GeoSmart Information

Environmental Thinking

SuDSmart Pro

Site address	77 Avenue Road London NW8 6JD
Site coordinates	526913, 183855
Report prepared for	Mr G Lipton 138 Barlby Road London W10 6BJ
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1. Executive summary

This report assesses the feasibility of infiltration SuDS 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. The Lead Local Flood Authority will require information as a statutory consultee on major planning applications planning 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.

Potential increase in run-off due to the development*1 Minimum attenuation assuming some off-site discharge.	Total run-off including climate change (+30%)*1 Maximum attenuation assuming no off-site discharge	Change in impermeable area on a previously developed / brownfield site (as a % of total area)
↑ -13 m^3	+87 m^3	↑ -24%

*1 for the 6 hour, 1 in 100 year event excluding mitigation

Low infiltration potential

The Site has a low potential for infiltration SuDS, according to the GeoSmart infiltration map. Guidance states that if infiltration SuDS are not possible, attenuation SuDS with a controlled discharge into nearby surface water feature or existing surface water drainage is recommended. Infiltration may not be practically feasible for this Site.

✓

Sustainable Drainage System summary

According to Section 9.3 of the London Borough of Camden development guidance (London Borough of Camden, 2015) and Policy 5.12 of the London Plan (Mayor of London, 2015) a reduction in the rate and volume of runoff to greenfield would be required for new development, for all storm events up to and including the 1 in 100 year 6 hour storm (including an allowance of 30% for climate change).

The Site is located on impermeable London Clay bedrock with a low potential for infiltration measures. Infiltration SuDS are likely to be unfeasible and due to the Site's distance away from a freely accessible surface water feature, attenuation storage features and a controlled discharge (<5 l/s) to the local sewer system are considered the most appropriate for the Site. The Site is not located within a source protection zone or a critical drainage area and is located within Flood Zone 1, where it is not considered to be at risk from fluvial flooding. Lined permeable paving and green roofs are currently proposed for the development.

Once the recommended mitigation measures are implemented, the development is considered extremely unlikely to increase the flood risk off-site. Site investigation and confirmation of the infiltration capacity is required for detailed design.

Next steps

Site investigation is necessary to confirm the infiltration capacity and detailed design is required. See further information section at the end of this report.

2. Potential SuDS scheme options layout

Potential options are indicated below with further supporting information provided in subsequent sections to provide attenuation of 39 m³ for the development (to achieve discharge to greenfield run-off rate with an allowance of 30% for climate change) in line with London Borough of Camden development policy and national guidance (LBC, 2010)(DEFRA, 2012)

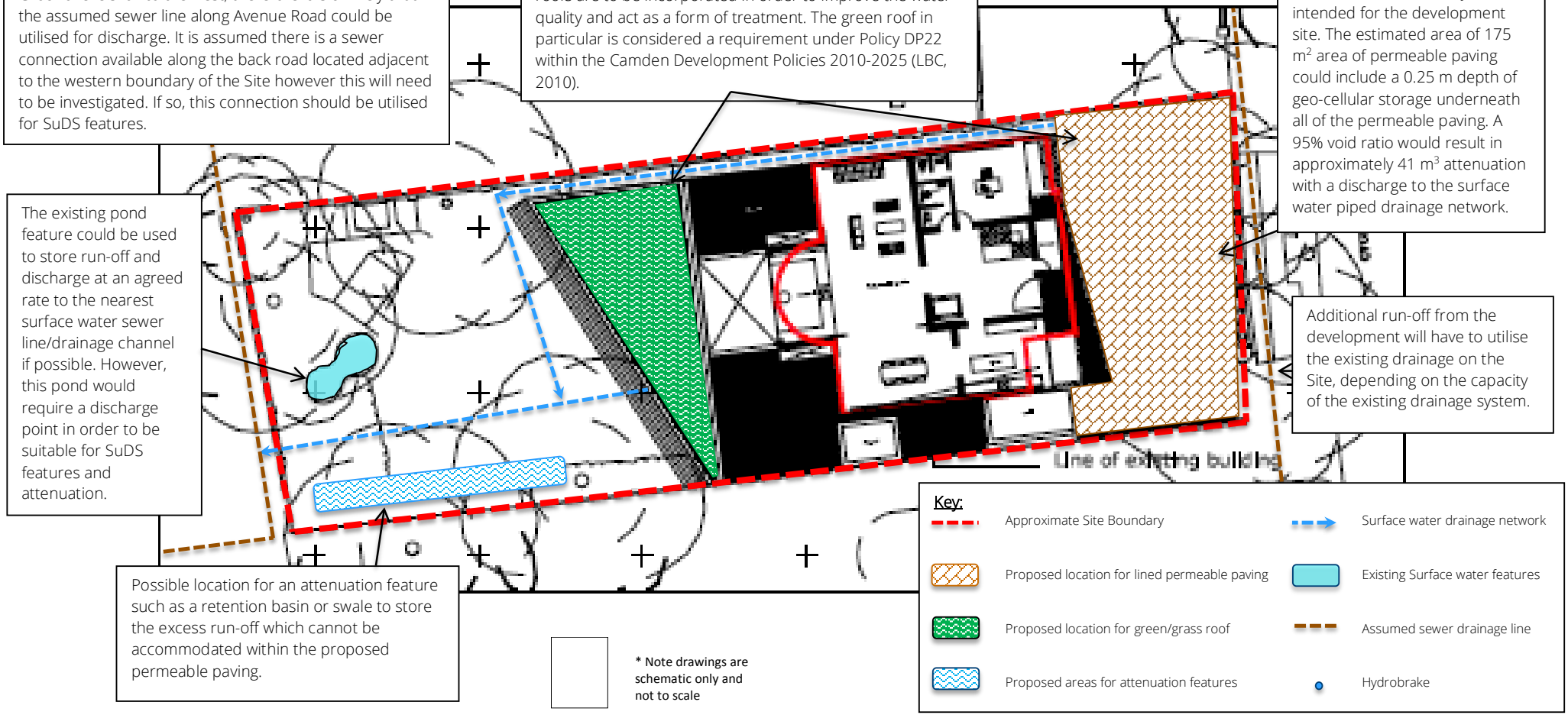
Ground levels fall to the west, therefore it is unlikely that the assumed sewer line along Avenue Road could be utilised for discharge. It is assumed there is a sewer connection available along the back road located adjacent to the western boundary of the Site however this will need to be investigated. If so, this connection should be utilised for SuDS features.

Source control SuDS such as permeable paving and green roofs are to be incorporated in order to improve the water quality and act as a form of treatment. The green roof in particular is considered a requirement under Policy DP22 within the Camden Development Policies 2010-2025 (LBC, 2010).

Lined permeable paving with an area of 175 m^2 is already intended for the development site. The estimated area of 175 m^2 area of permeable paving could include a 0.25 m depth of geo-cellular storage underneath all of the permeable paving. A 95% void ratio would result in approximately 41 m^3 attenuation with a discharge to the surface water piped drainage network.

The existing pond feature could be used to store run-off and discharge at an agreed rate to the nearest surface water sewer line/drainage channel if possible. However, this pond would require a discharge point in order to be suitable for SuDS features and attenuation.

Additional run-off from the development will have to utilise the existing drainage on the Site, depending on the capacity of the existing drainage system.

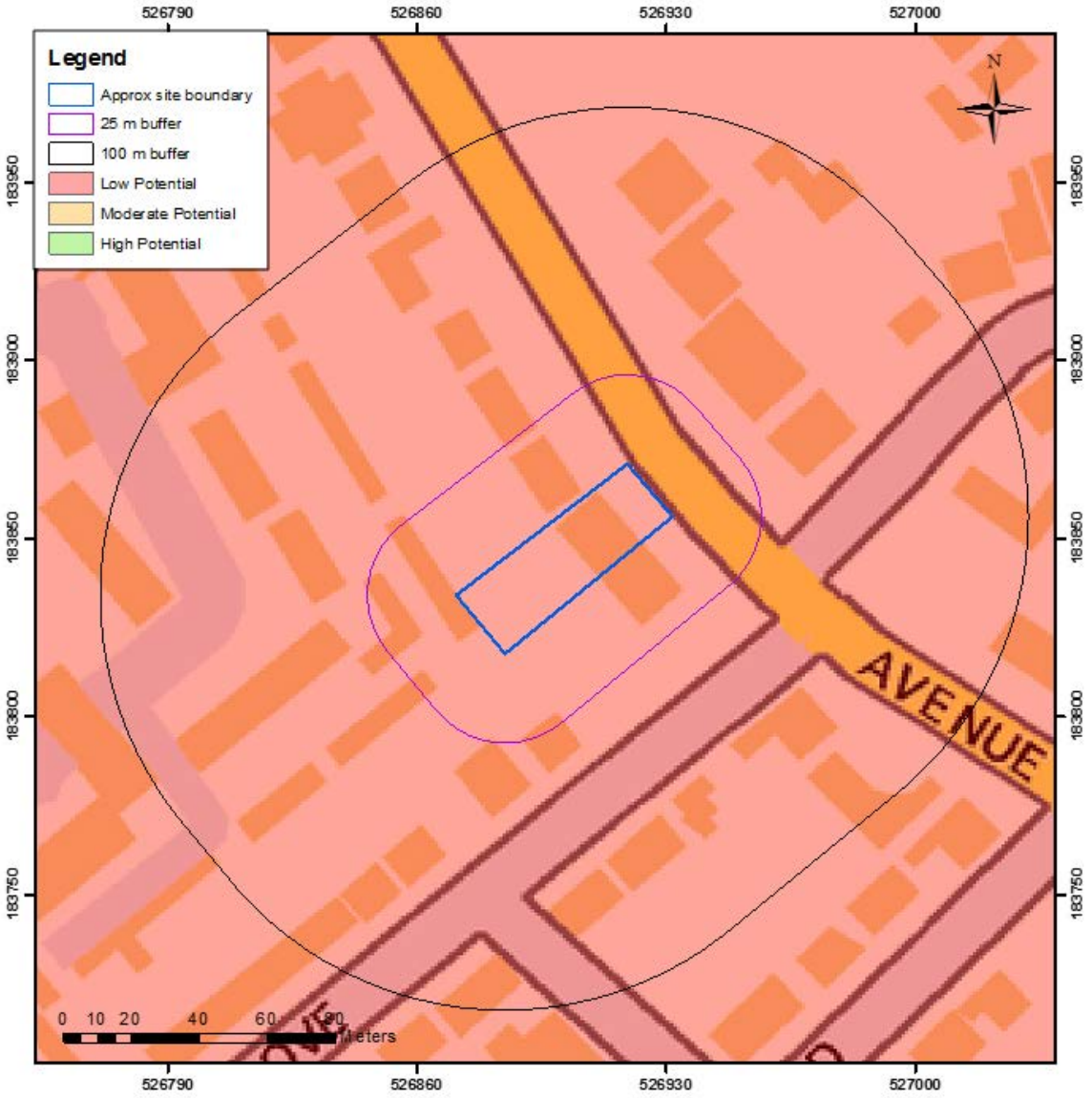


Possible location for an attenuation feature such as a retention basin or swale to store the excess run-off which cannot be accommodated within the proposed permeable paving.

* Note drawings are schematic only and not to scale

3. 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. The map combines information on the thickness and permeability of the underlying material and the depth to the high groundwater table. The report provides the attenuation volumes and run-off rates that will need to be considered. It supports conceptual site drainage assessment and the planning of further site investigation. The first part of the report addresses the constraints on the infiltration potential of the site, the second part provides the attenuation and storage volume requirements and the final sections provide options for the SuDS strategy and background information.



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Potential suitability for infiltration SuDS

(Based on the GeoSmart SuDS Infiltration Suitability Map (SD50))

Low infiltration potential There is a low potential for infiltration SuDS in parts of the Site. Comments: It is likely that the underlying geology at the Site, or in areas of the site, is relatively impermeable which would limit the effectiveness of a proposed infiltration SuDS scheme. Recommendations: Infiltration SuDS should be focused in more suitable parts of the site. If a site investigation confirms that infiltration SuDS are not possible at the Site then attenuation SuDS with a controlled discharge into a nearby surface water feature or existing surface water drainage is recommended.	✓
Moderate infiltration potential There is a moderate potential for infiltration SuDS in parts of the Site. Comments: It is likely that the permeability of the underlying material at the site would be suitable for infiltration drainage. However, there may be constraints on the use of infiltration SuDS as a result of any of the following: a high water table, the limited thickness of the receiving formation, the potential for a significant range in permeability in the underlying geology and confirmation of the infiltration capacity is recommended. Recommendations: 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. If a site investigation confirms that infiltration SuDS are possible at the Site then various options can be considered for infiltration SuDS and these include infiltration trenches, soakaways, swales, permeable pavements and infiltration basins without outlets.	✗
High infiltration potential There is a high potential for infiltration SuDS in parts of the Site. Comments: It is likely that the underlying geology at the Site is highly permeable and an infiltration SuDS scheme should be possible at the Site. Groundwater levels are expected to be sufficiently deep at the site. Recommendations: A site investigation is recommended to confirm the high infiltration capacity and the depth of the winter water table. Various options can be considered for infiltration SuDS and these include infiltration trenches, soakaways, swales, permeable pavements and infiltration basins without outlets.	✗

Underlying geology at the site

Geology present		Potentially permeable?
Superficial Geology	None Recorded	N/A
Bedrock Geology	London Clay Formation	✖

4. Site analysis

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 77 Avenue Road, London, NW8 6JD (the Site). The Site is located in a predominantly residential setting. According to topographic survey for the Site, the land slopes from northeast towards the southwest with elevations ranging from 58.99 mAOD to 49.73 mAOD (Coupdeville, 2008). Site plans and drawings are provided in Appendix A.

Development

The Site is currently used within a residential capacity. At present there is a single building with car park and landscaped areas. The proposed development is for a replacement dwelling of a similar size to the original with additional accommodation and services provided beneath the ground.

Geology, permeability and thickness

British geological Survey (BGS) records confirm the underlying geology as London Clay Formation (impermeable strata) where overlying superficial geology is not recorded (BGS, 2016). The closest borehole records held by the BGS relate to a location c.150 m to the south east of the Site. The borehole logs show clay to a depth of 30 m at which point drilling ceased, it is not known to what depth beyond this the clay continues.

Depth to groundwater

Based on a borehole record obtained for a Site located c.150 m south east of the Site (BGS Reference: TQ28SE353), no water was struck during the drilling process.

The presence of groundwater immediately beneath the Site is unlikely due to the Site's location away from a watercourse and the underlying impermeable bedrock geology; however this should be confirmed by a site investigation.

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.

Water quality

The site does not lie within a source protection zone. In this case an assessment of the quality of infiltrating runoff and the possibilities for pre-treatment is not 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.

Hydrology and drainage

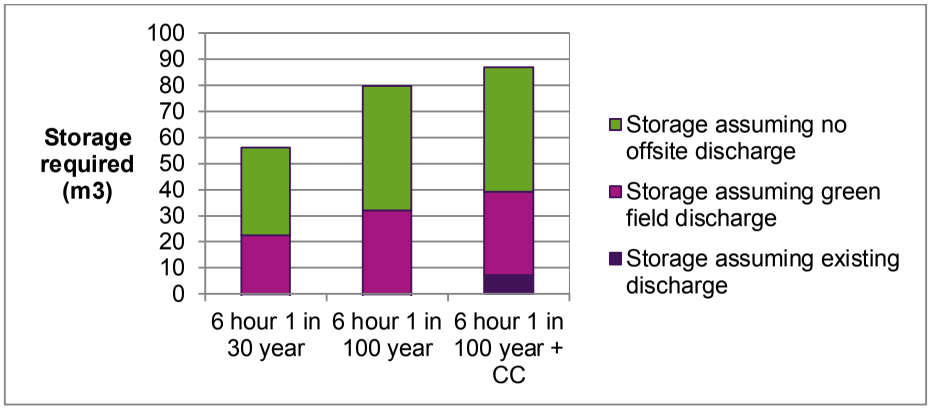
Site plans indicate a pond which is located within the western section of the Site. The closest watercourse to the Site is the Regent's Canal and is located c.795 m to the south east of the Site at the closet point.

Flood risk

The Site is located within Flood Zone 1, which has a low risk of fluvial flooding (Environment Agency, 2016). The Site is also at negligible risk of pluvial (surface water) flooding (Environment Agency, 2016) and a negligible risk of groundwater flooding (GeoSmart, 2016).

5. Storage, volume and peak flow rate

Suggested minimum and aspirational storage requirements for an infiltration 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.



Attenuation scenario	Attenuation requirement (m^3)	Explanation
Minimum	27	Storage required to meet London Plan Supplementary Planning Guidance to ensure runoff is reduced by no less than 50% of the existing site run-off (LBC, 2015).
Medium	39	Storage required to suitably meet the scope of the London Plan (Mayor of London, 2015) that flow is limited to the calculated greenfield rate. London Borough of Camden also expect sites to achieve greenfield run-off rates once SuDS have been installed (LBC, 2015).
Maximum	87	Storage required assuming no off site drainage for the 6 hour 1 in 100 year event, including the maximum effects of climate change. *Note: discharge off site will reduce this, and the increase as a result of climate change is less for buildings with a limited design life.*

Surface water run-off

. Reduction in run-off will help mitigate flood risk both on and off site. Further information on the surface water run-off calculations is provided in Section 6 '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 1: Change in impermeable area associated with the development

Total site area 1,200 m^2

Impermeable area (and as a percentage of the total area of the proposed development footprint of 1200 m^2)	
Pre-development	Post-development
715 m^2 (60%)	427m^2 (36%)
Impermeable Land use: Residential dwelling **Permeable Land use:** landscaped areas	**New impermeable land use:** 427 m^2 residential dwelling New permeable land use: **Landscaped areas and permeable paving**

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).

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 6 'Background Information'.

Table 2: Peak discharge rates associated with the development

Rainfall event	Greenfield run-off rates	Existing run-off rates[1] (l/s)	Potential run-off rates without attenuation	Potential minus existing (l/s)
QBAR	0.5	N/A	N/A	N/A
6 hour 1 in 1 year	0.5	0.5	0.5	-0.1
6 hour 1 in 10 year	0.9	1.9	1.6	-0.3
6 hour 1 in 30 year	1.2	2.6	2.2	-0.4
6 hour 1 in 100 year	1.7	3.7	3.1	-0.6
6 hour 1 in 100 year + 20% CC	N/A	N/A	3.7	0.0
6 hour 1 in 100 year + 30% CC	N/A	N/A	4.0	0.3

1 Assumes 100% run-off from impermeable surfaces. Assumes Greenfield run-off from permeable surfaces calculated using the IoH124 method.

Relevant local and regional plan policy should be consulted to determine restrictions on run-off 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 5 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 6 'Background Information'.

Table 3: Total discharge volumes associated with the development

Rainfall event	Greenfield run-off volume (m^3)	Existing run-off volume[2] (m^3)	Potential run-off volume without attenuation (m^3)	Potential minus existing (m^3)
QBAR	15	N/A	N/A	N/A
6 hour 1 in 1 year	7	12	10	-1.9
6 hour 1 in 10 year	24	41	34	-6.6
6 hour 1 in 30 year	34	56	47	-9.1
6 hour 1 in 100 year	48	80	67	-12.9
6 hour 1 in 100 year + 20% CC	N/A	N/A	80	0
6 hour 1 in 100 year + 30% CC	N/A	N/A	87	7

2 Assumes 100% run-off from impermeable surfaces. Assumes Greenfield run-off from permeable surfaces calculated using the IoH124 method.

Climate change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high-intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the National Planning Policy Framework (NPPF) recommends that the effects of climate change are incorporated into Flood Risk Assessments (Flood Risk Assessments: Climate Change Allowances Guidance, 2016).

Table 4: Peak rainfall intensity allowance in small and urban catchments

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%

6. Run-off destination

Options for the destination for the run-off 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 Draft National Standards for SuDS (2011). Flow attenuation using infiltration SuDS (discharge to ground) is generally the preferred option. If discharge to ground is not available, run-off 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 Section 3 the site has a low potential for infiltration. Based on the available geological information from the British Geological Society and the GeoSmart SuDS infiltration map, discharge to ground is unlikely to be feasible due to the permeability of the bedrock geology.

A Site investigation comprising trial pits is recommended to confirm the depth to groundwater and allow infiltration tests to be undertaken to ascertain the presence of any localised superficial deposits on the Site.

Discharge to surface watercourse

A pond is located within the southern section of the Site but this does not appear to discharge into any watercourse. Discharge to surface watercourses would not be feasibly practical as a connection to watercourses would involve crossing into other properties and public areas.

Discharge to sewer

Discharge to sewer is likely to be the optimum sustainable drainage option for the new development area. It is understood that the existing Site is currently drained to the main sewer located along the southern boundary of the Site along Grove Park Road.

Consultation with the local sewer undertaker should be undertaken as it is likely that if SuDS were implemented on the Site, discharge to sewer would be the only reasonably practical option for discharge.

As there will be an increase in the number of buildings on the Site, it is likely a Thames Water pre-development enquiry will be required to agree proposed surface water discharge rates from the Site. Foul discharge rates may also be required by Thames Water; however this feature and pre-development enquiry are not included within this report. Discharge to the sewer should be controlled, and onsite attenuation would be required. The ground levels on the site fall to the south west which is away from the existing drainage network, located towards the north east along Avenue road.

7. 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 a combination of low (roof water) to medium hazard (runoff from car parking and road). The site does not lie within a source protection zone and therefore additional treatment stages are not required.

Table 5: 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 extent of treatment depends on land use, level of pollution prevention in the catchment and the natural protection afforded by underlying soil layers. A high hazard site will require more treatment then low hazard. The treatment processes provided by different SuDS components will have varying capabilities for removal of different types of contaminants.

Table 6: Minimum water quality management requirements for discharges to receiving water bodies and groundwater

Hazard	Requirements for discharge to surface water and groundwater
Very Low	Removal of gross solids and sediments only
Low	Simple index approach
Medium	Surface water: Simple index approach, Groundwater: Simple index approach and Risk Screening
High	Guidance and risk assessment process in HA (2009). Discharge may require environmental permit or license. Obtain pre-permitting advice from environmental regulator. Risk assessment likely to be required.

8. Sustainable drainage systems

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

Based on the preceding sections of this report it is considered likely that attenuation SuDS will be a suitable option for this Site, subject to confirmation by Site testing. The proposed drainage strategy has been summarised in Section 2 of this report and as a minimum should provide a total storage of 27 m^3, sufficient to attenuate 50% of the existing brownfield site run-off for the 6 hour, 1 in 100 years including an allowance of 30% for Climate Change, in line with the London Borough of Camden's minimum requirements set out within the Camden Planning Guidance SPD (LBC, 2015).

However, London Borough of Camden's developer guidance (LBC, 2015), London Borough of Camden's policy DP23: Water within the Camden Development Policies 2010-2025 document (LBC, 2010), the London Plan: Policy 5.13 (MOL, 2015) and DEFRA non statutory guidance (DEFRA, 2015) states that developers should aim for runoff rates to be restricted to the greenfield runoff rate unless it is proven to be impractical for the Site. Therefore it is recommended that 39 m^3 of attenuation is provided on the Site to comply with both local and the national policies.

Potential SuDS options for this Site are set out below subject to confirmation by detailed design and testing.

1. Lined permeable paving over 175 m^2 with geo-cellular storage underlying this which includes a 95% porosity to provide a form of source control for surface run-off. For an estimated 175 m^2 area which consists of permeable paving with a 0.25 m depth of geo-cellular storage with 95% porosity, would result in approximately 41m^3 of attenuation with restricted discharge to the sewer. If permeable paving were to be unlined, a layer of material needs to be laid between the clay and the uppermost surface to act as a storage/drainage channel (LBC, 2015).

2. According to client provided plans, a grass roof/raised lawn is proposed for the development which is compliant with policy DP22: Promoting sustainable design and construction within the Camden Development Policies 2010-2025 document (LBC, 2010)

   Or

3. 39 m^3 could also be stored within an open water attenuation feature such as a retention swale/basin in the southwest of the Site. The attenuation feature could work alongside the proposed permeable paving already intended for the Site.

Use of the recommended SuDS for the development should ensure the proposed development is able to comply with Policy 5.12 of the London Plan, the Mayor's Supplementary Planning Guidance (SPG) on Sustainable Design and Policies DP22 and

DP23 of London Borough of Camden's Development Policies 2010-2025 document (LBC, 2010). The proposed SuDS features after mitigation should be able to follow the drainage hierarchy established within the London Plan (MOL, 2015).

Initial recommendation: Source control SuDS to reduce run-off with primary discharge to the onsite pond or the sewer.

Various options can be evaluated when considering Source control SuDS which include permeable paving and green roofs.

Lined permeable paving is intended for the area at the front of the property. Suitable aggregate materials (angular gravels with suitable grading as per CIRIA, 2015) will improve water quality due to their filtration capacity. Plastic geo-cellular systems beneath these surfaces can increase the void space and therefore storage but do not allow filtration unless they are combined with aggregate material and/or permeable geotextiles. 175 m² of permeable paving is proposed for the Site.

The proposed permeable paving, with a total area of 175m² and geo-cellular storage (95% porosity), with a depth of 0.25m would provide approximately 41m³ of attenuation. As the Site is situated above impermeable London Clay bedrock, permeable paving will need to be lined with a controlled discharge into the sewer line once the disposal route has been investigated.

Interception via green roofs will enable the storage of run-off and infiltrate collected water gradually into the underlying substrate; this provides various levels of storage depending on the surface area of the feature and the thickness / type of the substrate being use. The different types of green roof include the following:

- Extensive roofs, have low substrate depths (and therefore low loadings on the building structure), simple planting and low maintenance requirements; these tend not to be accessible.
- Intensive roofs (or roof gardens) have deeper substrates (and therefore higher loadings on the building structure) that can support a wide variety of accessible planting but which tend to require more intensive maintenance.

Green roofs can also provide improvements to water quality as they intercept water at the source, and the layering of the substrate can incorporate filtration measures to remove pollutants from the system.

It should be noted the extra loading imposed on the underpinning roof structure which varies with the type of green roof, but it is typically within a range of 0.7-5.0kN/m². Intensive roofs with trees together can impose loads up to 10 kN/m². The distributed load should account for a saturated growing medium (and snow loadings, if appropriate).

As the growing medium within green roofs are likely to struggle to meet interception requirements during cold, wet winter periods when they are likely to be saturated for much

of the time. The amount of rainfall that can be absorbed by a green roof before runoff takes place is very dependent on antecedent conditions. Thus, any assumptions regarding green roof performance during design storms should take a conservative position. With this in mind, additional attenuation should be provided as a precaution in the event of complete saturation of the green roof.

It is also worth adding that although green roofs absorb most of the rainfall that they receive during frequent events, there will always be a need to discharge excess water to the building's drainage system. The hydraulic performance of green roofs once saturated tends to be fairly similar to standard roofs. Therefore, the hydraulic design of green roof drainage should follow the advice in BS EN 12056-3:2000. Useful information is also provided in BS 6229:2003. Detailed guidelines for the planning, execution and upkeep of green roof sites are contained within GRO (2014).

As stated above, grass roof/raised lawn is proposed for the development. Camden Development Policies 2010-2025, policy DP22 requires some form of green roof/living walls to be considered for new developments (LBC, 2010).

Attenuation Tanks or Storage Crates could be feasible for the Site to provide the necessary storage in replacement of infiltration SuDS and if above ground attenuation SuDS are not practically feasible. Underground geocellular storage could be implemented towards the north of the development to attenuate surface run-off from the formal drainage system. They provide a below-ground void space for use of temporary storage via infiltration or controlled release. They can also be modified to suit specific characteristics of a site. DEFRA, 2015 states that the run-off volume from the development to drain to any sewer of surface water body in the 1 in 100 year rainfall event must be constrained to a value as close as is reasonably practical to the greenfield runoff volume for the same event but should never exceed the runoff volume from the development prior to redevelopment from the Site. Issues with geocellular storage crates are the level of accessibility, lack of treatment performance and cost in comparison to surface systems.

Secondary recommendation: Open water attenuation SuDS to reduce run-off with discharge to the onsite pond or the sewer.

Attenuation SuDS are used to store run-off and attenuate collected water gradually. The attenuation system on the ground surface should provide a total storage of 39 m^3 to prevent the volume of off-site run-off from the proposed development exceeding the greenfield run-off rate. A flow limiting device will be required to ensure discharge from the site does not exceed the Greenfield rate as SuDS features will be discharging into the proposed surface water sewer. If a simple flow control device is employed, the flow restriction is generally required to limit the final discharge from site during all return period events to the green field QBAR rate. A more complex flow restriction which varies the final discharge rate from the site will reduce the volume of storage required on site.

Retention swales / basins are flat bottomed, shallow open channels / basins used to attenuate surface water which work to decrease flow velocity by ponding run-off

temporarily. Grass swales/basins 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. Lined swales are appropriate for areas where infiltration to ground is not possible and/or recommended. The seasonal high groundwater level should be below the level of the liner. The extent of a retention swale could potentially be 15x4.5x0.6m to provide storage of approximately 40 m^3. As the attenuation feature would act as a source of storage and overflow from the permeable paving to allow for a controlled discharge to the proposed on site drainage system and eventually the public sewer system.

Additional recommendations

Additional SuDS options that may be considered for the site are as follows:

- Rain water harvesting can collect run-off from the roofs for use in non-potable situations, using water butts for example.

Rainwater Harvesting is primarily used to collect rainwater from impermeable areas and roofs for the use within development buildings and other miscellaneous usage. Water collected in the tanks wouldn't be suitable to consumption or bathing but could be utilized for bathroom facilities, gardening and washing machines. Cost in regards to rainwater harvesting is mainly due to the provision of a storage tank, pumps and pipework which is required for the system to be fully operational. As there is an issue with the storage capability of Rainwater Harvesting tanks, this method should only be used as an additional SuDS feature with a fixed attenuation volume and a controlled outlet to discharge into the proposed infiltration feature. 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.

SuDS maintenance

Regular maintenance is essential to ensure effective operation of the soakaway(s) 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 7: SuDS operation and recommended maintenance requirements

Asset type	Maintenance schedule (and frequency)
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).
Green Roof	Regular inspection: • Inspect all components (soil substrate, vegetation, drainage, irrigation systems, membranes and roof structure, waterproofing, structural stability (annually and after severe storms) • Inspect soil substrate for evidence of erosion channels (annually and after severe storms). • Inspect drain inlets for unrestricted run-off (annually and after severe storms). • Inspect underside of roof for leakage (annually and after severe storms). Regular maintenance: • Remove litter and debris from inlet drains (six monthly, annually or as required). • Cleaning of clippings (six monthly or as required). • Trimming of grasses and removal of nuisance weeds and invasive vegetation (six monthly or as required). • Replace dead plants (annually or as required). Monitoring: • Stabilise any erosion channels with extra soil substrate (as required). • Identify sources of erosion and control (as required). • Investigate and repair drain inlet if inlet has settled, cracked or moved (as required).
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
Rainwater harvesting	Regular maintenance:

	• Inspection of the tank for debris and sediment build-up, inlets/outlets/withdrawl devices, overflow areas, pumps, filters (Annually or following poor performance) Cleaning of tanks, inlets, outlets, gutters, withdrawl devices and roof drain filters (Annually or following poor performance)Monitoring: • Repair of overflow erosion damage or damage to tank (As required) • Pump Repairs (As Required)
Attenuation Storage	Regular maintenance: • Litter and debris removal • Weed/invasive plant control (If required). • Removal of sediment (as required) Monitoring: Plant health and amount of accumulated sediment

9. Further information and what to do next

Site investigation is necessary to confirm the infiltration capacity and detailed design is required. Further SuDS options can be assessed in conjunction with the developer. The following table includes a list of products by GeoSmart:

Recommendations for next steps		
	Additional assessment: SuDSmart Report 	The SuDSmart Report range assesses which drainage options are available for a Site. They build on technical detail starting from simple infiltration screening, and work up to more complex SuDS Assessments detailing alternative options. Please contact info@geosmartinfo.co.uk for further information.
✓	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: GroundSmart Report 	Should you require any geotechnical advice to inform your site development 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.

Client checklist for limitations to infiltration SuDS

Guidance	
Conditions set by Draft National Standards (Defra, 2011)	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?	

According to guidance available in the Draft National Standards for SuDS (Defra, 2011) surface water runoff must not be discharged to the ground where the conditions listed above occur. Should this be the case then attenuation SuDS features are recommended. Please contact GeoSmart for more information.

Client checklist for 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.	

10. Background information

What are SuDS?

SuDS are defined as:
A sustainable drainage system (SuDS) is designed to replicate, as closely as possible, the natural drainage from the Site (before development) to ensure that the flood risk downstream of the Site does not increase as a result of the land being developed. SuDS can also significantly improve the quality of water leaving the Site and can enhance the amenity and biodiversity that a site has to offer.

There are a range of SuDS options available to provide effective surface water management that intercept and store excess run-off. When considering these options the destination of the run off should be assessed using the order of preference outlined in the Building Regulations Part H document (HM Government, 2010) and DEFRA's Draft National Standards for SuDS (2011):

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
5. Discharge to a combined sewer

For general information on SuDS see www.susdrain.org

Infiltration SuDS

Guidance

Government policy for England is to introduce sustainable drainage systems (SuDS) via conditions in planning approvals. Guidance indicates that capturing rainfall run-off 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 run-off 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 run-off 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 run-off 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.

How was surface water run-off estimated from the site?

In accordance with The SuDS Manual (C753) (CIRIA, 2015), the Greenfield run-off from the Site has been calculated using the IoH124 method and is assumed representative of the run-off 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 run-off 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 run-off 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.

GeoSmart SuDS Infiltration Suitability Map (SD50)

In response to the need for national-scale information to support sustainable drainage and land-use planning, GeoSmart have produced the SuDS Infiltration Suitability Map (SD50) for preliminary assessment.

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 which is then informed by additional data on site constraints to give recommendations for SuDS 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 details:

- The GeoSmart SuDS Infiltration Suitability Map (SD50) model takes advantage of all the available data and provides a preliminary indication of infiltration SuDS suitability on a 50m grid covering England and Wales. Our approach is consistent with latest best practice for such assessments and based on authoritative science and quality assured methods.
- The map is a general purpose indicative screening tool, and is intended to provide a useful initial view for a wide variety of applications. However, it does not provide an alternative to a proper site-specific assessment.
- Further information on the GeoSmart SuDS Infiltration Suitability Map (SD50) is available at geosmartinfo.co.uk

Guidance

Data limitations

The data and information which GeoSmart interprets in Reports is obtained by GeoSmart from third parties including the British Geological Survey. The data, information and related records supplied can only be indicative and should not be taken as a substitute for specialist interpretations, professional advice and/or detailed site investigations. Geological observations are made according to the prevailing understanding of the subject at the time. The quality of such observations may be affected by subsequent advances in knowledge or improved methods of interpretation.

11. References and glossary

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Glossary[3]

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.

3 The terms included in this glossary have been taken from CIRIA guidance.

Appendices

Appendix A

Site plans (layout and topography)