GeoSmart Information

SuDSmart Plus

Sustainable Drainage Assessment

Site Address

New Zealand House
160 Abbey Foregate
Shrewsbury
SY2 6FD

Grid Reference

520291, 260888

Report Prepared for

Mr John Smith
Design House
Architect Road
Plan City
SY63 87X

Date

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Report Status

FINAL

Site Area

0.3 ha

Report Reference

SuDSmart Plus Example

Infiltrate to Ground

The proposed Sustainable Drainage Scheme (SuDS) strategy is comprised of rainwater harvesting butts, permeable paving and a swale, which will attenuate 14.1m^3 prior to infiltrating to ground, subject to site investigation.

Report Author

James Robinson

Senior Project Consultant

Report Checker

Jessica Bayliff

Senior Consultant

Report Reviewer

David South

Senior Consultant

GeoSmart Information Ltd
Suite 9-11, 1st Floor, Old Bank Buildings,
Bellstone, Shrewsbury, SY1 1HU
+44(0)1743 298 100
info@geosmartinfo.co.uk
www.geosmartinfo.co.uk

1 Executive summary

This report assesses the feasibility of a range of Sustainable Drainage Scheme (SuDS) options in support of the Site development process. A SuDS strategy is proposed to ensure surface water runoff can be managed effectively over the lifetime of the development.

SuDS suitability

Risk	Issue	Result
Discharge Location	What is the infiltration potential at the Site?	Moderate to High
	What is the potential to discharge to surface water features?	High
	What is the potential to discharge to sewers?	Low
	What is the potential to discharge to highway drains?	Low
Flooding	What is the fluvial flood risk at the Site?	Very Low to Medium
	What is the pluvial flood risk at the Site?	Very Low
	What is the groundwater flood risk at the Site?	Low to Moderate
Pollution	Is the groundwater a protected resource?	No
	Is the surface water feature a protected resource?	No

Summary of existing and proposed development

The Site is currently used within a commercial capacity. At present there is a single building with car park and landscaped areas. Development proposals comprise the construction of a new commercial building while keeping the existing features already located on the Site along with the installation of permeable paving.

Summary of discharge routes

GeoSmart's SuDS Infiltration Potential (SD50) map indicates the Site has a moderate to high potential for infiltration, primarily due to the high permeability of the underlying geology (river terrace deposits and sandstone). Infiltration to ground is therefore likely to be feasible.

Ordnance Survey (OS) mapping indicates a surface water feature is located within 60 m south of the Site. Therefore, discharge into this feature should be considered.

The regulated drainage and water search included in Appendix C confirms the Site is located within 20 m of the public sewer network and currently discharges to this. However due to the topographic gradient discharging to sewer from the proposed development is not considered to be feasible.

According to Google Streetview, highway gullies are located within Abbey Foregate, indicating the presence of the highway drainage network.

Runoff rate and attenuation requirements

Discharging via infiltration requires 14.1m^3 of attenuation to be provided to ensure there is no flooding as a result of the development in all storm events up to and including the 1 in 100 year (6 hour storm) including a 40% allowance for climate change. This volume is subject to the results of infiltration testing and would ensure runoff is not increased above the greenfield scenario.

Discharging off-Site would require 5.5m^3 of attenuation to be provided to ensure there is no flooding within the development in all storm events up to and including the 1 in 100 year including a 40% allowance for climate change. This volume is subject to the discharge rate being restricted to 2 l/s.

Proposed SuDS strategy

SuDS features comprised of rainwater harvesting butt, permeable paving and a swale are proposed to attenuate a minimum of 15 m^3 of surface water runoff. The SuDS features would provide some water quality benefits (interception and filtration) prior to infiltrating to ground. Focused infiltration features should be sited at least 5m from building foundations and 2-3m from adjacent highways.

The proposed SuDS strategy would ensure surface water runoff is stored on Site in SuDS features for the 1 in 100 year event including a 40% allowance for climate change and will not cause flooding to the proposed development in accordance with DEFRAs non-statutory technical standards (DEFRA, 2015).

SuDS & drainage network maintenance

The management and maintenance of the SuDS features, in line with the details and schedules outlined in Section 11 of this report, will be undertaken by contractors appointed by the owners and occupiers of the new residential building, where payments for the works will form part of the property deeds and / or rental agreements.

Recommendations / Next steps

A site investigation is required to confirm the infiltration capacity of the ground in line with BRE 365 guidelines to confirm the infiltration rate and the groundwater level.

Where site investigation confirms the underlying ground conditions are not conducive to infiltration, the condition and capacity of the surface watercourse should be confirmed and permission to discharge should be obtained from the Environment Agency.

2 Proposed SuDS strategy

The most suitable SuDS options are outlined below and a SuDS strategy schematic is shown overleaf. Supporting information is provided in subsequent sections.

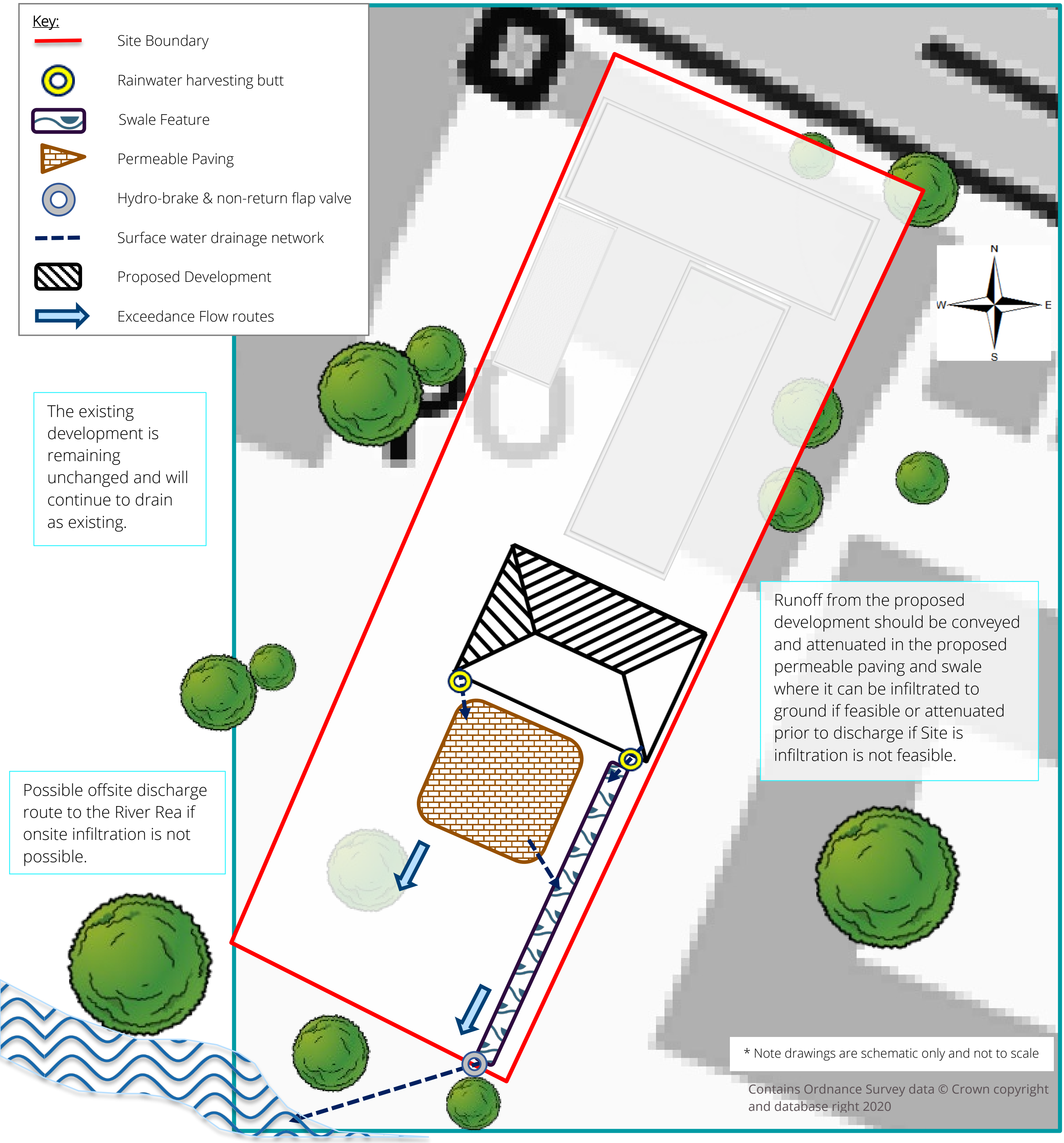
Table 1. Proposed SuDS type, features, discharge location and rate restriction

SuDS type	Source control (interception) and infiltration SuDS.
SuDS features	Rainwater harvesting butts, permeable paving and a swale.
Discharge location	Infiltration to ground.

Table 2. Proposed SuDS sizing (dimensions) and attenuation volumes

Rainwater Harvesting	A rainwater harvesting butts should be established for the proposed development. In terms of attenuation storage within this SuDS scheme, volume of run-off which could be attenuated by Rainwater Harvesting has not been considered within the Preliminary SuDS schematic.
Permeable paving	A 100 m^2 area of permeable paving (underlain with a Type 3 aggregate material) within the proposed driveway areas to a depth of 0.25 m, with a 30% porosity would result in c. 7.5 m^3 attenuation.
Swale	A shallow swale with a length of 30m, width of 1.75m and depth of 0.25m along the eastern boundaries of the Site would result in c. 7.5 m^3 attenuation.
Total Attenuation Provided	15 m^3
Total Attenuation Required	14.1 m^3
Freeboard Storage Provided	0.9 m^3

Figure 1. SuDS strategy schematic



3 Site analysis

Site location

Figure 2. Aerial Imagery (Bluesky, 2020)

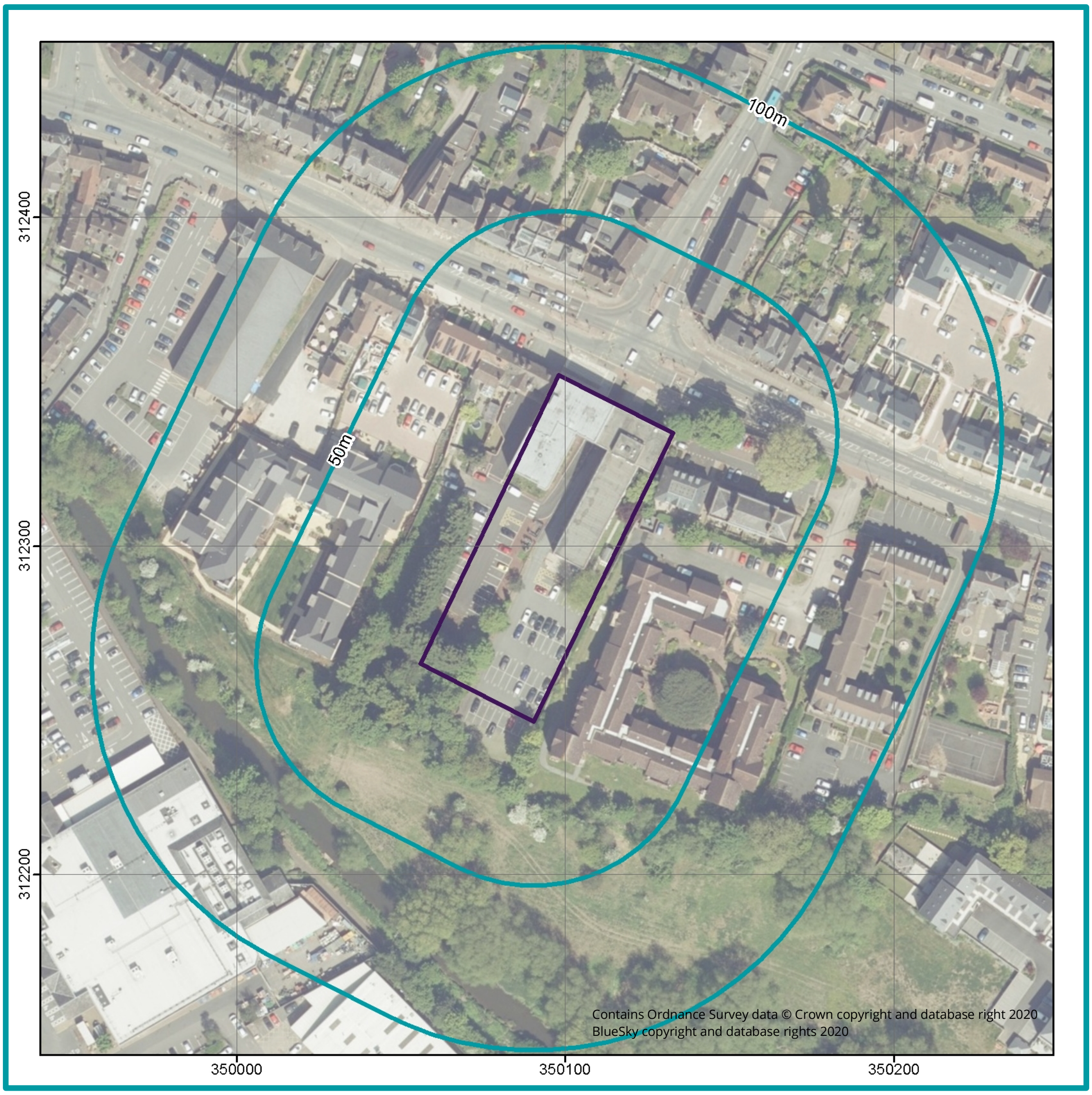
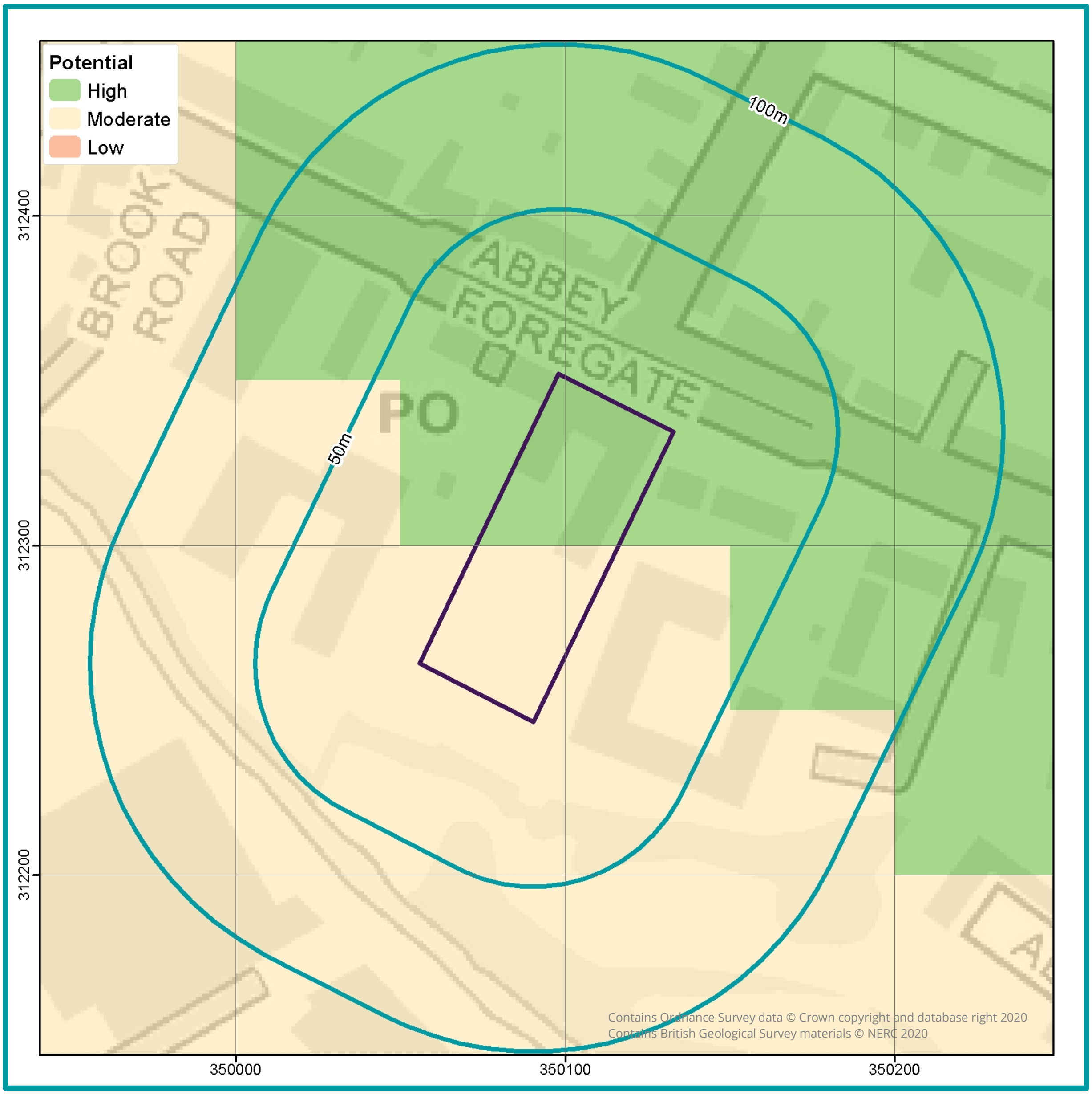


Figure 3. SuDS infiltration suitability (SD50) map (GeoSmart, 2020)

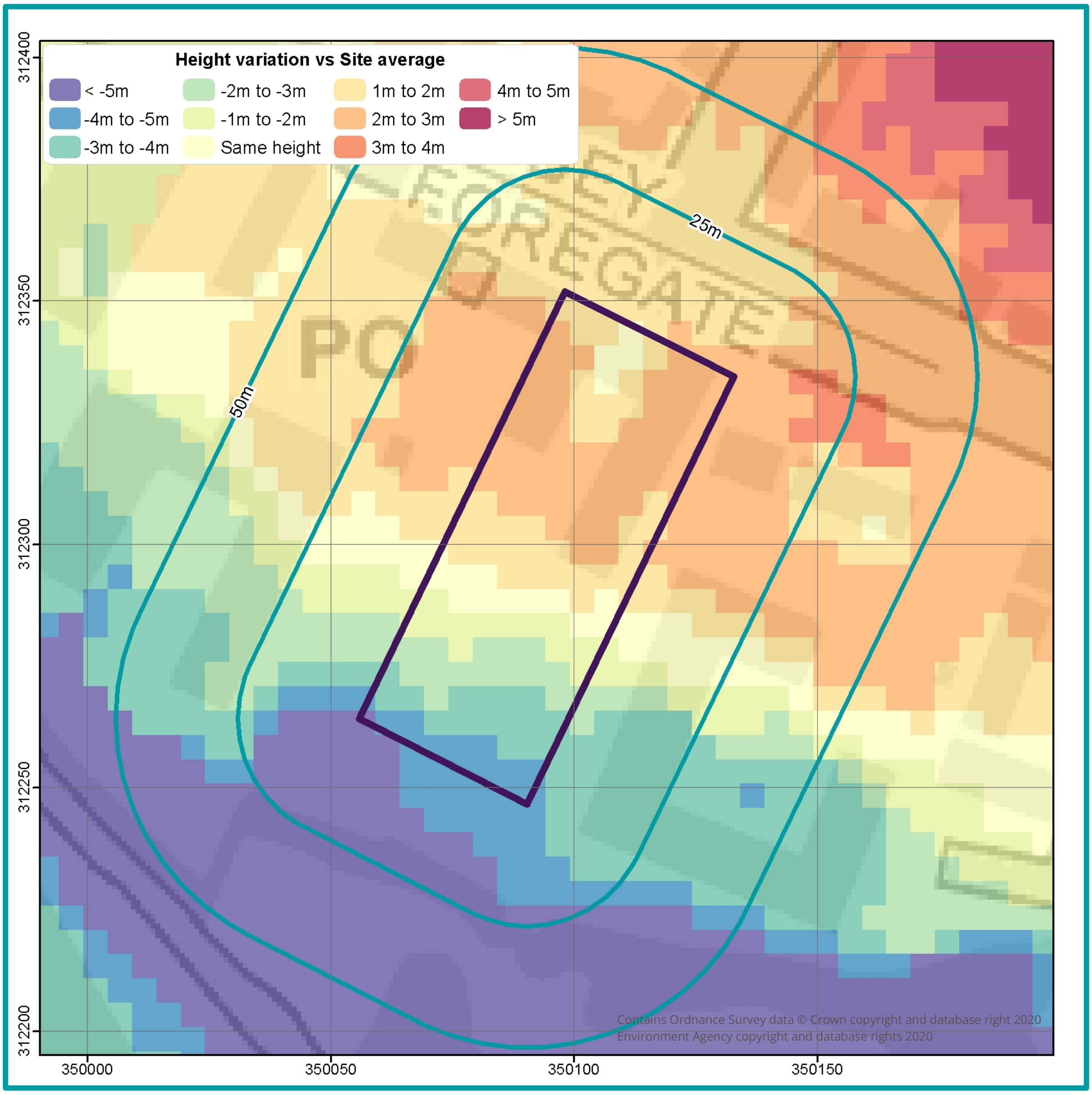


GeoSmart's SuDS Infiltration Suitability (SD50) Map screens the potential for infiltration drainage at the Site and indicates where further assessment is recommended. The map combines information on the thickness and permeability of the underlying material and the depth to the high groundwater table.

According to the SD50 map, there is a moderate to high potential for infiltration SuDS within the Site.

A Site investigation is recommended to investigate groundwater levels and formation thickness and to confirm that infiltration rates at the Site are sufficient to accommodate an infiltration SuDS feature.

Figure 4. Site topography (GeoSmart, 2020)

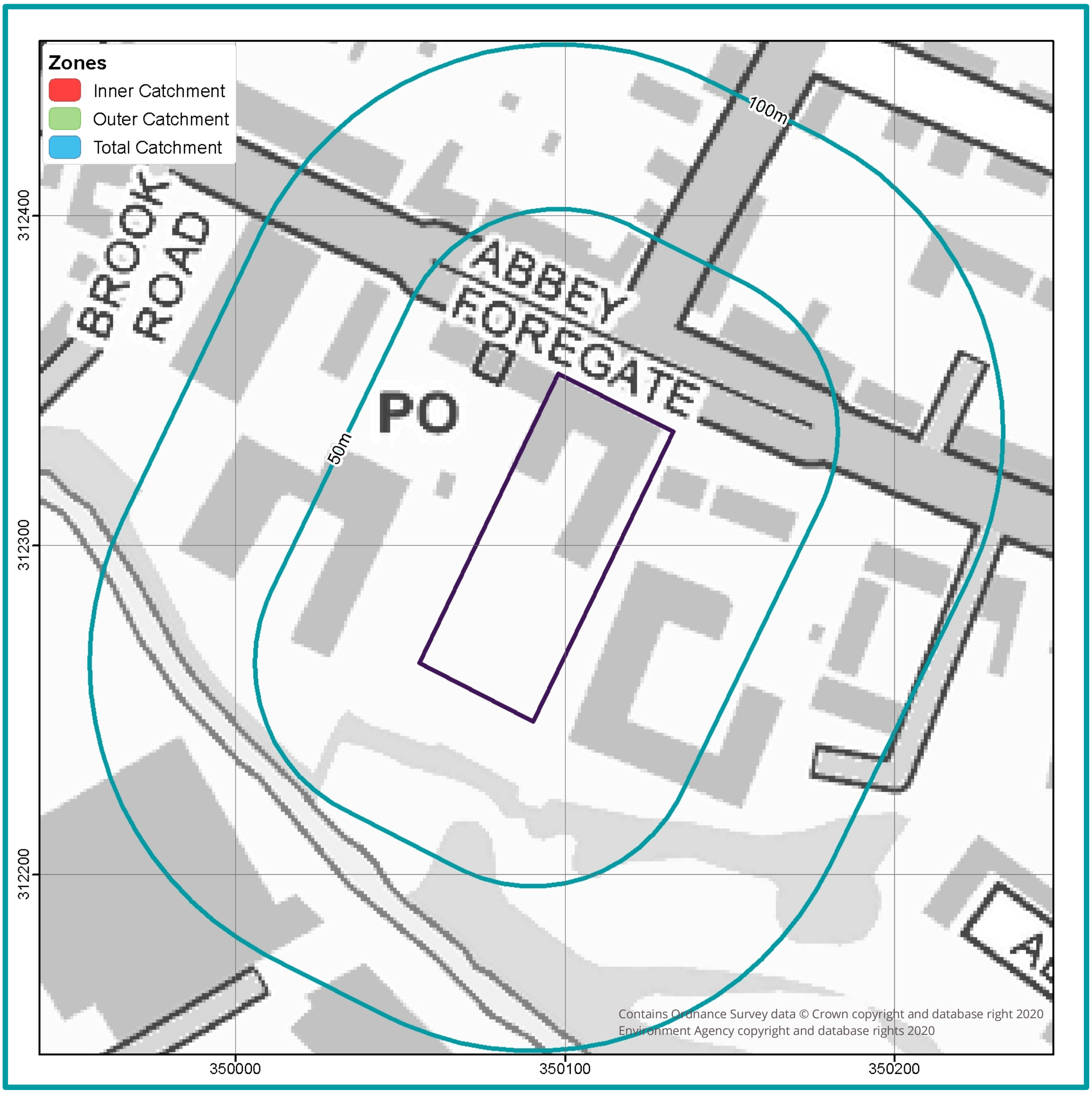


GeoSmart have undertaken an assessment of the topography at the Site and within its vicinity, using LiDAR elevation data from the Environment Agency (EA). The mapping shows a comparison between average ground levels on the Site with ground levels in the surrounding area.

The topographic data confirms the general level of the Site falls in a south westerly direction from 57.2 mAOD along the north eastern boundary to 51.6 mAOD along the south western boundary.

The EA LiDAR elevation obtained for the Site was to a 1m resolution with a vertical accuracy of ±150 mm.

Figure 5. Source protection zone map (EA, 2020)

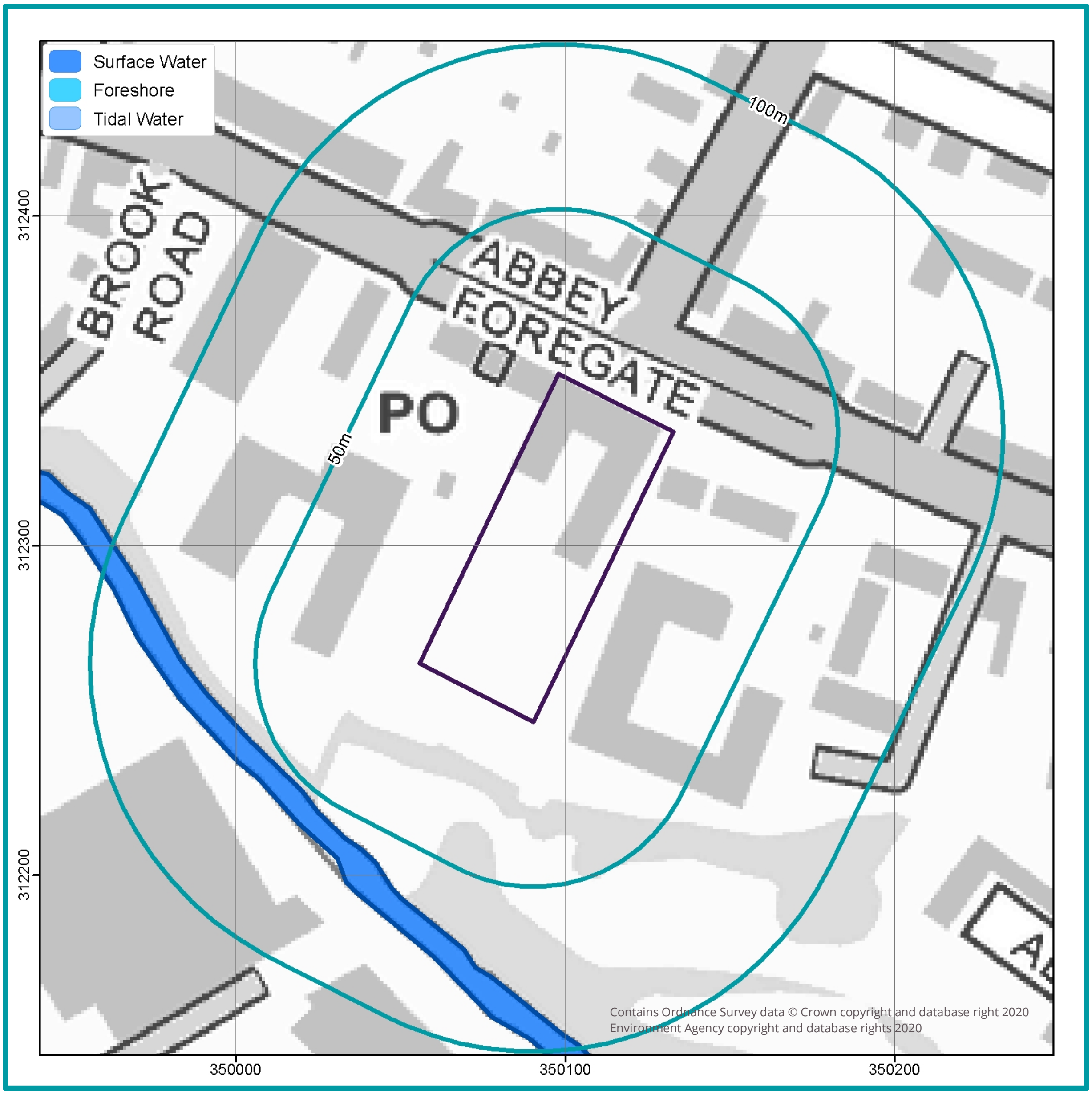


GeoSmart have undertaken an assessment of the EA groundwater Source Protection Zones (SPZ) within the vicinity of the Site.

The Site is not within a SPZ, therefore, if applicable, infiltration to the ground is likely to be acceptable providing suitable mitigation measures are in place if required to prevent an impact on water quality from the proposed or historical land use.

If hazards are identified, further consideration of the potential for any drainage system to cause pollution of groundwater is recommended. It is also recommended that the Local Authority and the EA are contacted to confirm the susceptibility of controlled water within the wider area.

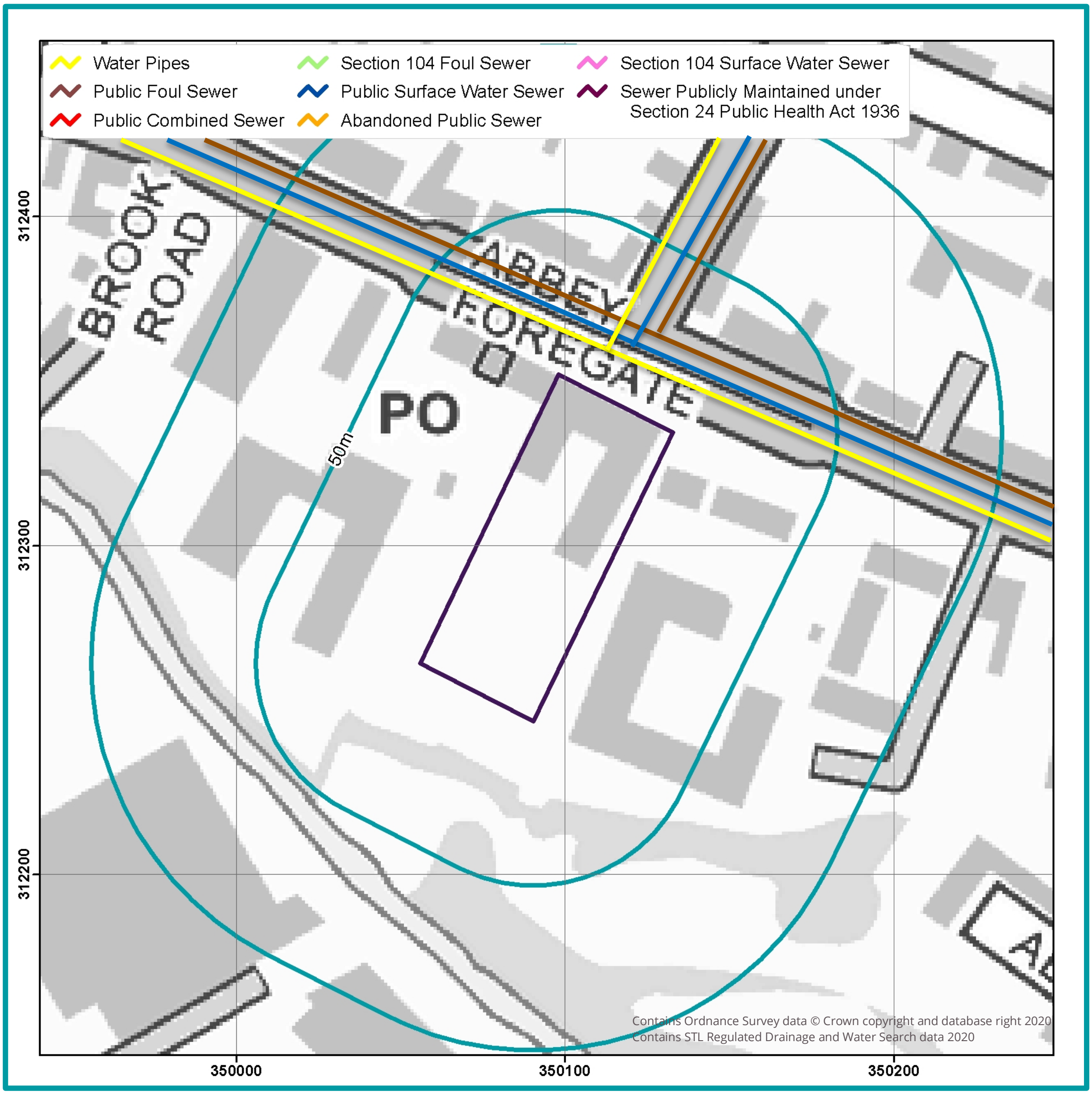
Figure 6. Surface water features map (EA, 2020)



GeoSmart have undertaken an assessment of the location of surface water features within the vicinity of the Site. The Rea Brook is located 55m south west of the Site and discharge to this watercourse is likely to be feasible.

Further analysis could be undertaken by visiting the Site or by contacting the Local Council and the EA to confirm the presence, location and condition of these watercourses.

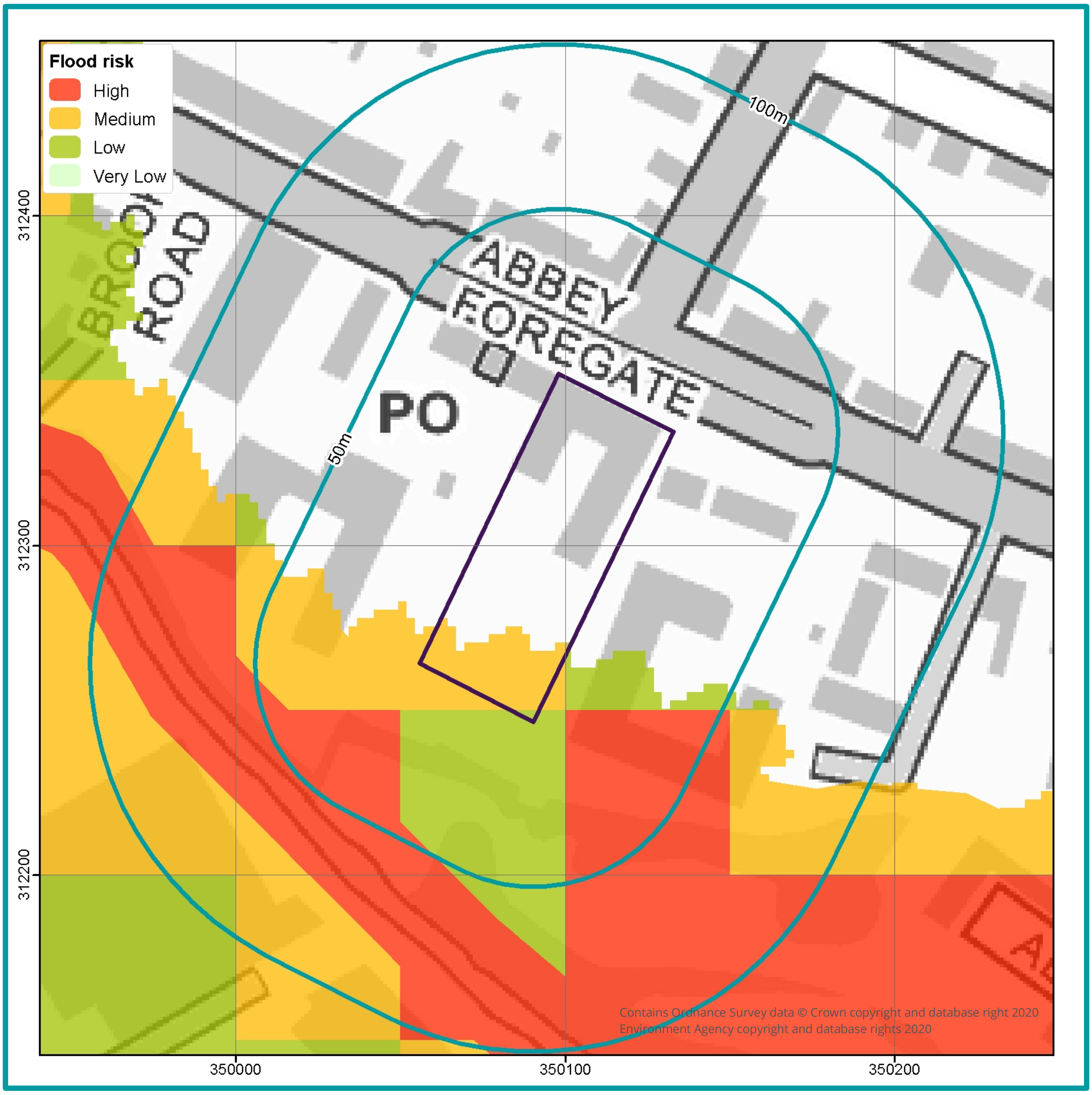
Figure 7. Sewer features map (OS & STL, 2020)



GeoSmart have undertaken an assessment of the location of sewer features within the vicinity of the Site. A public surface water sewer is located within Abbey Foregate. Discharge to sewer is unlikely to be feasible however as the topography of the Site falls steeply away from the sewer.

Further analysis of the connections and condition of the public surface water and foul drainage systems should be undertaken by carrying out a CCTV survey, or by contacting the drainage provider or the Local Council to confirm the presence, location and condition of these sewers. Consultation with the drainage provider would also be required to determine that sufficient capacity is available to accept the proposed discharge, and to gain permission to connect if required.

Figure 8. Risk of flooding from rivers & sea map (EA, 2020)

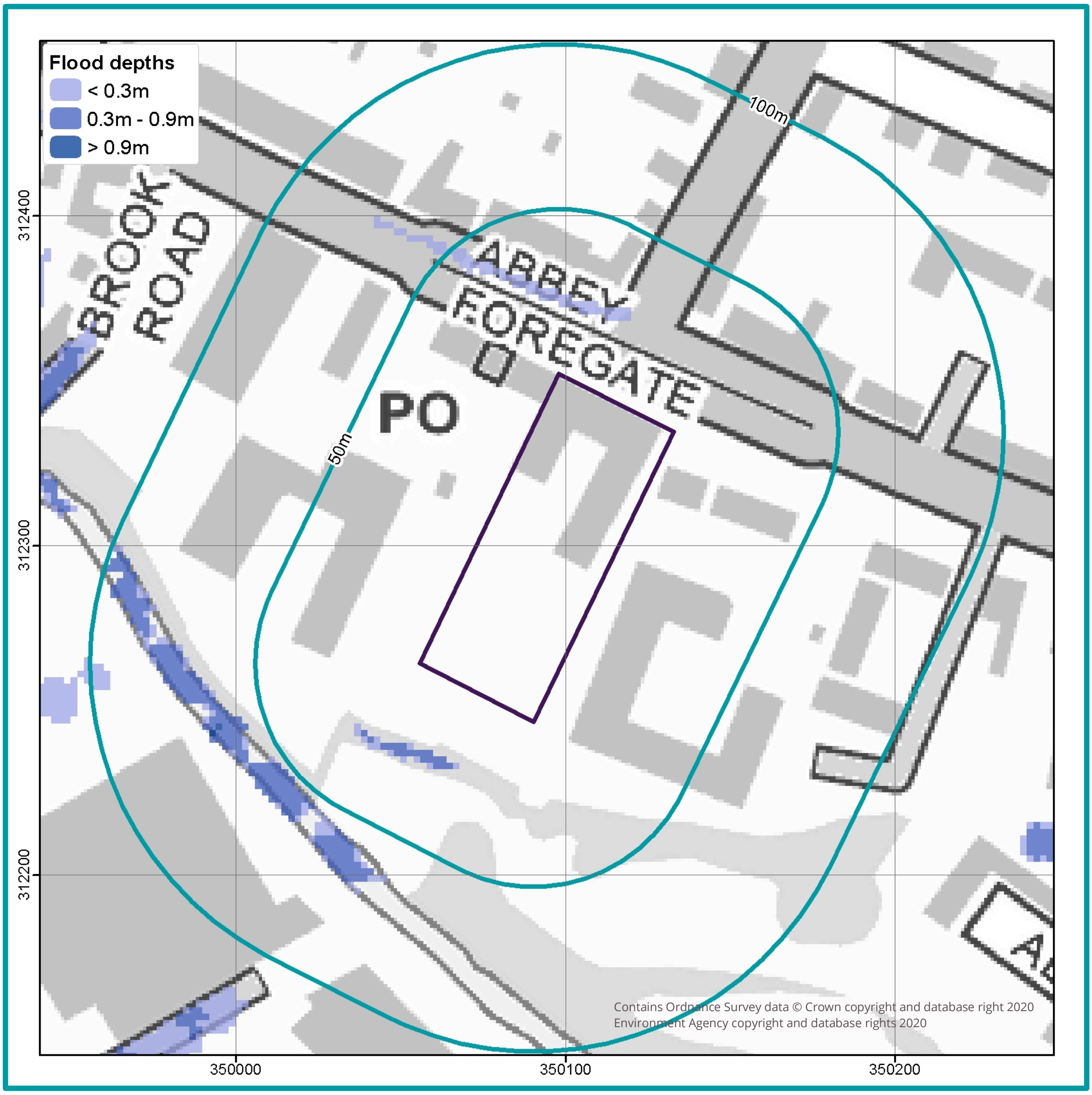


GeoSmart have undertaken an assessment of the risk of flooding from the rivers and the sea within the vicinity of the Site.

The majority of the Site is located at a negligible risk of flooding however the south of the Site is at medium risk of flooding.

Where there is a medium or high risk, further analysis could be undertaken by visiting the Site or by contacting the Local council and the EA to confirm the risk and the associated flood depths.

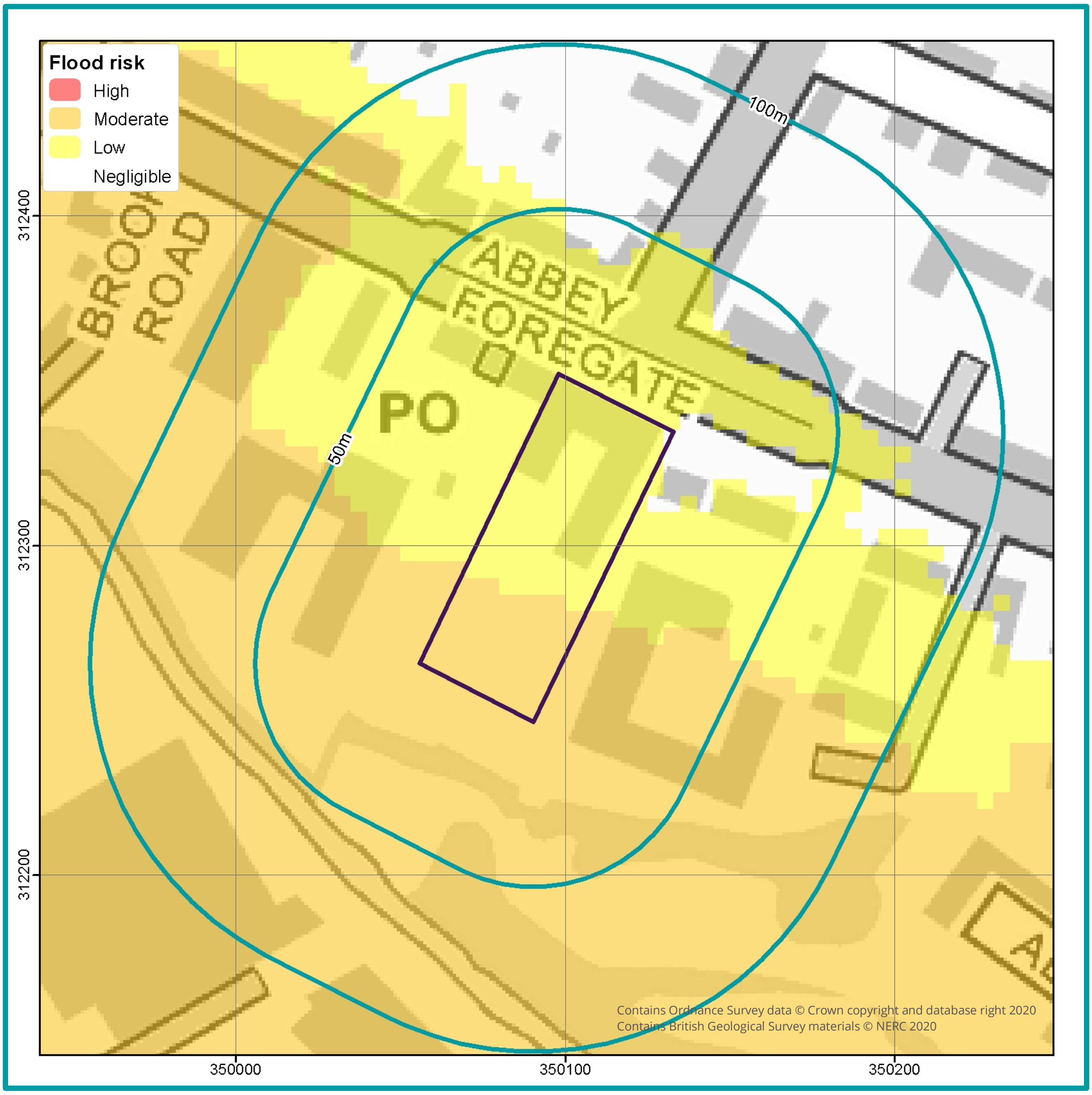
Figure 9. Risk of surface water flooding map (EA,2020)



GeoSmart have undertaken an assessment of the risk of flooding from pluvial sources within the vicinity of the Site. The Site has a very low risk of surface water flooding.

Further analysis could be undertaken by visiting the Site or by contacting the Local Council and the EA; to confirm the pluvial flood risk and flood depths and velocities where applicable.

Figure 10. Groundwater flood risk (GW5) map (GeoSmart, 2020)



GeoSmart have undertaken an assessment of the risk of flooding from groundwater sources within the vicinity of the Site. The Site has a low to moderate risk of groundwater flooding.

Therefore, SuDS design could potentially be affected by flooding through the underlying geology. It is necessary that any SuDS are designed to operate in times when groundwater levels are high, so Site specific investigation is necessary to establish the depth to groundwater.

4 Site context

Site information

The purpose of this report is to assess the potential for disposing of surface water through a sustainable drainage system (SuDS) for the site of New Zealand House, 160 Abbey Foregate, Shrewsbury, SY2 6FD (the Site). The Site is located at the centre of Shrewsbury in a setting of commercial and residential use. Site plans and drawings are provided in Appendix A.

Development

The Site is currently used within a commercial capacity. At present there is a single building with car park and landscaped areas. Development proposals comprise the construction of a new commercial building while keeping the existing features already located on the Site.

Geology, permeability and thickness

British Geological Survey (BGS) national superficial and bedrock geology mapping confirms a number of different formations underlie the site and each formation may have a range of permeability.

Table 3. Site Geology

Geology present on site		Potentially permeable?
Superficial geology	River terrace deposits (RTD3)	✓
Bedrock geology	Salop formation (sandstone) (SAL)	✓

Figure 11. Superficial Geology (BGS, 2020)

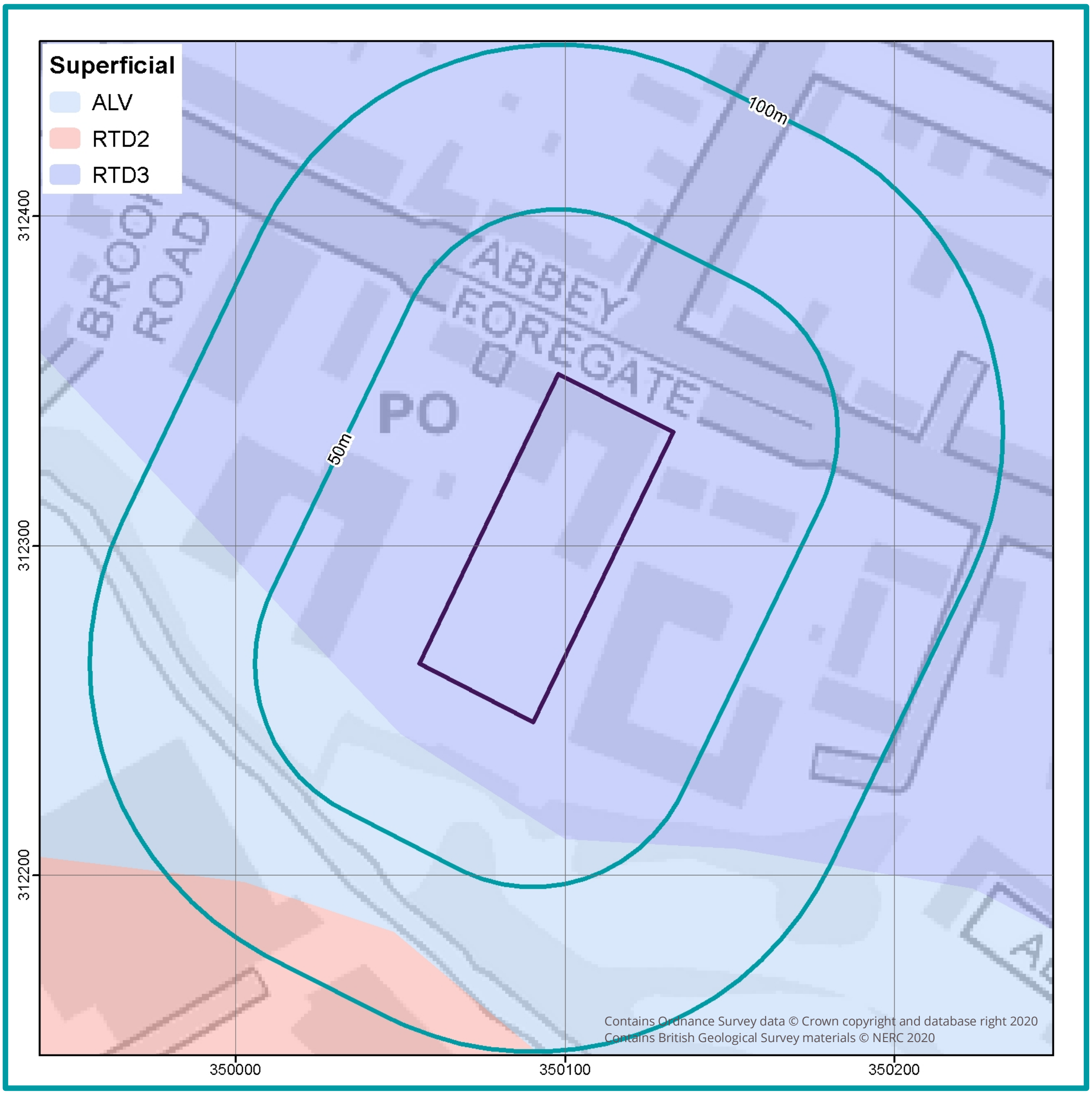
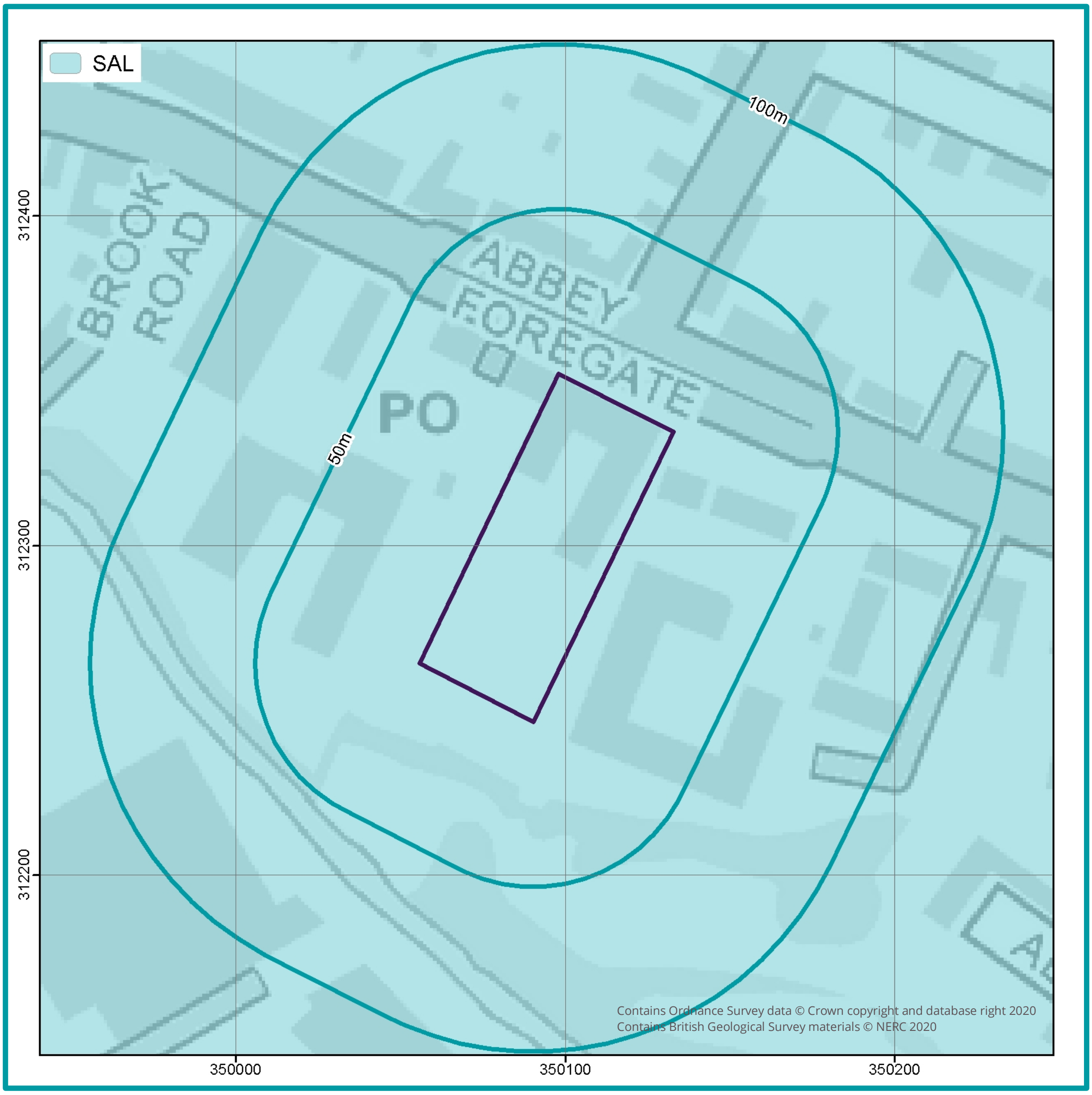


Figure 12. Bedrock Geology (BGS, 2020)



Surrounding borehole records (ref: SJ51SW11) were obtained from the BGS website, these are located approximately 300m to the east of the Site.

The borehole records confirm the underlying geology in the surrounding area comprises of gravelly topsoil to a depth of 0.3m below ground level (bgl) underlain by firm brown clayey silt to a depth of 6.25m bgl where the borehole ends.

The permeability of the underlying material at the Site is likely to be relatively high and confirmation of the infiltration capacity is recommended.

The soil infiltration coefficient must be sufficient to accommodate the constraints on the dimensions of the soakaway and its emptying time.

Infiltration SuDs are proposed directly into permeable superficial deposits.

Depth to groundwater

According to GeoSmart's Groundwater Flood Risk (GW5) map, shallow groundwater is potentially a problem at the Site.

The base of the infiltration system needs to be 1 m above the expected seasonal high-water table. Passage through unsaturated soil is important for improving the quality of infiltrating water before it reaches the water table.

The SuDS system should be designed to operate in periods of extreme groundwater levels.

Guidance

'It is essential that the consideration of sustainable drainage takes place at the land acquisition due diligence stage'

LASOO (2015), Practice Guidance, Local Authority SuDS Officer Organisation.

Ground conditions

A Site specific review of underlying ground conditions is recommended to ensure focused infiltration does not cause ground instability as a result of landslide or collapse associated with dissolution or shallow mining. Hazards that should be considered include soluble rocks, landslides, compressible ground, collapsible ground, shrink-swell clays, running sand and shallow mining.

Soakaways should be a minimum of 5m away from the foundations of a building and local guidance may recommend a greater distance, such as 10m on some areas of Chalk. A detailed ground assessment is recommended: on steep slopes where infiltrating water would produce saturation and instability downslope; or within layered geology, where infiltrating water would produce springs down gradient.

5 Water quality

The Site does not lie within an SPZ. The infiltrated water quality should be of sufficient quality that it does not give rise to pollution of the underlying groundwater. Further consultation with the water company is unlikely to be required.

Infiltration systems should not be used where there is a risk of contaminating groundwater by infiltrating polluted runoff or where receiving groundwater is particularly sensitive.

The influence of surface runoff on water quality will depend on whether there is a source of contamination on Site and the sensitivity of the receiving environment, either groundwater or surface water. The intervening pathway from source to receptor including mitigation and natural attenuation will determine the final impact.

The impact of contaminants on the groundwater will be reduced by travel and natural attenuation through the unsaturated soil zone. A greater depth of unsaturated zone and the presence of significant clay and organic material will provide greater protection for the underlying groundwater. Rapid flow through fractures will provide less protection than intergranular flow around soil and rock particles.

6 National & local policy context

National Guidance

CIRIA SuDS Manual (C753) (2015)

A development should utilise sustainable drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:

1. Use infiltration techniques, such as porous surfaces in non-clay areas,
2. attenuate rainwater in ponds or open water features for gradual release,
3. attenuate rainwater by storing in tanks or sealed water features for gradual release,
4. discharge rainwater direct to a watercourse,
5. discharge rainwater to a surface water sewer / drain,
6. discharge rainwater to the combined sewer.

Defra - Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems (2015)

Peak Flow control

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

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.

Volume control

Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event. The runoff volume must be discharged at a rate that does not adversely affect flood risk.

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.

Ministry of Housing, Communities & Local Government – National Planning Practice Guidance: Flood risk assessments: climate change allowances (2014)

The Peak rainfall intensity allowances section provides advice on the increased rainfall effects on river levels and land and urban drainage systems. The anticipated changes in peak rainfall intensity in small catchments (less than 5 km^2) and urban catchments are shown in Table 4.

For large rural catchments use the alternative allowances defined for rivers.

In order to understand the range of impact, both the central and upper end allowances should be assessed.

Table 4. Peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline)

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper end	10%	20%	40%
Central	5%	10%	20%

The drainage system should be designed to make sure there is no increase in the rate of runoff discharged from the site for the upper end allowance.

Where on-site flooding for the upper end allowance presents a significant flood hazard (for example, depths and velocities of surface water runoff cause a significant danger to people), you will need to take further mitigation measures to protect people and property (for example, raising finished floor levels). As a minimum, there should be no significant flood hazard to people from on-site flooding for the central allowance.

Local Policy

Shropshire Council - Surface Water Management: Interim Guidance for Developers

SuDS should, wherever possible, be constructed outside of Flood Zones 2 and 3 as indicated on the Environment Agency's Flood Maps.

As a minimum, developments on greenfield sites should limit surface water runoff to existing greenfield runoff rates for all events up to and including the 1% (100 year return period) design event with an allowance for climate change (20% allowance for nonresidential developments and 30% allowance for residential developments). In proposing the use of SuDS for greenfield development sites the ultimate aim should be for mimicry of the pre-developed site's drainage characteristics or, where necessary, to provide a betterment (especially where there are flood risk issues experienced downstream of the site). A greenfield site is one that has not previously been developed in any way.

To reduce flood risk downstream, the use of SuDS on brownfield redevelopment sites should reduce the existing rate of surface water runoff by a minimum of 50%. A brownfield site is one that has previously been developed.

7 Storage, volume and peak flow rate

Suggested minimum and aspirational storage requirements for an infiltration or attenuation SuDS scheme for the development footprint are set out below, with more detail provided in subsequent sections. Storage volumes may be reduced (but not below the minimum level) if the design incorporates off-site discharge.

Table 5. Storage requirements at the proposed development Site (Discharge runoff via infiltration)

<table>
<tr><th colspan="2">Attenuation scenario</th><th>Attenuation required (m^3)</th><th colspan="2">Explanation</th></tr>
<tr><td rowspan="3">Discharge runoff via infiltration</td><td>1 in 30 year</td><td>7.4</td><td>Attenuation required to ensure surface water runoff is attenuated in all storm events up to and including the 1 in 30 year event*.
Flooding of the Site of 2.4 m^3 should be contained within permeable landscaped areas within the Site to ensure no flooding of internal areas during the 1 in 100 year storm event.</td><td rowspan="2">A further 4.3 m^3 should be managed within overland flow routes to ensure there is no increase in flood risk in all events up to the 1 in 100 year including 40% allowance for climate change.</td></tr>
<tr><td>1 in 100 year</td><td>9.8</td><td>Attenuation required to ensure surface water runoff is attenuated in all storm events up to and including the 1 in 100 year event*.</td></tr>
<tr><td>1 in 100 year including 40% CC</td><td>14.1</td><td colspan="2">Attenuation required to ensure surface water runoff is attenuated in all storm events up to and including the 1 in 100 year event including a 40% allowance for climate change*.</td></tr>
</table>

*Subject to confirmation through infiltration testing.

Table 6. Storage requirements at the proposed development Site (Discharge runoff to surface watercourse)

<table>
<tr><th colspan="2">Attenuation scenario</th><th>Attenuation required (m^3)</th><th colspan="2">Explanation</th></tr>
<tr><td rowspan="3">Discharge runoff to surface watercourse</td><td>1 in 30 year</td><td>1.7</td><td>Attenuation required to ensure surface water runoff is attenuated in all storm events up to and including the 1 in 30 year (0.25 hour, Critical Storm Duration) event*.

Flooding of the Site of 1.5 m^3 should be contained within permeable landscaped areas within the Site to ensure no flooding of internal areas during the 1 in 100 year storm event.</td><td rowspan="2">A further 3.3 m^3 should be managed within overland flow routes to ensure there is no increase in flood risk in all events up to the 1 in 100 year including 40% allowance for climate change.</td></tr>
<tr><td>1 in 100 year</td><td>3.2</td><td>Attenuation required to ensure surface water runoff is attenuated in all storm events up to and including the 1 in 100 year (0.25 hour, Critical Storm Duration) event*.</td></tr>
<tr><td>1 in 100 year including 40% CC</td><td>5.5</td><td colspan="2">Attenuation required to ensure surface water runoff is attenuated in all storm events up to and including the 1 in 100 year (0.5 hour, Critical Storm Duration) event including a 40% allowance for climate change*.</td></tr>
</table>

*See Appendix B for associated runoff and discharge calculations. Discharge rates all restricted to greenfield rates in their respective events.

Surface water runoff

An increase in impermeable area on site will result in greater rainfall runoff. Reduction in runoff will help mitigate flood risk both on and off site. Further information on the surface water runoff calculations is provided in Section 13 'Background Information'.

Guidance

The Non-Statutory Technical Guidance for SuDS (Defra, March 2015) states:

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

Table 7. Change in impermeable area associated with the development

Total site area	$3775m^2$
Impermeable area (and as a percentage of the total area of the proposed development footprint of 150 m^2)	
Pre-development	Post-development
130 m^2 (87%)	150 m^2 (100%)
Impermeable Land use: car park Permeable Land use: landscaped areas	New impermeable land use: building roof

Guidance

"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' and '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"

(Defra, March 2015, non-statutory guidance).

Only the area intended for building development has been considered for the calculations. The existing commercial building is remaining unchanged and is therefore assumed to drain as existing.

Peak discharge rates

The table below presents peak discharge rates for a range of storm events used to assess the impact of the proposed development and select the maximum permitted discharge rate. Further information on the calculation and control of peak discharge rates is provided in Section 13 'Background Information'.

Table 8. Peak discharge rates associated with the development

Rainfall event	Greenfield runoff rates (l/s)	Existing runoff rates[1] (l/s)	Potential runoff rates without attenuation (l/s)	Potential minus existing (l/s)
QBAR	0.00	N/A	N/A	N/A
6 hour 1 in 1 year	0.00	0.14	0.16	0.02
6 hour 1 in 10 year	0.00	0.24	0.28	0.03
6 hour 1 in 30 year	0.00	0.33	0.38	0.05
6 hour 1 in 100 year	0.01	0.44	0.50	0.06
6 hour 1 in 100 year + 20% CC	N/A	N/A	0.60	0.16
6 hour 1 in 100 year + 40% CC	N/A	N/A	0.70	0.26

[1] Assumes 100% runoff from impermeable surfaces. Assumes Greenfield runoff from permeable surfaces calculated using the IoH124 method.

Relevant local and regional plan policy should be consulted to determine restrictions on runoff from previously developed sites. In some cases, green field rates may be requested. In practice it is difficult to restrict discharge rates at any one control point to less than 2 l/s.

Total discharge volumes

The table below presents discharge volumes for a range of storm events used to assess the impact of the proposed development and calculate the required storage volumes. Further information on the calculation of total discharge volumes is provided in Section 12 'Methodology and Limitations'.

Table 9. Total discharge volumes associated with the development

Rainfall event	Greenfield runoff volume (m^3)	Existing runoff volume[2] (m^3)	Potential runoff volume without attenuation (m^3)	Potential minus existing (m^3)
QBAR	0.38	N/A	N/A	N/A
6 hour 1 in 1 year	0.35	3.09	3.51	0.42
6 hour 1 in 10 year	0.62	5.28	6.00	0.72
6 hour 1 in 30 year	0.82	7.19	8.17	0.98
6 hour 1 in 100 year	1.08	9.54	10.84	1.30
6 hour 1 in 100 year + 20% CC	N/A	N/A	13.01	3.47
6 hour 1 in 100 year + 40% CC	N/A	N/A	15.18	5.64

[2] Assumes 100% runoff from impermeable surfaces. Assumes Greenfield runoff from permeable surfaces calculated using the IoH124 method.

Critical storm duration and volume requirements

Storage volumes for a range of return periods including the 1 in 30 year, 1 in 100 year and 1 in 100 year plus climate change (40%) events have been calculated to assess the impact of the proposed development. The required storage volumes for attenuation features have been calculated for the critical storm durations, limited to a maximum discharge rate of 2 l/s.

Table 10. Critical Storm Duration and Attenuation volume requirements

Return Period	Runoff rate restriction (l/s)	Critical Storm Duration (hr)	Attenuation volume required (m^3)
1 in 30 year	2	0.25	1.7
1 in 100 year	2	0.25	3.2
1 in 100 year plus 40% climate change	2	0.5	5.5

8 Runoff destination

Options for the destination for the runoff generated on-site have been assessed in line with the prioritisation set out in the Building Regulations Part H document (HM Government, 2010) and Defra's Non-statutory Technical Standards for SuDS (2015). Flow attenuation using infiltration SuDS (discharge to ground) is generally the preferred option. If discharge to ground is not available, runoff discharge to surface water is the other preferred method. Only if these two options are impractical should discharge to the sewer network be considered.

Discharge to ground

As discussed in the Site has high to moderate potential for infiltration, with permeable underlying gravel. Based on the available borehole information (subject to confirmation by site investigation) and groundwater flood risk mapping there is the potential for occasional high groundwater levels at the southern end of the site in response to rises in water level in the adjacent Rea Brook (See SuDS Infiltration Suitability Map (SD50)). There are no issues identified relating to site contamination or the presence of a source protection zone. A site investigation comprising trial pits is recommended to confirm the depth to groundwater and allow infiltration tests to be undertaken to confirm the feasibility of an infiltration SuDS scheme.

Discharge to surface watercourse

The Rea Brook is located within 50m of the site. It sits at a lower elevation then any potential SuDS scheme would be and is also in the direction of the natural flow path of runoff from the site. If site investigation proves onsite infiltration is not possible, then offsite discharge with flow attenuation and storage is an alternative option. There is a possible offsite discharge route to the River Rea across approximately 50m of neighbouring land. Access would need to be arranged and the outfall would be subject to river Level and flood conditions. The site is partly located within a Flood Zone 3 with the risk of flooding originating from Rea Brook. Therefore, it is advisable that discharge to the nearest surface watercourse is carefully considered.

Discharge to sewer

Discharge to sewer is not likely to be the optimum sustainable drainage option for the new development area. It is understood that the existing site drainage is to the sewer and this may continue for parts of the site outside the development footprint. If required consultation with the local sewer undertaker should be undertaken. Discharge to sewer would only be accepted if it can be demonstrated that none of the above options are reasonably practical. Discharge would have to be controlled and onsite attenuation would be required. The topographic gradient on the Site falls relatively steeply to the south away from the existing drainage network along the main road. It would be difficult to drain the proposed development under gravity to the nearby sewer network.

9 Water quality

A key requirement of any SuDS system is that it protects the receiving water body from the risk of pollution. This can be effectively managed by an appropriate "train" or sequence of SuDS components that are connected in series. The frequent and short duration rainfall events are those that are most loaded with potential contaminants (silts, fines, heavy metals and various organic and inorganic contaminants). Therefore, the first 5-10 mm of rainfall (first flush) should be adequately treated with SuDS.

The minimum number of treatment stages will depend on the sensitivity of the receiving water body and the potential hazard associated with the proposed development SuDS Manual (CIRIA, 2015). The proposed development is of low (roof water) hazard. The Site does not lie within an SPZ and therefore additional treatment stages are not required.

Table 11. Level of hazard

Hazard	Source of hazard
Very Low	Residential roof drainage
Low	Residential, amenity uses including low usage car parking spaces and roads, other roof drainage.
Medium	Commercial, industrial uses including car parking spaces and roads (excluding low usage roads, trunk roads and motorways).
High	Areas used for handling and storage of chemicals and fuels, handling of storage and waste (incl. scrap-yards).

The recommended minimum number treatment stages suggested for the different runoff waters identified for the proposed development is highlighted in the table below.

Table 12. Minimum number of treatment stages for runoff

		Sensitivity of the receiving water body		
		Low	Medium	High
Hazard	Low	1	1	1
	Med	2	2	2
	High	3	3	3

Permeable paving and a swale would offer sufficient treatment stages (storage/attenuation, filtration through sub-base and filtration through the unsaturated soil zone).

10 Proposed SuDS strategy

Sustainable drainage systems

It is recommended the drainage system has the capacity to accommodate the 1 in 100 year event before flooding occurs. Drainage from areas outside the development footprint will continue to use the existing drainage arrangements.

A surface water drainage strategy (summarised in Section 2 of this report) includes the following SuDS features to intercept, attenuate and treat surface water runoff.

Primary SuDS Strategy:

If infiltration to ground is achievable at the Site, a storage volume of 14.1 m^3 should be provided within SuDS features. This would ensure the attenuation of surface water runoff required to achieve greenfield run off volumes for a 1 in 100 year (6 hour) storm event, including a 40% allowance for climate change. This would be in line with Defra - Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems (March, 2015).

Table 13. Proposed SuDS type, features, discharge location and rate restriction

SuDS type	Source control (interception) and infiltration SuDS.
SuDS features	Rainwater harvesting butts, permeable paving and a swale.
Discharge location	Infiltration to ground.

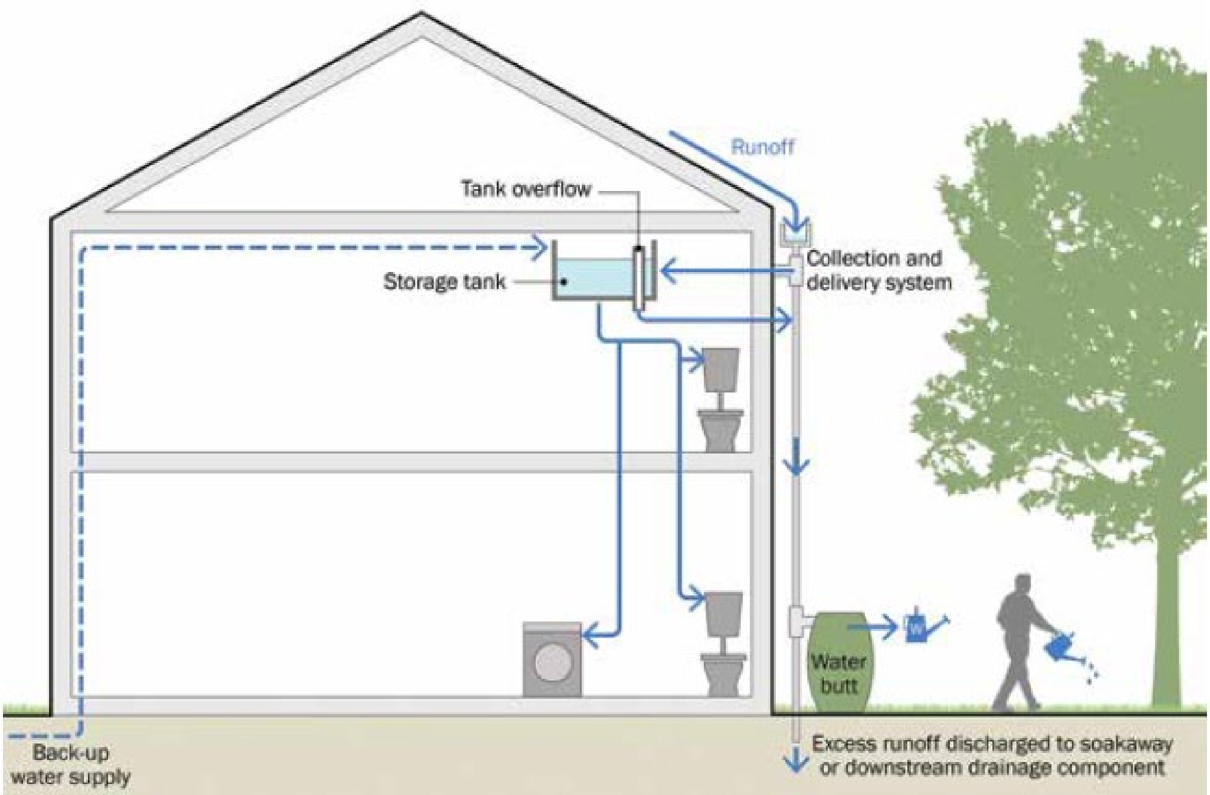
Table 14. Proposed SuDS sizing (dimensions) and attenuation volumes

Rainwater Harvesting	A rainwater harvesting butts should be established for the proposed development. In terms of attenuation storage within this SuDS scheme, volume of run-off which could be attenuated by Rainwater Harvesting has not been considered within the Preliminary SuDS schematic.
Permeable paving	A 100 m^2 area of permeable paving (underlain with a Type 3 aggregate material) within the proposed driveway areas to a depth of 0.25 m, with a 30% porosity would result in c. 7.5 m^3 attenuation.
Swale	A shallow swale with a length of 30m, width of 1.75m and depth of 0.25m along the eastern boundaries of the Site would result in c. 7.5 m^3 attenuation.

Total Attenuation Provided	15 m³
Total Attenuation Required	14.1 m³
Freeboard Storage Provided	0.9 m³

A rainwater harvesting butt should be established for the proposed development. The run-off from the proposed development roof should be led into rainwater harvesting butts via rainwater downpipes and guttering to catch run-off from the extension roof. Overflow from the butts should be discharged into the storage system provided by the permeable paving.

Due to the relatively insignificant amounts of attenuation provided by rainwater harvesting tanks in this instance and the requirement to retain water for non-potable uses such garden maintenance, the volume of run-off which could be attenuated by rainwater harvesting has not been considered within the report.

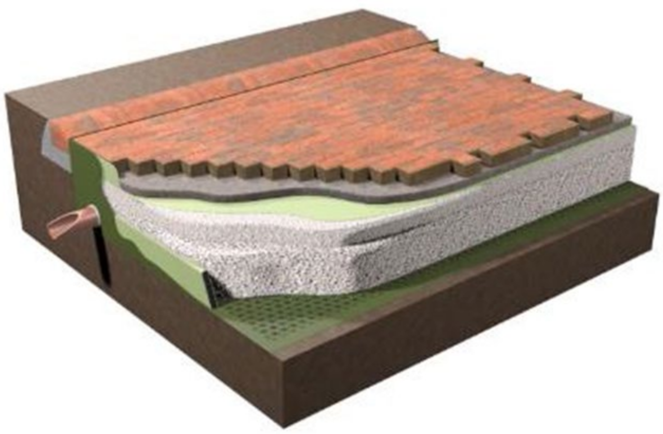


As there is an issue with the storage capability of Rainwater Harvesting tanks, this method should have a fixed attenuation volume and a controlled outlet to discharge into the proposed infiltration feature. An overflow system will be required for implementation on the Site due to exceedance events (where the pumps fail or there is a blockage within the system / or the number of residents and subsequent water usage is reduced).

Roof run-off is generally less polluted than run-off from road surfaces but can still generate pollutants such as sediments. Pollutants would be captured by the collection and filtration system and, by reducing the volume of run-off generated from the Site. Primary screening devices are used to prevent leaves and other debris from entering the butt and first flush devises can be designed to divert the first part of the rainfall away from the main storage tank and can pick up most of the dirt, debris and contaminates that collect on a residential roof.

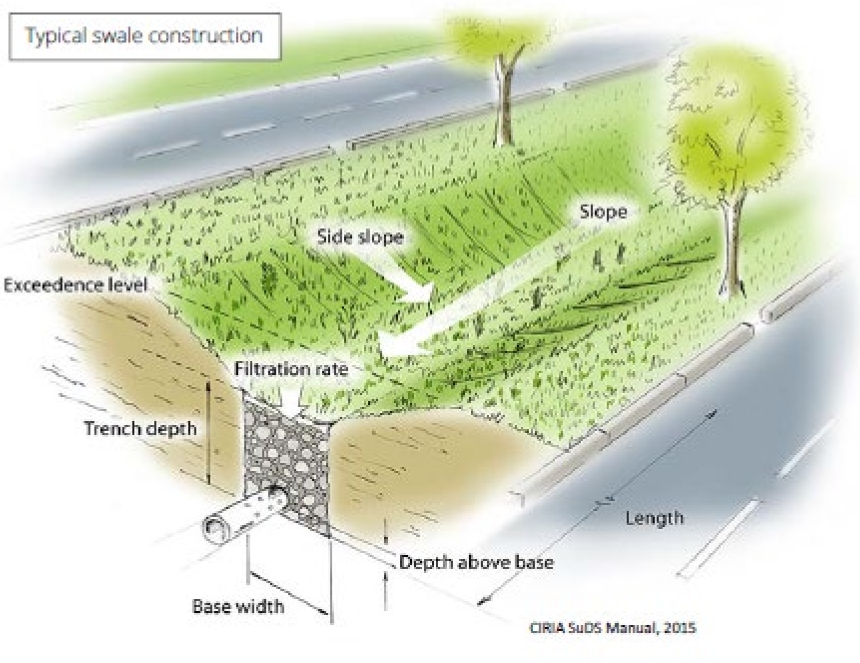
Permeable Paving is proposed for an area of the car park to intercept runoff. Suitable aggregate materials (angular gravels with suitable grading as per CIRIA, 2015) will improve water quality due to their filtration capacity and usually work to a 30% porosity. A geotextile layer will be required for paving underlain by aggregate material to intercept silt/particles. Permeable pavements are multi-layered surfacing systems. The surface layer is constructed out of permeable material allowing infiltration of water through gaps along its surface. A geomembrane isolates stored water from the surrounding soil, especially in contaminated areas and a geotextile layer prevents clogging and damage to the geo-cellular modules.

The geotextile layer works to intercept silt/particles flowing through the system via direct rainfall, or through vehicle use deposited onto the car park area and into the permeable paving. The majority of silt would be trapped within the top 30mm of the joining material between the paving blocks. Rainfall flowing into the permeable paving directly from the development roof/rainwater butts would not contain enough volumes of silt and or particles to cause blockage so will be fed directly into underlying porous substrate via rainwater pipes. Downpipes from the development roofs/rainwater butts should extend through the paving for c.5 meters to divert roof run-off away from building foundations. Paving could also implement an impermeable liner close to the building or creating a separate compartment within the permeable sub-base close to the building to further divert attenuated water away from building foundations.



Plastic geo-cellular systems could also be used, which can increase the void space and therefore storage but do not allow filtration unless they are combined with aggregate material and/or permeable geotextiles which could increase their storage potential by up to 20%. Geo-cellular modules also have the added advantage of reducing the amount of aggregate sub base required, thus keeping costs lower. Void systems, such as permavoids, have a void ratio of 95% (i.e. for every 1 m^3 there is 0.95 m^3 of space available for water storage), which has been factored into the storage capacity calculations.

Swales are flat bottomed, shallow open channels used to attenuate surface water which work to decrease flow velocity by ponding run-off temporarily. Grass swales have a bottom width of 0.5-0.2m and should allow for shallow flows and water quality treatment. Longitudinal slopes should be between 0.5-6% with a maximum side slope of 1 in 3 (33%) with a depth of 400mm-600mm. The treatment process within SuDS features is linked to velocity and retention time of run-off. Swales can offer primary and secondary treatment stages and can work to reduce sediment loads which enter the off-Site discharge route. As swales retain their vegetative state, the feature is able to remove coarse sediments through groundcover while the underlying soil can help to remove finer particles. The risk of swale erosion can be reduced with the implementation of inlets and flow spreaders (CIRIA, 2015).



Discharge Route:

Infiltration to ground.

Exceedance Flow Route:

Where possible, exceedance flows should be directed away from buildings and into non-essential areas of the Site such as the car park. The SuDS system recommended for the Site should provide enough storage that this method would only be utilized during a worst case scenario.

Secondary SuDS strategy:

If infiltration to ground is not achievable at the site, an attenuation volume of 5.5 m^3 should be stored within lined SuDS features to accommodate the calculated 0.5 hour Critical Storm Duration for surface water discharge runoff, restricted to 2 l/s (DEFRA, 2015).

Table 15. Proposed SuDS type, features, discharge location and rate restriction

SuDS type	Source control (interception) and attenuation SuDS.
SuDS features	Rainwater harvesting butt and swale.
Discharge location	Rea Brook.
Discharge rate	2 l/s.

Table 16. Proposed SuDS sizing (dimensions) and attenuation volumes

Rainwater Harvesting	A rainwater harvesting butt should be established for the proposed development. In terms of attenuation storage within this SuDS scheme, volume of run-off which could be attenuated by Rainwater Harvesting has not been considered within the Preliminary SuDS schematic.
Swale	A shallow swale with a length of 30m, width of 1.75m and depth of 0.25m along the eastern boundaries of the Site would result in c. 7.5 m^3 attenuation.
Total Attenuation Provided	7.5 m^3
Total Attenuation Required	5.5 m^3
Freeboard Storage Provided	2 m^3

Hydrobrake Flow control systems are required to reduce the runoff from the Site. These are usually a device used for controlling water flow into a connecting feature, such as a sewer, to a specific attenuation performance. The design consists of an intake, a volute and an outlet and the configuration is critical to ensure discharge control. For drainage areas which are less than 3 ha, outlet throttle diameters would have to be small (<150mm diameter) to achieve outflow rates which could result in blockage. For most SuDS features, a flow control device will comprise a fixed orifice or a throttle such as a short pipe.

A **Vortex Control** is usually a self-activating vortex flow device which directs water into a volute to form a vortex. For the Site, rainwater down pipes from the development roof should drain directly into the attenuation feature to reduce infill from potential flood water.

A **non-return flap value** is also recommended for the outflow pipes to reduce the risk of backflow from the channel/sewer during a large scale rainfall event.

Discharge Route:

Discharge of surface water runoff at 2 l/s via a hydro-brake or similar should be considered into the Rea Brook located south of the Site.

Exceedance Flow Route:

Where possible, exceedance flows should be directed away from buildings and into non-essential areas of the Site such as the car park. The SuDS system recommended for the Site should provide enough storage that this method would only be utilized during a worst case scenario.

11 SuDS maintenance

Regular maintenance is essential to ensure effective operation of the SuDS features over the intended lifespan of the proposed development. The SuDS Manual (C753) (CIRIA, 2015) provides a maintenance schedule for SuDs with details of the necessary required actions as shown in the Table below.

Table 17. SuDS operation and recommended maintenance requirements

Asset type	Maintenance schedule (and frequency)
Rainwater Harvesting	Regular maintenance: • Inspection of tank for debris and sediment build up (annually and following poor performance). • Inspection of inlets, outlets, overflow areas, pumps and filters (annually and following poor performance). • Cleaning of tank, inlets, outlets, gutters, roof drain filters and withdrawal devices (annually or as required). Remedial actions: • Repair or overflow erosion damage or damage to tank and associated components (as required)
Permeable pavements	Regular maintenance: • Brushing and vacuuming (three times per year). • Trimming any roots and surrounding grass and weeds that may be causing blockages (annually or as required). Monitoring: • Initial inspection (monthly). Inspect for poor performance and inspection chambers (annually).
Swales	Regular maintenance: • Remove litter and debris from basin (annually). • Trimming any roots and surrounding grass that may be causing blockages (annually or as required). Monitoring: • Inspect inlets, outlets and overflows for blockages (monthly).Remove and replace mulching (annually). Inspect and trim nearby trees
Hydro-Brake Flow Control	Low amounts of maintenance required as there are no moving parts within the Hydro-Brake® Flow Control. • Initial monthly inspection at the manhole once the construction phase is over.

Asset type	Maintenance schedule (and frequency)
	If blockages occur they normally do so at the intake. Hydro-Brake® Flow Controls are fitted with a pivoting by-pass door, which allows the manhole chamber to be drained down should blockages occur. Inspection should be undertaken annually or when a storm event occurs.

Client checklist

A drainage strategy has been recommended as suitable on the basis of the information provided. Prior to installation of the site drainage system it is recommended that the client carries out the following checks to confirm the development proposals. Geosmart would be able to support with any updates required to the drainage scheme, please contact us and we would be happy to provide you with a proposal to undertake the work.

Table 18. Potential SuDS limitations

Conditions in Non-Statutory Technical Standards (Defra, 2015), limitations to infiltration SuDS	Do these conditions arise at the site?
Is the surface runoff greater than the rate at which water can infiltrate into the ground?	
Is there an unacceptable risk of ground instability?	
Is there an unacceptable risk of mobilising contaminants?	
Is there an unacceptable risk of pollution to groundwater?	
Is there an unacceptable risk of groundwater flooding?	
Is the infiltration system going to create a high risk of groundwater leakage to the combined sewer?	

Table 19. SuDS design considerations

Confirm that potential flooding on site in excess of the design storm event and exceedance flow routes have been considered.	
Review options for the control of discharge rates (e.g. hydrobrake).	
Confirm the owners/adopters of the drainage system. Consider management options for multiple owners.	

Is there an unacceptable risk of pollution to groundwater?	
Review access and way leave requirements.	
Review maintenance requirements.	

Health and safety considerations for SuDS

GeoSmart Pro reports may include outline strategies or designs to support with development plans. Any drawings or advice provided do not comprise any form of detailed design. Implementation of any conceptual scheme options may constitute 'Construction Work' as defined by CDM Regulations (2015).

The CDM Regulations place specific Health and Safety duties on those commissioning, planning and undertaking construction works. If you are uncertain what this means you should seek the advice of your architect, builder or other competent professional.

GeoSmart does not provide health and safety advisory services but we are required to advise you of your general responsibilities under CDM (visit http://geosmartinfo.co.uk/knowledge-hub/cdm-2015/ for more information).

Please remember that detailed design work should be undertaken by a competent professional who might be your engineer, architect, builder or another competent party.

12 Methodology and limitations of study

This report assesses the feasibility of infiltration SuDS and alternative drainage strategies in support of the Site development process. From April 6th 2015 SuDS are regulated by Local Planning Authorities and will be required under law for major developments in all cases unless demonstrated to be inappropriate. What is considered appropriate in terms of costs and benefits by the Planning Authority will vary depending on local planning policy, and Site setting. The Lead Local Flood Authority will require information as a statutory consultee on major planning applications with surface water drainage implications. The National Planning Policy Framework requires that new developments in areas at risk of flooding should give priority to the use of SuDS and demonstrate that the proposed development does not increase flood risk downstream to third parties.

How was the suitability of SuDS estimated for the Site?

There are a range of SuDS options available to provide effective surface water management that intercept and store excess runoff. When considering these options, the destination of the runoff should be assessed using the order of preference outlined in the Building Regulations Part H document (HM Government, 2010) and Defra's National Standards for SuDS (2015):

1. Discharge to the ground;
2. Discharge to a surface water body;
3. Discharge to a surface water sewer;
4. Discharge to a local highway drain; and
5. Discharge to a combined sewer.

Data sets relating to each of the potential discharge options have been analysed to assess the feasibility of each option according to the hierarchy set out above. Hydrogeological characteristics for the Site are assessed in conjunction with the occurrence of SPZ's to assess infiltration suitability. The Site has been screened to determine whether flood risk from groundwater, surface water, fluvial or coastal sources may constrain SuDs. The distance to surface water bodies and sewers has been reviewed gauge whether these provide alternative options.

GeoSmart SuDS Infiltration Suitability Map (SD50)

The GeoSmart SuDS Infiltration Suitability Map (SD50) screens the suitability for infiltration drainage in different parts of the Site and indicates where further assessment is recommended. In producing the SuDS Infiltration Suitability Map (SD50), GeoSmart used data from the British Geological Survey on groundwater levels, geology and permeability to screen for areas where infiltration SuDS may be suitable. The map classifies areas into 3 categories of High, Medium and Low suitability for infiltration SuDS. This can then be used in conjunction with additional data on Site constraints to give recommendations for SuDS design and further investigation.

The primary constraint on infiltration potential is the minimum permeability of the underlying material and in some cases the range in permeability may be considerable, ranging down to low. The map classifies these areas as moderate infiltration suitability requiring further investigation. In cases where the thickness of the receiving permeable horizon is less than 1.5 meters then additional Site investigation is recommended. If the Site is at risk of groundwater flooding for up to the 1% annual occurrence the map classifies these areas as moderate infiltration suitability requiring further investigation.

The GeoSmart SuDS Infiltration Suitability Map (SD50) is a national screening tool for infiltration SuDS techniques but a Site specific assessment should be used before final detailed design is undertaken. Further information on the GeoSmart SuDS Infiltration Suitability Map (SD50) is available at geosmartinfo.co.uk

How is the suitability to discharge to sewers and watercourses calculated?

The suitability to discharge to discharge to sewers and watercourses has been calculated using the distance from the Site to both. For example, where the Site is within 50m of a surface water body. Discharge to surface water is potentially appropriate subject to land access arrangements and a feasibility assessment. Where the Site is within 50m of a sewer, discharge to sewer is potentially appropriate subject to land access arrangements and a feasibility assessment. The utility company should be contacted to agree connection feasibility and sewer capacity.

Further information relating to sewers available in the area can be found in Appendix A.

What is a Source Protection Zone?

The Environment Agency have defined Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. These zones show the risk of contamination from any activities that might cause pollution in the area. The closer the activity, the greater the risk. The maps show three main zones (inner, outer and total catchment) and a fourth zone of special interest, which is occasionally applied. The zones are used to set up pollution prevention measures in areas which are at a higher risk. The shape and size of a zone depends on the condition of the ground, how the groundwater is removed, and other environmental factors. Inner zone (Zone 1) is defined as the 50 day travel time from any point below the water table to the source (minimum radius of 50 metres). Outer zone (Zone 2) is defined by a 400 day travel time. Total catchment (Zone 3) is defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source.

How was surface water runoff estimated from the site?

In accordance with The SuDS Manual (C753) (CIRIA, 2015), the Greenfield runoff from the Site has been calculated using the IoH124 method and is assumed representative of the runoff generated on the undeveloped surfaces that are affected by the proposed development. The method used for calculating the runoff complies with the NPPF (DGLC, 2014). For the impermeable surfaces, it has been assumed that 100% runoff will occur (calculations provided in Appendix A). Rainfall data is derived from the Flood Estimation Handbook (FEH) CD-ROM, developed by NERC (2009). Only areas affected by the proposed development are considered in the flow and volume calculations. Permeable areas that remain unchanged are not included in the calculations as it is assumed these will not be actively drained and attenuated.

What is the peak discharge rate?

An estimation of peak runoff flow rate and volume is required to calculate infiltration, storage and discharge requirements. The peak discharge rate is the maximum flow rate at which surface water runoff leaves the site during a particular storm event, without considering the impact of any mitigation such as storage, infiltration or flow control. Proposed discharge rates (with mitigation) should be no greater than existing rates for all corresponding storm events. If all drainage is to infiltration there will be no discharge off site. Discharging all flow from site at the existing 1 in 100 event would increase flood risk during smaller events. Flow restriction is generally required to limit the final discharge from site during all events as a basic minimum to the green field QBAR rate. A more complex flow restriction which varies the final discharge rate from the site depending on the storm event will reduce the volume of storage required on site. Drainage to infiltration SuDS is subtracted from the total discharge off site to achieve a beneficial net affect.

What is the total discharge volume?

The total discharge volume is calculated on the basis of the surface water runoff that has the potential to leave the site as a result of the assumed 6 hour duration design storm event. The runoff is related to the underlying soil conditions, impermeable cover, rainfall intensity and duration of the storm event. The total volume generated by the current site is compared to the potential total volume from the developed site (not taking into consideration any mitigation). The difference provides the minimum total volume that will need to be stored and infiltrated on site or released at a controlled rate. Guidance indicates that the total discharge volume should never exceed the runoff volume from the development site prior to redevelopment for that event and should be as close as is reasonably practicable to the Greenfield runoff volume.

13 Background SuDS information

SuDS control surface water runoff close to where it falls. SuDS are designed to replicate, as closely as possible, the natural drainage from the Site before development to ensure that the flood risk downstream does not increase as a result of the Site being developed, and that the Site will have satisfactory drainage under current and likely future climatic conditions. SuDS provide opportunities to reduce the causes and impacts of flooding; remove pollutants from urban runoff at source; and combine water management with green space with benefits for amenity, recreation and wildlife. Government planning policy and planning decisions now include a presumption in favour of SuDS being used for all development Sites, unless they can be shown to be inappropriate.

For general information on SuDS see our web site: http://geosmartinfo.co.uk/

Infiltration SuDS

Government policy for England is to introduce sustainable drainage systems (SuDS) via conditions in planning approvals. Guidance indicates that capturing rainfall runoff on site and infiltrating it into the ground (infiltration SuDS) is the preferred method for managing surface water without increasing flood risk downstream.

The greatest benefit to general flood risk is if all runoff is infiltrated on site, however, this may not be feasible due to physical and economic constraints in which case infiltration may be considered as a part of an integrated drainage solution. The final design capacity for an infiltration SuDS system depends on the site constraints and the requirements of the individual Planning Authority and the Lead Local Flood Authority.

The capacity of the ground to receive infiltration depends on the nature, thickness and permeability of the underlying material and the depth to the high groundwater table. The final proportion of the site drained by infiltration will depend on topography, outfall levels and a suitable drainage gradient. It is important to note that, even if the whole site cannot be drained by infiltration, the use of partial infiltration is encouraged, with the remainder of runoff discharged via other SuDS systems.

Types of infiltration SuDS

Infiltration components include infiltration trenches, soakaways, swales and infiltration basins without outlets, rain gardens and permeable pavements. These are used to capture surface water runoff and allow it to infiltrate (soak) and filter through to the subsoil layer, before returning it to the water table below.

An infiltration trench is usually filled with permeable granular material and is designed to promote infiltration of surface water to the ground. An infiltration basin is a dry basin or depression designed to promote infiltration of surface water runoff into the ground. Soakaways are the most common type of infiltration device in the UK where drainage is often connected to over-sized square or rectangular, rubble-filled voids sited beneath lawns.

According to the guidance in Building Research Establishment (BRE) Digest 365 (2007) a soakaway must be able to discharge 50% of the runoff generated during a 1 in 10 year storm event within 24 hours in readiness for subsequent storm flow. This is the basic threshold criteria for a soakaway design and the internal surface area of the proposed soakaway design options should be calculated on this basis by taking into account the soil infiltration rate for the Site.

Developers need to ensure their design takes account of the construction, operation and maintenance requirements of both surface and subsurface components, allowing for any machinery access required.

SuDS maintenance and adoption

Regular maintenance is essential to ensure effective operation of the soakaway(s) over the intended lifespan of the proposed development. A maintenance schedule for SuDs is required. Sewerage undertakers or Local Authorities may adopt SuDS and will require maintenance issues to be dealt with in accordance with their Management Plan. If the SuDS will not be adopted other provision is required with associated financial implications. Maintenance is a long-term obligation requiring the upkeep of all elements of the SuDS, including mechanical components (e.g. pumps), as well as inspections, regular maintenance and repair.

Additional background SuDS information can be found on our website: http://geosmartinfo.co.uk/

14 Further information

The following table includes a list of additional products by GeoSmart:

Additional GeoSmart Products			
✓	Additional assessment: FloodSmart Report		The FloodSmart Report range provides clear and pragmatic advice regarding the nature and potential significance of flood hazards which may be present at a site. Our consultants assess available data to determine the level of risk based on professional judgement and years of experience. Please contact info@geosmartinfo.co.uk for further information.
✓	Additional assessment: EnviroSmart Report		Provides a robust desk-based assessment of potential contaminated land issues, taking into account the regulatory perspective. Our EnviroSmart reports are designed to be the most cost effective solution for planning conditions. Each report is individually prepared by a highly experienced consultant conversant with Local Authority requirements. Ideal for pre-planning or for addressing planning conditions for small developments. Can also be used for land transactions. Please contact info@geosmartinfo.co.uk for further information.

15 References and glossary

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Glossary

General terms

Attenuation	Reduction of peak flow and increased duration of a flow event.
Combined sewer	A sewer designed to carry foul sewage and surface water in the same pipe.
Detention basin	A vegetated depression, normally is dry except after storm events, constructed to store water temporarily to attenuate flows. May allow infiltration of water to the ground.
Evapotranspiration	The process by which the Earth's surface or soil loses moisture by evaporation of water and by uptake and then transpiration from plants.
FEH	Flood Estimation Handbook, produced by Centre for Ecology and Hydrology, Wallingford (formerly the Institute of Hydrology).
Filter drain or trench	A linear drain consisting of a trench filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage, to store and conduct water, but may also be designed to permit infiltration.
First flush	The initial runoff from a site or catchment following the start of a rainfall event. As runoff travels over a catchment it will collect or dissolve pollutants, and the "first flush" portion of the flow may be the most contaminated as a result. This is especially the case for intense storms and in small or more uniform catchments. In larger or more complex catchments pollution.
Flood plain	Land adjacent to a watercourse that would be subject to repeated flooding under natural conditions (see Environment Agency's Policy and practice for the protection of flood plains for a fuller definition).
Greenfield runoff	This is the surface water runoff regime from a site before development, or the existing site conditions for brownfield redevelopment sites.
Impermeable surface	An artificial non-porous surface that generates a surface water runoff after rainfall.
Permeability	A measure of the ease with which a fluid can flow through a porous medium. It depends on the physical properties of the medium, for example grain size, porosity and pore shape.

Runoff	Water flow over the ground surface to the drainage system. This occurs if the ground is impermeable, is saturated or if rainfall is particularly intense.
Sewerage undertaker	This is a collective term relating to the statutory undertaking of water companies that are responsible for sewerage and sewage disposal including surface water from roofs and yards of premises.
Soakaway	A subsurface structure into which surface water is conveyed to allow infiltration into the ground.
Treatment	Improving the quality of water by physical, chemical and/or biological means.

The terms included in this glossary have been taken from CIRIA (2015) guidance.

Data Sources

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16 Appendices

Appendix A

Site plans

Appendix B

Rainfall runoff calculations

Developed site run-off calculation sheet

1 in 1 year

Proposed impermeable area	0.015	ha
CC Factor	40%	
Total volume for surfaces during 6 hour event	3.51	m^3
Total volume for 6 hour event inc CC	4.91	m^3
Total volume for 6 hour event exc CC	3.51	m^3

Duration	**Rainfall 1 yr event**	**Run-off rate 1 yr event**	**Run-off rate 1 yr +cc event**
hours	**mm**	**m^3**	**m^3**
0.25	7.00	1.05	1.47
0.5	8.93	1.34	1.88
0.75	10.23	1.53	2.15
1	11.10	1.67	2.33
2	15.55	2.33	3.27
3	18.37	2.76	3.86
4	20.43	3.06	4.29
5	22.06	3.31	4.63
6	23.40	3.51	4.91
8	25.50	3.83	5.36
10	27.11	4.07	5.69
12	28.43	4.26	5.97
16	30.50	4.58	6.41
20	32.16	4.82	6.75
24	33.57	5.04	7.05
28	34.77	5.22	7.30
32	35.87	5.38	7.53
36	36.88	5.53	7.74
40	37.84	5.68	7.95
44	38.74	5.81	8.14
48	39.61	5.94	8.32

1 in 30 year

Proposed impermeable area	0.015	ha
CC Factor	40%	
Total volume for surfaces during 6 hour event	8.17	m^3
Total volume for 6 hour event inc CC	11.44	m^3
Total volume for 6 hour event exc CC	8.17	m^3

Duration	**Rainfall 30 yr event**	**Run-off volume 30 yr event**	**Run-off volume 30 yr +cc event**	Outflow at 2 l/s	inflow from rain	Diff (storage required)
hours	**mm**	**m^3**	**m^3**			
0.25	23.31	3.50	4.90	1.80	3.50	1.70
0.5	30.42	4.56	6.39	3.60	4.56	0.96
0.75	34.78	5.22	7.30	5.40	5.22	-0.18
1	37.87	5.68	7.95	7.20	5.68	-1.52
2	44.78	6.72	9.40	14.40	6.72	-7.68
3	48.58	7.29	10.20	21.60	7.29	-14.31
4	51.13	7.67	10.74	28.80	7.67	-21.13
5	53.00	7.95	11.13	36.00	7.95	-28.05
6	54.47	8.17	11.44	43.20	8.17	-35.03
8	56.74	8.51	11.92	57.60	8.51	-49.09
10	58.47	8.77	12.28	72.00	8.77	-63.23
12	59.89	8.98	12.58	86.40	8.98	-77.42
16	62.17	9.33	13.06	115.20	9.33	-105.87
20	64.01	9.60	13.44	144.00	9.60	-134.40
24	65.62	9.84	13.78	172.80	9.84	-162.96
28	67.09	10.06	14.09	201.60	10.06	-191.54
32	68.49	10.27	14.38	230.40	10.27	-220.13
36	69.82	10.47	14.66	259.20	10.47	-248.73
40	71.11	10.67	14.93	288.00	10.67	-277.33
44	72.36	10.85	15.20	316.80	10.85	-305.95
48	73.58	11.04	15.45	345.60	11.04	-334.56

1 in 100 year

Proposed impermeable area	0.015	ha
CC Factor	40%	
Total volume for surfaces during 6 hour event	10.84	m^3
Total volume for 6 hour event inc CC	15.18	m^3
Total volume for 6 hour event exc CC	10.84	m^3

Duration	**Rainfall 100 yr event**	**Run-off volume 100 yr event**	**Run-off volume 100 yr +cc event**	Outflow at 2 l/s	inflow from rain	100yr Scenario: Diff (storage required)	CC Scenario: Diff (storage required)
hours	**mm**	**m^3**	**m^3**				
0.25	32.97	4.95	6.92	1.80	6.92	3.15	5.12
0.5	43.34	6.50	9.10	3.60	9.10	2.90	5.50
0.75	49.64	7.45	10.42	5.40	10.42	2.05	5.02
1	54.41	8.16	11.43	7.20	11.43	0.96	4.23
2	62.38	9.36	13.10	14.40	13.10	-5.04	-1.30
3	66.46	9.97	13.96	21.60	13.96	-11.63	-7.64
4	69.05	10.36	14.50	28.80	14.50	-18.44	-14.30
5	70.88	10.63	14.88	36.00	14.88	-25.37	-21.12
6	72.27	10.84	15.18	43.20	15.18	-32.36	-28.02
8	74.22	11.13	15.59	57.60	15.59	-46.47	-42.01
10	75.66	11.35	15.89	72.00	15.89	-60.65	-56.11
12	76.81	11.52	16.13	86.40	16.13	-74.88	-70.27
16	78.67	11.80	16.52	115.20	16.52	-103.40	-98.68
20	80.18	12.03	16.84	144.00	16.84	-131.97	-127.16
24	81.51	12.23	17.12	172.80	17.12	-160.57	-155.68
28	82.81	12.42	17.39	201.60	17.39	-189.18	-184.21
32	84.07	12.61	17.65	230.40	17.65	-217.79	-212.75
36	85.31	12.80	17.92	259.20	17.92	-246.40	-241.28
40	86.53	12.98	18.17	288.00	18.17	-275.02	-269.83
44	87.74	13.16	18.43	316.80	18.43	-303.64	-298.37
48	88.94	13.34	18.68	345.60	18.68	-332.26	-326.92

Greenfield Site Run-Off Calculations usng the IoH124 method

Greenfield peak run-off rate (QBAR):

Parameters	Input	Units	Comments
Area	50	ha	mimimum 50ha
SAAR	637	mm	FEH CD ROM (NERC, 2009)
SPR	0.10	N/A	Soil run-off coefficient
Region	4	N/A	Region on Hydrological area map

QBAR

$$Q_{BAR(rural)} = 1.08AREA^{0.89}SAAR^{1.17}SPR^{2.17}$$

Where:

$Q_{BAR(rural)}$ is the mean annual flood (a return period of 2.3 years) in l/s
AREA is the area of the catchment in km² (minimum of 0.5km²)
SAAR is the standard average rainfall for the period 1941 to 1970 in mm
SPR is the soil run-off coefficient

$Q_{BAR(rural)}$ can be factored by the UK Flood Studies Report regional growth curves to produce peak flood flows for any return period.

$Q_{BAR(rural)}$	=	7.52	l/s for 50ha site
Divided by 50 to scale down	=	0.15	l/s/ha
Actual Area of the entire Site	=	0.02	ha

Return Periods (Growth curves obtained from DEFRA report)

Return Period		Growth Factor	l/s/ha	Peak site run-off rate (l/s)
1	**$Q_{BAR(rural)}$ x**	**0.85**	**0.13**	**0.002**
2	$Q_{BAR(rural)}$ x	0.89	0.13	0.00
5	$Q_{BAR(rural)}$ x	1.23	0.19	0.00
10	$Q_{BAR(rural)}$ x	1.49	0.22	0.00
25	$Q_{BAR(rural)}$ x	1.87	0.28	0.00
30	**$Q_{BAR(rural)}$ x**	**1.92**	**0.29**	**0.004**
50	$Q_{BAR(rural)}$ x	2.2	0.33	0.00
100	**$Q_{BAR(rural)}$ x**	**2.57**	**0.39**	**0.01**
200	$Q_{BAR(rural)}$ x	2.98	0.45	0.01

Greenfield total run-off volume:

= actual area of the entire site x SPR x 6 hour rainfall depth

Return Period	6 hour rainfall (mm) from FEH CD-ROM	Area (ha)	SPR	Total run-off (m^3)
2.3 (QBAR)	25.04	0.02	0.10	0.4
1	23.4	0.02	0.10	0.4
10	41.11	0.02	0.10	0.6
30	54.47	0.02	0.10	0.8
100	72.27	0.02	0.10	1.1

Summary

Entire site area:	0.015	ha	
Climate Change Factor	40%		
	Current	*Proposed*	
Permeable Surface (ha)	0.002	0.000	
Impermeable Surface (ha)	0.013	0.015	

1 in 1 year

Greenfield run-off volume total: 0.35 m^3

RUN-OFF During a 1 in 1 year 6 hour event:	Greenfield Site	Current Development	Proposed Development	Proposed Development +CC
From permeable surfaces (using GF total run-off) (m^3)	0.35	0.05	0.00	0.00
From impermeable surfaces (m^3)		3.04	3.51	4.91
TOTAL run-off produced from Site (m^3)	0.35	3.09	3.51	4.91

Difference between greenfield site and proposed +cc development (m^3):	**4.56**
	1300%
Difference between current and proposed +cc development (m^3):	**1.83**
	59%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**0.00**

1 in 10 year

Greenfield run-off volume total: 0.62 m^3

RUN-OFF During a 1 in 1 year 6 hour event:	Greenfield Site	Current Development	Proposed Development	Proposed Development +CC
From permeable surfaces (using GF total run-off) (m^3)	0.62	0.08	0.00	0.00
From impermeable surfaces (m^3)		5.20	6.00	8.40
TOTAL run-off produced from Site (m^3)	0.62	5.28	6.00	8.40

Difference between greenfield site and proposed +cc development (m^3):	**7.78**
	1262%
Difference between current and proposed +cc development (m^3):	**3.12**
	59%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**0.00**

1 in 30 year

Greenfield run-off volume total: 0.82 m^3

RUN-OFF During a 1 in 30 year 6 hour event:	Greenfield Site	Current Development	Proposed Development	Proposed Development +CC
From permeable surfaces (using GF total run-off) (m^3)	0.82	0.11	0.00	0.00
From impermeable surfaces (m^3)		7.08	8.17	11.44
TOTAL run-off produced from Site (m^3)	0.82	7.19	8.17	11.44

Difference between greenfield site and proposed +cc development (m^3):	**10.62**
	1300%
Difference between current and proposed +cc development (m^3):	**4.25**
	59%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**0.00**

1 in 100 year

Greenfield run-off volume total: 1.08 m^3

RUN-OFF During a 1 in 100 year 6 hour event:	Greenfield Site	Current Development	Proposed Development	Proposed Development +CC
From permeable surfaces (using GF total run-off) (m^3)	1.08	0.14	0.00	0.00
From impermeable surfaces (m^3)		9.40	10.84	15.18
TOTAL run-off produced from Site (m^3)	1.08	9.54	10.84	15.18

Difference between greenfield site and proposed +cc development (m^3):	**14.09**
	1300%
Difference between current and proposed +cc development (m^3):	**5.64**
	59%
Peak Greenfield run-off rate that must not be exceeded in the run-off from the proposed development (l/s):	**0.01**

Appendix C

Regulated Drainage and Water Search

SAMPLE DRAINAGE
SEARCH

Email:
SAMPLE DRAINAGE SEARCH

01483 000 SAMPLE

Regulated Drainage & Water Search

Property:

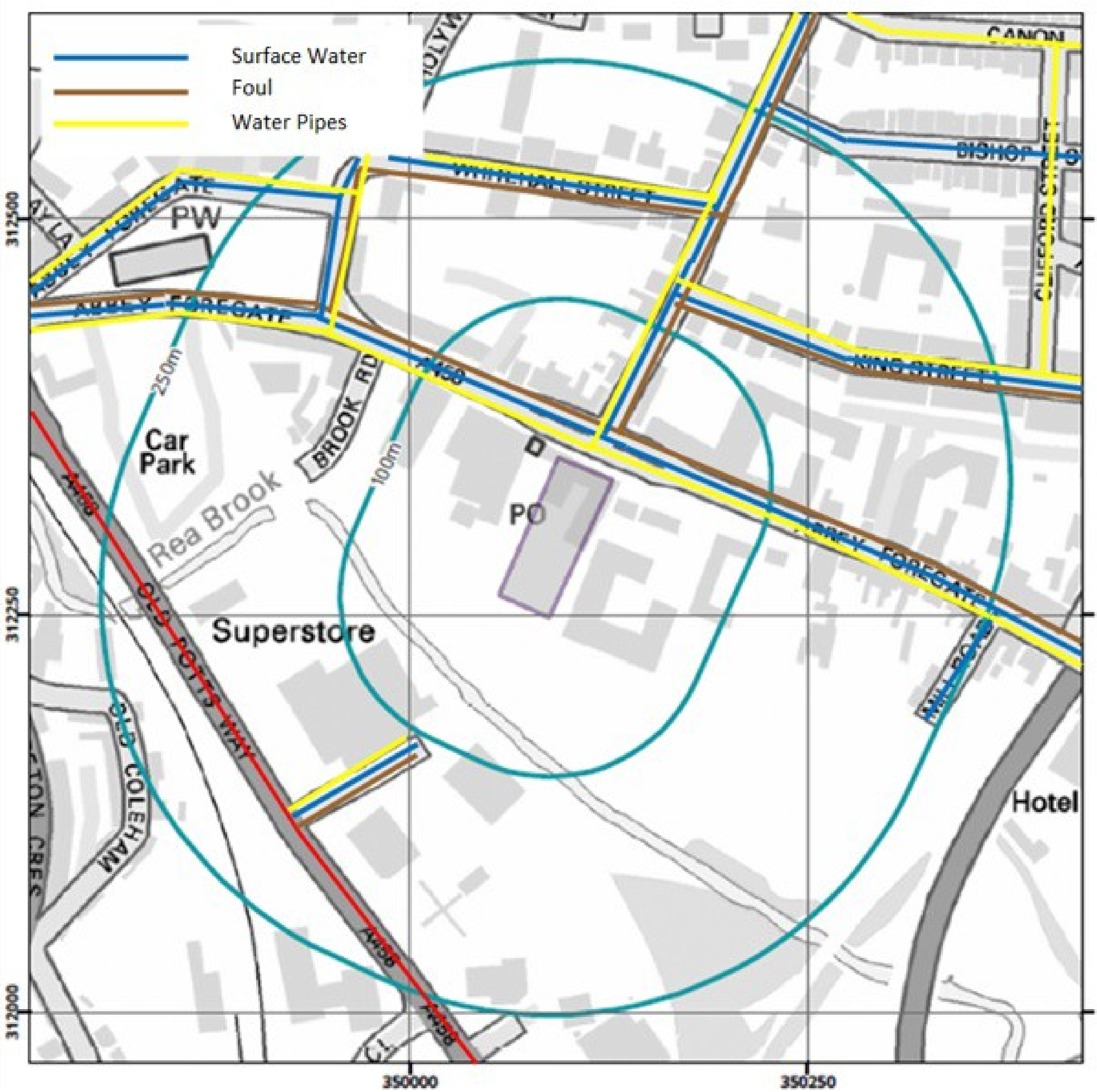
160 Abbey Foregate, Shrewsbury

Sewerage Water Company:
Severn Trent Water Plc

Clean Water Company:
Severn Trent Water Plc

Date of Search:	Reference:	Client Reference:
18/05/2016	1665925	SAMPLE

Public Sewer & Water Map



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Information on confidence levels and ways to improve this report can be provided for any location on written request to info@geosmart.co.uk or via our website. Updates to our model are ongoing and additional information is being collated from several sources to improve the database and allow increased confidence in the findings. Further information on groundwater levels and flooding are being incorporated in the model to enable improved accuracy to be achieved in future versions of the map. Please contact us if you would like to join our User Group and help with feedback on infiltration SuDS and mapping suggestion.

Important consumer protection information

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Tel: 01743 298 100

Email: info@geosmartinfo.co.uk

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TPOs contact details:

The Property Ombudsman scheme

Milford House

43-55 Milford Street

Salisbury

Wiltshire SP1 2BP

Tel: 01722 333306

Fax: 01722 332296

Email: admin@tpos.co.uk

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- Normally deal with it fully and provide a final response, in writing, within 20 working days of receipt.
- Keep you informed by letter, telephone or e-mail, as you prefer, if we need more time.
- Provide a final response, in writing, at the latest within 40 working days of receipt.
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We will co-operate fully with the Ombudsman during an investigation and comply with his final decision. Complaints should be sent to:

Martin Lucass

Commercial Director

GeoSmart Information Limited

Suite 9-11, 1st Floor,

Old Bank Buildings,

Bellstone, Shrewsbury, SY1 1HU

Tel: 01743 298 100

martinlucass@geosmartinfo.co.uk

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