Land South of Allington Lane, Eastleigh

Flood Risk Assessment

Hallam Land Management

Brookbanks

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1 Introduction

1.1 Brookbanks Consulting Ltd is appointed by Hallam Land Management Ltd to complete a Flood Risk Assessment for a proposed mixed use development on Land South of Allington Lane, Eastleigh.

1.2 The objective of the study is to demonstrate the development proposals are acceptable from a flooding risk and drainage viewpoint.

1.3 This report summarises the findings of the study and specifically addresses the following issues in the context of the current legislative regime:

- Flooding risk
- Surface water drainage
- Foul water drainage

1.4 Plans showing the existing and proposed development are contained within the appendices.

2 Background Information

Location & Details

2.1 The site being promoted, as shown below, lies between the existing urban areas of Eastleigh and Hedge End, and is bound on two sides by existing transport infrastructure. The southern boundary of the site has the M27, with the site extending up to the Portsmouth Harbour to Eastleigh railway line to the north. The western boundary of the site comprises Allington Lane, with the eastern boundary of the site being existing field boundaries or the rear of properties along Burnett's Lane.

2.2 The site location is shown illustratively on Figure 2b below:

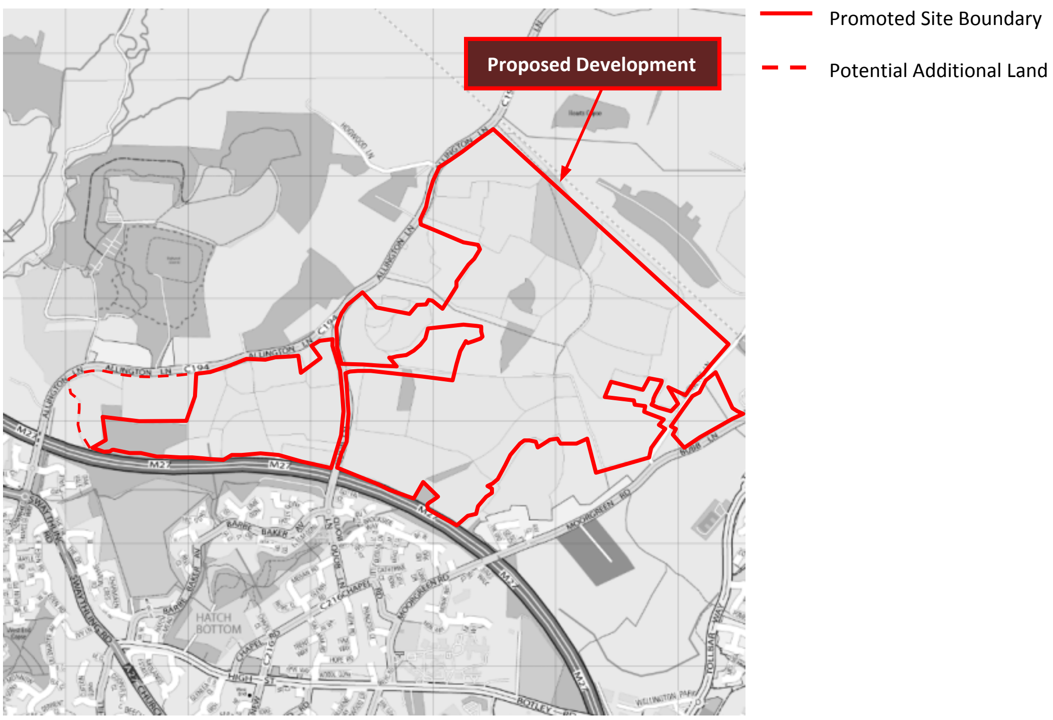


Figure 2b: Proposed Development Site Location

Development Criteria

2.3 For the purposes of initial technical appraisal, it has been assumed that the Proposed Development is to comprise up to 2,500 homes, 10,000m^2 of B1 Employment, two 2 Form Entry Schools and a Local Centre, which can deliver a broad range of house types, tenures and amenities to meet the future needs of the Local Planning Authority, Eastleigh Borough Council. Through the ongoing design process, this mix may obviously change, for which the detailed assessments will need to be reconsidered within the overall vision and strategy identified.

2.4 The Proposed Development site has an area in excess of 150ha.

Sources of Information

2.5 The following bodies have been consulted while completing the study:

- Environment Agency (EA) - Flood and Coastal Management (FCRM)
- Hampshire County Council (HCC) - Surface water and drainage
- Southern Water - Foul water

2.6 The following additional information has been available while completing the study:

- Mastermap Data - Ordnance Survey
- Published Geology - British Geological Survey
- Strategic Flood Risk Assessment – *Final Report* - Atkins for the Partnership for Urban South Hampshire (PUSH), December 2007

  Strategic Flood Risk Assessment – *2016 Update* - Eastern Solent Coastal Partnership on behalf of PUSH, February 2016
- Eastleigh Surface Water Management Plan - Hampshire County Council, December 2012
- Eastleigh Borough Local Plan 2011-2029 Background Paper EN3, *Water: supply, waste water and flooding* - Eastleigh Borough Council, July 2014

Topography & Site Survey

2.7 Topography across each of the study area has been taken from a detailed topographical survey completed in 2016 with each area described in detail below.

West Area

2.8 Topography in this area is characterised by moderate gradients falling generally in a north-west direction. Levels fall from a high point of approximately 31mAOD on the southern boundary of the site adjacent to the M27 down to a low point of circa 12mAOD adjacent to Allington Lane the northern site boundary.

East Area

2.9 In the eastern area, the existing contours fall generally towards a rail track on the eastern boundary. Levels in this area are characterised by moderate to steep gradients in some parts. with levels falling from a high point of circa 32mAOD on the south eastern corner to about 18mAOD on the rail track on the eastern boundary of the site.

Ground Conditions

Geology

2.10 With reference to the British Geological Survey map, the majority of the Site is shown to be underlain by sand, silt and clays of the Earnley Sand Formation, with areas to the west and north underlain by sand, silt and clay of the Wittering Formation. A slither of superficial clay, silt, sand and gravel Alluvium is shown running through the east of the Site.

2.11 There are no areas of Artificial Ground/ Made Ground / Infilled Ground or Landslip areas reported on Site.

2.12 The Site geology is illustrated on Figure 2b.

Proposed Site Boundary

Potential Additional Land

Bedrock Geology:

Earnley Sand Formation (Sand, Silt and Clay)

Wittering Formation (Sand, Silt and Clay)

London Clay Formation (Clay, Silt and Sand)

Portsmouth Sand Member (Sand)

Superficial Geology:

Alluvium (Clay, Silt, Sand and Gravel)

River Terrace Deposits (Sand and Gravel / Clay and Silt)

Figure 2b: BGS Published Geology

2.13 BGS records include the following ratings for a number of potential ground stability hazards on or within 250m of the Site boundary:

Watercourse Systems & Drainage

2.14 Reference to the Flood Estimation Handbook CD dataset V3 shows the site to show the majority of the land to lie within the wider catchment of the River Itchen, several watercourses thought to be tributaries of the River Itchen passes through the site boundary. Having a combined URBEXT2000 value of 0.4984 the FEH catchment can be described as “very heavily urbanised”.

2.15 The FEH catchment is given in Figure 2c:

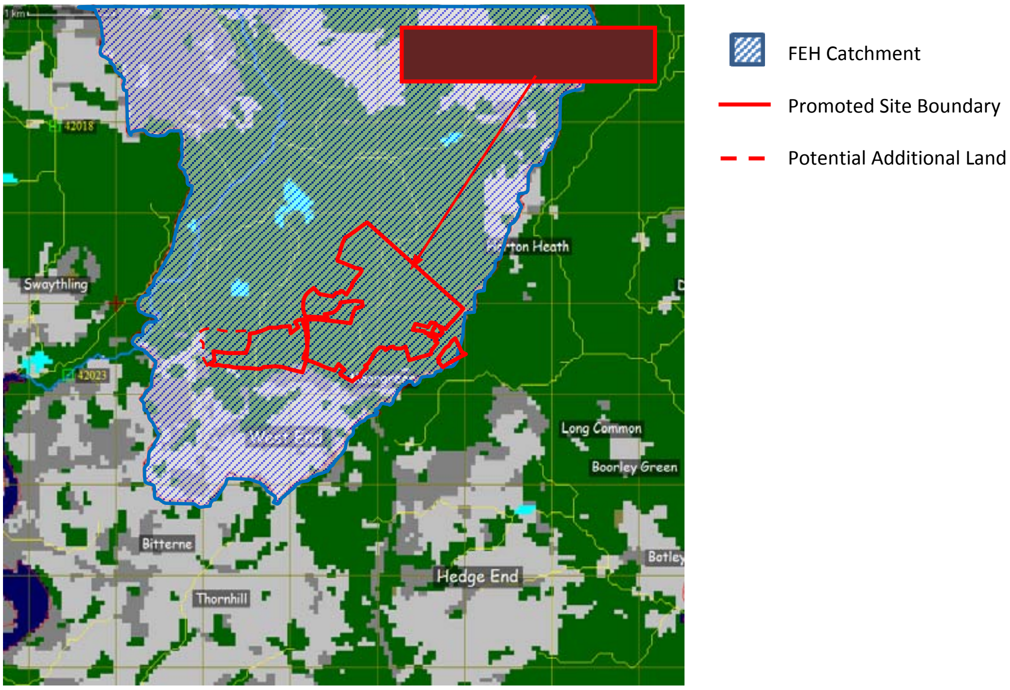


Figure 2c FEH reported catchment.

2.16 With the exception of the watercourse features outlined above, an unnamed watercourse (tributary of Standon Brook) runs within the site, draining the existing golf club ponds. Site inspection also shows the presence of several minor field ditches that run within the site and follow the existing hedge lines and field boundaries.

3 Flooding Risk

National Planning Context

3.1 The new National Planning Policy Framework (NPPF) was introduced in March 2012, which sets out Governmental Policy on a range of matters, including Development and Flood Risk. The policies were largely carried over from the former PPS25: Development & Flood Risk, albeit with certain simplification. The allocation of development sites and local planning authorities' development control decisions must be considered against a risk based search sequence, as provided by the document.

3.2 Allocation and planning of development must be considered against a risk based search sequence, as provided by the NPPF guidance. In terms of fluvial flooding, the guidance categorises flood zones in three principal levels of risk, as follows in figure 3a.

Flood Zone	Annual Probability of Flooding
Zone 1: Low probability	< 0.1 %
Zone 2: Medium probability	0.1 – 1.0 %
Zone 3a / 3b: High probability	> 1.0 %

Figure 3a: NPPF Flood Risk Parameters.

3.3 The Guidance states that Planning Authorities should *"apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change."*

3.4 According to the NPPF guidance, residential development at the proposed site, being designated as "More Vulnerable" classifications, should lie outside the envelope of the predicted 1 in 100 year (1%) flood, with preference given to sites lying outside the 1 in 1,000 (0.1%) year events and within Flood Zone 1.

3.5 Sites with the potential to flood during a 1 in 100 (1%) year flood event (Flood Zone 3a) are not normally considered appropriate for proposed residential development unless on application of the "Sequential Test", the site is demonstrated to be the most appropriate for development and satisfactory flood mitigation can be provided. Additionally, proposed residential developments within Flood Zone 3a are required to pass the "Exception Test", the test being that:

- The development is to provide wider sustainability benefits
- The development will be safe, not increase flood risk and where possible reduce flood risk

Regional & Local Policy

3.6 **Strategic Flood Risk Assessment:** To support local planning policy, NPPF guidance recommends that local planning authorities produce a Strategic Flood Risk Assessment (SFRA). The SFRA should be used to help define the Local Plan and associated policies; considering potential development zones in the context of the sequential test defined in the guidance.

3.7 The Partnership for Urban South Hampshire (PUSH), comprises 10 Local Authorities and Hampshire County Council, of which Eastleigh Borough lies within. Urban South Hampshire, is a strategic growth area that has been identified in the South East Plan/ Regional Spatial Strategy (Adopted May 2009). A Strategic Flood Risk Assessment (SFRA) was produced in December 2007 and updated in 2016, in accordance with the Government's latest development planning and flood risk guidance.

3.8 The SFRA document describes the overall risk of flooding in the wider area, considered from the following sources, which are discussed further in this document:

- Surface Water Flooding
- Sewer Flooding
- Overland flooding
- Groundwater Flooding

3.9 The SFRA does not specifically refer to the site at Eastleigh. It does, however provide recommendations to developers with regards to Sustainable Urban Design Systems (SUDS) which will be investigated further in Section 4, land use planning, development management and flood warning and emergency planning.

3.10 **Catchment Flood Management Plans:** A Catchment Flood Management Plan (CFMP) is a high-level strategic plan through which the Environment Agency seeks to work with other key-decision makers within a river catchment to identify and agree long-term policies for sustainable flood risk management.

3.11 **Development Flood Risk Assessment:** At a local site by site level, the NPPF guidance and supporting documents advocate the preparation of a Flood Risk Assessment (FRA). The NPPF requires that developments covering an area of greater than one hectare prepare a FRA in accordance with the guidance. The FRA is required to be proportionate to the risk and appropriate to the scale, nature and location of the development.

3.12 This document forms a Flood Risk Assessment (FRA), to accord with current guidance and addresses national, regional and local policy requirements in demonstrating that the proposed development lies within the acceptable flood risk parameters.

Flood Mechanisms

3.13 Having completed a site hydrological desk study and walk over inspection, the possible flooding mechanisms at the site are identified as follows in Figure 3b.

Mechanisms	Potential Risk	Comment
Fluvial (Annex C: C4)	N	A small watercourse runs through the site, but this poses no significant risk of flooding.
Coastal & tidal (Annex C: C5)	N	No tidal watercourses lie within an influencing distance of the Proposed Development.
Overland flow (Annex C: C6)	Y	There is very small risk from overland flow from low lying areas within the site.
Sewers (Annex C: C8)	N	Investigations with Southern Water will be carried out to understand the location and capacity of the existing sewer networks.
Reservoirs, Canals etc. (Annex C: C9)	Y	Several reservoirs lie within the catchment of the River Itchen. There are two reservoirs within close proximity to the site.

Figure 3b: Flooding mechanisms.

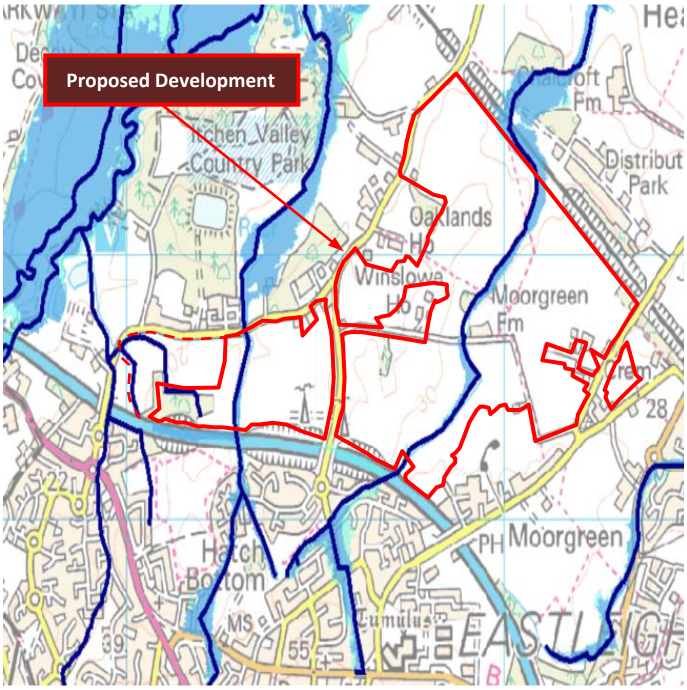
3.14 Where potential risks are identified in Figure 3c, above, more detailed assessments have been completed and are outlined below. Further background is also outlined below.

Fluvial Flooding: C4

3.15 The Environment Agency's (EA) National Generalised Modelling (NGM) Flood Zones Plan indicates predicted flood envelopes of Main Rivers across the UK. In many circumstances, the NGM is based on basic catchment characteristic data and modelling techniques. Where appropriate, more accurate Section 105 / SFRM models are produced using more robust analysis techniques.

3.16 The mapping shows the site lies within Flood Zone 1; being an area of Low Probability of flooding, outside both the 1 in 100 (1% AEP) and 1 in 1,000 (0.1% AEP) year flood events. The EA Flood Zone plan reprinted as Figure 3c. The Proposed Development site has also been established to lie predominately within Flood Zone 1, with a very small section along onsite water courses with flood zone 2 and 3.

3.18 The flooding along the onsite watercourse is believed to be as a result of bank overtopping, this is when a water levels within a watercourse exceeds banks level. As it is not yet known the level of detail used by the EA to map flooding across the site, it is recommended that a more detailed hydraulic model for the onsite watercourse be carried out to understand the extent of flooding along the onsite watercourses.



Flooding from rivers without defences – 1 in 100 year (1%) event (Zone 3)

Extent of extreme flood – 1 in 1,000 year (0.1%) event (Zone 2)

Flood defences

Areas benefiting from flood defences

Promoted Site Boundary

Potential Additional Land

Figure 3c: EA Flood Zone Plan showing 1 in 100 & 1 in 1,000-year floodplain

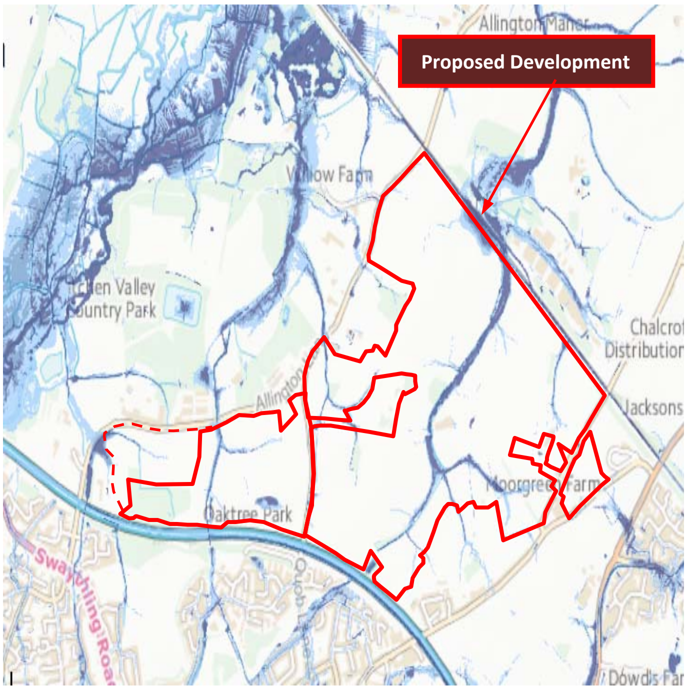
Coastal Flooding C5

3.19 The site lies a significant distance from the nearest tidal watercourse and the coast. As such there is no risk of tidal or coastal flooding at this location.

Overland Flow: C6

3.20 Overflow flow mechanisms result from the inability of unpaved ground to infiltrate rainfall or due to inadequacies of drainage systems in paved areas to accommodate flow directed to gullies, drainage downpipes or similar. In minor cases, local ponding may occur. In more extreme events, flows accumulate and may be conveyed across land following the topography.

3.21 The Environment Agency has recently produced a series of surface water flood maps for many parts of the UK. The plan containing the Proposed Development site is reprinted as Figure 3d.



Promoted Site Boundary

Potential Additional Land

Figure 3d: EA Surface Water Mapping.

High – chance of flooding greater than 1 in 30 (3.3%)
Medium – Chance of flooding between 1 in 100 (1%) and 1 in 30 (3.3%)
Low – Chance of flooding between 1 in 1,000 (0.1%) and 1 in 100 (1%)
Very Low – Chance of flooding less than 1 in 1,000 (0.1%)

3.22 The mapping provided by the EA identifies majority of the site out of surface water flooding with a very small area of surface water flooding within the site boundary as seen from figure 4d above.

3.23 Initial investigations suggest that the risk of overland flow relates primarily to the topography of the site; low areas of the site naturally store water limiting the surface runoff in concentrated areas. As part of the development, the topography will be altered, providing a rationalised surface for water runoff.

3.24 Recognising the risk of overland flow mechanisms, published guidance in the form of Sewers for Adoption 7th Edition and the Environment Agency document Improving the Flood Performance of New Buildings: Flood Resilient Construction et al advocate the design of developments that implement infrastructure routes through the development that will safely convey flood waters resulting from sewer flooding or overland flows away from buildings and along defined corridors. Further to protect the Proposed Development, current good practice measures defined by guidance will be incorporated. However, given the nature of the development this is unlikely to be onerous or to have any material effect on layout.

3.25 Further investigations will be required to understand the existing surface water regime and possible ways to mitigate against surface water flooding.

Groundwater: C7

3.26 Groundwater related flooding is fortunately quite rare, although where flooding is present, persistent issues can arise that are problematic to resolve. Such mechanisms often develop due to construction activities that may have an unforeseen effect on the local geology or hydrogeology.

3.27 Positive drainage systems incorporated into the Proposed Development will further reduce the risk as a result of permeable pipe bedding materials and filter drains incorporated within elements of the built development.

3.28 Given the baseline site characteristics and further mitigating measures to be implemented, residual flood risk from a ground water mechanism is considered to be of a low probability.

Sewerage Systems: C8

3.29 Initial investigations with SW provide no evidence of present or historic sewer flooding at the site.

3.30 Positive drainage measures incorporated on site, coupled with sustainable drainage systems (SUDS) will ensure that no increase in surface water will result from the site. Flood risk associated with sewer flooding is therefore considered to be a low probability.

Artificial Water Bodies - Reservoirs & Canals:

3.31 The Reservoirs are situated to the north of the Proposed Development. The Reservoirs are located at grid reference 445651, 115861 and are part of the Itchen Valley Country Park.

3.32 The mapping provided by the EA identifies areas of surface water flooding at risk of flooding in a situation where the Reservoir fails.

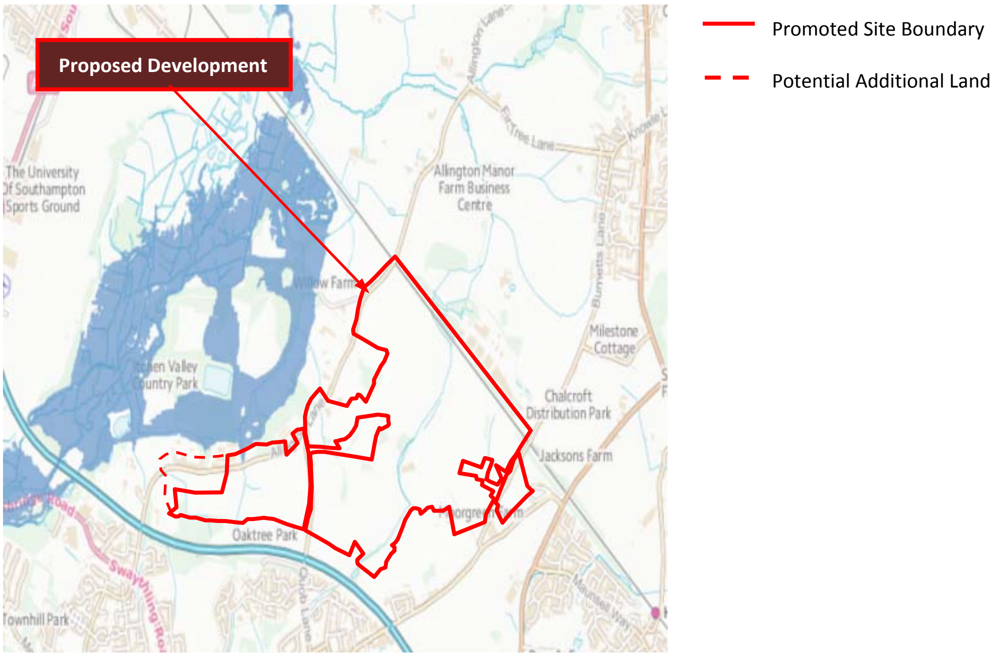


Figure 3e: EA Flood Zone Plan showing Reservoir breach extent.

3.33 The Risk Designation of the reservoirs is yet to be determined by the EA. A reservoir is defined as high risk, if peoples' lives would be in danger as a result of an uncontrolled release of water from the reservoir.

3.34 Further discussions with the EA regarding the safety and reliability of the Reservoir in light of the Proposed Development will be undertaken.

Summary

3.35 In terms of fluvial and tidal flood risk, the site lies substantially within Flood Zone 1 and hence has a low probability of flooding from this mechanism.

3.36 Assessment of other potential flooding mechanisms shows the land to have a low, to medium probability of flooding from overland flow, ground water and sewer flooding.

3.37 The site has the potential to impact on several reservoirs within the River Itchen catchment. Further works will be carried out to determine the safety and reliability of the Reservoirs.

3.38 Accordingly, the Proposed Development land is in a preferable location for development when appraised in accordance with the NPPF Sequential Test and local policy.

Objectives

3.39 The key development objectives that are recommended in relation to flooding are:

- Work collaboratively with the Environment Agency to identify potential flooding.
- Compliance with SFA 7th Edition and EA guidance in relation to flood routing through the Proposed Development in the event of sewer blockages.

4 Storm Drainage

4.1 Site inspections confirm the majority of the land presently discharges storm water to the watercourses within the proposed site.

4.2 As the site is currently greenfield, initial investigations into the existing surface water is assumed to either infiltrate into the underlying sub-soil to ground water systems or move laterally through the sub soils to watercourses which cross the site, and eventually into River Itchen.

Drainage Options

4.3 The following paragraphs in this section outline the proposed drainage strategy to meet national and local design requirements and guidance.

4.4 Current guidance[1] requires that new developments implement means of storm water control, known as SUDS (Sustainable Drainage Systems), to maintain flow rates discharged to the surface water receptor at the pre-development 'baseline conditions' and improve the quality of water discharged from the land.

4.5 It is proposed to implement a SUDS scheme consistent with local and national policy at the proposed development.

4.6 When appraising suitable storm water discharge options for a development site, Part H of the Building Regulations 2002 (and associated guidance) provides the following search sequence for identification of the most appropriate drainage methodology.

"Rainwater from a system provided pursuant to sub-paragraphs (1) or (2) shall discharge to one of the following, listed in order of priority -

(a) an adequate soakaway or some other adequate infiltration system; or where that is not reasonably practicable,

[1] NPPF, CIRIA C522, C609, C753 et al.

(b) ***a watercourse; or where that is not reasonably practicable,***

(c) ***a sewer. "***

4.7 Dealing with the search order in sequence:

(a) Source control systems treat water close to the point of collection, in features such as soakaways, porous pavements, infiltration trenches and basins. The use of such can have the benefit of discharging surface water back to ground rather than just temporarily attenuating peak flows before discharging it to a receiving watercourse or sewer.

As source control measures generally rely upon the infiltration of surface water to ground, it is a prerequisite that the ground conditions are appropriate for such. Site ground investigations specific to flood risk have yet to be completed. Published geology for the area suggests the presence of potentially permeable formations within the site. While the ground formations may not be possible for a wholesale infiltration based drainage strategy, where subsequent investigations show infiltration is viable locally to work, this may be incorporated into the design.

As such, source control measures will therefore be primarily restricted to detention and conveyance systems placed close to source by way of measures such as lined permeable surfaces and conveyance strips along selected new roads.

(b) Next in the search sequence, defined by Part H, is discharge to a watercourse or suitable receiving water body. Where coupled with appropriate upstream attenuation measures, this means of discharge can provide a sustainable drainage scheme that ensures that peak discharges and flood risk in the receiving water body are not increased.

The unknown watercourse lies to the northern boundary of the Proposed Development site and as such is appropriate receptor for storm water discharge and as such, has the potential to receive flows from the Proposed Development once restricted to the pre-existing 'greenfield' rates of run-off.

(c) Last in the search sequence is discharge to a sewer. In the context of SUDS this is the least preferable scheme as it relies on 'engineered' methods to convey large volumes of water from development areas, has a higher likelihood of flooding due to blockage and provides less intrinsic treatment to the water.

4.8 The search sequence outlined above indicates that on site watercourses are the most appropriate receptor of storm water from the Proposed Development, having the potential to employ source control measures to control peak discharges to no greater than the baseline conditions. Where post planning investigations demonstrate the viability of localised infiltration drainage, these should be incorporated into the source control measures in the final design.

4.9 Coupled with the storm water control benefits, the use of SUDS can also provide betterment on water quality. National guidance in the form of CIRIA 753 outlines that by implementing SUDS, storm water from the site can be polished to an improved standard thus ensuring the development proposals have no adverse effects on the wider hydrology

4.10 The following paragraphs outline the potential SUDS features appropriate for use on site and their place within a multi-tiered system.

Primary Drainage Systems (source control)

4.11 At the head of the drainage network, across the site, source control measures will be implemented to reduce the amount of run-off being conveyed directly to open ditches or piped drainage systems.

4.12 Through work on other similar strategically sized projects, BCL has shown that peak discharges of circa 35% in residential areas can readily be achieved using source control measures without unacceptable impacts on net developable land or prohibitive financial implications.

4.13 Through consultations at outline planning stage, it has been agreed that the nature of source control measures to be implemented will need to remain flexible, providing a 'toolkit' of options to reach an agreed target for peak discharge reduction and water treatment. The following paragraphs describe a number of options available.

Preliminary Drainage Proposals

4.14 Preliminary assessment of the requirements for storm drainage have been based on the following criteria:

Sewer design return period(2)	1 in 1 years
Sewer flood protection(2)	1 in 30 years
Fluvial / Development flood protection (1)	1 in 100 years
M5-60(3)	20.0 mm
Ratio r (2)	0.400
Minimum cover to sewers (1)	1.2 m
Minimum velocity (1)	1.0 m/sec
Pipe ks value (1)	0.6 mm
Allowance for climate change (4)	40%

4.15 National policy[1] requires that new developments control the peak discharge of storm water from a site to the baseline, undeveloped, site conditions. Over very large development areas, the baseline rate of run-off is normally estimated using the FEH methodologies. However, Paragraph 3.1.2 of the FEH guidance states:

4.16 *"The* frequency *estimation procedures can be used on any catchment, gauged or ungauged, that drains an area of at least 0.5km^2.* The *flood estimation procedures can be applied on smaller catchments only where the catchment is gauged and offers simple flood peak or flood event data".*

4.17 On undeveloped and ungauged catchments of less than 0.5km^2 in area, it is correct to complete baseline site discharge assessments using the nationally accepted IoH124 methodology for small rural catchments. Local policy is to employ IoH124 in a manner set out by CIRIA C697. This methodology requires that, for catchments of less than 50ha, the IoH assessment is completed for a 50ha area with the results linearly interpolated to determine the flow rate value based on the ratio of the development to 50ha.

4.18 The overall application boundary is above the 50ha threshold, thus the ICP SUDS Method is therefore the most appropriate for appraising the baseline run-off from the development. The ICP SUDS method is the direct application of the IoH124 methodology without scaling.

[2] Sewers for Adoption 7th Edition
[3] Wallingford Report

4.19 The baseline IoH run-off rates are shown on Figure 4a below:

Event	IoH 124 (50ha)	IoH 124 Scaled to 1ha
1 in 1 year (l/s)	241.1	4.82
Qbar (l/s)	283.6	5.67
1 in 100 year (l/s)	904.8	18.10

Figure 4a: IoH124 baseline discharge rates.

4.20 In order to determine the permitted rates of run-off from the development, the future impermeable catchment areas must be derived. This has been based on a BCL measured ratio from previous projects. Calculations below show these ratios and areas and how these correlate to the rates of discharge.

4.21 The calculations for this are shown in Figure 4b below:

Catchment	Land Use	Developable Area (ha)	Impermeable Area (ha)	Existing 100 Year Run-off (l/s)	Proposed 100 Year Run-off (l/s)
A	Residential	29.61	16.29	294.7	92.4
B	Residential	26.28	14.45	261.6	82.0
C	Residential	3.01	1.66	30.0	9.4
D	Residential	26.08	14.34	259.6	81.4
E	Residential	27.21	9.26	167.6	52.5
		112.2	**56.00**	**1013.3**	**317.7**

Figure 4b: Run-off calculation.

4.22 Using these methods, development at the site will comply with the requirements set out in paragraph 9 of the Technical Guide to the National Planning Policy Framework (NPPF), with the discharge of surface water from the proposed developments not exceeding that of the existing greenfield sites, thus ensuring that there is no material increase in the flood risk to surrounding areas.

4.23 Assessments have thereafter been completed to determine the characteristics of proposed SUDS features to be situated within the development. Best practice methods have been employed by performing detention routing calculations for both the 1 in 1 and 1 in 100 years + 40%cc. The summary calculations are contained in the Appendix.

Catchment A

4.24 Calculations demonstrate that storm water detention storage extending to maximum 11,612m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year plus climate change event storm. This will limit the peak discharges to 92.4l/s, being equivalent to the mean annual storm (Qbar), estimated by the previously shown IoH124 calculations, representing a circa 68% reduction on peak greenfield rates. Figure 4c summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
29.6	16.29	92.4	11,612	Detention basin

Figure 4c: Summary run-off & detention assessment output.

[4] NPPF requirements for residential development

Catchment B

4.25 Calculations demonstrate that storm water detention storage extending to maximum 10,288m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year plus climate change event storm. This will limit the peak discharges to 82l/s, being equivalent to the mean annual storm (Qbar), estimated by the previously shown IoH124 calculations, representing a circa 68% reduction on peak greenfield rates. Figure 4d summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
26.28	14.45	82	10,288	Detention basin

Figure 4d: Summary run-off & detention assessment output.

Catchment C

4.26 Calculations demonstrate that storm water detention storage extending to maximum 684.8m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year plus climate change event storm. This will limit the peak discharges to 9.4l/s, being equivalent to the mean annual storm (Qbar), estimated by the previously shown IoH124 calculations, representing a circa 68% reduction on peak greenfield rates. Figure 4e summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
3	1.66	9.4	685	Detention basin

Figure 4e: Summary run-off & detention assessment output.

Catchment D

4.27 Calculations demonstrate that storm water detention storage extending to maximum 10,216m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year plus climate change event storm. This will limit the peak discharges to 81.4l/s, being equivalent to the mean annual storm (Qbar), estimated by the previously shown IoH124 calculations, representing a circa 68% reduction on peak greenfield rates. Figure 4f summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
26.1	14.34	81.4	10,216	Detention basin

Figure 4f: Summary run-off & detention assessment output.

Catchment E

4.28 Calculations demonstrate that storm water detention storage extending to maximum 8,714m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year plus climate change event storm. This will limit the peak discharges to 69.5l/s, being equivalent to the mean annual storm (Qbar), estimated by the previously shown IoH124 calculations, representing a circa 68% reduction on peak greenfield rates. Figure 4g summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
27.21	12.24	569.5	8,714	Detention basin

Figure 4g: Summary run-off & detention assessment output.

4.29 In accordance with legislative requirements, the detention proposals have been assessed for the potential effects of climate change. The 1 in 100 year (1% AEP) return events have been modelled for 40% climate change (including peak rainfall intensity). Calculations for the climate change scenarios are contained within the Appendix B. Climate change assessments show each detention feature to perform adequately by retaining the additional flows within the system without overflow.

4.30 As seen from the drainage plan 10440-DR-01 in appendix A, the existing watercourses will be retained across the site, and where reasonable server as additional storage and conveyance.

4.31 The storm water management system will provide features that are designed to provide extended detention of storm water collected from within the development. This approach will maximise the passive treatment characteristics of the system and improve water quality discharged to the wider River Itchen catchment.

Water Quality

4.32 Traditional impermeable surfaces collect pollutants from a wide variety of sources including cleaning activities, wear from car tyres, vehicle oil and exhaust leaks and general atmospheric deposition (source: CIRIA C609). The implementation of SUDS in development drainage provides a significant benefit in removal of pollutant from development run-off.

4.33 In most cases, contaminants become attached to sediment particles either before entering the water body or upon entry. CIRIA 609 reports that up to 90% of certain contaminants, usually trace elements, are transported in this way leaving a dissolved concentration of circa 10%.

4.34 Furthermore, by implementation of SUDS features it is possible to optimize overall pollutant removal as water will undergo this process of filtering before being discharged to an appropriate receptor. The overall percentage of removal can be calculated individually for each differing SUDS technique; this is shown by the formula below:

Overall pollutant removal = (TPLxC1) + (RPLxC2) + (RPLxC3) +…..for each other control in series

Where: TPL – Total Pollutant Load
RPL – Remaining Pollutant Load (after previous treatment(s))
C(x) – Suds Control removal efficiency

Figure 4h: Pollutant removal formula as set out in CIRIA C609.

4.35 At present, the site and surrounding area does not benefit from any additional measures of stormwater treatment, except for the ditches along the site boundary.

4.36 Due to the need to provide wider sustainability benefits and view the development at a strategic level, SUDS will be implemented to passively treat run off from the development so as to have a positive impact on the surrounding natural environment.

4.37 The site will employ SUDS features, porous paving, filter strips, formal swales, balancing ponds/detention basins and underground storage crates. These are widely accepted to be of high pollutant removal efficiency (CIRIA 609). This provides for one stage of treatment onsite. Coupled with this however, the unknown watercourse should also be seen as an additional stage of treatment as the sedimentation process is not limited to artificial drainage systems but is taken from the natural processes observed within the water cycle. This gives 2-3 stages of treatment, providing an extensive system by which to effectively decrease pollutant load within stormwater run-off.

4.38 As the site is not presently served by any means of storm water treatment mechanisms, by providing the afore mentioned SUDS within the proposed development it will be possible to maintain present water quality in the area and thus the development can be seen to be having no significant environmental impact in relation to water.

Implementation Proposals

4.39 The conceptual drainage proposals have been developed in a manner that will allow the site wide system to be designed to encourage passive treatment of discharged flows and to improve the water quality by removing the low-level silts, oils which could be attributed to track/parking area run off of this nature. Final design will provide for appropriate geometry and planting to maximise this benefit.

4.40 The storm water management features will be constructed and operational prior to the first use of the site, derived on a phase-by-phase requirement.

4.41 It has previously been the case that the functionality of the storm water management system would be ensured by ongoing maintenance, completed by the Local Authority, Drainage Authority, or a private maintenance company as appropriate. It is proposed that, for this development, a private maintenance company will be appointed to carry out the maintenance regime below.

4.42 It is usual for the following maintenance regime to be implemented:

Frequency	Operation
Post major storm events	Inspection and removal of debris.
Every two months	Grass mowing (growing season) & litter removal.
Annual	Weeding & vegetation maintenance. Minor swale clearance. Sweeping of permeable pavements.
2 years	Tree pruning.
5-10 years	Desilting of channels. Remove silt around inlet and outlet structures.
15-20 years	Major vegetation maintenance and watercourse channel works.

Figure 4i: Framework maintenance of detention / retention system.

4.43 The conceptual drainage masterplan proposals outlined in this report will be used for final drainage design and detailing. The storm water management system will be constructed and operational in full prior to first use of the relevant phase of development.

Summary

4.44 A strategy for storm drainage at the site has been developed to meet both national and local policy. The above options outline the viability of the site to employ means of drainage to comply with NPPF guidance, together with the MVDC SFRA and other national and local guidance.

4.45 The development drainage system will manage storm water by way of a SUDS management train and ensure peak discharges from the developed land is not increase from the appraised baseline rates. The system will also provide to maintain the quality of water discharged from the development.

Objectives

4.46 The key objectives for the site drainage will be:

- Implementation of a sustainable drainage scheme in accordance with current national and local policy together with principles of good practice design.
- Control of peak discharges from the site to a rate commensurate with the baseline conditions.
- Development of storm water management proposals that maintain water quality and biodiversity of the site.
- Implementation of the storm water management system prior to first use of the site.

5 Foul Drainage

Background

5.1 Consultation with Southern Water (SW) is ongoing to determine the location and capacity of an adequate sewer system near the Proposed Development site.

Existing Conditions

5.2 SW operate Foul Water, Surface Water and Foul Rising Mains within the vicinity of the proposed development.

5.3 SW operate a 300mm CP Foul Water main along a track crossing the west of the proposed development. A Foul Water 225mm VC / 300mm CP Foul Water main is shown to the west and north of the proposed development along Allington Lane. An additional 150mm SI Foul Water main is shown to the south-east along Moorgreen Road.

5.4 SW operate Foul Water, Surface Water and Foul Rising Mains south and south-east of the proposed development along individual roads supplying the adjacent residential dwellings. A Foul Rising Main is operated by SW crossing the M27.

5.5 Initial assessment and discussions with SW has confirmed that additional modelling would be required to confirm their capability to supply the proposed development. However, SW has confirmed that a recent review of the design standards has been completed and adopted for all future modelling works. The modelling procedures are also been reviewed and are currently being updated. Pending this review, SW has temporarily withdrawn their Level 2 Sewerage capacity checks, with SW seeking to simplify their procedures to improve transparency.

5.6 Further options are currently being reviewed to progress the Site.

5.7 There are two sewage treatment works within 3km of the Proposed Development area and to the west of the River Itchen. The closest is Eastleigh Sewage Treatment Works approximately 2.5km north of the site, whilst Portswood Waste Water Treatment Works is situated approximately 2.9km south-west of the site. Their locations are shown on Figure 5a.

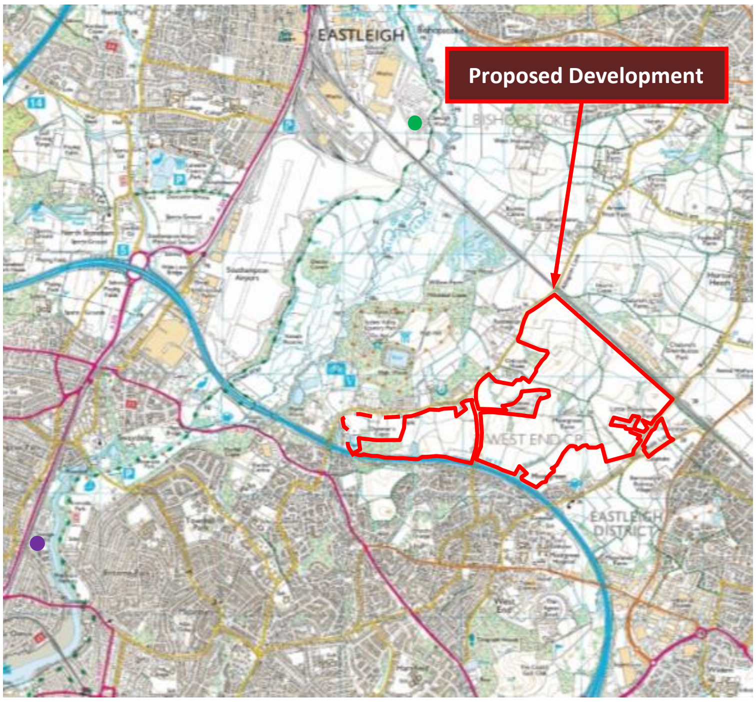


Figure 5a: Local Sewage Treatment Works

5.8 SW are currently reviewing their network capacity within Eastleigh to determine what strategic upgrades are necessary to facilitate development.

Design Criteria

5.9 Peak design discharges have been calculated based on the current development criteria as described in Section 2 of this report and for the following:

Domestic peak	=	4,000 litres / dwelling / day (peak)

5.10 Assessed in accordance with SFA 7th Edition requirements, the development will have a design peak discharge of approximately 115.7l/s.

Summary

5.11 A site drainage strategy for foul water discharge is yet to be established which is sufficiently sized to accommodate the new development.

6 Summary

6.1 This FRA has identified no prohibitive engineering constraints in developing the proposed site for the proposed developments.

6.2 Assessment of fluvial flood risk shows the land to lie fully within Flood Zone 1.

6.3 Assessment of other potential flooding mechanisms shows the land to have a low to medium probability of flooding from overland flow, ground water and sewer flooding.

6.4 A foul water drainage strategy is yet to be established.

6.5 The site is fully able to comply with NPPF guidance together with associated local and national policy guidance.

7 Limitations

7.1 The conclusions and recommendations contained herein are limited to those given the general availability of background information and the planned usage of the site.

7.2 Third party information has been used in the preparation of this report, which Brookbanks Consulting Ltd, by necessity assumes is correct at the time of writing. While all reasonable checks have been made on data sources and the accuracy of data, Brookbanks Consulting Ltd accepts no liability for same.

7.3 The benefits of this report are provided solely to Hallam Land Management for the proposed development Land South of Allington Lane, Eastleigh, only.

7.4 Brookbanks Consulting Ltd excludes third party rights for the information contained in the report.

Appendices A

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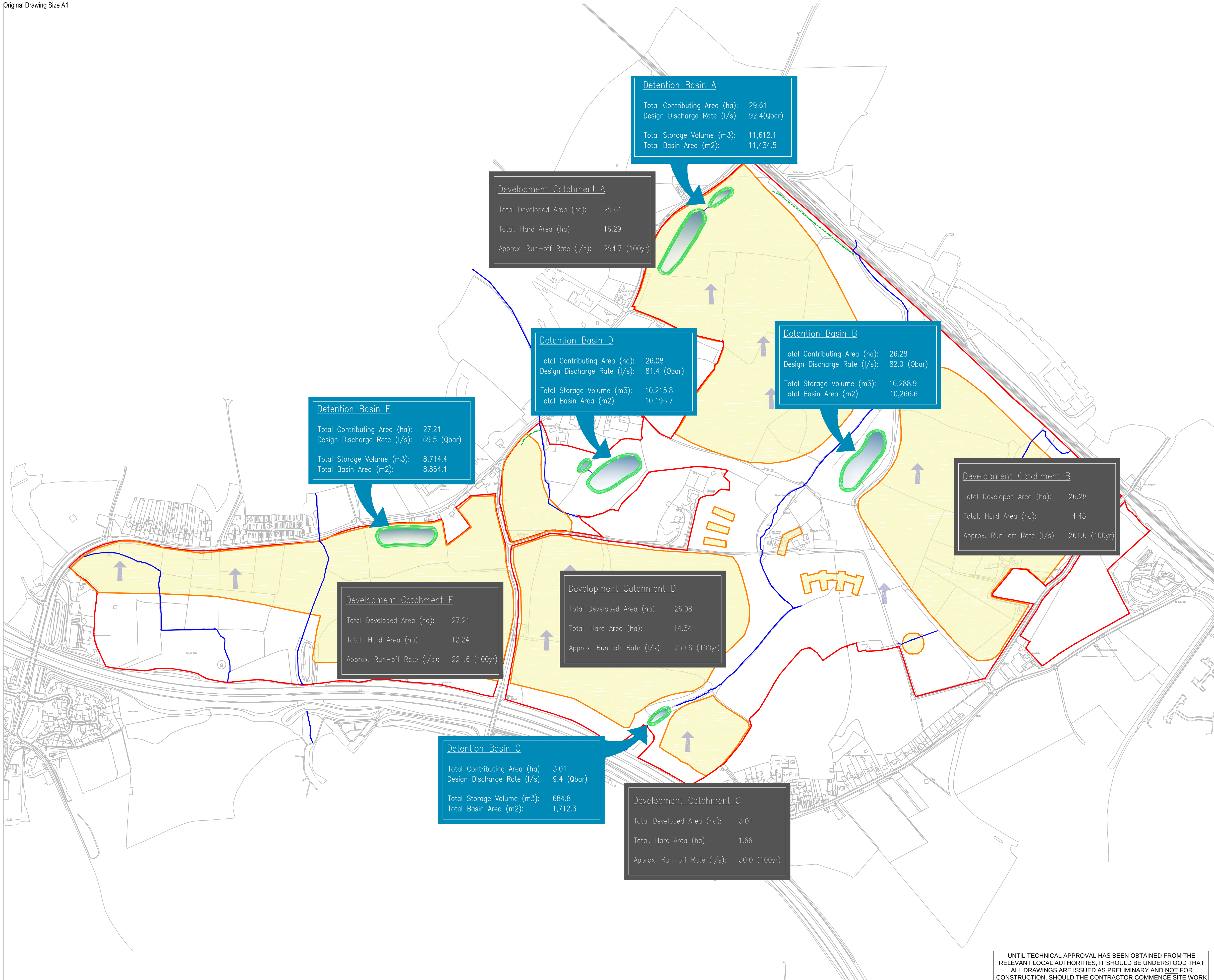
Original Drawing Size A1



Construction Design and Management (CDM)
Key Residual Risks

Contractors entering the site should gain permission from the relevant land owners and/or principle contractor working on site at the time of entry. Contractors shall be responsible for carrying out their own risk assessments and for liaising with the relevant services companies and authorities. Listed below are Site Specific key risks associated with the project.

1) Overhead and underground services
2) Street Lighting Cables
3) Working adjacent to water courses and flood plain
4) Soft ground conditions
5) Working adjacent to live highways and railway line
6) Unchartered services
7) Existing buildings with potential asbestos hazards

NOTES:

1. Do not scale from this drawing.
2. All dimensions are in metres unless otherwise stated.
3. Brookbanks Consulting Ltd has prepared this drawing for the sole use of the client. The drawing may not be relied upon by any other party without the express agreement of the client and Brookbanks Consulting Ltd. Where any data supplied by the client or from other sources has been used, it has been assumed that the information is correct. No responsibility can be accepted by Brookbanks Consulting Ltd for inaccuracies in the data supplied by any other party. The drawing has been produced based on the assumption that all relevant information has been supplied by those bodies from whom it was requested.
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KEY:

Site Boundary
Potential SuDS Basin
Existing Onsite Watercourse
Direction of flow

-	First Issue	AM	-	LW	26.08.16

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Land South of Allington Lane
Eastleigh

Preliminary Surface Water Drainage Strategy

Status	Status Date	
DRAFT	OCT 2016	
Drawn	Checked	Date
SO	LW	24.10.2016
Scale	Number	Rev
1:2,500	10440-PDR-01	A

0 50 100 150 200 250
METRES

UNTIL TECHNICAL APPROVAL HAS BEEN OBTAINED FROM THE RELEVANT LOCAL AUTHORITIES, IT SHOULD BE UNDERSTOOD THAT ALL DRAWINGS ARE ISSUED AS PRELIMINARY AND NOT FOR CONSTRUCTION. SHOULD THE CONTRACTOR COMMENCE SITE WORK PRIOR TO APPROVAL BEING GIVEN, IT IS ENTIRELY AT HIS OWN RISK.

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Appendices B

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.382	0.382	35.4	2750.4	O K
30 min Summer	0.506	0.506	42.3	3679.7	O K
60 min Summer	0.636	0.636	48.4	4675.1	O K
120 min Summer	0.765	0.765	53.8	5683.3	O K
180 min Summer	0.834	0.834	56.5	6230.7	O K
240 min Summer	0.876	0.876	58.0	6570.6	O K
360 min Summer	0.934	0.934	60.1	7039.4	O K
480 min Summer	0.968	0.968	61.3	7316.0	O K
600 min Summer	0.989	0.989	62.0	7483.3	O K
720 min Summer	1.001	1.001	62.5	7579.0	O K
960 min Summer	1.010	1.010	62.8	7652.3	O K
1440 min Summer	1.015	1.015	63.0	7701.0	O K
2160 min Summer	1.007	1.007	62.7	7633.3	O K
2880 min Summer	0.987	0.987	62.0	7469.1	O K
4320 min Summer	0.933	0.933	60.1	7031.8	O K
5760 min Summer	0.875	0.875	58.0	6562.1	O K
7200 min Summer	0.821	0.821	56.0	6124.4	O K
8640 min Summer	0.771	0.771	54.0	5726.7	O K
10080 min Summer	0.725	0.725	52.2	5367.6	O K
15 min Winter	0.427	0.427	38.0	3081.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	121.090	0.0	1862.1	27
30 min Summer	81.353	0.0	2523.9	41
60 min Summer	52.120	0.0	4144.7	70
120 min Summer	32.198	0.0	5120.5	130
180 min Summer	23.910	0.0	5678.3	188
240 min Summer	19.209	0.0	6051.6	248
360 min Summer	14.146	0.0	6600.7	366
480 min Summer	11.363	0.0	6964.2	484
600 min Summer	9.579	0.0	7214.3	602
720 min Summer	8.327	0.0	7383.3	722
960 min Summer	6.669	0.0	7571.8	874
1440 min Summer	4.867	0.0	7623.3	1110
2160 min Summer	3.545	0.0	11115.2	1500
2880 min Summer	2.827	0.0	11683.5	1908
4320 min Summer	2.051	0.0	12119.8	2728
5760 min Summer	1.632	0.0	14151.3	3528
7200 min Summer	1.367	0.0	14781.1	4328
8640 min Summer	1.183	0.0	15289.9	5104
10080 min Summer	1.048	0.0	15646.5	5856
15 min Winter	121.090	0.0	2103.8	26

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
30 min Winter	0.565	0.565	45.1	4124.2	O K
60 min Winter	0.709	0.709	51.5	5242.4	O K
120 min Winter	0.853	0.853	57.2	6378.9	O K
180 min Winter	0.930	0.930	60.0	7000.4	O K
240 min Winter	0.977	0.977	61.6	7389.2	O K
360 min Winter	1.043	1.043	63.9	7932.1	O K
480 min Winter	1.083	1.083	65.2	8261.1	O K
600 min Winter	1.108	1.108	66.0	8469.5	O K
720 min Winter	1.124	1.124	66.5	8600.0	O K
960 min Winter	1.138	1.138	67.0	8714.4	O K
1440 min Winter	1.134	1.134	66.9	8686.5	O K
2160 min Winter	1.116	1.116	66.3	8534.4	O K
2880 min Winter	1.082	1.082	65.2	8248.8	O K
4320 min Winter	0.998	0.998	62.4	7555.4	O K
5760 min Winter	0.912	0.912	59.3	6857.5	O K
7200 min Winter	0.834	0.834	56.5	6226.8	O K
8640 min Winter	0.764	0.764	53.7	5670.9	O K
10080 min Winter	0.702	0.702	51.2	5183.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	81.353	0.0	2805.6	41
60 min Winter	52.120	0.0	4653.2	70
120 min Winter	32.198	0.0	5724.3	128
180 min Winter	23.910	0.0	6333.1	186
240 min Winter	19.209	0.0	6732.1	244
360 min Winter	14.146	0.0	7301.7	358
480 min Winter	11.363	0.0	7660.1	474
600 min Winter	9.579	0.0	7892.3	588
720 min Winter	8.327	0.0	8053.0	700
960 min Winter	6.669	0.0	8236.1	916
1440 min Winter	4.867	0.0	8265.9	1158
2160 min Winter	3.545	0.0	12436.0	1608
2880 min Winter	2.827	0.0	13039.4	2076
4320 min Winter	2.051	0.0	13373.1	2944
5760 min Winter	1.632	0.0	15865.3	3800
7200 min Winter	1.367	0.0	16572.1	4616
8640 min Winter	1.183	0.0	17146.8	5376
10080 min Winter	1.048	0.0	17564.4	6160

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 12.240

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	4.080	4	8	4.080	8	12	4.080

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	6965.8	0.400	7447.2	0.800	7944.7	1.200	8458.3
0.100	7084.6	0.500	7570.1	0.900	8071.6	1.300	8589.2
0.200	7204.5	0.600	7694.0	1.000	8199.5	1.400	8721.1
0.300	7325.3	0.700	7818.8	1.100	8328.4	1.500	8854.1

Orifice Outflow Control

Diameter (m) 0.177 Discharge Coefficient 0.600 Invert Level (m) 0.000

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.383	0.383	41.2	3223.1	O K
30 min Summer	0.508	0.508	49.4	4311.9	O K
60 min Summer	0.639	0.639	56.7	5478.3	O K
120 min Summer	0.769	0.769	63.1	6660.3	O K
180 min Summer	0.838	0.838	66.3	7302.4	O K
240 min Summer	0.881	0.881	68.2	7701.2	O K
360 min Summer	0.940	0.940	70.7	8251.7	O K
480 min Summer	0.974	0.974	72.1	8576.8	O K
600 min Summer	0.995	0.995	73.0	8773.8	O K
720 min Summer	1.007	1.007	73.5	8886.6	O K
960 min Summer	1.016	1.016	73.8	8975.4	O K
1440 min Summer	1.023	1.023	74.1	9038.7	O K
2160 min Summer	1.016	1.016	73.8	8967.1	O K
2880 min Summer	0.996	0.996	73.0	8780.5	O K
4320 min Summer	0.942	0.942	70.8	8275.7	O K
5760 min Summer	0.884	0.884	68.3	7730.1	O K
7200 min Summer	0.829	0.829	65.9	7219.7	O K
8640 min Summer	0.779	0.779	63.6	6755.1	O K
10080 min Summer	0.733	0.733	61.4	6335.5	O K
15 min Winter	0.428	0.428	44.3	3610.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	121.090	0.0	2128.0	27
30 min Summer	81.353	0.0	2908.1	41
60 min Summer	52.120	0.0	4803.0	70
120 min Summer	32.198	0.0	5944.7	130
180 min Summer	23.910	0.0	6597.4	188
240 min Summer	19.209	0.0	7034.7	248
360 min Summer	14.146	0.0	7683.4	366
480 min Summer	11.363	0.0	8116.9	484
600 min Summer	9.579	0.0	8420.1	602
720 min Summer	8.327	0.0	8630.2	722
960 min Summer	6.669	0.0	8859.5	866
1440 min Summer	4.867	0.0	8924.4	1108
2160 min Summer	3.545	0.0	12969.7	1496
2880 min Summer	2.827	0.0	13632.4	1908
4320 min Summer	2.051	0.0	14153.5	2728
5760 min Summer	1.632	0.0	16550.5	3528
7200 min Summer	1.367	0.0	17283.7	4328
8640 min Summer	1.183	0.0	17871.6	5104
10080 min Summer	1.048	0.0	18276.9	5856
15 min Winter	121.090	0.0	2410.9	26

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
30 min Winter	0.567	0.567	52.8	4832.6	O K
60 min Winter	0.712	0.712	60.4	6143.0	O K
120 min Winter	0.857	0.857	67.1	7475.1	O K
180 min Winter	0.935	0.935	70.5	8203.7	O K
240 min Winter	0.983	0.983	72.5	8659.8	O K
360 min Winter	1.050	1.050	75.2	9296.6	O K
480 min Winter	1.090	1.090	76.7	9682.7	O K
600 min Winter	1.116	1.116	77.7	9927.4	O K
720 min Winter	1.132	1.132	78.3	10080.9	O K
960 min Winter	1.146	1.146	78.8	10215.8	O K
1440 min Winter	1.143	1.143	78.7	10188.7	O K
2160 min Winter	1.125	1.125	78.0	10015.6	O K
2880 min Winter	1.091	1.091	76.7	9684.8	O K
4320 min Winter	1.006	1.006	73.4	8878.5	O K
5760 min Winter	0.920	0.920	69.9	8064.9	O K
7200 min Winter	0.841	0.841	66.4	7329.1	O K
8640 min Winter	0.771	0.771	63.2	6680.4	O K
10080 min Winter	0.709	0.709	60.2	6111.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	81.353	0.0	3244.8	41
60 min Winter	52.120	0.0	5398.1	70
120 min Winter	32.198	0.0	6651.5	128
180 min Winter	23.910	0.0	7365.9	186
240 min Winter	19.209	0.0	7837.2	244
360 min Winter	14.146	0.0	8516.0	358
480 min Winter	11.363	0.0	8950.5	474
600 min Winter	9.579	0.0	9235.5	588
720 min Winter	8.327	0.0	9427.1	700
960 min Winter	6.669	0.0	9646.3	914
1440 min Winter	4.867	0.0	9686.0	1156
2160 min Winter	3.545	0.0	14516.7	1608
2880 min Winter	2.827	0.0	15221.3	2072
4320 min Winter	2.051	0.0	15645.5	2944
5760 min Winter	1.632	0.0	18557.5	3800
7200 min Winter	1.367	0.0	19380.7	4608
8640 min Winter	1.183	0.0	20046.9	5368
10080 min Winter	1.048	0.0	20523.3	6160

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 14.340

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	4.780	4	8	4.780	8	12	4.780

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	8162.0	0.400	8682.5	0.800	9219.0	1.200	9771.6
0.100	8290.6	0.500	8815.1	0.900	9355.6	1.300	9912.3
0.200	8420.2	0.600	8948.7	1.000	9493.3	1.400	10054.0
0.300	8550.8	0.700	9083.4	1.100	9632.0	1.500	10196.7

Orifice Outflow Control

Diameter (m) 0.192 Discharge Coefficient 0.600 Invert Level (m) 0.000

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.342	0.342	38.5	349.5	O K
30 min Summer	0.435	0.435	45.3	454.2	O K
60 min Summer	0.514	0.514	50.2	545.5	O K
120 min Summer	0.559	0.559	52.9	599.2	O K
180 min Summer	0.571	0.571	53.5	613.7	O K
240 min Summer	0.570	0.570	53.5	612.7	O K
360 min Summer	0.559	0.559	52.9	598.9	O K
480 min Summer	0.539	0.539	51.7	575.6	O K
600 min Summer	0.517	0.517	50.4	549.7	O K
720 min Summer	0.495	0.495	49.1	523.7	O K
960 min Summer	0.454	0.454	46.5	475.2	O K
1440 min Summer	0.386	0.386	41.8	397.8	O K
2160 min Summer	0.316	0.316	36.4	321.0	O K
2880 min Summer	0.273	0.273	32.5	274.9	O K
4320 min Summer	0.228	0.228	25.1	227.3	O K
5760 min Summer	0.201	0.201	20.6	198.7	O K
7200 min Summer	0.182	0.182	17.7	179.5	O K
8640 min Summer	0.168	0.168	15.5	165.1	O K
10080 min Summer	0.157	0.157	13.7	153.8	O K
15 min Winter	0.380	0.380	41.4	392.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	121.090	0.0	362.0	24
30 min Summer	81.353	0.0	490.8	37
60 min Summer	52.120	0.0	641.3	62
120 min Summer	32.198	0.0	794.0	100
180 min Summer	23.910	0.0	885.1	134
240 min Summer	19.209	0.0	948.6	168
360 min Summer	14.146	0.0	1048.4	236
480 min Summer	11.363	0.0	1123.1	304
600 min Summer	9.579	0.0	1183.6	370
720 min Summer	8.327	0.0	1234.7	434
960 min Summer	6.669	0.0	1318.3	560
1440 min Summer	4.867	0.0	1441.9	808
2160 min Summer	3.545	0.0	1583.6	1168
2880 min Summer	2.827	0.0	1683.1	1508
4320 min Summer	2.051	0.0	1827.6	2248
5760 min Summer	1.632	0.0	1947.6	2952
7200 min Summer	1.367	0.0	2038.0	3680
8640 min Summer	1.183	0.0	2115.7	4408
10080 min Summer	1.048	0.0	2180.9	5144
15 min Winter	121.090	0.0	407.0	24

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
30 min Winter	0.484	0.484	48.4	510.9	O K
60 min Winter	0.572	0.572	53.6	615.7	O K
120 min Winter	0.620	0.620	56.3	674.4	O K
180 min Winter	0.629	0.629	56.7	684.8	O K
240 min Winter	0.622	0.622	56.3	675.9	O K
360 min Winter	0.596	0.596	55.0	644.4	O K
480 min Winter	0.563	0.563	53.1	604.2	O K
600 min Winter	0.529	0.529	51.1	563.4	O K
720 min Winter	0.496	0.496	49.2	524.6	O K
960 min Winter	0.437	0.437	45.4	456.4	O K
1440 min Winter	0.348	0.348	39.0	356.5	O K
2160 min Winter	0.272	0.272	32.3	273.3	O K
2880 min Winter	0.236	0.236	26.4	235.6	O K
4320 min Winter	0.194	0.194	19.6	192.0	O K
5760 min Winter	0.170	0.170	15.7	166.9	O K
7200 min Winter	0.153	0.153	13.1	150.2	O K
8640 min Winter	0.138	0.138	11.4	135.1	O K
10080 min Winter	0.127	0.127	10.2	123.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	81.353	0.0	551.3	37
60 min Winter	52.120	0.0	719.2	62
120 min Winter	32.198	0.0	890.1	108
180 min Winter	23.910	0.0	992.2	142
240 min Winter	19.209	0.0	1063.3	180
360 min Winter	14.146	0.0	1175.1	254
480 min Winter	11.363	0.0	1258.8	324
600 min Winter	9.579	0.0	1326.7	394
720 min Winter	8.327	0.0	1383.9	460
960 min Winter	6.669	0.0	1477.7	588
1440 min Winter	4.867	0.0	1616.4	834
2160 min Winter	3.545	0.0	1774.2	1172
2880 min Winter	2.827	0.0	1885.9	1532
4320 min Winter	2.051	0.0	2048.5	2252
5760 min Winter	1.632	0.0	2181.7	2992
7200 min Winter	1.367	0.0	2283.2	3744
8640 min Winter	1.183	0.0	2370.5	4488
10080 min Winter	1.048	0.0	2444.6	5152

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 1.660

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.553	4	8	0.553	8	12	0.553

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	945.3	0.400	1127.7	0.800	1326.2	1.200	1540.8
0.100	989.4	0.500	1175.8	0.900	1378.3	1.300	1596.9
0.200	1034.5	0.600	1224.9	1.000	1431.5	1.400	1654.1
0.300	1080.6	0.700	1275.1	1.100	1485.6	1.500	1712.3

Orifice Outflow Control

Diameter (m) 0.193 Discharge Coefficient 0.600 Invert Level (m) 0.000

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.383	0.383	41.6	3247.8	O K
30 min Summer	0.508	0.508	49.9	4344.9	O K
60 min Summer	0.639	0.639	57.3	5520.1	O K
120 min Summer	0.769	0.769	63.7	6710.9	O K
180 min Summer	0.838	0.838	67.0	7357.7	O K
240 min Summer	0.881	0.881	68.9	7759.2	O K
360 min Summer	0.940	0.940	71.4	8313.3	O K
480 min Summer	0.974	0.974	72.8	8640.3	O K
600 min Summer	0.995	0.995	73.7	8838.0	O K
720 min Summer	1.007	1.007	74.2	8951.1	O K
960 min Summer	1.016	1.016	74.6	9040.2	O K
1440 min Summer	1.023	1.023	74.8	9103.9	O K
2160 min Summer	1.015	1.015	74.5	9031.2	O K
2880 min Summer	0.996	0.996	73.7	8842.6	O K
4320 min Summer	0.942	0.942	71.5	8333.0	O K
5760 min Summer	0.884	0.884	69.0	7782.6	O K
7200 min Summer	0.829	0.829	66.5	7267.7	O K
8640 min Summer	0.778	0.778	64.2	6799.3	O K
10080 min Summer	0.733	0.733	62.0	6376.5	O K
15 min Winter	0.428	0.428	44.7	3638.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	121.090	0.0	2143.1	27
30 min Summer	81.353	0.0	2930.6	41
60 min Summer	52.120	0.0	4838.9	70
120 min Summer	32.198	0.0	5990.4	130
180 min Summer	23.910	0.0	6648.8	188
240 min Summer	19.209	0.0	7090.1	248
360 min Summer	14.146	0.0	7745.4	366
480 min Summer	11.363	0.0	8184.2	484
600 min Summer	9.579	0.0	8491.6	602
720 min Summer	8.327	0.0	8705.8	722
960 min Summer	6.669	0.0	8939.4	864
1440 min Summer	4.867	0.0	9006.8	1106
2160 min Summer	3.545	0.0	13069.4	1496
2880 min Summer	2.827	0.0	13739.0	1908
4320 min Summer	2.051	0.0	14270.1	2728
5760 min Summer	1.632	0.0	16676.5	3520
7200 min Summer	1.367	0.0	17415.4	4328
8640 min Summer	1.183	0.0	18007.6	5104
10080 min Summer	1.048	0.0	18415.7	5856
15 min Winter	121.090	0.0	2428.4	26

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
30 min Winter	0.567	0.567	53.3	4869.5	O K
60 min Winter	0.712	0.712	61.0	6189.8	O K
120 min Winter	0.857	0.857	67.8	7531.9	O K
180 min Winter	0.935	0.935	71.2	8265.8	O K
240 min Winter	0.983	0.983	73.2	8725.0	O K
360 min Winter	1.050	1.050	75.9	9366.0	O K
480 min Winter	1.090	1.090	77.5	9754.4	O K
600 min Winter	1.116	1.116	78.5	10000.3	O K
720 min Winter	1.132	1.132	79.1	10154.2	O K
960 min Winter	1.145	1.145	79.6	10288.9	O K
1440 min Winter	1.143	1.143	79.5	10261.4	O K
2160 min Winter	1.125	1.125	78.8	10085.7	O K
2880 min Winter	1.090	1.090	77.5	9751.0	O K
4320 min Winter	1.006	1.006	74.1	8936.9	O K
5760 min Winter	0.919	0.919	70.5	8116.2	O K
7200 min Winter	0.840	0.840	67.1	7374.3	O K
8640 min Winter	0.770	0.770	63.8	6720.9	O K
10080 min Winter	0.708	0.708	60.8	6147.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	81.353	0.0	3271.0	41
60 min Winter	52.120	0.0	5439.1	70
120 min Winter	32.198	0.0	6703.4	128
180 min Winter	23.910	0.0	7424.2	186
240 min Winter	19.209	0.0	7900.3	244
360 min Winter	14.146	0.0	8587.0	358
480 min Winter	11.363	0.0	9027.8	474
600 min Winter	9.579	0.0	9318.1	588
720 min Winter	8.327	0.0	9512.2	700
960 min Winter	6.669	0.0	9734.8	914
1440 min Winter	4.867	0.0	9776.6	1154
2160 min Winter	3.545	0.0	14629.4	1608
2880 min Winter	2.827	0.0	15341.4	2072
4320 min Winter	2.051	0.0	15779.5	2944
5760 min Winter	1.632	0.0	18699.1	3800
7200 min Winter	1.367	0.0	19528.4	4608
8640 min Winter	1.183	0.0	20199.9	5368
10080 min Winter	1.048	0.0	20679.7	6160

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 14.450

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	4.817	4	8	4.817	8	12	4.817

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	8224.6	0.400	8747.0	0.800	9285.5	1.200	9840.1
0.100	8353.7	0.500	8880.1	0.900	9422.6	1.300	9981.2
0.200	8483.8	0.600	9014.2	1.000	9560.8	1.400	10123.4
0.300	8614.9	0.700	9149.4	1.100	9699.9	1.500	10266.6

Orifice Outflow Control

Diameter (m) 0.193 Discharge Coefficient 0.600 Invert Level (m) 0.000

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.384	0.384	46.5	3662.1	O K
30 min Summer	0.509	0.509	55.9	4899.1	O K
60 min Summer	0.641	0.641	64.4	6224.5	O K
120 min Summer	0.771	0.771	71.7	7567.9	O K
180 min Summer	0.842	0.842	75.4	8298.2	O K
240 min Summer	0.885	0.885	77.6	8751.9	O K
360 min Summer	0.944	0.944	80.5	9378.5	O K
480 min Summer	0.979	0.979	82.1	9748.9	O K
600 min Summer	1.000	1.000	83.1	9973.7	O K
720 min Summer	1.012	1.012	83.7	10102.7	O K
960 min Summer	1.022	1.022	84.1	10206.4	O K
1440 min Summer	1.029	1.029	84.4	10284.4	O K
2160 min Summer	1.022	1.022	84.1	10210.5	O K
2880 min Summer	1.003	1.003	83.2	10004.2	O K
4320 min Summer	0.950	0.950	80.7	9438.7	O K
5760 min Summer	0.892	0.892	77.9	8823.8	O K
7200 min Summer	0.837	0.837	75.2	8246.3	O K
8640 min Summer	0.786	0.786	72.5	7720.3	O K
10080 min Summer	0.740	0.740	70.1	7244.9	O K
15 min Winter	0.429	0.429	50.1	4102.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	121.090	0.0	2365.1	27
30 min Summer	81.353	0.0	3254.1	41
60 min Summer	52.120	0.0	5404.3	70
120 min Summer	32.198	0.0	6699.6	130
180 min Summer	23.910	0.0	7440.2	188
240 min Summer	19.209	0.0	7936.8	248
360 min Summer	14.146	0.0	8677.2	366
480 min Summer	11.363	0.0	9175.8	484
600 min Summer	9.579	0.0	9528.0	602
720 min Summer	8.327	0.0	9776.7	722
960 min Summer	6.669	0.0	10050.1	864
1440 min Summer	4.867	0.0	10128.2	1104
2160 min Summer	3.545	0.0	14681.5	1496
2880 min Summer	2.827	0.0	15431.0	1908
4320 min Summer	2.051	0.0	16028.9	2728
5760 min Summer	1.632	0.0	18772.1	3520
7200 min Summer	1.367	0.0	19600.5	4328
8640 min Summer	1.183	0.0	20260.5	5104
10080 min Summer	1.048	0.0	20708.9	5856
15 min Winter	121.090	0.0	2685.7	26

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
30 min Winter	0.568	0.568	59.8	5490.5	O K
60 min Winter	0.714	0.714	68.6	6979.4	O K
120 min Winter	0.860	0.860	76.4	8493.4	O K
180 min Winter	0.939	0.939	80.2	9321.7	O K
240 min Winter	0.988	0.988	82.5	9840.4	O K
360 min Winter	1.055	1.055	85.6	10564.7	O K
480 min Winter	1.096	1.096	87.4	11004.1	O K
600 min Winter	1.122	1.122	88.6	11282.8	O K
720 min Winter	1.138	1.138	89.3	11457.6	O K
960 min Winter	1.152	1.152	89.9	11612.1	O K
1440 min Winter	1.149	1.149	89.7	11586.6	O K
2160 min Winter	1.132	1.132	89.0	11395.4	O K
2880 min Winter	1.098	1.098	87.5	11023.4	O K
4320 min Winter	1.013	1.013	83.7	10113.9	O K
5760 min Winter	0.927	0.927	79.6	9193.9	O K
7200 min Winter	0.848	0.848	75.7	8361.2	O K
8640 min Winter	0.777	0.777	72.1	7627.2	O K
10080 min Winter	0.715	0.715	68.6	6982.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	81.353	0.0	3641.7	41
60 min Winter	52.120	0.0	6079.4	70
120 min Winter	32.198	0.0	7501.9	128
180 min Winter	23.910	0.0	8313.4	186
240 min Winter	19.209	0.0	8851.8	244
360 min Winter	14.146	0.0	9631.9	358
480 min Winter	11.363	0.0	10137.3	474
600 min Winter	9.579	0.0	10475.3	588
720 min Winter	8.327	0.0	10698.2	700
960 min Winter	6.669	0.0	10951.7	914
1440 min Winter	4.867	0.0	11001.3	1154
2160 min Winter	3.545	0.0	16438.1	1608
2880 min Winter	2.827	0.0	17235.9	2072
4320 min Winter	2.051	0.0	17743.0	2944
5760 min Winter	1.632	0.0	21051.3	3800
7200 min Winter	1.367	0.0	21981.3	4608
8640 min Winter	1.183	0.0	22731.3	5368
10080 min Winter	1.048	0.0	23259.7	6160

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.800	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 16.290

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	5.430	4	8	5.430	8	12	5.430

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	9273.2	0.400	9827.4	0.800	10397.7	1.200	10984.1
0.100	9410.2	0.500	9968.5	0.900	10542.8	1.300	11133.2
0.200	9548.3	0.600	10110.6	1.000	10688.9	1.400	11283.4
0.300	9687.4	0.700	10253.6	1.100	10836.0	1.500	11434.5

Orifice Outflow Control

Diameter (m) 0.205 Discharge Coefficient 0.600 Invert Level (m) 0.000

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