Flo

Consulting Engineers

Project_

Residential Development at
Land East of 47 Hawthorn Road
Worthing, BN14 9LT

Title_

Surface Water Management Report

Project No_

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Date_

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Contents

1.	Introduction	2
2.	National / Local Policies and Water Management Guidance	3
3.	Site Setting and Description	4
4.	Surface Water Management Principles	5
5.	Surface Water Run-Off Destination	7
6.	SuDS Feasibility	8
7.	Development Greenfield Run-Off Rate and Volumes	11
8.	Drainage Networks and Surface Water Management Calculation	13
9.	Maintenance Requirements	16
10.	Surface Water Exceedance Event	17
11.	Water Quality	18
12.	Development Management and Construction Phase	19
13.	Conclusion / Summary	20

Appendices

Appendix A	-	Site Location and Block Plan
Appendix B	-	Proposed Site Plans
Appendix C	-	British Geological Survey Data
Appendix D	-	Southern Water Sewer Plans
Appendix E	-	Greenfield Run-Off Calculation
Appendix F	-	Surface Water Management Layout and Details
Appendix G	-	Surface Water Management Calculations

1. Introduction

Flo Consult UK Ltd have prepared this report to meet Worthing Borough Council planning Conditions 7 and 8 for a new residential development at land east of 47 Hawthorn Road, Worthing, West Sussex, BN14 9LT (hereafter referred to as 'the Site').

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

- National Planning Policy Framework (NPPF), September 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:

- Worthing Borough Council Local Plan 2020 – 2036 (Adopted 28th Marh 2023) – Relevant Policies DM5 and DM 20;
- Adur and Worthing Level 1 and Level 2 Strategic Flood Risk Assessment (July 2020);
- West Sussex LLFA Policy for the Management of Surface Water (November 2018);
- West Sussex Local Flood Risk Management Strategy (May 2014);
- West Sussex Preliminary Flood Risk Assessment (May 2011).

Subsequently, Worthing Borough Council, 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 (September 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).

2.3. Worthing Borough Council Local Plan 2020-2036

Relevant sections (sustainable drainage) of Policy DM 20 states:

'The surface water drainage scheme should use Sustainable Drainage Systems, unless there is clear evidence that this would be inappropriate, and be designed to:

i. limit runoff to greenfield 1-year rates for events up to and including the 100-year plus climate change event where possible, and always ensure no increase in flows as a result of development;

ii. follow natural drainage flow paths and work with existing site topography;

iii. provide adequate capacity for the 30-year plus climate change event to be contained within the drainage system, and demonstrate that the development is safe for the 100-year plus climate change event scenario and does not increase in flood risk off site;

iv. incorporate green infrastructure and maximise multi-functional benefits ensuring adequate treatment of surface water prior to discharge to ensure that the quality of local water is not adversely affected;

v. be sensitively located and designed to promote an enhanced landscape/townscape and good quality spaces that improve public amenity;

vi. discharge run-off according to the following hierarchy: (1) into the ground (infiltration), (2) to a surface water body, (3) to a surface water sewer, (4) to a combined sewer. Surface water connections to the public sewerage network should only be made with prior agreement of the relevant sewerage undertaker and where it can be demonstrated that there are no feasible alternatives (this applies to new developments and redevelopments) and where there is no detriment to existing users.

Clear management arrangements and funding for their ongoing maintenance over the lifetime of the development should be proposed. Planning conditions or obligations will be used to secure these arrangements'.

3. Site Setting and Description

3.1. Site Location

The Site is in a residential area of Worthing, is approximately 2.0km north of Worthing train station, and as shown on the block and location plan in Appendix A, is bound by Hawthorn Gardens to the north and east, Hawthorn Road to the south, and an existing dwelling (No.47 Hawthorn Gardens) to the west.

The full address of the Site is land east of Hawthorn Road, Worthing, West Sussex, BN14 9LT, with the co-ordinates of the centre of the site being: Easting: 514590, Northing: 104935.

3.2. Existing Site and Topography

The Site, in a pre-development state, is undeveloped and is deemed to be a '**Greenfield'.**

In terms of topography, the Site has a general fall from north to south with levels falling towards Hawthorn Road.

3.3. Proposed Development

The proposed plan is shown in Appendix B, with a full description of the Site being provided by the Architect. In brief, and in relation to this report, the proposal is to build a detached bungalow in the centre of the Site, with a driveway area to the front (south), and potential patio area to the rear (north).

3.4. Ground Conditions

The ground conditions can be determined by the British Geological Survey (BGS) website, where it shows the Site to have superficial deposits of Head (clay, silt sand and gravel), over bedrock consisting of Spetisbury Chalk Member (chalk).

The BGS website also shows public borehole log data areas 1km north of the Site (Clarenden Road), and within the same strata (see Appendix C), which shows the ground to predominantly consist of clay over sandy chalk strata.

3.5. Waterbodies

There are no known waterbodies near the Site, with the nearest being unnamed watercourses approximately 1.5 km to the east and Teville Stream approximately 3 km to the south-east.

3.6. Existing Drainage / Sewers

The Southern Water asset plan in Appendix D shows the nearest sewer to the Site to be a 225mm diameter surface water sewer in Hawthorn Road that flows in a westerly direction.

The Site is currently undeveloped, and therefore the surface water currently discharges of the Site at a greenfield rate.

3.7. Development Areas

The Site has an overall area of approximately 250m² / **0.025 ha**.

The Site, in a pre-development state, is undeveloped and therefore in terms of greenfield run-off calculations, the Site has an urban factor of **0**.

The Site, in a post development state, will consist of the new residential dwelling, driveway and potential patio area, which equates to approximately 130m² / 0.013 ha, with the remaining garden areas equating to approximately 120m² / 0.012 ha.

The surface water run-off from the garden areas will continue to discharge off the Site at a natural / greenfield rate, and therefore the surface water management area is **0.013 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:

*'**S2** For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100-year rainfall event should never exceed the peak greenfield runoff rate for the same event'.*

4.5. Volume Control

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

*'**S4** Where reasonably practicable, for greenfield development, 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 should never exceed the greenfield runoff volume for the same 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 S4 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk'.*

Relevant sections (sustainable drainage) of Policy DM 20 states:

'The surface water drainage scheme should use Sustainable Drainage Systems, unless there is clear evidence that this would be inappropriate, and be designed to limit runoff to greenfield 1-year rates for events up to and including the 100-year plus climate change event where possible, and always ensure no increase in flows as a result of development'.

Therefore, based on the guidance, the surface water run-off will be reduced to as low as possible (dependent on feasible flow control diameter to prevent blockage and subsequent flooding), without exceeding the 100-year greenfield rate.

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

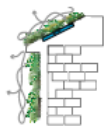
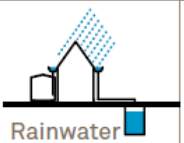
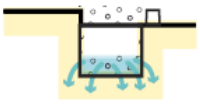
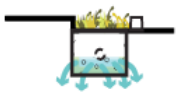
The destination of the surface water run-off from the Site, in a post development state, has been assessed against the prioritisation set by the Approved Document H (2010). The feasibility of the surface water run-off to the priority receptors are as follows:

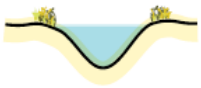
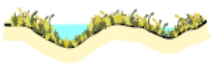
Run-Off Destination	Feasible / Required?	Description
Discharge to Ground	No	As stated in Section 3.4, the BGS data identifies the ground at the Site to consist of clay over sandy chalk. Sandy chalk is likely to be suitable strata for the surface water to discharge to ground. However, in accordance with Approved Document H, any soakaway needs to be at least 5m from, structures and previous studies have found that this is likely to increase to 10m for soakaways on chalk. Due to the relatively small areas of the Site, there are inadequate areas for a soakaway to be built, and therefore this is deemed to be an unfeasible surfacing water discharge destination.
Discharge to Surface Water Body	No	There are no known waterbodies near to the Site, and therefore this is not a feasible surface water discharge destination.
Discharge to Surface Water Sewer	**Yes**	As the surface water cannot discharge to ground due to the small nature of the Site, and there are no waterbodies near the Site, the only alternative is to discharge the surface water (at a restricted rate) to the 225mm diameter surface eater sewer in Hawthorn Road (south of the Site).
Discharge to Highway Drain or Other	No	There are no known highway or other drains near to the Site, and therefore this is not a feasible surface water discharge destination.
Discharge to Combined Water Sewer	No	There are no known combined water sewers near to the Site, and therefore this is not a feasible surface water discharge destination.

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	No	The new dwelling roof is pitched, and therefore is not suitable for living roofs.
Rainwater Harvesting	**Yes**	The cost of dual pipework for rainwater harvesting use within the new dwelling is not financially viable for this development. However, water butts can be installed at some rainwater popes where the water can be collected and re-used for irrigation.
Soakaway	No	The BGS data identifies the ground at the Site to consist of clay over sandy chalk. Sandy chalk is likely to be suitable strata for the surface water to discharge to ground. However, in accordance with Approved Document H, any soakaway needs to be at least 5m from structures and previous studies have found that this is likely to increase to 10m for soakaways on chalk. Due to the relatively small areas of the Site, there are inadequate areas for a soakaway to be built, and therefore this is not a feasible SuDS method.

Filter Drains	**Yes**	A filter drain system can be formed along the edge of the potential patio areas, and will consist of a 300x300mm, 20mm no fine granular filled trench housing a perforated pipe. The surface water run-off from the potential patio 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 surfacing / paving systems can be formed in the driveway area. The surface water will not discharge to ground (for reasons stated above) 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 / surfacing system will reduce the surface water run-off rate from the driveway areas and will act as a pollutant control.
Bioretention Areas / Swales / Pond	No	All external 'soft-landscaping' will be used for private garden areas, and therefore due to inadequate areas, bioretention areas, swales and ponds are not feasible SuDS methods.
Hardscape Storage	No	There are no suitable developed external areas within the Site that are suitable for hardscape storage without permeable paving / surfacing being used. Therefore, this is not a feasible SuDS method.
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 x AREA$^{0.89}$ x SAAR$^{1.17}$ x SOIL$^{2.17}$

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

Area	=	50.00 ha
SAAR	=	748
Soil	=	0.400
Urban Factor	=	0.00
Region Number	=	7

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

QBAR = 171.0 l/s

This figure is for the catchment area of 50.00 ha, and is to be reduced to reflect the surface water catchment area (0.013 ha) of the development site. Therefore, the QBAR (greenfield run-off) for development area has been calculated to be:

QBAR = **0.05 l/s (3.42 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 7.

Based on the figures shown in the table, the growth factors, and the existing greenfield run-off rates for each of the storm events for the development areas of the site are as follows:

Storm Event	QBAR	Growth Factor (C753 Table 24.2)	Greenfield Run-off Rate
Q_2	0.05 l/s	0.88	**0.1 l/s**
Q_{30}	0.05 l/s	2.40	**0.1 l/s**
Q_{100}	0.05 l/s	3.19	**0.2 l/s**

Note: Greenfield rates are rounded up to single decimal place to adhere to MicroDrainage calculations.

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 E.

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

Site Location = GB 514590 104935 TQ 14590 04935

Area = 0.013 ha

SAAR = 748

CWI = 111.194

SPR Host = 47.000

URBTEXT = 0.00

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

$Q_{100\ (6\text{-Hour})}$ = 4.53m³ (348.46m³/ha)

8. Drainage Networks and Surface Water Management Calculation

8.1. 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.

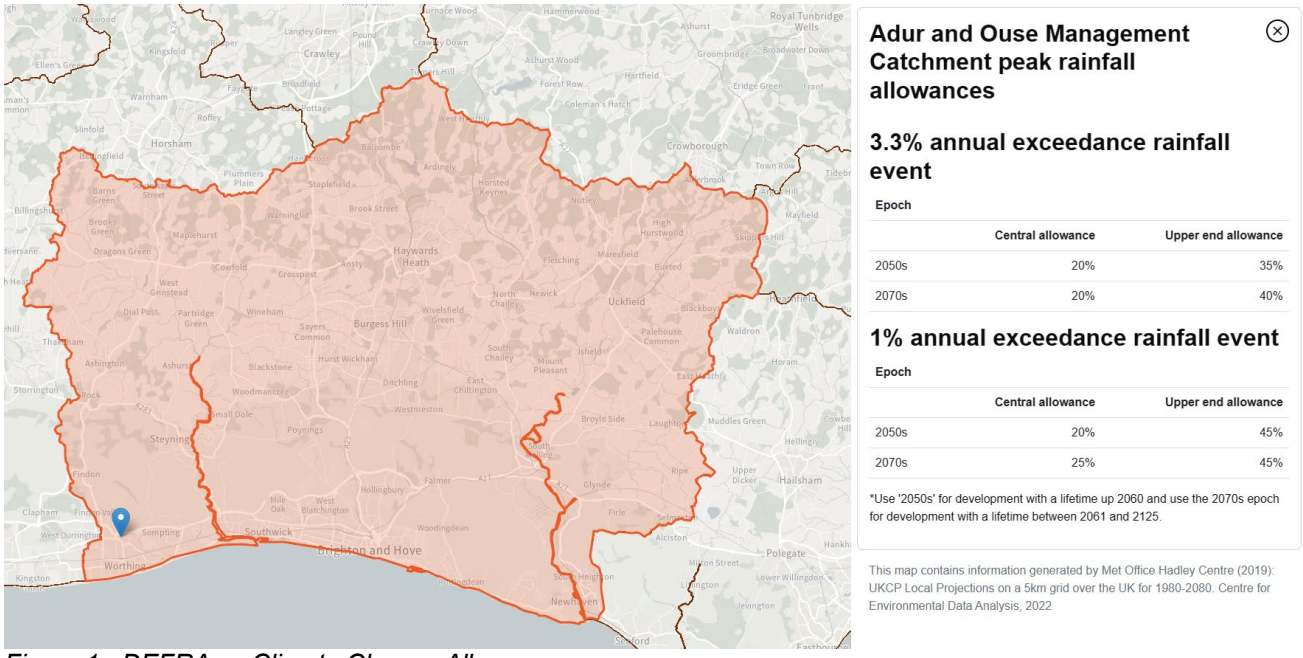


Figure 1 - DEFRAs – Climate Change Allowances

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 **40%** and **45%** for the 30-year and 100-year storm respectively.

8.2. 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 0.013 ha, and the rainfall data given by the Flood Estimation Handbook (FEH 2013).

8.3. Surface Water Drainage Network

As shown on the surface water management layout in Appendix F, the proposed surface water network will consist of 150mm diameter pipes; 150mm diameter perforated pipes; 460mm diameter inspection and silt trap chambers; a 500mm diameter flow control chamber containing an orifice; a water butt; a filter drain system, permeable surfacing / paving system, and an attenuation tank in the form of cellular units.

The surface water run-off from the dwelling roof areas will discharge to the main network via water butts and trapped gullies (capturing first 5mm); the surface water run-off from the driveway areas will discharge to the main network via permeable surfacing / paving systems; and surface water run-off from the potential patio area will discharge to the main network via a filter drain.

The main surface water network will flow to the south-west 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 Hawthorn Road.

Surface water is to be restricted by the flow control (orifice) prior to the discharge to the surface water sewer, with restricted surface water surcharging the network and being attenuated within the cellular units up to 100-year + climate change event.

8.4. 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 0.1 l/s for the 1 in 2-year storm event; 0.1 l/s for the 1 in 30-year storm event including 40% allowance, and 1.2 l/s for the 1 in 100-year storm event including 45% allowance.

For the surface water run-off volume to be a betterment of, or equivalent to, the greenfield volume (100-year,6-hour storm event), the surface water discharge rates need to be a maximum of 0.2 l/s (4.53m³ x 1000 / 60 x 60 x 6).

For this development, to achieve the 1-year and 100-year greenfield rates, the size of the flow control opening (orifice opening) is 10mm.

As shown in the output calculation from the MicroDrainage computer software in Appendix G, if the orifice opening is set at 10mm, the maximum surface water run-off rates for each storm event will be as follows:

Q_2 - **0.1 l/s** - 360-minute winter storm duration

$Q_{30 + CC}$ - **0.2 l/s** - 360-minute winter storm duration

$Q_{100 + CC}$ - **0.2 l/s** - 240-minute winter storm duration

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

Greenfield Rate to Post Development Rate

Storm	-	**Greenfield**	-	**Post Dev**	-	**Difference**
Q_2	-	0.1 l/s	-	0.1 l/s	-	Equivalent
$Q_{30 + CC}$	-	0.2 l/s	-	0.2 l/s	-	Increase
$Q_{100 + CC}$	-	0.2 l/s	-	0.2 l/s	-	Equivalent

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

Therefore, the rates still adhere to DEFRA National Non-Statutory Technical Standards for Sustainable Drainage Systems (S2).

8.5. 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. 45% CC), within the MicroDrainage computer software in Appendix G, based on the peak discharge rate, where:

$Q_{100\ (6\text{-hour})}$ = 0.2 l/s x (60 x 60 x 6) = 4,320 litres = **4.32m³**

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

Greenfield Volume to Post Development Volume

Storm	-	**Greenfield**	-	**Post Dev**	-	**Difference**
Q_{100}	-	4.53m³	-	4.32m³	-	Equivalent

The surface water run-off volume for the 100-year, 6-hour storm event is equivalent to the greenfield volume.

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 (S4-S6).

8.6. 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 form all storms up to and including the 100-year + 45% climate change event. There will be an overflow pipe from the flow control to the proposed pond to attenuate water exceeding this event.

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

Cellular Units

Attenuation Tank Length	-	6.00m
Attenuation Tank Width	-	2.00m
Attenuation Tank Area	-	12.00m²
Attenuation Tank Depth	-	0.80m
Attenuation Tank Volume	-	9.60m³
Porosity	-	0.95
Attenuation Volume	-	**9.12m³**

The MicroDrainage calculations (Appendix H) show that with the cellular unit volume, no flooding will occur for all storms up to and including the 100-year + 45% 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).

9. 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.

9.1. 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 the new dwelling, where payments of the works will form part of the property deeds and / or rental agreements.

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.

9.2. 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:

Private House 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 house owner you have responsibilities for the maintenance of the surface water drainage system which fall within the extent of the title which you own.

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 title of your property are owned by you as the owner & as such responsibility for maintenance / repairs & replacement are yours as the house owner. Private drainage is identified as any drainage within the site boundary.

'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':

9.3. 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*

9.4. Permeable Surfacing / 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*

9.5. 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.

10. Surface Water Exceedance Event

In the event of an extreme storm event (greater than 100-year + 45% 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 southern boundary, and will discharge directly onto Hawthorn Road.

Flood water will flow away from the new dwelling, and will not flow directly towards existing dwellings / properties / buildings prior to discharge to the road. Flood water will be contained within the road due to the road gradient and upstand kerbs, and therefore, no increased risk of flooding to any areas within or near the Site will occur in an exceedance event.

11. 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.

11.1. 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**

11.2. External Area Pollutant Mitigation

Mitigation Measures:

- **Filter Drains and Permeable Surfacing / 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.

12. Development Management and Construction Phase

All existing drainage networks (if found) within the Site are to be maintained during construction. The flow control and attenuation tank 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.

12.1. 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:

12.2. Construction Access

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

12.3. 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.

12.4. 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.

12.5. Main Surface Water Run-Off Systems

The flow control chamber and attenuation tank 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.

12.6. 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.

12.7. 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.

12.8. Construction of Permeable Surfacing / Paving

Construction of permeable surfacing / paving is 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.

13. Conclusion / Summary

13.1. Discharge Destination and SuDS Principles

All feasible SuDS methods, and surface water discharge destination have been assessed, with the feasible SuDS methods being water butts, permeable surfacing / 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.

13.2. Peak Flow Control

The surface water run-off rates are greater than the 30-year greenfield rate, but are equivalent to the 2-year and 100-year greenfield rate. Therefore, the rates still adhere to DEFRA National Non-Statutory Technical Standards for Sustainable Drainage Systems (S2).

13.3. Volume Control

The surface water run-off volume for the 100-year, 6-hour storm event is equivalent to the greenfield volume. 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 (S4-S6).

13.4. Flood Risk within the Development

With the cellular unit volume, no flooding will occur for all storms up to and including the 100-year + 45% 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).

13.5. 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 dwelling, where payments of the works will form part of the property deeds and / or rental agreements.

13.6. Surface Water Exceedance Design

Surface water flow paths will follow existing and proposed ground topography, where water will flow towards the southern boundary, and will discharge directly onto Hawthorn Road.

Flood water will flow away from the new dwelling, and will not flow directly towards existing dwellings / properties / buildings prior to discharge to the road. Flood water will be contained within the road due to the road gradient and upstand kerbs, and therefore, no increased risk of flooding to any areas within or near the Site will occur in an exceedance event.

13.7. 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.

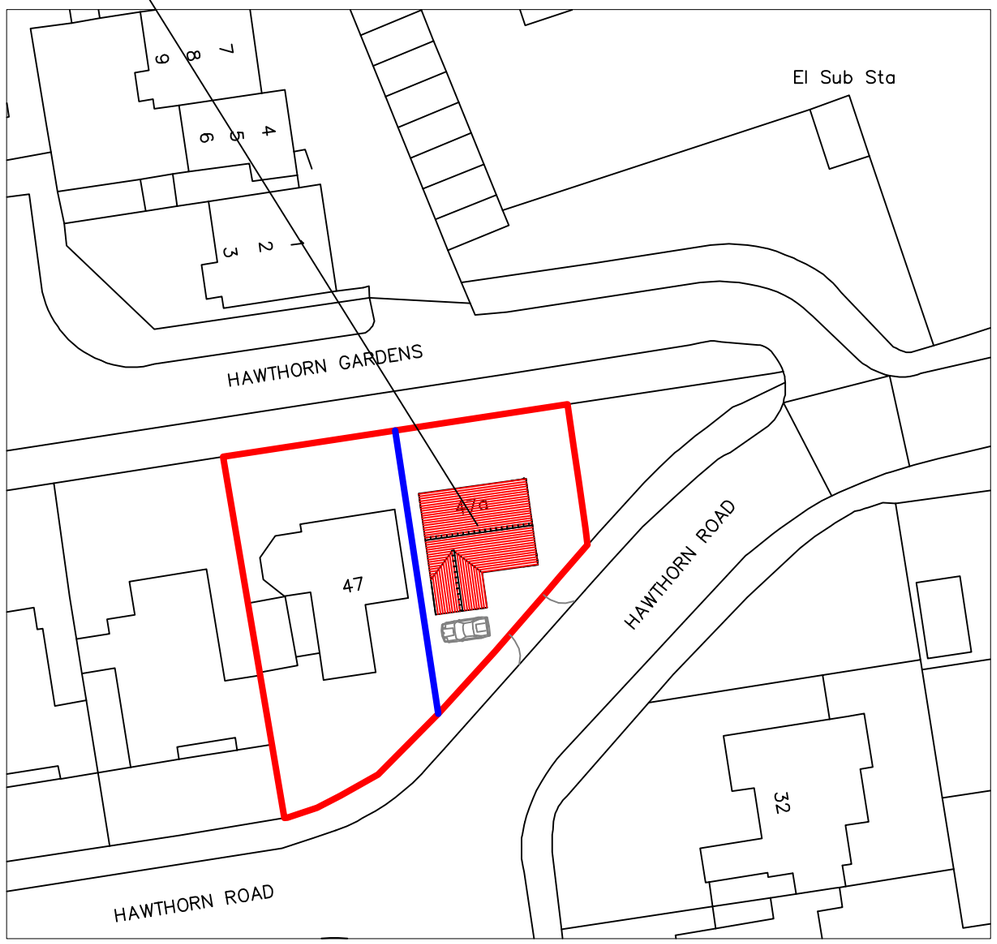
The mitigation indices are greater than the pollution hazard index, and therefore suitable water quality is achieved.

13.8. 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 attenuation tank 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.

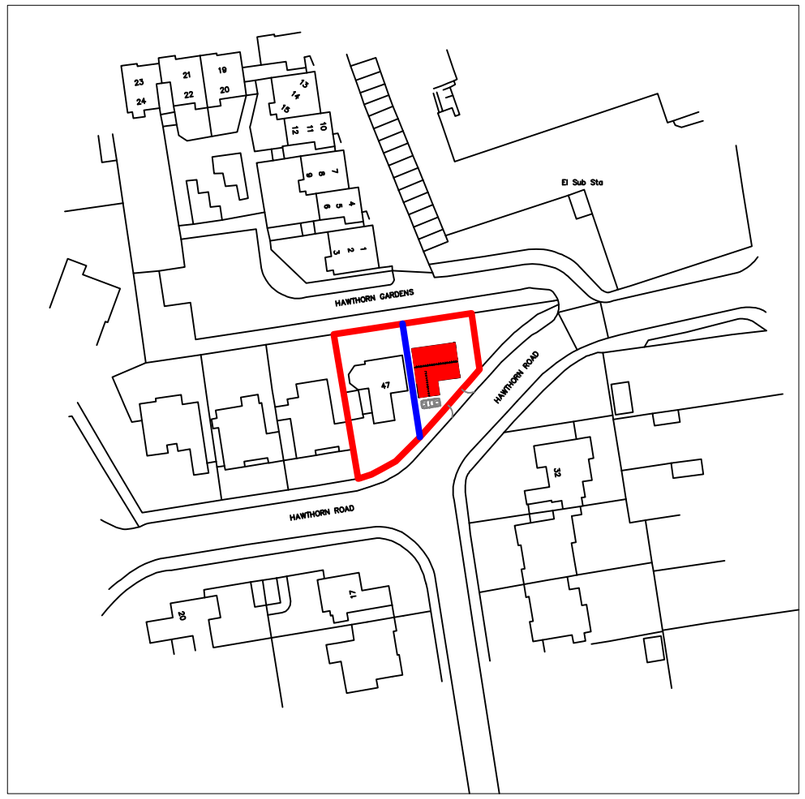
Appendix A Block and Location Plan



BLOCK PLAN 1:500

10m 20m 30m 40m

1:500 Scale Bar



Location PLAN 1:1250

10m 20m 30m 40m 50m

1:1250 Scale Bar

Note: All dimensions to be checked on site.

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01273 441009
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website: bjwarchitectural.co.uk

Project:
Proposed works at:
47 Hawthorn Road Worthing

Title:
BLOCK & Location PLAN

Client:

Scale:
1:500, 1:1250 @ A3 paper size

Date: 7.12.2021

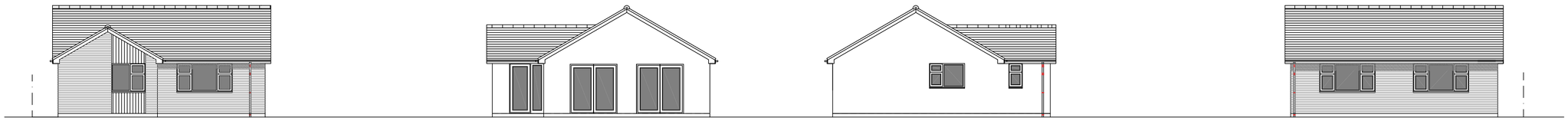
Drawn: BJW

Drg. No. 05

Rev'n

Appendix B Proposed Plans

Proposed Elevations 1:100 - 47A Hawthorn Road Worthing



South facing (front) Elevation

East facing (side) Elevation

West facing (side) Elevation

North facing (rear) Elevation

1m 2m 3m 4m 5m 6m 7m 8m 9m 10m
1:100 Scale Bar

DO NOT SCALE FROM THIS DRAWING EXCEPT FOR PLANNING
AS PHOTOCOPIES WILL BE SUBJECT TO DISTORTION
DRAWINGS TO BE READ IN CONJUCTION WITH ALL OTHER ARCHITECT'S & STRUCTURAL ENGINEER'S CONTRACT DRAWINGS & SPECIFICATIONS.
ANY DISCREPANCIES MUST BE BROUGHT TO THE ATTENTION OF THE ARCHITECT IMMEDIATELY.
THE CONTRACTOR MUST VERIFY ALL DIMENSIONS BY SITE MEASUREMENT BEFORE ORDERING MATERIALS OR MANUFACTURING COMPONENTS.
SUBSTITUTE MATERIALS & PRODUCTS TO THOSE NAMED WILL BE ACCEPTABLE IF PROVEN TO BE OF EQUAL OR HIGHER PERFORMANCE AND NOT IN CONFLICT WITH OTHER ELEMENTS.

NOTES:

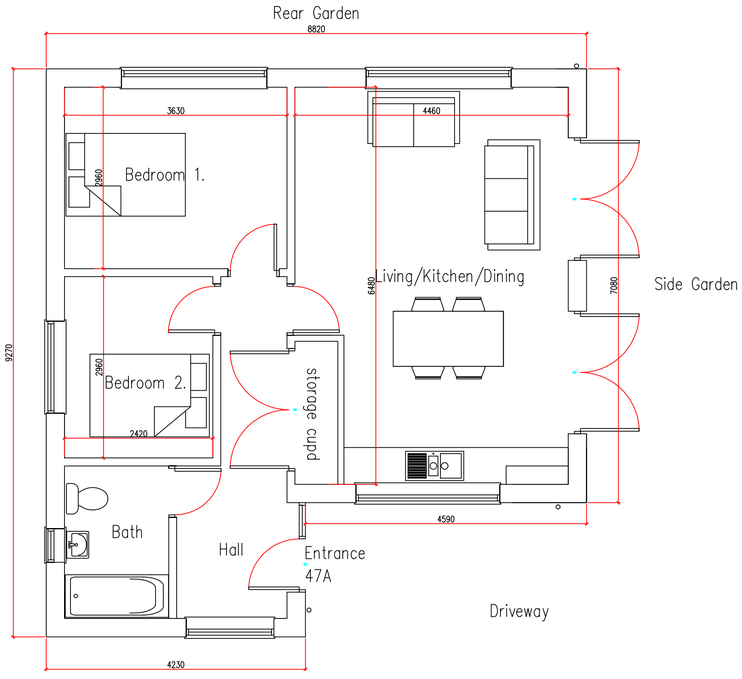
MATERIALS:

ROOF: Plain concrete tiles

WALLS: face brickwork

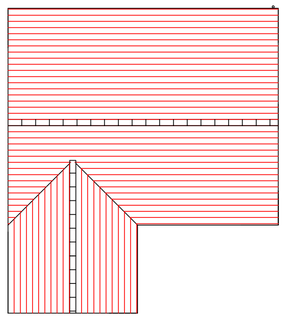
WINDOWS & DOORS: UPVC double glazed windows and doors

Proposed 2 bed dwelling - Internal Floor Area - 63m2





Proposed Street Scene south facing - 1:200

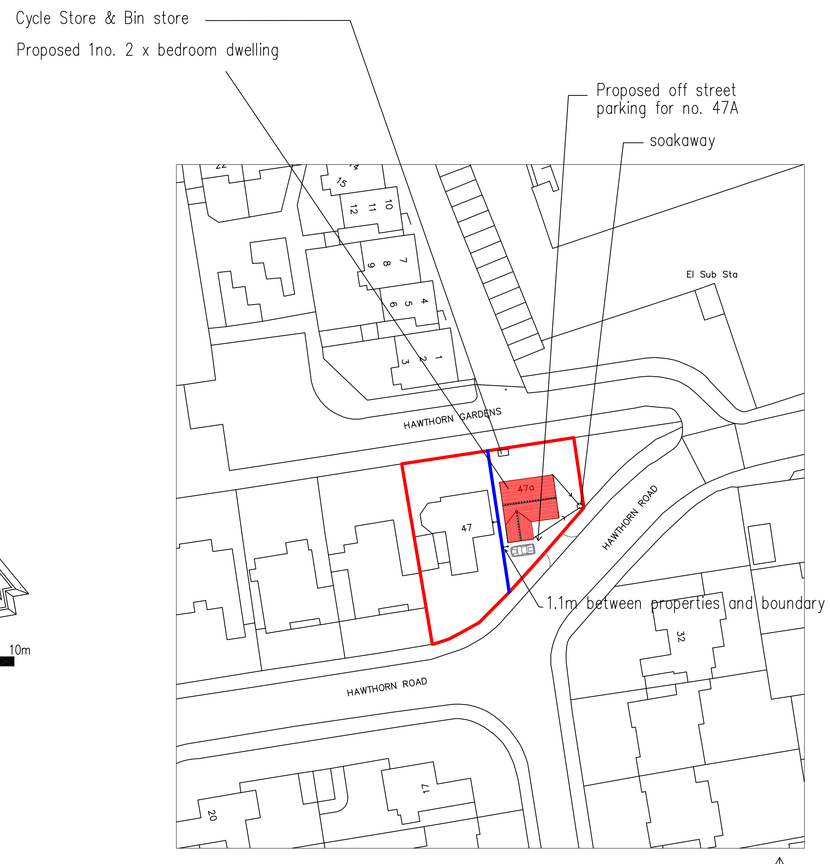


Proposed roof plan

1m 2m 3m 4m 5m 6m 7m 8m 9m 10m
1:100 Scale Bar

Ground Floor Plan - 47A

1:50 Scale Bar
1m 2m 3m 4m 5m 6m 7m 8m 9m 10m



BLOCK PLAN 1:500 (As Proposed)

10m 20m 30m 40m
1:500 Scale Bar

Planning Drawing Only

Project:
Proposed Development
At:
Land to east of
47 Hawthorn Road
Worthing
West Sussex
BN14 9LT

Drawing title:
Plans & Elevations As Proposed
Incl. Location & Block Plans

Client: Mr Hall

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website: bjwarchitectural.co.uk

Scale: As Shown
Paper size: A1
Date: 8.12.2021
Drawn: BJW
Drg. No. 01
Rev'n F

Note: All dimensions to be checked on site.

Appendix C British Geological Survey Data

British Geological Survey
BGS ID: 577815 : BGS Reference: TQ10SE9
British National Grid (27700) : 515400,104700

1 Page 1-7

TQ 10 SE 9.
154 047
FEB. 1957

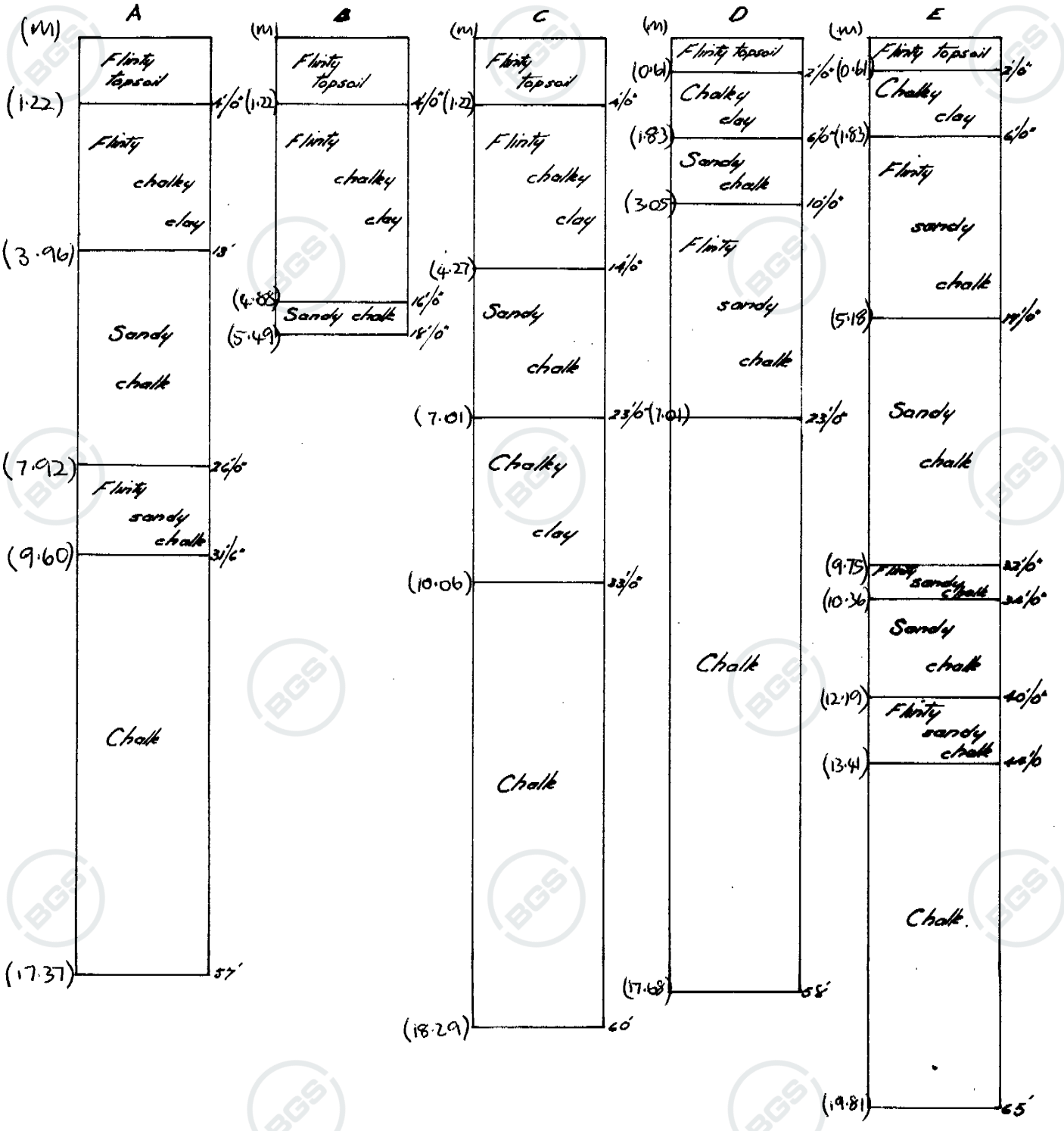
CLARENDEN ROAD

File Nº A/HR/1.

SCALE :- 8FT to 1IN

MAP GRID L7

SITE Nº 8



Contact BGS: ngdc@bgs.ac.uk

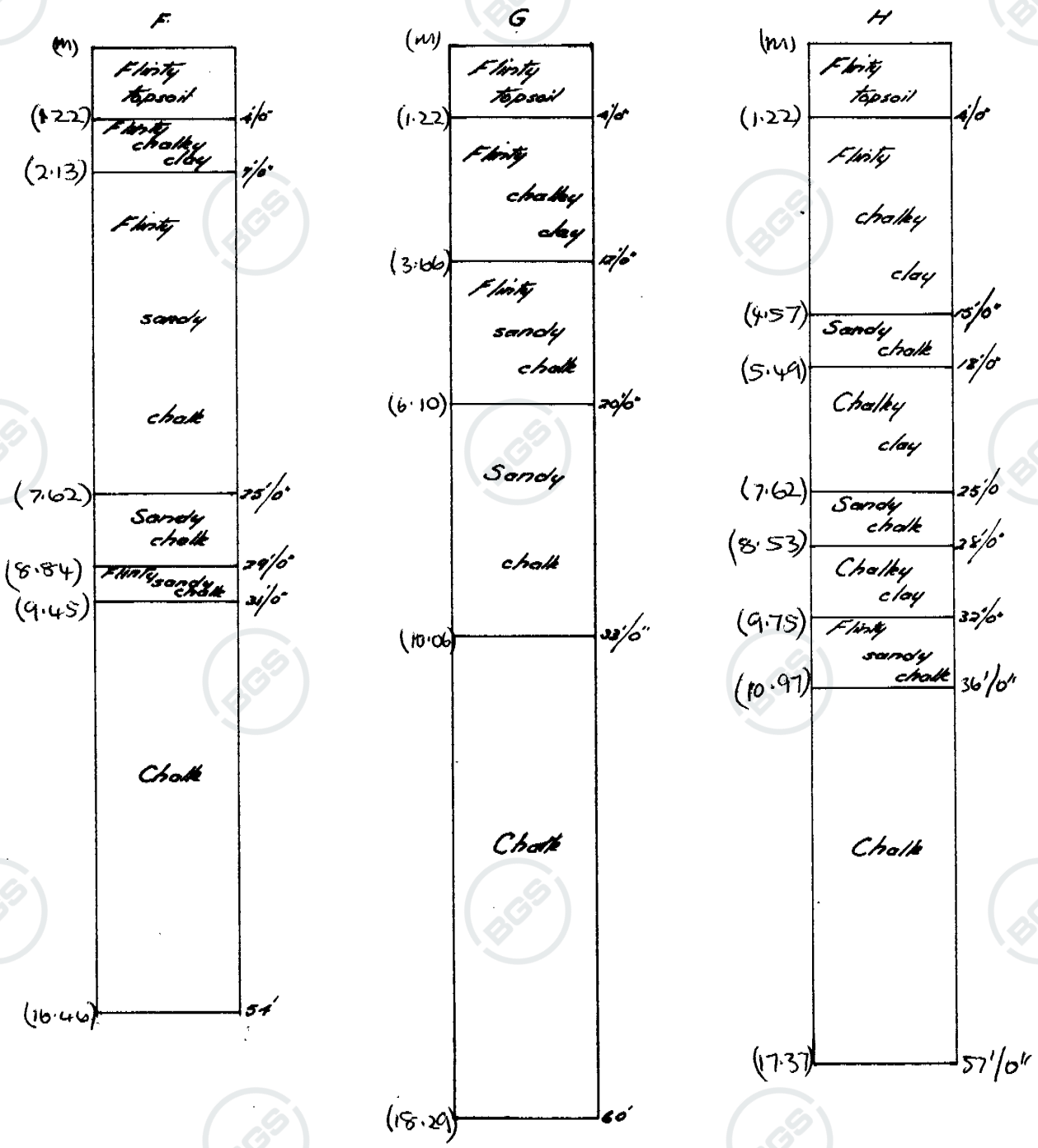
2

TQ10SE,9
154 047
FEB. 1957

CLARENDEN ROAD
File No A/HR/1.
MAP GRID L7

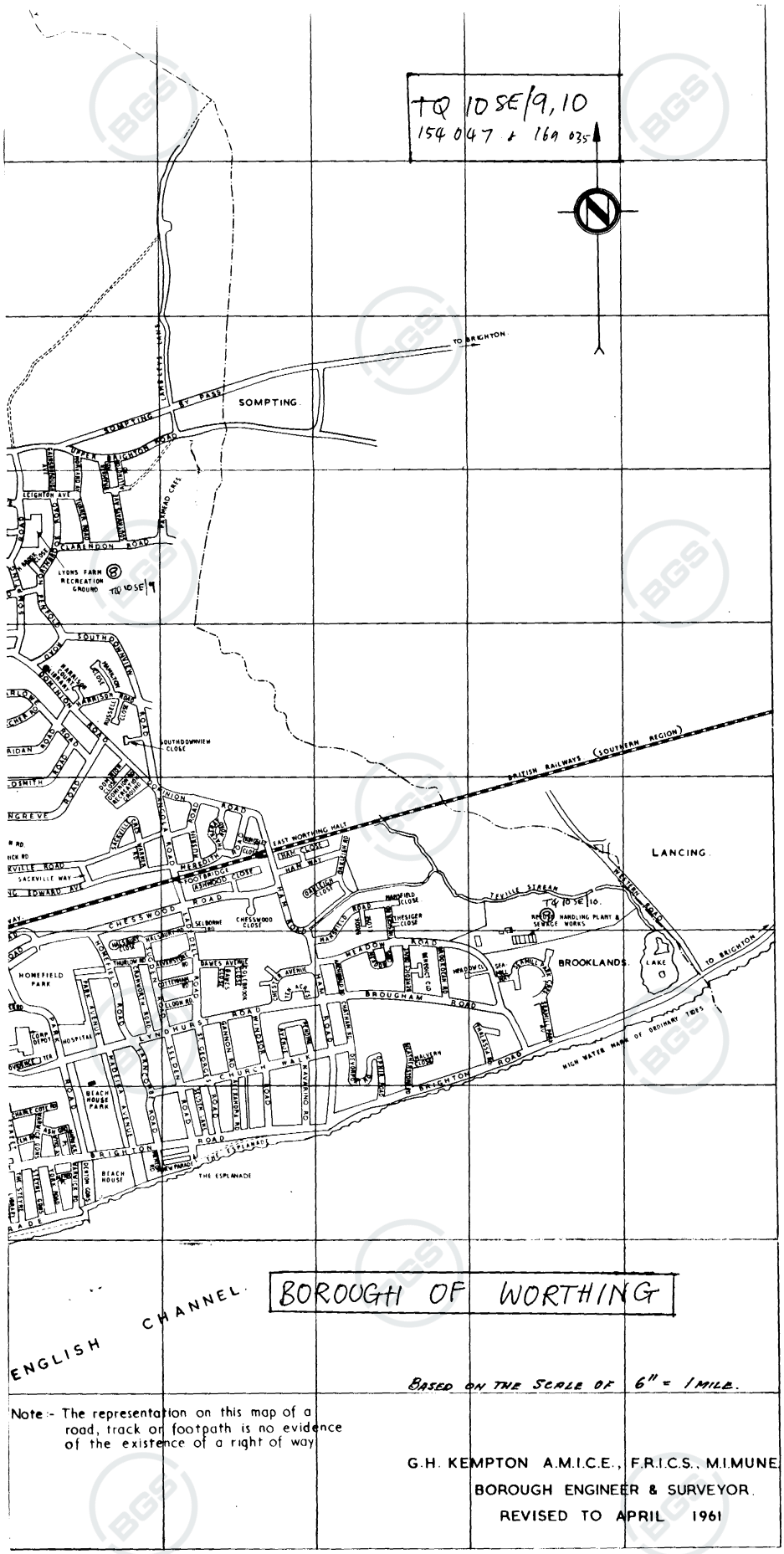
SCALE :- 8 FT. to 1 IN.

SITE No 8



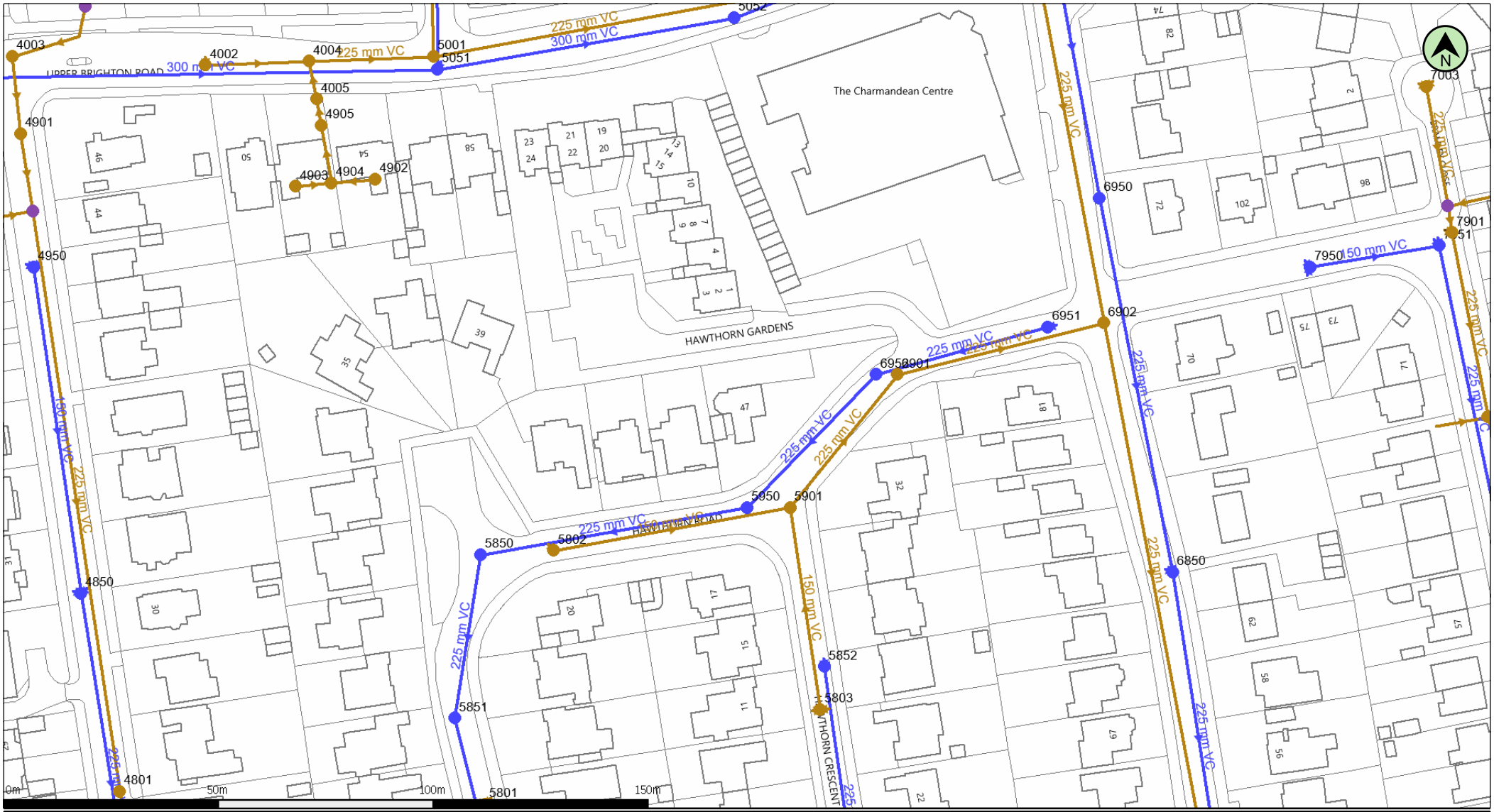
British Geological Survey

BGS ID: 577815 : BGS Reference: TQ10SE9
British National Grid (27700) : 515400,104700



Contact BGS: ngdc@bgs.ac.uk

Appendix D Southern Water Sewer Plan



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Date: 07/11/23 | Scale: 1:1250 | Map Centre: 514574,104933 | Data updated: 02/11/23 | Our Ref: 1315407 - 1 | Wastewater Plan A4

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2023 Ordnance Survey 100031673 .This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

Foul Gravity Sewer
Combined Gravity Sewer
Culverted Water Course or Treated Effluent
Surface Water Gravity Sewer
Rising Main, Vacuum or Syphon
Combined Outfall
Surface Water Outfall
Foul Outfall
Surface Water Inlet
Combined Pumping Station
Surface Water Pumping Station
Foul Pumping Station
Water Treatment Works
Section 104 Area
Building Over Agreement Area
Foul Manhole
Combined Manhole
Surface Water Manhole
Side Entry Manhole, Decarcation Chamber, Dummy Manhole or Surface Water Soakaway

mark@flo-consult.co.uk

47 Hawthorn Road

WATER for LIFE
from Southern Water.

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
4002	F	15.29	0.00	-
4003	F	15.92	0.00	-
4004	F	0.00	0.00	-
4005	F	0.00	0.00	-
4801	F	13.21	0.00	-
4901	F	15.39	0.00	-
4902	F	0.00	0.00	-
4903	F	0.00	0.00	-
4904	F	0.00	0.00	-
4905	F	0.00	0.00	-
5001	F	14.52	11.41	-
5801	F	12.47	10.37	-
5802	F	12.61	11.27	-
5803	F	11.32	9.39	-
5901	F	12.08	8.93	-
6901	F	11.78	8.70	-
6902	F	11.51	8.40	-
7003	F	11.43	9.42	-
7901	F	10.99	0.00	-
7903	F	0.00	0.00	-
4850	S	13.90	12.45	-
4950	S	14.99	13.53	-
5051	S	14.48	12.76	-
5052	S	13.64	12.07	-
5850	S	12.65	9.07	-
5851	S	12.66	8.68	-
5852	S	11.43	10.42	-
5950	S	12.17	9.65	-
6850	S	10.64	9.18	-
6950	S	12.00	10.22	-
6951	S	11.51	10.53	-
6952	S	11.80	10.12	-

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
7950	S	11.28	9.56	-
7951	S	10.95	9.14	-

Appendix E Greenfield Run-Off Calculation

IH 124 Mean Annual Flood

Input

Return Period (years) 100 SAAR (mm) 703 Urban 0.000
Area (ha) 50.000 Soil 0.400 Region Number Region 7

Results l/s

QBAR Rural	171.0
QBAR Urban	171.0
Q100 years	545.4
Q1 year	145.3
Q2 years	150.6
Q5 years	218.8
Q10 years	277.0
Q20 years	342.5
Q25 years	367.2
Q30 years	387.5
Q50 years	447.9
Q100 years	545.4
Q200 years	641.1
Q250 years	671.9
Q1000 years	882.2

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Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	2013
Site Location	GB 514590 104935 TQ 14590 04935
Data Type	Point
Areal Reduction Factor	1.00
Area (ha)	0.013
SAAR (mm)	748
CWI	111.194
SPR Host	47.000
URBEXT (USER)	0.0000

Results

Percentage Runoff (%)	48.61
Greenfield Runoff Volume (m^3)	4.534

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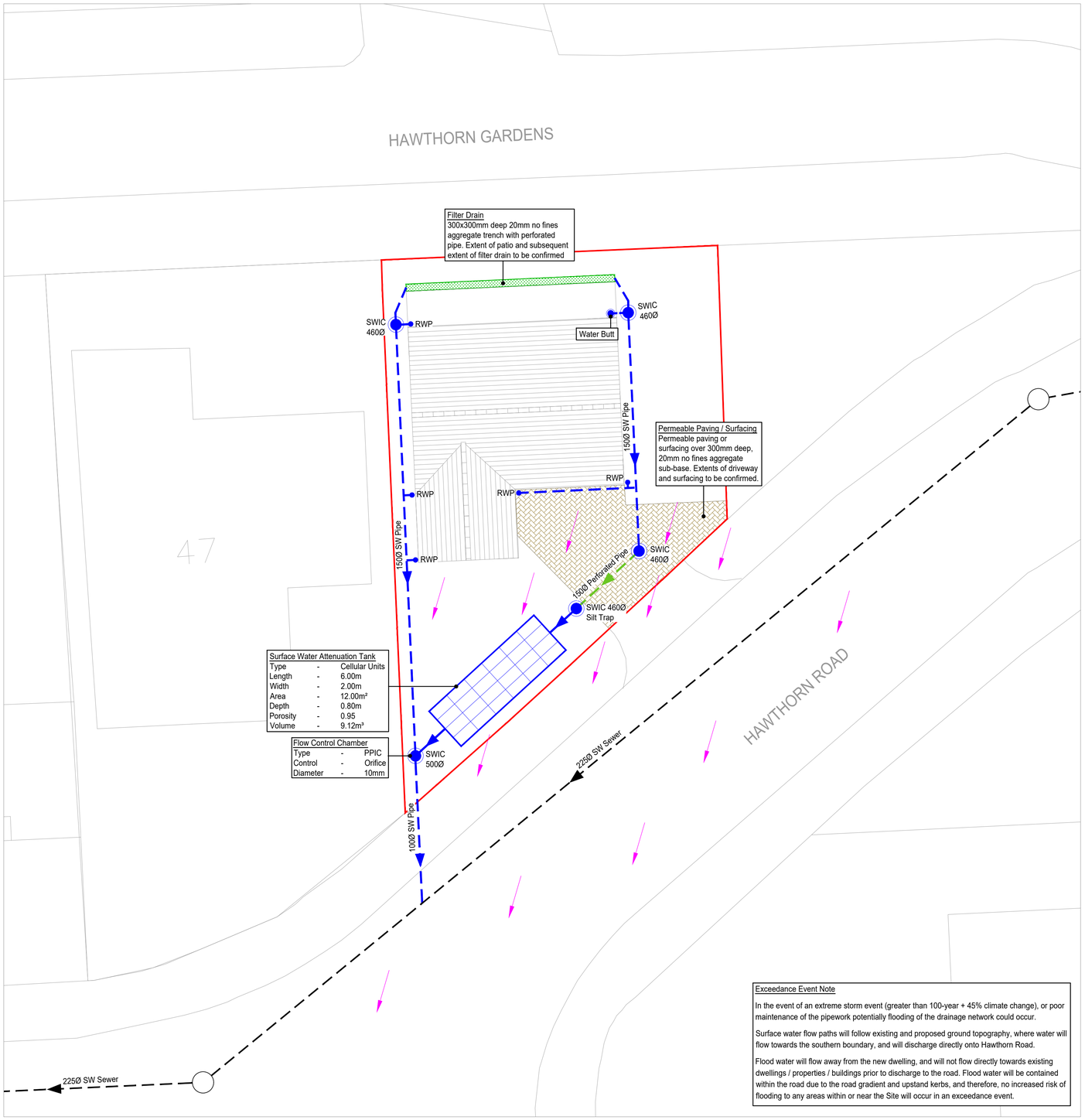
Appendix F Surface Water Management Layout and Details

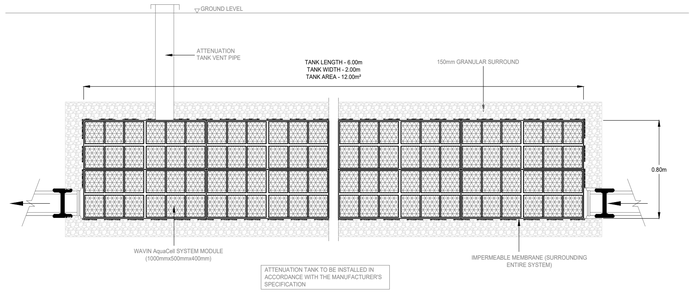


Exceedance Event Note

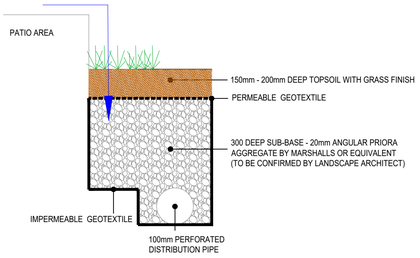
In the event of an extreme storm event (greater than 100-year + 45% climate change), or poor maintenance of the pipework potentially flooding of the drainage network could occur.

Surface water flow paths will follow existing and proposed ground topography, where water will flow towards the southern boundary, and will discharge directly onto Hawthorn Road.

Flood water will flow away from the new dwelling, and will not flow directly towards existing dwellings / properties / buildings prior to discharge to the road. Flood water will be contained within the road due to the road gradient and upstand kerbs, and therefore, no increased risk of flooding to any areas within or near the Site will occur in an exceedance event.



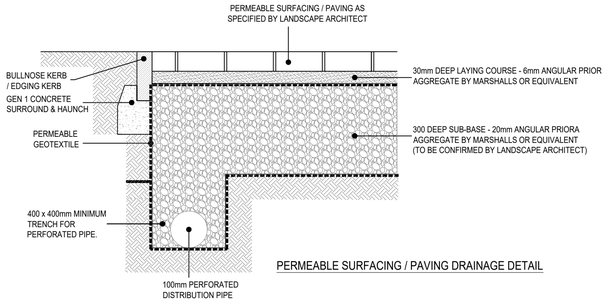
TYPICAL CELLULAR UNIT / TANK DETAIL



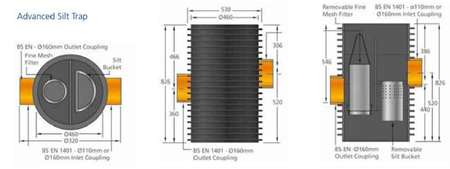
FILTER DRAIN DETAIL



FLOW CONTROL DETAIL



PERMEABLE SURFACING / PAVING DRAINAGE DETAIL



SILT TRAP DETAIL

Drainage Key:

- Surface Water Pipes - Solid
- Proposed Perforated Pipe
- Permeable Paving
- Filter Drain
- Exceedance Flow Path
- Development Boundary

Rev	Description	Drn	Chk	Date
P1	ISSUED FOR APPROVAL	MDS	NC	08.11.23

Client
MR LEE HALL

Project
LAND EAST OF
47 HAWTHORN ROAD
WORTHING, BN14 9LT

Drawing
SURFACE WATER MANAGEMENT
LAYOUT AND DETAILS

Scale	Date	Drawn by	Checked
1:100@A1	08.11.23	MDS	NC

Status
APPROVAL

Flo
Chiltern View Studio
Buslins Lane, Chesham
Buckinghamshire, HP5 2XD
m.07772 033 937
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www.flo-consult.co.uk

Job No.	Drg. No.	Rev
987	DR-100	P1

Appendix G Surface Water Management Calculations

Summary of Results for 2 year Return Period

Half Drain Time : 248 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.576	0.076	0.0	0.1	0.1	0.9	O K
30 min Summer	8.598	0.098	0.0	0.1	0.1	1.1	O K
60 min Summer	8.618	0.118	0.0	0.1	0.1	1.3	O K
120 min Summer	8.652	0.152	0.0	0.1	0.1	1.7	O K
180 min Summer	8.665	0.165	0.0	0.1	0.1	1.9	O K
240 min Summer	8.672	0.172	0.0	0.1	0.1	2.0	O K
360 min Summer	8.677	0.177	0.0	0.1	0.1	2.0	O K
480 min Summer	8.676	0.176	0.0	0.1	0.1	2.0	O K
600 min Summer	8.673	0.173	0.0	0.1	0.1	2.0	O K
720 min Summer	8.669	0.169	0.0	0.1	0.1	1.9	O K
960 min Summer	8.659	0.159	0.0	0.1	0.1	1.8	O K
1440 min Summer	8.642	0.142	0.0	0.1	0.1	1.6	O K
2160 min Summer	8.622	0.122	0.0	0.1	0.1	1.4	O K
2880 min Summer	8.608	0.108	0.0	0.1	0.1	1.2	O K
4320 min Summer	8.588	0.088	0.0	0.1	0.1	1.0	O K
5760 min Summer	8.576	0.076	0.0	0.1	0.1	0.9	O K
7200 min Summer	8.567	0.067	0.0	0.1	0.1	0.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	37.904	0.0	0.9	28
30 min Summer	24.748	0.0	1.2	41
60 min Summer	15.589	0.0	1.5	68
120 min Summer	10.742	0.0	2.1	122
180 min Summer	8.381	0.0	2.4	170
240 min Summer	6.940	0.0	2.7	200
360 min Summer	5.224	0.0	3.0	266
480 min Summer	4.221	0.0	3.3	334
600 min Summer	3.564	0.0	3.5	402
720 min Summer	3.097	0.0	3.6	472
960 min Summer	2.478	0.0	3.9	608
1440 min Summer	1.812	0.0	4.2	874
2160 min Summer	1.336	0.0	4.7	1260
2880 min Summer	1.086	0.0	5.1	1640
4320 min Summer	0.827	0.0	5.8	2380
5760 min Summer	0.692	0.0	6.5	3112
7200 min Summer	0.608	0.0	7.1	3824

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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	8.560	0.060	0.0	0.0	0.0	0.7	O K
10080 min Summer	8.555	0.055	0.0	0.0	0.0	0.6	O K
15 min Winter	8.585	0.085	0.0	0.1	0.1	1.0	O K
30 min Winter	8.610	0.110	0.0	0.1	0.1	1.3	O K
60 min Winter	8.633	0.133	0.0	0.1	0.1	1.5	O K
120 min Winter	8.672	0.172	0.0	0.1	0.1	2.0	O K
180 min Winter	8.689	0.189	0.0	0.1	0.1	2.2	O K
240 min Winter	8.696	0.196	0.0	0.1	0.1	2.2	O K
360 min Winter	8.700	0.200	0.0	0.1	0.1	2.3	O K
480 min Winter	8.697	0.197	0.0	0.1	0.1	2.2	O K
600 min Winter	8.692	0.192	0.0	0.1	0.1	2.2	O K
720 min Winter	8.685	0.185	0.0	0.1	0.1	2.1	O K
960 min Winter	8.671	0.171	0.0	0.1	0.1	2.0	O K
1440 min Winter	8.646	0.146	0.0	0.1	0.1	1.7	O K
2160 min Winter	8.618	0.118	0.0	0.1	0.1	1.3	O K
2880 min Winter	8.598	0.098	0.0	0.1	0.1	1.1	O K
4320 min Winter	8.573	0.073	0.0	0.1	0.1	0.8	O K
5760 min Winter	8.558	0.058	0.0	0.0	0.0	0.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.550	0.0	7.7	4512
10080 min Summer	0.509	0.0	8.3	5248
15 min Winter	37.904	0.0	1.0	29
30 min Winter	24.748	0.0	1.3	42
60 min Winter	15.589	0.0	1.7	68
120 min Winter	10.742	0.0	2.3	122
180 min Winter	8.381	0.0	2.7	176
240 min Winter	6.940	0.0	3.0	224
360 min Winter	5.224	0.0	3.4	282
480 min Winter	4.221	0.0	3.7	360
600 min Winter	3.564	0.0	3.9	434
720 min Winter	3.097	0.0	4.1	510
960 min Winter	2.478	0.0	4.3	654
1440 min Winter	1.812	0.0	4.7	930
2160 min Winter	1.336	0.0	5.2	1324
2880 min Winter	1.086	0.0	5.7	1704
4320 min Winter	0.827	0.0	6.5	2432
5760 min Winter	0.692	0.0	7.2	3176

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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	8.549	0.049	0.0	0.0	0.0	0.6	O K
8640 min Winter	8.542	0.042	0.0	0.0	0.0	0.5	O K
10080 min Winter	8.538	0.038	0.0	0.0	0.0	0.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Winter	0.608	0.0	8.0	3896
8640 min Winter	0.550	0.0	8.6	4592
10080 min Winter	0.509	0.0	9.3	5264

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	2
FEH Rainfall Version	2013
Site Location	GB 514590 104935 TQ 14590 04935
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) 0.013

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.004	4	8	0.003	8	12	0.003	12	16	0.003

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Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

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

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	12.0	0.0	2.600	0.0	0.0
0.200	12.0	0.0	2.800	0.0	0.0
0.400	12.0	0.0	3.000	0.0	0.0
0.600	12.0	0.0	3.200	0.0	0.0
0.800	12.0	0.0	3.400	0.0	0.0
1.000	0.0	0.0	3.600	0.0	0.0
1.200	0.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Orifice Outflow Control

Diameter (m) 0.010 Discharge Coefficient 0.600 Invert Level (m) 8.500

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Summary of Results for 30 year Return Period (+40%)

Half Drain Time : 417 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.746	0.246	0.0	0.1	0.1	2.8	O K
30 min Summer	8.825	0.325	0.0	0.1	0.1	3.7	O K
60 min Summer	8.904	0.404	0.0	0.1	0.1	4.6	O K
120 min Summer	8.973	0.473	0.0	0.1	0.1	5.4	O K
180 min Summer	9.002	0.502	0.0	0.1	0.1	5.7	O K
240 min Summer	9.015	0.515	0.0	0.1	0.1	5.9	O K
360 min Summer	9.016	0.516	0.0	0.1	0.1	5.9	O K
480 min Summer	9.010	0.510	0.0	0.1	0.1	5.8	O K
600 min Summer	9.001	0.501	0.0	0.1	0.1	5.7	O K
720 min Summer	8.991	0.491	0.0	0.1	0.1	5.6	O K
960 min Summer	8.970	0.470	0.0	0.1	0.1	5.4	O K
1440 min Summer	8.929	0.429	0.0	0.1	0.1	4.9	O K
2160 min Summer	8.880	0.380	0.0	0.1	0.1	4.3	O K
2880 min Summer	8.842	0.342	0.0	0.1	0.1	3.9	O K
4320 min Summer	8.786	0.286	0.0	0.1	0.1	3.3	O K
5760 min Summer	8.747	0.247	0.0	0.1	0.1	2.8	O K
7200 min Summer	8.718	0.218	0.0	0.1	0.1	2.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	119.863	0.0	2.9	29
30 min Summer	79.815	0.0	3.9	43
60 min Summer	50.835	0.0	4.9	72
120 min Summer	31.149	0.0	6.1	128
180 min Summer	23.125	0.0	6.8	184
240 min Summer	18.602	0.0	7.2	242
360 min Summer	13.541	0.0	7.9	312
480 min Summer	10.738	0.0	8.4	374
600 min Summer	8.950	0.0	8.7	438
720 min Summer	7.703	0.0	9.0	506
960 min Summer	6.074	0.0	9.5	642
1440 min Summer	4.354	0.0	10.2	916
2160 min Summer	3.149	0.0	11.0	1320
2880 min Summer	2.521	0.0	11.8	1708
4320 min Summer	1.867	0.0	13.1	2468
5760 min Summer	1.524	0.0	14.3	3224
7200 min Summer	1.310	0.0	15.3	3960

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Summary of Results for 30 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	8.696	0.196	0.0	0.1	0.1	2.2	O K
10080 min Summer	8.678	0.178	0.0	0.1	0.1	2.0	O K
15 min Winter	8.777	0.277	0.0	0.1	0.1	3.2	O K
30 min Winter	8.865	0.365	0.0	0.1	0.1	4.2	O K
60 min Winter	8.955	0.455	0.0	0.1	0.1	5.2	O K
120 min Winter	9.034	0.534	0.0	0.2	0.2	6.1	O K
180 min Winter	9.070	0.570	0.0	0.2	0.2	6.5	O K
240 min Winter	9.086	0.586	0.0	0.2	0.2	6.7	O K
360 min Winter	9.089	0.589	0.0	0.2	0.2	6.7	O K
480 min Winter	9.079	0.579	0.0	0.2	0.2	6.6	O K
600 min Winter	9.068	0.568	0.0	0.2	0.2	6.5	O K
720 min Winter	9.054	0.554	0.0	0.2	0.2	6.3	O K
960 min Winter	9.024	0.524	0.0	0.2	0.2	6.0	O K
1440 min Winter	8.966	0.466	0.0	0.1	0.1	5.3	O K
2160 min Winter	8.895	0.395	0.0	0.1	0.1	4.5	O K
2880 min Winter	8.840	0.340	0.0	0.1	0.1	3.9	O K
4320 min Winter	8.764	0.264	0.0	0.1	0.1	3.0	O K
5760 min Winter	8.714	0.214	0.0	0.1	0.1	2.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.164	0.0	16.3	4672
10080 min Summer	1.056	0.0	17.3	5360
15 min Winter	119.863	0.0	3.3	29
30 min Winter	79.815	0.0	4.3	43
60 min Winter	50.835	0.0	5.5	70
120 min Winter	31.149	0.0	6.8	126
180 min Winter	23.125	0.0	7.6	182
240 min Winter	18.602	0.0	8.1	238
360 min Winter	13.541	0.0	8.9	344
480 min Winter	10.738	0.0	9.4	390
600 min Winter	8.950	0.0	9.8	466
720 min Winter	7.703	0.0	10.1	542
960 min Winter	6.074	0.0	10.6	694
1440 min Winter	4.354	0.0	11.4	986
2160 min Winter	3.149	0.0	12.4	1408
2880 min Winter	2.521	0.0	13.2	1812
4320 min Winter	1.867	0.0	14.7	2592
5760 min Winter	1.524	0.0	16.0	3336

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Summary of Results for 30 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	8.678	0.178	0.0	0.1	0.1	2.0	O K
8640 min Winter	8.652	0.152	0.0	0.1	0.1	1.7	O K
10080 min Winter	8.633	0.133	0.0	0.1	0.1	1.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Winter	1.310	0.0	17.2	4040
8640 min Winter	1.164	0.0	18.3	4760
10080 min Winter	1.056	0.0	19.4	5456

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 514590 104935 TQ 14590 04935
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) 0.013

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.004	4	8	0.003	8	12	0.003	12	16	0.003

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Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

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

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	12.0	0.0	2.600	0.0	0.0
0.200	12.0	0.0	2.800	0.0	0.0
0.400	12.0	0.0	3.000	0.0	0.0
0.600	12.0	0.0	3.200	0.0	0.0
0.800	12.0	0.0	3.400	0.0	0.0
1.000	0.0	0.0	3.600	0.0	0.0
1.200	0.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Orifice Outflow Control

Diameter (m) 0.010 Discharge Coefficient 0.600 Invert Level (m) 8.500

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Summary of Results for 100 year Return Period (+45%)

Half Drain Time : 487 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.825	0.325	0.0	0.1	0.1	3.7	O K
30 min Summer	8.933	0.433	0.0	0.1	0.1	4.9	O K
60 min Summer	9.044	0.544	0.0	0.2	0.2	6.2	O K
120 min Summer	9.125	0.625	0.0	0.2	0.2	7.1	O K
180 min Summer	9.162	0.662	0.0	0.2	0.2	7.5	O K
240 min Summer	9.178	0.678	0.0	0.2	0.2	7.7	O K
360 min Summer	9.180	0.680	0.0	0.2	0.2	7.8	O K
480 min Summer	9.172	0.672	0.0	0.2	0.2	7.7	O K
600 min Summer	9.162	0.662	0.0	0.2	0.2	7.5	O K
720 min Summer	9.151	0.651	0.0	0.2	0.2	7.4	O K
960 min Summer	9.128	0.628	0.0	0.2	0.2	7.2	O K
1440 min Summer	9.083	0.583	0.0	0.2	0.2	6.6	O K
2160 min Summer	9.023	0.523	0.0	0.2	0.2	6.0	O K
2880 min Summer	8.974	0.474	0.0	0.1	0.1	5.4	O K
4320 min Summer	8.899	0.399	0.0	0.1	0.1	4.6	O K
5760 min Summer	8.845	0.345	0.0	0.1	0.1	3.9	O K
7200 min Summer	8.803	0.303	0.0	0.1	0.1	3.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.414	0.0	3.8	30
30 min Summer	105.724	0.0	5.1	44
60 min Summer	67.843	0.0	6.6	72
120 min Summer	40.654	0.0	7.9	128
180 min Summer	29.902	0.0	8.7	186
240 min Summer	23.934	0.0	9.3	242
360 min Summer	17.339	0.0	10.1	336
480 min Summer	13.719	0.0	10.7	390
600 min Summer	11.425	0.0	11.1	452
720 min Summer	9.834	0.0	11.5	518
960 min Summer	7.771	0.0	12.1	656
1440 min Summer	5.587	0.0	13.0	928
2160 min Summer	4.040	0.0	14.2	1332
2880 min Summer	3.224	0.0	15.1	1732
4320 min Summer	2.365	0.0	16.6	2508
5760 min Summer	1.911	0.0	17.9	3240
7200 min Summer	1.627	0.0	19.0	3968

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Summary of Results for 100 year Return Period (+45%)

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	8.770	0.270	0.0	0.1	0.1	3.1	O K
10080 min Summer	8.743	0.243	0.0	0.1	0.1	2.8	O K
15 min Winter	8.865	0.365	0.0	0.1	0.1	4.2	O K
30 min Winter	8.986	0.486	0.0	0.1	0.1	5.5	O K
60 min Winter	9.112	0.612	0.0	0.2	0.2	7.0	O K
120 min Winter	9.206	0.706	0.0	0.2	0.2	8.1	O K
180 min Winter	9.250	0.750	0.0	0.2	0.2	8.6	O K
240 min Winter	9.271	0.771	0.0	0.2	0.2	8.8	O K
360 min Winter	9.278	0.778	0.0	0.2	0.2	8.9	O K
480 min Winter	9.264	0.764	0.0	0.2	0.2	8.7	O K
600 min Winter	9.251	0.751	0.0	0.2	0.2	8.6	O K
720 min Winter	9.237	0.737	0.0	0.2	0.2	8.4	O K
960 min Winter	9.205	0.705	0.0	0.2	0.2	8.0	O K
1440 min Winter	9.140	0.640	0.0	0.2	0.2	7.3	O K
2160 min Winter	9.054	0.554	0.0	0.2	0.2	6.3	O K
2880 min Winter	8.983	0.483	0.0	0.1	0.1	5.5	O K
4320 min Winter	8.879	0.379	0.0	0.1	0.1	4.3	O K
5760 min Winter	8.808	0.308	0.0	0.1	0.1	3.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.430	0.0	20.1	4680
10080 min Summer	1.286	0.0	21.1	5448
15 min Winter	157.414	0.0	4.3	30
30 min Winter	105.724	0.0	5.7	43
60 min Winter	67.843	0.0	7.4	72
120 min Winter	40.654	0.0	8.9	126
180 min Winter	29.902	0.0	9.8	182
240 min Winter	23.934	0.0	10.4	238
360 min Winter	17.339	0.0	11.3	348
480 min Winter	13.719	0.0	12.0	442
600 min Winter	11.425	0.0	12.5	476
720 min Winter	9.834	0.0	12.9	552
960 min Winter	7.771	0.0	13.6	706
1440 min Winter	5.587	0.0	14.6	1004
2160 min Winter	4.040	0.0	15.9	1432
2880 min Winter	3.224	0.0	16.9	1844
4320 min Winter	2.365	0.0	18.6	2608
5760 min Winter	1.911	0.0	20.0	3360

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Summary of Results for 100 year Return Period (+45%)

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	8.756	0.256	0.0	0.1	0.1	2.9	O K
8640 min Winter	8.717	0.217	0.0	0.1	0.1	2.5	O K
10080 min Winter	8.687	0.187	0.0	0.1	0.1	2.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
7200 min Winter	1.627	0.0	21.3	4112
8640 min Winter	1.430	0.0	22.5	4840
10080 min Winter	1.286	0.0	23.6	5552

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 514590 104935 TQ 14590 04935
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 %	+45

Time Area Diagram

Total Area (ha) 0.013

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.004	4	8	0.003	8	12	0.003	12	16	0.003

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Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

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

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	12.0	0.0	2.600	0.0	0.0
0.200	12.0	0.0	2.800	0.0	0.0
0.400	12.0	0.0	3.000	0.0	0.0
0.600	12.0	0.0	3.200	0.0	0.0
0.800	12.0	0.0	3.400	0.0	0.0
1.000	0.0	0.0	3.600	0.0	0.0
1.200	0.0	0.0	3.800	0.0	0.0
1.400	0.0	0.0	4.000	0.0	0.0
1.600	0.0	0.0	4.200	0.0	0.0
1.800	0.0	0.0	4.400	0.0	0.0
2.000	0.0	0.0	4.600	0.0	0.0
2.200	0.0	0.0	4.800	0.0	0.0
2.400	0.0	0.0	5.000	0.0	0.0

Orifice Outflow Control

Diameter (m) 0.010 Discharge Coefficient 0.600 Invert Level (m) 8.500

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