Foul Drainage Assessment and

Surface Water Management Plan

Land at Mill Lane

Hawkinge

CT18 7BY

RMB Consultants (Civil Engineering) Ltd

March 2015

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1. Background and Introduction

The following Foul Drainage Assessment and Surface Water Management Plan accompanies an outline planning application for proposed residential development on land at Mill Lane, Hawkinge, CT18 7BY.

2. Development Description and Location

Development Location

The site is located at land off Mill Lane, Hawkinge, Figure 1.

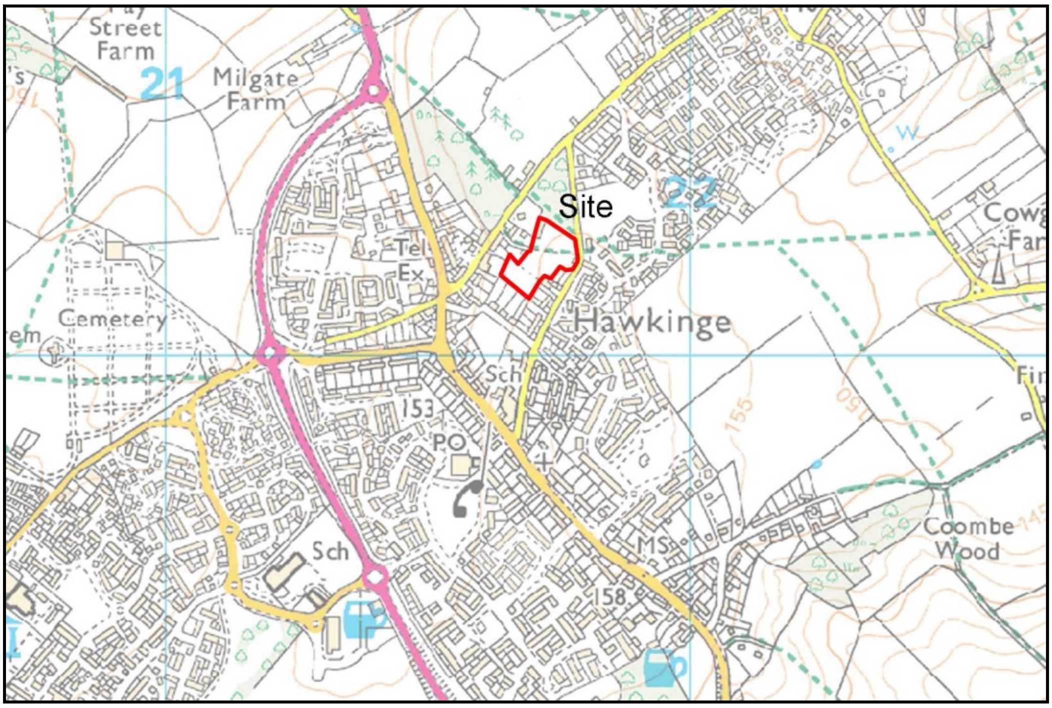


Figure 1. Site location with site edged red.

The site is situated in Hawkinge to the north of Folkestone. It is a greenfield site covering 1.1ha, Figure 2.

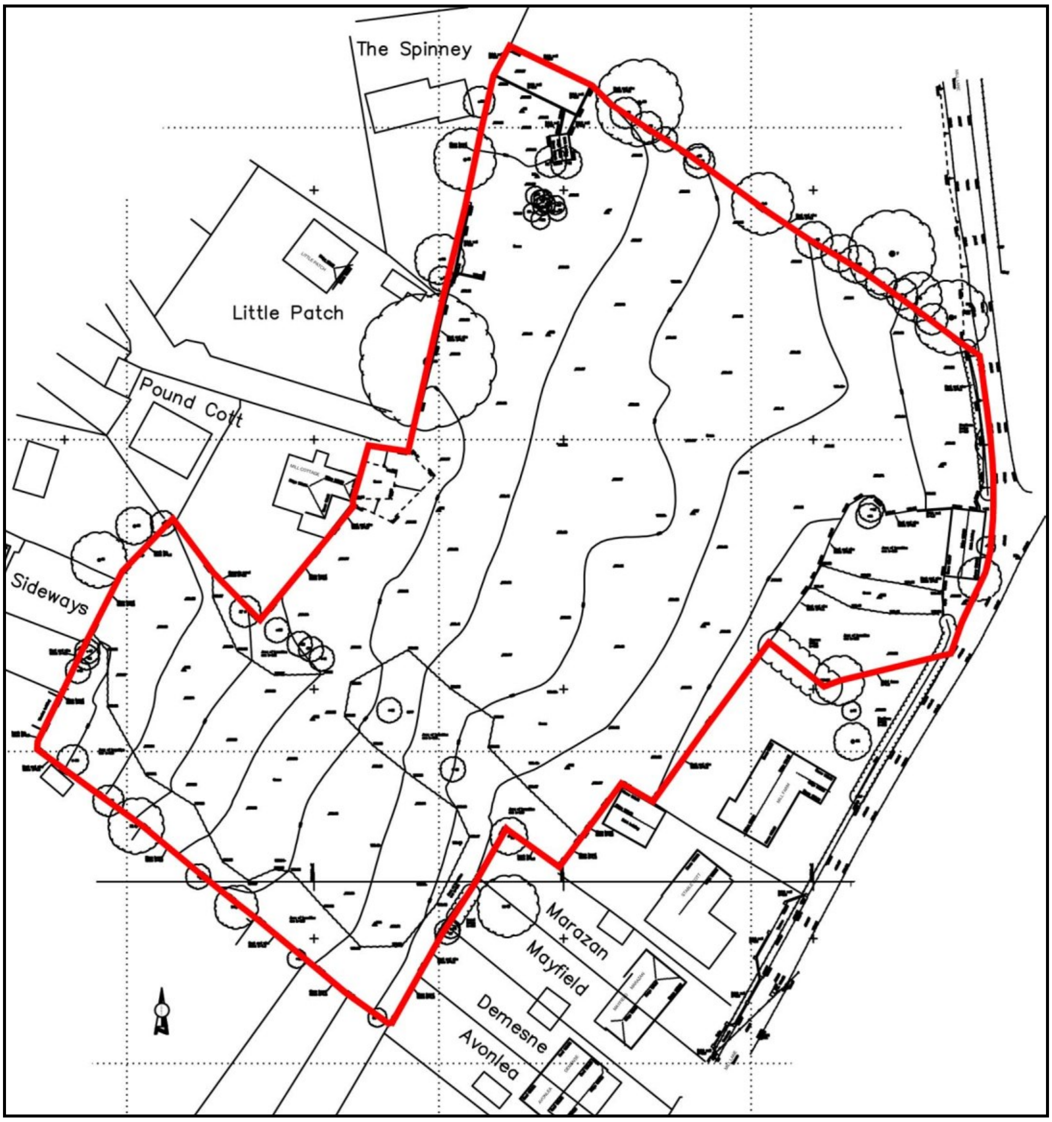


Figure 2. Existing site.

Development Proposals

The proposed development is for 14 dwellings, Figure 3.

Figure 3. Proposed development.

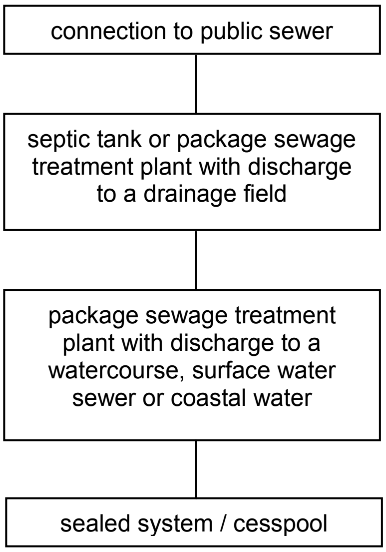
FOUL DRAINAGE ASSESSMENT

3. Foul Sewage Disposal

Choosing the right sewage treatment and disposal method is essential for the protection of public health and the environment and ensures effective long term performance of the system.

Sewage treatment and disposal can be provided by a sewerage undertaker or by a private treatment system. Pollution Prevention Guidelines (PPG4), published by the Environment Agency in 2006 states that developments proposing the use of private sewage treatment systems are usually only acceptable where connection to the public sewer is not possible. Private treatment systems may however offer a more sustainable solution to the overall water management of the site.

There is therefore a hierarchy of methods for disposing of foul sewage.



Connection to Public Sewer

The site is close to public foul sewers serving properties within Mill Lane and The Street, Figure 4.

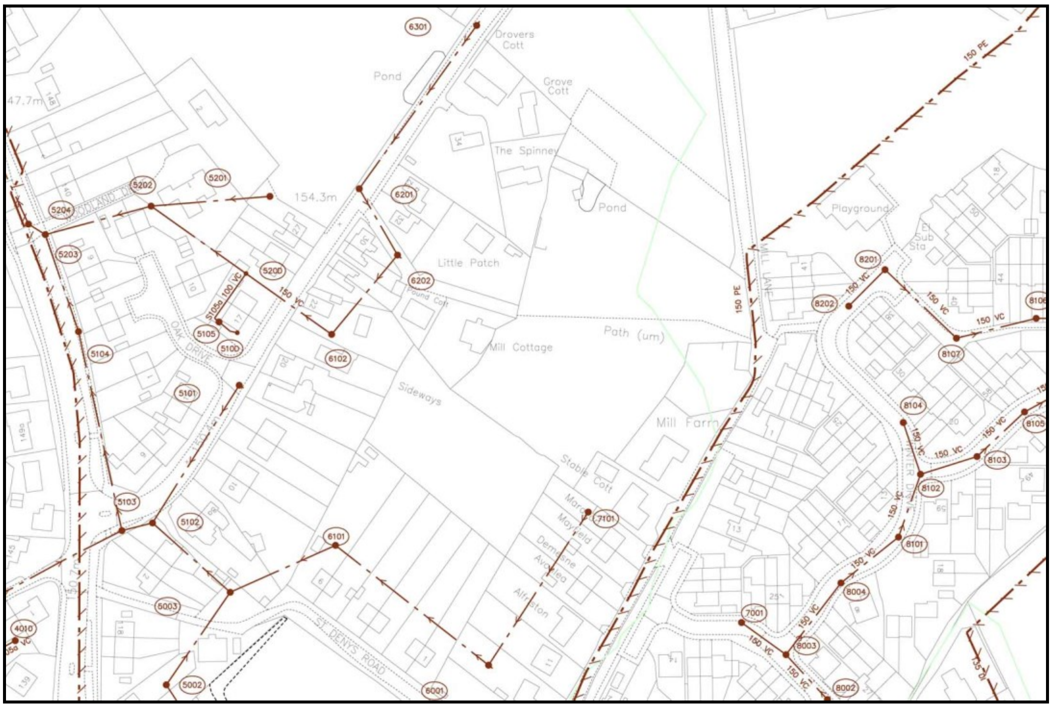


Figure 4. Public sewer record extract.

Foul Sewage Flows

Proposed Flows

The proposed development creates 14 residential properties. Sewers for Adoption 7th Edition states that design flow rates for dwellings should be 4,000 litres per dwelling per day. The foul flows from the proposed residential development will be 0.65 l/s.

A design capacity check has been submitted to Southern Water. This indicates that there is currently adequate capacity in the local sewerage network to accommodate a foul flow of 0.7 l/s within the sewers at Mill Lane or The Street, Appendix A.

If connections have to cross third party land a s98 sewer requisition could be requested from Southern Water to provide foul drainage infrastructure.

The proposals are considered to be acceptable from a foul drainage perspective.

SURFACE WATER MANAGEMENT PLAN

4. Policy Background

The management of surface water across the development has to comply with a number of local policy documents adopted by Shepway District Council.

Shepway District Council Strategic Flood Risk Assessment

Shepway District Council published a Strategic Flood Risk Assessment in 2009. The SFRA states that:

At the conceptual stage of the scheme design it is necessary to make an assessment of the way in which the surface water discharge from the site will be managed and the options that are available to achieve this without increasing the risk of flooding. One factor that is key in this decision making process is the type of superficial and underlying geology, as this has a fundamental impact on the approach to be followed for the SuDS system. There are two fundamental variations in SuDS, these are:

- *Infiltration within the attenuation facilities to partly or fully dispose of runoff*
- *Not using any infiltration techniques but providing attenuation facilities that maintain the discharges at pre-development levels*

Either of these approaches balances the increase in runoff due to climate change and hence minimises the effect of any development work on the receiving watercourses.

Large increases in impermeable area contribute to significant increases in surface runoff volumes and peak flows and could increase flood risk elsewhere unless adequate SuDS techniques are implemented. It is relatively simple to avoid the increase in peak flows by providing attenuation or detention storage that temporarily stores the required amounts of runoff within the site boundary.

SuDS elements may also be able to prevent increases in surface runoff volumes where significant infiltration is practicable.

For sites greater than 1 ha the SFRA states that:

The application will need to be accompanied by a site-specific FRA. This will need to include a Surface Water Management Strategy and will also need to demonstrate that, where possible, a sustainable drainage (SuDS) approach has been adopted.

Core Strategy

The Core Strategy Local Plan was adopted in September 2013. The Core Strategy is currently supplemented by remaining detailed guidance in 'saved' policies from the Shepway District Local Plan Review 2006.

Policy CSD5 of the Core Strategy covers Water and Coastal Environmental Management in Shepway and states that:

Development should contribute to sustainable water resource management which maintains or improves the quality and quantity of surface and ground water bodies, and where applicable, the quality of the coastal environment and bathing waters.

This will be achieved by protecting or enhancing natural water reserves through sustainable design and construction, managing development in relation to wastewater infrastructure, and promoting long-term resilience to climatic pressures on the coast and water systems. Proposals must be designed to contribute to the maintenance of a sustainable supply of water resources in the district; the achievement of water management plans for the district; and the maintenance of coastal ecological habitats (through seeking to avoid the inhibition of natural coastal processes.

Development will be permitted where the following criteria are met:

a. All developments should incorporate water efficiency measures appropriate to the scale and nature of the use proposed. Planning applications for the construction of new dwellings should include specific design features and demonstrate a maximum level of usage of 105 litres per person per day, or less.

b. New buildings and dwellings must be delivered in line with wastewater capacity, and designed so as to ensure that peak rate and surface water runoff from the site is not increased above the existing surface water runoff rate, incorporating appropriate sustainable drainage and water management features. The quality of water passed on to watercourses and the sea must be maintained or improved, and flood risk must not be increased by developments within the district.

Water reserves and the coastal environment will be maintained and enhanced through Shepway District Council working with partners to manage development and upgrade water infrastructure and quality, and through green infrastructure provisions (policy CSD4).

The Shepway Local Plan was adopted during March 2006, and a number of policies it contains are saved by the Core Strategy. Those that are considered relevant to the proposed development are as follows:

POLICY SD 1 requires that all development proposals take account of the broad aim of sustainable development. This includes the requirement to *prevent negative impacts on coastal protection, flood defence, land drainage and groundwater resources*.

POLICY U3 states that:

Planning permission will not be granted for the use of septic or settlement tanks unless it can be demonstrated that the ground conditions are such that the discharge can be absorbed through the year without causing odour nuisance and without polluting ground or surface waters.

POLICY U4 states that:

Development will be permitted unless it is demonstrated that it would lead to an unacceptable risk to the quality or potential yield of surface or ground water resources or lead to an unacceptable risk of pollution. Groundwater resources most sensitive to development are indicated on the Proposals Map as Groundwater Source Protection Zones.

5. Site Characteristics

Existing Surface Water Drainage Patterns

The site lies within a catchment with the rest of Hawkinge. There are no defined watercourses close to the site, Figure 5.

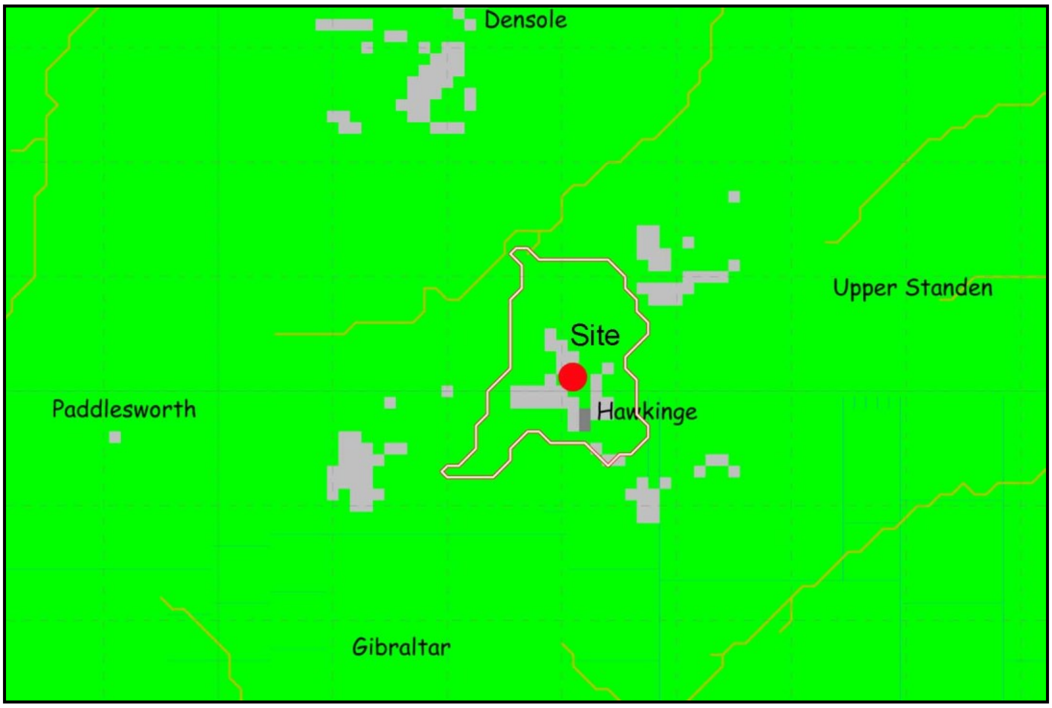


Figure 5. Drainage catchment.

Topographical Survey - A detailed topographical survey has been carried out. The site slopes from west to east from 160 to 156mAOD (Above Ordnance Datum), Figure 6.

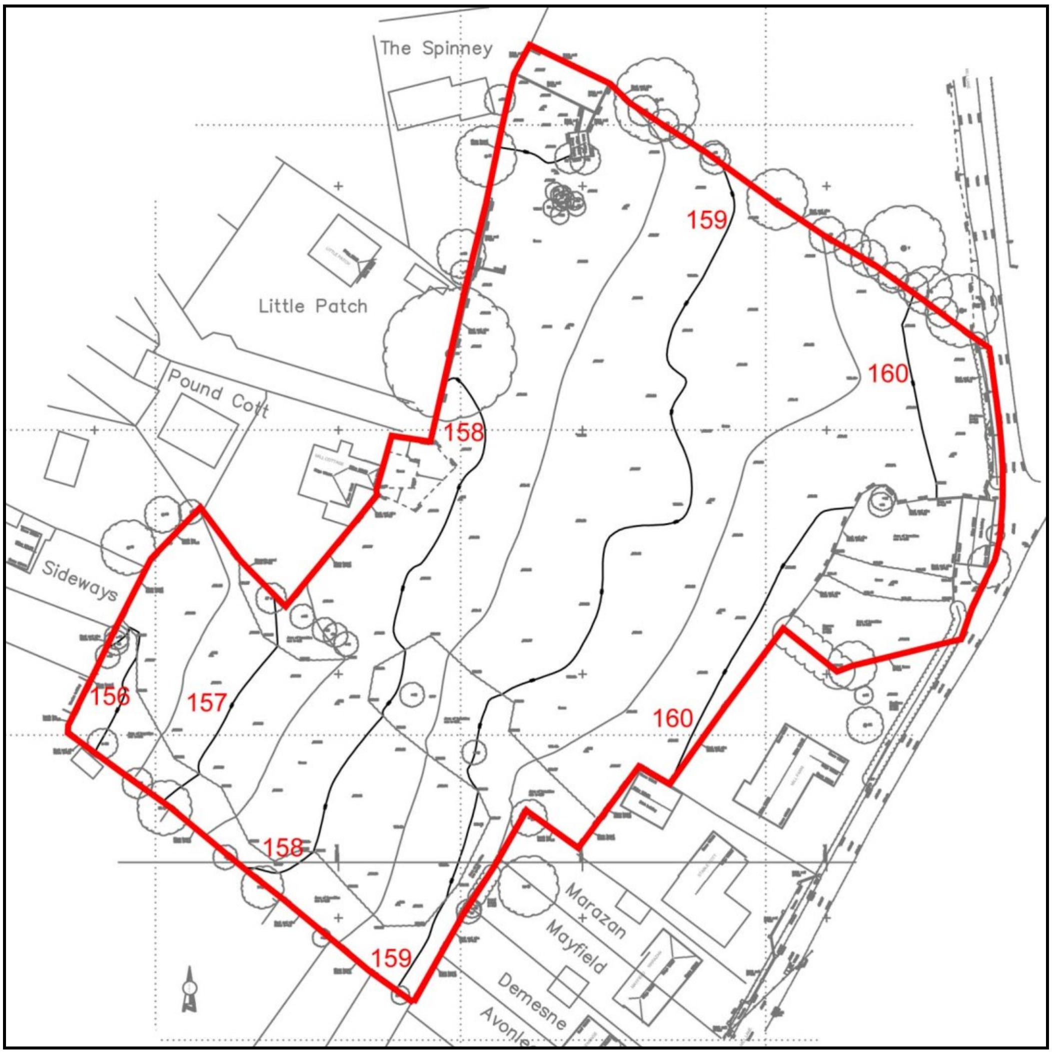


Figure 6. Local topography.

Geology and Soils - The bedrock geology consists of the Lewes Nodular Chalk Formation with superficial deposits of Clay-with-flints, sand. Soils are characterised as loamy and clayey soils with slightly impeded drainage.

Groundwater Protection Zone - The site lies within the total catchment groundwater source protection zone (zone 3), Figure 7. This is defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source. The chalk is designated a principal bedrock aquifer, Figure 8.

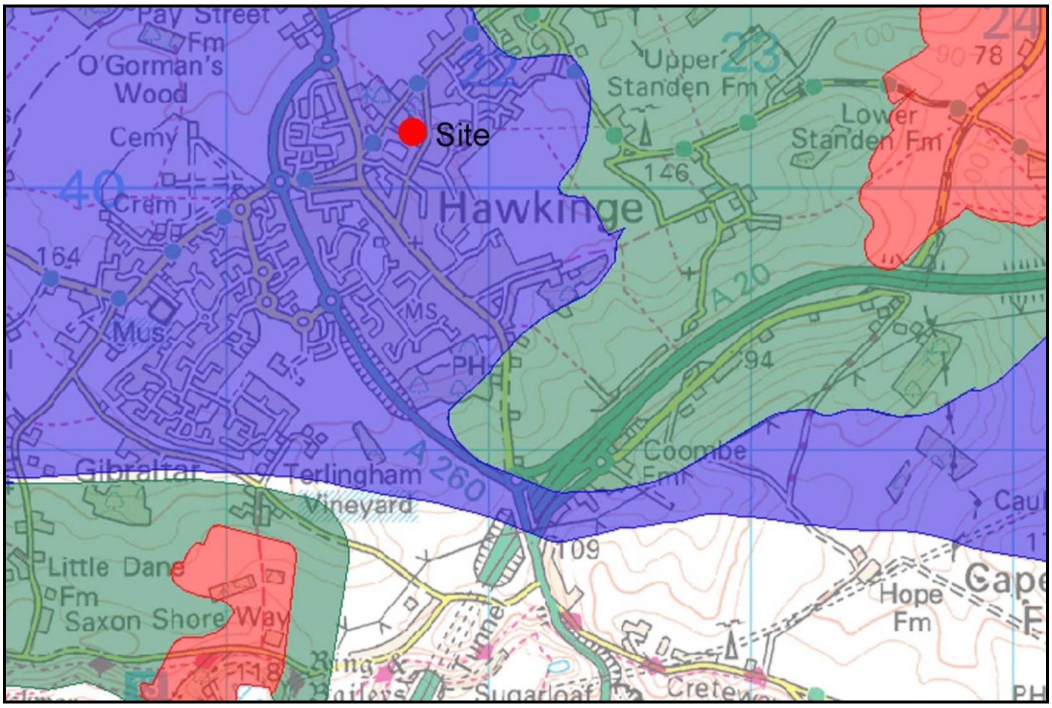


Figure 7. Groundwater source protection zone map. (© Environment Agency)

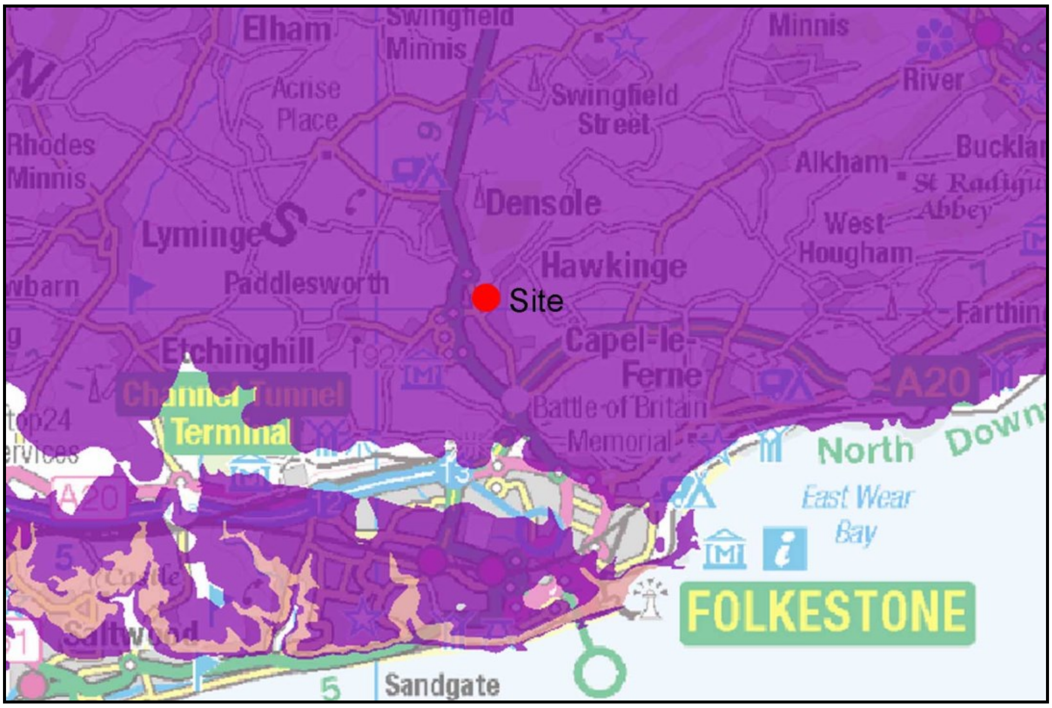


Figure 8. Aquifer map showing principal bedrock aquifer (purple). (© Environment Agency)

Infiltration Rates - Soakage testing has not been carried out at the site.

Clay-with-flints generally has a low soakage potential whereas the Upper Chalk bedrock will have a medium to high soakage potential. Deep bored soakaways discharging into the upper chalk are likely to be a more viable option than shallower conventional soakaways within the clay-with-flints strata. Deep bored soakaways have been used extensively in recent development at Hawkinge.

Boreholes carried out for development at west Hawkinge and at Paddlesworth Court indicate that the superficial deposits of clay-with-flints are approximately 18m deep. The Environment Agency has previously stated that soakaways are acceptable in Hawkinge up to three metres into the Upper Chalk Formation.

The final choice of soakaway will depend on detailed site investigation.

Infiltration rates for common types of soil are shown in Table 1.

Soil Type	**Infiltration Rate *f***
gravel	2.8×10^{-3} to 0.28 m/s
sand	2.8×10^{-5} to 0.028 m/s
loamy sand	2.8×10^{-6} to 2.8×10^{-4} m/s
sandy loam	1.4×10^{-5} to 1.4×10^{-4} m/s
loam	2.8×10^{-7} to 2.8×10^{-5} m/s
silt loam	1.4×10^{-7} to 2.8×10^{-5} m/s
chalk	2.8×10^{-7} to 0.028 m/s
sandy clay loam	2.8×10^{-7} to 2.8×10^{-5} m/s
clayey gravels	1.0×10^{-8} to 1.0×10^{-6} m/s
clayey sands	1.0×10^{-9} to 1.0×10^{-6} m/s

Table 1. Infiltration rates for typical soils.

An infiltration rate of 5×10^{-4} m/s has been assumed for infiltration within the chalk. An infiltration rate of 2×10^{-6} m/s has been assumed for infiltration within the clay with flints. These assumed rates will need to be verified before the design and construction of any infiltration devices.

Flood Risk - The NPPF states that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk. Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change by applying the Sequential Test.

Flood zones are the starting point for the Sequential Test. These zones are a broad assessment of flood risk as given below.

Zone 1 Low Probability - land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).

Zone 2 Medium Probability - land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.

Zone 3a High Probability - land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

Zone 3b The Functional Floodplain - land where water has to flow or be stored in times of flood, land which would flood with an annual probability of 1 in 20 (5%) of greater in any year or designed to flood in an extreme flood.

The site lies within flood zone 1, Figure 9 and therefore residential development is appropriate.

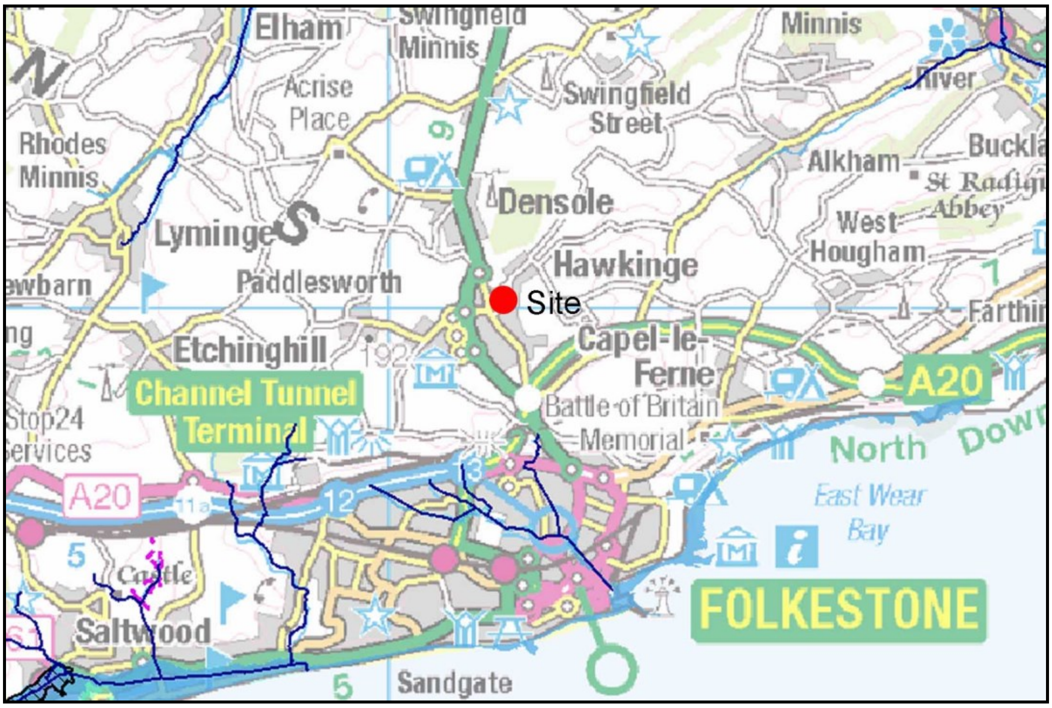


Figure 9. Environment Agency's Flood Map with the site circled red. (© Environment Agency)

Surface Water - The Environment Agency has recently published surface water flooding maps. These show the site to be within an area where the risk of surface water flooding is very low, Figure 10. The definition of each category is given below:

Very Low (white) a chance of flooding of less than 1 in 1000 (0.1%)
Low (pale blue) a chance of flooding of between 1 in 1000 (0.1%) and 1 in 100 (1%)
Medium (mid blue) a chance of flooding of between 1 in 100 (1%) and 1 in 30 (3.3%)
High (dark blue) a chance of flooding of greater than 1 in 30 (3.3%)

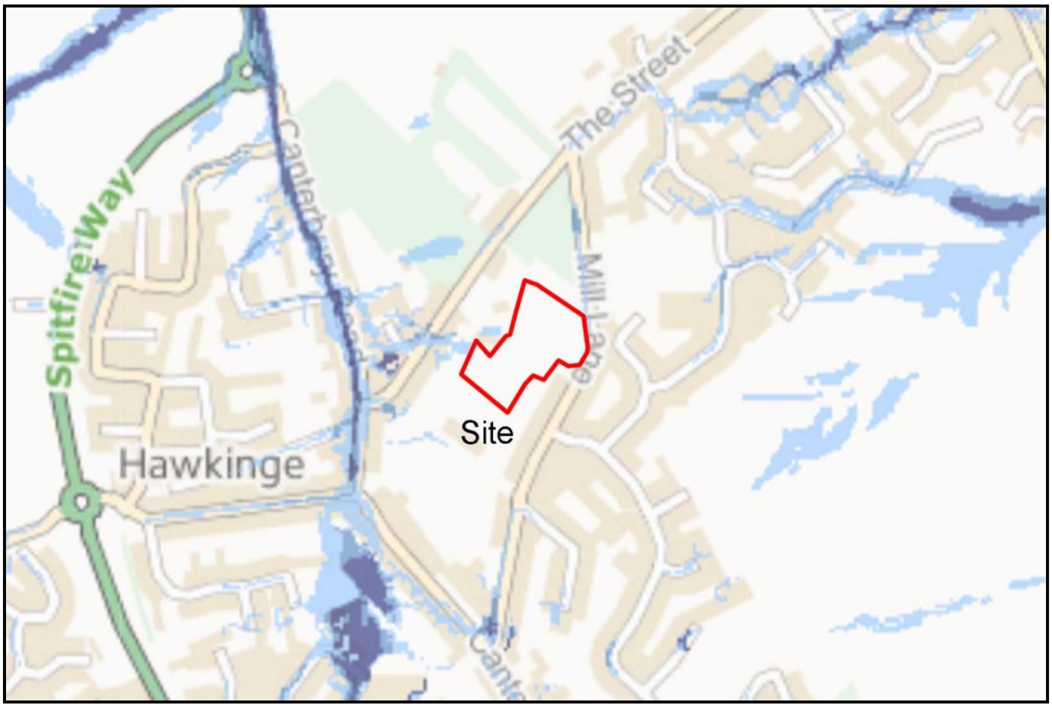


Figure 10. Environment Agency's surface water flood map with the site edged red. (© Environment Agency)

Groundwater - Water levels below the ground rise during wet winter months, and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' (streams that only flow for part of the year). Where land that is prone to groundwater flooding has been built on, the effect of a flood can be very costly, and because groundwater responds slowly compared with rivers, floods can last for weeks or months.

Chalk shows some of the largest seasonal variations in groundwater level, and is thus particularly prone to groundwater flooding incidents. The Nailbourne at Lyminge, 5km west of the site gives an indication of groundwater level. The Nailbourne flows below the 95m contour. Springs 2km south of the site emerge below the 90m contour. Groundwater level is therefore significantly below the level of the site which is at 156mAOD.

The SFRA records historic groundwater flooding incidents. There are none reported in Hawkinge.

The risk of groundwater flooding at the site is considered to be low.

Infrastructure - The SFRA also records historic flooding incidents from infrastructure failure. There are none reported in Hawkinge.

There are no reservoirs in the vicinity of the site. The risk of flooding due to infrastructure failure is considered to be low.

Existing Site

The site is a greenfield site covering 1.1 ha.

The peak greenfield runoff for the critical storm duration for the pre-development site, is shown in Table 2.

	Q l/s	
Return Period	**per ha.**	**Site (1.1 ha)**
1	2.0	2.2
30	5.4	5.9
100	7.5	8.3
100+30%	9.8	10.8

Table 2. Pre-development greenfield runoff rate for the site.

6. Climate Change

The global climate is constantly changing, but it is widely recognised that we are now entering a period of accelerating change. Climate change will result in an increase in sea levels, rainfall intensity and river flows.

The impact of climate change will be to reduce the standard of protection provided by current defences with time and increase the risk of flooding in undefended areas. The Technical Guidance to the NPFF recommends using the following increases due to climate change to 2115 in any assessment:

Peak rainfall intensity	+30%
Peak river flow	+20%
Offshore wind speed	+10%
Extreme wave height	+10%

The surface water calculations include an increase of 30% on peak rainfall intensity in accordance with the NPPF for a development life of 100 years.

7. Detailed Development Proposals

The proposed development consists of 14 houses and associated roads, drives and parking areas.

The proposals are for an outline application and an indicative layout has been produced, Figure 11. Analysis of the layout indicates that impermeable surfaces will cover approximately 2,200m^2, consisting of 900m^2 of roof and 1,300m^2 of impermeable paving. This does not include driveways and parking areas that can be designed with permeable paving to provide attenuation for surface water runoff.

Figure 11. Proposed impermeable areas.

The peak runoff for the critical storm duration for the post-development site, based on the runoff from an area of 2,200m^2, is shown in Table 3.

Return Period	Q l/s
1	19.4
30	47.0
100	61.9
100+30%	80.4

Table 3. Post-development runoff rate for the site.

8. Surface Water Management Strategy

Objectives

The aim of the surface water management strategy is to dispose of surface water runoff, on site, through the use of permeable paving and deep bore soakaways with associated storm water storage.

Surface Water Management Strategy

The Strategy has been modelled using MicroDrainage software published by XP Solutions Ltd.

Runoff from roof areas and impermeable road areas will be discharged to deep bore soakaways. These soakaways will be connected to storm water storage in the form of oversized pipes and additional manhole chambers. For the outline application it is assumed that four soakaways are provided to serve the development and that each one has an associated 27m^3 of storm water storage. The parameters used for the assessment of the deep bore soakaways are shown in Table 4. The assessment is presented in Appendix B.

Parameter	Deep Bore Soakaways
Rainfall return period	1 in 100 year + 30%
Infiltration rate (chalk)	5 x 10^{-4} m/s
Infiltration rate (clay)	-
Factor of safety	2
Soakaway type	deep bore soakaway
Soakaway storage	27m^3 per soakaway
Soakaway chamber depth	3.0m
Borehole diameter	0.15m
Borehole length	18m
Borehole length within chalk	3m
Contributing area	2,200m^2
No. of soakaways	4
Cover level	156mAOD
Maximum water level	156mAOD

Table 4. Deep bore soakaway parameters for roof and road runoff.

The private drives and parking areas are assumed to be laid with permeable paving. The parameters used for the assessment of the permeable paving are shown in Table 5. The assessment is presented in Appendix C.

Parameter	Permeable Paving
Rainfall return period	1 in 100 year + 30%
Infiltration rate	2 x 10^{-6} m/s
Factor of safety	2
sub-base depth	0.3m
Maximum water depth	0.185m

Table 5. Permeable paving parameters.

The above demonstrates that a combination of deep bore soakaways and permeable paving can be provided to deal with all surface water runoff on site. Assumed infiltration rates will need to be verified before the design and construction of any infiltration devices.

The proposals are considered to be acceptable from a surface water drainage perspective.

9. Water Quality

The level of pollution associated with any runoff event depends on;

- the land use, with runoff from paved areas being more polluting than roof areas,
- the length of time since the last rainfall event, with runoff after long dry periods being more polluting and
- the duration and intensity of the rainfall.

Pollution concentration is higher near the beginning of a storm, known as the first flush, and it follows that frequent small events are more polluting than longer and larger events.

To remove the major proportion of pollution it is necessary to capture and treat runoff from frequent, small events and the initial runoff from larger events.

Including a number of components in the SUDS management train has the following benefits:

- Different components maximise the treatment efficiency for a wide range of pollutants.
- Pollution is contained within upper SUDS components, minimising risk to the receiving waters.
- Coarse sediments are removed through permeable paving and filter strips whilst finer sediments are removed through detention in permeable paving and through infiltration.

The number of treatment train components recommended by the SUDS Manual (c697) is shown in Table 6.

	Receiving Water Sensitivity		
Catchment characteristics	**Low**	**Medium**	**High**
Roofs	1	1	1
Roads and parking	2	2	2

Table 6. Treatment train components required for various development types.

The SUDS Manual indicates that the following can be used as treatment train components:

- Infiltration
- Permeable paving
- Vegetative filtering and detention
- Granular filtering and detention
- Retention (permanent ponds)

- Proprietary oil/silt/debris traps

The development uses some of these components to provide a suitable treatment train for runoff from different parts of the development as shown in Table 7. The number refers to the stage of treatment for example surface water falling on drives receives the first stage of treatment by percolation through the permeable paving with the second stage being infiltration through the ground. In some instances there are alternatives or additional stages.

Element	Permeable paving	Filter strip	Oil/silt/debris traps	Infiltration
Roof				1
Drive/parking areas	1			2
Highway		1	1	2

Table 7. Treatment train components required for various development surfaces.

The runoff from all parts of the development therefore receives an appropriate level of treatment in accordance with the SUDS Manual.

10. Conclusion

This Foul Drainage Assessment and Surface Water Management Plan accompanies an outline planning application for proposed residential development on land at Mill Lane, Hawkinge, CT18 7BY.

Foul Water Drainage

The site is close to public foul sewers serving properties within Mill Lane and The Street.

A design capacity check has been submitted to Southern Water. This indicates that there is currently adequate capacity in the local sewerage network to accommodate a foul flow of 0.7 l/s within the sewers at Mill Lane or The Street.

The proposals are considered to be acceptable from a foul drainage perspective.

Surface Water Drainage

The site covers 1.1ha and is a greenfield site. The proposed development introduces an estimated 2,200m^2 of impermeable area from roofs and impermeable paving. The private drives and parking areas are assumed to be laid with permeable paving.

The surface water management strategy is to dispose of surface water runoff, on site, through the use of permeable paving and deep bore soakaways with associated storm water storage.

The strategy demonstrates that a combination of deep bore soakaways and permeable paving can be provided to deal with all surface water runoff on site.

The surface water management strategy provides a treatment train of SUDS components including filter strips, permeable paving, oil/silt traps and infiltration allowing runoff from all areas of the development to receive the level of treatment recommended within the SUDS Manual.

The proposals are considered to be acceptable from a surface water drainage perspective.

Appendix A - Foul Drainage Capacity Check

Southern Water

STUDY INTO THE OPTIONS FOR FOUL WATER DRAINAGE PROVISION AT LAND AT MILL LANE

MILL LANE

HAWKINGE

KENT

CT18 7BY

04 February 2015

REQUESTED:
RMB CONSULTANTS (CIVIL ENG) LTD

Study into the Options for Foul Drainage Provision along Street Road and Mill Lane, Copthorne

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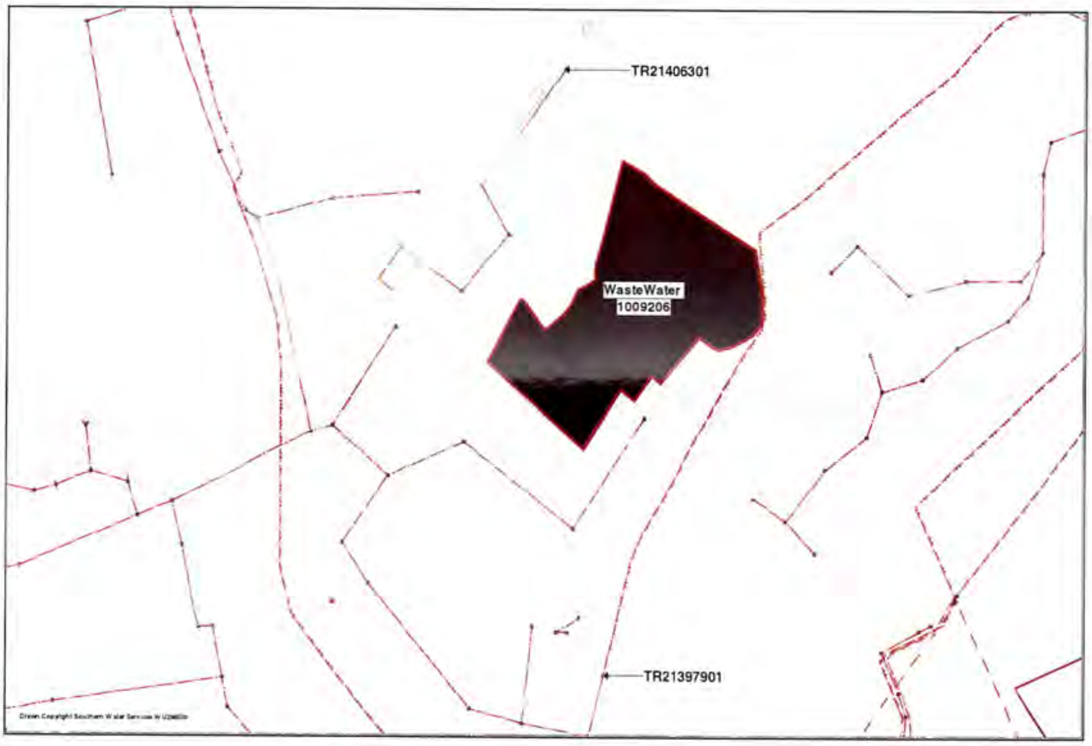
Proposed Development:

The proposal is to discharge 0.7 l/s of foul flow to the public sewerage system from the development site. The connection point to the public sewerage system for the foul flow is at manhole references TR21406301 and TR21397901 which are located in The Street and Mill Lane respectively.

Fig 1- Proposed Development:



Result:

Foul System - There is currently adequate capacity within the local foul sewerage network to accommodate a flow of 0.7 l/s at manhole references TR21406301 and TR21397901.

Surface Water System - As a surface water capacity check has not been requested it is assumed that Surface Water will be disposed of by alternative means i.e. Soakaway or any local drainage watercourses, subject to all interested parties approval.

Before any connections are made, an application form needs to be completed and approved by Southern Water Services.

Please note: - The information provided above does not grant approval for any designs /drawings submitted for the capacity analysis. The results quoted above are only valid for 12 months from the date of issue of this letter.

SOUTHERN WATER

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.

Southern Water

O.S. REF: TR2140SE	Scale: 1:1250	N	Printed By: giriyar	Date: 16-1-2015
Sewer Plot			Southern Water MapGuide Browser	
WARNING: BAC pipes are constructed of Bonded Asbestos Cement			Requested By:	
WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement				

Appendix B - Draft Deep Bore Soakaway Design

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 312 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	154.329	19.329	0.8	12.3	O K
30 min Summer	154.767	19.767	0.8	16.2	O K
60 min Summer	155.177	20.177	0.8	19.9	O K
120 min Summer	155.468	20.468	0.8	22.5	O K
180 min Summer	155.516	20.516	0.8	23.0	O K
240 min Summer	155.479	20.479	0.8	22.6	O K
360 min Summer	155.367	20.367	0.8	21.6	O K
480 min Summer	155.275	20.275	0.8	20.8	O K
600 min Summer	155.190	20.190	0.8	20.0	O K
720 min Summer	155.104	20.104	0.8	19.3	O K
960 min Summer	154.928	19.928	0.8	17.7	O K
1440 min Summer	154.583	19.583	0.8	14.6	O K
2160 min Summer	154.108	19.108	0.8	10.3	O K
2880 min Summer	153.713	18.713	0.8	6.7	O K
4320 min Summer	153.190	18.190	0.8	2.0	O K
5760 min Summer	141.777	6.777	0.8	0.1	O K
7200 min Summer	137.717	2.717	0.6	0.0	O K
8640 min Summer	137.350	2.350	0.6	0.0	O K
10080 min Summer	137.079	2.079	0.5	0.0	O K
15 min Winter	154.508	19.508	0.8	13.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	129.834	0.0	25
30 min Summer	87.106	0.0	39
60 min Summer	55.618	0.0	68
120 min Summer	34.146	0.0	126
180 min Summer	25.219	0.0	182
240 min Summer	20.302	0.0	240
360 min Summer	14.931	0.0	298
480 min Summer	11.985	0.0	360
600 min Summer	10.098	0.0	426
720 min Summer	8.774	0.0	496
960 min Summer	7.022	0.0	632
1440 min Summer	5.119	0.0	900
2160 min Summer	3.724	0.0	1280
2880 min Summer	2.968	0.0	1644
4320 min Summer	2.151	0.0	2300
5760 min Summer	1.712	0.0	2936
7200 min Summer	1.435	0.0	3672
8640 min Summer	1.242	0.0	4256
10080 min Summer	1.100	0.0	5064
15 min Winter	129.834	0.0	25

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	155.010	20.010	0.8	18.4	O K
60 min Winter	155.490	20.490	0.8	22.7	O K
120 min Winter	155.862	20.862	0.8	26.1	Flood Risk
180 min Winter	155.960	20.960	0.8	27.0	Flood Risk
240 min Winter	155.965	20.965	0.8	27.0	Flood Risk
360 min Winter	155.845	20.845	0.8	25.9	Flood Risk
480 min Winter	155.698	20.698	0.8	24.6	O K
600 min Winter	155.581	20.581	0.8	23.5	O K
720 min Winter	155.454	20.454	0.8	22.4	O K
960 min Winter	155.185	20.185	0.8	20.0	O K
1440 min Winter	154.645	19.645	0.8	15.1	O K
2160 min Winter	153.923	18.923	0.8	8.6	O K
2880 min Winter	153.368	18.368	0.8	3.6	O K
4320 min Winter	137.945	2.945	0.7	0.1	O K
5760 min Winter	137.339	2.339	0.6	0.0	O K
7200 min Winter	136.958	1.958	0.5	0.0	O K
8640 min Winter	136.693	1.693	0.4	0.0	O K
10080 min Winter	136.497	1.497	0.4	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	87.106	0.0	39
60 min Winter	55.618	0.0	68
120 min Winter	34.146	0.0	124
180 min Winter	25.219	0.0	180
240 min Winter	20.302	0.0	236
360 min Winter	14.931	0.0	342
480 min Winter	11.985	0.0	386
600 min Winter	10.098	0.0	462
720 min Winter	8.774	0.0	538
960 min Winter	7.022	0.0	688
1440 min Winter	5.119	0.0	972
2160 min Winter	3.724	0.0	1352
2880 min Winter	2.968	0.0	1680
4320 min Winter	2.151	0.0	2196
5760 min Winter	1.712	0.0	2928
7200 min Winter	1.435	0.0	3592
8640 min Winter	1.242	0.0	4272
10080 min Winter	1.100	0.0	4960

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	21.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.055

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.018	4	8	0.018	8	12	0.019

Model Details

Storage is Online Cover Level (m) 156.000

Deep Bore Soakaway Structure

Chamber Invert Level (m) 153.000
Chamber Diameter/Width (m) 3.000
Chamber Length (m) 3.000
Borehole Diameter (m) 0.150
Borehole Depth (m) 18.000
Infiltration Coefficient Base (m/hr) 1.80000
Safety Factor 2.0

Depth (m)	**Side Infil. Coef. (m/hr)**	**Depth (m)**	**Side Infil. Coef. (m/hr)**	**Depth (m)**	**Side Infil. Coef. (m/hr)**	**Depth (m)**	**Side Infil. Coef. (m/hr)**	**Depth (m)**	**Side Infil. Coef. (m/hr)**
0.000	1.80000	3.200	0.00000	6.800	0.00000	10.400	0.00000	14.000	0.00000
0.400	1.80000	3.600	0.00000	7.200	0.00000	10.800	0.00000	14.400	0.00000
0.800	1.80000	4.000	0.00000	7.600	0.00000	11.200	0.00000	14.800	0.00000
1.200	1.80000	4.400	0.00000	8.000	0.00000	11.600	0.00000	15.200	0.00000
1.600	1.80000	4.800	0.00000	8.400	0.00000	12.000	0.00000	15.600	0.00000
2.000	1.80000	5.200	0.00000	8.800	0.00000	12.400	0.00000	16.000	0.00000
2.400	1.80000	5.600	0.00000	9.200	0.00000	12.800	0.00000	16.400	0.00000
2.800	1.80000	6.000	0.00000	9.600	0.00000	13.200	0.00000	16.800	0.00000
3.000	1.80000	6.400	0.00000	10.000	0.00000	13.600	0.00000	18.000	0.00000

Appendix C - Draft Permeable Paving Design

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 471 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	155.762	0.062	0.1	1.9	Flood Risk
30 min Summer	155.788	0.088	0.1	2.7	Flood Risk
60 min Summer	155.815	0.115	0.1	3.4	Flood Risk
120 min Summer	155.839	0.139	0.1	4.2	Flood Risk
180 min Summer	155.849	0.149	0.1	4.5	Flood Risk
240 min Summer	155.854	0.154	0.1	4.6	Flood Risk
360 min Summer	155.859	0.159	0.1	4.8	Flood Risk
480 min Summer	155.860	0.160	0.1	4.8	Flood Risk
600 min Summer	155.860	0.160	0.1	4.8	Flood Risk
720 min Summer	155.859	0.159	0.1	4.8	Flood Risk
960 min Summer	155.855	0.155	0.1	4.7	Flood Risk
1440 min Summer	155.845	0.145	0.1	4.3	Flood Risk
2160 min Summer	155.826	0.126	0.1	3.8	Flood Risk
2880 min Summer	155.809	0.109	0.1	3.3	Flood Risk
4320 min Summer	155.779	0.079	0.1	2.4	Flood Risk
5760 min Summer	155.759	0.059	0.1	1.8	Flood Risk
7200 min Summer	155.749	0.049	0.1	1.5	Flood Risk
8640 min Summer	155.743	0.043	0.1	1.3	Flood Risk
10080 min Summer	155.739	0.039	0.1	1.2	Flood Risk
15 min Winter	155.772	0.072	0.1	2.2	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	129.834	0.0	19
30 min Summer	87.106	0.0	33
60 min Summer	55.618	0.0	62
120 min Summer	34.146	0.0	122
180 min Summer	25.219	0.0	182
240 min Summer	20.302	0.0	240
360 min Summer	14.931	0.0	352
480 min Summer	11.985	0.0	406
600 min Summer	10.098	0.0	466
720 min Summer	8.774	0.0	528
960 min Summer	7.022	0.0	664
1440 min Summer	5.119	0.0	936
2160 min Summer	3.724	0.0	1340
2880 min Summer	2.968	0.0	1728
4320 min Summer	2.151	0.0	2424
5760 min Summer	1.712	0.0	3112
7200 min Summer	1.435	0.0	3752
8640 min Summer	1.242	0.0	4496
10080 min Summer	1.100	0.0	5240
15 min Winter	129.834	0.0	18

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	155.801	0.101	0.1	3.0	Flood Risk
60 min Winter	155.831	0.131	0.1	3.9	Flood Risk
120 min Winter	155.858	0.158	0.1	4.8	Flood Risk
180 min Winter	155.871	0.171	0.1	5.1	Flood Risk
240 min Winter	155.878	0.178	0.1	5.3	Flood Risk
360 min Winter	155.884	0.184	0.1	5.5	Flood Risk
480 min Winter	155.885	0.185	0.1	5.6	Flood Risk
600 min Winter	155.883	0.183	0.1	5.5	Flood Risk
720 min Winter	155.882	0.182	0.1	5.4	Flood Risk
960 min Winter	155.876	0.176	0.1	5.3	Flood Risk
1440 min Winter	155.859	0.159	0.1	4.8	Flood Risk
2160 min Winter	155.831	0.131	0.1	3.9	Flood Risk
2880 min Winter	155.804	0.104	0.1	3.1	Flood Risk
4320 min Winter	155.762	0.062	0.1	1.9	Flood Risk
5760 min Winter	155.746	0.046	0.1	1.4	Flood Risk
7200 min Winter	155.739	0.039	0.1	1.2	Flood Risk
8640 min Winter	155.734	0.034	0.1	1.0	Flood Risk
10080 min Winter	155.730	0.030	0.1	0.9	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	87.106	0.0	33
60 min Winter	55.618	0.0	62
120 min Winter	34.146	0.0	120
180 min Winter	25.219	0.0	178
240 min Winter	20.302	0.0	236
360 min Winter	14.931	0.0	348
480 min Winter	11.985	0.0	454
600 min Winter	10.098	0.0	544
720 min Winter	8.774	0.0	570
960 min Winter	7.022	0.0	722
1440 min Winter	5.119	0.0	1024
2160 min Winter	3.724	0.0	1448
2880 min Winter	2.968	0.0	1820
4320 min Winter	2.151	0.0	2504
5760 min Winter	1.712	0.0	3112
7200 min Winter	1.435	0.0	3816
8640 min Winter	1.242	0.0	4504
10080 min Winter	1.100	0.0	5248

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	21.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.010

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.010

Model Details

Storage is Online Cover Level (m) 156.000

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00720	Width (m)	10.0
Membrane Percolation (mm/hr)	1000	Length (m)	10.0
Max Percolation (l/s)	27.8	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	155.700	Cap Volume Depth (m)	0.200