

PROPOSED RESIDENTIAL
DEVELOPMENT, CABBAGEFIELD
ROW, HAVANT, HAMPSHIRE

FLOOD RISK ASSESSMENT AND
SURFACE WATER DRAINAGE
STRATEGY

Prepared for

SOCOTEC UK Ltd

August 2021
Ref:223/01/cr/fra/0821



S M Foster Associates Limited
Hydrological and Hydrogeological Consultants

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1. Introduction

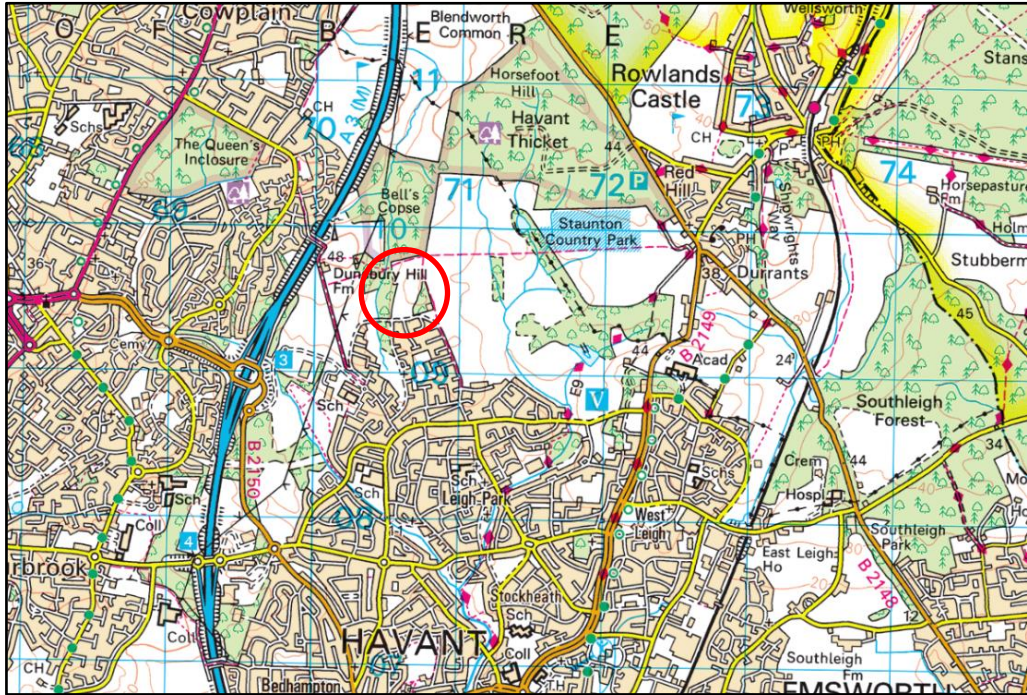
- 1.1 This report has been prepared in response to instructions dated 22nd March 2021 from SOCOTEC UK Ltd. The report presents a Flood Risk Assessment and Surface Water Drainage Strategy related to proposed residential development on land at Cabbagefield Row, Havant, Hampshire. The Site is located within the surface water catchment of Park Lane Stream, a tributary of Hermitage Stream. The Site is designated as being at low risk of fluvial flooding (Flood Zone 1) on the current Environment Agency Flood Map for Planning.
- 1.2 The proposed development area extends to approximately 3.75ha and therefore a Flood Risk Assessment (FRA) is required to support an outline planning application for the proposed development. The primary objective of this FRA is to evaluate the potential risk of flooding from all sources and the potential impact of the proposed development on flood risk elsewhere. Assessments have been undertaken of potential flood risk related to:
- (i) Flooding from rivers and sea
 - (ii) Flooding from surface water
 - (iii) Flooding from groundwater
 - (iv) Flooding from sewers and drainage infrastructure
- 1.3 This assessment also incorporates a Surface Water Drainage Strategy assessment to provide information related to surface water management provision at the Site and to confirm that the proposed development would not lead to any increase in local flood risk.
- 1.4 The assessment has incorporated desk-based analysis of flood mechanisms, a hydrological Site assessment and evaluation of flood risk constraints on potential development at the Site. The assessment has been prepared in accordance with the requirements of the National Planning Policy Framework (NPPF), Environment Agency flood risk Standing Advice and local authority policy regarding development and flood risk.
- 1.5 The proposed surface water drainage scheme for the development has been prepared in accordance with the principles of sustainable drainage systems (SuDS) with reference to both national and local development drainage policy and practice.

- 1.6 Flood hazard analysis has been informed by reference to a number of published data sources that include the following:
- Environment Agency flood maps;
 - Havant Borough Council PUSH Strategic Flood Risk Assessment (SFRA) 2016;
 - Havant Borough Council SFRA Local Plan Sites 2018;
 - Havant Borough Council Adopted Local Plan Core Strategy 2011;
 - Havant Borough Council Local Plan 2036 (emerging)
 - Hampshire County Council SuDS Guidance 2018;
 - Local Authority records;
 - British Geological Survey;
 - Ordnance Survey; and
 - Online records search.
- 1.7 In February 2016 (updated July 2021) the Government published new climate change allowances for flood risk assessment¹. Allowances relate to river and sea level changes and rainfall intensity changes for a range of future timescales. For the purpose of this FRA, climate change allowances for fluvial flood level and rainfall intensity have been applied to hydrological analysis.
- 1.8 In accordance with the requirements of Hampshire County Council, acting as Lead Local Flood Authority (LLFA), a Surface Water Checklist has been completed and accompanies this report.

2. Site location and flood risk status

- 2.1 The proposed development area is located on land referred to as Cabbagefield Row, to the north of Swanmore Road on the northern side of Havant in Hampshire. The Site is currently undeveloped and consists of unmanaged woodland in the south and scrub grassland in the north. The total Site area extends to approximately 7.4ha, however, proposed residential development would be restricted to the southern part of the Site which extends to approximately 3.75ha. Site location is shown in Figure 1.
- 2.2 The Site is bounded to the east and west by woodland. Open agricultural grassland is situated beyond the eastern boundary and to the west woodland extends along the Park Lane Stream valley. It is noted that land to the east of the Site is subject to an application for reservoir development (Havant Thicket Reservoir). At present there is informal pedestrian access to the Site from Swanmore Road. An aerial view of the Site and surrounding area is presented as Figure 2.
- 2.3 A detailed topographic survey of the Site confirms that existing ground levels achieve a maximum elevation of 41.13mAOD at the central eastern boundary, falling to a minimum elevation of 27.24mAOD at the north western corner. In general, ground levels fall from east to west, towards Park Lane Stream which flows north to south at a distance of 50m to 75m west of the western site boundary. To the east, ground levels on surrounding land fall in an easterly direction away from the Site. A copy of the topographic survey is included at Appendix A.

¹ Environment Agency 2016. Flood Risk Assessments: Climate change allowances. February 2016 (Updated July 2021)

Figure 1: Site location © Ordnance Survey

- 2.4 The proposed development area is situated within the surface water catchment of Park Lane Stream, a tributary of Hermitage Stream. Park Lane Stream, which is defined as an ordinary watercourse, flows north to south to the west of the Site before draining to Hermitage Stream via a culverted outlet in north west Havant. There are no water bodies within the Site boundary. A field drain flows north to south adjacent to a path to the east of the eastern site boundary. The location of the Site in relation to local hydrology is shown on Drawing 223/01/01.

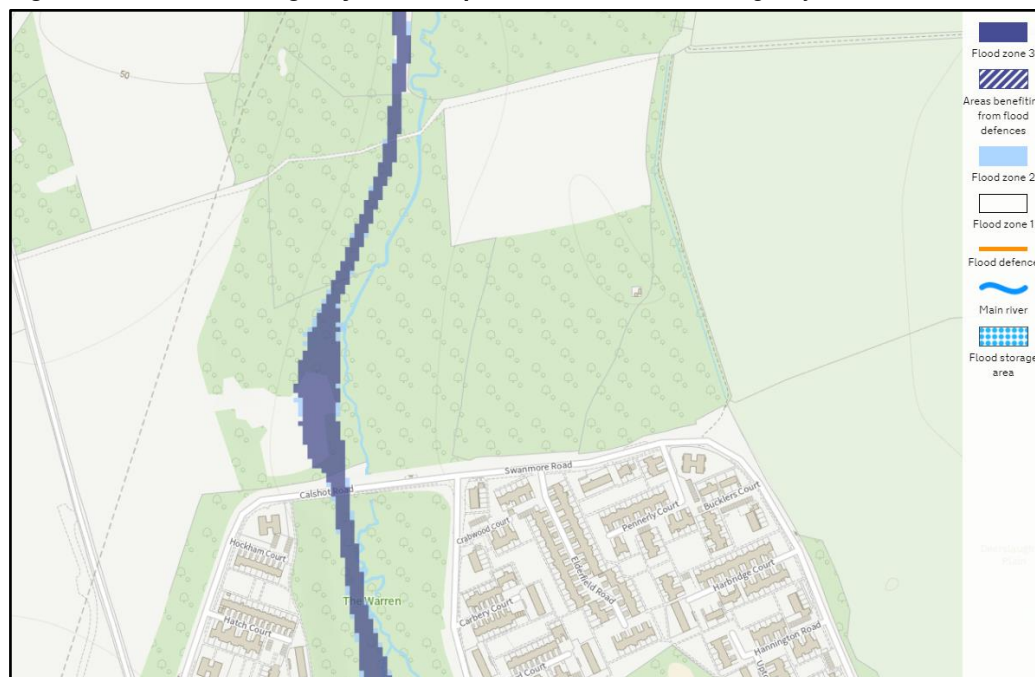
Figure 2: Aerial view of the site © Ordnance Survey

- 2.5 National planning policy related to flood risk is set out in the National Planning Policy Framework (NPPF) and supporting technical guidance. The primary objectives of the NPPF are to direct new development to areas at lowest flood risk where possible, and to ensure that new development can be safely established without adverse impact on flood risk in surrounding areas. NPPF guidance, based on the preceding PPS25 Development and Flood Risk, is typically incorporated into the local authority Strategic Flood Risk Assessment (SFRA) which sets out local policy with regard to development and flood risk.

Flood risk status

- 2.6 The flood risk status of the Site and surrounding area is indicated on the current Environment Agency Flood Map for Planning which indicates that the entire Site is designated Flood Zone 1 and therefore at low risk of fluvial or tidal flooding. An extract from the map is included as Figure 3. Land designated Flood Zone 1 is defined by the Environment Agency as '*land having a less than 1 in 1,000 annual probability of river or sea flooding*'. The Flood Map for Planning shows a high risk flood zone along land to the west of Park Lane Stream. The flood zone is not aligned with the route of the stream which may indicate an error in the mapping process or out-of-bank flow further upstream of the Site.

Figure 3: Environment Agency flood map extract © Environment Agency



- 2.7 As shown in Figure 4, Environment Agency surface water flood risk mapping indicates that the proposed development Site and surrounding area are considered to be at very low risk of surface water flooding. High surface water flood risk zones in the area are generally restricted to the route of Park Lane Stream and local residential roads to the south of the Site.

Figure 4: Environment Agency surface water flood risk map © Environment Agency

- 2.8 In summary, it is concluded that the proposed development Site is at low risk of flooding from fluvial or surface water sources for storm events up to at least 1:1,000yrs frequency of occurrence.

3. Proposed development

- 3.1 The proposed development would consist of 150 new residential properties, each with gardens and driveways. The development would incorporate a new Site access road from Swanmore Road and internal access and parking areas. The proposed development layout is shown on development design drawings at Appendix B of this report.
- 3.2 The total Site area is approximately 7.4ha but only the southern 3.75ha would be subject to built development. The northern part of the Site would be established as open amenity space. As the Site currently consists of previously undeveloped grassland and woodland, the development would result in the introduction of new impermeable surfaces. The land use breakdown within the Site would be approximately as follows:

Houses	-	8,500m ²
Roads, drives & parking areas	-	11,500m ²
Gardens/green space	-	17,500m ²

The development would therefore introduce new impermeable surfaces with a total area of approximately 20,000m².

- 3.3 As shown on drawings at Appendix B, the proposed development would incorporate extensive areas of internal green space and maintain existing peripheral hedgerows and woodland.
- 3.4 At present, the Site drains naturally to Park Lane Stream. It is proposed that surface water generated from the development would continue to drain to Park Lane Stream by direct discharge from the Site surface water drainage system. To comply with national standards for sustainable drainage, the proposed development would incorporate a Sustainable Drainage System (SuDS) that would include on-Site stormwater attenuation capacity and flow restriction to ensure that off-Site surface water discharge rates do not exceed current greenfield rates, as required.

4. Strategic context and sequential planning

- 4.1 The strategic approach to development and flood risk is defined at a national level in the National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG), and at a local level in the Havant Borough Council PUSH Strategic Flood Risk Assessment (SFRA) Level 1 published in February 2011 and updated in 2016, and more recent Havant Borough Council SFRA Local Plan Sites published in November 2018.
- 4.2 The NPPF aims to direct new development to locations at lowest flood risk, wherever possible. A sequential approach to assessment of development suitability is based on consideration of development vulnerability to flood hazards. Local planning policy, as defined in the SFRA, is consistent with the objectives of the NPPF. Local planning policy with regard to development and flood risk is set out in the Adopted Local Plan Core Strategy 2011 at Policy CS15 as follows.

Policy CS15 Flood and Coastal Erosion Risk

Development in areas at risk of flooding now and in the future as identified on the latest Environment Agency flood risk maps and Strategic Flood Risk Assessment climate change maps will only be permitted where:

- 1. It meets the sequential and exception test (where required) in relation to PPS25.*
- 2. The site is located in a low hazard area as defined in the Strategic Flood Risk Assessment.*
- 3. A site-specific flood risk assessment demonstrates that the development will be safe, including the access, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*
- 4. The scheme incorporates flood protection, flood resilience and resistance measures appropriate to the character and biodiversity of the area and the specific requirements of the site.*
- 5. Appropriate flood warning and evacuation plans are in place.*
- 6. New site drainage systems are designed taking account of events which exceed the normal design standard. All development will be required to ensure that there is no net increase in surface water run off. Priority should be given to incorporating Sustainable Drainage Systems (SuDS) to manage surface water drainage, unless it is proven that SuDS are not appropriate. Where SuDS are provided arrangements must be put in place for their whole life management and maintenance.*

The council will work with partners to implement the Coastal Policy Zones in the North Solent Shoreline Management Plan to ensure that development avoids areas at risk from coastal erosion and coastal flooding and that areas required to offset coastal squeeze and prevent habitat fragmentation, to allow species to adapt to climate change, are identified and protected from development

- 4.3 The Havant Borough Council emerging Local Plan 2036 (Submission 23/06/2021) provides further detail on proposed policy regarding development and flood risk as follows.

E19 | Managing flood risk in new development

Planning permission will only be granted where:

- a. The proposal meets the sequential and exception tests as set out in the NPPF and relevant local guidance;*
- b. The development will be safe over its lifetime without increasing flood risk elsewhere;*
- c. Any proposed flood protection, resilience and resistance measures address the specific requirements of the site, and are appropriate to the character and biodiversity of the area;*
- d. Opportunities have been explored to reduce flood risk;*
- e. Where necessary, appropriate flood warning and evacuation plans are in place; and*
- f. Where necessary, a contribution has been made towards any identified flood alleviation scheme(s).*

E20 | Drainage infrastructure in new development

Planning permission will only be granted where:

- a. Run-off rates have been reduced to below the pre-development rate, or, if this is not possible, there is no net increase in surface water run-off compared with the pre-development rate;*
- b. Drainage systems meet the drainage needs of the development in full over the lifetime of the development and do not increase flood risk elsewhere;*
- c. The drainage strategy incorporates SuDS, unless there is clear evidence that this would be inappropriate;*
- d. Arrangements have been made between the applicant and the service provider for the timely delivery of sewerage network reinforcement; and*
- e. Any existing sewerage infrastructure is taken into account in site layout, to safeguard future access for maintenance and upsizing purposes*

- 4.4 NPPF PPG provides confirmation of sequential planning policy with regard to development and flood risk as follows:

‘The Sequential Test ensures that a sequential approach is followed to steer new development to areas with the lowest probability of flooding. The flood zones as refined in the Strategic Flood Risk Assessment for the area provide the basis for applying the Test. The aim is to steer new development to Flood Zone 1 (areas with a low probability of river or sea flooding).’

‘Nor should it normally be necessary to apply the Sequential Test to development proposals in Flood Zone 1 (land with a low probability of flooding from rivers or the sea), unless the Strategic Flood Risk Assessment for the area, or other more recent

information, indicates there may be flooding issues now or in the future (for example, through the impact of climate change).'

- 4.5 Havant Borough Council provide detailed guidance² on the application of the Sequential and Exception Tests, restating the requirements of NPPF with the aim of directing new development to land at low risk of flooding.
- 4.6 As discussed in Section 2, the Site is located in Flood Zone 1 outside the limit of high or moderate fluvial flood risk. With regard to development and flood risk, NPPF states that *'all uses of land are appropriate in this zone'*.
- 4.7 In relation to flood risk vulnerability, the proposed development would be classified as *'more vulnerable'* development. NPPF Guidance (Table 3) confirms that more vulnerable development is considered to be *'appropriate development'* in Flood Zone 1. NPPF confirms that consideration of flood risk issues should focus on vulnerability to other sources of flooding and the potential to increase flood risk elsewhere due to hard surfaces and the effect of new development on surface runoff.
- 4.8 With regard to spatial planning policy and the Sequential Test, the development is to be located in an area of lowest flood risk. This is consistent with the objectives of NPPF and the local authority planning policy. As confirmed by reference to Table 3 of NPPF Guidance the proposed development passes the Sequential Test and there is no requirement to undertake the Exception Test.
- 4.9 The Adopted Local Plan (2011) identifies the Site as an allocated site for housing development (Ref: LP5A) and the 2018 SFRA confirms that the Site passes the Sequential Test with no requirement to undertake the Exception Test. The assessment confirms that there are no flood risk issues at the Site. In the emerging Local Plan 2036 the Site is allocated for housing development (Ref:H34). Additional Site-specific information states that a Flood Risk Assessment and Drainage Strategy would be required to support development proposals at the Site. It is noted that the Site is underlain by clay soils that may influence drainage design.
- 4.10 Hampshire County Council, acting as Lead Local Flood Authority (LLFA), has published guidance³ on the design and use of SuDS based surface water drainage systems. The adoption of SuDS approaches to surface water drainage is a key requirement of both current and emerging Havant Borough Council Local Plan Policy.
- 4.11 The information contained within this report is intended to demonstrate that the proposed development could be established in full accordance with both local and national flood risk and drainage policy and guidance. In particular, the following points are relevant.
- The Site is located in Flood Zone 1 and passes the Sequential Test
 - The Site is at low risk of flooding from all sources
 - The proposed SuDS scheme would prevent increased flood risk elsewhere

² Havant Borough Council (2020). Flood Risk Sequential Test and Exception Test: Policy guidance for applicants and planning officers. (October 2020)

³ Hampshire County Council (2018). Information for developers on SuDS principles and application – version 2.0 (June 2018)

5. Flood risk assessment

Flood mechanisms

- 5.1 Environment Agency flood zone maps indicate that the Site is not at risk of fluvial or tidal flooding in response to either the 1 in 100 year or 1 in 1000 year flood event in local surface watercourses. Reference to the Environment Agency historic flood map confirms that there is no recorded history of flooding at the site. NPPF Guidance suggests that consideration should be given to Site vulnerability to other potential sources of flooding including:
- flooding from groundwater;
 - flooding from sewer systems;
 - flooding from surface water drainage.

Groundwater flood risk

- 5.2 British Geological Survey (BGS) mapping indicates that the Site is underlain at depth by the London Clay Formation consisting of consolidated clay, silt and sand. The southern area of the Site is underlain by the Bognor Sand Member described as a sand horizon within the London Clay Formation. There are no superficial deposits recorded at the Site.
- 5.3 The London Clay Formation in general is designated 'unproductive strata' with no significant potential for transmission of groundwater. The Bognor Sand Member is designated a Secondary A aquifer which is defined by the Environment Agency as follows:

'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers'

- 5.4 Site investigation, consisting of multiple window sample test locations, has demonstrated that, beneath the application Site, the Bognor Sand Member typically consists of slightly sandy/silty orange/brown clay to a depth of up to 4mbgl, underlain by a stiff dark grey clay. No groundwater was encountered in any of the window sample holes. The presence of clay-rich, and hence generally low permeability deposits, beneath the Site will tend to restrict the potential for groundwater recharge and as a consequence, groundwater level response to rainfall is likely to be highly attenuated with no significant potential for groundwater emergence at surface. It is therefore concluded that the Site is at low risk of groundwater flooding.

Sewer flood risk

- 5.5 Land to the east, west and north of the application Site is undeveloped greenfield land that is not served by any form of positive drainage system. Local stormwater sewer systems serving residential development to the south are expected to follow the route of the main roads and residential access roads. Ordnance Survey mapping of the area confirms that ground level falls towards Park Lane Stream in a south westerly direction, away from the application Site. Any surface flooding due to incapacity of the sewer system on residential land to the south of the Site would therefore tend to drain away

from the Site towards the stream. Excess flood water would tend to flow in a westerly direction along Swanmore Road without risk of flooding at the application Site. On this basis it is concluded that the Site is at low risk of flooding in response to a failure of existing surface water sewer infrastructure.

Surface water flood risk

- 5.6 As shown on Figure 4, the Environment Agency surface water flood risk map for the area indicates that the Site is not considered to be at risk of surface water flooding. Land surrounding the Site in all directions is also designated low risk of surface water flooding. However, the route of Park Lane Stream, to the west of the Site is designated medium to high risk of surface water flooding.
- 5.7 As detailed at Section 3, the proposed development will incorporate a new stormwater drainage system that will be designed in accordance with current best practice to ensure that the Site does not flood during a storm event of up to 1:100yr frequency and that any localised surface water flooding during more extreme events would not be a risk to the development.
- 5.8 With regard to overland flow from surrounding land it has been noted that ground levels in the area generally fall from east to west towards Park Lane Stream. Ground levels on land to the east of the Site falls in an easterly direction away from the Site. Any excess surface water runoff from surrounding land to the north, east and west would tend to drain away from the Site without introducing risk of surface water flooding. Excess surface water runoff from developed land to the south would tend to drain along internal roads in a south westerly direction, away from the Site. It is therefore concluded that the proposed development is at low risk of flooding from surface water runoff.

6. Flood protection

- 6.1 Flood risk assessment has demonstrated that the proposed development is at low risk of flooding from all sources. With the exception of the installation of a sustainable surface water drainage system to provide effective Site drainage, no other flood risk management measures are proposed.

7. Surface water drainage assessment

Surface water management

- 7.1 In addition to the requirement to consider flood risk to the development it is also necessary to consider the implications of development on flood risk in the surrounding area. In particular, it is necessary to demonstrate that surface water generated from the proposed development can be sustainably managed without introducing risk of flooding to the Site or surrounding land.
- 7.2 In accordance with the requirements of the NPPF, surface water will be managed at the Site through installation and operation of a Sustainable Drainage System (SuDS).

Current National Standards⁴ for Sustainable Drainage Systems (National Standards - Defra 2011) require that, where reasonably practicable, all new developments are to be equipped with sustainable drainage systems (SuDS) that are approved by Lead Local Flood Authority (LLFA). Hampshire County Council is the LLFA for this Site.

7.3 The proposed development of 150 new residential dwellings would result in the introduction of new impermeable surfaces to the Site. The total impermeable area is estimated at approximately 20,000m². New impermeable surfacing would lead to an increase in both the peak rate and total volume of surface water runoff from the Site.

7.4 Basic standards for SUDS design at previously undeveloped sites is stated in the current Defra Non-statutory technical standards (NSTS) for sustainable drainage systems⁵ as follows:

'S2 For greenfield developments, 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 should never exceed the greenfield runoff rate from the development for the same rainfall event.'

'S4 Where reasonably practicable, for greenfield developments, 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.'

As the Site is currently in greenfield condition the requirement of the NSTS is interpreted as a requirement to restrict off-site discharge and volume to current greenfield rates.

7.5 Sustainable drainage systems are generally based on a stormwater management train that assigns priority to local control of surface water. SUDS systems should be designed to optimise control at the earliest stage in this sequence.

1. Prevention: Good site management, best practice approaches to minimise the risk of flooding or migration of pollutants to surface water;
2. Source control: control of runoff at or close to the source using permeable surfaces, filter trenches or swales etc.;
3. Site control: local facilities that receive surface runoff to attenuate off-site discharge i.e. balancing ponds etc.;
4. Regional Control: larger ponds and wetlands used to control flow and quality prior to final discharge to receiving water.

7.6 National Standards define the appropriate SUDS approach to final discharge destination as the following, in order of preference:

⁴ Defra 2011. *National Standards for sustainable drainage systems*. December 2011. Defra

⁵ Defra 2015. *Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems*. March 2015

1. Discharge into the ground
2. Discharge to a surface water body
3. Discharge to a surface water sewer
4. Discharge to a combined sewer

This approach is consistent with the requirements of Havant Borough Council and Hampshire City Council planning policy.

- 7.7 Hydrogeological evidence available from Site investigation indicates that the Site and surrounding area is underlain by low permeability deposits that are unlikely to be suitable for the use of soakaways, or any other form of infiltration device, for the disposal of Site surface water. Window sample borehole logs and location plan are included at Appendix C.
- 7.8 At present, the Site drains naturally to Park Lane Stream by overland flow across undeveloped grassland and woodland to the stream approximately 50m-75m to west. In the absence of an option to drain surface water to ground it is proposed that all Site surface water continues to drain to Park Lane Stream as at present. The drainage system would therefore achieve the highest available SuDS preference for off-Site discharge destination.

Proposed drainage scheme

- 7.9 In accordance with the principles of sustainable drainage, and local SuDS policy, it is required that the peak rate and volume of surface water discharged from the Site should not exceed the greenfield rate and volume. As noted at Section 4 of this FRA, the proposed development will result in the establishment of an increase in total impermeable area (ignoring the presence of any permeable paving) of approximately 20,000m². The additional runoff generated from these surfaces will be managed to prevent an increase in off-Site discharge.
- 7.10 Surface water from the proposed development would be collected by a stormwater drainage system that would be established along internal roads. All runoff from building roofs, drives and any other impermeable areas, would drain to the stormwater drainage system that would also accommodate runoff from internal roads. Outline definition of the proposed surface water drainage system is shown on Drawing 223/01/02.
- 7.11 The development stormwater drainage system would discharge to new outfalls to Park Lane Stream as shown on Drawing 223/01/02. Discharge to each outfall would be restricted to current greenfield rates by installation of a flow control device e.g. Hydrobrake or similar, and on-Site stormwater storage. The northern area of the developed Site would drain to a stormwater detention basin that would be established on undeveloped land close to the western side boundary. The southern part of the Site would drain in a south westerly direction to a stormwater attenuation basin at the southern Site boundary.
- 7.12 New outfalls to Park Lane Stream would be established with formal headwall and apron to prevent channel or bank erosion. All SuDS features would be designed to optimise the landscape and ecological value of the system.

- 7.13 Hydrological analysis to estimate the on-Site stormwater storage requirement has been undertaken through application of both the HR Wallingford IH124 Method and through application of Flood Estimation Handbook ReFH2 Methodology. The analysis is based on a total development Site area of 3.75ha of which up to 2ha would be subject to some form of impermeable cover. No allowance is made for any form of permeable surfacing. Full analysis is included at Appendix D.
- 7.14 The stormwater drainage system would be designed to accommodate surface water runoff from a 1:100yr storm event plus allowance for climate change. In accordance with current Government guidance, a 40% allowance for climate change has been added to rainfall depths. A further 10% allowance for potential future urban creep has also been included in the analysis.
- 7.15 As detailed at Appendix D, IH124 analysis indicates a requirement for on-Site stormwater attenuation storage of 1,575m³ plus additional long term storage of 46m³ making a total of 1,620m³.
- 7.16 ReFH2 analysis results in much higher greenfield runoff rates and hence lower attenuation storage requirement post-development. The results are summarised at Appendix D. However, the ReFH2 method QMED greenfield runoff rate equates to approximately 10l/s/ha which does not seem credible and therefore the storage estimate produced from the IH124 method, as summarised at Appendix D, is considered more reliable.
- 7.17 As indicated on Drawing 223/01/02, approximately 60% of the Site area would drain to the north western outfall, with the remaining 40% draining to the south western outfall. Approximate attenuation storage volumes required at each location have therefore been determined on an sub-catchment area basis resulting in a requirement for 1,020m³ storage upstream of the north western outfall and 600m³ storage upstream of the south western outfall.
- 7.18 Stormwater detention basin design would be undertaken at detailed design stage following review of ecological objectives and opportunities. However, from a hydrological design perspective, drainage invert levels would allow up to 2m depth of water during extreme storm events, plus a 1m freeboard. On this basis, the north western basin would require a surface footprint of approximately 510m² and the south western basin would require a surface footprint of approximately 300m². Detailed detention basin design, including preferred maximum water depth and basin configuration, would be undertaken as part of system modelling and ecological review at detailed design stage but the above analysis demonstrates the hydrological feasibility of providing adequate on-Site stormwater attenuation capacity, as indicated on Drawing 223/01/02. An example of a detention basin serving a new residential development is presented for reference as Figure 5 which is abstracted from Ciria C753 The SuDS Manual.
- 7.19 Off-Site discharge to Park Lane Stream would be regulated by installation of flow control devices upstream of each outfall, as shown on Drawing 223/01/01. Allowable discharge rates would be restricted to existing greenfield rates at each location as summarised in Table 1.

Figure 5: Example of a detention basin serving a housing development (Source: Ciria C753)**Table 1: Proposed off-Site discharge rates**

Storm frequency (yrs)	Greenfield rate (l/s)	North western outfall (l/s)	South western outfall (l/s)
1	15.1	9.1	6.0
30	40.9	24.5	16.4
100	56.7	34.0	22.7

- 7.20 The hydrological feasibility of achieving design discharge rates with the proposed detention basin head variation is demonstrated by provisional design of Hydrobrake flow control systems. Full details are included at Appendix E.
- 7.21 The proposed stormwater drainage system has been designed by reference to post-development ground levels and standard drain specification in general accordance with the provisions of Sewers for Adoption 6th Edition. Drainage pipework would have a minimum diameter of 150mm and a minimum gradient of 1:150 to ensure that all drains remain self-cleaning. It is anticipated that the majority of connecting pipework from individual property developments would be installed at 100mm diameter, subject to detailed design.
- 7.22 Surface water generated from roof areas would drain directly to the Site stormwater system without risk of contamination. Water quality management for surface water runoff from roads and drives would be delivered at the respective detention basins that would be designed to provide both a filtration and settlement function.
- 7.23 It is anticipated that, once constructed, the Site stormwater drainage system would be suitable for adoption by the local sewerage undertaker. The scheme would be designed to meet the requirements of Sewers for Adoption. It is noted that, as designed, the Site drainage system would not discharge to any existing public sewerage system.

- 7.24 The above analysis demonstrates the hydrological feasibility of sustainable surface water management at the proposed development and the ability to establish surface water drainage systems that are in full compliance with national and local drainage policy. It is noted that by including the potential future effect of climate change in drainage design and on-Site attenuation storage capacity, the proposed development would result in a net reduction in future greenfield drainage rates to Park Lane Stream with consequent benefit in relation to downstream flood risk.

Exceedance flows

- 7.25 The proposed Site drainage system would be designed to accommodate surface water runoff from storm events up to and including the 1:100yr event plus a 40% allowance for climate change, without flooding of the Site. During more extreme events, any surface water in excess of drainage system capacity would tend to drain onto the internal Site access roads. With a Site-wide surface gradient towards the west, excess surface water would drain towards the western Site boundary with overland flow onto the adjacent undeveloped woodland area between the Site and Park Lane Stream. On this basis, exceedance flows could be managed without risk of flooding at the proposed development Site and without increasing flood risk elsewhere.

8. Residual risk

- 8.1 The assessment documented in this report has incorporated identification of potential flooding mechanisms and confirmed that the Site is at low risk of flooding from fluvial, groundwater, surface water and sewer sources. The proposed SUDS-based surface water management scheme could be established in compliance with national guidance and local authority policy to ensure that the development would have no adverse impact on flood risk in the surrounding area. The proposed restriction of peak off-Site discharge rates to the current greenfield rates for all storm events would ensure that there is no increase in off-Site surface water flood risk, with net flood risk benefit when climate change allowances are accounted for.
- 8.2 In the absence of risk to the Site or surrounding area there is no requirement for any additional flood risk mitigation or management measures for the development.

9. Summary and conclusions

- 9.1 An outline planning application for proposed residential development on land at Cabbagefield Row, Havant, Hampshire is to be submitted to Hampshire County Council. A Flood Risk Assessment has been prepared to support the application.
- 9.2 This assessment has been prepared by S M Foster Associates Limited following a hydrological Site review, analysis of available hydrological data sources and flood hazard review. The assessment has resulted in the following conclusions:
- The Site is fully located in Flood Zone 1 and therefore at low risk of fluvial or tidal flooding. The development is classed as 'more vulnerable' development which is defined as 'appropriate development' in Flood Zone 1. The proposed development passes the Sequential Test with no requirement to pass the Exception Test.

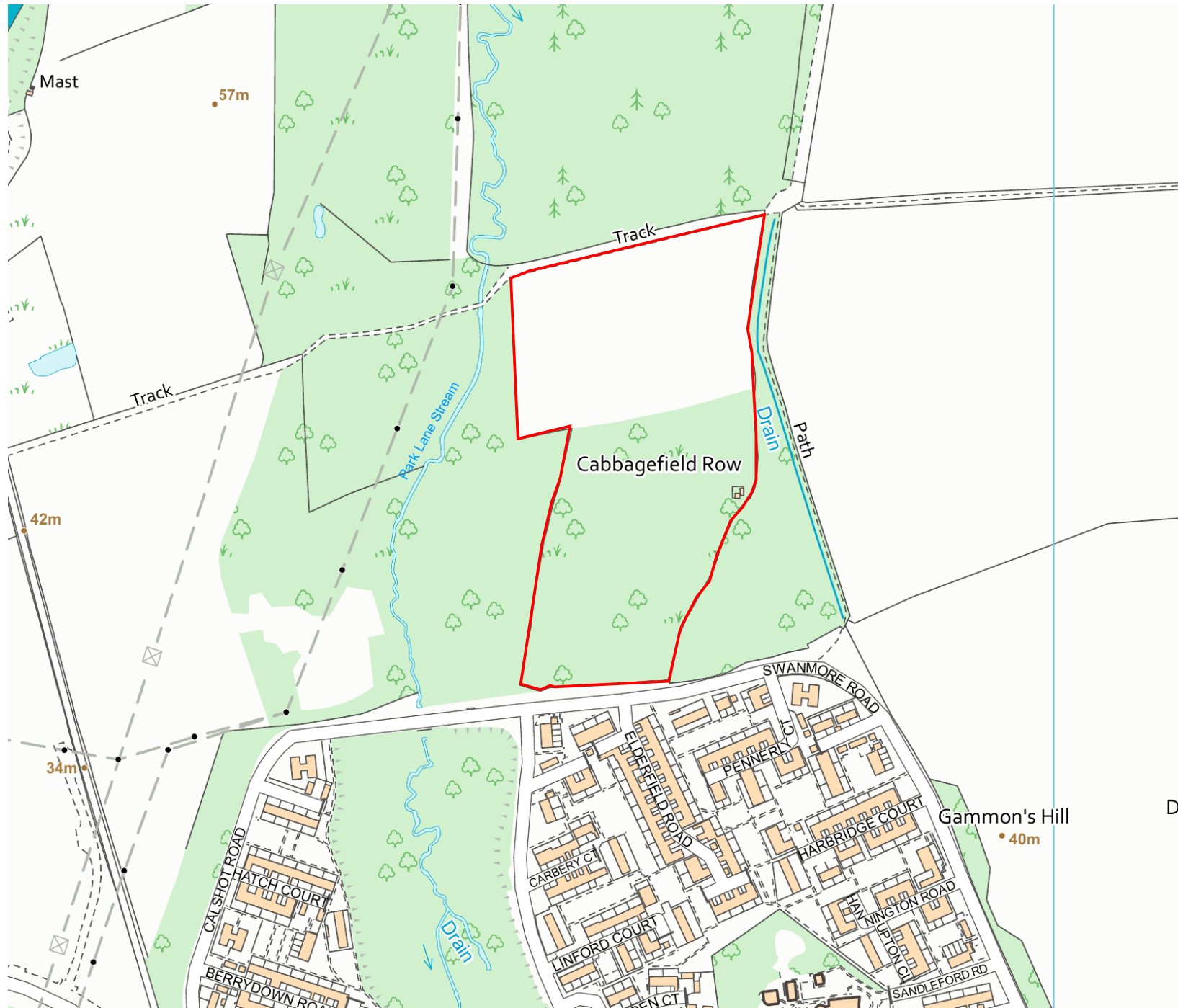
- Flood hazard analysis has demonstrated that the development is also at low risk of flooding from groundwater, surface water or sewer sources.
- The proposed SUDS-based surface water drainage scheme would incorporate on-Site stormwater attenuation capacity designed to ensure that off-Site discharge of surface water would be restricted to current greenfield rates. Site surface water would be drained to Park Lane Stream, as at present, with restricted capacity outfall and on-Site stormwater attenuation storage capacity. The proposed SuDS scheme would result in net reduction in Site-wide surface water discharge to Park Lane Stream when potential future climate change effects are accounted for.
- The proposed SuDS scheme for the Site would incorporate two stages of water treatment to mitigate risk of off-Site pollutant migration. It is anticipated that, once constructed, management of the SuDS system would be passed to the local sewerage undertaker through the formal adoption process.
- In the absence of risk to the Site or surrounding area there is no requirement for any additional flood risk mitigation or management measures for the development.
- The development can be established in full compliance with the National Planning Policy Framework and Hampshire County Council policy related to development and flood risk.

For S M Foster Associates Limited



Stephen M Foster
BSc MSc CGEOL MCIWEM CSi CEnv FIQ
Principal Consultant

Drawings



7 Bownas Road, Boston Spa, Wetherby
West Yorkshire, LS23 6EX, UK
Tel: 01937 849950, Fax: 01937 849951
Email: stephen.foster@smfassociates.co.uk

Approximate site boundary

CLIENT:
SOCOTEC UK LIMITED

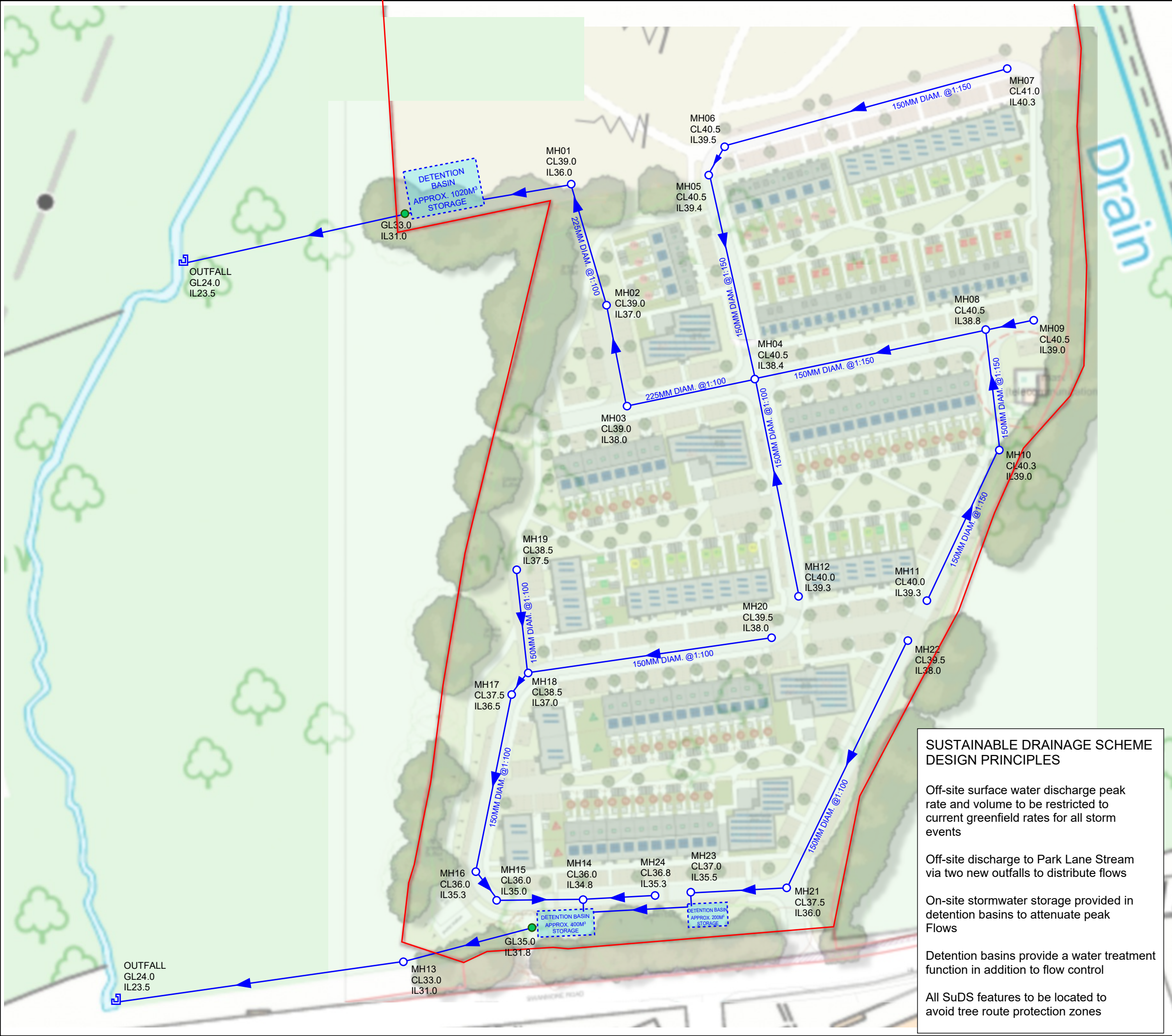
PROJECT:
PROPOSED RESIDENTIAL
DEVELOPMENT, CABBAGEFIELD
ROW, HAVANT

FLOOD RISK ASSESSMENT & SURFACE
WATER DRAINAGE STRATEGY

De
Ref:223/01/01/0521 Date: July 2021

Approved: smf Rev: Rev 1

DRAWING 223/01/01
SITE LOCATION AND LOCAL
HYDROLOGY



7 Bownas Road, Boston Spa, Wetherby
West Yorkshire, LS23 6EX, UK
Tel: 01937 849950, Fax: 01937 849951
Email: stephen.foster@smfassociates.co.uk

- 

Approximate site boundary
- 

Stormwater drain with flow direction
- 

Trapped gully with invert elevation
- 

Detention basin
- 

Flow control device with invert
- 

New outfall with headwall

Note: Indicative drainage scheme only. Drawing not to be referenced as detailed design and not to be used for construction design purposes.

CLIENT:
SOCOTEC UK LIMITED

PROJECT:
PROPOSED RESIDENTIAL
DEVELOPMENT, CABBAGEFIELD
ROW, HAVANT

FLOOD RISK ASSESSMENT & SURFACE
WATER DRAINAGE STRATEGY

Ref:223/01/02/0821

Date: August 2021

Approved: smf

Rev: Rev2

DRAWING 223/01/02
OUTLINE SUSTAINABLE DRAINAGE
SCHEME ARRANGEMENT

**SUSTAINABLE DRAINAGE SCHEME
DESIGN PRINCIPLES**

Off-site surface water discharge peak rate and volume to be restricted to current greenfield rates for all storm events

Off-site discharge to Park Lane Stream via two new outfalls to distribute flows

On-site stormwater storage provided in detention basins to attenuate peak Flows

Detention basins provide a water treatment function in addition to flow control

All SuDS features to be located to avoid tree route protection zones

Appendix A

Topographic survey

Appendix B

Indicative site layout



notes

this drawing is the copyright of the **pdp architecture llp** and must not be reproduced in whole or part or used for the execution of works without their permission.

all dimensions to be checked on site prior to commencement of construction works and the architect notified of any discrepancy.

figured dimensions are to be used in preference to scaled dimensions.

no deviation from this drawing will be permitted without prior consent of the architect.

all drawings are prepared subject to a full measured and structural survey of the buildings and site.

all structural work is subject to the appointment of a structural engineer to confirm and agree the structural proposals.

os promap licence no. 100020449.

health & safety:
exceptional risks involving specific methods of construction or exceptional maintenance issues can be found within the designers risk assessment.

revision	notes	date	drawn	checked
A	Revised Layout	04.06.21	MAS	IR
B	Revised 4 & 5 beds	09.06.21	MAS	IR
C	M4(3) units amended	11.06.21	MAS	IR
D	Minor amends to site layout to client comments	21.06.21	MAS	IR
E	Planning Issue	26.07.21	MAS	IR



PLANNING



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chartered architects town planning
interior design consultants
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tel 023 9248 1100
fax 023 9247 5050
email pdp@pdp-architects.co.uk
www.pdp-architects.co.uk

project	Proposed Development Cabbagefield Row Swanmore Rd, Leigh Park Site Layout Plan			
drawn	MAS	checked	IR	
date	May 2021	status	Planning	
a1 scale	1:500	a3 scale	1:1000	rev 28079-PD111 E

Appendix C

Borehole locations and logs



- Legend to symbols:
-  Window sample borehole location
 -  Site boundary
 -  Site entrance gate

Not to Scale
Aerial photo courtesy of Google

Title
Exploratory Hole Location Plan

Project
Cabbagefield Row, Havant



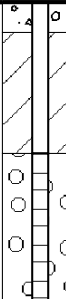
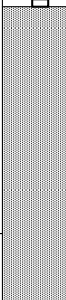
Project No
STH1016/002

Figure No
2

Borehole Log



Drilled	GC	Start	Equipment, Methods and Remarks			Depth from	to	Diameter	Casing Depth	Ground Level
Logged	AC	26/05/2021	Insulated hand tools. Hand dug inspection pit to 1.3 m.			(m)	(m)	(mm)	(m)	Coordinates (m)
Checked	MG	End								National Grid
Approved	SM	26/05/2021								
Samples and Tests					Strata Description					
Depth	Type & No.	Records	Date Casing	Time Water	Main	Detail	Depth, Level (Thickness)	Legend	Backfill	
0.05 - 0.25	ES 1				Dark brown slightly clayey sandy SILT with frequent roots and rootlets. (TOPSOIL)		(0.25)			
0.25 - 0.50	ES 2				Stiff brownish grey slightly sandy silty CLAY with occasional partings of fine orange sand. (LONDON CLAY FORMATION)		(1.05)			
					END OF EXPLORATORY HOLE		1.30			
Groundwater Entries					Depth Related Remarks			Hard Boring		
No.	Depth	Strike (m)	Remarks	Depth Sealed (m)	Depths (m)	Remarks	Depths (m)	Duration (mins)	Tools used	
Notes: For explanation of symbols and abbreviations see Key to Exploratory Hole Records. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.					Project			Borehole		
Scale 1:50 © Copyright SOCOTEC UK Limited 17/06/2021 10:10:30					Project			WS1		
AGS					Cabbagefield Row, Havant			Sheet 1 of 1		
					Project No.					
					Carried out for					
					STH1016					
					Portsmouth City Council					

Drilled	GC	Start	Equipment, Methods and Remarks				Depth from (m)	to (m)	Diameter (mm)	Casing Depth (m)	Ground Level		
Logged	AC	26/05/2021	Archway Competitor 130. Hand dug inspection pit to 1.2 m followed by dynamic sampling with a competitor rig.									Coordinates (m)	
Checked	MG	End										National Grid	
Approved	SM	26/05/2021											
Samples and Tests							Strata Description						
Depth	Type & No.	Records	Date Casing	Time Water	Main	Detail	Depth, Level (Thickness)	Legend	Backfill				
0.10 - 0.25	ES 1				Dark brown slightly clayey sandy SILT with frequent roots and rootlets. (TOPSOIL)		(0.25)						
0.25 - 1.10	ES 2						0.25						
1.20 - 1.65	SPT S	N=12 (0,2/2,2,4,4)			Firm orangish brown slightly sandy SILT / CLAY with partings of fine orange sand. (LONDON CLAY FORMATION)								
2.00 - 2.45	SPT S	N=15 (3,3/3,4,4,4)					(3.25)						
3.00 - 3.45	SPT S	N=19 (3,3/4,5,5,5)					3.50						
					END OF EXPLORATORY HOLE								

Borehole Log



Drilled	GC	Start	Equipment, Methods and Remarks			Depth from	to	Diameter	Casing Depth	Ground Level		
Logged	AC	26/05/2021	Archway Competitor 130. Hand dug inspection pit to 1.2 m followed by dynamic sampling with a competitor rig.			(m)	(m)	(mm)	(m)	Coordinates (m)		
Checked	MG	End								National Grid		
Approved	SM	26/05/2021										
Samples and Tests					Strata Description							
Depth	Type & No.	Records	Date Casing	Time Water	Main	Detail	Depth, Level (Thickness)	Legend	Backfill			
0.10 - 0.30	ES 1				Dark brown slightly clayey sandy SILT with frequent roots and rootlets. (TOPSOIL)		(0.30)					
0.30 - 1.00	ES 2				Firm orangish brown slightly sandy SILT / CLAY with partings of fine orange sand. (LONDON CLAY FORMATION)		0.30					
1.20 - 1.65	SPT S	N=12 (2,2/2,3,3,4)										
2.00 - 2.45	SPT S	N=14 (2,2/4,3,4,3)										
3.00 - 3.45	SPT S	N=13 (3,3/2,4,3,4)										
					END OF EXPLORATORY HOLE		4.00					
Groundwater Entries					Depth Related Remarks				Hard Boring			
No.	Depth	Strike (m)	Remarks	Depth Sealed (m)	Depths (m)	Remarks	Depths (m)	Duration (mins)	Tools used			
Notes: For explanation of symbols and abbreviations see Key to Exploratory Hole Records. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.					Project				Borehole			
Scale 1:50					Cabbagefield Row, Havant				WS3			
© Copyright SOCOTEC UK Limited					Project No.				Sheet 1 of 1			
17/06/2021 10:10:31					Carried out for							
					STH1016							
					Portsmouth City Council							

SOCOTEC

[illegible]

[illegible]

[illegible]

Borehole Log



Drilled	GC	Start	Equipment, Methods and Remarks			Depth from	to	Diameter	Casing Depth	Ground Level
Logged	AC	25/05/2021	Archway Competitor 130. Hand dug inspection pit to 1.2 m followed by dynamic sampling with a competitor rig.			(m)	(m)	(mm)	(m)	Coordinates (m)
Checked	MG	End								National Grid
Approved	SM	25/05/2021								
Samples and Tests					Strata Description					
Depth	Type & No.	Records	Date	Time	Main	Detail	Depth, Level (Thickness)	Legend	Backfill	
			Casing	Water						
0.10 - 0.25	ES 1				Dark brown slightly clayey slightly gravelly sandy SILT with frequent roots and rootlets. Gravel is angular to sub-rounded fine to medium of flint. (TOPSOIL) Firm yellowish brown slightly silty slightly gravelly sandy CLAY. Gravel is sub-angular to sub-rounded fine to medium of flint quartzite and rare fragment of red tile (4x3x1 cm). Firm orangish brown slightly sandy SILT / CLAY with partings of fine orange sand. (LONDON CLAY FORMATION)		(0.25)			
0.50 - 0.80	ES 2						(0.75)			
1.20 - 1.65	SPT S	N=13 (0,2/2,3,4,4)					1.00			
2.00 - 2.45	SPT S	N=14 (2,3/3,3,3,5)					(1.45)			
					END OF EXPLORATORY HOLE		2.45			
Groundwater Entries					Depth Related Remarks			Hard Boring		
No.	Depth	Strike (m)	Remarks	Depth Sealed (m)	Depths (m)	Remarks	Depths (m)	Duration (mins)	Tools used	
Notes: For explanation of symbols and abbreviations see Key to Exploratory Hole Records. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.					Project			Borehole		
Scale 1:50					Cabbagefield Row, Havant			WS8		
© Copyright SOCOTEC UK Limited					Project No.			Sheet 1 of 1		
17/06/2021 10:10:32					Carried out for					
					STH1016					
					Portsmouth City Council					

Borehole Log



Drilled	GC	Start	Equipment, Methods and Remarks			Depth from	to	Diameter	Casing Depth	Ground Level
Logged	AC	25/05/2021	Archway Competitor 130. Hand dug inspection pit to 1.2 m followed by dynamic sampling with a competitor rig.			(m)	(m)	(mm)	(m)	Coordinates (m)
Checked	MG	End								National Grid
Approved	SM	25/05/2021								
Samples and Tests					Strata Description					
Depth	Type & No.	Records	Date	Time	Main	Detail	Depth, Level (Thickness)	Legend	Backfill	
			Casing	Water						
0.10 - 0.25	ES 1				Dark brown slightly clayey sandy SILT with frequent roots and rootlets. (TOPSOIL)		(0.25)			
0.25 - 1.00	ES 2						Firm yellowish brown slightly silty sandy CLAY.			(0.75)
1.20 - 1.65	SPT S	N=11 (0,1/2,3,2,4)			Firm orangish brown slightly sandy SILT / CLAY with partings of fine orange sand. (LONDON CLAY FORMATION)		1.00			
2.00 - 2.45	SPT S	N=14 (2,3/3,3,4,4)					(2.40)			
3.00 - 3.45	SPT S	N=21 (6,3/4,6,5,6)			Stiff dark grey silty CLAY. (LONDON CLAY FORMATION)		3.40			
							(0.60)			
					END OF EXPLORATORY HOLE		4.00			
Groundwater Entries					Depth Related Remarks			Hard Boring		
No.	Depth	Strike (m)	Remarks	Depth Sealed (m)	Depths (m)	Remarks	Depths (m)	Duration (mins)	Tools used	
Notes: For explanation of symbols and abbreviations see Key to Exploratory Hole Records. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.					Project			Borehole		
Scale 1:50					Project No.			WS9		
© Copyright SOCOTEC UK Limited					Carried out for			Sheet 1 of 1		
17/06/2021 10:10:32					Cabbagefield Row, Havant					
					STH1016					
					Portsmouth City Council					

Appendix D

Stormwater attenuation calculations



Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:

Site name:

Site location:

Site Details

Latitude:

Longitude:

Reference:

Date:

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	3.75
Significant public open space (ha):	0.5
Area positively drained (ha):	3.25
Impermeable area (ha):	2
Percentage of drained area that is impermeable (%):	62
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	3.25
Net impermeable area for storage volume design (ha):	2.18
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:

Urban creep allowance factor:

Volume control approach:

Interception rainfall depth (mm):

Minimum flow rate (l/s):

Methodology

esti:

Q_{BAR} estimation method:

SPR estimation method:

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	90.86
FEH / FSR conversion factor:	1.18	1.18
SAAR (mm):	779	779
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydrological region:	7	7
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 10 year:	1.62	1.62
Growth curve factor 30 year:	2.3	2.3
Growth curve factor 100 years:	3.19	3.19
Q_{BAR} for total site area (l/s):	20.52	20.52
Q_{BAR} for net site area (l/s):	17.78	17.78

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	15.1	15.1
1 in 30 years (l/s):	40.9	40.9
1 in 100 year (l/s):	56.7	56.7

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	1575	1575
Long term storage 1/100 years (m^3):	46	46
Total storage 1/100 years (m^3):	1620	1620

This report was produced using the storage estimation tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at <http://uksuds.com/terms-and-conditions.htm>. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.



Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:

Site name:

Site location:

Site Details

Latitude:

Longitude:

Reference:

Date:

This is an estimation of the storage volume requirements that are needed to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	3.75
Significant public open space (ha):	0.5
Area positively drained (ha):	3.25
Impermeable area (ha):	2
Percentage of drained area that is impermeable (%):	62
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	3.25
Net impermeable area for storage volume design (ha):	2.15
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:

Urban creep allowance factor:

Volume control approach:

Interception rainfall depth (mm):

Minimum flow rate (l/s):

Soil characteristics

	Default	Edited
SPR HOST:	--	0.4

Flow inputs

	Default
Q1 (l/s):	51.6
Q1 (l/s):	44.7
Q30 (l/s):	114
Q100 (l/s):	143

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	44.19
Rainfall 100 yrs 12 hrs:	--	51.7
FEH / FSR conversion factor:	1.18	0.67
SAAR (mm):	779	779
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydrological region:	7	7
Q_{BAR} for net site area (l/s):	58.62	50.8

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	38.7	38.7
1 in 30 years (l/s):	98.8	98.8
1 in 100 year (l/s):	123.9	123.9

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m³):	485	373
Long term storage 1/100 years (m³):	32	133
Total storage 1/100 years (m³):	517	506

This report was produced using the storage estimation tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at <http://www.uksuds.com/terms-and-conditions.htm>. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

Appendix E

Provisional Hydrobrake ratings

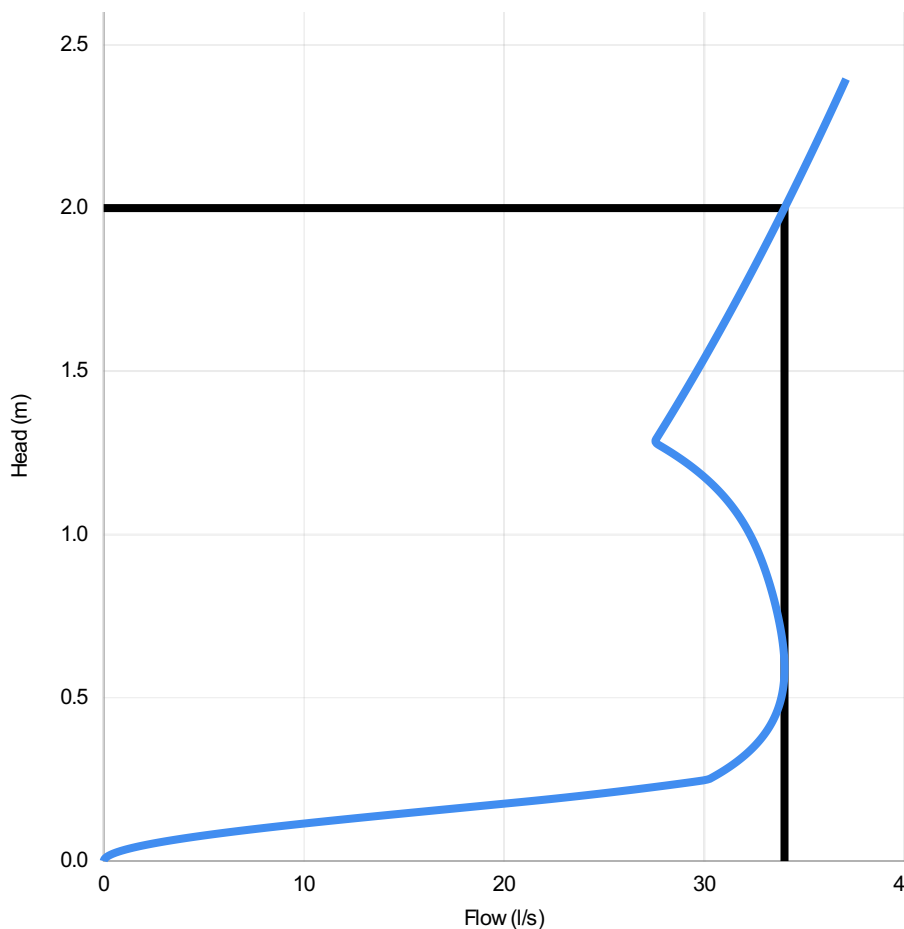
Technical Specification

Control Point	Head (m)	Flow (l/s)
Primary Design	2.000	34.000
Flush-Flo	0.590	34.000
Kick-Flo®	1.281	27.472
Mean Flow		29.441



PT/329/0412

hydro-int.com/patents



Head (m)	Flow (l/s)
0.000	0.000
0.069	3.926
0.138	13.643
0.207	24.818
0.276	30.937
0.345	32.381
0.414	33.271
0.483	33.764
0.552	33.974
0.621	33.986
0.690	33.862
0.759	33.645
0.828	33.359
0.897	33.002
0.966	32.551
1.034	31.959
1.103	31.158
1.172	30.066
1.241	28.592
1.310	27.769
1.379	28.458
1.448	29.130
1.517	29.785
1.586	30.425
1.655	31.051
1.724	31.664
1.793	32.265
1.862	32.854
1.931	33.432
2.000	34.000

DESIGN ADVICE



The head/flow characteristics of this SHE-0236-3400-2000-3400 Hydro-Brake Optimum® Flow Control are unique. Dynamic hydraulic modelling evaluates the full head/flow characteristic curve.

The use of any other flow control will invalidate any design based on this data and could constitute a flood risk.

Hydro
International

DATE	13/07/2021 16:41
Site	Cabbagefield Row
DESIGNER	Stephen Foster
Ref	223/01

SHE-0236-3400-2000-3400
Hydro-Brake Optimum®