LAND OFF BANNISTER LANE, LEYLAND

FLOOD RISK ASSESSMENT

Draft Report v1.1

February 2013

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1 INTRODUCTION

Weetwood has been instructed by Wainhomes Developments Limited to undertake a Flood Risk Assessment (FRA) for the proposed development of a site located off Bannister Lane, Leyland, in accordance with the requirements of the National Planning Policy Framework (NPPF) and its supporting Technical Guidance.

1.1 SITE LOCATION

The site is located at Ordnance Survey National Grid Reference SD 529 237, as shown in **Figure 1**. The site is approximately 4.56 hectares (ha) in area.

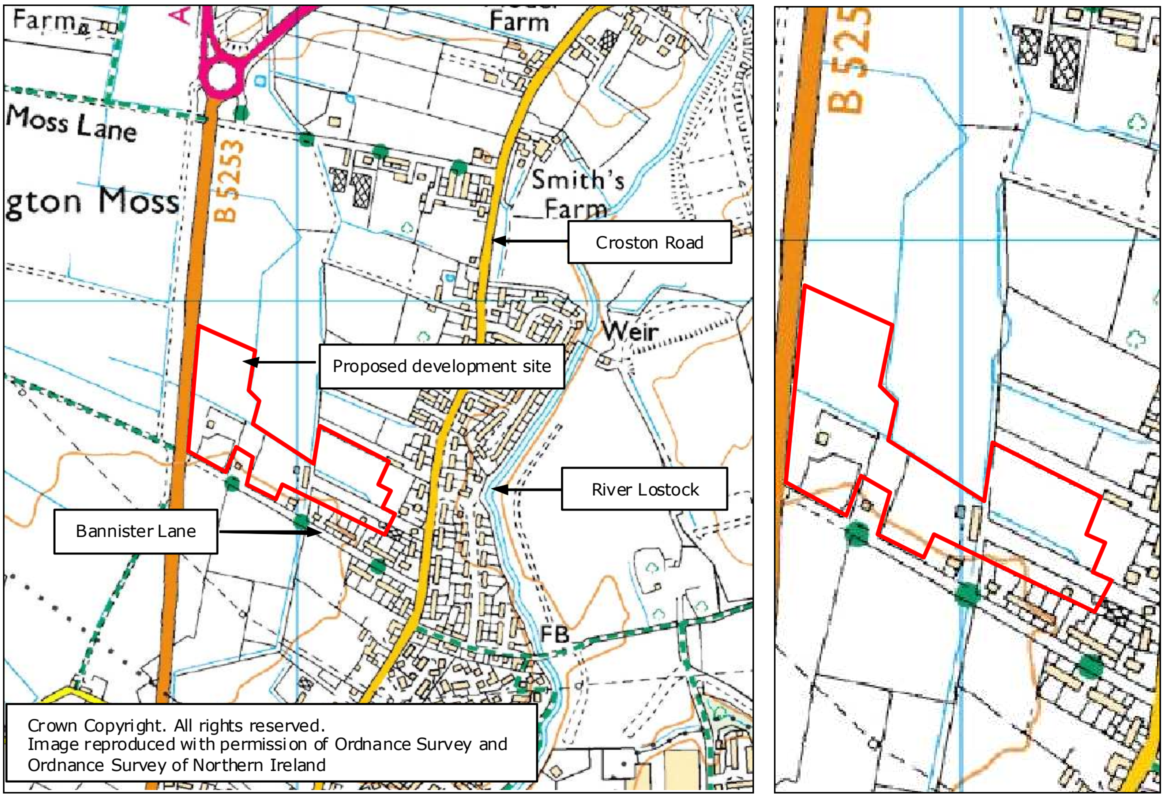


Figure 1: Site Location

1.2 EXISTING AND PROPOSED DEVELOPMENT

The current site mainly comprises of several privately owned fields with some associated buildings.

Proposals are for the development of 112 residential dwellings (**Appendix A**).

Residential development is classified as *'more vulnerable development'* under Table 2 of the NPPF Technical Guidance.

1.3 SITE LEVELS

A topographic survey of the site has been undertaken by JLP Surveys Ltd and is provided in **Appendix B**. Levels at the west of the site are approximately 25.90 metres Above Ordnance Datum (m AOD) to the north, falling to approximately 23.90m AOD to the south. Levels at the east of the site are approximately 25.70m AOD to the north, falling to approximately 24.60m AOD to the south. The Digital Elevation Model (DEM) in **Figure 2** illustrates this general sloping towards the south of the site.

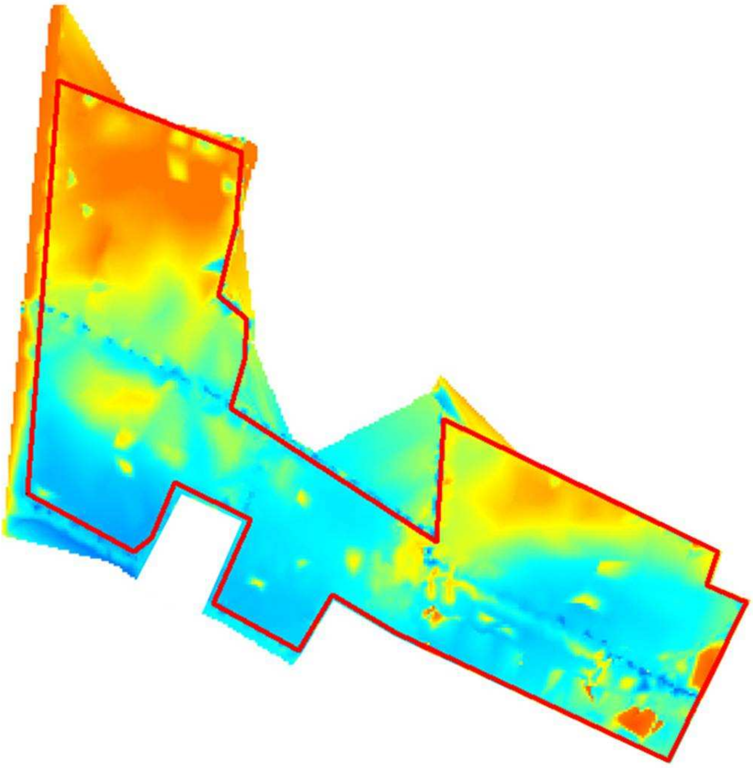


Figure 2: DEM Derived from Topographic Survey

1.4 ACCESS AND EGRESS

Access and egress to the site is provided via Bannister Lane to the south.

Levels along Bannister Lane are in the region of 24.54m AOD to the south-west of the site rising up to approximately 25.75m AOD to the to the south-east before joining Croston Road.

2 NATIONAL PLANNING POLICY FRAMEWORK (NPPF)

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

2.1 FLOOD ZONE DESIGNATION

Table 1 of the NPPF provides the definitions for each of the flood zones, which are summarised as follows:

- **Flood Zone 1: Low Probability.** Land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year.
- **Flood Zone 2: Medium Probability**. Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding or between a 1 in 200 and 1 in 1000 annual probability of flooding from the sea in any year.
- **Flood Zone 3a: High Probability.** Land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
- **Flood Zone 3b: The Functional Floodplain.** Land where water has to flow or be stored in times of flood. The identification of the functional floodplain should take account of local circumstance and not be defined solely on rigid probability parameters. However, land which would flood with an annual probability of 1 in 20 or greater in any year should provide a starting point for consideration and discussion.

2.1.1 Environment Agency Flood Map

According to the Environment Agency (EA) Flood Map (**Figure 3**) the site is located in Flood Zone 1.

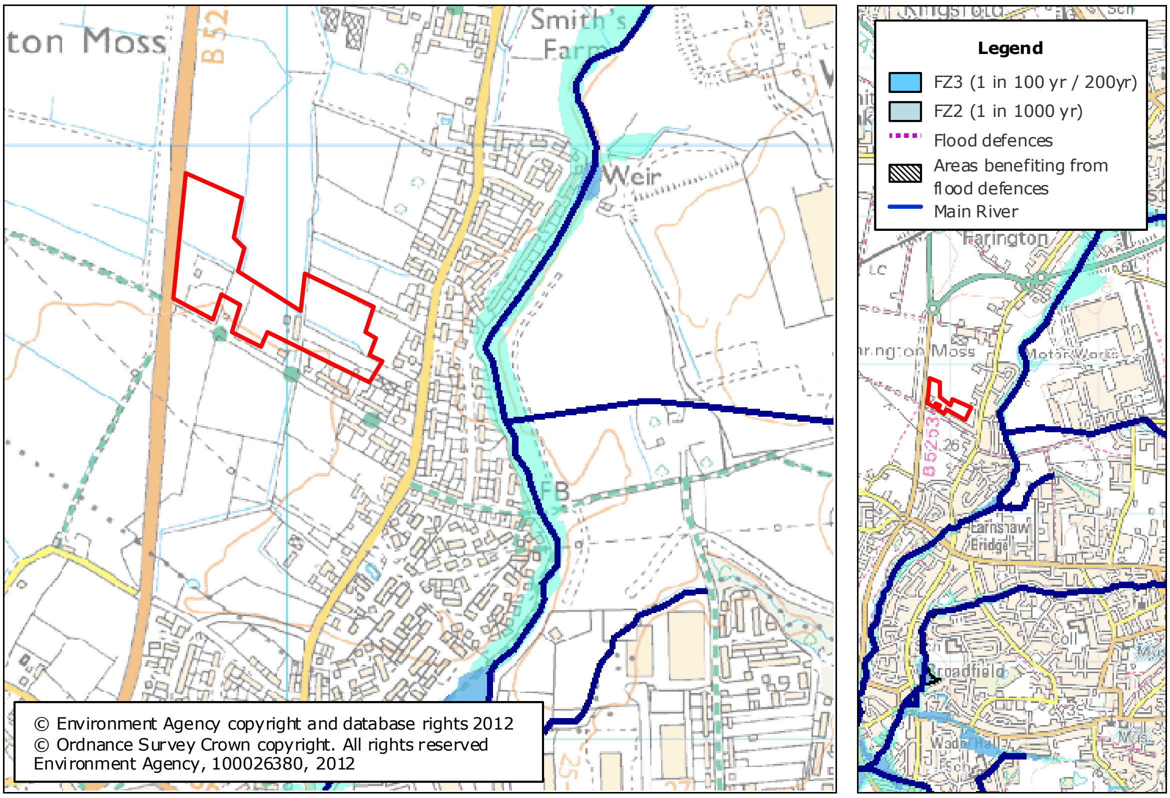


Figure 3: Environment Agency Flood Map

(Source: Environment Agency website)

2.1.2 Strategic Flood Risk Assessment

A Level 1 SFRA for Central Lancashire has been co-published by Preston City Council, South Ribble Borough Council and Chorley Borough Council in December 2007. The SFRA has been used to help inform this report.

2.2 SEQUENTIAL TEST

The aim of the Sequential Test (as outlined in Chapter 10 of the NPPF and paragraphs 3-5 of the Technical Guidance) is to encourage development to be located in areas at the lowest probability of flooding.

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

2.3 DEVELOPMENT AND FLOOD RISK

Table 1 of the NPPF Technical Guidance states that for development proposals on sites in Flood Zone 1 comprising one hectare or above, the vulnerability to flooding from other sources and the effect of the new development on surface water runoff should be incorporated in a FRA.

Other potential sources of flooding are discussed in **Section 3** of this report. The effect of the new development on surface water run-off is addressed in **Section 5**.

3 FLOOD RISK

3.1 HISTORICAL RECORDS OF FLOODING

The EA has confirmed[1] that it does not hold any records of historical flooding at the site.

The British Hydrological Society (BHS) Chronology[2] does not list any historical records of flooding at or within the vicinity of the site[3].

3.2 FLUVIAL

3.2.1 River Lostock

The River Lostock flows in a predominately southerly direction approximately 0.12km to the east of the site (**Figure 4**).

(i) Looking north upstream adjacent to site

(ii) Looking south at footbridge south-east of the site

Figure 4: River Lostock adjacent to site

The EA Flood Map confirms that the site is not at risk of flooding from this source.

3.2.2 Land Drains

Figure 5 and **Figure 6** show the land drains that are situated within and around the proposed development site.

Drain A (**Figure 5**) comprises of a land drain network from the north/west that flows towards the south-east corner of the site via channels that are approximately 1m wide. They merge together before entering a 1m diameter culvert to the south-east of the site which ultimately discharges into the River Lostock (**Figure 6**).

Drains B and C adjacent to Bannister Lane to the south of the site appeared to have no flow and were not connected to Drain A. Given the surrounding topography (**Figure 2**) it is reasonable to assume that surface water runoff from the adjacent land to the north currently attenuates here.

[1] Email from EA to Weetwood dated 8 January 2013
[2] British Hydrological Society Chronology www.dundee.ac.uk/geography/cbhe/
[3] Based on the following keyword searches River Lostock, Bannister Lane, Leyland

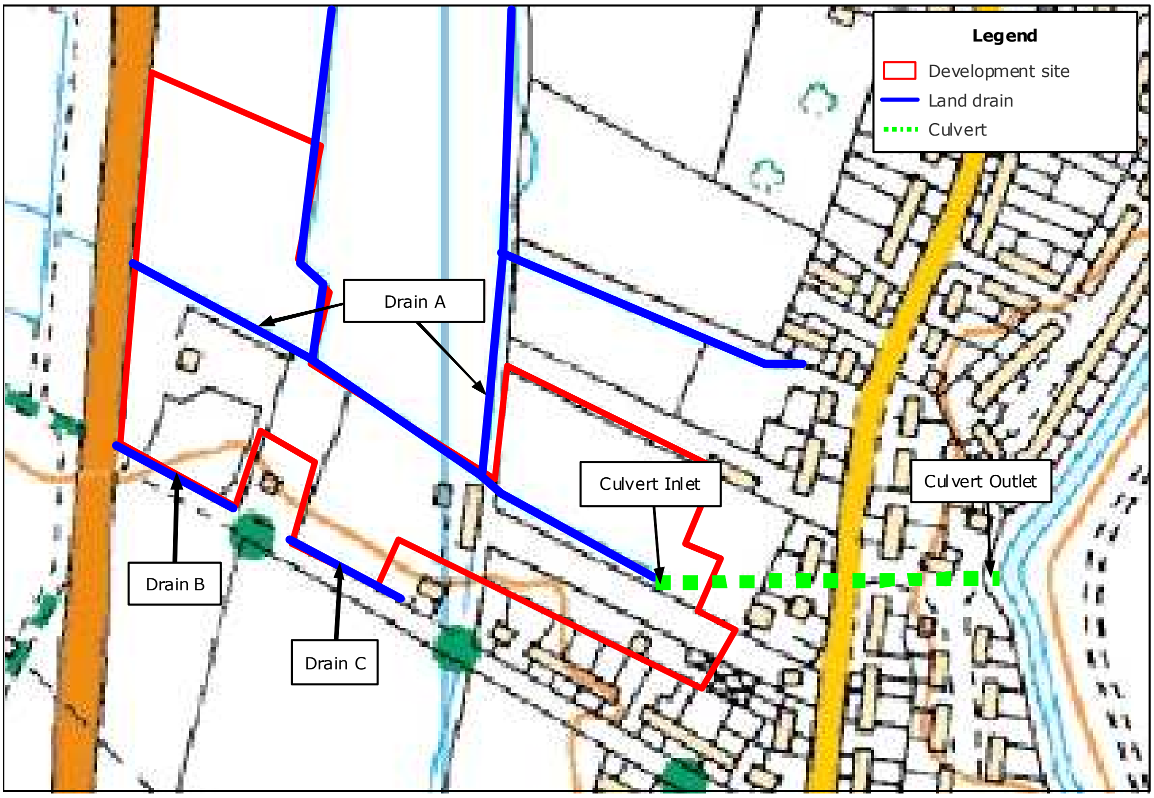


Figure 5: OS map showing drainage network and culvert


(i) Land drain


(ii) Culvert inlet from land drains


(iii) Culvert outlet into River Lostock

Figure 6: Land drain and culvert

Any risk of flooding from this source will be mitigated though the implementation of measures proposed in **Section 4** of this report.

3.3 RESERVOIRS, CANALS AND OTHER ARTIFICIAL SOURCES

Reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

There are no canals located within the vicinity of the site. The EA Risk of Flooding from Reservoirs Map indicates that the site is not a risk of flooding from reservoirs, canals or other artificial sources.

3.4 GROUNDWATER

Groundwater flooding generally occurs during intense, long-duration rainfall events, when infiltration of rainwater into the ground raises the level of the water table until it exceeds ground levels. It is most common in low-lying areas overlain by permeable soils and permeable geology, or in areas with a naturally high water table.

According to the Soilscapes maps produced by the National Soils Research Institute[4] soil conditions at the site and within the surrounding area are described as '*Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils*'. The permeability of the underlying soil conditions and the subsequent propensity for groundwater flooding may therefore be considered low.

The EA has confirmed[5] that it has no records of groundwater flooding at the site. This reiterated in the SFRA which states that there are no reported occurrences of groundwater flooding from hard rock aquifers or superficial deposits in the Northwest EA region.

According to the British Geological Survey (BGS) Groundwater Flooding Hazard map (**Figure 7**) the susceptibility to groundwater flooding is moderate.

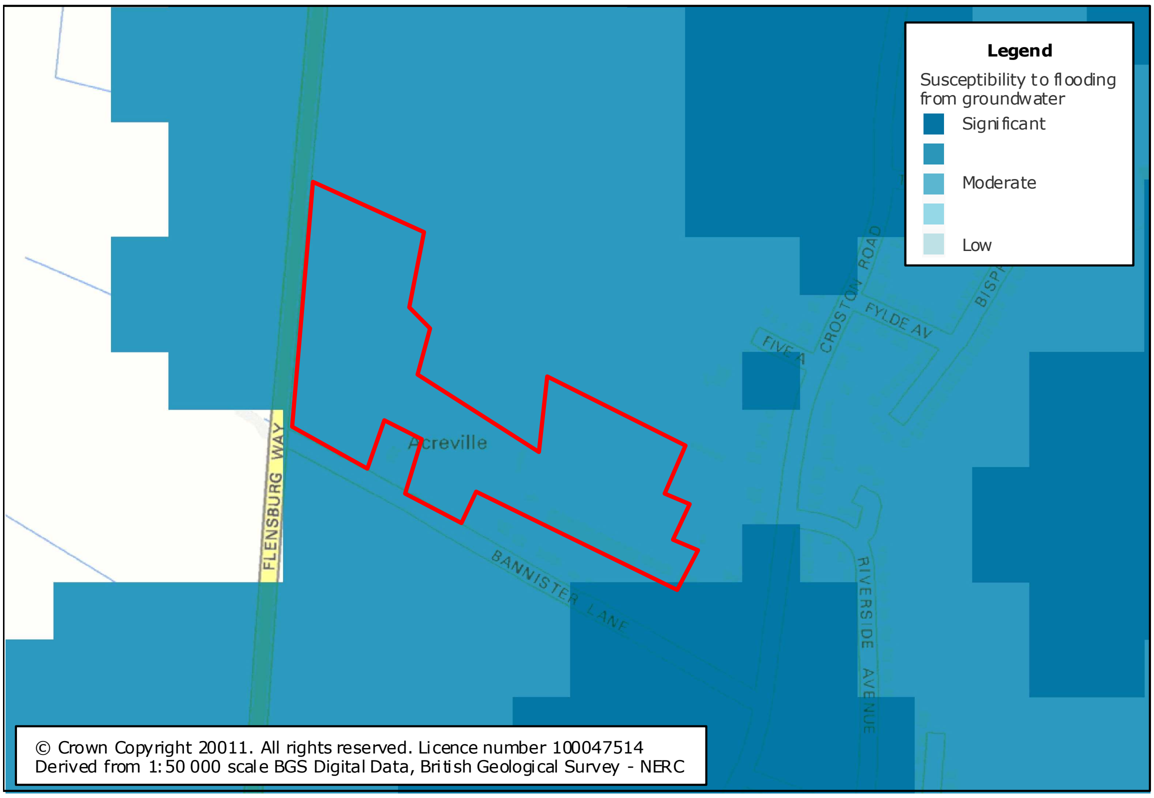


Figure 7: BGS Groundwater Flooding Hazard Map

(Source: Findmaps)

[4] Soilscapes www.landis.org.uk/soilscapes/

[5] Footnote 1

Recognising the information above, the propensity for groundwater flooding may be considered low to moderate. Any residual risk of flooding from this source will be mitigated through the implementation of the measures proposed in **Section 4** of this report.

3.5 SURFACE WATER

Surface water flooding comprises pluvial, sewer and highway drains and gullies.

3.5.1 Pluvial

Pluvial flooding results from rainfall-generated overland flow, before the runoff enters any watercourse or sewer, or where the sewerage/drainage systems and watercourses are overwhelmed and therefore unable to accept surface water. Pluvial flooding is usually associated with high intensity rainfall events but may also occur with lower intensity rainfall where the ground is saturated, developed or otherwise has low permeability resulting in overland flow and ponding within depressions in the topography.

As detailed previously, according to the Soilscapes maps soil conditions are described as '*Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils*'. There may therefore be the propensity for surface water flooding at the existing site. However, the topography of the site (**Section 1.3**) may suggest that surface water could runoff towards the land drains (**Figure 1**). As such it may be reasonable to assume that surface water may not be expected to accumulate to any significant depth at the site itself.

The EA has confirmed[6] that it holds no records of surface water flooding at the site.

The SFRA states that there are no records of pluvial or overland flooding at or within the vicinity of the site.

Any residual concern regarding flood risk from this source will be addressed through the mitigation measures as detailed in **Section 4** and the surface water drainage strategy in **Section 5**.

3.5.2 Sewer

Sewer flooding can occur when the capacity of the sewer system is overwhelmed by heavy rainfall, becomes blocked or is of inadequate capacity, resulting in flooding of land and/or property. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters.

United Utilities has been consulted to ascertain whether it holds any records of sewer flooding at the site. A response is awaited, although given the undeveloped nature of the site it is reasonable to assume that the likelihood of any sewer flooding is low.

[6] Footnote 1

3.5.3 Highway Drains and Gullies

Lancashire County Council has been consulted to ascertain whether it holds any records of highways flooding at or within the vicinity of the site. A response is awaited. Again, given the undeveloped nature of the site and its general topography relative to adjacent highways, it is reasonable to assume that the likelihood of flooding from highway drainage is low.

4 MITIGATION MEASURES

4.1 FLOOD MITIGATION

Any risk of flooding from the land drains and any residual risk of flooding from groundwater and surface water will be mitigated though the implementation of the measures proposed within the following section of this report.

4.1.1 Finished Floor Levels

Finished floor levels should be set at a minimum of 0.15m above adjacent ground levels.

This will enable any potential surface water to be conveyed safely across the site without affecting property in accordance with the approach promoted within DEFRA's Making Space for Water.

4.2 ACCESS AND EGRESS

Following development, access and egress will be provided via Bannister Lane to the south (**Appendix A**). This route is shown to be located entirely within Flood Zone 1 and should therefore provide safe and dry access and egress to the site.

4.3 LAND DRAIN CULVERT INLET

The land drain is classified as an ordinary watercourse and therefore the Lead Local Flood Authority (LLFA) should be consulted prior to any works involving modifications to the watercourse.

Development proposals include the reconstruction of the culvert inlet, including a new grill. Developers must ensure that flows are not restricted by these proposals.

For the avoidance of blockage, it is recommended that there should be suitable arrangements in place for the maintenance of the new culvert inlet structure and grill.

In light of the above, it is expected that betterment would be provided following development compared to the existing situation.

5 SURFACE WATER

5.1 REQUIREMENTS FOR SURFACE WATER DRAINAGE

Surface water arising from a developed site should, as far as is practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development.

Development of the site should be such that the peak flow rates of surface water leaving the developed site are no greater than the rates prior to development. Opportunities to reduce surface water runoff, and the associated flood risk, should also be identified and climate change taken into consideration.

Recognising the above, and the requirements of the EA[7], Building Regulations Approved Document H, the Code for Sustainable Homes Technical Guide (Category 4) and the requirement placed upon local planning authorities within the NPPF and its supporting Technical Guidance to promote the use of Sustainable Drainage Systems (SUDS), surface water runoff from the proposed site should demonstrate:

- No increase in existing flow rates discharged to watercourse/public sewer
- The use of SUDS as the preferred method of dealing with surface water
- How runoff up to the 1 in 100 year event plus an allowance for climate change will be dealt with without increasing flood risk elsewhere

5.1.1 Preston City, Ribble Borough and Chorley Borough Councils

The Central Lancashire SFRA states that SUDS should be included in new developments unless where it is demonstrably not possible to manage surface water using these techniques.

5.2 SITE AREAS

The existing and proposed impermeable and permeable areas at the site are shown in **Table 1**. This indicates that the extent of impermeable area at the site will increase by 1.51ha following development.

Table 1: Site Areas

	Existing Site	Developed Site
Impermeable area (ha)	0.33	1.90
Permeable area (ha)	4.23	2.66
TOTAL	4.56	4.56

5.3 SURFACE WATER RUNOFF FROM THE EXISTING SITE

The current site mainly comprises of several privately owned fields with some associated buildings.

[7] Preliminary Rainfall Runoff Management for Developments, R&D Technical Report W5-074/A/TR/1 Revision C, 2005

As detailed previously, existing site levels are generally shown to fall towards the existing land drains. It may therefore be reasonable to assume that the majority of surface water runoff currently disposes into these watercourses before discharging into the River Lostock to the east.

Public sewer records show that combined sewers are currently located directly to the east, south and west of the site, which may also contribute to the disposal of surface water runoff.

5.3.1 Existing Site Runoff Rate

The peak runoff rates for the existing site are summarised in **Table 2**.

- The Modified Rational Method[8] has been used to calculate the runoff from the impermeable surfaces at the existing site, as detailed in **Appendix C**.
- Greenfield runoff rates from permeable surfaces have been calculated using the ICP SUDS method within MicroDrainage. Details of the MicroDrainage input parameters and the output results are provided in **Appendix D.**

Table 2: Total Peak Runoff Rate - Existing Site

Return Period	Runoff Rate (l/s)		
	Impermeable areas	Permeable areas	Total
1 in 2 year	50.5	26.6	77.1
1 in 30 year	92.0	44.9	96.9
1 in 100 year	116.0	55.4	171.4

5.4 SURFACE WATER RUNOFF FROM THE DEVELOPED SITE

Table 1 indicates that impermeable areas at the site will increase following development. The following sections describe how surface water runoff from the developed site may be managed in accordance with the requirements of the NPPF and its supporting Technical Guidance.

5.4.1 Disposal of Surface Water

Building Regulations Approved Document Part H sets out a hierarchy of preferred methods for the disposal of surface water runoff[9]. These are listed below in order of preference:

1. Disposal by infiltration - As detailed previously, according to the Soilscapes maps produced by the National Soils Research Institute, soil conditions at the site are *'Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils'*. It is therefore unlikely that infiltration will be a feasible method for disposal of surface water runoff from the developed site.

[8] The Wallingford Procedure, Volume 4, 1981

[9] Building Regulations Approved Document H Section 3 page 45

2. Disposal to a watercourse - As detailed previously, based on the topography of the site, it is assumed that surface water currently runs off to the land drains that are situated within the site. These then ultimately discharge into the River Lostock via a 1m diameter culvert. Post development it is therefore proposed to continue to discharge surface water from the proposed impermeable areas within the site to this watercourse.
3. Disposal to a public sewer - Public sewer records show a concrete combined sewer located to the west and east of the site and a vitrified clay combined sewer to the south. Although it is unlikely that discharging surface water runoff into the public sewer system would be necessary following redevelopment, this would remain as a potential option.

5.4.2 Surface Water Discharge Rate

The surface water drainage arrangements for any site should be such that the peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development.

It is proposed to limit runoff rates from impermeable areas to **50.5l/s** following development. This is the existing 1 in 2 year flow rate from the existing impermeable areas, as calculated in **Appendix C** and shown in **Table 2**. This will ensure that runoff rates from the site do not increase following development, and that betterment is provided for all greater return period events. The drainage system for the proposed site will be designed to manage flows in up to the 1 in 100 year event including an allowance for climate change. The existing permeable areas will continue to drain at greenfield runoff rates.

The total proposed peak runoff rates from the proposed site are shown in **Table 3**.

Table 3: Total Peak Runoff Rate – Developed Site

Return Period	Runoff Rate (l/s)		
	Impermeable areas	Permeable areas	Total
1 in 2 year	50.5	16.8	67.3
1 in 30 year	50.5	28.2	78.7
1 in 100 year	50.5	34.8	85.3

Comparison of the total peak runoff rates from the existing site (**Table 2**) with those from the developed site (**Table 3**) indicates that development will provide for significant betterment in terms of reduced surface water flows as encouraged by the NPPF and its supporting Technical Guidance.

5.4.3 SUDS Options and Storage Calculations

In order to restrict runoff rates from the proposed impermeable areas as set out in **Section 5.4.2**, attenuation storage will be provided. SUDS elements may be used to provide the required storage.

SUDS aim to mimic natural drainage and can achieve multiple objectives such as removing pollutants from urban runoff at source, controlling surface water runoff from developments, and ensuring that flood risk is not increased downstream. Combining water management with green space can provide amenity and biodiversity enhancement. Typical SUDS components include surface or subsurface storage with flow limiting devices, roadside swales, detention basins and infiltration areas or soakaways.

The surface water storage facilities described in the following sections have been modelled using the Detailed Design module of MicroDrainage Source Control.

5.4.3.1 Storage Volume Calculation

The required storage volume has been sized to store the 1 in 100 year storm event including a 30% increase in rainfall intensity in order to allow for climate change in accordance with Table 5 of the NPPF Technical Guidance.

The parameters used in the storage calculation along with the MicroDrainage Source Control output results are provided in **Appendix E**. This indicates that a total storage volume of 770.5m^3 would be required. It is assumed that the pipes discharging surface water would be able to store water up to the 1 in 30 year rainfall event, which has been calculated at 366.7m^3 (**Appendix F**). Therefore, an additional storage volume of at least **403.8m^3** would be required elsewhere on the site.

The calculations have assumed a 1.5m deep storage tank, which fills to a depth of 1.0m with a 0.5m freeboard; however the size and depth of the storage tanks can vary and it would be possible to use one of a lower depth, provided the area is increased accordingly to accommodate the required volume.

It has been confirmed[10] that the areas of open space in the development plans (**Appendix A**) equate to a total area in excess of 4,500m². As such, there should be sufficient area to accommodate the additional attenuation of surface water runoff. This could be achieved by, but is not restricted to, lowering the areas of public open space to incorporate dry detention basins (at a depth to be agreed). This may require reprofiling parts of the site to allow surface water to runoff towards these areas from small sub-catchments.

5.4.4 Maintenance of SUDS

In the past local planning authorities and water companies have been reluctant to adopt SUDS. With no arrangements in place that require local planning authorities or water companies to adopt SUDS their maintenance has subsequently been the responsibility of the developer.

The Flood and Water Management Act (2010) is currently being implemented through a series of Commencement Orders. Section 32 introduces Schedule 3: Sustainable Drainage. This introduces:

[10] Correspondence with Steve Robinson

- New standards for the design, construction, operation and maintenance of new rainwater drainage systems
- A new 'approving body' (generally a unitary, county or county borough local authority)
- A requirement for the approving body to approve most types of rainwater drainage systems before any construction work with drainage implications can start, subject to: (i) the system being constructed in line with an approved drainage plan to national standards; (ii) the approving body being satisfied the drainage system has been built and functions in accordance with the drainage plan, and (iii) the system being a sustainable drainage system, as defined by regulations.

However, this provision is awaiting commencement following further work by DEFRA on arrangements for adoption and maintenance of SUDS, including technical guidance. At present it is envisaged that implementation of theses arrangements will be 2014.

In the meantime, other options for maintenance of SUDS include:

- SUDS elements within the curtilage of residential dwellings (e.g. soakaways, permeable paving) will be the responsibility of the owner of the property
- The pipe network, designed to Sewers for Adoption (7^{th} edition) standard, will be adopted by the sewerage undertaker
- Roadside swales will be adopted by the highways authority
- SUDS in public open spaces (e.g. dry detention basin) may be adopted by the local authority
- A management company

5.4.5 Final Drainage Layout

The purpose of this FRA is to demonstrate that a surface water drainage strategy is feasible for the site given the development proposals and the land available. The proposals provide the opportunity for the inclusion of SUDS elements, ensuring that there will be no increase in surface water runoff from the proposed development.

This FRA has demonstrated that, not only can the required storage be accommodated within the site layout, but that various options are feasible and ample land is available, providing flexibility for the final drainage solution. A final decision on the types of storage to be provided will be made at the detailed drainage design stage.

This FRA provides a holistic approach to surface water drainage in accordance with and satisfying the requirements of the NPPF and its supporting Technical Guidance and as such will enable phased development conditions to be applied in line with this strategy.

6 SUMMARY

There are proposals for the development of 117 residential dwellings on an area of land located north of Bannister Lane, Leyland.

According to the EA flood map the proposed development site is located outside the 1 in 1000 year flood outline and is therefore defined as being situated within Flood Zone 1 under the NPPF and its supporting Technical Guidance.

The proposed development site, being located in Flood Zone 1, satisfies the requirements of the Sequential Test.

The River Lostock flows in a predominately southerly direction approximately 0.12km to the east of the site. The EA Flood Map confirms that the site is not at risk from this source.

There is a network of land drains located within and around the proposed development site which may be a potential flood risk.

There may be a slight propensity for surface water and groundwater flooding. The flood risk from all other sources is considered low.

To mitigate against potential flood risk, finished floor levels should be set at a minimum of 0.15m above adjacent ground levels.

Following development, access and egress will be provided via Bannister Lane to the south, which should provide safe and dry access and egress to the site beyond the 1 in 1000 year flood event.

There should be arrangements in place for the maintenance of the culvert inlet structure.

Following development the overall impermeable areas at the site are expected to increase. A scheme for the provision and implementation of a surface water regulation system following the principles set out in this FRA should be submitted to and approved in writing by the local planning authority, prior to the commencement of development. This FRA provides a holistic approach to drainage in accordance with and satisfying the requirements of the NPPF and its supporting Technical Guidance and as such will enable phased development conditions to be applied in line with this strategy.

7 RECOMMENDATIONS

This FRA has demonstrated that the proposed development may be completed without conflicting with the requirements of the NPPF and its supporting Technical Guidance subject to the following:

- Finished floor levels to be set at 0.15m above adjacent ground levels

- Developers must ensure that flows from the land drain are not restricted from the reconstruction of the new culvert inlet.

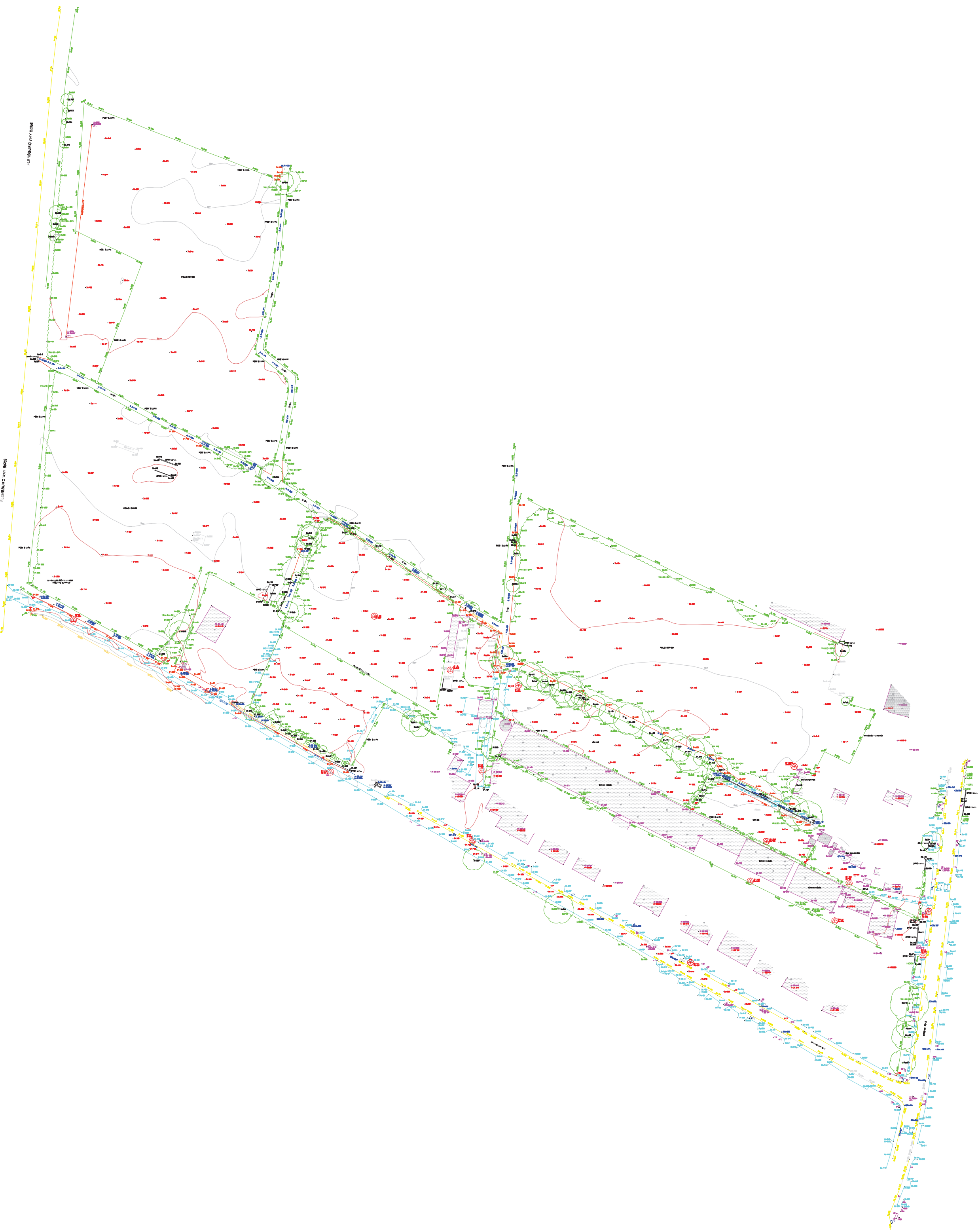
- Following development there should be arrangements in place for the maintenance of the new culvert inlet to avoid blockages

- The detailed drainage design, developed in accordance with the principles set down in this FRA, should be submitted to and approved by the local planning authority prior to the commencement of development with a view to allowing phased development of the site to proceed without compromising the holistic approach to dealing with surface water across the whole site.

APPENDIX A: Development Proposals


NORTH
Mix Schedule
LDG ASSOCIATES
LDG Associates Limited
Barn Meadow House
SKETCH
LAYOUT

APPENDIX B: Topographic Survey



SURVEY STATIONS			
STN	EASTING	NORTHING	LEVEL(m)
STN1	353014.397	4[illegible]3611.404	24[illegible]597
STN1A	353115.052	4[illegible]3555.432	25[illegible]469
STN1B	352949.045	4[illegible]3843.122	25[illegible]034
STN1C	352830.582	4[illegible]3713.196	24[illegible]804
STN2	353018.922	4[illegible]3643.863	24[illegible]602
STN3	353004.322	4[illegible]3690.153	25[illegible]279
STN3A	353036.893	4[illegible]3685.006	25[illegible]209
STN3B	352969.341	4[illegible]3714.946	24[illegible]892
STN3C	353149.908	4[illegible]3611.248	25[illegible]196
STN3CC	353182.791	4[illegible]3845.747	25[illegible]040
STN3D	353188.110	4[illegible]3592.001	25[illegible]185
STN4	353224.824	4[illegible]3578.987	25[illegible]500
STN5	353222.193	4[illegible]3558.452	25[illegible]593
STN5A	353181.509	4[illegible]3574.804	25[illegible]225
STN5B	353142.830	4[illegible]3592.907	25[illegible]238

APPENDIX C: Modified Rational Method Calculation

The Modified Rational Method[11] has been used to calculate the runoff from the impermeable surfaces at the existing site.

The following parameters have been obtained from the maps in Volume 3 of the Wallingford Procedure:

M5-60 minute rainfall depth:	19 mm
Ratio of M5-60 to M5-2 day rainfall:	35
Average Annual Rainfall:	950 mm
Winter Rain Acceptance Potential/ Soil Type :	4
The Urban Catchment Wetness Index (UCWI) value:	105.00

A time of concentration of 5 minutes has been used comprising a time of entry of 4 minutes and a time of flow of 1 minute.

A rainfall estimation calculation has been carried out to convert the M5-60 minute rainfall to the 5-minute duration rainfall for the 1 in 2 year, 1 in 30 year and 1 in 100 year return period events. The calculated rainfall intensities for these events are 64.67, 117.82 and 148.50 mm/hr respectively.

The flow rate as given by the Modified Rational Method is:

$$Q = 2.78 \times C_v \times C_r \times \text{rainfall intensity} \times \text{impermeable area}$$

where:

C_v is the volumetric runoff coefficient = P_r/PIMP = 0.6549
where P_r is Percentage Runoff and PIMP is Percentage Impermeable Area
C_r is the routing coefficient = 1.3
Impermeable Area = 0.33 ha

The flow rates for the impermeable areas at the existing site are shown in the table below:

Flow Rates for Impermeable Areas, Existing Site

Return Period	Flow Rate for 0.33 ha impermeable area (l/s)
1 in 2 year	50.51
1 in 30 year	92.03
1 in 100 year	115.98

[11] The Wallingford Procedure, Volume 4, 1981

APPENDIX D: MicroDrainage Outputs for Greenfield Runoff

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.450
Area (ha)	1.000	Urban	0.000
SAAR (mm)	950	Region Number	Region 10

Results	**l/s**
QBAR Rural	6.3
QBAR Urban	6.3
Q100 years	13.1
Q1 year	5.5
Q30 years	10.6
Q100 years	13.1

APPENDIX E: MicroDrainage Storage Volume Calculation (1 in 100 year + CC)

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	0.493	0.493	44.3	381.4	O K
30 min Summer	0.647	0.647	44.3	501.0	O K
60 min Summer	0.785	0.785	45.0	607.3	O K
120 min Summer	0.865	0.865	47.1	669.6	O K
180 min Summer	0.883	0.883	47.6	683.4	O K
240 min Summer	0.880	0.880	47.5	681.3	O K
360 min Summer	0.853	0.853	46.8	660.6	O K
480 min Summer	0.816	0.816	45.8	631.7	O K
600 min Summer	0.775	0.775	44.8	599.6	O K
720 min Summer	0.732	0.732	44.3	566.7	O K
960 min Summer	0.648	0.648	44.3	501.6	O K
1440 min Summer	0.487	0.487	44.3	377.0	O K
2160 min Summer	0.357	0.357	41.9	276.0	O K
2880 min Summer	0.294	0.294	37.1	227.4	O K
4320 min Summer	0.234	0.234	29.0	180.8	O K
5760 min Summer	0.202	0.202	23.7	156.3	O K
7200 min Summer	0.181	0.181	20.1	140.4	O K
8640 min Summer	0.167	0.167	17.6	128.9	O K
10080 min Summer	0.155	0.155	15.6	120.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	115.731	21
30 min Summer	77.804	35
60 min Summer	49.937	62
120 min Summer	30.956	110
180 min Summer	23.058	140
240 min Summer	18.577	172
360 min Summer	13.656	242
480 min Summer	10.974	310
600 min Summer	9.254	380
720 min Summer	8.046	446
960 min Summer	6.447	578
1440 min Summer	4.709	814
2160 min Summer	3.432	1152
2880 min Summer	2.739	1500
4320 min Summer	1.989	2208
5760 min Summer	1.583	2944
7200 min Summer	1.325	3672
8640 min Summer	1.147	4408
10080 min Summer	1.015	5136

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 Winter	0.556	0.556	44.3	430.3	O K
30 min Winter	0.730	0.730	44.3	565.2	O K
60 min Winter	0.887	0.887	47.7	686.5	O K
120 min Winter	0.984	0.984	50.2	761.6	O K
180 min Winter	0.995	0.995	50.5	770.5	O K
240 min Winter	0.987	0.987	50.3	763.6	O K
360 min Winter	0.940	0.940	49.1	727.6	O K
480 min Winter	0.880	0.880	47.5	681.3	O K
600 min Winter	0.816	0.816	45.8	631.8	O K
720 min Winter	0.752	0.752	44.3	581.9	O K
960 min Winter	0.622	0.622	44.3	481.5	O K
1440 min Winter	0.401	0.401	44.0	310.2	O K
2160 min Winter	0.286	0.286	36.3	221.6	O K
2880 min Winter	0.239	0.239	29.8	184.9	O K
4320 min Winter	0.192	0.192	22.0	148.6	O K
5760 min Winter	0.167	0.167	17.6	129.2	O K
7200 min Winter	0.151	0.151	14.8	116.5	O K
8640 min Winter	0.139	0.139	12.8	107.3	O K
10080 min Winter	0.130	0.130	11.4	100.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	115.731	21
30 min Winter	77.804	35
60 min Winter	49.937	62
120 min Winter	30.956	116
180 min Winter	23.058	146
240 min Winter	18.577	184
360 min Winter	13.656	262
480 min Winter	10.974	336
600 min Winter	9.254	408
720 min Winter	8.046	480
960 min Winter	6.447	616
1440 min Winter	4.709	826
2160 min Winter	3.432	1164
2880 min Winter	2.739	1504
4320 min Winter	1.989	2212
5760 min Winter	1.583	2944
7200 min Winter	1.325	3672
8640 min Winter	1.147	4408
10080 min Winter	1.015	5136

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	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 1.900

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	4-8	0.900

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)
0.000	774.0

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md3 Invert Level (m) 0.000
Design Flow (l/s) 50.5 Diameter (mm) 228

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.0	1.200	55.5	3.000	87.7	7.000	134.0
0.200	23.4	1.400	59.9	3.500	94.7	7.500	138.7
0.300	37.7	1.600	64.1	4.000	101.3	8.000	143.2
0.400	43.9	1.800	67.9	4.500	107.4	8.500	147.6
0.500	42.7	2.000	71.6	5.000	113.2	9.000	151.9
0.600	41.4	2.200	75.1	5.500	118.8	9.500	156.1
0.800	45.4	2.400	78.4	6.000	124.0		
1.000	50.6	2.600	81.6	6.500	129.1		

APPENDIX F: MicroDrainage Storage Volume Calculation (1 in 30 year)

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.583	0.583	44.3	214.7	O K
30 min Summer	0.741	0.741	44.3	272.7	O K
60 min Summer	0.846	0.846	46.6	311.4	O K
120 min Summer	0.890	0.890	47.8	327.4	O K
180 min Summer	0.876	0.876	47.4	322.5	O K
240 min Summer	0.843	0.843	46.6	310.4	O K
360 min Summer	0.764	0.764	44.5	281.2	O K
480 min Summer	0.684	0.684	44.3	251.8	O K
600 min Summer	0.605	0.605	44.3	222.7	O K
720 min Summer	0.527	0.527	44.3	194.0	O K
960 min Summer	0.412	0.412	44.2	151.7	O K
1440 min Summer	0.310	0.310	38.6	113.9	O K
2160 min Summer	0.245	0.245	30.7	90.1	O K
2880 min Summer	0.212	0.212	25.5	78.0	O K
4320 min Summer	0.175	0.175	19.1	64.4	O K
5760 min Summer	0.154	0.154	15.3	56.6	O K
7200 min Summer	0.140	0.140	13.0	51.4	O K
8640 min Summer	0.129	0.129	11.3	47.6	O K
10080 min Summer	0.121	0.121	10.1	44.6	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	68.836	20
30 min Summer	45.828	33
60 min Summer	29.238	56
120 min Summer	18.112	88
180 min Summer	13.534	122
240 min Summer	10.952	158
360 min Summer	8.106	224
480 min Summer	6.544	290
600 min Summer	5.539	354
720 min Summer	4.832	414
960 min Summer	3.892	522
1440 min Summer	2.866	754
2160 min Summer	2.108	1108
2880 min Summer	1.693	1472
4320 min Summer	1.242	2204
5760 min Summer	0.996	2936
7200 min Summer	0.839	3672
8640 min Summer	0.730	4400
10080 min Summer	0.648	5136

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	0.660	0.660	44.3	243.0	O K
30 min Winter	0.839	0.839	46.4	308.6	O K
60 min Winter	0.961	0.961	49.6	353.6	O K
120 min Winter	0.996	0.996	50.5	366.7	O K
180 min Winter	0.965	0.965	49.7	355.0	O K
240 min Winter	0.909	0.909	48.3	334.5	O K
360 min Winter	0.785	0.785	45.0	288.8	O K
480 min Winter	0.660	0.660	44.3	243.0	O K
600 min Winter	0.530	0.530	44.3	195.0	O K
720 min Winter	0.425	0.425	44.3	156.3	O K
960 min Winter	0.327	0.327	39.9	120.5	O K
1440 min Winter	0.248	0.248	31.2	91.3	O K
2160 min Winter	0.200	0.200	23.3	73.5	O K
2880 min Winter	0.174	0.174	18.9	64.1	O K
4320 min Winter	0.145	0.145	13.9	53.4	O K
5760 min Winter	0.128	0.128	11.1	47.2	O K
7200 min Winter	0.117	0.117	9.4	43.1	O K
8640 min Winter	0.109	0.109	8.2	39.9	O K
10080 min Winter	0.102	0.102	7.3	37.5	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	68.836	20
30 min Winter	45.828	33
60 min Winter	29.238	58
120 min Winter	18.112	94
180 min Winter	13.534	132
240 min Winter	10.952	170
360 min Winter	8.106	242
480 min Winter	6.544	310
600 min Winter	5.539	372
720 min Winter	4.832	418
960 min Winter	3.892	528
1440 min Winter	2.866	754
2160 min Winter	2.108	1108
2880 min Winter	1.693	1472
4320 min Winter	1.242	2204
5760 min Winter	0.996	2936
7200 min Winter	0.839	3648
8640 min Winter	0.730	4352
10080 min Winter	0.648	5048

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time / Area Diagram

Total Area (ha) 1.900

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	4-8	0.900

Model Details

Storage is Online Cover Level (m) 1.500

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)
0.000	368.0

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md3 Invert Level (m) 0.000
Design Flow (l/s) 50.5 Diameter (mm) 228

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	7.0	1.200	55.5	3.000	87.7	7.000	134.0
0.200	23.4	1.400	59.9	3.500	94.7	7.500	138.7
0.300	37.7	1.600	64.1	4.000	101.3	8.000	143.2
0.400	43.9	1.800	67.9	4.500	107.4	8.500	147.6
0.500	42.7	2.000	71.6	5.000	113.2	9.000	151.9
0.600	41.4	2.200	75.1	5.500	118.8	9.500	156.1
0.800	45.4	2.400	78.4	6.000	124.0		
1.000	50.6	2.600	81.6	6.500	129.1		