Policy DMEI 10: Water Management Efficiency and Quality, state:

a) *Applications for all new build developments (not conversions, change of use, or refurbishment) are required to include a drainage assessment demonstrating that appropriate sustainable drainage systems (SuDS) have been incorporated in accordance with the London Plan Hierarchy (Policy 5.13: Sustainable drainage).*

b) *All major new build developments, as well as minor developments in Critical Drainage Areas or an area identified at risk from surface water flooding must be designed to reduce surface water run-off rates to no higher than the pre-development greenfield run-off rate in a 1:100 year storm scenario, plus an appropriate allowance for climate change for the worst storm duration. The assessment is required regardless of the changes in impermeable areas and the fact that a site has an existing high run-off rate will not constitute justification.*

c) *Rain Gardens and non-householder development should be designed to reduce surface water run-off rates to Greenfield run-off rates.*

d) *Schemes for the use of SuDS must be accompanied by adequate arrangements for the management and maintenance of the measures used, with appropriate contributions made to the Council where necessary.*

e) *Proposals that would fail to make adequate provision for the control and reduction of surface water run-off rates will be refused.*

f) *Developments should be drained by a SuDs system and must include appropriate methods to avoid pollution of the water environment. Preference should be given to utilising the drainage options in the SuDS hierarchy which remove the key pollutants that hinder improving water quality in Hillingdon. Major development should adopt a 'treatment train' approach where water flows through different SuDS to ensure resilience in the system.*

3. Site Setting and Description

3.1. Site Location

The Site is in a residential area of Northwood, approximately 2 km north of Northwood Hills station, and as detailed in Appendix A, is bound by residential dwellings to the north and south, Woodridge Way to the east, and Sandy Lodge Way to the west. The full address of the Site is 2 Sandy Lodge Way, Northwood, HA6 2AJ, with the co-ordinates of the centre of the site being: Easting: 509050, Northing: 191775.

3.2. Existing Site and Topography

The Site, in a pre-development state, consists of a detached residential building, with hard-standing driveway / parking areas to the font (west), and hard-standing pedestrian areas leading to a garden to the rear (east). The Site is developed, and therefore the purpose of this report, is deemed to be **'Brownfield'.**

As detailed in Appendix B, the Site has a general fall in an easterly direction, with the levels ranging from approximately 77.45m AOD at the north-west boundary, to approximately 75.00m AOD at the south-east boundary.

3.3. Proposed Development

The proposed site plan is shown in Appendix C, with a full description of the development site being provided by the Architect. In brief, as stated by LBH the proposal is the: *'Demolition of the existing property with a replacement building of up to 2.5 storeys comprising six self-contained flats with associated parking, cycle and bin storage, and landscaping'.* Parking and bin store areas are to the front of the building (west), with the cycle store, terrace and amenity garden areas being to the rear (east).

3.4. Ground Conditions

The geology at the Site can be determined by, and sourced from, the British Geological Survey (BGS), which shows the Site to have no superficial deposits and a bedrock consisting of London Clay formation. The BGS data also shows public record borehole logs, within the same bedrock strata areas and within 200m radius of the development site. As detailed in Appendix D, the borehole logs show the ground to predominantly consist of silty clay.

3.5. Waterbodies

There are no known waterbodies near to the development site, with the nearest waterbody being an unnamed watercourse approximately 1 km to the south.

3.6. Existing Drainage

The Thames Water asset plan in Appendix E shows there to be 225mm foul and 150mm surface water sewers in Sandy Lodge Way (west), and a 225mm diameter surface water sewer in Woodridge Way (east).

3.7. Development Areas

The Site has an overall area of approximately 1,050m² / **0.105 ha**.

The Site, in a pre-development state, consists of the residential building and external hard-standign areas, which equates to approximately 750m² / 0.075 ha, and remaining garden areas which equate to approximately 300m² / 0.030 ha. It is believed that the surface water run-off from the residential building and external hard-standing areas discharge to the surface water sewer (west of the Site). Therefore, in terms of pre-development surface water run-off calculations, the area of **0.075 ha** is to be used, and in terms of greenfield run-off calculations, the site has an urban factor of **0.71** (0.075 ha / 0.105 ha).

The Site, in a post development state, will consist of the new residential building, parking, terrace and bin / bike store areas which equates to approximately 68m² / 0.068 ha, and amenity garden areas which equates to approximately 370m² / 0.037 ha. The surface water run-off from the garden areas will discharge off the Site at a natural / greenfield rate, and therefore the surface water management area is **0.068 ha**.

4. Surface Water Management Principles

The surface water for the Site is to be managed so that it adheres to the current national regulations and local authority requirements.

4.1. Run-Off Destination

Surface water run-off is to discharge to one or more of the following in the order of priority shown:

- Discharge into the ground (infiltration);
- Discharge to a surface water body;
- Discharge to a surface water sewer, highway drain or other drain;
- Discharge to combined sewer.

4.2. The Management Train

A concept fundamental to implementing a successful SuDS scheme is the management train. This is a sequence of SuDS components that serve to reduce run-off rates and volumes and reduce pollution. The hierarchy of techniques that are to be used for the surface water management of the development are:

- Prevention - Prevention of run-off by good site design and reduction of impermeable areas;
- Source Control - Dealing with water where and when it falls (e.g. infiltration techniques);
- Site Control - Management of water in the local area (e.g. swales, detention basins);
- Regional Control - Management of run-off from sites (e.g. balancing ponds, wetlands).

4.3. Design Principles

The design principles for the surface water management of the development will be to:

- Ensure that people, property, and critical infrastructure are protected from flooding;
- Ensure that the development does not increase flood risk off site;
- Ensure that SuDS can be economically maintained for the development.

4.4. Peak Surface Water Flow

DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems states:

*'**S3** For developments which were previously developed, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1-year rainfall event and the 1 in 100-year rainfall event must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event'.*

4.5. Volume Control

DEFRA Non-statutory technical standards for sustainable drainage systems states:

***S5** Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100-year, 6-hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event.*

***S6** Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk'.*

4.6. Flood Risk within Development

DEFRA Non-statutory technical standards for sustainable drainage systems states:

*'**S7** The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30-year rainfall event.*

***S8** The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1 in 100-year rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.*

***S9** The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100-year rainfall event are managed in exceedance routes that minimise the risks to people and property'.*

4.7. Pollution / Water Quality

The SuDS design for the development site will ensure that the quality of any receiving water body is not adversely affected and preferably enhanced in accordance with Ciria SuDS Manual C753, Chapter 4.

4.8. Designing for Exceedance

The development site design will be such that when SuDS features fail or are exceeded, exceedance flows do not cause flooding of properties on or off site. This is achieved by completely containing the surface water within the drainage system (including areas designed to hold or convey water) for all events up to a 1 in 30-year event. The design of the site ensures that flows from rainfall more than a 1 in 100-year rainfall event are managed in exceedance routes that avoid risk to people and property both on and off site.

5. Surface Water Run-Off Destination

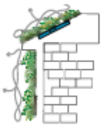
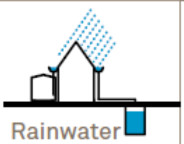
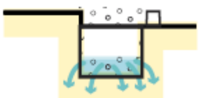
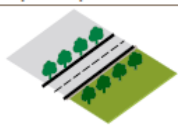
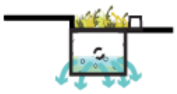
The destination of the surface water run-off from the Site, in a post development state, has been assessed against the prioritisation set by the Approved Document H (2010). The feasibility of the surface water run-off to the priority receptors are as follows:

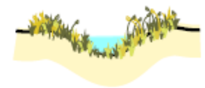
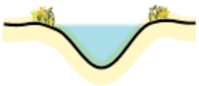
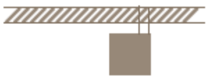
Run-Off Destination	Feasible / Required?	Description
Discharge to Ground	No	As stated in Section 3.4, the BGS data identifies the ground at the Site to predominantly consist of Silty Clay. Clay is known to have an exceptionally low or no infiltration value, and therefore discharge of the surface water to ground is not feasible.
Discharge to Surface Water Body	No	There are no known waterbodies near the Site, and therefore this is not a feasible surface water run-off destination.
Discharge to Surface Water Sewer	**Yes**	As the ground is not suitable for infiltration, and as there are no known waterbodies near the Site, the only alternative is to discharge the surface water to the 225mm surface water sewer in Woodridge Way.
Discharge to Highway Drain or Other	No	This surface water discharge destination is not required as the surface water will discharge to a surface water sewer.
Discharge to Combined Water Sewer	No	This surface water discharge destination is not required as the surface water will discharge to a surface water sewer.

6. SuDS Feasibility

To reduce the surface water run-off from the Site in a post development state, SuDS methods are to be introduced to the design.

SuDS methods as per the Sustainable Drainage System (SuDS) hierarchy, and the Non-Statutory Technical Standards for Sustainable Drainage Systems – March 2015, that can be used are detailed below:

	Description	Setting	Required area
 Green roofs	A planted soil layer is constructed on the roof of a building to create a living surface. Water is stored in the soil layer and absorbed by vegetation.	 Building	Building integrated.
 Rainwater harvesting	Rainwater is collected from the roof of a building or from other paved surfaces and stored in an overground or underground tank for treatment and reuse locally. Water could be used for toilet flushing and irrigation.	 Building	Water storage (underground or above ground).
 Soakaway	A soakaway is designed to allow water to quickly soak into permeable layers of soil. Constructed like a dry well, an underground pit is dug filled with gravel or rubble. Water can be piped to a soakaway where it will be stored and allowed to gradually seep into the ground.	 Open space	Dependant on runoff volumes and soils.
 Filter Strip	Filter strips are grassed or planted areas that runoff is allowed to run across to promote infiltration and cleansing.	 Open space	Minimum length 5 metres.
Permeable paving	Paving which allows water to soak through. Can be in the form of paving blocks with gaps between solid blocks or porous paving where water filters through the block itself. Water can be stored in the sub-base beneath or allowed to infiltrate into ground below.	 Street/open space	Can typically drain double its area.
 Bioretention area	A vegetated area with gravel and sand layers below designed to channel, filter and cleanse water vertically. Water can infiltrate into the ground below or drain to a perforated pipe and be conveyed elsewhere. Bioretention systems can be integrated with tree-pits or gardens.	 Street/open space	Typically surface area is 5-10% of drained area with storage below.

	Description	Setting	Required area
 Swale	Swales are vegetated shallow depressions designed to convey and filter water. These can be 'wet' where water gathers above the surface, or 'dry' where water gathers in a gravel layer beneath. Can be lined or unlined to allow infiltration.	 Street/open space	Account for width to allow safe maintenancce typically 2-3 metres wide.
 Hardscape storage	Hardscape water features can be used to store run-off above ground within a constructed container. Storage features can be integrated into public realm areas with a more urban character.	 Open space	Could be above or below ground and sized to storage need.
 Pond / Basin	Ponds can be used to store and treat water. 'Wet' ponds have a constant body of water and run-off is additional, while 'dry' ponds are empty during periods without rainfall. Ponds can be designed to allow infiltration into the ground or to store water for a period of time before discharge.	 Open space	Dependant on runoff volumes and soils.
 Wetland	Wetlands are shallow vegetated water bodies with a varying water level. Specially selected plant species are used to filter water. Water flows horizontally and is gradually treated before being discharged. Wetlands can be integrated with a natural or hardscape environment.	 Open space	Typically 5-15% of drainage area to provide good treatment.
 Underground storage	Water can be stored in tanks, gravel or plastic crates beneath the ground to provide attenuation.	 Open space	Dependant on runoff volumes and soils.

The feasibility of the above SuDS methods for the post developed site are summarised in the table below:

SuDS Method	Feasible Use	Description
Living Roofs	**Yes**	The new residential building roof is to be pitched, and therefore is not suitable for green roofs. However, green roofs could be established on the bin and cycle store roofs, which will reduce the surface water run-off, act as a pollutant control, and add biodiversity to the development. Suitability and details to be confirmed.
Rainwater Harvesting	**Yes**	The annual water demand for the residential building will be greater than the annual rainwater yield (6-units in one building), and therefore rainwater harvesting for re-use in the building is not suitable. However, water butts can be installed at some rainwater pipes where the water can be collected and re-used for irrigation.
Soakaway	No	The BGS data identifies the ground at the Site to predominantly consist of Silty Clay. Clay is known to have an exceptionally low or no infiltration value, and therefore discharge of the surface water to ground is not feasible.

Filter Drains	**Yes**	A filter drain system can be formed along the edge of the footpath leading to the cycle store, and around the cycle store perimeter, which will consist of a 300x300mm, 20mm no fine granular filled trench housing a perforated pipe. The surface water run-off from the footpath and cycle store areas will discharge onto the filter drain, will not infiltrate to ground, but will be convey the surface water to the main network via a perforated pipe, and will reduce run-off rates and act as a pollutant control.
Permeable Surfacing / Paving	**Yes**	Permeable paving systems can be formed in parking bays to the west of the Site, and in the terrace area to the east. The permeable paving will take the surface water run-off form the parking and terrace areas, will not discharge to ground, but will be conveyed via a perforated pipe from the sub-base of the paving system, and into the main drainage network. A permeable paving will reduce the surface water run-off rate from the parking areas, and will act as a pollutant control.
Bioretention area / Swales / Ponds	No	There are only small areas of soft-landscaping and private amenity garden areas within the Site. Therefore, due to the limited areas, the use of bioretention areas, swales or ponds are not feasible.
Hardscape Storage	No	Surface water run-off from external areas is to discharge to either preamble paving or filter drains, Therefore, there are no suitable other areas within the Site for hardscape storage.
Underground Storage	**Yes**	The surface water run-off from the Site will be restricted. The rate will be lower than the surface water run-off rate, therefore there will be a requirement to have (in addition to pond) underground storage within cellular units and the drainage network to prevent flooding.

7. Development Greenfield Run-Off Rate and Volumes

To minimise the surface water run-off from the Site, it is preferred that the post development surface water run-off be restricted to the equivalent greenfield run-off rates and volume where possible.

7.1. Greenfield Run-Off Rate

The Flood Estimation Handbook (FEH) is often used for the calculation of the greenfield run-off rate, however, relevant documents state that to calculate the greenfield run-off rates on small catchments less than 25km², the IH 124 QBAR equation (and the equation for the instantaneous time to peak for the unit hydrograph approach) is to be used. The IH method is based on the Flood Studies Report (FSR) approach and is developed for use on catchments less than 25km². It yields the Mean Annual Maximum Flood (QBAR). This reference also recommends the use Ciria C753 Table 24.2 to generate Growth Factors. These are used to convert QBAR to different return periods for different regions in the UK.

The input variables to establish QBAR are:

Return Period (years)	Results based on a range of return periods and the specified RP;
Area	Catchment Area (ha) which is adjusted to km2 for use in the equation;
SAAR	Average annual rainfall in mm (1941-1970) from FSR figure II.3.1;
Soil	Procedure Volume 3. Soil classes 1 to 5 have Soil Index values of 0.15, 0.3, 0.4, 0.45 and 0.5 respectively;
Urban	Proportion of area urbanised expressed as a decimal;
Region Number	Region number of the catchment based on FSR Figure I.2.4.

QBAR(l/s)

The output variables to establish QBAR are calculated using the following formula (equation yields m³/s):

QBAR = $0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$

The IH 124 Variables (taken from FSR) that are specific to this site are as follows:

Area	=	50.00 ha
SAAR	=	703
Soil	=	0.300
Urban Factor	=	0.71
Region Number	=	6

Based on these variables, and the calculation results provided by the MicroDrainage computer software (Appendix F), the QBAR for a 50.00ha catchment area is:

QBAR = 282.6 l/s

This figure is for the catchment area of 50.00 ha, and is to be reduced to reflect the surface water management area (0.068 ha) of the Site. Therefore, the QBAR (greenfield run-off) for development area has been calculated to be:

QBAR = **0.38 l/s (5.65 l/s/ha)**

Ciria C753 Table 24.2 identifies the growth factors for each of the storm events, based on the known QBAR figure. The growth factors from the table vary depending on the site location. In this case hydrometric area (Region Number) is 6.

Based on the figures shown in the table, the growth factors, and the greenfield run-off rates for each of the storm events for the surface water management areas of the Site are as follows:

Storm Event	QBAR	Growth Factor (C753 Table 24.2)	Greenfield Run-off Rate
Q_2	0.38 l/s	0.88	**0.3 l/s**
Q_{30}	0.38 l/s	2.40	**0.9 l/s**
Q_{100}	0.38 l/s	3.19	**1.2 l/s**

7.2. Greenfield Run-Off Volume

The greenfield run-off volume for the 100-year, 6-hour storm event has also been calculated in the MicroDrainage software using the data from the FEH 2013, with the results shown in Appendix F.

The FEH 2013 data and variables used to calculate the greenfield run-off volume at the Site location area as follows:

Site Location = GB 509051 191779 TQ 09051 91779

Area = 0.068 ha

SAAR = 676

CWI = 100.680

SPR Host = 47.000

URBTEXT = 0.50 (actually 0.71, but 0.50 highest for calculation)

Based on these calculation results (Appendix F), the greenfield run-off volume for the surface water management area of the Site is:

$Q_{100\ (6\text{-Hour})}$ = 28.47m³ (418.68m³/ha)

8. Pre-Development Surface Water Run-Off Rates and Volume

The pre-development surface water run-off rates and volume are to be calculated, to establish the rate at which the surface water currently discharges off the Site, and for the post development to be a reduction of the rates, and not exceeding the volume to reduce the probability of flooding.

The calculations to determine the pre-development surface water run-off rates and volume are based on the pre-development surface water run-off area of 0.075 ha, the rainfall data given by the FEH 2013, and simulation / calculations in the MicroDrainage computer software (see Appendix G).

Based on the FEH 2013 data and computer software results, the pre-development surface water run-off rates are as follows:

Q_2 = 11.6 l/s (15-minute storm duration)

Q_{30} = 29.2 l/s (15-minute storm duration)

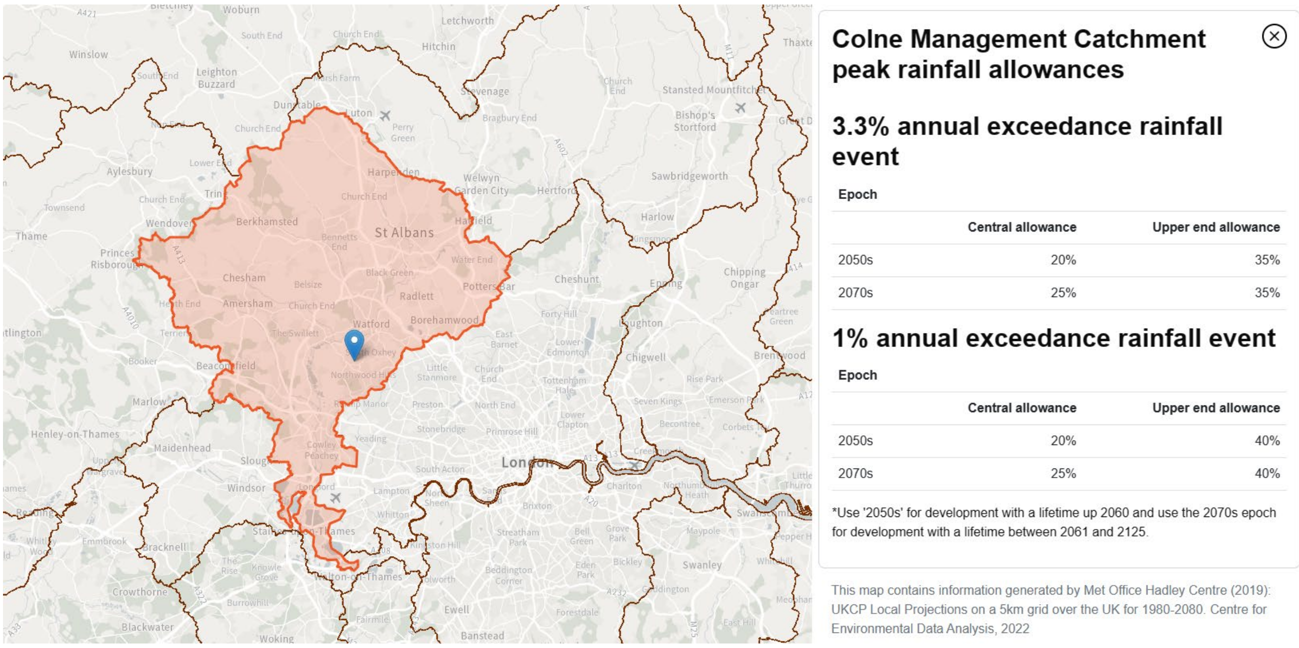
Q_{100} = 37.7 l/s (15-minute storm duration)

Based on the FEH 2013 data and computer software results, the pre-development surface water run-off volume is as follows:

Q_{100} = 49.06m³ (360-minute storm duration)

9. Climate Change Allowance

The NPPF makes it a planning requirement to account for climate change in the proposed design. The recommended allowances are taken from the Environment Agency guidance summarised in Figure 1 below.



Epoch	Central allowance	Upper end allowance
2050s	20%	35%
2070s	25%	35%

Epoch	Central allowance	Upper end allowance
2050s	20%	40%
2070s	25%	40%

Figure 1 - DEFRAs – Climate Change Allowances

The lifetime of the residential building is likely to be beyond 2061, and therefore the Epoch 2070's is to be used with Upper End Allowance. Therefore, the climate change allowance for the pre and post development surface water run-off will be **35%** and **40%** for the 30-year and 100-year storm respectively.

10. Drainage Networks and Surface Water Management Calculation

10.1. Surface Water Network Calculations

The calculations to determine the post development surface water run-off rates are based on the post development surface water run-off area of 0.068 ha, and the rainfall data given by the Flood Estimation Handbook (FEH 2013).

10.2. Surface Water Drainage Network

As shown on the surface water management layout in Appendix H, the proposed surface water network will consist of 150mm diameter pipes; 150mm diameter perforated pipes; 460mm diameter inspection and silt trap chambers; a 1200mm diameter flow control chamber containing a hydro-brake; water butts; filter drain systems; permeable paving systems; and an attenuation tank in the form of cellular units.

The surface water run-off from the building roof areas will discharge to the main network via the and water butts and trapped gullies (capturing first 5mm); the surface water run-off from the parking and terrace areas will discharge to the main network via permeable paving system; the surface water run-off from the bin store will discharge to the main network via a living roof, and surface water run-off from the footpath and cycle store areas will discharge to the main network via filter drains.

The main surface water network will flow to the east of the Site, where the surface water will flow through the flow control chamber prior to discharge to the 225mm diameter surface water sewer in Woodridge Way.

Surface water is to be restricted by the flow control prior to the discharge to the surface water sewer, with restricted surface water surcharging the network and being attenuated within the cellular units.

10.3. Surface Water Run-Off Rate

For the surface water run-off from the Site, in a post-development state, to be at the greenfield run-off rate, they are to be restricted to 0.3 l/s for the 1 in 2-year storm event, 0.9 l/s for the 1 in 30-year storm event including 35% allowance, and 1.2 l/s for the 1 in 100-year storm event including 40% allowance.

For the surface water run-off from the Site, in a post-development state, to be a reduction of the pre-development rates are to be restricted to less than 11.6 l/s for the 1 in 2-year storm event, 29.2 l/s for the 1 in 30-year storm event including 35% allowance; and 37.7 l/s for the 1 in 100-year storm event including 40% allowance.

An assessment of the suitable flow control opening, and subsequent surface water discharge also needs to assessed, where CIRIA document C753 – The SuDS Manual states that: *'the flow controls / orifice design should be designed so that it has simplicity on operation, and has resistance to clogging, blocking or mechanical failure'.*

For this development, the 2-year and 30-year greenfield run-off rates are deemed to be too low, where the flow control opening to achieve these greenfield rates will have to be at a size where it is likely to cause a blockage and subsequent flooding. The suitable / minimum size of the flow control opening (hydro-brake opening) to reduce the risk of blockage is deemed to be 50mm.

As shown in the output calculation from the MicroDrainage computer software in Appendix I, if the hydro-brake opening is set at 50mm, the design flow at 1.2 l/s, with a design head of 1.10m, the maximum surface water run-off rates for each storm event will be as follows:

Q_2	-	**1.0 l/s**	-	180-minute winter storm duration
$Q_{30 + CC}$	-	**1.0 l/s**	-	240-minute winter storm duration
$Q_{100 + CC}$	-	**1.2 l/s**	-	240-minute winter storm duration

A summary of the post development surface water run-off rates compared to the greenfield and pre-development rates are as follows:

Greenfield Rate to Post Development Rate

Storm	-	Greenfield	-	Post Dev	-	Difference
Q_2	-	0.3 l/s	-	1.0 l/s	-	Increase
$Q_{30 + CC}$	-	0.9 l/s	-	1.0 l/s	-	Increase
$Q_{100 + CC}$	-	1.2 l/s	-	1.2 l/s	-	Equivalent

Pre-Development Rate to Post Development Rate

Storm	-	Pre-Dev	-	Post Dev	-	Difference
Q_2	-	11.6 l/s	-	1.0 l/s	-	Reduction
$Q_{30 + CC}$	-	29.2 l/s	-	1.0 l/s	-	Reduction
$Q_{100 + CC}$	-	37.7 l/s	-	1.2 l/s	-	Reduction

The calculations show that the surface water run-off rates are greater than the 2-year and 30-year greenfield rates, but equivalent to the 100-year greenfield rate, and a reduction of pre-development rates.

Therefore, the rates will still adhere to DEFRA National Non-Statutory Technical Standards for Sustainable Drainage Systems (S3).

10.4. Surface Water Run-Off Volume

The surface water run-off volumes for the post development site have also been calculated for 1 in 100-Year the 6-hour duration (Inc. 40% climate change allowance), within the MicroDrainage computer software in Appendix I, based on the peak discharge rate, where:

$Q_{100\ (6\text{-hour})}$ = 1.2 l/s x (60 x 60 x 6) = 25,920 litres = **25.90m³**

A summary of the post development surface water run-off volume compared to the greenfield volumes are as follows:

Greenfield Volume to Post Development Volume

Storm	-	Greenfield	-	Post Dev	-	Difference
Q_{100}	-	28.47m³	-	25.90m³	-	Reduction

Pre-Development Volume to Post Development Volume

Storm	-	Pre-Dev	-	Post Dev	-	Difference
Q_{100}	-	49.06m³	-	25.90m³	-	Reduction

The surface water run-off volume for the 100-year, 6-hour storm event is a reduction of the greenfield and pre-development run-off volumes.

Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements of DEFRA National Non-statutory technical standards for sustainable drainage systems (S5-S6), where the risk of flooding to the watercourse has been reduced.

10.5. Surface Water Network and Attenuation Calculations

As stated above, the post development run-off rates are restricted, there will be a requirement for surface water attenuation.

Ciria SuDS Manual 2015, Paragraph 10.2.4 states that: *'Exceedance flows (i.e. flows in excess of those for which the system is designed) should be managed safely in above-ground space such that risks to people and property are acceptable'.*

Attenuation structure formed of below ground attenuation tank in the form of cellular units.

As detailed in the MicroDrainage calculations (Appendix I) and surface water management layout (Appendix H), the attenuation volume and details for this SuDS methods are as follows:

Cellular Units

Attenuation Tank Length	-	6.50m
Attenuation Tank Width	-	6.00m
Attenuation Tank Area	-	39.00m²
Attenuation Tank Depth	-	1.20m
Attenuation Tank Volume	-	46.80m³
Porosity	-	0.95
Attenuation Volume	-	**44.46m³**

The MicroDrainage calculations (Appendix I) show that with the cellular unit volume, no flooding will occur for all storms up to and including the 100-year + 40% storm event.

Therefore, the attenuation volume is deemed to be acceptable, as they meet the requirements set out in the Non-Statutory Technical Standards for Sustainable Drainage Systems (S7-S9).

11. Maintenance Requirements

Details of the maintenance required, and the parties to carry out the maintenance of all drainage aspects, to ensure that the SuDS methods are working effectively, and subsequently reducing the risk of flooding on the Site, are set out below.

11.1. Drainage Responsibilities

The management and maintenance of the surface water drainage networks and SuDS features within the Site will be by contractors appointed by the owners / residents of each of the new residential units, where payments of the works will form part of the property deeds and / or rental agreements. The management and maintenance of the draiange / SuDS will form part of the overall management of the communal areas.

A copy of the draiange design layout / details and a draiange maintenance / management document will be handed to the occupants on completion of the property purchase, where they will be made aware of the features within the Site, and responsibility to maintain the drainage features shown on said drawings and details.

11.2. Maintenance and Management Document on Completion

The document produced, and handed to the owners of the new properties, will state the following:

'The owners & parties with responsibilities for the surface water drainage system on this development will comprise of the following stakeholders:

Residential Unit Owners

All of which is clearly defined on the surface water drainage plan included within your handover pack & property deeds package.

As you are a residential unit owner on this development you have responsibilities for the maintenance of the surface water drainage system which fall within the extent of Site as defined within the 'development boundary' (shown in red on surface water management drawing).

Failure to maintain or removal of surface water drainage features may result in civil litigation with neighbouring owners if flooding occurs as a result.

Surface water drainage pipes, inspection chambers, water butts, permeable paving, filter drains, flow control chamber and cellular units within the Site are owned by you as the owner & as such responsibility for maintenance / repairs & replacement are yours as the unit owner'.

The following will be included within the document:

'The operation and frequency of the maintenance and management set out in this report and as shown on the draiange layout are to be carried out as follows:

11.3. Drainage Networks, Water Butts, Flow Control and Cellular Units

Operation	***Frequency***
Inspect and identify any areas that are not operating correctly, if required, take remedial actions	*Monthly for 3 months, then six monthlies*
Debris removal from manholes (where may cause risk performance)	*Monthly*
Where rainfall into network from above, check surface or filter for blockage or silt, algae, or other matter by jetting	*As required, but at least twice a year*

Remove sediment from pipework by jetting.	*Annually or as required*
Repair/check all inlets, outlets, and overflow pipes	*As required*
Inspect/check all inlets, outlets, and overflow pipes to ensure that they are in good condition and operating as designed	*Annually and after large storms*

11.4. Permeable Paving and Filter Drains

Operation	***Frequency***
Inspect and identify any areas that are not operating correctly, if required, take remedial actions	*Monthly for 3 months, then six monthlies*
Debris removal from on surface of permeable surfacing / paving and filter drain or near system (where may cause risk performance)	*Monthly*
Rainfall infiltration into permeable surfacing / paving and / or filter drain is ensured working effectively.	*As required, but at least twice a year*

11.5. Linked and Further Maintenance and Maintenance Activities

The maintenance of the drainage network and SuDS features are to be linked with the wider site maintenance plan for the industrial estate.

A log of all maintenance activities is to be kept and made available to the local planning authority (LPA) and / or the Lead Local Flood Authority (LLFA) on request.

12. Surface Water Exceedance Event

In the event of an extreme storm event (greater than 100-year + 40% climate change), or poor maintenance of the pipework potentially flooding of the drainage network could occur.

Surface water flow paths will follow existing and proposed ground topography, where water will flow towards the eastern boundary, and will discharge directly onto Woodridge Way.

Flood water will flow away from the residential building and will not flow directly towards existing dwellings / properties / buildings prior to discharge to Woodridge Way.

Woodridge Way will contain the surface water due to upstand kerbs and channels having gradients (water to flow in road), and therefore, there will be no increased risk of flooding to any areas within or near the Site will occur in an exceedance event.

The pre-development site also has no below ground attenuation volume, and therefore the surface water run-off volume in a post development state will always be 44.46m³ less than in the pre-development state, for all storm events and flood scenarios.

13. Water Quality

The level of water treatment (for external areas subject to pollutants) is to be assessed against the details set out in Ciria SuDS Manual C753. Chapter 26 sets out the Pollution Hazard Indices for different land classifications, and how to calculate that against the SuDS mitigation indices to show suitable levels of treatment.

13.1. External Area Pollutant Hazard

C753 Table 26.2 Pollution Hazard Level = Low

C753 Table 26.2 Pollution Hazard Index:

- Total Suspended Solid (TSS) = 0.5
- Metals = 0.4
- Hydrocarbons = 0.4

Pollution Hazard Index = **1.30**

13.2. External Area Pollutant Mitigation

Mitigation Measures:

- **Filter Drains and Permeable Paving**

Permeable Surfacing / Paving Pollutant Mitigation Indices

Total Suspended Solid (TSS) = 0.7

Metals = 0.6

Hydrocarbons = 0.7

SuDS Mitigation Indices = **2.00**

The mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

Note: Surface water run-off from residential roof to have very low pollutants, and will flow through trapped gullies and water butts prior to discharge to main draiange network. Therefore, roof surface water run-off will not affect the water quality.

14. Development Management and Construction Phase

All existing drainage networks (if found) within the Site are to be maintained during construction. The flow control and cellular units are to be the first part of the drainage network to be built. This will ensure that the surface water discharge at a reduced rate during all phases of the build.

14.1. Construction Environment Management Plan

Full details of the construction environment management plan (CEMP) are to be confirmed by the chosen contractor who has been appointed for the development. However, it will conform to the requirements of CIRIA 753 – The SuDS Manual – Chapter 31, and will include:

14.2. Construction Access

The main construction traffic will access the site from the western boundary (Sandy Lodge Way). The set-up areas will be limited to avoid the cellular units, with protection measures (i.e. concrete slab) put over the installed attenuation tank to prevent damage during vehicle movements.

14.3. Sediments and Traps

Sediment basins and traps are to be installed before any site earthworks take place, with further sediment traps and silt fences being installed as the earthworks progress. This will keep sediment contained on site at appropriate locations.

14.4. Run-Off Control Measures

Run-off control measures are to be used in conjunction with sediment traps to divert water around planned earthworks areas to remove silts. Any surface water upstream of the site is to be diverted around the development areas, and to discharge to the surface water sewer. The surface water run-off destination for the diverted surface water will continue as existing.

14.5. Main Surface Water Run-Off Systems

The flow control chamber and cellular units are to be built prior to any phase of construction of site. Temporary inlet and outlet protection measures and appropriate silt traps are to be installed to prevent silt ingress into the main drainage network.

14.6. Clearing and Earthworks

Clearing and earthworks will only start when adequate erosion and sediment control measures are in place. Once the development areas are cleared, earthworks will follow immediately to ensure that the ground cover can be re-established quickly. Adjacent land to that being developed will be left undisturbed for as long as possible.

14.7. Surface Stabilisation Measures

Surface stabilisation measures will be applied to completed areas, channels ditches and other disturbed areas after the land is cleared and profiled. Permanent stabilisation measures will be installed as soon as possible after final profiling.

14.8. Construction of Permeable Surfacing / Paving

Construction of permeable paving and filter drains are to be left to the later stages of construction. Unsuitable sediment is to be removed from surfacing prior to installation of sand binder layer and paving.

15. Conclusion / Summary

15.1. Discharge Destination and SuDS Principles

All feasible SuDS methods, and surface water discharge destination have been assessed, with the feasible SuDS methods being living roofs, water butts, permeable paving systems, filter drain systems, a flow control chamber and an attenuation tank in the form of cellular units, with the surface water destination being to a surface water sewer.

15.2. Peak Flow Control

The surface water run-off rates are greater than the 2-year and 30-year greenfield rates, but equivalent to the 100-year greenfield rate, and a reduction of pre-development rates. Therefore, the rates will still adhere to DEFRA National Non-Statutory Technical Standards for Sustainable Drainage Systems (S3).

15.3. Volume Control

The surface water run-off volume for the 100-year, 6-hour storm event is a reduction of the greenfield and pre-development run-off volumes. Therefore, the discharge volume is deemed to be acceptable, as it meets the requirements of DEFRA National Non-statutory technical standards for sustainable drainage systems (S5-S6), where the risk of flooding to the watercourse has been reduced.

15.4. Flood Risk within the Development

With the cellular unit volume, no flooding will occur for all storms up to and including the 100-year + 40% storm event. Therefore, the attenuation volume is deemed to be acceptable, as they meet the requirements set out in the Non-Statutory Technical Standards for Sustainable Drainage Systems (S7-S9).

15.5. Management and Maintenance

The management and maintenance of the surface water drainage networks and SuDS features will be by contractors appointed by the owners / residents of the new residential units, where payments of the works will form part of the property deeds and / or rental agreements, and will form part of the management and maintenance of the overall site and communal areas.

15.6. Surface Water Exceedance Design

Surface water will flow towards the eastern boundary, and will discharge directly onto Woodridge Way. Flood water will flow away from the residential building and will not flow directly towards existing dwellings / properties / buildings prior to discharge to Woodridge Way. Woodridge Way will contain surface water due to upstand kerbs and channels having gradients (water to flow in road), and therefore, there will be no increased risk of flooding to any areas within or near the Site will occur in an exceedance event. The pre-development sire also has no below ground attenuation volume, and therefore the surface water run-off volume in a post development state will always be 44.46m³ less than in the pre-development state, for all storm events and flood scenarios.

15.7. Water Quality

The level of water treatment is to be assessed against the details set out in Ciria SuDS Manual C753. Chapter 26 sets out the Pollution Hazard Indices for different land classifications, and how to calculate that against the SuDS mitigation indices to show suitable levels of treatment. The mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

15.8. Development Management and Construction Phase

All existing drainage networks (if found) within the development area are to be maintained during construction. The flow control and cellular units are to be the first part of the drainage network to be built. This will ensure that the surface water discharge at a restricted rate during all phases of the build. Full details of the construction environment management plan (CEMP) are to be confirmed by the chosen contractor who has been appointed for the development. However, it will conform to the requirements of CIRIA 753 – The SuDS Manual – Chapter 31.

Appendix A Site Location Plan

0 25 50 m 75 100

Scale 1:1250

ASCOT DESIGN
Timeless architecture

Ascot Design Ltd,
Ashurst Manor,
Ashurst Park,
Ascot,
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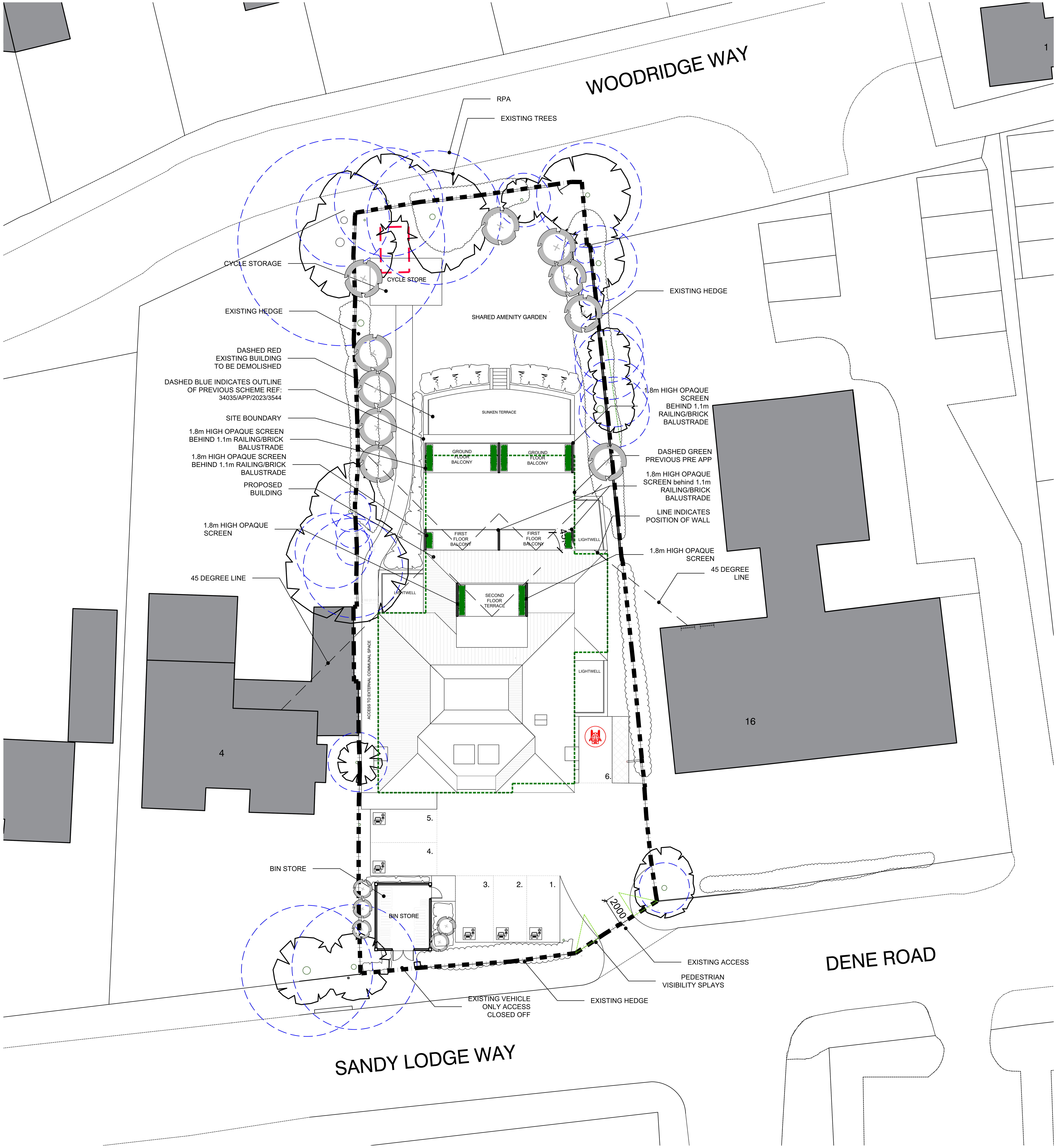
Status	PRE PLANNING
Client	GAVACAN HOMES
Project Title	2 SANDY LODGE WAY, NORTHWOOD HA6 2AJ
Rev.	
Date	
Detail	
DRAWING Title	LOCATION PLAN
Scale.	1:1250 @ A4
Date	NOV '23
Drawn	DQ
DRAWING No.	23- J4296 - LP
Rev.	

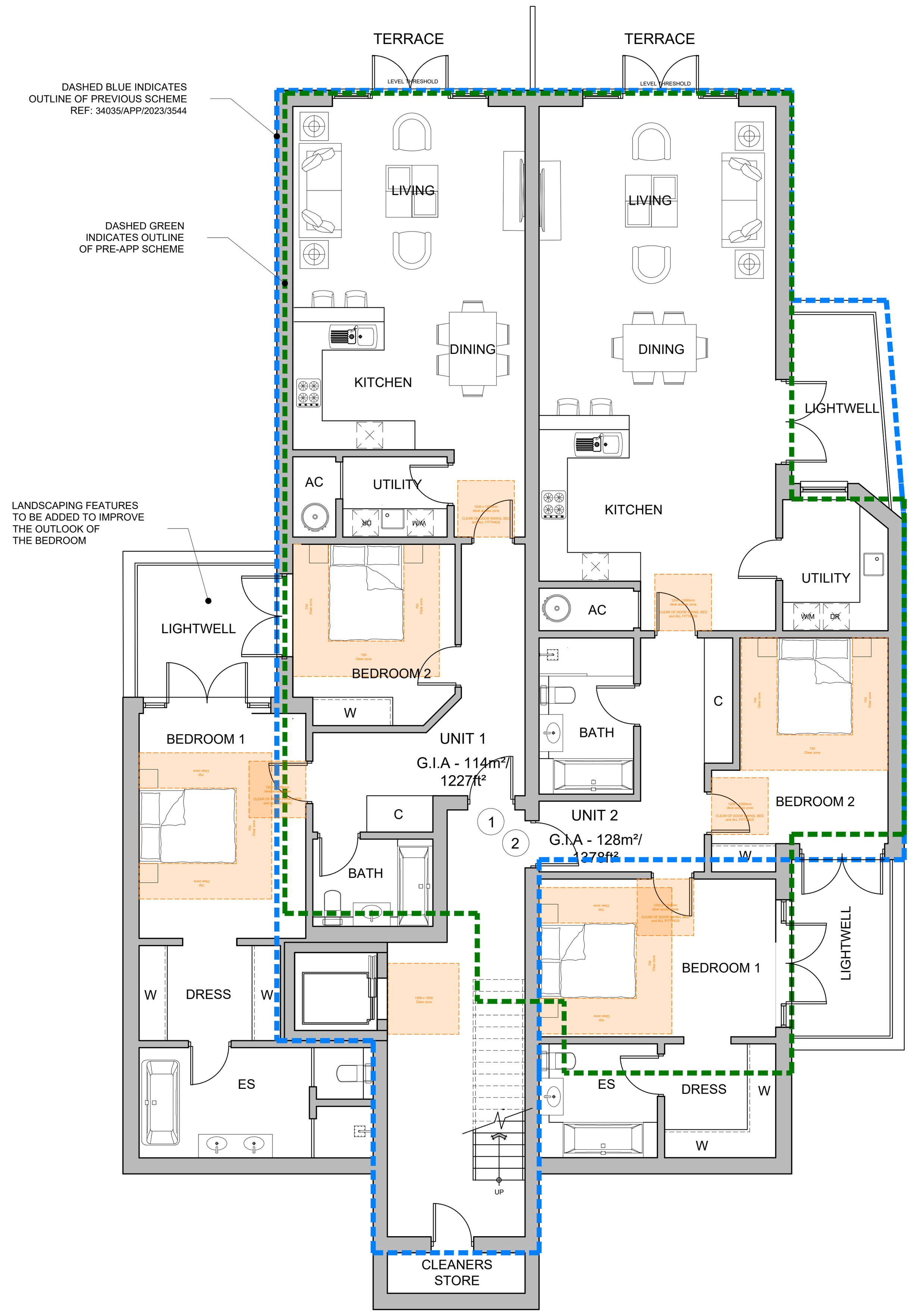
Appendix B Topographical Survey

No.4
No.2
SANDY LODGE WAY
Lapboard Fence 1.3m
Block Edging
Privet Hedge Typically 2m
Crazy Paving
Planting
Gravel
Asphalt
Concrete Paving
Overhead Building Line
Overhead Staircase
Retaining Brick Wall
Concrete Paving
Ramp
Bushes
Grass
Shed
Concrete Base
Lapboard & Trellis Fence 2.5m
Lapboard Fence 1.8m
Lapboard Fence 1.7m
Brick Wall
Cypress Rootline
Trellis Fence 1.9m
Panel Fence 1.9m
Bushes & Ivy 2.5m
Retaining Stone Wall
Steps Up
Kerb
Drop Kerb
Hedge Typically 2m
Concrete Edging

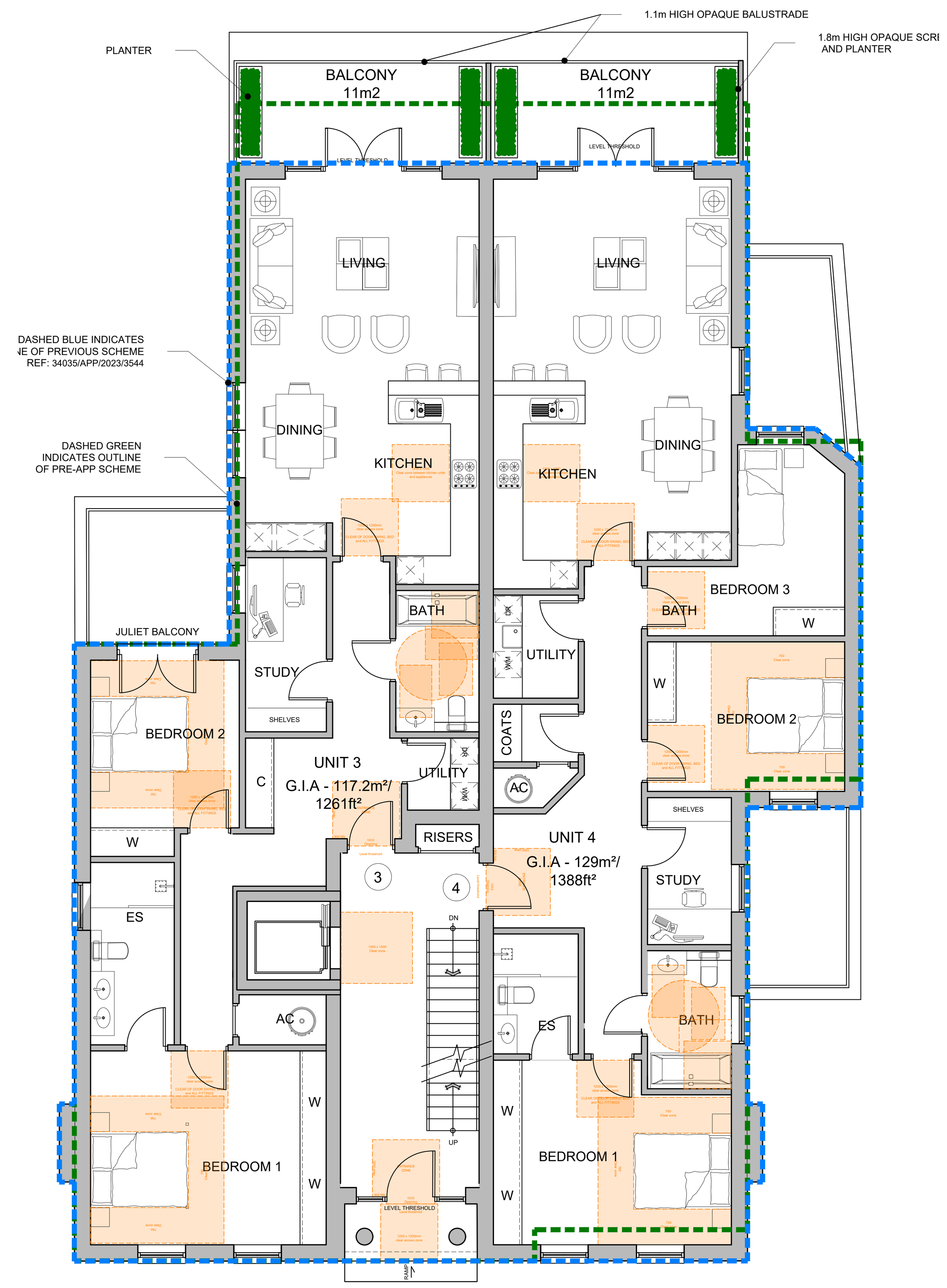
Appendix C Proposed Site Plans



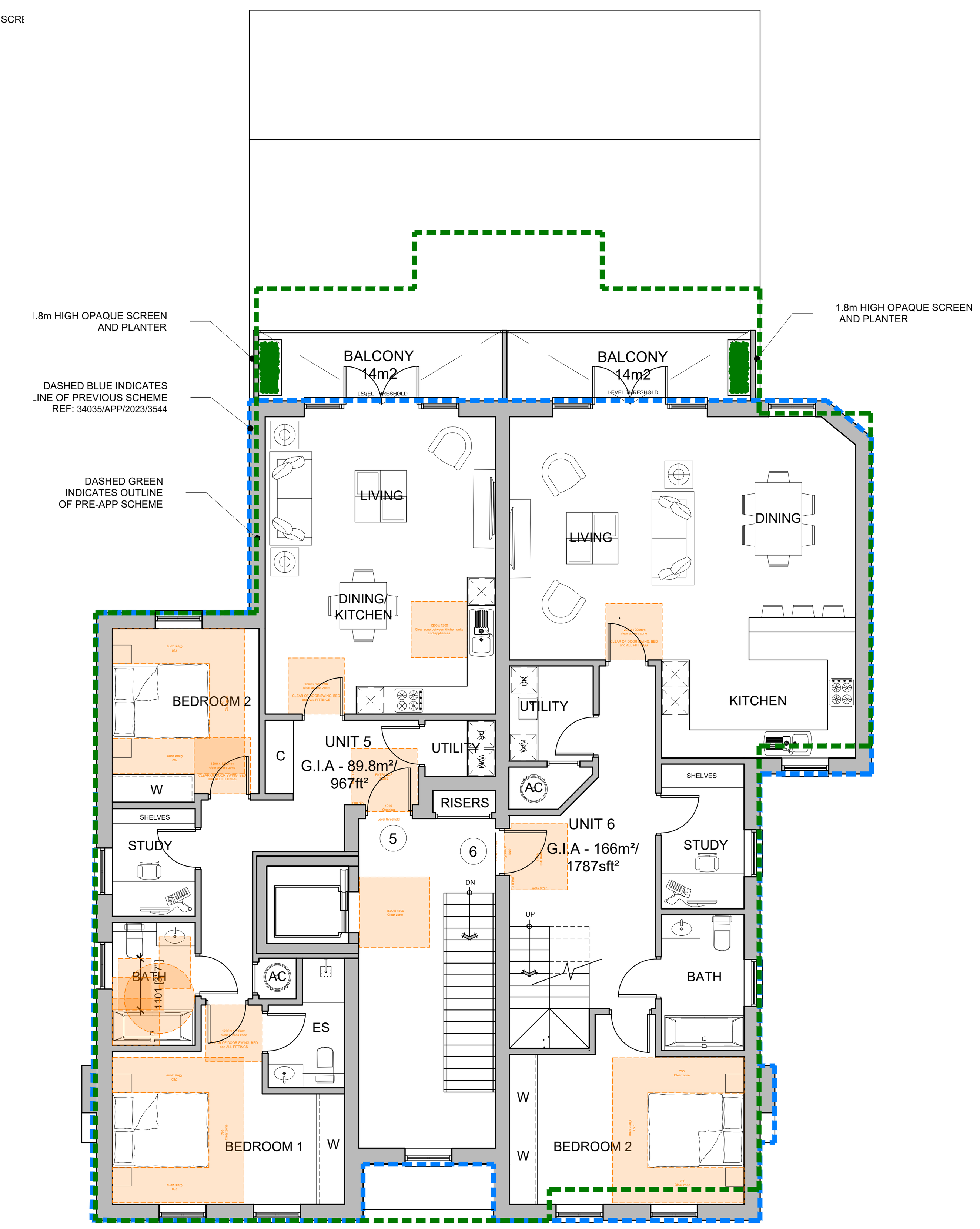
WOODRIDGE WAY
RPA
EXISTING TREES
CYCLE STORAGE
CYCLE STORE
EXISTING HEDGE
SHARED AMENITY GARDEN
DASHED RED
EXISTING BUILDING
TO BE DEMOLISHED
DASHED BLUE INDICATES OUTLINE
OF PREVIOUS SCHEME REF:
34035/APP/2023/3544
SITE BOUNDARY
1.8m HIGH OPAQUE SCREEN
BEHIND 1.1m RAILING/BRICK
BALUSTRADE
1.8m HIGH OPAQUE SCREEN
BEHIND 1.1m RAILING/BRICK
BALUSTRADE
PROPOSED
BUILDING
1.8m HIGH OPAQUE
SCREEN
45 DEGREE LINE
SUNKEN TERRACE
GROUND
FLOOR
BALCONY
GROUND
FLOOR
BALCONY
FIRST
FLOOR
BALCONY
FIRST
FLOOR
BALCONY
LIGHTWELL
SECOND
FLOOR
TERRACE
LIGHTWELL
LIGHTWELL
ACCESS TO EXTERNAL COMMUNAL SPACE
1.8m HIGH OPAQUE
SCREEN
BEHIND 1.1m
RAILING/BRICK
BALUSTRADE
DASHED GREEN
PREVIOUS PRE APP
1.8m HIGH OPAQUE
SCREEN behind 1.1m
RAILING/BRICK
BALUSTRADE
LINE INDICATES
POSITION OF WALL
1.8m HIGH OPAQUE
SCREEN
45 DEGREE
LINE
1
16
4
6.
5.
4.
3.
2.
1.
BIN STORE
BIN STORE
2000
EXISTING ACCESS
PEDESTRIAN
VISIBILITY SPLAYS
EXISTING HEDGE
EXISTING VEHICLE
ONLY ACCESS
CLOSED OFF
DENE ROAD
SANDY LODGE WAY



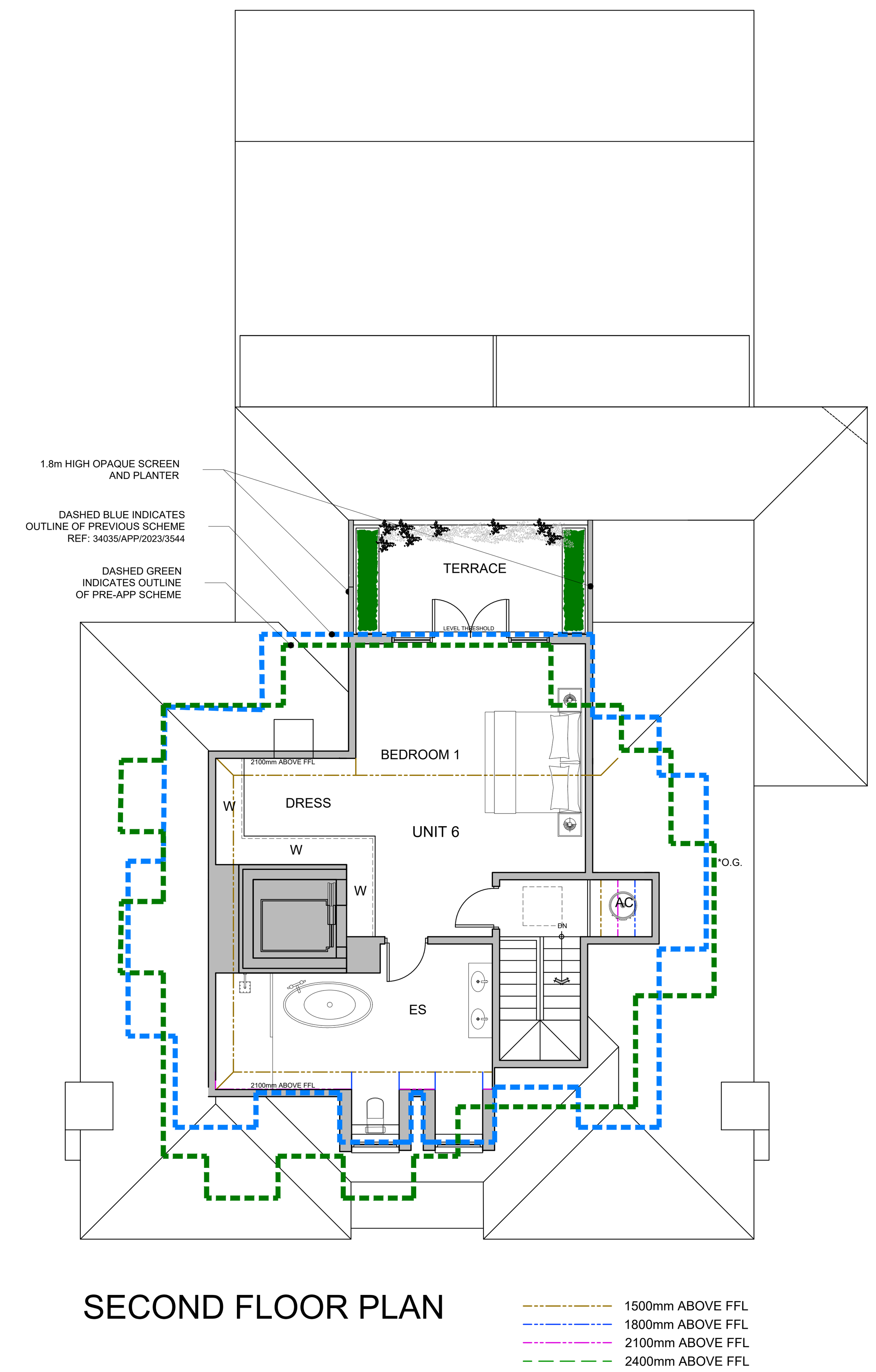
LOWER GROUND FLOOR PLAN



GROUND FLOOR PLAN



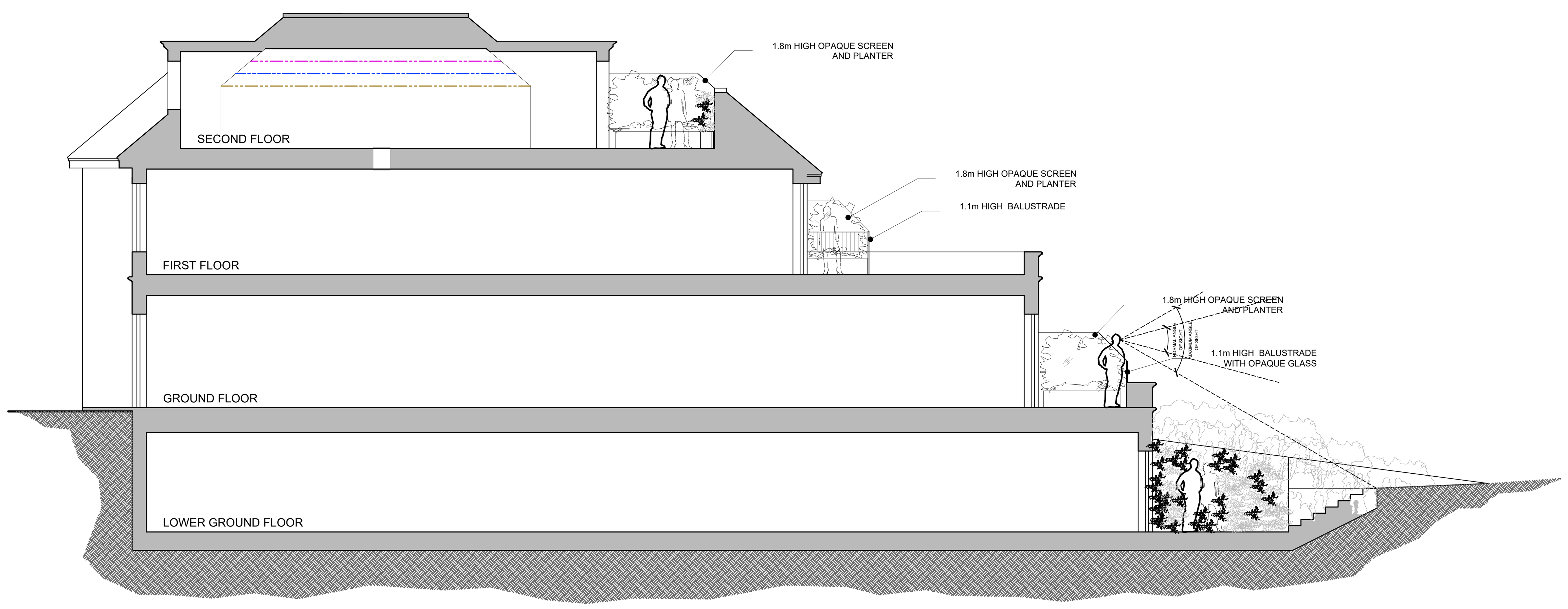
FIRST FLOOR PLAN



SECOND FLOOR PLAN

Proposed Schedule of Accommodation

Plot No	Bed	GIA m²	GIA ft²
Plot 1	2 BED(4 person)	114.0	1227
Plot 2	2 BED(4 person)	128.0	1378
Plot 3	2 BED+STUDY(4 person)	117.2	1261
Plot 4	2 BED+STUDY(4person)	129.0	1388
Plot 5	2 BED+STUDY(4person)	89.8	967
Plot 6	2 BED+STUDY(4person)	166.0	1787
Total		744.0	8008



SECTION

Scale 1:100

Rev. | Date | Detail

Status: PLANNING

ASCOT DESIGN
Timeless architecture

Ascot Design Ltd, Ashurst Manor, Ashurst Park, Ascot, Berkshire, SL5 7DD Tel: 01344 299330 Fax: 01344 299331 Email: info@ascotdesign.com www.ascotdesign.com

Client: GAVACAN HOMES

Project Title: 2 SANDY LODGE WAY NORTHWOOD HA6 2BZ

Drawing Title: FLOOR PLANS AND SECTION

Scale: 1-100@A1 | Date: MAY24 | Drawn: KMB

Drawing No.: 23 - J4296 - 301 | Rev.: -

Appendix D British Geological Survey Data

TQ 09SE/86

Contract Name	Borehole No. 2
28 Halland Way, Northwood	Sheet 1 of 2

Method of boring: Light Cable Percussion
Diameter: 150mm
Ground level: OD ca + 80m
Start: 13.3.86
Finish: 14.3.86
NGR. 0876 9190

Daily progress	Water levels	In-situ tests	Samples	Depth (m)	Reduced level (m O.D.)	Thickness (m)	Description of Strata	Legend
				0.10		0.10	*	
			J	0.65		0.55	(Soft to firm brown silty clay with traces of ash and brick occasional gravel — Made Ground	
13/3			U	1.70		1.05	(Soft dark grey silty clay with traces of decaying organic matter some ash, brick and gravel) — Made Ground	
			J, U, J, U, J, U	6.30		4.60	Firm becoming stiff brown fissured silty CLAY with occasional small pockets and partings of orange-brown fine sand and silt, some blue grey reduction along fissures to about 4m, small pockets of selenite	
13/3			J, U, J, U, J	9.90		3.60	Stiff brown fissured silty CLAY with small pockets and partings of fine sand and silt numerous small pockets of selenite	

Notes: * (Soft dark brown silty clay)

Terresearch Limited	Report No. S36/635	Appendix 1	Sheet 3

Contract Name GREEN LANE, NORTHWOOD

Borehole No. HA2

Sheet 1 **of** 1

Method of boring Hand auger

Diameter 100 mm nominal

Ground level 71.0 m O.D. 0890

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
				0.15	70.95	0.15	Topsoil
			U* U*	1.00	70.10	0.85	Soft mottled light brown grey silty clay with numerous traces of organic material and some root fibres
			U* U* U* U*	2.73	68.37	1.73	Firm to very stiff light brown grey silty clay with traces of organic material
10/9							Bottom of Borehole

Notes

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

Contract Name GREEN LANE, NORTHWOOD	**Borehole No.** HA1 **Sheet** 1 **of** 1

Method of boring Hand auger
Diameter 100 mm nominal
Ground level about 70.0 m O.D
Start 10.9.76 0890
Finish 10.9.76 9154

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

Notes

Contract Name GREEN LANE, NORTHWOOD

Borehole No. HA1

Sheet 1 **of** 1

Method of boring Hand auger

Diameter 100 mm nominal

Ground level about 70.0 m O.D

Start 10.9.76 0890

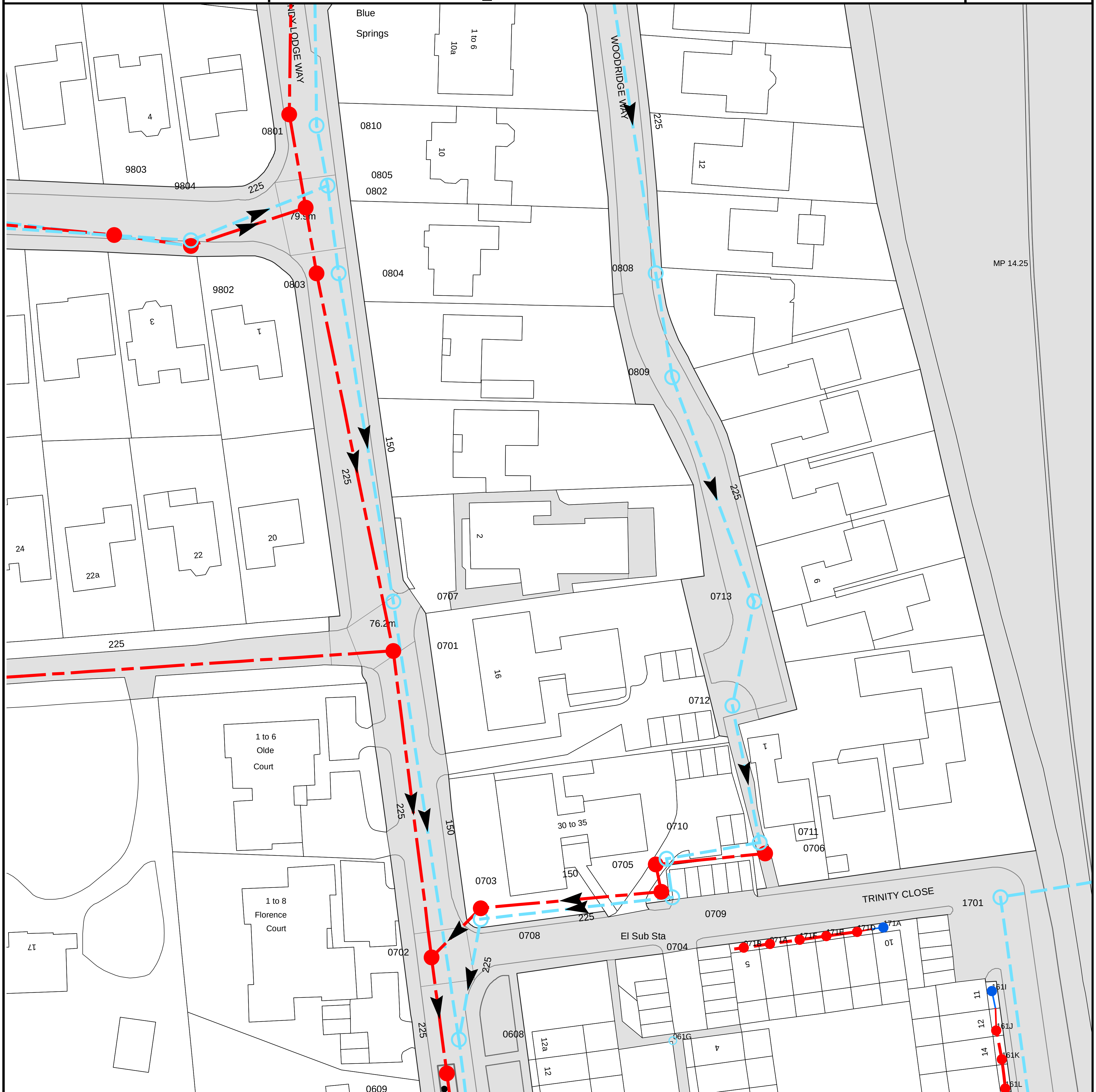
Finish 10.9.76 9154

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

Notes

Appendix E Thames Water Asset Plan

Asset Location Search Sewer Map - ALS/ALS Standard/2023_4914891



The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 509057,191778

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
161L	n/a	n/a
161K	n/a	n/a
161J	n/a	n/a
161I	n/a	n/a
0712	n/a	n/a
071B	n/a	n/a
0713	n/a	n/a
0711	n/a	n/a
0706	n/a	n/a
071A	n/a	n/a
171F	n/a	n/a
171E	n/a	n/a
171D	n/a	n/a
171A	n/a	n/a
1701	72.25	70.62
0808	n/a	n/a
0809	n/a	n/a
9803	n/a	n/a
9802	80.44	77.96
9804	n/a	n/a
0801	80.57	77.15
0802	79.89	76.47
0803	79.23	75.89
0810	80.51	78.31
0805	79.93	77.66
0804	79	76.73
0707	76.28	74.28
0701	76.18	73.65
0702	74.4	71.22
0609	73.7	69.22
0608	73.65	71.97
0703	n/a	n/a
0708	n/a	n/a
0705	n/a	n/a
0704	n/a	n/a
0710	n/a	n/a
0709	n/a	n/a
061G	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.

Asset Location Search - Sewer Key

Public Sewer Types (Operated and maintained by Thames Water)

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

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

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

- Storm Sewer
- Sludge Sewer
- Foul Trunk Sewer
- Surface Trunk Sewer
- Combined Trunk Sewer
- Foul Rising Main
- Surface Water Rising Main
- Combined Rising Main
- Vacuum
- Thames Water Proposed
- Vent Pipe
- Gallery

Other Sewer Types (Not operated and maintained by Thames Water)

- Sewer
- Culverted Watercourse
- Proposed
- Decommissioned Sewer
- Content of this drainage network is currently unknown
- Ownership of this drainage network is currently unknown

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
- Meter
- Dam Chase
- Vent
- Fitting

Operational Controls

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

- Ancillary
- Drop Pipe
- Control Valve
- 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.

- Inlet
- Outfall
- Undefined End

Other Symbols

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

- Change of Characteristic Indicator
- Public / Private Pumping Station
- Invert Level
- Summit

Areas

Lines denoting areas of underground surveys, etc.

- Agreement
- Chamber
- Operational Site

Ducts or Crossings

- Casement
- Conduit Bridge
- Subway
- Tunnel

Ducts may contain high voltage cables. Please check with Thames Water.

Notes:

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plan are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate the 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 indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in millimeters. 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, please contact Property Searches on 0800 009 4540.

Appendix F Greenfield Run-Off Calculation

IH 124 Mean Annual Flood

Input

Return Period (years)	2	SAAR (mm)	703	Urban	0.710
Area (ha)	50.000	Soil	0.300	Region Number	Region 6

Results l/s

QBAR Rural	91.6
QBAR Urban	282.6
Q2 years	284.9
Q1 year	240.2
Q2 years	284.9
Q5 years	379.4
Q10 years	431.0
Q20 years	475.7
Q25 years	487.4
Q30 years	497.3
Q50 years	526.9
Q100 years	580.4
Q200 years	625.0
Q250 years	638.0
Q1000 years	724.7

Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Areal Reduction Factor	1.00
Area (ha)	0.068
SAAR (mm)	676
CWI	100.680
SPR Host	47.000
URBEXT (USER)	0.5000

Results

Percentage Runoff (%)	53.82
Greenfield Runoff Volume (m^3)	28.470

Appendix G Pre-Development Run-Off Calculation

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FEH Rainfall Model

Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Maximum Rainfall (mm/hr)	50
Maximum Time of Concentration (mins)	30
Foul Sewage (l/s/ha)	0.000
Volumetric Runoff Coeff.	0.750
PIMP (%)	100
Add Flow / Climate Change (%)	0
Minimum Backdrop Height (m)	0.200
Maximum Backdrop Height (m)	1.500
Min Design Depth for Optimisation (m)	1.200
Min Vel for Auto Design only (m/s)	1.00
Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Simulation Criteria for Storm

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

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

Synthetic Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840

Synthetic Rainfall Details

Storm Duration (mins) 30

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

Simulation Criteria

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

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

Synthetic Rainfall Details

Rainfall Model	FEH
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Cv (Summer)	0.750
Cv (Winter)	0.840

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	2, 30, 100
Climate Change (%)	0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.000	1	15 Winter	2	+0%					75.082
1.001	2	15 Winter	2	+0%	100/15 Summer				75.045

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.143	0.000	0.28			8.8	OK	
1.001	2	-0.130	0.000	0.37			11.6	OK	

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

Simulation Criteria

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

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

Synthetic Rainfall Details

Rainfall Model	FEH
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Cv (Summer)	0.750
Cv (Winter)	0.840

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	2, 30, 100
Climate Change (%)	0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.000	1	15 Winter	30	+0%					75.140
1.001	2	15 Winter	30	+0%	100/15 Summer				75.123

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.085	0.000	0.67			21.2	OK	
1.001	2	-0.052	0.000	0.93			29.2	OK	

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

Simulation Criteria

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

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

Synthetic Rainfall Details

Rainfall Model	FEH
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Cv (Summer)	0.750
Cv (Winter)	0.840

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

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	2, 30, 100
Climate Change (%)	0, 0, 0

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
1.000	1	15 Winter	100	+0%					75.220
1.001	2	15 Winter	100	+0%	100/15 Summer				75.191

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	-0.005	0.000	0.88			27.6	OK	
1.001	2	0.016	0.000	1.20			37.7	SURCHARGED	

Simulation Criteria for Storm

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

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

Synthetic Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Storm Duration (mins)	30

Summary Wizard of 360 minute 100 year Winter I+0% for Storm

Simulation Criteria

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

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

Synthetic Rainfall Details

Rainfall Model	FEH
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Cv (Summer)	0.750
Cv (Winter)	0.840

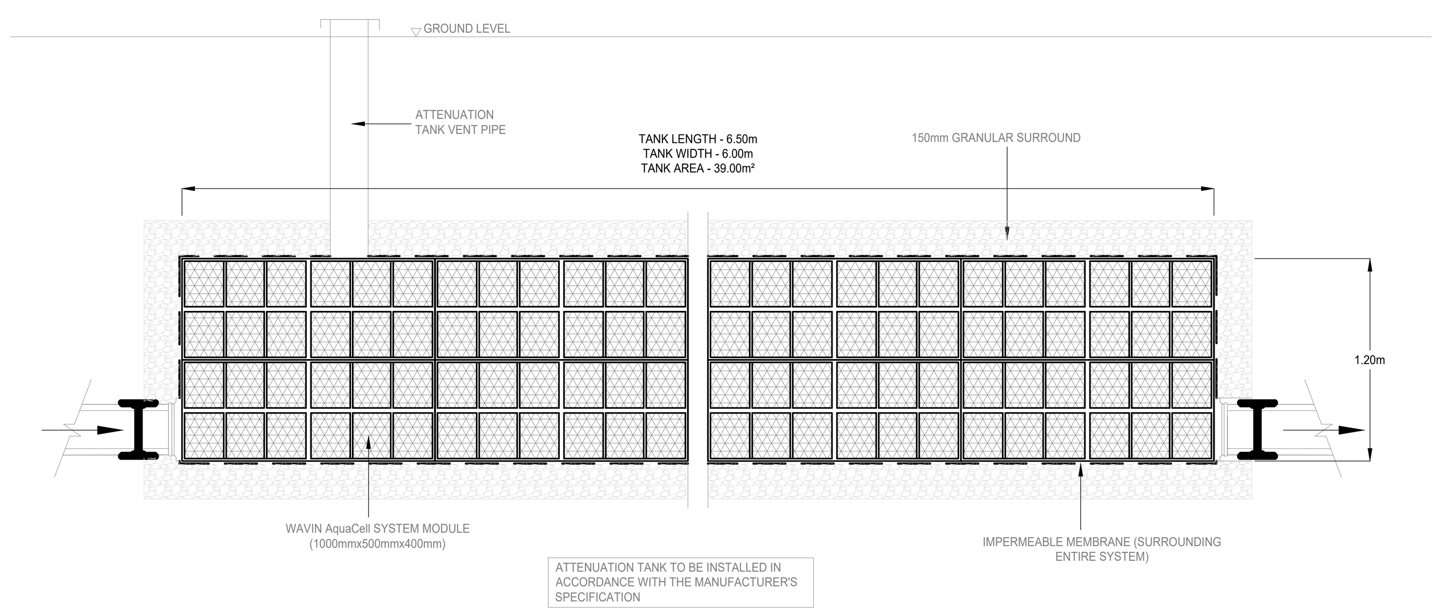
Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	2, 30, 100
Climate Change (%)	0, 0, 0

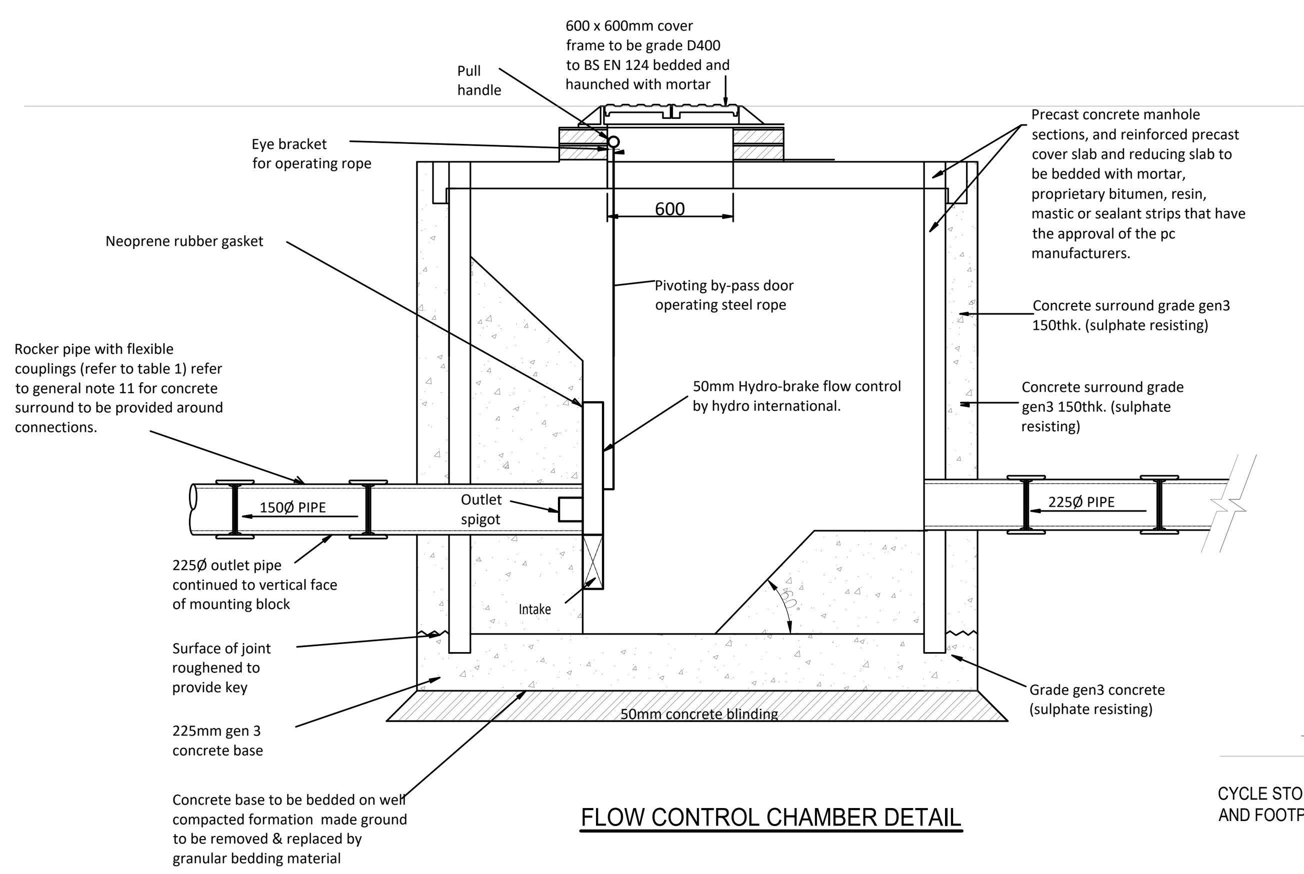
PN	US/MH Name	Event	US/CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.
1.000	1	360 minute 100 year Winter I+0%	76.000	75.054	-0.171	0.000	0.13
1.001	2	360 minute 100 year Winter I+0%	76.000	75.014	-0.161	0.000	0.18

PN	US/MH Name	Overflow (l/s)	Half Drain Discharge Vol (m³)	Time (mins)	Pipe Flow (l/s)	Status
1.000	1		35.940		4.2	OK
1.001	2		49.055		5.7	OK

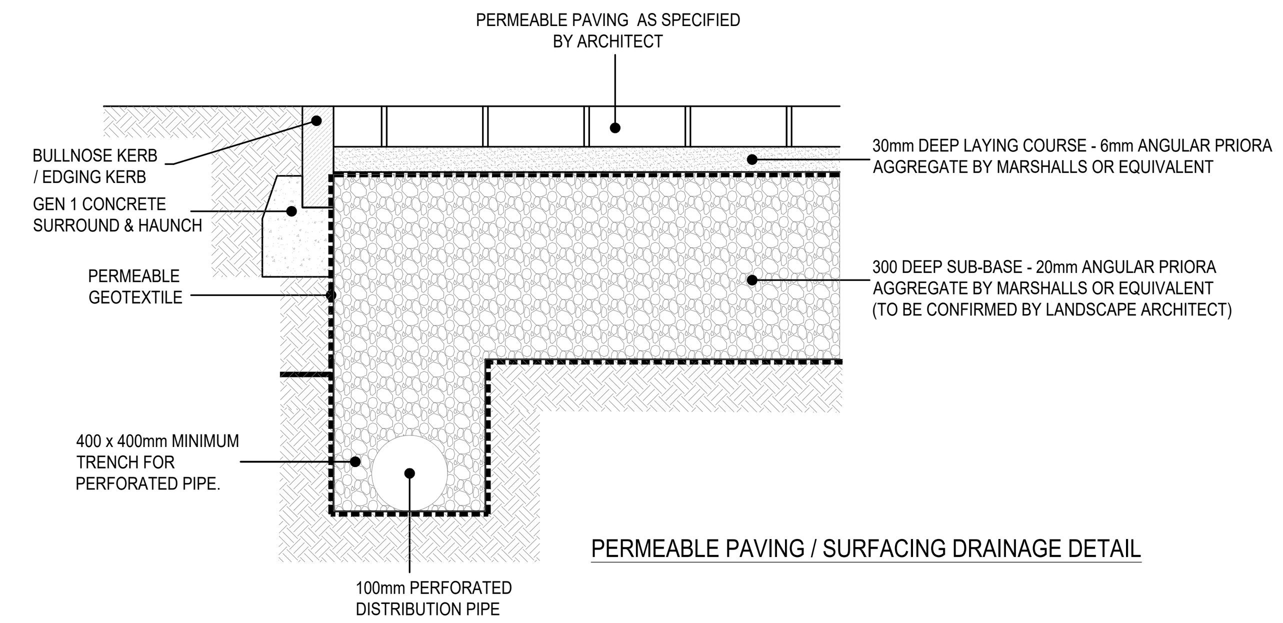
Appendix H Surface Water Management Layout and Details



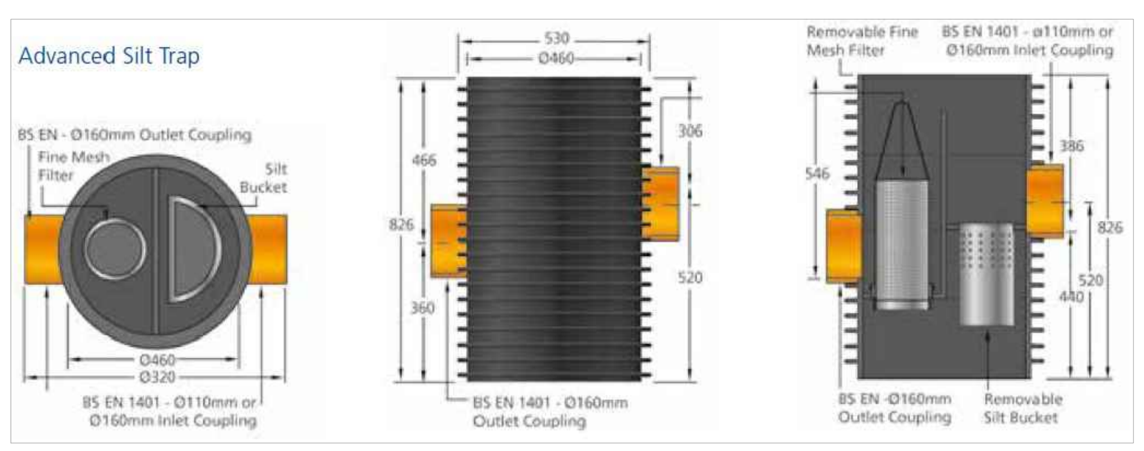
TYPICAL CELLULAR UNIT / TANK DETAIL



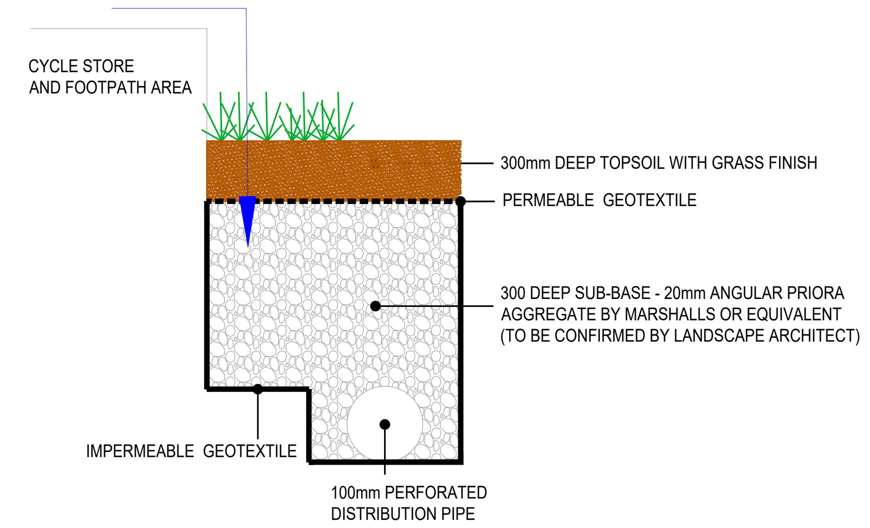
FLOW CONTROL CHAMBER DETAIL



PERMEABLE PAVING / SURFACING DRAINAGE DETAIL



SILT TRAP DETAIL



FILTER DRAIN DETAIL

Drainage Key:

- Surface Water Pipes - Solid
- Proposed perforated Pipe
- Existing Surface Water Sewer
- Permeable Paving
- Filter Drain
- Green Roof
- Exceedance Flow Path
- SW Management Boundary

Rev	Description	Drn	Chk	Date
P2	ISSUED FOR APPROVAL	MDS	NC	18.06.24
P1	ISSUED FOR APPROVAL	MDS	NC	27.11.23

Client
GAVACAN HOMES
c/o HGH CONSULTING

Project
RESIDENTIAL DEVELOPMENT AT
2 SANDY LODGE WAY
NORTHWOOD, HA6 2AJ

Drawing
SURFACE WATER
MANAGEMENT LAYOUT

Scale	Date	Drawn by	Checked
1:100@A1	27.11.23	MDS	NC

Status
APPROVAL

Flo
Chiltern View Studio
Buslins Lane, Chesham
Buckinghamshire, HP5 2XD
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e.mark@flo-consult.co.uk
www.flo-consult.co.uk

Job No.	Drg. No.	Rev
998	DR-100	P2

Appendix I Surface Water Management Calculations

Summary of Results for 2 year Return Period

Half Drain Time : 68 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	74.403	0.103	0.0	0.9	0.9	3.8	O K
30 min Summer	74.426	0.126	0.0	0.9	0.9	4.7	O K
60 min Summer	74.440	0.140	0.0	0.9	0.9	5.2	O K
120 min Summer	74.474	0.174	0.0	1.0	1.0	6.4	O K
180 min Summer	74.482	0.182	0.0	1.0	1.0	6.7	O K
240 min Summer	74.480	0.180	0.0	1.0	1.0	6.7	O K
360 min Summer	74.466	0.166	0.0	1.0	1.0	6.2	O K
480 min Summer	74.448	0.148	0.0	1.0	1.0	5.5	O K
600 min Summer	74.431	0.131	0.0	0.9	0.9	4.9	O K
720 min Summer	74.416	0.116	0.0	0.9	0.9	4.3	O K
960 min Summer	74.393	0.093	0.0	0.9	0.9	3.4	O K
1440 min Summer	74.368	0.068	0.0	0.8	0.8	2.5	O K
2160 min Summer	74.352	0.052	0.0	0.6	0.6	1.9	O K
2880 min Summer	74.344	0.044	0.0	0.5	0.5	1.6	O K
4320 min Summer	74.336	0.036	0.0	0.4	0.4	1.3	O K
5760 min Summer	74.332	0.032	0.0	0.3	0.3	1.2	O K
7200 min Summer	74.330	0.030	0.0	0.3	0.3	1.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	36.058	0.0	4.6	26
30 min Summer	22.954	0.0	5.8	36
60 min Summer	14.199	0.0	7.2	56
120 min Summer	10.082	0.0	10.3	92
180 min Summer	7.903	0.0	12.1	128
240 min Summer	6.542	0.0	13.3	162
360 min Summer	4.905	0.0	15.0	230
480 min Summer	3.940	0.0	16.1	294
600 min Summer	3.307	0.0	16.8	356
720 min Summer	2.858	0.0	17.5	416
960 min Summer	2.262	0.0	18.4	532
1440 min Summer	1.623	0.0	19.8	764
2160 min Summer	1.175	0.0	21.6	1120
2880 min Summer	0.942	0.0	23.1	1476
4320 min Summer	0.704	0.0	25.8	2204
5760 min Summer	0.581	0.0	28.4	2912
7200 min Summer	0.506	0.0	31.0	3648

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	74.328	0.028	0.0	0.3	0.3	1.0	O K
10080 min Summer	74.327	0.027	0.0	0.2	0.2	1.0	O K
15 min Winter	74.416	0.116	0.0	0.9	0.9	4.3	O K
30 min Winter	74.443	0.143	0.0	0.9	0.9	5.3	O K
60 min Winter	74.460	0.160	0.0	1.0	1.0	5.9	O K
120 min Winter	74.496	0.196	0.0	1.0	1.0	7.3	O K
180 min Winter	74.502	0.202	0.0	1.0	1.0	7.5	O K
240 min Winter	74.496	0.196	0.0	1.0	1.0	7.3	O K
360 min Winter	74.472	0.172	0.0	1.0	1.0	6.4	O K
480 min Winter	74.445	0.145	0.0	0.9	0.9	5.4	O K
600 min Winter	74.421	0.121	0.0	0.9	0.9	4.5	O K
720 min Winter	74.401	0.101	0.0	0.9	0.9	3.7	O K
960 min Winter	74.375	0.075	0.0	0.8	0.8	2.8	O K
1440 min Winter	74.354	0.054	0.0	0.6	0.6	2.0	O K
2160 min Winter	74.341	0.041	0.0	0.5	0.5	1.5	O K
2880 min Winter	74.336	0.036	0.0	0.4	0.4	1.3	O K
4320 min Winter	74.330	0.030	0.0	0.3	0.3	1.1	O K
5760 min Winter	74.327	0.027	0.0	0.2	0.2	1.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.456	0.0	33.4	4408
10080 min Summer	0.419	0.0	35.9	5072
15 min Winter	36.058	0.0	5.1	26
30 min Winter	22.954	0.0	6.5	37
60 min Winter	14.199	0.0	8.1	60
120 min Winter	10.082	0.0	11.5	100
180 min Winter	7.903	0.0	13.5	138
240 min Winter	6.542	0.0	14.9	176
360 min Winter	4.905	0.0	16.8	246
480 min Winter	3.940	0.0	18.0	312
600 min Winter	3.307	0.0	18.9	372
720 min Winter	2.858	0.0	19.6	430
960 min Winter	2.262	0.0	20.7	536
1440 min Winter	1.623	0.0	22.2	768
2160 min Winter	1.175	0.0	24.1	1124
2880 min Winter	0.942	0.0	25.8	1476
4320 min Winter	0.704	0.0	28.9	2176
5760 min Winter	0.581	0.0	31.8	2896

Summary of Results for 2 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
7200 min Winter	74.325	0.025	0.0	0.2	0.2	0.9	O K
8640 min Winter	74.323	0.023	0.0	0.2	0.2	0.9	O K
10080 min Winter	74.322	0.022	0.0	0.2	0.2	0.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Winter	0.506	0.0	34.7	3744
8640 min Winter	0.456	0.0	37.5	4392
10080 min Winter	0.419	0.0	40.2	5128

Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.068

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.017	4	8	0.017	8	12	0.017	12	16	0.017

Model Details

Storage is Online Cover Level (m) 76.000

Cellular Storage Structure

Invert Level (m) 74.300 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	39.0	0.0	5.200	0.0	0.0
0.400	39.0	0.0	5.600	0.0	0.0
0.800	39.0	0.0	6.000	0.0	0.0
1.200	39.0	0.0	6.400	0.0	0.0
1.600	0.0	0.0	6.800	0.0	0.0
2.000	0.0	0.0	7.200	0.0	0.0
2.400	0.0	0.0	7.600	0.0	0.0
2.800	0.0	0.0	8.000	0.0	0.0
3.200	0.0	0.0	8.400	0.0	0.0
3.600	0.0	0.0	8.800	0.0	0.0
4.000	0.0	0.0	9.200	0.0	0.0
4.400	0.0	0.0	9.600	0.0	0.0
4.800	0.0	0.0	10.000	0.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0050-1200-1100-1200
Design Head (m)	1.100
Design Flow (l/s)	1.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	50
Invert Level (m)	74.300
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	1.2	Kick-Flo®	0.449	0.8
Flush-Flo™	0.222	1.0	Mean Flow over Head Range	-	0.9

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

Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.9	1.200	1.2	3.000	1.9	7.000	2.8
0.200	1.0	1.400	1.3	3.500	2.0	7.500	2.9
0.300	1.0	1.600	1.4	4.000	2.2	8.000	3.0
0.400	0.9	1.800	1.5	4.500	2.3	8.500	3.1
0.500	0.8	2.000	1.6	5.000	2.4	9.000	3.1
0.600	0.9	2.200	1.6	5.500	2.5	9.500	3.2
0.800	1.0	2.400	1.7	6.000	2.6		
1.000	1.1	2.600	1.8	6.500	2.7		

Summary of Results for 30 year Return Period (+35%)

Half Drain Time : 260 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	74.670	0.370	0.0	1.0	1.0	13.7	O K
30 min Summer	74.777	0.477	0.0	1.0	1.0	17.7	O K
60 min Summer	74.867	0.567	0.0	1.0	1.0	21.0	O K
120 min Summer	74.964	0.664	0.0	1.0	1.0	24.6	O K
180 min Summer	74.990	0.690	0.0	1.0	1.0	25.5	O K
240 min Summer	74.987	0.687	0.0	1.0	1.0	25.5	O K
360 min Summer	74.961	0.661	0.0	1.0	1.0	24.5	O K
480 min Summer	74.926	0.626	0.0	1.0	1.0	23.2	O K
600 min Summer	74.890	0.590	0.0	1.0	1.0	21.8	O K
720 min Summer	74.854	0.554	0.0	1.0	1.0	20.5	O K
960 min Summer	74.785	0.485	0.0	1.0	1.0	18.0	O K
1440 min Summer	74.644	0.344	0.0	1.0	1.0	12.8	O K
2160 min Summer	74.511	0.211	0.0	1.0	1.0	7.8	O K
2880 min Summer	74.438	0.138	0.0	0.9	0.9	5.1	O K
4320 min Summer	74.378	0.078	0.0	0.8	0.8	2.9	O K
5760 min Summer	74.361	0.061	0.0	0.7	0.7	2.2	O K
7200 min Summer	74.352	0.052	0.0	0.6	0.6	1.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	117.047	0.0	14.9	29
30 min Summer	75.904	0.0	19.3	42
60 min Summer	46.908	0.0	23.9	70
120 min Summer	29.729	0.0	30.3	126
180 min Summer	22.278	0.0	34.1	182
240 min Summer	17.969	0.0	36.6	220
360 min Summer	13.069	0.0	40.0	282
480 min Summer	10.321	0.0	42.1	348
600 min Summer	8.558	0.0	43.6	416
720 min Summer	7.326	0.0	44.8	486
960 min Summer	5.712	0.0	46.6	624
1440 min Summer	4.008	0.0	49.0	868
2160 min Summer	2.821	0.0	51.8	1212
2880 min Summer	2.211	0.0	54.1	1544
4320 min Summer	1.591	0.0	58.4	2216
5760 min Summer	1.274	0.0	62.4	2944
7200 min Summer	1.083	0.0	66.3	3672

Summary of Results for 30 year Return Period (+35%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	74.346	0.046	0.0	0.5	0.5	1.7	O K
10080 min Summer	74.342	0.042	0.0	0.5	0.5	1.6	O K
15 min Winter	74.719	0.419	0.0	1.0	1.0	15.5	O K
30 min Winter	74.839	0.539	0.0	1.0	1.0	20.0	O K
60 min Winter	74.942	0.642	0.0	1.0	1.0	23.8	O K
120 min Winter	75.058	0.758	0.0	1.0	1.0	28.1	O K
180 min Winter	75.094	0.794	0.0	1.0	1.0	29.4	O K
240 min Winter	75.096	0.796	0.0	1.0	1.0	29.5	O K
360 min Winter	75.062	0.762	0.0	1.0	1.0	28.2	O K
480 min Winter	75.018	0.718	0.0	1.0	1.0	26.6	O K
600 min Winter	74.969	0.669	0.0	1.0	1.0	24.8	O K
720 min Winter	74.920	0.620	0.0	1.0	1.0	23.0	O K
960 min Winter	74.822	0.522	0.0	1.0	1.0	19.3	O K
1440 min Winter	74.617	0.317	0.0	1.0	1.0	11.7	O K
2160 min Winter	74.449	0.149	0.0	1.0	1.0	5.5	O K
2880 min Winter	74.384	0.084	0.0	0.8	0.8	3.1	O K
4320 min Winter	74.355	0.055	0.0	0.6	0.6	2.0	O K
5760 min Winter	74.345	0.045	0.0	0.5	0.5	1.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.954	0.0	70.1	4400
10080 min Summer	0.862	0.0	73.8	5136
15 min Winter	117.047	0.0	16.7	29
30 min Winter	75.904	0.0	21.6	42
60 min Winter	46.908	0.0	26.8	70
120 min Winter	29.729	0.0	33.9	124
180 min Winter	22.278	0.0	38.2	180
240 min Winter	17.969	0.0	41.0	234
360 min Winter	13.069	0.0	44.8	294
480 min Winter	10.321	0.0	47.1	370
600 min Winter	8.558	0.0	48.9	448
720 min Winter	7.326	0.0	50.2	524
960 min Winter	5.712	0.0	52.2	676
1440 min Winter	4.008	0.0	54.9	920
2160 min Winter	2.821	0.0	58.0	1236
2880 min Winter	2.211	0.0	60.6	1536
4320 min Winter	1.591	0.0	65.4	2212
5760 min Winter	1.274	0.0	69.9	2912

Summary of Results for 30 year Return Period (+35%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
7200 min Winter	74.339	0.039	0.0	0.4	0.4	1.5	O K
8640 min Winter	74.336	0.036	0.0	0.4	0.4	1.3	O K
10080 min Winter	74.334	0.034	0.0	0.3	0.3	1.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Winter	1.083	0.0	74.2	3672
8640 min Winter	0.954	0.0	78.5	4360
10080 min Winter	0.862	0.0	82.7	5128

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+35

Time Area Diagram

Total Area (ha) 0.068

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.017	4	8	0.017	8	12	0.017	12	16	0.017

Model Details

Storage is Online Cover Level (m) 76.000

Cellular Storage Structure

Invert Level (m) 74.300 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	39.0	0.0	5.200	0.0	0.0
0.400	39.0	0.0	5.600	0.0	0.0
0.800	39.0	0.0	6.000	0.0	0.0
1.200	39.0	0.0	6.400	0.0	0.0
1.600	0.0	0.0	6.800	0.0	0.0
2.000	0.0	0.0	7.200	0.0	0.0
2.400	0.0	0.0	7.600	0.0	0.0
2.800	0.0	0.0	8.000	0.0	0.0
3.200	0.0	0.0	8.400	0.0	0.0
3.600	0.0	0.0	8.800	0.0	0.0
4.000	0.0	0.0	9.200	0.0	0.0
4.400	0.0	0.0	9.600	0.0	0.0
4.800	0.0	0.0	10.000	0.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0050-1200-1100-1200
Design Head (m)	1.100
Design Flow (l/s)	1.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	50
Invert Level (m)	74.300
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	1.2	Kick-Flo®	0.449	0.8
Flush-Flo™	0.222	1.0	Mean Flow over Head Range	-	0.9

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

Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.9	1.200	1.2	3.000	1.9	7.000	2.8
0.200	1.0	1.400	1.3	3.500	2.0	7.500	2.9
0.300	1.0	1.600	1.4	4.000	2.2	8.000	3.0
0.400	0.9	1.800	1.5	4.500	2.3	8.500	3.1
0.500	0.8	2.000	1.6	5.000	2.4	9.000	3.1
0.600	0.9	2.200	1.6	5.500	2.5	9.500	3.2
0.800	1.0	2.400	1.7	6.000	2.6		
1.000	1.1	2.600	1.8	6.500	2.7		

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 350 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	74.814	0.514	0.0	1.0	1.0	19.0	O K
30 min Summer	74.966	0.666	0.0	1.0	1.0	24.7	O K
60 min Summer	75.100	0.800	0.0	1.0	1.0	29.6	O K
120 min Summer	75.245	0.945	0.0	1.1	1.1	35.0	O K
180 min Summer	75.301	1.001	0.0	1.1	1.1	37.1	O K
240 min Summer	75.314	1.014	0.0	1.2	1.2	37.6	O K
360 min Summer	75.292	0.992	0.0	1.1	1.1	36.8	O K
480 min Summer	75.253	0.953	0.0	1.1	1.1	35.3	O K
600 min Summer	75.209	0.909	0.0	1.1	1.1	33.7	O K
720 min Summer	75.166	0.866	0.0	1.1	1.1	32.1	O K
960 min Summer	75.084	0.784	0.0	1.0	1.0	29.0	O K
1440 min Summer	74.942	0.642	0.0	1.0	1.0	23.8	O K
2160 min Summer	74.757	0.457	0.0	1.0	1.0	16.9	O K
2880 min Summer	74.588	0.288	0.0	1.0	1.0	10.7	O K
4320 min Summer	74.438	0.138	0.0	0.9	0.9	5.1	O K
5760 min Summer	74.384	0.084	0.0	0.8	0.8	3.1	O K
7200 min Summer	74.366	0.066	0.0	0.7	0.7	2.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	158.859	0.0	20.2	29
30 min Summer	104.070	0.0	26.5	43
60 min Summer	64.605	0.0	32.9	70
120 min Summer	40.775	0.0	41.6	126
180 min Summer	30.690	0.0	46.9	184
240 min Summer	24.850	0.0	50.7	240
360 min Summer	18.150	0.0	55.5	300
480 min Summer	14.356	0.0	58.5	362
600 min Summer	11.899	0.0	60.7	430
720 min Summer	10.174	0.0	62.2	498
960 min Summer	7.900	0.0	64.4	636
1440 min Summer	5.495	0.0	67.2	910
2160 min Summer	3.810	0.0	69.9	1320
2880 min Summer	2.945	0.0	72.1	1624
4320 min Summer	2.070	0.0	76.0	2292
5760 min Summer	1.625	0.0	79.6	2952
7200 min Summer	1.358	0.0	83.1	3672

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	74.357	0.057	0.0	0.7	0.7	2.1	O K
10080 min Summer	74.350	0.050	0.0	0.6	0.6	1.9	O K
15 min Winter	74.879	0.579	0.0	1.0	1.0	21.4	O K
30 min Winter	75.051	0.751	0.0	1.0	1.0	27.8	O K
60 min Winter	75.204	0.904	0.0	1.1	1.1	33.5	O K
120 min Winter	75.377	1.077	0.0	1.2	1.2	39.9	O K
180 min Winter	75.449	1.149	0.0	1.2	1.2	42.6	O K
240 min Winter	75.473	1.173	0.0	1.2	1.2	43.5	O K
360 min Winter	75.449	1.149	0.0	1.2	1.2	42.6	O K
480 min Winter	75.402	1.102	0.0	1.2	1.2	40.8	O K
600 min Winter	75.348	1.048	0.0	1.2	1.2	38.8	O K
720 min Winter	75.291	0.991	0.0	1.1	1.1	36.7	O K
960 min Winter	75.178	0.878	0.0	1.1	1.1	32.5	O K
1440 min Winter	74.979	0.679	0.0	1.0	1.0	25.2	O K
2160 min Winter	74.689	0.389	0.0	1.0	1.0	14.4	O K
2880 min Winter	74.494	0.194	0.0	1.0	1.0	7.2	O K
4320 min Winter	74.375	0.075	0.0	0.8	0.8	2.8	O K
5760 min Winter	74.357	0.057	0.0	0.7	0.7	2.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.179	0.0	86.6	4400
10080 min Summer	1.052	0.0	90.1	5136
15 min Winter	158.859	0.0	22.6	29
30 min Winter	104.070	0.0	29.7	43
60 min Winter	64.605	0.0	36.9	70
120 min Winter	40.775	0.0	46.6	126
180 min Winter	30.690	0.0	52.6	182
240 min Winter	24.850	0.0	56.8	236
360 min Winter	18.150	0.0	62.2	338
480 min Winter	14.356	0.0	65.6	382
600 min Winter	11.899	0.0	67.9	458
720 min Winter	10.174	0.0	69.7	536
960 min Winter	7.900	0.0	72.2	686
1440 min Winter	5.495	0.0	75.3	980
2160 min Winter	3.810	0.0	78.3	1372
2880 min Winter	2.945	0.0	80.7	1656
4320 min Winter	2.070	0.0	85.1	2244
5760 min Winter	1.625	0.0	89.1	2944

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
7200 min Winter	74.347	0.047	0.0	0.5	0.5	1.7	O K
8640 min Winter	74.342	0.042	0.0	0.5	0.5	1.6	O K
10080 min Winter	74.339	0.039	0.0	0.4	0.4	1.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Winter	1.358	0.0	93.1	3672
8640 min Winter	1.179	0.0	97.0	4408
10080 min Winter	1.052	0.0	100.9	5024

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 509051 191779 TQ 09051 91779
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.068

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.017	4	8	0.017	8	12	0.017	12	16	0.017

Model Details

Storage is Online Cover Level (m) 76.000

Cellular Storage Structure

Invert Level (m) 74.300 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	39.0	0.0	5.200	0.0	0.0
0.400	39.0	0.0	5.600	0.0	0.0
0.800	39.0	0.0	6.000	0.0	0.0
1.200	39.0	0.0	6.400	0.0	0.0
1.600	0.0	0.0	6.800	0.0	0.0
2.000	0.0	0.0	7.200	0.0	0.0
2.400	0.0	0.0	7.600	0.0	0.0
2.800	0.0	0.0	8.000	0.0	0.0
3.200	0.0	0.0	8.400	0.0	0.0
3.600	0.0	0.0	8.800	0.0	0.0
4.000	0.0	0.0	9.200	0.0	0.0
4.400	0.0	0.0	9.600	0.0	0.0
4.800	0.0	0.0	10.000	0.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0050-1200-1100-1200
Design Head (m)	1.100
Design Flow (l/s)	1.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	50
Invert Level (m)	74.300
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	1.2	Kick-Flo®	0.449	0.8
Flush-Flo™	0.222	1.0	Mean Flow over Head Range	-	0.9

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

Hydro-Brake® Optimum Outflow Control

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.9	1.200	1.2	3.000	1.9	7.000	2.8
0.200	1.0	1.400	1.3	3.500	2.0	7.500	2.9
0.300	1.0	1.600	1.4	4.000	2.2	8.000	3.0
0.400	0.9	1.800	1.5	4.500	2.3	8.500	3.1
0.500	0.8	2.000	1.6	5.000	2.4	9.000	3.1
0.600	0.9	2.200	1.6	5.500	2.5	9.500	3.2
0.800	1.0	2.400	1.7	6.000	2.6		
1.000	1.1	2.600	1.8	6.500	2.7		