LAND OFF COBBLERS LANE, PONTEFRACT

FLOOD RISK AND DRAINAGE ASSESSMENT

Final Report v1.0

November 2018

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Report Title	**Land off Cobblers Lane, Pontefract** Flood Risk Assessment Final Report v1.0
Client	Mr N Dando
Date of issue	7 November 2018

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1 INTRODUCTION

1.1 PURPOSE OF REPORT

Weetwood Services Ltd ('Weetwood') has been instructed by Mr N Dando to prepare a Flood Risk Assessment (FRA) report to accompany an outline planning application for the proposed development of a site off Cobblers Lane, Pontefract.

The assessment has been undertaken in accordance with the requirements of the National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG).

1.2 STRUCTURE OF THE REPORT

The report is structured as follows:

Section 1	Introduction and report structure
Section 2	Presents national and local flood risk and drainage planning policy
Section 3	Provides background information relating to the development site, the development proposals, ground conditions and existing site access arrangements
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 to ensure that surface water runoff is sustainably managed and flood risk is not increased elsewhere.
Section 7	Presents a summary of key findings
Section 8	Presents the recommendations

2 PLANNING POLICY AND GUIDANCE

2.1 NATIONAL PLANNING POLICY AND GUIDANCE

2.1.1 National Planning Policy Framework

The aim of the NPPF is to ensure that flood risk is taken into account at all stages in the planning process and is appropriately addressed.

2.1.1.1 Sequential Test

Paragraph 155 of the NPPF states that "*inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere"*.

This policy is implemented through the application of the sequential test (NPPF paragraph 158).

2.1.1.2 Exception Test

Paragraph 159-161 of the NPPF states *"If it is not possible for the 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 potential vulnerability of the site and of the development proposed, in line with the Flood Risk Vulnerability Classification set out in the national planning guidance"* (Paragraph 159).

"The application of the exception test should be informed by a strategic or site-specific FRA, depending on whether it is being applied during plan production or at the application stage. For the exception test to be passed it should be demonstrated that: a) the development would provide wider sustainability benefits to the community that outweigh the flood risk; and b) 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" (Paragraph 160).

"Both elements of the exception test should be satisfied for development to be allocated or permitted" (Paragraph 161).

2.1.1.3 Surface Water Drainage

Paragraph 163 of the NPPF states that development should only be allowed in areas at risk of flooding if it incorporates sustainable drainage systems unless there is clear evidence that this would be inappropriate.

The NPPF also states, in paragraph 165 that applications for major developments as defined in the Town and Country Planning (Development Management Procedure) (England) Order 2015, 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.

2.1.2 Technical Standards for Sustainable Drainage Systems (DEFRA, March 2015)

The non-statutory technical standards state that surface water drainage systems must be designed so that:

- Flooding does not occur on any part of the site for a 1:30 annual probability rainfall event, unless an area is designed to hold and/or convey water as part of the design;
- Flooding does not occur in any part of a building during a 1:100 annual probability event; and
- Flows resulting from rainfall in excess of a 1:100 annual probability rainfall event are managed in exceedance routes that minimise the risks to people and property, so far as is reasonably practicable.
- For greenfield developments, the peak runoff rate from the development to any drain, sewer or surface water body for the 1:1 and 1:100 annual probability rainfall event should never exceed the peak greenfield runoff rate for the same event. For developments which were previously developed, the peak runoff rate must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event.
- Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1:100 annual probability, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event. Where reasonably practicable, for developments which have been previously developed, the runoff volume must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event.
- Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body, the runoff volume must be discharged at a rate that does not adversely affect flood risk.

2.2 LOCAL PLANNING POLICY AND GUIDANCE

Wakefield Metropolitan District Council (MDC) Local Development Framework was adopted April 2009 and includes the following relevant policies.

'Policy D24 – Flood Risk' states:

- (Stem c): "*Applicants must demonstrate that developments can be considered safe over their predicted lifetime, and that they will not increase flooding elsewhere*"
- (Stem d): "*Measures to mitigate the risk of flooding and to manage any residual flood risk must be provided as part of the development and provision must be made for their future maintenance*."

'Policy D25 – Drainage' states that major flooding events have occurred within the district caused by surface water and sewer flooding and:

- (Stem 1): "*Surface water from new developments must be managed using sustainable drainage techniques unless it can be demonstrated that they are not technically feasible. New developments on brownfield sites will be expected to reduce runoff rates by at least 30%, and must not increase existing rates on greenfield sites*."

- (Stem 2): "*Development will only be permitted if infrastructure required to service the development is available or the provision of infrastructure can be co-ordinated to meet the demand generated by the new development*."

The reduction to runoff rates on brownfield sites must be applied to a 1 in 1 year rainfall event. On-site storage for surface water for a 1 in 100 year event must also be incorporated.

Policy D28 - Sustainable Construction and Efficient Use of Resources states: "*The Council will require that new development within the district shall be energy and water efficient and incorporate built-in conservation measures. Opportunities to* conserve *energy and water resources through the layout and design of the development shall be maximised. In considering planning applications the Council will require where practical*:"

- Stem c): "The use of green roofs, rainwater and grey water storage and recycling, and sustainable drainage systems."

Policy CS 13 - Mitigating and Adapting to Climate Change and Efficient Use of Resources states:

"*In order to be sustainable, development must minimise the impact and mitigate the likely effects of climate change on existing and future occupants, the wider community and the environment and minimise the use of natural resources. This will be achieved by*:"

- (Stem a): "*Avoiding unacceptable levels of flood risk, particularly in areas of high flood risk such as the Calder River Valley, the Went River Basin, and river tributaries in the south east of the district*";
- (Stem d): "*Proactively managing surface water through the promotion of sustainable drainage techniques and positive land management*."

2.3 CONSENTS

An Environmental Permit for Flood Risk Activities may be required from the Environment Agency (EA) for work:

- In, under, over or near a main river (including where the river is in a culvert)
- On or near a flood defence on a main river
- In the flood plain of a main river
- On or near a sea defence

Further information can be found at https://www.gov.uk/guidance/flood-risk-activities-environmental-permits.

Land drainage consent may be required from the Lead Local Flood Authority or Internal Drainage Board for work to an Ordinary Watercourse. Undertaking activities controlled by local byelaws (made under the Water Resources Act 1991) also requires the relevant consent.

2.4 RELEVANT DOCUMENTS

The assessment has been informed by the following documents:

- Strategic Flood Risk Assessment (SFRA) Level 2, Wakefield MDC, January 2009
- Calder Catchment SFRA Volume II, Wakefield Council, July 2016
- Preliminary Flood Risk Assessment (PFRA), Wakefield MDC, June 2011

3 SITE DETAILS AND PROPOSED DEVELOPMENT

3.1 SITE DETAILS

The approximately 1.28 ha greenfield site is located to the east of Cobblers Lane, Pontefract at Ordnance Survey National Grid Reference SE 471 226, as shown in **Figure 1**.

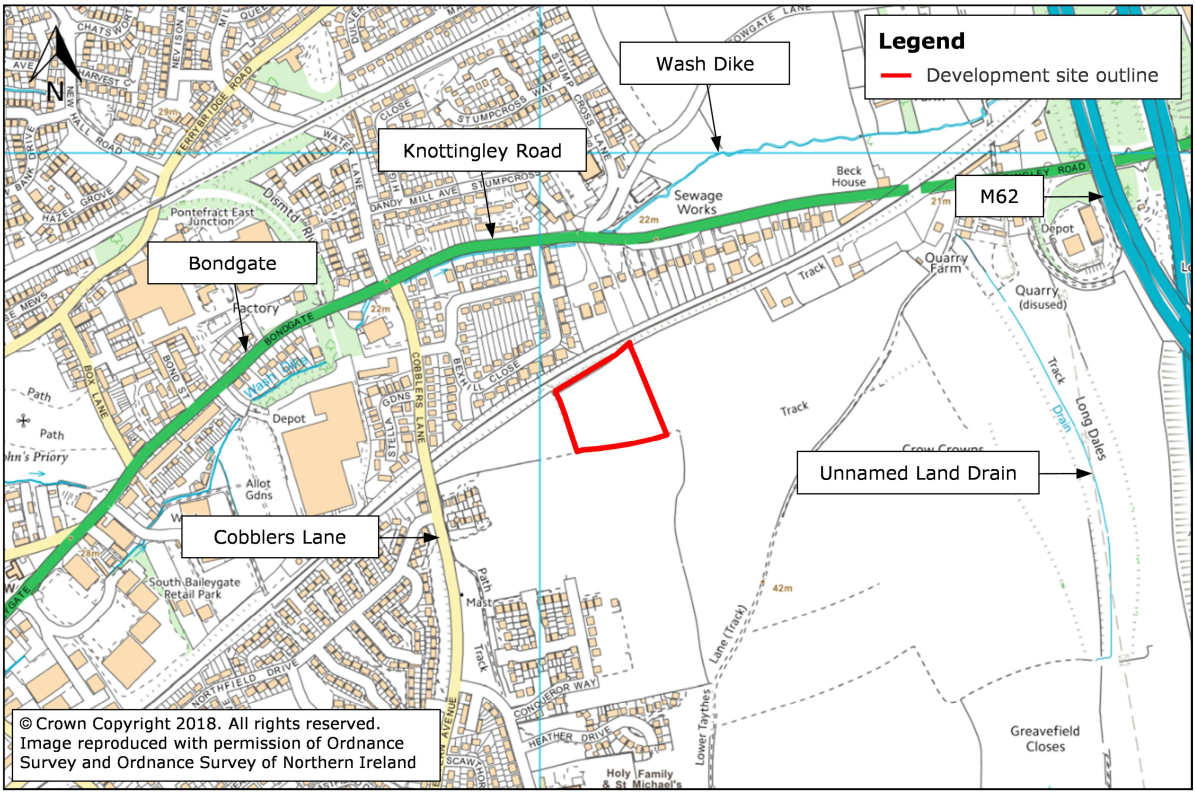

Figure 1: Site Location

3.2 PROPOSED DEVELOPMENT

The proposed development is for the construction of up to 50 dwellings with associated access and landscaped areas including green open space.

The NPPG classifies residential development as More Vulnerable land use.

3.3 WATERBODIES IN THE VICINITY OF THE SITE

Wash Dike flows predominantly in a north-easterly direction approximately 180 m to the north of the site. Wash Dike outfalls into the Aire and Calder Navigation approximately 2.3 km to the north-east of the site.

An unnamed land drain is located approximately 520 m east of the site. The land drain is classified as an ordinary watercourse.

3.4 GROUND CONDITIONS

National Soils Research Institute mapping[1] classifies soil conditions at the site and within the surrounding area as 'Slowly permeable seasonally wet acid loamy and clayey soils'.

British Geological Survey (BGS) Surface Geology mapping[2] indicates the underlying bedrock to comprise of mudstone, siltstone and sandstone. No superficial deposits are recorded.

A site investigation[3] on land adjacent to the south of the site indicates ground conditions to generally comprise topsoil over natural clay underlain by limestone bedrock.

BGS borehole records located along Cobblers Lane to the west indicates ground conditions to comprise of the following:

- BGS reference SE42SE509: Silt up to 0.7 metres below ground level (m bgl)
- BGS reference SE42SE174: Clay up to 1.2 m bgl underlain by limestone up to 1.4 m bgl
- BGS reference SE42SE175: Clay and gravel up to 2.5 m bgl underlain by limestone up to 3.0 m bgl
- BGS reference SE42SE510 and E42SE511: Sand up to 0.5 m bgl
- BGS reference SE42SE223 and SE42SE467: Limestone up to 20 m bgl

Soakaway testing on land adjacent to the southern boundary of the site indicated that infiltration rates varied from 4.3 to 38 $x10^{-6}$ m/sec[4].

DEFRA mapping classifies the underlying bedrock as a Principal aquifer. These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

The site is not shown to be located within a designated Groundwater Source Protection Zone.

3.5 SITE LEVELS

A topographic survey of the site has been undertaken by Landmark Surveys (UK) Ltd and is provided in **Appendix A**.

This information has been utilised to develop a digital terrain model as illustrated in **Figure 2**. Site levels are generally shown to be in the region of 36.0 to 43.3 m Above Ordnance Datum (AOD), with ground levels sloping down towards the north-east corner of the site.

LiDAR has been used to develop a digital terrain model of the surrounding area as illustrated in **Figure 3**.

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1 www.landis.org.uk/soilscapes/

2 http://mapapps.bgs.ac.uk/geologyofbritain/home.html

3 Phase 1 Geotechnical and Geo-Environmental Site Investigation, Cobblers Lane, Pontefract, Eastwood and Partners, August 2016

4 Land at Cobblers Lane, Pontefract – Infiltration Investigation, Eastwood and Partners, December 2014

Figure 2: Digital Terrain Model from Topographical Survey

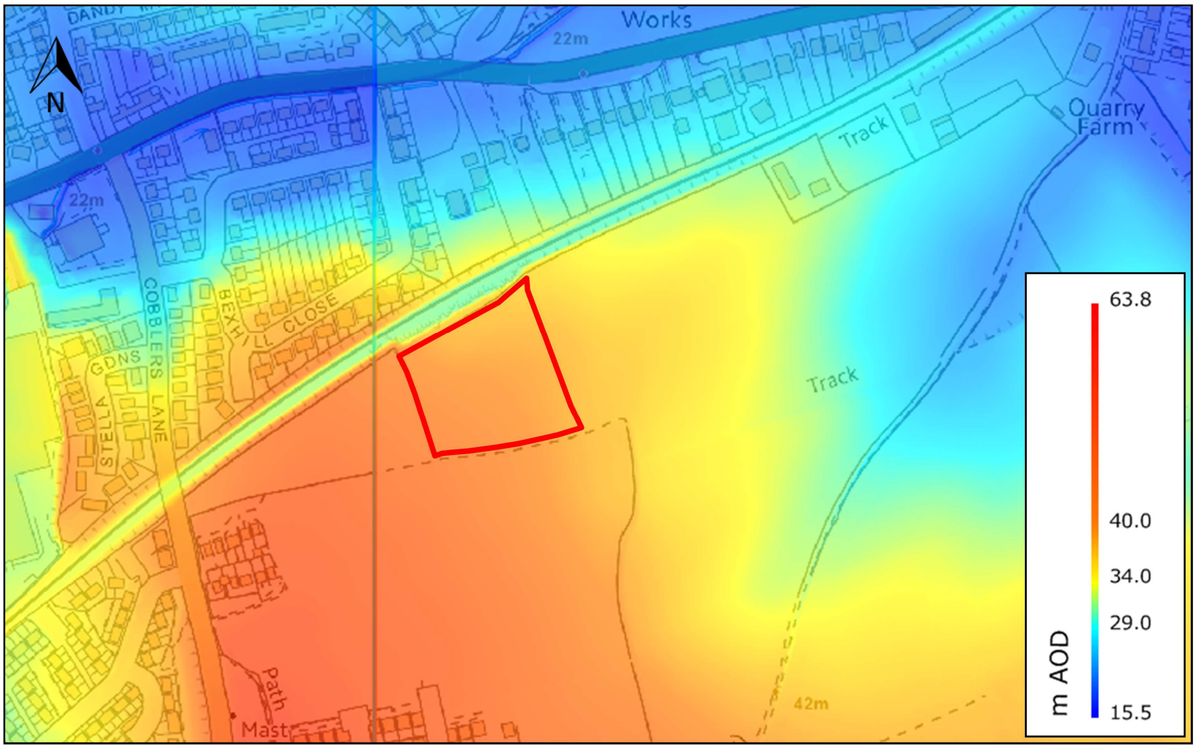

Figure 3: Digital Terrain Model from LiDAR

3.6 ACCESS AND EGRESS

Access and egress to the site is provided off Cobblers Lane. Levels along Cobblers Lane adjacent to the site are generally shown to be in the region of 39.5 to 40.0 m AOD, with levels sloping down in a northerly direction.

4 REVIEW OF FLOOD RISK

4.1 FLOOD ZONE DESIGNATION

Flood zones refer to the probability of river and sea flooding. The NPPG defines flood zones as follows:

- Flood Zone 1: Low Probability. Land having a less than 1:1,000 annual probability of river or sea flooding.
- Flood Zone 2: Medium Probability. Land having between a 1:100 and 1:1,000 annual probability of river flooding; or Land having between a 1:200 and 1:1,000 annual probability of sea flooding.
- Flood Zone 3a: High Probability. Land having a 1:100 or greater annual probability of river flooding; or Land having a 1:200 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 Flood Map for Planning. The zones do not account for possible future changes in flooding due to the impact of climate change or the presence of flood defences (although areas benefitting from flood defences may be indicated).

According to the Flood Map for Planning (**Figure 4**) the site is located in Flood Zone 1. Map W of the Calder Catchment SFRA reaffirms the sites Flood Zone 1 designation.

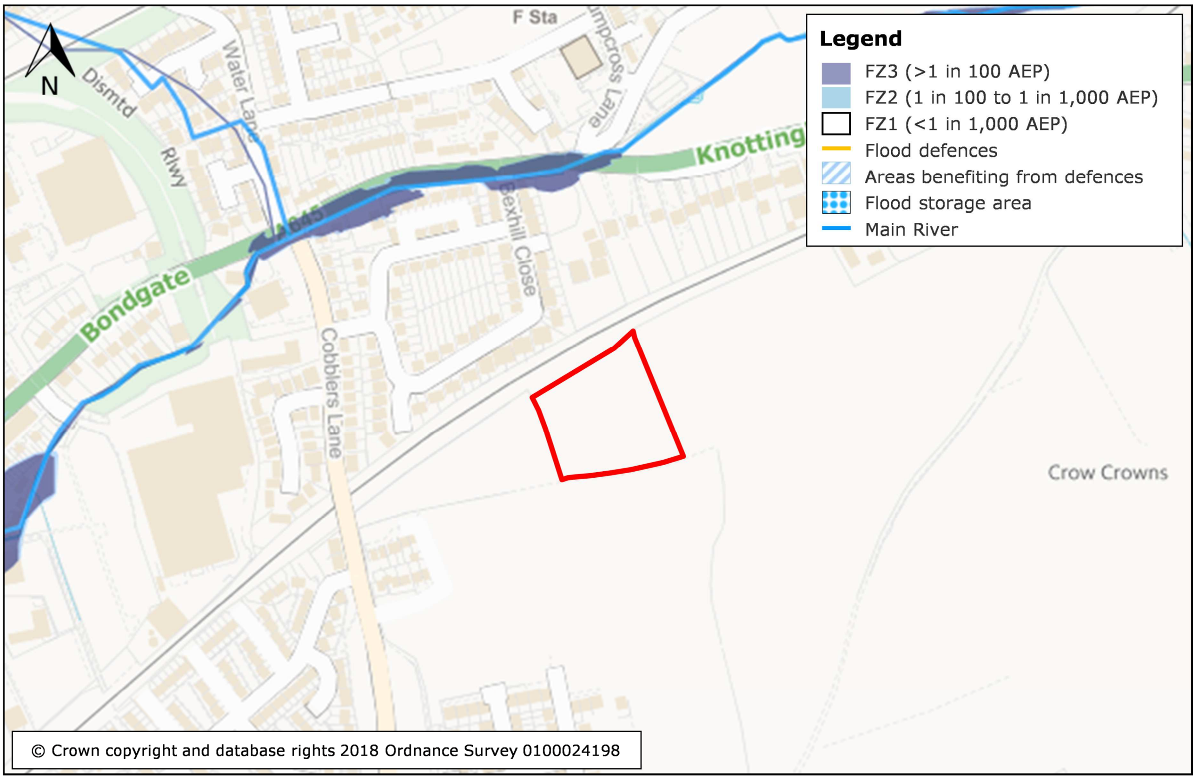

Figure 4: Flood Map for Planning
(Source: gov.uk website)

4.2 SEQUENTIAL TEST AND EXCEPTION TEST

The proposed development site is situated within Flood Zone 1 and therefore satisfies the requirements of the sequential test.

Furthermore, the application of the exception test is subsequently not deemed to be necessary; however, the proposals should still meet the requirements for site specific FRAs.

4.3 HISTORICAL RECORDS OF FLOODING

Map W of the Calder Valley SFRA does not contain any records of historic flood events within the vicinity of the site.

4.4 FLUVIAL FLOOD RISK

LiDAR data indicates that Wash Dike and the unnamed land drain are over 14 m below site levels. In addition, the development site is located in Flood Zone 1. As such, the site is assessed not to be at risk of fluvial flooding.

4.5 FLOOD RISK FROM SURFACE WATER

The Flood Risk from Surface Water map (**Figure 5**) indicates that the site is at 'Very Low' risk of flooding from surface water.

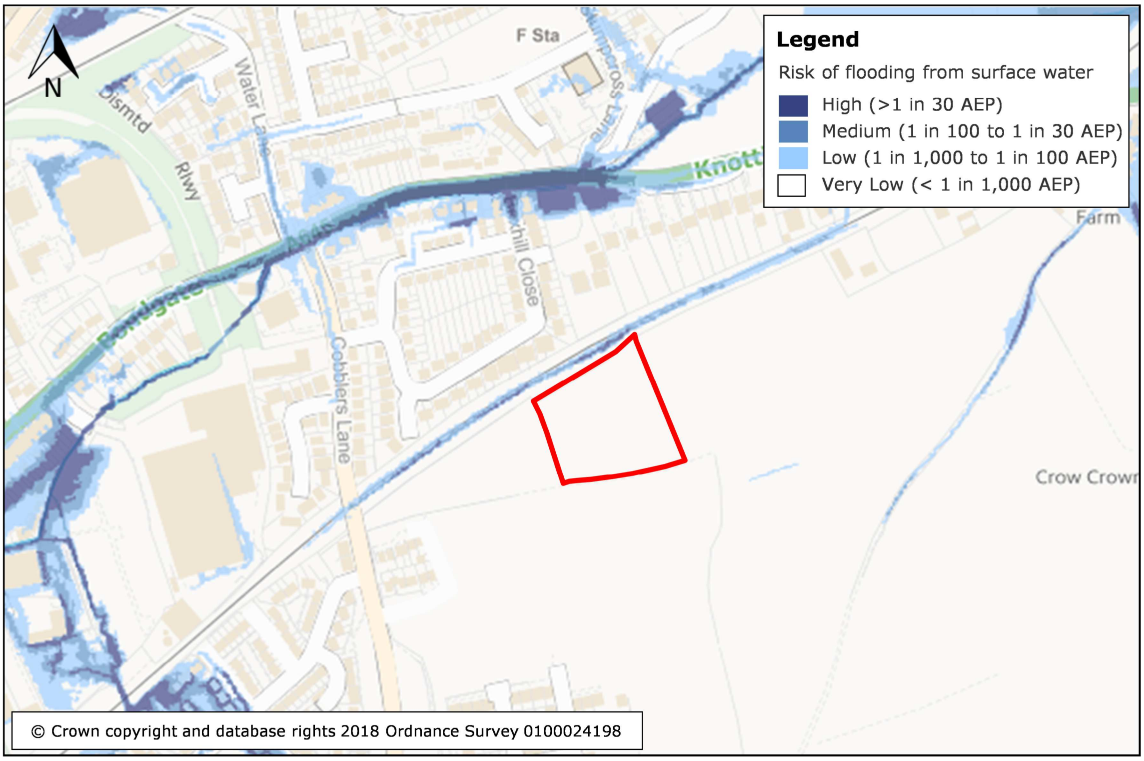

Figure 5: Flood Risk from Surface Water
(Source: gov.uk website)

4.6 FLOOD RISK FROM RESERVOIRS, CANALS AND OTHER ARTIFICIAL SOURCES

There are no canals or 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 assessed not to be at risk of flooding from reservoirs, canals or other artificial sources.

4.7 FLOOD RISK FROM GROUNDWATER

According to the BGS Groundwater Flooding Hazard map (**Figure 6**) the susceptibility to groundwater flooding is 'Low'.

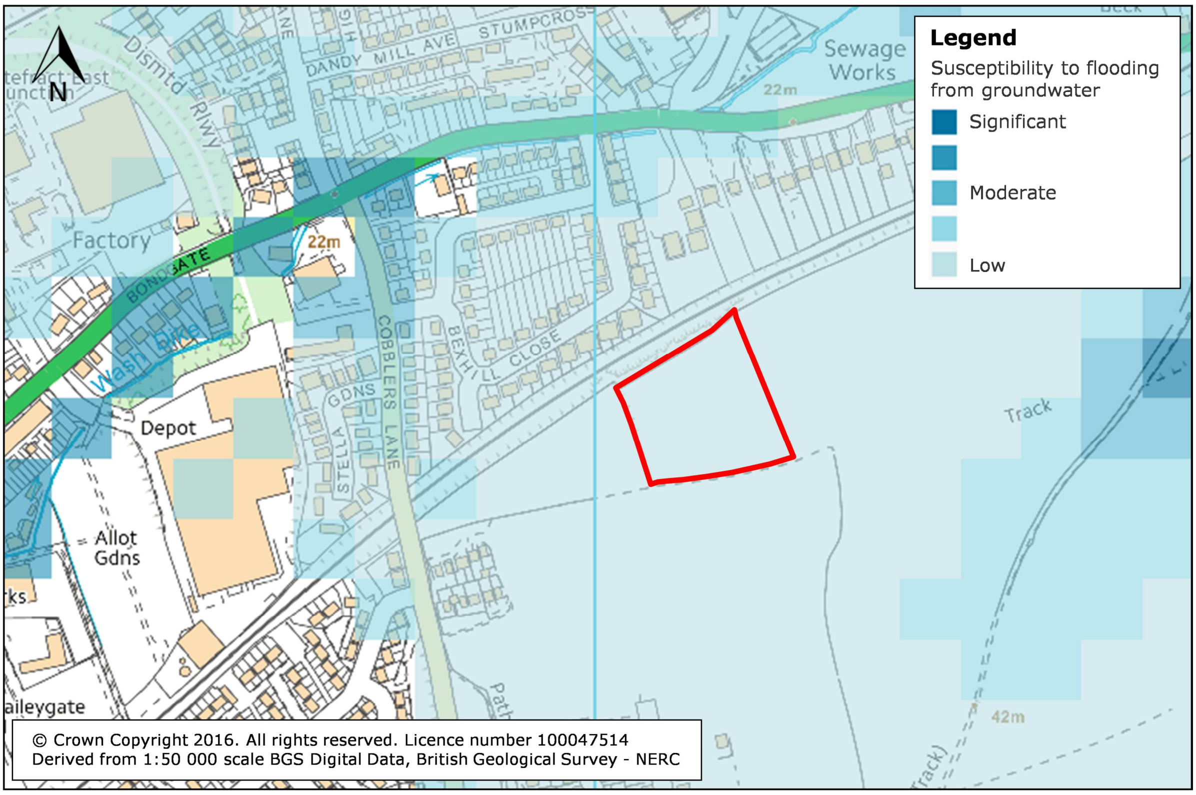

Figure 6: Groundwater Flooding Hazard Map
(Source: Findmaps)

5 FLOOD RISK MITIGATION MEASURES

5.1 FINISHED FLOOR LEVELS

Finished floor levels should be set at a minimum of 0.15 m above adjacent ground levels following re-profiling of the site in order to mitigate the residual risk of flooding from groundwater.

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[5].

5.2 ACCESS AND EGRESS

Dry access and egress to the site may be provided via Cobblers Lane via the Barratt Homes estate (currently under construction/near completion) adjacent to the south of the site.

[5] 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 EXISTING FLOW REGIMES

The site comprises approximately 1.28 ha of undeveloped greenfield land. Given site topography and ground conditions, surface water runoff would be expected to infiltrate where conditions allow and/or flow overland in a north-easterly direction towards the railway line.

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

Annual probability of rainfall event	Greenfield Runoff Rate (l/s/ha)	Greenfield Runoff Rate for 1.28 ha Site (l/s)
1:1	3.2	4.1
QBAR	3.7	4.7
1:30	6.4	8.2
1:100	7.6	9.7

6.2 POST DEVELOPMENT IMPERMEABLE AREA

The layout of the development is yet to be fixed. As such, for the purposes of this assessment the area of impermeable surfaces has been estimated to be 0.51 ha, based on guidance provided in Urban Drainage[6].

6.3 DISPOSAL OF SURFACE WATER

In accordance with the NPPG[7], 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.

The preliminary assessment of ground conditions presented in **Section 3.4** indicates that the disposal of surface water by infiltration may be feasible. However, on-site percolation tests would need to be undertaken to confirm this at the discharge of condition/reserved matters stage.

In the event that infiltration is not feasible, surface water runoff from impermeable surfaces would be discharged to the unnamed land drain to the east of the site.

6.4 INDICATIVE DRAINAGE SCHEME

Two drainage schemes have been prepared for the proposed development – Option 1 disposal via infiltration and Option 2 disposal to a watercourse.

For both options, attenuation storage will be provided to store surface water runoff generated across roofs and hardstanding.

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6 Urban Drainage 3rd Edition, Butler, D and Davies, J.W, 2011, Section 11.3.2 and Table 11.2

7 Paragraph 080, Reference ID: 7-080-20150323

The storage facilities have been modelled using the Detailed Design module of MicroDrainage Source Control. The assessment has been undertaken for the 1:100 annual probability storm event including a 20% increase in rainfall intensity in order to allow for climate change in accordance with the 2016 guidance[6]. A sensitivity analysis has been undertaken using a 40% increase in rainfall intensity in order to allow for uncertainty with respect to climate change.

6.4.1 Option 1: Disposal of Surface Water via Infiltration

For the purposes of the outline surface water drainage strategy, it has been assumed that surface water runoff from impermeable surfaces of the developed site will be drained via one or more infiltration basins.

Assuming an infiltration rate of 0.15 m/hr and a 1.3 m depth infiltration basin (including a 0.3 m freeboard and a side slope of 1 in 3), an area of approximately 343 m^2 would be required (see **Appendix C**).

The sensitivity analysis for climate change indicates that the additional volume of surface water would be catered for within the freeboard of the infiltration basin (see **Appendix D**). As such, no flooding of the drainage system would therefore be expected in the 1:100 annual probability rainfall event including a 40% increase in rainfall intensity.

6.4.2 Option 2: Disposal of Surface Water to a Watercourse

6.4.2.1 Peak Flow Control

It is proposed to restrict surface water runoff to the existing greenfield QBAR rate of 4.7 l/s post development, as outlined in **Table 1**.

6.4.2.2 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 1:100 annual probability, 6 hour rainfall event should not exceed the greenfield runoff volume for the same event.

This is usually addressed by designing a long term storage facility within the site. However, as outlined within the CIRIA SuDS Manual 2015 an alternative approach to managing extra runoff volumes from extreme events is to release all runoff (above the 1:1 annual probability event) from the site at a maximum rate of 2 l/s/ha or QBAR, whichever is the higher value.

Given the proposals to restrict peak discharge rates to the existing QBAR rate in up to the 1:100 annual probability event, including an allowance or climate change, long term storage is not required.

6.4.2.3 Attenuation Storage

For the purposes of the surface water drainage strategy, it has been assumed that surface water storage would be provided within an attenuation basin.

Assuming a peak discharge rate of 4.7 l/s, an approximate storage volume of 225 m^3 would be required. This could be accommodated within a 1.3 m deep basin (including a 0.3 m freeboard and a side slope of 1 in 3) with a surface area of approximately 369 m^2 (see **Appendix E**).

The sensitivity analysis for climate change indicates that the additional volume of surface water would be catered for within the freeboard of the detention basin structures (see **Appendix F**). As such, no flooding of the drainage system would therefore be expected in the 1:100 annual probability rainfall event including a 40% increase in rainfall intensity.

The calculations assume that all storage is provided within the formal attenuation storage facility; with no storage being provided in the proposed pipe network. As such, the volumes of storage presented are likely to be an overestimate and would be expected to reduce when the drainage scheme is refined at the discharge of conditions/reserved matters stage.

In practice the storage is likely to be provided in a number of different storage facilities. The potential for alternative and/or additional SuDS features (for example, permeable paving, geo-cellular storage tanks and retention ponds) and the sizing and location of the storage facilities will be confirmed at the discharge of condition/reserved matters stage.

6.4.2.4 Exceedance Routes

Flows resulting from rainfall in excess of the 1:100 annual probability rainfall event including an allowance for climate change (20% and 40%) will be directed away from built development and along managed exceedance routes.

6.5 ADOPTION AND MAINTENANCE OF SUDS

The pipe network 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 2**.

Table 2: Indicative SuDS Maintenance Schedule (Infiltration/Attenuation Basin)

Schedule	Required action	Frequency
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)
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every two years, or as

Schedule	Required action	Frequency
	Remove sediments from inlets/outlets and main basin when required	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	

6.6 SUMMARY

The findings of this report have demonstrated that a surface water drainage strategy at the site is feasible and in accordance with planning policy for the development proposals. Through the implementation of a surface water drainage strategy and taking climate change into account, flood risk would not be increased elsewhere.

7 SUMMARY

This report has been prepared on behalf of Mr N Dando and relates to the proposed development of a site off Cobblers Lane, Pontefract.

According to the Flood Map for Planning the proposed development is located outside the 1:1,000 annual probability 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 applied.

The site is assessed not to be at risk of flooding from fluvial sources, surface water, reservoirs, canals or other artificial sources and at a low risk of groundwater flooding.

Dry access and egress to the site may be provided via Cobblers Lane via the Barratt Homes estate (currently under construction/near completion) adjacent to the south of the site.

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

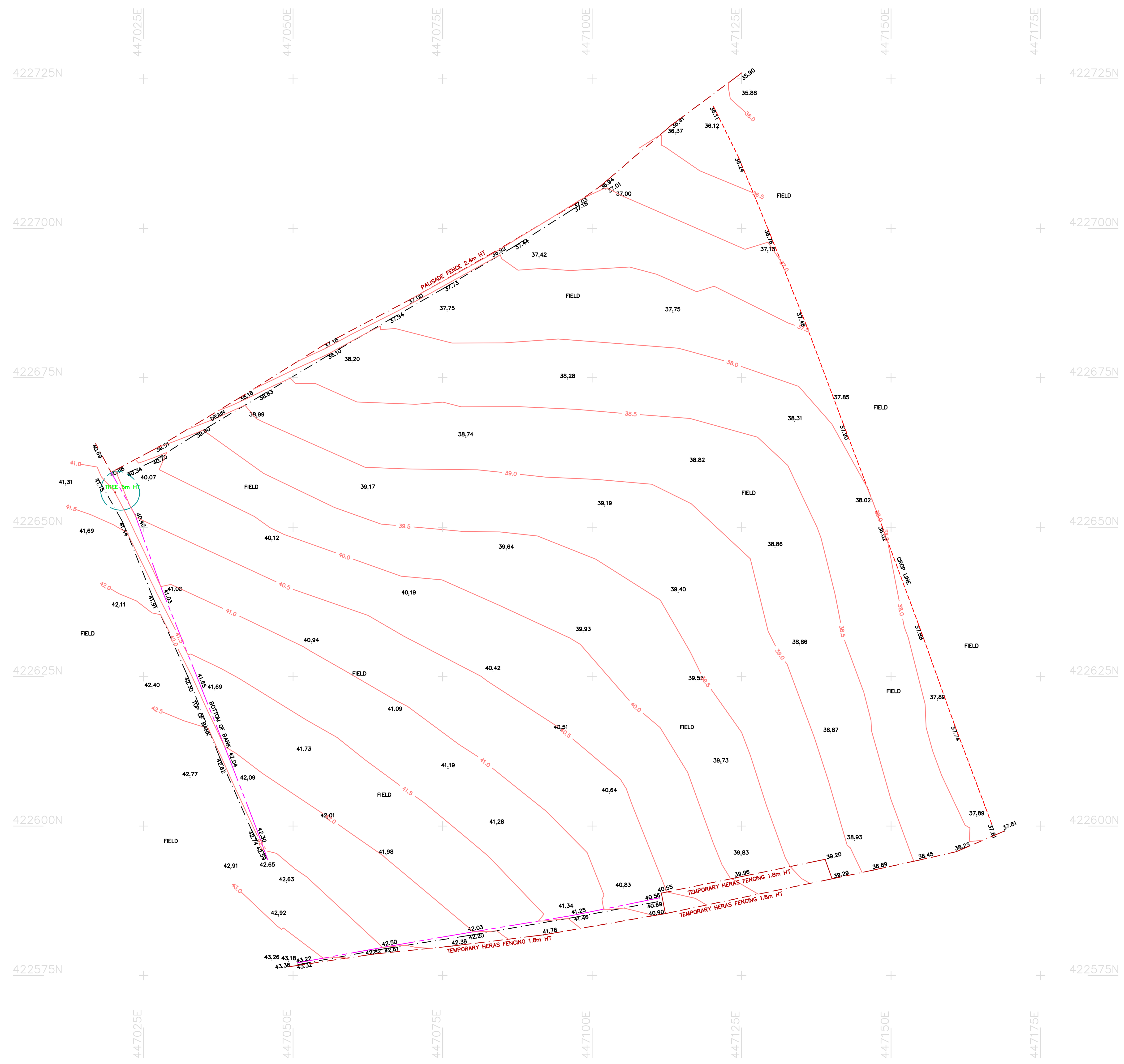
8 RECOMMENDATIONS

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 0.15 m above adjacent ground levels following any re-profiling at the site.

- The detailed drainage design to be submitted to and approved by the local planning authority prior to the commencement of development.

APPENDIX A:	Topographic Survey



NOTES

LEVEL DATUM.....OS ORTHOMETRIC HTS

GRID ORIENTATION.....OSGB36

NORTH

KEY

- FIRE HYDRANT
- BRITISH TELECOM MANHOLE
- ELECTRICITY INSPECTION COVER
- CABLE TV
- WATER STOP VALVE
- GAS VALVE
- ELECTRICITY POST/PYLON
- LIGHT
- TRAFFIC LIGHT
- ROAD SIGN
- TELEGRAPH POLE
- STAY WIRE
- ROAD GULLEY
- KERB OUTLET
- DRAINAGE MANHOLE
- WASHOUT
- DRAIN/DIKE WATER LEVEL
- DRAIN/DIKE INVERT LEVEL
- TOP OF BANK
- BOTTOM OF BANK
- CONCRETE
- TRACK
- BUILDING
- ROAD CHANNEL
- HEDGEROW
- TREE CANOPY
- FENCE

REVISIONS

Date	Details

Landmark Surveys (UK) Ltd

149 ROYSTON ROAD
CUDWORTH
BARNSLEY
S72 8BW
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FAX. 01226 780070
MOBILE TEL. 07801 697470
E-MAIL mark.landmark@btinternet.com

Client

MR.N.DANDO

Site

SITE OFF COBBLERS LANE
PONTEFRACT

Scale	1 : 500	Date	OCT 2018
Drawn by:	M.R.GILMORE	Surveyed by:	M.R.G.,B.P
Checked by:		Plan Ref.	NBA006SP

APPENDIX B:	Greenfield Runoff Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.450
Area (ha)	1.000	Urban	0.000
SAAR (mm)	600	Region Number	Region 3

Results	**l/s**
QBAR Rural	3.7
QBAR Urban	3.7
Q100 years	7.6
Q1 year	3.2
Q30 years	6.4
Q100 years	7.6

APPENDIX C:	Option 1: Surface Water Attenuation - Storage Volume Calculation

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 213 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	36.278	0.578	6.5	100.5	O K
30 min Summer	36.407	0.707	7.4	129.7	O K
60 min Summer	36.514	0.814	8.2	156.0	O K
120 min Summer	36.580	0.880	8.6	173.1	O K
180 min Summer	36.590	0.890	8.7	175.8	O K
240 min Summer	36.589	0.889	8.7	175.4	O K
360 min Summer	36.573	0.873	8.6	171.2	O K
480 min Summer	36.552	0.852	8.4	165.7	O K
600 min Summer	36.528	0.828	8.3	159.6	O K
720 min Summer	36.504	0.804	8.1	153.5	O K
960 min Summer	36.459	0.759	7.8	142.1	O K
1440 min Summer	36.377	0.677	7.2	122.6	O K
2160 min Summer	36.273	0.573	6.5	99.4	O K
2880 min Summer	36.187	0.487	5.9	81.5	O K
4320 min Summer	36.054	0.354	5.0	55.9	O K
5760 min Summer	35.956	0.256	4.4	38.7	O K
7200 min Summer	35.881	0.181	3.9	26.5	O K
8640 min Summer	35.826	0.126	3.6	18.0	O K
10080 min Summer	35.783	0.083	3.3	11.7	O K
15 min Winter	36.334	0.634	6.9	112.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	110.050	0.0	18
30 min Summer	72.924	0.0	33
60 min Summer	46.096	0.0	62
120 min Summer	28.170	0.0	120
180 min Summer	20.837	0.0	158
240 min Summer	16.722	0.0	188
360 min Summer	12.192	0.0	254
480 min Summer	9.749	0.0	324
600 min Summer	8.189	0.0	392
720 min Summer	7.099	0.0	462
960 min Summer	5.662	0.0	598
1440 min Summer	4.109	0.0	866
2160 min Summer	2.977	0.0	1252
2880 min Summer	2.366	0.0	1616
4320 min Summer	1.709	0.0	2336
5760 min Summer	1.355	0.0	3064
7200 min Summer	1.131	0.0	3816
8640 min Summer	0.976	0.0	4496
10080 min Summer	0.861	0.0	5152
15 min Winter	110.050	0.0	18

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	36.475	0.775	7.9	146.2	O K
60 min Winter	36.592	0.892	8.7	176.4	O K
120 min Winter	36.670	0.970	9.3	197.7	O K
180 min Winter	36.685	0.985	9.4	201.9	O K
240 min Winter	36.680	0.980	9.3	200.4	O K
360 min Winter	36.660	0.960	9.2	195.0	O K
480 min Winter	36.633	0.933	9.0	187.3	O K
600 min Winter	36.600	0.900	8.8	178.5	O K
720 min Winter	36.567	0.867	8.5	169.6	O K
960 min Winter	36.501	0.801	8.1	152.7	O K
1440 min Winter	36.387	0.687	7.3	124.9	O K
2160 min Winter	36.245	0.545	6.3	93.5	O K
2880 min Winter	36.133	0.433	5.5	70.7	O K
4320 min Winter	35.967	0.267	4.5	40.7	O K
5760 min Winter	35.854	0.154	3.8	22.3	O K
7200 min Winter	35.776	0.076	3.3	10.7	O K
8640 min Winter	35.747	0.047	2.9	6.5	O K
10080 min Winter	35.742	0.042	2.6	5.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	72.924	0.0	32
60 min Winter	46.096	0.0	60
120 min Winter	28.170	0.0	118
180 min Winter	20.837	0.0	170
240 min Winter	16.722	0.0	196
360 min Winter	12.192	0.0	272
480 min Winter	9.749	0.0	348
600 min Winter	8.189	0.0	422
720 min Winter	7.099	0.0	498
960 min Winter	5.662	0.0	642
1440 min Winter	4.109	0.0	912
2160 min Winter	2.977	0.0	1316
2880 min Winter	2.366	0.0	1696
4320 min Winter	1.709	0.0	2420
5760 min Winter	1.355	0.0	3120
7200 min Winter	1.131	0.0	3816
8640 min Winter	0.976	0.0	4280
10080 min Winter	0.861	0.0	5120

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	0.381	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.510

Time (mins) From:	To:	Area (ha)
0	4	0.510

Model Details

Storage is Online Cover Level (m) 37.000

Infiltration Basin Structure

Invert Level (m) 35.700 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.15000 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.15000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	135.0	1.300	343.4

APPENDIX D:	Option 1: Surface Water Attenuation - Sensitivity

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 232 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	36.355	0.655	7.0	117.6	O K
30 min Summer	36.499	0.799	8.0	152.2	O K
60 min Summer	36.619	0.919	8.9	183.7	O K
120 min Summer	36.697	0.997	9.5	205.4	O K
180 min Summer	36.711	1.011	9.6	209.5	O K
240 min Summer	36.712	1.012	9.6	209.6	O K
360 min Summer	36.698	0.998	9.5	205.7	O K
480 min Summer	36.679	0.979	9.3	200.2	O K
600 min Summer	36.656	0.956	9.2	193.7	O K
720 min Summer	36.632	0.932	9.0	187.0	O K
960 min Summer	36.584	0.884	8.6	174.1	O K
1440 min Summer	36.498	0.798	8.0	152.0	O K
2160 min Summer	36.389	0.689	7.3	125.5	O K
2880 min Summer	36.298	0.598	6.7	104.8	O K
4320 min Summer	36.155	0.455	5.7	75.1	O K
5760 min Summer	36.047	0.347	5.0	54.7	O K
7200 min Summer	35.964	0.264	4.5	40.1	O K
8640 min Summer	35.898	0.198	4.0	29.2	O K
10080 min Summer	35.846	0.146	3.7	21.0	O K
15 min Winter	36.418	0.718	7.5	132.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	128.392	0.0	18
30 min Summer	85.078	0.0	33
60 min Summer	53.779	0.0	62
120 min Summer	32.864	0.0	120
180 min Summer	24.310	0.0	164
240 min Summer	19.509	0.0	192
360 min Summer	14.224	0.0	258
480 min Summer	11.373	0.0	326
600 min Summer	9.554	0.0	396
720 min Summer	8.282	0.0	464
960 min Summer	6.605	0.0	600
1440 min Summer	4.794	0.0	866
2160 min Summer	3.473	0.0	1256
2880 min Summer	2.760	0.0	1640
4320 min Summer	1.993	0.0	2376
5760 min Summer	1.581	0.0	3112
7200 min Summer	1.320	0.0	3816
8640 min Summer	1.138	0.0	4504
10080 min Summer	1.004	0.0	5240
15 min Winter	128.392	0.0	18

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
30 min Winter	36.574	0.874	8.6	171.4	O K
60 min Winter	36.704	1.004	9.5	207.5	O K
120 min Winter	36.795	1.095	10.2	234.1	O K
180 min Winter	36.815	1.115	10.3	240.5	Flood Risk
240 min Winter	36.811	1.111	10.3	239.2	Flood Risk
360 min Winter	36.795	1.095	10.2	234.2	O K
480 min Winter	36.769	1.069	10.0	226.5	O K
600 min Winter	36.738	1.038	9.8	217.3	O K
720 min Winter	36.705	1.005	9.5	207.6	O K
960 min Winter	36.638	0.938	9.0	188.7	O K
1440 min Winter	36.518	0.818	8.2	156.8	O K
2160 min Winter	36.369	0.669	7.1	120.7	O K
2880 min Winter	36.248	0.548	6.3	94.1	O K
4320 min Winter	36.068	0.368	5.1	58.5	O K
5760 min Winter	35.941	0.241	4.3	36.3	O K
7200 min Winter	35.849	0.149	3.7	21.6	O K
8640 min Winter	35.781	0.081	3.3	11.4	O K
10080 min Winter	35.749	0.049	3.0	6.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	85.078	0.0	32
60 min Winter	53.779	0.0	62
120 min Winter	32.864	0.0	118
180 min Winter	24.310	0.0	172
240 min Winter	19.509	0.0	216
360 min Winter	14.224	0.0	274
480 min Winter	11.373	0.0	352
600 min Winter	9.554	0.0	428
720 min Winter	8.282	0.0	500
960 min Winter	6.605	0.0	646
1440 min Winter	4.794	0.0	924
2160 min Winter	3.473	0.0	1320
2880 min Winter	2.760	0.0	1700
4320 min Winter	1.993	0.0	2424
5760 min Winter	1.581	0.0	3168
7200 min Winter	1.320	0.0	3888
8640 min Winter	1.138	0.0	4576
10080 min Winter	1.004	0.0	5120

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	0.381	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.510

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.510

Model Details

Storage is Online Cover Level (m) 37.000

Infiltration Basin Structure

Invert Level (m) 35.700 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.15000 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.15000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	135.0	1.300	343.4

APPENDIX E:	Option 2: Surface Water Attenuation - Storage Volume Calculation

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	36.233	0.533	4.7	100.5	O K
30 min Summer	36.361	0.661	4.7	131.2	O K
60 min Summer	36.474	0.774	4.7	160.4	O K
120 min Summer	36.559	0.859	4.7	184.0	O K
180 min Summer	36.588	0.888	4.7	192.1	O K
240 min Summer	36.592	0.892	4.7	193.5	O K
360 min Summer	36.573	0.873	4.7	188.0	O K
480 min Summer	36.550	0.850	4.7	181.4	O K
600 min Summer	36.529	0.829	4.7	175.6	O K
720 min Summer	36.511	0.811	4.7	170.3	O K
960 min Summer	36.475	0.775	4.7	160.6	O K
1440 min Summer	36.403	0.703	4.7	141.8	O K
2160 min Summer	36.285	0.585	4.7	112.5	O K
2880 min Summer	36.151	0.451	4.7	82.3	O K
4320 min Summer	35.948	0.248	4.7	41.6	O K
5760 min Summer	35.822	0.122	4.6	19.4	O K
7200 min Summer	35.753	0.053	4.3	8.2	O K
8640 min Summer	35.721	0.021	4.0	3.2	O K
10080 min Summer	35.707	0.007	3.6	1.0	O K
15 min Winter	36.288	0.588	4.7	113.3	O K
30 min Winter	36.427	0.727	4.7	148.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	110.050	0.0	105.1	19
30 min Summer	72.924	0.0	139.3	33
60 min Summer	46.096	0.0	176.3	62
120 min Summer	28.170	0.0	215.3	122
180 min Summer	20.837	0.0	239.0	182
240 min Summer	16.722	0.0	256.0	240
360 min Summer	12.192	0.0	279.8	344
480 min Summer	9.749	0.0	298.3	400
600 min Summer	8.189	0.0	313.0	464
720 min Summer	7.099	0.0	325.9	528
960 min Summer	5.662	0.0	346.4	664
1440 min Summer	4.109	0.0	377.0	938
2160 min Summer	2.977	0.0	409.7	1360
2880 min Summer	2.366	0.0	434.0	1704
4320 min Summer	1.709	0.0	470.4	2380
5760 min Summer	1.355	0.0	497.5	3056
7200 min Summer	1.131	0.0	519.0	3744
8640 min Summer	0.976	0.0	537.3	4408
10080 min Summer	0.861	0.0	553.0	5136
15 min Winter	110.050	0.0	117.7	19
30 min Winter	72.924	0.0	156.1	33

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	36.551	0.851	4.7	181.6	O K
120 min Winter	36.649	0.949	4.7	210.1	O K
180 min Winter	36.685	0.985	4.7	221.2	O K
240 min Winter	36.697	0.997	4.7	224.7	O K
360 min Winter	36.688	0.988	4.7	222.1	O K
480 min Winter	36.665	0.965	4.7	214.9	O K
600 min Winter	36.637	0.937	4.7	206.6	O K
720 min Winter	36.613	0.913	4.7	199.6	O K
960 min Winter	36.566	0.866	4.7	185.8	O K
1440 min Winter	36.465	0.765	4.7	157.9	O K
2160 min Winter	36.288	0.588	4.7	113.2	O K
2880 min Winter	36.080	0.380	4.7	67.3	O K
4320 min Winter	35.818	0.118	4.6	18.8	O K
5760 min Winter	35.722	0.022	4.0	3.3	O K
7200 min Winter	35.701	0.001	3.4	0.2	O K
8640 min Winter	35.700	0.000	2.9	0.0	O K
10080 min Winter	35.700	0.000	2.6	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	46.096	0.0	197.2	62
120 min Winter	28.170	0.0	241.4	120
180 min Winter	20.837	0.0	267.8	178
240 min Winter	16.722	0.0	286.3	234
360 min Winter	12.192	0.0	313.4	346
480 min Winter	9.749	0.0	334.0	450
600 min Winter	8.189	0.0	350.6	486
720 min Winter	7.099	0.0	365.0	560
960 min Winter	5.662	0.0	387.9	714
1440 min Winter	4.109	0.0	422.6	1024
2160 min Winter	2.977	0.0	459.0	1472
2880 min Winter	2.366	0.0	486.4	1788
4320 min Winter	1.709	0.0	527.0	2380
5760 min Winter	1.355	0.0	557.2	2944
7200 min Winter	1.131	0.0	581.4	3672
8640 min Winter	0.976	0.0	601.8	0
10080 min Winter	0.861	0.0	619.4	0

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	0.381	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.510

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.510

Model Details

Storage is Online Cover Level (m) 37.000

Tank or Pond Structure

Invert Level (m) 35.700

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	151.0	1.300	368.7

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0101-4700-1100-4700
Design Head (m)	1.100
Design Flow (l/s)	4.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	101
Invert Level (m)	35.600
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	4.7
Flush-Flo™	0.325	4.7
Kick-Flo®	0.690	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	4.9	3.000	7.5	7.000	11.2
0.200	4.5	1.400	5.3	3.500	8.1	7.500	11.6
0.300	4.7	1.600	5.6	4.000	8.6	8.000	12.0
0.400	4.7	1.800	5.9	4.500	9.1	8.500	12.3
0.500	4.5	2.000	6.2	5.000	9.6	9.000	12.6
0.600	4.3	2.200	6.5	5.500	10.0	9.500	13.0
0.800	4.1	2.400	6.8	6.000	10.4		
1.000	4.5	2.600	7.0	6.500	10.8		

APPENDIX F:	Option 2: Surface Water Attenuation - Sensitivity

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	36.309	0.609	4.7	118.2	O K
30 min Summer	36.451	0.751	4.7	154.3	O K
60 min Summer	36.578	0.878	4.7	189.4	O K
120 min Summer	36.678	0.978	4.7	218.9	O K
180 min Summer	36.715	1.015	4.7	230.4	O K
240 min Summer	36.726	1.026	4.7	234.0	O K
360 min Summer	36.716	1.016	4.7	230.8	O K
480 min Summer	36.694	0.994	4.7	223.9	O K
600 min Summer	36.673	0.973	4.7	217.4	O K
720 min Summer	36.654	0.954	4.7	211.6	O K
960 min Summer	36.619	0.919	4.7	201.3	O K
1440 min Summer	36.553	0.853	4.7	182.2	O K
2160 min Summer	36.454	0.754	4.7	155.0	O K
2880 min Summer	36.351	0.651	4.7	128.6	O K
4320 min Summer	36.107	0.407	4.7	73.0	O K
5760 min Summer	35.934	0.234	4.7	38.9	O K
7200 min Summer	35.824	0.124	4.6	19.7	O K
8640 min Summer	35.760	0.060	4.3	9.3	O K
10080 min Summer	35.726	0.026	4.1	4.0	O K
15 min Winter	36.368	0.668	4.7	132.9	O K
30 min Winter	36.523	0.823	4.7	173.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	128.392	0.0	122.7	19
30 min Summer	85.078	0.0	162.6	33
60 min Summer	53.779	0.0	205.8	64
120 min Summer	32.864	0.0	251.1	122
180 min Summer	24.310	0.0	279.0	182
240 min Summer	19.509	0.0	298.6	242
360 min Summer	14.224	0.0	326.5	360
480 min Summer	11.373	0.0	348.0	418
600 min Summer	9.554	0.0	365.2	482
720 min Summer	8.282	0.0	379.9	544
960 min Summer	6.605	0.0	404.2	676
1440 min Summer	4.794	0.0	440.1	954
2160 min Summer	3.473	0.0	478.5	1364
2880 min Summer	2.760	0.0	506.6	1784
4320 min Summer	1.993	0.0	549.1	2468
5760 min Summer	1.581	0.0	580.2	3120
7200 min Summer	1.320	0.0	605.7	3816
8640 min Summer	1.138	0.0	626.7	4488
10080 min Summer	1.004	0.0	645.1	5144
15 min Winter	128.392	0.0	137.5	19
30 min Winter	85.078	0.0	182.1	33

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	36.662	0.962	4.7	214.1	O K
120 min Winter	36.775	1.075	4.8	249.5	O K
180 min Winter	36.820	1.120	4.9	264.4	Flood Risk
240 min Winter	36.838	1.138	5.0	270.5	Flood Risk
360 min Winter	36.840	1.140	5.0	270.9	Flood Risk
480 min Winter	36.823	1.123	4.9	265.4	Flood Risk
600 min Winter	36.797	1.097	4.9	256.8	O K
720 min Winter	36.773	1.073	4.8	249.0	O K
960 min Winter	36.729	1.029	4.8	234.7	O K
1440 min Winter	36.638	0.938	4.7	206.9	O K
2160 min Winter	36.494	0.794	4.7	165.7	O K
2880 min Winter	36.334	0.634	4.7	124.5	O K
4320 min Winter	35.966	0.266	4.7	44.9	O K
5760 min Winter	35.783	0.083	4.4	13.0	O K
7200 min Winter	35.719	0.019	4.0	2.9	O K
8640 min Winter	35.702	0.002	3.4	0.3	O K
10080 min Winter	35.700	0.000	3.0	0.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	53.779	0.0	230.0	62
120 min Winter	32.864	0.0	281.4	120
180 min Winter	24.310	0.0	312.4	178
240 min Winter	19.509	0.0	334.4	236
360 min Winter	14.224	0.0	365.8	348
480 min Winter	11.373	0.0	389.8	456
600 min Winter	9.554	0.0	409.3	550
720 min Winter	8.282	0.0	425.9	572
960 min Winter	6.605	0.0	452.6	728
1440 min Winter	4.794	0.0	492.6	1038
2160 min Winter	3.473	0.0	535.4	1476
2880 min Winter	2.760	0.0	567.5	1928
4320 min Winter	1.993	0.0	614.7	2512
5760 min Winter	1.581	0.0	650.1	3112
7200 min Winter	1.320	0.0	678.3	3672
8640 min Winter	1.138	0.0	702.1	4400
10080 min Winter	1.004	0.0	722.7	0

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	0.381	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.510

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.510

Model Details

Storage is Online Cover Level (m) 37.000

Tank or Pond Structure

Invert Level (m) 35.700

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	151.0	1.300	368.7

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0101-4700-1100-4700
Design Head (m)	1.100
Design Flow (l/s)	4.7
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	101
Invert Level (m)	35.600
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.100	4.7
Flush-Flo™	0.325	4.7
Kick-Flo®	0.690	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	4.9	3.000	7.5	7.000	11.2
0.200	4.5	1.400	5.3	3.500	8.1	7.500	11.6
0.300	4.7	1.600	5.6	4.000	8.6	8.000	12.0
0.400	4.7	1.800	5.9	4.500	9.1	8.500	12.3
0.500	4.5	2.000	6.2	5.000	9.6	9.000	12.6
0.600	4.3	2.200	6.5	5.500	10.0	9.500	13.0
0.800	4.1	2.400	6.8	6.000	10.4		
1.000	4.5	2.600	7.0	6.500	10.8		

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