BRADLEY VILLA FARM, BRADLEY ROAD, BRADLEY, HUDDERSFIELD, HD2 2JX

FLOOD RISK ASSESSMENT
FINAL REPORT V1.3

May 2021

Weetwood
Suite C22
Joseph's Well
Hanover Walk
Leeds
LS3 1AB

0113 244 1377
info@weetwood.net
www.weetwood.net

Report Title	**Bradley Villa Farm, Bradley Road, Bradley, Huddersfield, HD2 2JX** Flood Risk Assessment Final Report v1.3
Client	Redrow Homes (Yorkshire) Ltd, R. Kershaw and S. Gill
Date of issue	4 May 2021

Prepared by	Keely Bonser BSc (Hons) MSc PhD Associate Director
Checked and Approved by	Kevin Tilford BSc MSc PhD MBA CEnv CWEM FCIWEM Managing Director

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1 INTRODUCTION

1.1 Background

Weetwood Services Ltd ('Weetwood') has been instructed by Redrow Homes (Yorkshire) Ltd, R. Kershaw and S. Gill to prepare a Flood Risk Assessment (FRA) report for the proposed development of land at Bradley Villa Farm, Bradley, Huddersfield ("the site").

The assessment has been undertaken in accordance with the requirements of the revised National Planning Policy Framework (NPPF) updated on 19 June 2019 and the National Planning Practice Guidance (NPPG) updated on 1 October 2019.

The site is allocated for housing (site reference HS11) in the adopted Kirklees Local Plan (2019). Flood Risk and Drainage Assessment (FRDA) reports have been prepared by Weetwood[1] for the "Bradley Villa Farm Phase of Development" of the site (referred to as "BVF Phase" in **Figure 1**; for consistency within this report, it will be referred to as BVF Phase) and by Alan Wood and Partners[2] for "Land at Tithe House Way" (see **Figure 1**). Both assessments are reported separately and referenced in **Section 1.3** and in Footnotes 1 and 2. For completeness, both parcels of land are included within this report including a summary of the proposed surface water drainage strategies outlined within the FRDA reports.

1.2 Structure of the Report

The report is structured as follows:

Section 1	Introduction and report structure
Section 2	Provides background information relating to the development site
Section 3	Presents national and local flood risk and drainage planning policy
Section 4	Assesses the potential sources of flooding to the development site
Section 5	Presents flood risk mitigation measures based on the findings of the assessment
Section 6	Addresses the effect of the proposed development on surface water runoff and presents an illustrative surface water drainage scheme
Section 7	Presents a summary of key findings and the recommendations

1.3 Relevant Documents

The assessment has been informed by the following documents:

- Calder Catchment Strategic Flood Risk Assessment (SFRA), Volume I, Kirklees Council, Calderdale Metropolitan Borough Council and Wakefield Council, April 2016
- Calder Catchment Strategic Flood Risk Assessment (SFRA), Volume II, Kirklees Council, July 2016
- Bradley Golf Course Flood Risk and Drainage Plan Report for Kirklees Council, Revision P1, RES Environmental Ltd, March 2018
- Bradley Villa Farm Phase of Development, Bradley Road, Bradley, Huddersfield, HD2 2JX, Flood Risk and Drainage Assessment, Final Report v1.5, Weetwood, May 2021
- Flood Risk and Drainage Assessment for Cushman and Wakefield Debenham Tie Leung Limited, Proposed Development – Land at Tithe House Way, Bradley Park (Phase 1), Huddersfield, West Yorkshire, HD2 1RD, Alan Wood and Partners, December 2019 (Issue G)

[1] Bradley Villa Farm Phase of Development, Bradley Road, Bradley, Huddersfield, HD2 2JX, Flood Risk and Drainage Assessment, Final Report v1.5, Weetwood, May 2021

[2] Flood Risk and Drainage Assessment for Cushman and Wakefield Debenham Tie Leung Limited, Proposed Development – Land at Tithe House Way, Bradley Park (Phase 1), Huddersfield, West Yorkshire, HD2 1RD, Alan Wood and Partners, December 2019 (Issue G)

2 SITE DETAILS AND PROPOSED DEVELOPMENT

2.1 Site Location

The approximately 71 hectare (ha) greenfield site is located at Bradley Villa Farm and Bradley Park Golf Course, Bradley, Huddersfield at Ordnance Survey National Grid Reference SE 158 208, as indicated by the red line on **Figure 1**. The purple and orange lines on **Figure 1** indicates Parcels R and A respectively.

The site is located to the north of Bradley Road, to the east of Bradford Road, to the west of Bradley Park Waste Management and a residential estate and to the south of woodland and the M62. Bradley Park Golf Course and Driving Range is located within the site outline.

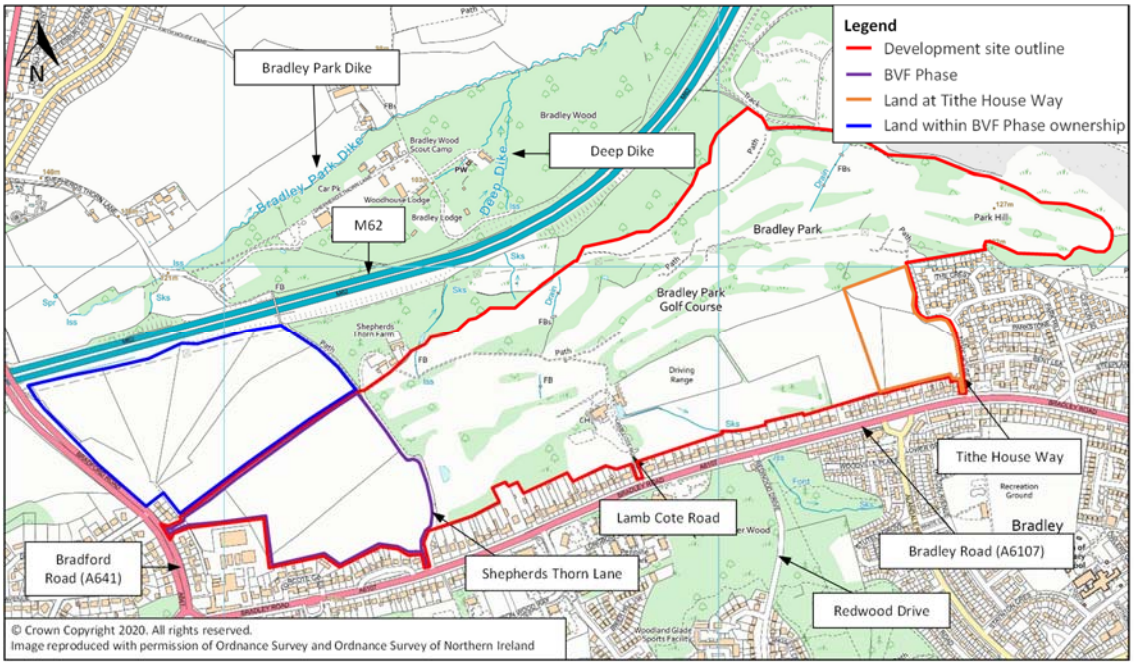

Figure 1: Site Location

2.2 Existing and Proposed Development

The development proposals are for a residential led mixed-use garden suburb development comprising circa 1,958 dwellings, a two-form entry primary school, a local centre, landscaping/greenspace and associated infrastructure. A concept masterplan is provided in **Appendix A**.

The NPPG classifies residential and educational development as More Vulnerable to flood risk.

2.3 Waterbodies in the Vicinity of the Site

Bradley Park Dike flows predominantly in a north-easterly direction a minimum of approximately 330 m to the north of the site. Based on OS mapping, it is assumed that Bradley Park Dike flows into the Calder and Hebble Navigation Kirklees Cut approximately 500 m to the north of the eastern portion of the site.

Deep Dike issues within the western portion of the site near to the northern boundary and flows in a north-easterly direction towards Bradley Park Dike approximately 380 m to the north of the site.

The River Calder, a designated main river, is located approximately 520 m to the north of the site. The Calder and Hebble Navigation Kirklees Cut spurs off the right bank of the River Calder approximately 500 m north of the site.

Two unnamed watercourses are indicated to emerge on site (for the purposes of this report, these are referred to as Unnamed Watercourse 1 (UW1) and UW2; it is unclear from OS mapping where UW1 and UW2 flow to although UW1 appears to flow into a pond.

The FRDA report prepared by Alan Wood and Partners[2] states that a previous drainage assessment concluded that the pond does not appear to have any outfalls, and that based on Flood Risk from Surface Water mapping (see **Figure 4,**) flow from this pond may follow a route along the northern boundary of the site and then adjacent to the M62 potentially discharging to Bradley Park Dike via a culvert under the M62 to the north.

The FRDA report states that UW2 leaves the site via a culverted course between dwellings on Bradley Road near to Redwood Drive, eventually connecting into a watercourse located in Screamer Wood adjacent to Redwood Drive.

In addition, the report identifies a culverted land drain located in the south-eastern corner of Land at Tithe House Way.

Larger rivers and streams are usually designated as 'main river'; other rivers are called 'ordinary watercourses'. All ordinary watercourses are shown in **Figure 2**.

The Environment Agency carries out maintenance, improvement and construction work on main rivers to manage flood risk. Lead local flood authorities, district councils and internal drainage boards carry out flood risk management work on ordinary watercourses.

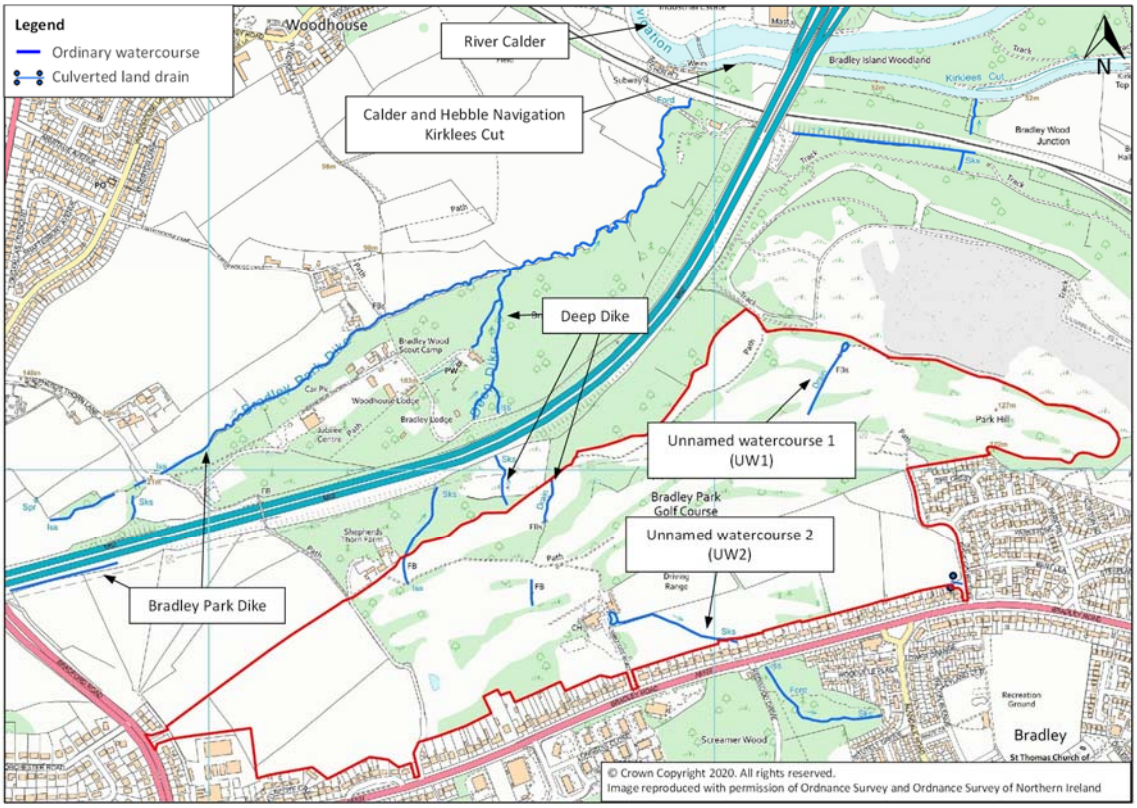

Figure 2: Location of Ordinary Watercourses

2.4 Ground Conditions

A geo-environmental appraisal of BVF Phase was undertaken in March 2019 by Lithos[3]. Fieldwork was undertaken between 12 and 14 February 2019 and included 41 No. trial pits up to depths of 3.1 m and soakaway tests within six trial pits.

The appraisal report described ground conditions as follows:

- Topsoil: Slightly sandy slightly gravelly clay up to a typical depth of 300 mm
- Cohesive residual soil: Slightly sandy slightly gravelly clay up to a depth of 1.9 m
- Granular residual soil: Slightly clayey sands and gravel/cobble encountered below the cohesive residual soils up to a depth of 3.0 m
- Bedrock: Encountered at the base of each trial pit up to a depth of 3.1 m

Groundwater seepages were encountered in six trial pits between depths of 1.2 m and 2.4 m.

Soakaway tests were carried out in general accordance with BRE 365[4] to determine infiltration rates. Water levels did not fall sufficiently to enable an infiltration rate to be determined in five of the trial pits. The report concluded that soakaways are unlikely to provide a suitable drainage solution for the discharge of surface water runoff at the site.

A Phase 1 geo-environmental appraisal was undertaken for Land at Tithe House Way in October 2018 by Alan Wood and Partners[5]. The report indicates that the underlying bedrock formation comprises Pennine Lower Coal Measures Formation (mudstone, siltstone and sandstone) and that no superficial deposits were recorded.

As part of the Land at Tithe House Way FRDA report fieldwork was undertaken comprising of foul trial pits. Ground conditions are described as predominantly clayey up to a depth of 0.8 m bgl underlain by Pennine Lower Coal Measures.

British Geological Survey mapping of surface geology[6] indicates that the underlying bedrock at the site comprises of a combination of Pennine Lower Coal Measures Formation (mudstone, siltstone and sandstone) and Thick Stone (sandstone). No superficial deposits are recorded.

The National Geoscience Data Centre's Single Onshore Borehole Index[7] holds records of two on-site boreholes and a number of boreholes in the vicinity of the site, in particular along the course of the M62. Records indicate that ground conditions comprise of layers of clay, sandstone, siltstone and shale.

According to the MAGIC website[8] the underlying bedrock is classified as a Secondary A aquifer. The site is not shown to be located within a designated groundwater source protection zone.

2.5 Site Levels

LiDAR data has been used to develop a digital terrain model of the site and surrounding area as illustrated in **Figure 3**. Ground levels range between approximately 93.8 metres Above Ordnance Datum (m AOD) to 168.5 m AOD with levels generally falling in a north-easterly/easterly direction. The south-eastern portion of the site falls in a south-easterly direction.

[3] Land at Bradley Villa Park, Huddersfield. Geoenvironmental Appraisal. Lithos, March 2019
[4] BRE Digest 365 Soakaway Design, Building Research Establishment, 2016
[5] Phase 1 Geo-Environmental Assessment Report and Coal Mining Risk Assessment, Tithe House Way, Bradley Park, Huddersfield, HD2 1RD, Alan Wood and Partners, October 2018
[6] http://mapapps.bgs.ac.uk/geologyofbritain/home.html
[7] https://www.bgs.ac.uk/products/onshore/SOBI.html
[8] https://magic.defra.gov.uk/MagicMap.aspx

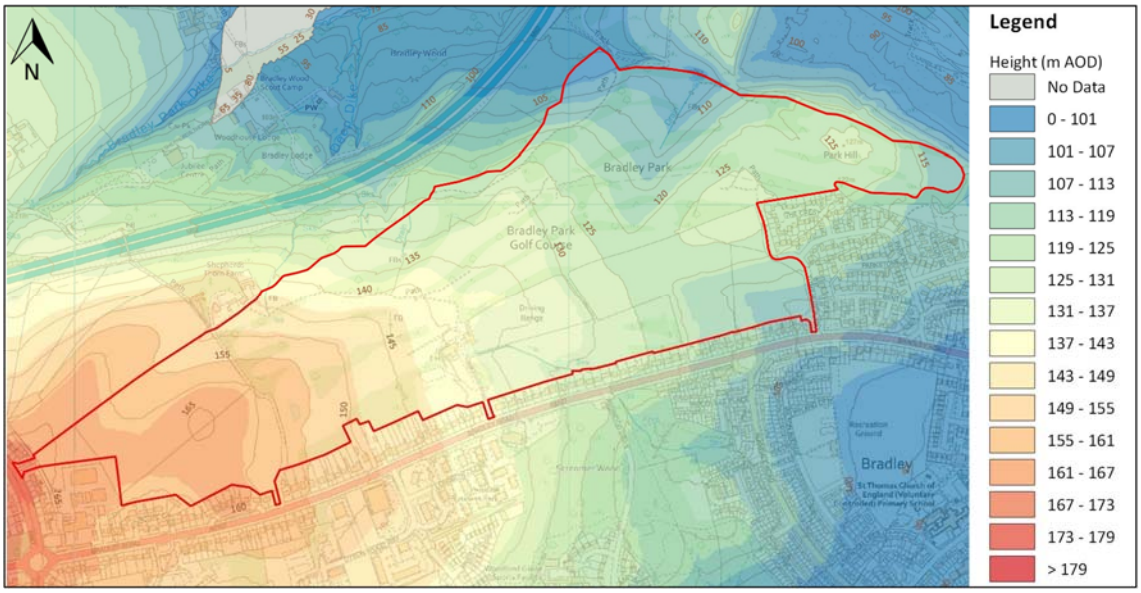

Figure 3: Digital Terrain Model from Topographic Survey

2.6 Access and Egress

The site is accessed via Bradford Road and via Shepherds Thorn Lane, Lamb Cote Road and Tithe House Way off Bradley Road. Approximate ground levels at the site access points are as follows:

- Bradford Road: 168.5 m AOD
- Shepherds Thorn Lane: 157.9 m AOD
- Lamb Cote Road: 137.8 m AOD
- Tithe House Way: 108.9 m AOD

2.7 Flood Zone Designation

Flood zones refer to the probability of river and sea flooding. Table 1 of the NPPG defines flood zones as follows[9]:

- Flood zone 1: Low Probability. Land having a less than 1 in 1,000 annual probability of river or sea flooding
- Flood zone 2: Medium Probability. Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding
- Flood zone 3a: High Probability. Land having a 1 in 100 or greater annual probability of river flooding or a 1 in 200 or greater annual probability of sea flooding
- Flood zone 3b: Functional Floodplain. Land where water has to flow or be stored in times of flood.

The flood zones are shown on the Environment Agency Flood Map for Planning (Rivers and Sea)[10].

The flood zones shown on the flood map are defined by the predicted extent of flooding during the present day 1 in 100 (non-tidal rivers), 1 in 200 (tidal rivers and sea) and 1 in 1,000 (rivers and sea) annual exceedance probability (AEP) events. The zones do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

[9] https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables
[10] https://flood-map-for-planning.service.gov.uk/

Flood zone 3b (functional floodplain) is not separately distinguished on the Flood Map for Planning but is usually identified by local planning authorities in their SFRAs. The boundary of flood zone 3b is normally defined as land that would flood during the present day 1 in 20 AEP event, although definitions may vary particularly in some districts and in urban areas.

Where an area benefits from formal flood defences providing a minimum standard of protection, the defended area may be indicated as an area benefiting from flood defences. However, not all areas are shown as such, and unless specifically indicated, the Flood Map for Planning conservatively shows land at risk of flooding in the absence of flood defences.

The Environment Agency Flood Map for Planning (**Figure 4**) indicates the site to be located in flood zone 1. Map K of the SFRA reaffirms the sites flood zone 1 designation.

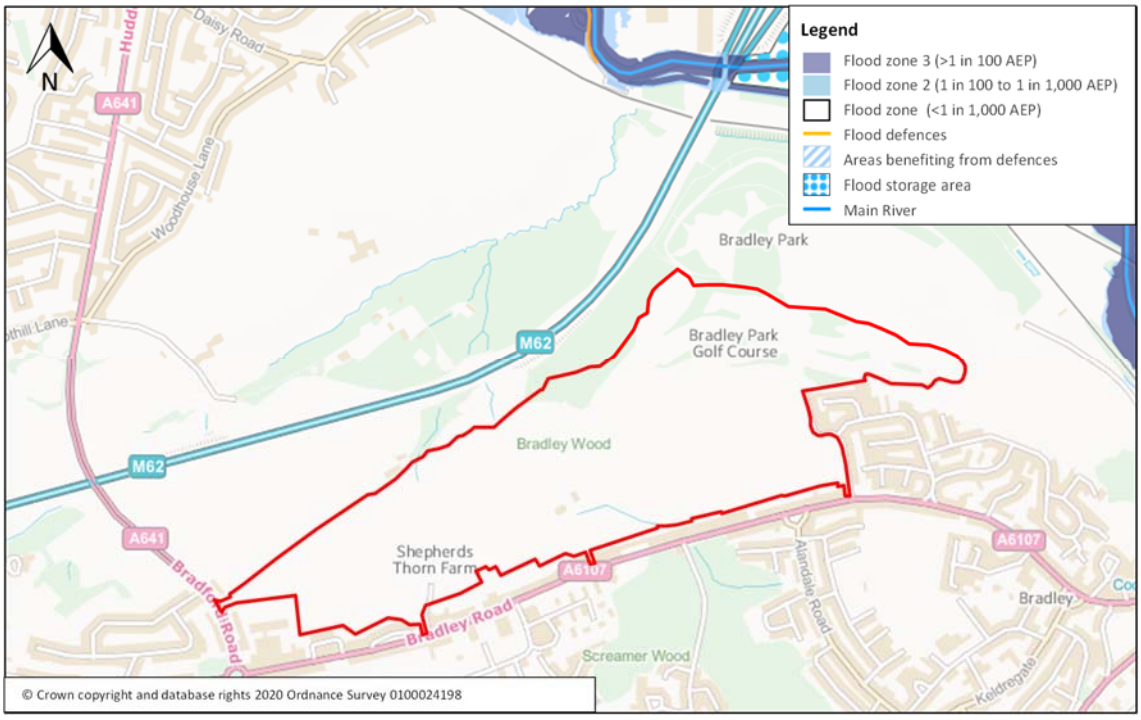

Figure 4: Flood Map for Planning
Source: gov.uk website; Accessed: March 2021

3 PLANNING POLICY AND GUIDANCE

3.1 National Requirements

3.1.1 Water Framework Directive

The Water Framework Directive (WFD) provides a legal framework for the protection, improvement and sustainable use of inland surface waters, groundwater, transitional waters, and coastal waters across England, and seeks to:

- Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters
- Achieve at least 'good' status for all waterbodies by 2015
- Promote the sustainable use of water as a natural resource
- Conserve habitats and species that depend directly on water
- Progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants; and
- Contribute to mitigating the effects of floods and droughts.

The WFD applies to any proposed development which has the potential to impact on a waterbody. Where this is the case, the Environment Agency may require evidence demonstrating that the proposed development does not compromise the aims of the WFD.

3.1.2 National Planning Policy Framework

The NPPF sets out government's planning policies for England and how these are expected to be applied. The NPPF seeks to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

Footnote 50 of the NPPF states that a site-specific flood risk assessment should be submitted for all development proposed in flood zone 2 and flood zone 3 whilst in flood zone 1, an assessment should accompany all proposals involving: sites of 1 ha or more; land identified as having critical drainage problems or as being at increased flood risk in future; or land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

NPPF paragraph 155 states that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk but accepts that where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere. The policy of seeking to direct development away from areas at highest risk of flooding is implemented through the application of the sequential test (NPPF paragraph 158).

Paragraph 159 of the NPPF states that if it is not possible for a development to be located in zones with a lower risk of flooding, taking into account wider sustainable development objectives, the exception test may have to be applied.

The need for the exception test will depend on the flood zone of the site and the vulnerability of the development proposed (as set out in NPPG Table 2 and 3).

NPPF paragraph 160 states that application of the exception test for development proposals at the application stage should be informed by a site-specific flood risk assessment. For the test to be passed it should be demonstrated that: the development would provide wider sustainability benefits to the community that outweigh the flood risk; and the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

NPPF Paragraph 161 states that both elements of the exception test should be satisfied for development to be permitted.

NPPF paragraph 163 states that development should only be allowed in areas at risk of flooding if it incorporates sustainable drainage systems (SuDS) unless there is clear evidence that this would be inappropriate. NPPF paragraph 165 states that applications for major developments should incorporate sustainable drainage systems to appropriate operational standards and with maintenance arrangements in place unless there is clear evidence that this would be inappropriate.

3.1.3 National Guidance

Non-statutory technical standards for sustainable drainage published by DEFRA in March 2015 set out how surface water runoff generated during the present day 1 in 30 and 1 in 100 AEP rainfall events and for events exceeding the present day 1 in 100 AEP event should be managed, how peak runoff rates should be restricted and how runoff volumes should be controlled.

3.2 Local Planning Policy and Guidance

The Kirklees Local Plan was adopted on 27 February 2019. The following policies are relevant in respect of flood risk and drainage:

- Policy LP5: Masterplanning Sites Part M states, in part, that masterplans will be expected to provide appropriate measures to mitigate flood risk and ensure that the development is resilient to the potential impacts of climate change.
- Policy LP24: Design Part D vii states, in part, that proposals should promote good design by ensuring high levels of sustainability through designing buildings that are resilient and resistant to flood risk.
- Policy LP27: Flood Risk is summarised as follows:
    - *Proposals for development which require a Sequential Test will need to demonstrate that development has been directed to areas at the lowest probability of flooding, following a sequential risk-based approach*
    - *Proposals within flood zone 3ai will be assessed in accordance with national policies relating to flood zone 3a but with all of the following additional restrictions: No new highly vulnerable or more vulnerable uses will be permitted; Less vulnerable uses may only be permitted where the sequential test has been passed and where extensions are linked operationally to an existing business or where redevelopment of a site provides buildings with the same or a smaller footprint*
    - *All proposals will be expected to include flood mitigation measures which should be identified and considered through a site-specific flood risk assessment*
    - *Development will not be permitted within the functional floodplain*
- Policy LP28: Drainage is summarised as follows:
    - *SuDS will be used to assist in achieving the following:*
        - *Greenfield runoff rates should not be exceeded*
        - *Brownfield sites should have a minimum 30% reduction in runoff where previous positive surface water connections from the site can be proven. New connections will be subject to at least greenfield restrictions*
        - *No negative impact on local water quality*
        - *Consider whether proposed open spaces and green infrastructure within sites can contribute to sustainable drainage of the site*
    - *Local conditions may require a lower runoff rate to be agreed to reflect volume control, local surface water risks, watercourse capacity and flood risk further downstream*
    - *There will be a general presumption against pumping surface water. Also demonstrate that the surface water management solution is designed for the lifetime of the development including maintenance arrangements*
    - *Accommodate flow paths by ensuring paths are designed to avoid buildings and curtilages*
    - *Development will only be permitted if water supply and waste water infrastructure is available or can be co-ordinated to meet the demand from the new development.*

3.3 Land Drainage Consent

Land drainage consent may be required from the lead local flood authority or drainage board for work to an ordinary watercourse.

Undertaking activities controlled by local byelaws also requires the relevant consent.

4 REVIEW OF FLOOD RISK

4.1 Sequential Test and Exception Test

The site is located within flood zone 1. As such the proposals satisfy the requirements of the sequential test and the exception test need not be applied. Nevertheless, the proposals are still required to meet the requirements for site specific flood risk assessments.

4.2 Historical Records of Flooding

There are no records of historic flooding at the site in the SFRA or in the Environment Agency's Recorded Flood Outlines database[11].

4.3 Fluvial Flood Risk

The Flood Map for Planning only presents flood outlines for watercourses with a catchment area greater than 3.0 km²; land in the vicinity of watercourses with a smaller catchment area is shown to be in flood zone 1 by default. As such, the flood map may not represent flood risk from small watercourses.

The catchment area for Bradley Park Dike (including Deep Dike) is 1.64 km² i.e. below the 3.0 km² mapping threshold. UW1 and UW2 are not recognised on the FEH web service. In instances such as this, the Flood Risk from Surface Water map provides a useful proxy for fluvial flood risk.

The Flood Risk from Surface Water map (**Figure 5** and **Figure 6**) indicates that land adjacent to the on-site watercourses are at Low risk of flooding during extreme events, and therefore, there may be some propensity for localised flooding from the on-site watercourses with flood depths predominately less than 300 mm.

4.4 Flood Risk from Surface Water

The Flood Risk from Surface Water map (**Figure 5**) indicates that the site is predominantly at Very Low risk of flooding from surface water. A small number of surface water flow paths are indicated to be present on-site, however, most of the flow paths coincide with the on-site watercourses and as such, the risk of flooding is assumed to be associated with the watercourses. A surface water flow path is indicated to be present in the south-eastern corner of the site where the natural contours of the land forms a shallow swale feature where overland flow would be directed. The risk and extent of surface water flow paths, however, are reduced during less extreme events (**Figure 6**).

4.5 Flood Risk from Reservoirs, Canals and Other Artificial Sources

The site is a minimum of approximately 40 m above ground levels adjacent to the canal. Given the difference in elevation levels, the site is not considered to be at risk of flooding from this source. There are no other impounded waterbodies located within the immediate vicinity of the site. The Flood Risk from Reservoirs map indicates that the site is not at risk of flooding from such sources. The site is therefore not assessed to be at risk of flooding from reservoirs, canals or other artificial sources.

4.6 Flood Risk from Groundwater

The JBA Groundwater Flood Risk Indicator map (**Figure 7**) indicates that the site is at Negligible to Very Low risk of flooding from groundwater i.e. peak groundwater levels are at least 5.0 m below the ground surface during a 100 year return period event.

[11] https://data.gov.uk/dataset/16e32c53-35a6-4d54-a111-ca09031eaaaf/recorded-flood-outlines

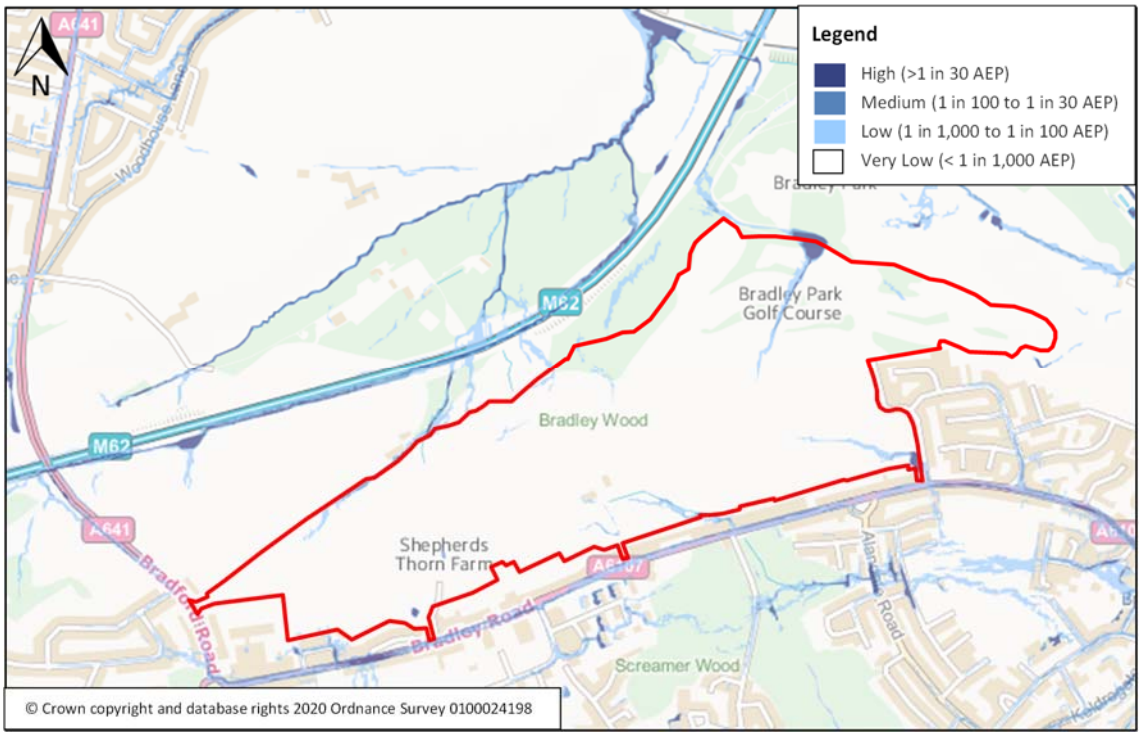

Figure 5: Flood Risk from Surface Water
Source: gov.uk website; Accessed: March 2021

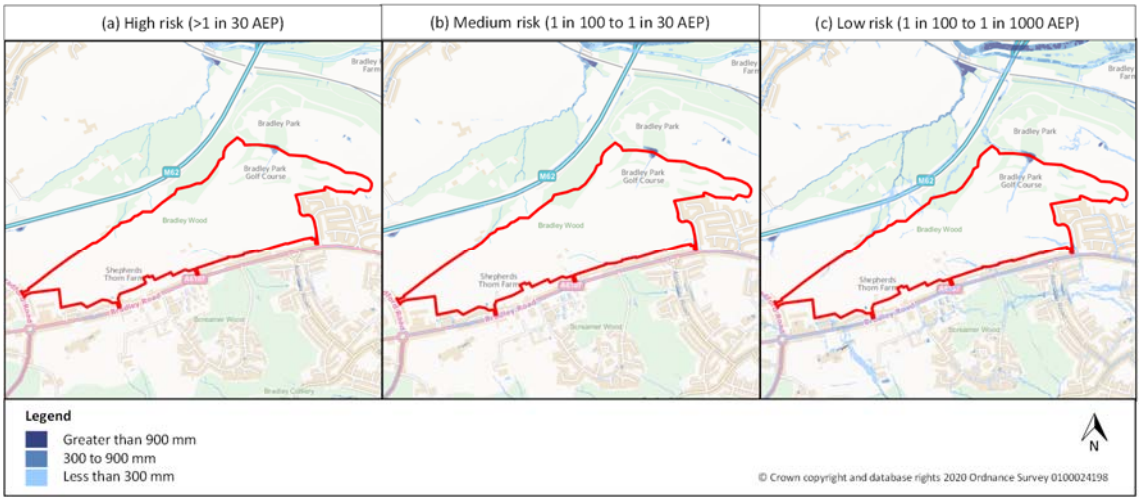

Figure 6: Flood Risk from Surface Water - Depth
Source: gov.uk website; Accessed: March 2021

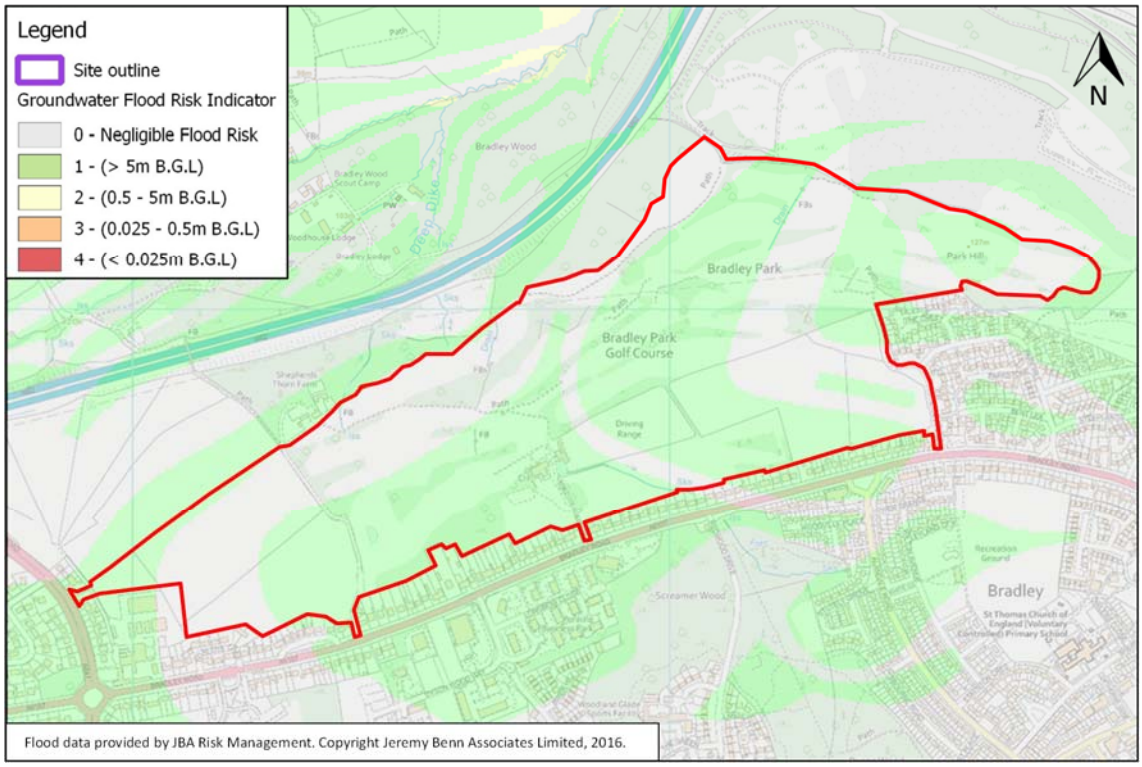

Figure 7: JBA Groundwater Flood Risk Indicator Map
Source: Blue Sky Maps; Accessed: September 2020

5 FLOOD RISK MITIGATION MEASURES

The risk of flooding to the proposed development from local watercourses and surface water will be mitigated through the implementation of the measures proposed within the following section of this report.

5.1 Finished Floor Levels

Finished floor levels should be set at a minimum of 0.15 m above adjacent ground levels following any reprofiling of the site.

This will, subject to the implementation of an appropriately designed surface water drainage scheme (**Section 6**), enable any potential overland flows to be conveyed safely across the site without affecting property in accordance with the approach promoted by government policy[12].

5.2 Bridge Design Principles

The conveyance capacity of any new culverts or bridges over Deep Dike and/or UW2 should maintain existing channel conveyance capacity so as not to increase flood risk; further details are to be provided at the detailed design stage.

5.3 Drain Maintenance

A maintenance regime should be implemented to minimise the risk of channel and/or culvert blockage.

[12] Making Space for Water, Taking forward a new Government strategy for flood and coastal erosion risk management in England, March 2005, Dept for Environment, Food and Rural Affairs

6 SURFACE WATER MANAGEMENT

6.1 Surface Water Drainage at the Existing Site

The site is undeveloped greenfield. As detailed in the RES report, the golf course has a complex drainage system, consisting of field drains and open drainage ditches; most of these ditches were reported to be dry during a site (March 2018) despite much of the ground being saturated with pooled water within localised low spots thus demonstrating poor drainage or saturated land.

Given site topography and ground conditions, surface water runoff would be expected to flow overland in a direction determined by local topography and slowly infiltrate where conditions allow.

The greenfield surface water runoff rates for the site, calculated using the ICP SUDS method within MicroDrainage are presented in **Table 1**. Details of the input parameters and the output results are provided in **Appendix B**.

Table 1: Greenfield Runoff Rate

AEP of Rainfall Event	Greenfield Runoff Rate (l/s/ha)
1 in 1	5.3
QBAR	6.3
1 in 30	11.1
1 in 100	13.2

6.2 Surface Water Drainage at the Developed Site

6.2.1 Disposal of Surface Water

In accordance with the NPPG[13], surface water runoff should be disposed of according to the following hierarchy: Into the ground (infiltration); To a surface water body; To a surface water sewer, highway drain, or another drainage system; To a combined sewer.

As stated in **Section 2.4,** infiltration testing has been undertaken within the BVF Phase. The results show that soakaways are unlikely to provide a suitable drainage solution for the discharge of surface water runoff. Based on ground conditions for the remainder of the site, including Land at Tithe House Way, the disposal of surface water via infiltration is unlikely to be feasible. In addition, the RES report indicates the topography of the site to have slopes greater than 1 in 10, and thus, the site is not considered suitable for infiltration due to the potential for re-emergence of flows lower down the slopes. Should areas of the site appear to be suitable for the use of soakaways, however, then infiltration tests may be undertaken at the detailed design stage in accordance with the guidelines in BRE365[4].

It is proposed to direct all runoff from the developed site to existing watercourses and the culverted land drain (as illustrated in **Figure 8**).

6.2.2 Post Development Impermeable Area

To facilitate the development of an illustrative drainage scheme, the proposed development has been subdivided into eight drainage areas (in addition to Parcels R and A), as illustrated in **Figure 8**. The drainage areas are based on the Areas Plan (**Appendix A**) and site topography.

[13] Paragraph 080, Reference ID: 7-080-20150323

The area of impermeable surfaces at the site are estimated to be as follows:

- Residential areas: 55%
- Primary school: 65%
- Local centre: 90%

A breakdown of each drainage area and the estimated impermeable surfaces within each area are presented in **Table 2**.

For the BVF Phase and Land at Tithe House Way, the impermeable areas have been calculated to be 4.884 ha[1] and 2.020 ha[2] respectively.

It should be noted that land to the west of Land at Tithe House Way (referred to as 'Phase 2' in the FRDA report[2]) has an estimated impermeable area of 2.135 ha; however, the Phase 2 area would need to be increased based on the current Areas Plan (as shown in **Figure 8**) and therefore the estimated impermeable area for Phase 2 would increase to 3.134 ha.

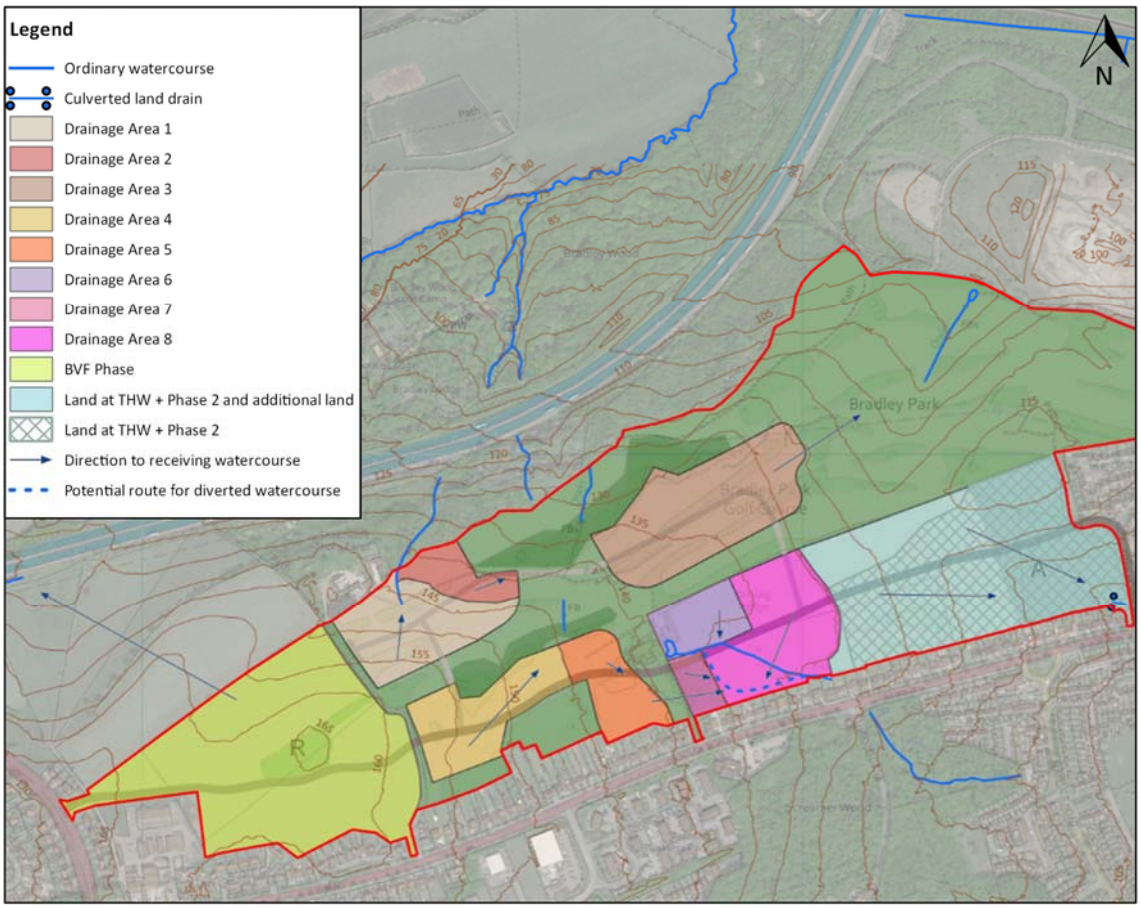

Figure 8: Indicative Drainage Areas

6.2.3 Peak Flow Control

It is proposed to restrict surface water runoff within each drainage area to the existing greenfield QBAR rate of 6.3 l/s/ha post development. The peak runoff rate for each drainage area is presented in **Table 2**.

For the BVF Phase, a discharge rate of 22.0 l/s has been agreed with Kirklees Council..

For Land at Tithe House Way, a discharge rate of 13.5 l/s has been agreed with Kirklees Council. Phase 2 is also accounted for within the agreed discharge rate.

6.2.4 Volume Control

Where reasonably practicable, for greenfield sites, the runoff volume from the proposed development to any highway drain, sewer or surface water body in the 1 in 100 AEP, 6 hour rainfall event should not exceed the greenfield runoff volume for the same event.

As outlined within the CIRIA SuDS Manual 2015 extra runoff volumes in extreme events may be managed by releasing all runoff (above the 1 in 1 AEP event) from the site at a maximum rate of 2 l/s/ha or QBAR, whichever is the higher value.

It is proposed to restrict peak discharge rates to the existing QBAR rate for drainage areas 1 – 8, 22.0 l/s for the BVF Phase and 13.5 l/s for Land at Tithe House Way (including land to the west) in up to the 1 in 100 annual probability event including an allowance for climate change. Therefore, the runoff volume will not exceed the greenfield runoff volume during the 1 in 100 AEP, 6 hour rainfall event.

6.2.5 Attenuation Storage

Attenuation storage will be provided within each drainage area to store surface water runoff generated across roofs and hardstanding.

The attenuation storage facilities have been modelled using the Source Control module of MicroDrainage (**Appendix C**). The required storage volumes have been sized to store the 1 in 100 AEP rainfall event including a 30% increase in rainfall intensity to allow for climate change.

The storage volumes including the approximate land-takes required for each drainage area based on the peak runoff rates are provided in **Table 2**.

For residential areas (drainage areas 1-5 and 8) storage could be provided in above ground facilities such as attenuation basins filling to a depth of 1.0 m with a 0.3 m freeboard and a 1 in 3 side slope. For the primary school and local centre (drainage areas 6 and 7 respectively) storage could be provided in below ground facilities such as geo-cellular storage crates.

Table 2: Impermeable Areas, Indicative Peak Runoff Rates, Storage Volumes and Land Take

	Drainage Area (DA)							
	DA1	**DA2**	**DA3**	**DA4**	**DA5**	**DA6**	**DA7**	**DA8**
Development platform (ha)	2.541	0.926	4.186	2.258	1.460	1.139	0.489	3.071
Post development impermeable area (ha)	1.397	0.509	2.302	1.242	0.803	0.740	0.440	1.689
Proposed peak runoff rate (l/s)	8.8	3.2	14.5	7.8	5.1	4.7	2.8	10.6
Indicative attenuation storage volume (m^3)	857	307	1426	760	487	450	274	1041
Land take of above ground storage (m^2)	1126	473	1763	1012	691	-	-	1332

Additional SuDS features, such as rainwater harvesting, bioretention areas, filter strips, swales or filter drains may be incorporated into the surface water drainage strategy at the detailed design stage. As detailed in the RES report, it may be feasible to utilise the existing drainage on the golf course once fully mapped and its condition understood.

It should be noted that the calculations assume that all storage is provided within the attenuation storage facilities; with no storage being provided in the proposed pipe network. As such, the volumes of storage presented are likely to be an overestimate.

For the BVF Phase, it is proposed to store surface water runoff generated from roofs and hardstanding within an attenuation tank up to the 1 in 2 AEP event with an offline attenuation basin providing storage for all rainfall events greater than the 1 in 2 AEP event and up to the 1 in 100 plus 30% climate change AEP event.

For Land at Tithe House Way, the FRDA report proposes that both Phases 1 and 2 will have their own storage facility to store surface water runoff, with the Phase 2 storage system cascading into the Phase 1 storage system prior to discharging into the culverted land drain at a restricted rate of 13.5 l/s.

6.2.6 Exceedance Routes

Flows resulting from rainfall in excess of the 1 in 100 AEP plus climate change rainfall event will be managed in exceedance routes. It is assumed that as the development is constructed, exceedance flows would be directed towards carriageways and away from built development.

6.2.7 Pollution Control

Kirklees Council requires that two levels of treatment be provided for new residential developments to reduce the risk of pollution to receiving waterbodies. SuDS features such as permeable paving across proposed driveways, filter strips or swales for the drainage of the proposed highways before outfalling into an attenuation basin may be incorporated into the design of the drainage systems.

Attenuation basins can provide water quality benefits via the settlement of pollutants in still or slow-moving water, adsorption by the soil, and biological activity. The potential for additional SuDS features to be utilised at the site would be investigated further at the detailed design stage.

6.2.8 Adoption and Maintenance of SuDS

The pipe network, designed in accordance with the Design and Construction Guidance[14], may be adopted by the sewerage undertaker.

SuDS elements within the curtilage of residential dwellings would be the responsibility of the owner of the property.

SuDS in open spaces may be maintained by a management company.

An indicative maintenance schedule is presented in **Table 3**.

Table 3: Maintenance Requirements

Schedule	Required action	Frequency
Attenuation Basin		
Regular maintenance	Remove litter and debris	Monthly
	Cut grass	Monthly during grow season Or as required)
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required.	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies	Monthly for first year, then annually or as required
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from inlets/outlets	Annually (or as required)
	Reseed areas of poor vegetation growth	As required

[14] Design and Construction Guidance for foul and surface water sewers offered for adoption under the Code for adoption agreements for water and sewerage companies operating wholly or mainly in England ("the Code"), Approved Version 2.0, 10 March 2020

Schedule	Required action	Frequency
Occasional maintenance	Prune and trim any trees and remove cuttings	Every two years, or as required
	Remove sediments from inlets/outlets and main basin when required	
Remedial actions	Repair erosion or other damage by reseeding or re-turfing	As required
	Realignment of rip-rap	
	Repair/rehabilitation of inlets/outlets	
	Relevel uneven surface and reinstate design levels	
Geo-cellular Attenuation Storage Tank		
Regular maintenance	Inspect and identify any areas that are not operating correctly	Monthly for 3 months, then annually
	Remove debris from the catchment surface	Monthly
	Remove sediment from internal forebays	Annually, or as required
Remedial action	Repair inlet/outlet and vents	As required
Monitoring	Inspect catchpit manholes and note rate of sediment accumulation	Monthly in the first year and then annually
	Inspect inlet/outlet and vents to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years, or as required
Flow Control Unit		
Routine maintenance	Remove litter and debris and inspect for sediment, oil and grease accumulation	Six Monthly
	Remove sediment, oil, grease and floatables	As necessary – Indicated by system inspections or immediately following significant spill
Remedial actions	Replace malfunctioning parts or structures	As required
Monitoring	Inspect for evidence of poor operation	Six Monthly
	Inspect filter media and establish appropriate replacement frequencies	Six Monthly
	Inspect sediment accumulation rates and establish appropriate removal frequencies	Monthly during first year of operation, then every six months

7 SUMMARY AND RECOMMENDATIONS

This report has been prepared on behalf of Redrow Homes (Yorkshire) Ltd, R. Kershaw and S. Gill and relates to the proposed development of land at Bradley Villa Farm, Bradley, Huddersfield.

According to the Environment Agency Flood Map for Planning the proposed development is located outside the 1 in 1,000 AEP flood outline and is therefore defined by the NPPF as being situated within flood zone 1.

As the site is in flood zone 1, the sequential test is deemed to have been addressed and the exception test need not be addressed.

The site is assessed not to be at risk of flooding from the Calder and Hebble Navigation, groundwater and reservoirs.

The Flood Map for Planning does not present flood outlines for watercourses with a catchment area less than 3.0 km^2; In instances such as this, the Flood Risk from Surface Water map provides a useful proxy for fluvial flood risk.

The Flood Risk from Surface Water map indicates that the site is predominantly at Very Low risk of flooding from surface water. A small number of surface water flow paths are indicated to be present on-site, however, most of the flow paths coincide with the on-site watercourses and as such, the risk of flooding is assumed to be associated with the watercourses. The mapping indicates that land adjacent to the on-site watercourses are at Low risk of flooding during extreme events, and therefore, there may be some propensity for localised flooding from the on-site watercourses with flood depths predominately less than 300 mm.

A surface water flow path is indicated to be present in the south-eastern corner of the site where the natural contours of the land forms a shallow swale feature where overland flow would be directed. The risk and extent of surface water flow paths, however, are reduced during less extreme events.

This report has demonstrated that the proposed development may be completed in accordance with the requirements of planning policy subject to the following:

- Finished floor levels to be set 150 mm above adjacent ground levels following any re-profiling at the site
- New culverts and/or bridges along the course of Deep Dike and/or any unnamed watercourses should maintain existing channel conveyance capacity
- A channel maintenance regime to be implemented
- A surface water drainage system that accords with the broad principles presented in this report.

Surface water runoff from the developed site can be sustainably managed in accordance with planning policy and is not expected to impact flood risk elsewhere.

APPENDIX A

Development Proposals

REDROW

Bradley Park

Wildlife Areas

O/H Power lines

Buffer Planting

Link Road

Approved site
for 105 Dwellings

Existing Track
Shepherd's Thorn Lane

Primary
School

Local
Centre

Site Access

East West Primary Route

Secondary routes

BRADFORD ROAD

Housing Area

Site Access

BRADLEY ROAD

Site Access

Key Nodes

Proposed Redrow
housing parcel

STEN ARCHITECTURE
The Studio
Harrison Street
Wakefield
WF1 1PS
Tel: 01924 950985
www.sten-architecture.co.uk

0 100 200 300 400 500

MASTERPLAN CONCEPT 2 | NOVEMBER 2020 | 1:5000 @ A2

BRADLEY FARM VILLA

APPENDIX B

Greenfield Runoff Rate

ICP SUDS Mean Annual Flood

Input

Return Period (years) 100 SAAR (mm) 956 Urban 0.000
Area (ha) 1.000 Soil 0.450 Region Number Region 3

Results l/s

QBAR Rural 6.3
QBAR Urban 6.3

Q100 years 13.2

Q1 year 5.4
Q30 years 11.1
Q100 years 13.2

APPENDIX C

Surface Water Attenuation - Storage Volume Calculation

Joseph's Well
Hanover Walk
Leeds, LS3 1AB

Date 12/11/2020 10:41 | Designed by MichaelDarby
File 2020-11-12 4937 DA1 100... | Checked by
XP Solutions | Source Control 2020.1

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	8.8	292.7	O K
30 min Summer	0.501	0.501	8.8	392.8	O K
60 min Summer	0.623	0.623	8.8	499.8	O K
120 min Summer	0.740	0.740	8.8	606.7	O K
180 min Summer	0.798	0.798	8.8	661.3	O K
240 min Summer	0.830	0.830	8.8	692.5	O K
360 min Summer	0.866	0.866	8.8	727.0	O K
480 min Summer	0.881	0.881	8.8	741.7	O K
600 min Summer	0.884	0.884	8.8	745.0	O K
720 min Summer	0.881	0.881	8.8	741.5	O K
960 min Summer	0.870	0.870	8.8	731.1	O K
1440 min Summer	0.841	0.841	8.8	702.9	O K
2160 min Summer	0.791	0.791	8.8	654.5	O K
2880 min Summer	0.737	0.737	8.8	603.9	O K
4320 min Summer	0.614	0.614	8.8	491.6	O K
5760 min Summer	0.498	0.498	8.8	390.2	O K
7200 min Summer	0.401	0.401	8.8	308.3	O K
8640 min Summer	0.323	0.323	8.8	244.5	O K
10080 min Summer	0.263	0.263	8.8	196.7	O K
15 min Winter	0.426	0.426	8.8	328.6	O K
30 min Winter	0.557	0.557	8.8	441.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	288.7	22
30 min Summer	77.440	0.0	391.2	36
60 min Summer	49.937	0.0	517.1	66
120 min Summer	31.091	0.0	644.3	124
180 min Summer	23.207	0.0	721.5	184
240 min Summer	18.718	0.0	775.8	244
360 min Summer	13.796	0.0	857.3	362
480 min Summer	11.103	0.0	919.4	482
600 min Summer	9.374	0.0	969.5	600
720 min Summer	8.158	0.0	1011.5	684
960 min Summer	6.546	0.0	1079.3	792
1440 min Summer	4.790	0.0	1171.3	1044
2160 min Summer	3.498	0.0	1314.8	1468
2880 min Summer	2.794	0.0	1400.0	1876
4320 min Summer	2.032	0.0	1525.5	2680
5760 min Summer	1.619	0.0	1626.8	3400
7200 min Summer	1.358	0.0	1704.3	4104
8640 min Summer	1.177	0.0	1771.3	4760
10080 min Summer	1.042	0.0	1828.1	5448
15 min Winter	114.680	0.0	323.9	22
30 min Winter	77.440	0.0	438.1	36

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
60 min Winter	0.692	0.692	8.8	562.7	O K
120 min Winter	0.821	0.821	8.8	683.5	O K
180 min Winter	0.886	0.886	8.8	746.7	O K
240 min Winter	0.923	0.923	8.8	783.8	O K
360 min Winter	0.966	0.966	8.8	826.9	O K
480 min Winter	0.987	0.987	8.8	848.2	O K
600 min Winter	0.996	0.996	8.8	856.6	O K
720 min Winter	0.996	0.996	8.8	857.0	O K
960 min Winter	0.983	0.983	8.8	843.5	O K
1440 min Winter	0.945	0.945	8.8	805.6	O K
2160 min Winter	0.876	0.876	8.8	737.1	O K
2880 min Winter	0.799	0.799	8.8	662.2	O K
4320 min Winter	0.614	0.614	8.8	491.3	O K
5760 min Winter	0.435	0.435	8.8	336.8	O K
7200 min Winter	0.300	0.300	8.8	225.9	O K
8640 min Winter	0.211	0.211	8.6	156.3	O K
10080 min Winter	0.161	0.161	8.2	117.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	49.937	0.0	579.4	64
120 min Winter	31.091	0.0	721.8	122
180 min Winter	23.207	0.0	808.1	180
240 min Winter	18.718	0.0	868.7	240
360 min Winter	13.796	0.0	959.6	354
480 min Winter	11.103	0.0	1028.7	468
600 min Winter	9.374	0.0	1084.1	580
720 min Winter	8.158	0.0	1130.2	690
960 min Winter	6.546	0.0	1203.2	894
1440 min Winter	4.790	0.0	1282.9	1112
2160 min Winter	3.498	0.0	1472.7	1580
2880 min Winter	2.794	0.0	1568.1	2044
4320 min Winter	2.032	0.0	1709.0	2896
5760 min Winter	1.619	0.0	1822.3	3576
7200 min Winter	1.358	0.0	1909.2	4184
8640 min Winter	1.177	0.0	1984.4	4760
10080 min Winter	1.042	0.0	2048.7	5344

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 1.397

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.000	4	8	0.397

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	710.0	1.300	1126.2

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0137-8800-1000-8800
Design Head (m)	1.000
Design Flow (l/s)	8.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	137
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	8.8
Flush-Flo™	0.299	8.8
Kick-Flo®	0.664	7.3
Mean Flow over Head Range	-	7.6

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.0	1.200	9.6	3.000	14.8	7.000	22.2
0.200	8.5	1.400	10.3	3.500	15.9	7.500	22.9
0.300	8.8	1.600	11.0	4.000	17.0	8.000	23.7
0.400	8.7	1.800	11.6	4.500	18.0	8.500	24.4
0.500	8.4	2.000	12.2	5.000	18.9	9.000	25.0
0.600	7.9	2.200	12.8	5.500	19.8	9.500	25.7
0.800	7.9	2.400	13.3	6.000	20.6		
1.000	8.8	2.600	13.8	6.500	21.4		

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	0.420	0.420	3.2	107.0	O K
30 min Summer	0.540	0.540	3.2	143.3	O K
60 min Summer	0.659	0.659	3.2	182.1	O K
120 min Summer	0.768	0.768	3.2	219.8	O K
180 min Summer	0.821	0.821	3.2	239.0	O K
240 min Summer	0.850	0.850	3.2	249.7	O K
360 min Summer	0.880	0.880	3.2	261.1	O K
480 min Summer	0.892	0.892	3.2	265.5	O K
600 min Summer	0.892	0.892	3.2	265.8	O K
720 min Summer	0.887	0.887	3.2	263.8	O K
960 min Summer	0.874	0.874	3.2	258.7	O K
1440 min Summer	0.843	0.843	3.2	247.1	O K
2160 min Summer	0.794	0.794	3.2	229.1	O K
2880 min Summer	0.744	0.744	3.2	211.1	O K
4320 min Summer	0.635	0.635	3.2	174.0	O K
5760 min Summer	0.508	0.508	3.2	133.3	O K
7200 min Summer	0.405	0.405	3.2	102.5	O K
8640 min Summer	0.321	0.321	3.2	79.1	O K
10080 min Summer	0.257	0.257	3.2	61.8	O K
15 min Winter	0.464	0.464	3.2	120.1	O K
30 min Winter	0.596	0.596	3.2	161.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	107.8	19
30 min Summer	77.440	0.0	145.7	34
60 min Summer	49.937	0.0	189.8	64
120 min Summer	31.091	0.0	236.4	122
180 min Summer	23.207	0.0	264.7	182
240 min Summer	18.718	0.0	284.7	242
360 min Summer	13.796	0.0	314.7	362
480 min Summer	11.103	0.0	337.6	480
600 min Summer	9.374	0.0	356.1	600
720 min Summer	8.158	0.0	371.7	684
960 min Summer	6.546	0.0	397.2	790
1440 min Summer	4.790	0.0	433.4	1042
2160 min Summer	3.498	0.0	480.1	1468
2880 min Summer	2.794	0.0	511.4	1876
4320 min Summer	2.032	0.0	557.6	2720
5760 min Summer	1.619	0.0	593.2	3408
7200 min Summer	1.358	0.0	621.6	4104
8640 min Summer	1.177	0.0	646.3	4760
10080 min Summer	1.042	0.0	667.6	5448
15 min Winter	114.680	0.0	120.8	19
30 min Winter	77.440	0.0	163.1	33

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
60 min Winter	0.726	0.726	3.2	204.8	O K
120 min Winter	0.845	0.845	3.2	248.0	O K
180 min Winter	0.904	0.904	3.2	270.4	O K
240 min Winter	0.938	0.938	3.2	283.4	O K
360 min Winter	0.975	0.975	3.2	298.2	O K
480 min Winter	0.992	0.992	3.2	305.2	O K
600 min Winter	0.998	0.998	3.2	307.5	O K
720 min Winter	0.997	0.997	3.2	307.0	O K
960 min Winter	0.982	0.982	3.2	300.9	O K
1440 min Winter	0.943	0.943	3.2	285.5	O K
2160 min Winter	0.876	0.876	3.2	259.8	O K
2880 min Winter	0.804	0.804	3.2	232.7	O K
4320 min Winter	0.641	0.641	3.2	175.9	O K
5760 min Winter	0.442	0.442	3.2	113.5	O K
7200 min Winter	0.298	0.298	3.2	72.9	O K
8640 min Winter	0.203	0.203	3.1	48.1	O K
10080 min Winter	0.146	0.146	2.9	33.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	49.937	0.0	212.6	62
120 min Winter	31.091	0.0	264.8	122
180 min Winter	23.207	0.0	296.5	180
240 min Winter	18.718	0.0	318.8	238
360 min Winter	13.796	0.0	352.3	354
480 min Winter	11.103	0.0	377.9	468
600 min Winter	9.374	0.0	398.5	578
720 min Winter	8.158	0.0	415.8	688
960 min Winter	6.546	0.0	443.7	894
1440 min Winter	4.790	0.0	474.7	1112
2160 min Winter	3.498	0.0	537.8	1580
2880 min Winter	2.794	0.0	572.7	2044
4320 min Winter	2.032	0.0	624.6	2940
5760 min Winter	1.619	0.0	664.4	3576
7200 min Winter	1.358	0.0	696.3	4184
8640 min Winter	1.177	0.0	723.9	4840
10080 min Winter	1.042	0.0	747.9	5440

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.509

Time (mins) From:	To:	Area (ha)
0	4	0.509

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	220.0	1.300	472.8

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0085-3200-1000-3200
Design Head (m)	1.000
Design Flow (l/s)	3.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	85
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	3.2
Flush-Flo™	0.296	3.2
Kick-Flo®	0.624	2.6
Mean Flow over Head Range	-	2.8

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.6	1.200	3.5	3.000	5.3	7.000	7.9
0.200	3.1	1.400	3.7	3.500	5.7	7.500	8.2
0.300	3.2	1.600	4.0	4.000	6.1	8.000	8.5
0.400	3.1	1.800	4.2	4.500	6.4	8.500	8.7
0.500	3.0	2.000	4.4	5.000	6.8	9.000	8.9
0.600	2.7	2.200	4.6	5.500	7.1	9.500	9.2
0.800	2.9	2.400	4.8	6.000	7.4		
1.000	3.2	2.600	5.0	6.500	7.7		

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	0.370	0.370	14.4	480.9	O K
30 min Summer	0.489	0.489	14.4	646.5	O K
60 min Summer	0.611	0.611	14.4	823.6	O K
120 min Summer	0.730	0.730	14.4	1001.5	O K
180 min Summer	0.791	0.791	14.4	1093.9	O K
240 min Summer	0.825	0.825	14.4	1147.0	O K
360 min Summer	0.863	0.863	14.4	1207.0	O K
480 min Summer	0.881	0.881	14.4	1234.3	O K
600 min Summer	0.886	0.886	14.4	1242.1	O K
720 min Summer	0.883	0.883	14.4	1238.6	O K
960 min Summer	0.875	0.875	14.4	1225.0	O K
1440 min Summer	0.848	0.848	14.4	1183.3	O K
2160 min Summer	0.799	0.799	14.4	1105.9	O K
2880 min Summer	0.744	0.744	14.4	1022.1	O K
4320 min Summer	0.620	0.620	14.4	836.2	O K
5760 min Summer	0.509	0.509	14.4	675.4	O K
7200 min Summer	0.415	0.415	14.4	542.9	O K
8640 min Summer	0.339	0.339	14.4	438.9	O K
10080 min Summer	0.281	0.281	14.4	360.3	O K
15 min Winter	0.413	0.413	14.4	540.0	O K
30 min Winter	0.544	0.544	14.4	726.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	465.6	25
30 min Summer	77.440	0.0	632.8	39
60 min Summer	49.937	0.0	846.4	68
120 min Summer	31.091	0.0	1055.3	126
180 min Summer	23.207	0.0	1181.7	186
240 min Summer	18.718	0.0	1270.7	246
360 min Summer	13.796	0.0	1404.0	364
480 min Summer	11.103	0.0	1505.3	482
600 min Summer	9.374	0.0	1586.7	600
720 min Summer	8.158	0.0	1654.8	684
960 min Summer	6.546	0.0	1763.9	794
1440 min Summer	4.790	0.0	1908.5	1046
2160 min Summer	3.498	0.0	2162.1	1468
2880 min Summer	2.794	0.0	2301.9	1876
4320 min Summer	2.032	0.0	2506.6	2644
5760 min Summer	1.619	0.0	2678.6	3400
7200 min Summer	1.358	0.0	2805.8	4104
8640 min Summer	1.177	0.0	2915.1	4760
10080 min Summer	1.042	0.0	3006.4	5448
15 min Winter	114.680	0.0	523.2	25
30 min Winter	77.440	0.0	709.1	39

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
60 min Winter	0.681	0.681	14.4	926.8	O K
120 min Winter	0.813	0.813	14.4	1128.2	O K
180 min Winter	0.881	0.881	14.4	1234.0	O K
240 min Winter	0.920	0.920	14.4	1296.7	O K
360 min Winter	0.966	0.966	14.4	1370.4	O K
480 min Winter	0.989	0.989	14.4	1407.8	O K
600 min Winter	0.999	0.999	14.5	1423.7	O K
720 min Winter	1.000	1.000	14.5	1426.2	O K
960 min Winter	0.988	0.988	14.4	1407.2	O K
1440 min Winter	0.953	0.953	14.4	1349.9	O K
2160 min Winter	0.885	0.885	14.4	1240.6	O K
2880 min Winter	0.806	0.806	14.4	1117.7	O K
4320 min Winter	0.619	0.619	14.4	834.8	O K
5760 min Winter	0.448	0.448	14.4	590.0	O K
7200 min Winter	0.317	0.317	14.4	409.1	O K
8640 min Winter	0.230	0.230	14.2	293.4	O K
10080 min Winter	0.183	0.183	13.7	231.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	49.937	0.0	948.8	68
120 min Winter	31.091	0.0	1182.3	124
180 min Winter	23.207	0.0	1323.6	182
240 min Winter	18.718	0.0	1422.9	240
360 min Winter	13.796	0.0	1571.4	356
480 min Winter	11.103	0.0	1683.8	470
600 min Winter	9.374	0.0	1773.6	582
720 min Winter	8.158	0.0	1848.1	690
960 min Winter	6.546	0.0	1964.7	894
1440 min Winter	4.790	0.0	2090.7	1114
2160 min Winter	3.498	0.0	2422.0	1580
2880 min Winter	2.794	0.0	2578.3	2044
4320 min Winter	2.032	0.0	2808.4	2860
5760 min Winter	1.619	0.0	3000.7	3576
7200 min Winter	1.358	0.0	3143.5	4192
8640 min Winter	1.177	0.0	3266.5	4768
10080 min Winter	1.042	0.0	3370.3	5256

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 2.302

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.000	4	8	1.000	8	12	0.302

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1230.0	1.300	1762.7

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0172-1450-1000-1450
Design Head (m)	1.000
Design Flow (l/s)	14.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	172
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	14.5
Flush-Flo™	0.320	14.4
Kick-Flo®	0.699	12.2
Mean Flow over Head Range	-	12.3

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.1	1.200	15.8	3.000	24.5	7.000	36.8
0.200	13.9	1.400	17.0	3.500	26.3	7.500	38.0
0.300	14.4	1.600	18.1	4.000	28.1	8.000	39.2
0.400	14.3	1.800	19.2	4.500	29.7	8.500	40.4
0.500	14.0	2.000	20.1	5.000	31.3	9.000	41.5
0.600	13.5	2.200	21.1	5.500	32.7	9.500	42.6
0.800	13.0	2.400	22.0	6.000	34.1		
1.000	14.5	2.600	22.8	6.500	35.5		

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	0.387	0.387	7.8	260.2	O K
30 min Summer	0.506	0.506	7.8	349.2	O K
60 min Summer	0.628	0.628	7.8	444.3	O K
120 min Summer	0.745	0.745	7.8	539.1	O K
180 min Summer	0.802	0.802	7.8	587.4	O K
240 min Summer	0.834	0.834	7.8	615.0	O K
360 min Summer	0.869	0.869	7.8	645.3	O K
480 min Summer	0.884	0.884	7.8	658.1	O K
600 min Summer	0.887	0.887	7.8	660.7	O K
720 min Summer	0.883	0.883	7.8	657.4	O K
960 min Summer	0.872	0.872	7.8	647.7	O K
1440 min Summer	0.843	0.843	7.8	622.1	O K
2160 min Summer	0.792	0.792	7.8	578.8	O K
2880 min Summer	0.738	0.738	7.8	533.8	O K
4320 min Summer	0.616	0.616	7.8	434.1	O K
5760 min Summer	0.499	0.499	7.8	343.6	O K
7200 min Summer	0.402	0.402	7.8	270.9	O K
8640 min Summer	0.323	0.323	7.8	214.3	O K
10080 min Summer	0.262	0.262	7.8	171.8	O K
15 min Winter	0.430	0.430	7.8	292.1	O K
30 min Winter	0.563	0.563	7.8	392.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	257.7	21
30 min Summer	77.440	0.0	349.1	36
60 min Summer	49.937	0.0	460.3	64
120 min Summer	31.091	0.0	573.5	124
180 min Summer	23.207	0.0	642.2	184
240 min Summer	18.718	0.0	690.6	242
360 min Summer	13.796	0.0	763.1	362
480 min Summer	11.103	0.0	818.5	482
600 min Summer	9.374	0.0	863.1	600
720 min Summer	8.158	0.0	900.6	684
960 min Summer	6.546	0.0	961.1	792
1440 min Summer	4.790	0.0	1043.8	1044
2160 min Summer	3.498	0.0	1169.4	1468
2880 min Summer	2.794	0.0	1245.2	1876
4320 min Summer	2.032	0.0	1357.0	2680
5760 min Summer	1.619	0.0	1446.5	3400
7200 min Summer	1.358	0.0	1515.5	4104
8640 min Summer	1.177	0.0	1575.1	4760
10080 min Summer	1.042	0.0	1625.9	5448
15 min Winter	114.680	0.0	289.1	21
30 min Winter	77.440	0.0	390.9	36

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
60 min Winter	0.698	0.698	7.8	500.3	O K
120 min Winter	0.826	0.826	7.8	607.5	O K
180 min Winter	0.890	0.890	7.8	663.4	O K
240 min Winter	0.927	0.927	7.8	696.2	O K
360 min Winter	0.970	0.970	7.8	734.3	O K
480 min Winter	0.990	0.990	7.8	753.0	O K
600 min Winter	0.998	0.998	7.8	760.3	O K
720 min Winter	0.998	0.998	7.8	760.4	O K
960 min Winter	0.985	0.985	7.8	748.1	O K
1440 min Winter	0.947	0.947	7.8	713.8	O K
2160 min Winter	0.878	0.878	7.8	652.6	O K
2880 min Winter	0.800	0.800	7.8	585.9	O K
4320 min Winter	0.616	0.616	7.8	434.2	O K
5760 min Winter	0.436	0.436	7.8	296.5	O K
7200 min Winter	0.300	0.300	7.8	198.2	O K
8640 min Winter	0.211	0.211	7.6	136.5	O K
10080 min Winter	0.158	0.158	7.3	101.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	49.937	0.0	515.8	64
120 min Winter	31.091	0.0	642.5	122
180 min Winter	23.207	0.0	719.2	180
240 min Winter	18.718	0.0	773.3	238
360 min Winter	13.796	0.0	854.2	354
480 min Winter	11.103	0.0	915.8	468
600 min Winter	9.374	0.0	965.2	580
720 min Winter	8.158	0.0	1006.4	688
960 min Winter	6.546	0.0	1071.7	894
1440 min Winter	4.790	0.0	1142.9	1112
2160 min Winter	3.498	0.0	1309.8	1580
2880 min Winter	2.794	0.0	1394.7	2044
4320 min Winter	2.032	0.0	1520.2	2896
5760 min Winter	1.619	0.0	1620.3	3576
7200 min Winter	1.358	0.0	1697.7	4184
8640 min Winter	1.177	0.0	1764.6	4832
10080 min Winter	1.042	0.0	1822.0	5352

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 1.242

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.000	4	8	0.242

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	620.0	1.300	1012.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0130-7800-1000-7800
Design Head (m)	1.000
Design Flow (l/s)	7.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	130
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	7.8
Flush-Flo™	0.302	7.8
Kick-Flo®	0.664	6.4
Mean Flow over Head Range	-	6.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.7	1.200	8.5	3.000	13.1	7.000	19.6
0.200	7.6	1.400	9.1	3.500	14.1	7.500	20.3
0.300	7.8	1.600	9.7	4.000	15.0	8.000	20.9
0.400	7.7	1.800	10.3	4.500	15.9	8.500	21.6
0.500	7.5	2.000	10.8	5.000	16.7	9.000	22.2
0.600	7.1	2.200	11.3	5.500	17.5	9.500	22.7
0.800	7.0	2.400	11.8	6.000	18.2		
1.000	7.8	2.600	12.2	6.500	18.9		

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	0.404	0.404	5.1	168.9	O K
30 min Summer	0.524	0.524	5.1	226.2	O K
60 min Summer	0.645	0.645	5.1	287.4	O K
120 min Summer	0.758	0.758	5.1	347.5	O K
180 min Summer	0.813	0.813	5.1	378.1	O K
240 min Summer	0.844	0.844	5.1	395.3	O K
360 min Summer	0.876	0.876	5.1	413.6	O K
480 min Summer	0.888	0.888	5.1	420.9	O K
600 min Summer	0.889	0.889	5.1	421.6	O K
720 min Summer	0.885	0.885	5.1	418.8	O K
960 min Summer	0.872	0.872	5.1	411.5	O K
1440 min Summer	0.841	0.841	5.1	393.7	O K
2160 min Summer	0.790	0.790	5.1	365.2	O K
2880 min Summer	0.737	0.737	5.1	336.2	O K
4320 min Summer	0.618	0.618	5.1	273.4	O K
5760 min Summer	0.495	0.495	5.1	212.1	O K
7200 min Summer	0.395	0.395	5.1	164.6	O K
8640 min Summer	0.314	0.314	5.1	128.2	O K
10080 min Summer	0.252	0.252	5.1	101.2	O K
15 min Winter	0.448	0.448	5.1	189.5	O K
30 min Winter	0.580	0.580	5.1	254.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	168.7	19
30 min Summer	77.440	0.0	228.2	34
60 min Summer	49.937	0.0	298.7	64
120 min Summer	31.091	0.0	372.1	122
180 min Summer	23.207	0.0	416.7	182
240 min Summer	18.718	0.0	448.1	242
360 min Summer	13.796	0.0	495.2	362
480 min Summer	11.103	0.0	531.2	480
600 min Summer	9.374	0.0	560.3	600
720 min Summer	8.158	0.0	584.8	672
960 min Summer	6.546	0.0	624.7	788
1440 min Summer	4.790	0.0	680.6	1040
2160 min Summer	3.498	0.0	756.9	1452
2880 min Summer	2.794	0.0	806.1	1876
4320 min Summer	2.032	0.0	878.8	2680
5760 min Summer	1.619	0.0	935.6	3400
7200 min Summer	1.358	0.0	980.3	4104
8640 min Summer	1.177	0.0	1019.1	4760
10080 min Summer	1.042	0.0	1052.4	5448
15 min Winter	114.680	0.0	189.1	19
30 min Winter	77.440	0.0	255.5	33

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
60 min Winter	0.713	0.713	5.1	323.3	O K
120 min Winter	0.837	0.837	5.1	391.8	O K
180 min Winter	0.899	0.899	5.1	427.4	O K
240 min Winter	0.934	0.934	5.1	448.0	O K
360 min Winter	0.974	0.974	5.1	471.6	O K
480 min Winter	0.992	0.992	5.1	482.8	O K
600 min Winter	0.999	0.999	5.1	486.7	O K
720 min Winter	0.998	0.998	5.1	486.0	O K
960 min Winter	0.982	0.982	5.1	476.8	O K
1440 min Winter	0.943	0.943	5.1	453.3	O K
2160 min Winter	0.874	0.874	5.1	412.6	O K
2880 min Winter	0.797	0.797	5.1	369.2	O K
4320 min Winter	0.617	0.617	5.1	273.0	O K
5760 min Winter	0.428	0.428	5.1	180.2	O K
7200 min Winter	0.289	0.289	5.1	117.4	O K
8640 min Winter	0.199	0.199	5.0	78.8	O K
10080 min Winter	0.146	0.146	4.7	56.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	49.937	0.0	334.7	62
120 min Winter	31.091	0.0	416.8	122
180 min Winter	23.207	0.0	466.6	180
240 min Winter	18.718	0.0	501.7	238
360 min Winter	13.796	0.0	554.4	354
480 min Winter	11.103	0.0	594.5	468
600 min Winter	9.374	0.0	626.9	578
720 min Winter	8.158	0.0	654.0	686
960 min Winter	6.546	0.0	697.4	892
1440 min Winter	4.790	0.0	748.4	1110
2160 min Winter	3.498	0.0	847.8	1576
2880 min Winter	2.794	0.0	902.8	2044
4320 min Winter	2.032	0.0	984.4	2900
5760 min Winter	1.619	0.0	1048.0	3576
7200 min Winter	1.358	0.0	1098.1	4184
8640 min Winter	1.177	0.0	1141.6	4760
10080 min Winter	1.042	0.0	1179.1	5352

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.803

Time (mins) From:	To:	Area (ha)
0	4	0.803

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	375.0	1.300	690.5

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0107-5100-1000-5100
Design Head (m)	1.000
Design Flow (l/s)	5.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	107
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	5.1
Flush-Flo™	0.297	5.1
Kick-Flo®	0.640	4.2
Mean Flow over Head Range	-	4.4

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.6	1.200	5.6	3.000	8.5	7.000	12.8
0.200	5.0	1.400	6.0	3.500	9.2	7.500	13.2
0.300	5.1	1.600	6.3	4.000	9.8	8.000	13.6
0.400	5.0	1.800	6.7	4.500	10.3	8.500	14.0
0.500	4.9	2.000	7.0	5.000	10.9	9.000	14.4
0.600	4.5	2.200	7.4	5.500	11.4	9.500	14.8
0.800	4.6	2.400	7.7	6.000	11.9		
1.000	5.1	2.600	8.0	6.500	12.3		

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

Half Drain Time : 829 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.415	0.415	0.0	4.7	4.7	155.7	O K
30 min Summer	0.555	0.555	0.0	4.7	4.7	208.4	O K
60 min Summer	0.706	0.706	0.0	4.7	4.7	264.8	O K
120 min Summer	0.855	0.855	0.0	4.7	4.7	320.9	O K
180 min Summer	0.931	0.931	0.0	4.7	4.7	349.4	O K
240 min Summer	0.974	0.974	0.0	4.7	4.7	365.5	O K
360 min Summer	1.021	1.021	0.0	4.7	4.7	383.0	O K
480 min Summer	1.040	1.040	0.0	4.7	4.7	390.2	O K
600 min Summer	1.043	1.043	0.0	4.7	4.7	391.3	O K
720 min Summer	1.037	1.037	0.0	4.7	4.7	389.0	O K
960 min Summer	1.020	1.020	0.0	4.7	4.7	382.8	O K
1440 min Summer	0.978	0.978	0.0	4.7	4.7	366.9	O K
2160 min Summer	0.909	0.909	0.0	4.7	4.7	340.9	O K
2880 min Summer	0.837	0.837	0.0	4.7	4.7	314.1	O K
4320 min Summer	0.674	0.674	0.0	4.7	4.7	252.8	O K
5760 min Summer	0.530	0.530	0.0	4.7	4.7	198.8	O K
7200 min Summer	0.417	0.417	0.0	4.7	4.7	156.6	O K
8640 min Summer	0.332	0.332	0.0	4.7	4.7	124.6	O K
10080 min Summer	0.268	0.268	0.0	4.6	4.6	100.5	O K
15 min Winter	0.466	0.466	0.0	4.7	4.7	174.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	155.0	19
30 min Summer	77.440	0.0	209.8	34
60 min Summer	49.937	0.0	275.1	64
120 min Summer	31.091	0.0	342.7	122
180 min Summer	23.207	0.0	383.7	182
240 min Summer	18.718	0.0	412.6	242
360 min Summer	13.796	0.0	456.0	362
480 min Summer	11.103	0.0	489.1	480
600 min Summer	9.374	0.0	515.9	600
720 min Summer	8.158	0.0	538.4	684
960 min Summer	6.546	0.0	574.9	790
1440 min Summer	4.790	0.0	625.5	1050
2160 min Summer	3.498	0.0	697.3	1468
2880 min Summer	2.794	0.0	742.6	1876
4320 min Summer	2.032	0.0	809.6	2680
5760 min Summer	1.619	0.0	862.1	3400
7200 min Summer	1.358	0.0	903.3	4104
8640 min Summer	1.177	0.0	939.0	4760
10080 min Summer	1.042	0.0	969.6	5448
15 min Winter	114.680	0.0	173.8	19

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.624	0.624	0.0	4.7	4.7	234.2	O K
60 min Winter	0.795	0.795	0.0	4.7	4.7	298.2	O K
120 min Winter	0.964	0.964	0.0	4.7	4.7	361.6	O K
180 min Winter	1.052	1.052	0.0	4.7	4.7	394.6	O K
240 min Winter	1.103	1.103	0.0	4.7	4.7	413.8	O K
360 min Winter	1.162	1.162	0.0	4.7	4.7	435.9	O K
480 min Winter	1.190	1.190	0.0	4.7	4.7	446.5	O K
600 min Winter	1.200	1.200	0.0	4.7	4.7	450.4	O K
720 min Winter	1.199	1.199	0.0	4.7	4.7	450.1	O K
960 min Winter	1.178	1.178	0.0	4.7	4.7	442.1	O K
1440 min Winter	1.123	1.123	0.0	4.7	4.7	421.4	O K
2160 min Winter	1.025	1.025	0.0	4.7	4.7	384.8	O K
2880 min Winter	0.920	0.920	0.0	4.7	4.7	345.3	O K
4320 min Winter	0.672	0.672	0.0	4.7	4.7	252.1	O K
5760 min Winter	0.456	0.456	0.0	4.7	4.7	171.2	O K
7200 min Winter	0.310	0.310	0.0	4.7	4.7	116.3	O K
8640 min Winter	0.218	0.218	0.0	4.5	4.5	81.8	O K
10080 min Winter	0.162	0.162	0.0	4.2	4.2	60.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	77.440	0.0	234.9	33
60 min Winter	49.937	0.0	308.2	62
120 min Winter	31.091	0.0	383.8	122
180 min Winter	23.207	0.0	429.7	180
240 min Winter	18.718	0.0	462.0	238
360 min Winter	13.796	0.0	510.5	354
480 min Winter	11.103	0.0	547.4	468
600 min Winter	9.374	0.0	577.1	578
720 min Winter	8.158	0.0	602.0	686
960 min Winter	6.546	0.0	641.6	892
1440 min Winter	4.790	0.0	685.6	1110
2160 min Winter	3.498	0.0	781.1	1580
2880 min Winter	2.794	0.0	831.8	2044
4320 min Winter	2.032	0.0	906.9	2892
5760 min Winter	1.619	0.0	965.7	3568
7200 min Winter	1.358	0.0	1011.8	4184
8640 min Winter	1.177	0.0	1051.9	4840
10080 min Winter	1.042	0.0	1086.4	5448

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.740

Time (mins) From:	To:	Area (ha)
0	4	0.740

Model Details

Storage is Online Cover Level (m) 1.950

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	395.0	0.0	1.201	1.0	0.0
1.200	395.0	0.0	1.950	1.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0099-4700-1200-4700
Design Head (m)	1.200
Design Flow (l/s)	4.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	99
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	4.7
Flush-Flo™	0.356	4.7
Kick-Flo®	0.746	3.8
Mean Flow over Head Range	-	4.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.3	1.200	4.7	3.000	7.2	7.000	10.8
0.200	4.4	1.400	5.0	3.500	7.7	7.500	11.1
0.300	4.7	1.600	5.4	4.000	8.3	8.000	11.5
0.400	4.7	1.800	5.7	4.500	8.7	8.500	11.8
0.500	4.6	2.000	6.0	5.000	9.2	9.000	12.1
0.600	4.4	2.200	6.2	5.500	9.6	9.500	12.4
0.800	3.9	2.400	6.5	6.000	10.0		
1.000	4.3	2.600	6.7	6.500	10.4		

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

Half Drain Time : 829 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.267	0.267	0.0	2.8	2.8	92.7	O K
30 min Summer	0.358	0.358	0.0	2.8	2.8	124.1	O K
60 min Summer	0.454	0.454	0.0	2.8	2.8	157.5	O K
120 min Summer	0.550	0.550	0.0	2.8	2.8	190.7	O K
180 min Summer	0.601	0.601	0.0	2.8	2.8	208.3	O K
240 min Summer	0.631	0.631	0.0	2.8	2.8	218.8	O K
360 min Summer	0.666	0.666	0.0	2.8	2.8	230.9	O K
480 min Summer	0.682	0.682	0.0	2.8	2.8	236.6	O K
600 min Summer	0.688	0.688	0.0	2.8	2.8	238.5	O K
720 min Summer	0.686	0.686	0.0	2.8	2.8	238.0	O K
960 min Summer	0.676	0.676	0.0	2.8	2.8	234.4	O K
1440 min Summer	0.648	0.648	0.0	2.8	2.8	224.8	O K
2160 min Summer	0.595	0.595	0.0	2.8	2.8	206.4	O K
2880 min Summer	0.541	0.541	0.0	2.8	2.8	187.5	O K
4320 min Summer	0.443	0.443	0.0	2.8	2.8	153.6	O K
5760 min Summer	0.359	0.359	0.0	2.8	2.8	124.5	O K
7200 min Summer	0.291	0.291	0.0	2.8	2.8	100.9	O K
8640 min Summer	0.238	0.238	0.0	2.8	2.8	82.7	O K
10080 min Summer	0.198	0.198	0.0	2.7	2.7	68.6	O K
15 min Winter	0.300	0.300	0.0	2.8	2.8	104.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	90.8	19
30 min Summer	77.440	0.0	123.1	34
60 min Summer	49.937	0.0	162.9	64
120 min Summer	31.091	0.0	203.0	122
180 min Summer	23.207	0.0	227.3	182
240 min Summer	18.718	0.0	244.4	242
360 min Summer	13.796	0.0	270.0	362
480 min Summer	11.103	0.0	289.5	482
600 min Summer	9.374	0.0	305.2	600
720 min Summer	8.158	0.0	318.4	720
960 min Summer	6.546	0.0	339.6	830
1440 min Summer	4.790	0.0	367.9	1084
2160 min Summer	3.498	0.0	414.1	1472
2880 min Summer	2.794	0.0	441.0	1848
4320 min Summer	2.032	0.0	480.5	2636
5760 min Summer	1.619	0.0	512.4	3392
7200 min Summer	1.358	0.0	536.8	4104
8640 min Summer	1.177	0.0	557.9	4760
10080 min Summer	1.042	0.0	575.8	5448
15 min Winter	114.680	0.0	101.9	19

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.402	0.402	0.0	2.8	2.8	139.4	O K
60 min Winter	0.511	0.511	0.0	2.8	2.8	177.2	O K
120 min Winter	0.621	0.621	0.0	2.8	2.8	215.5	O K
180 min Winter	0.681	0.681	0.0	2.8	2.8	236.0	O K
240 min Winter	0.716	0.716	0.0	2.8	2.8	248.1	O K
360 min Winter	0.757	0.757	0.0	2.8	2.8	262.5	O K
480 min Winter	0.779	0.779	0.0	2.8	2.8	270.0	O K
600 min Winter	0.789	0.789	0.0	2.8	2.8	273.4	O K
720 min Winter	0.791	0.791	0.0	2.8	2.8	274.2	O K
960 min Winter	0.782	0.782	0.0	2.8	2.8	271.1	O K
1440 min Winter	0.745	0.745	0.0	2.8	2.8	258.3	O K
2160 min Winter	0.681	0.681	0.0	2.8	2.8	236.0	O K
2880 min Winter	0.599	0.599	0.0	2.8	2.8	207.8	O K
4320 min Winter	0.440	0.440	0.0	2.8	2.8	152.7	O K
5760 min Winter	0.316	0.316	0.0	2.8	2.8	109.7	O K
7200 min Winter	0.227	0.227	0.0	2.8	2.8	78.8	O K
8640 min Winter	0.168	0.168	0.0	2.6	2.6	58.2	O K
10080 min Winter	0.129	0.129	0.0	2.5	2.5	44.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	77.440	0.0	137.9	33
60 min Winter	49.937	0.0	182.5	62
120 min Winter	31.091	0.0	227.4	122
180 min Winter	23.207	0.0	254.5	180
240 min Winter	18.718	0.0	273.6	238
360 min Winter	13.796	0.0	302.1	354
480 min Winter	11.103	0.0	323.8	470
600 min Winter	9.374	0.0	341.1	582
720 min Winter	8.158	0.0	355.5	692
960 min Winter	6.546	0.0	378.0	906
1440 min Winter	4.790	0.0	398.5	1140
2160 min Winter	3.498	0.0	463.8	1604
2880 min Winter	2.794	0.0	493.9	2048
4320 min Winter	2.032	0.0	538.3	2812
5760 min Winter	1.619	0.0	573.9	3528
7200 min Winter	1.358	0.0	601.3	4184
8640 min Winter	1.177	0.0	625.0	4848
10080 min Winter	1.042	0.0	645.3	5448

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.440

Time (mins) From:	To:	Area (ha)
0	4	0.440

Model Details

Storage is Online Cover Level (m) 1.550

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	365.0	0.0	0.801	1.0	0.0
0.800	365.0	0.0	1.550	1.0	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0080-2800-1000-2800
Design Head (m)	1.000
Design Flow (l/s)	2.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	80
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	2.8
Flush-Flo™	0.299	2.8
Kick-Flo®	0.623	2.3
Mean Flow over Head Range	-	2.5

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.3	1.200	3.0	3.000	4.7	7.000	6.9
0.200	2.7	1.400	3.3	3.500	5.0	7.500	7.2
0.300	2.8	1.600	3.5	4.000	5.3	8.000	7.4
0.400	2.8	1.800	3.7	4.500	5.6	8.500	7.6
0.500	2.6	2.000	3.9	5.000	5.9	9.000	7.8
0.600	2.4	2.200	4.0	5.500	6.2	9.500	8.0
0.800	2.5	2.400	4.2	6.000	6.4		
1.000	2.8	2.600	4.4	6.500	6.7		

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	0.378	0.378	10.6	354.2	O K
30 min Summer	0.497	0.497	10.6	475.3	O K
60 min Summer	0.619	0.619	10.6	604.6	O K
120 min Summer	0.737	0.737	10.6	734.4	O K
180 min Summer	0.796	0.796	10.6	801.0	O K
240 min Summer	0.829	0.829	10.6	839.3	O K
360 min Summer	0.866	0.866	10.6	882.0	O K
480 min Summer	0.882	0.882	10.6	900.9	O K
600 min Summer	0.886	0.886	10.6	905.6	O K
720 min Summer	0.883	0.883	10.6	902.1	O K
960 min Summer	0.873	0.873	10.6	890.5	O K
1440 min Summer	0.845	0.845	10.6	857.6	O K
2160 min Summer	0.795	0.795	10.6	799.7	O K
2880 min Summer	0.741	0.741	10.6	738.3	O K
4320 min Summer	0.617	0.617	10.6	601.8	O K
5760 min Summer	0.504	0.504	10.6	481.8	O K
7200 min Summer	0.408	0.408	10.6	383.8	O K
8640 min Summer	0.331	0.331	10.6	306.8	O K
10080 min Summer	0.271	0.271	10.5	248.9	O K
15 min Winter	0.422	0.422	10.6	397.6	O K
30 min Winter	0.553	0.553	10.6	533.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	114.680	0.0	346.5	22
30 min Summer	77.440	0.0	470.0	37
60 min Summer	49.937	0.0	623.8	66
120 min Summer	31.091	0.0	777.4	126
180 min Summer	23.207	0.0	870.5	184
240 min Summer	18.718	0.0	936.1	244
360 min Summer	13.796	0.0	1034.3	362
480 min Summer	11.103	0.0	1109.1	482
600 min Summer	9.374	0.0	1169.4	600
720 min Summer	8.158	0.0	1219.8	686
960 min Summer	6.546	0.0	1301.0	794
1440 min Summer	4.790	0.0	1410.0	1050
2160 min Summer	3.498	0.0	1588.5	1468
2880 min Summer	2.794	0.0	1691.4	1876
4320 min Summer	2.032	0.0	1842.7	2676
5760 min Summer	1.619	0.0	1966.3	3400
7200 min Summer	1.358	0.0	2059.9	4104
8640 min Summer	1.177	0.0	2140.6	4760
10080 min Summer	1.042	0.0	2208.7	5448
15 min Winter	114.680	0.0	389.0	22
30 min Winter	77.440	0.0	526.4	36

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
60 min Winter	0.689	0.689	10.6	680.7	O K
120 min Winter	0.819	0.819	10.6	827.3	O K
180 min Winter	0.885	0.885	10.6	904.2	O K
240 min Winter	0.923	0.923	10.6	949.5	O K
360 min Winter	0.968	0.968	10.6	1002.5	O K
480 min Winter	0.990	0.990	10.6	1029.0	O K
600 min Winter	0.999	0.999	10.6	1040.0	O K
720 min Winter	0.999	0.999	10.6	1041.1	O K
960 min Winter	0.987	0.987	10.6	1025.9	O K
1440 min Winter	0.950	0.950	10.6	981.4	O K
2160 min Winter	0.881	0.881	10.6	899.8	O K
2880 min Winter	0.803	0.803	10.6	809.4	O K
4320 min Winter	0.617	0.617	10.6	601.8	O K
5760 min Winter	0.443	0.443	10.6	419.0	O K
7200 min Winter	0.309	0.309	10.6	285.2	O K
8640 min Winter	0.220	0.220	10.4	200.2	O K
10080 min Winter	0.169	0.169	10.0	152.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	49.937	0.0	699.1	66
120 min Winter	31.091	0.0	870.9	124
180 min Winter	23.207	0.0	975.0	182
240 min Winter	18.718	0.0	1048.2	240
360 min Winter	13.796	0.0	1157.7	356
480 min Winter	11.103	0.0	1240.8	470
600 min Winter	9.374	0.0	1307.3	582
720 min Winter	8.158	0.0	1362.7	690
960 min Winter	6.546	0.0	1449.7	894
1440 min Winter	4.790	0.0	1542.7	1114
2160 min Winter	3.498	0.0	1779.4	1580
2880 min Winter	2.794	0.0	1894.5	2044
4320 min Winter	2.032	0.0	2064.3	2860
5760 min Winter	1.619	0.0	2202.7	3576
7200 min Winter	1.358	0.0	2307.7	4184
8640 min Winter	1.177	0.0	2398.4	4832
10080 min Winter	1.042	0.0	2475.6	5344

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.341	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 1.689

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.000	4	8	0.689

Model Details

Storage is Online Cover Level (m) 1.300

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	875.0	1.300	1331.7

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0150-1060-1000-1060
Design Head (m)	1.000
Design Flow (l/s)	10.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	150
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	10.6
Flush-Flo™	0.309	10.6
Kick-Flo®	0.682	8.8
Mean Flow over Head Range	-	9.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.4	1.200	11.5	3.000	17.8	7.000	26.7
0.200	10.2	1.400	12.4	3.500	19.2	7.500	27.6
0.300	10.6	1.600	13.2	4.000	20.4	8.000	28.5
0.400	10.5	1.800	14.0	4.500	21.6	8.500	29.4
0.500	10.2	2.000	14.7	5.000	22.7	9.000	30.2
0.600	9.8	2.200	15.4	5.500	23.8	9.500	31.0
0.800	9.5	2.400	16.0	6.000	24.8		
1.000	10.6	2.600	16.6	6.500	25.8		

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