Drainage and Flood Management Strategy

Hereford Enterprise Zone

January 2021

www.jbaconsulting.com

Herefordshire Council
Plough Lane
Hereford
HR4 OLE

JBA Project Manager

George Baker BEng AIEMA CEnv IEng MCIWEM C.WEM
Kings Chambers
7-8 High Street
Newport
South Wales
NP20 1QU

Revision History

Revision Ref/Date	Amendments	Issued to
13/08/2019	Draft Report Version 1.0	Mark Pearce
12/09/2019	Draft Report 2.0	Mark Pearce
20/07/2020	Draft 3.0	Mark Pearce
21/01/2020	Final v4.0	Mark Pearce

Contract

This report describes work commissioned by Hereford Enterprise Zone, on behalf of Herefordshire Council, by a letter dated 4th December 2018. Hereford Enterprise Zone's representative for the contract was Mark Pearce.

Prepared by ..... Eleanor Maxfield

Senior Analyst BSc MCIWEM

Input provided by ..... Marta Lubiejewska-Jones

Principal Engineer MSc CEng CEnv MCIWEM C.WEM

Input provided by ..... Paul Redbourne

Analyst BSc PGCert

Reviewed by ..... George Baker

Technical Director AIEMA CEnv IEng MCIWEM C.WEM

Purpose

This document has been prepared as a Draft Report for Herefordshire Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Hereford Council.

Copyright

Contents

List of Figures

List of Tables

Abbreviations

AEP	Annual Exceedance Probability
EA	Environment Agency
DFMS	Drainage and Flood Management Strategy
FFL	Finished Flood Level
FRA	Flood Risk Assessment
JBA	Jeremy Benn Associates Ltd
LDP	Local Development Plan
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
SFRA	Strategic Flood Risk Assessment

1 Introduction

1.1 Terms of Reference

JBA Consulting (JBA) were commissioned by Hereford Enterprise Zone in December 2018 to provide an updated Drainage and Flood Management Strategy to support the continued development of the Hereford Enterprise Zone at Rotherwas Industrial Estate, Hereford.

This document constitutes the Drainage and Flood Management Strategy (DFMS) for the revised Hereford Enterprise Zone Local Development Order (LDO).

1.2 Scope of works

The principal aim of the Strategy is to ensure that flood risk and sustainable drainage requirements are identified and managed for the continued and sustainable development of Hereford Enterprise Zone.

In 2009 Herefordshire Council published the first Drainage and Flood Management Strategy to support the application for the Hereford Enterprise Zone LDO. The Drainage and Flood Management Strategy was approved by planners and the Environment Agency and incorporated into the adopted LDO. As development of the Enterprise Zone proceeded, the strategy has been progressively reviewed and updated to reflect infrastructure improvements and completed development.

The first LDO expired in November 2018. This updated DFMS will form part of the revised LDO for Hereford Enterprise Zone and supersedes the 2009 strategy. The approach to the updated DFMS is generally consistent with the previous strategy. The updated strategy reflects changes to national and local policy, current built areas of the site and the latest flood risk datasets and hydraulic modelling. It has been developed in consultation with the Environment Agency and Herefordshire Council.

1.3 Structure and intended use

This DFMS document is to be used as a summary technical report and is supplemented by technical appendices.

The strategy focuses on the remaining development areas and proposed LDO extension areas, which have been divided into separate 'mini-zones'. The DFMS should provide and summarise the necessary flood risk and drainage guidance for developers, to ensure that development is consistent with the requirements of the Council and the LDO.

The strategy document includes an overview of the previous strategy and provides background information that applies to all mini-zones. Flood risk has then been considered at a strategic level for Hereford Enterprise Zone within a separate section. This allows for generic advice that applies to all mini-zones and a review of the effectiveness of the existing Rotherwas Flood Alleviation Scheme.

Each mini-zone has then been considered in a standalone section of the DFMS. Recommended approaches to flood management and surface water drainage have been developed for each mini-zone using site-specific data and modelling results, in accordance with local and national policy. These mini-zone sections of the report provide information to be used for the design and planning approval of individual development plots, including drainage proposals and additional infrastructure needs or flood mitigation measures.

The recommendations of this report have sought to reflect the likely development patterns for Hereford Enterprise Zone. A masterplan was provided by Hereford Enterprise Zone on 14th June 2019 and provided the anticipated location, scale and layout of proposed development plots. This masterplan has been applied to the analysis and recommendations detailed in this strategy. However, it is emphasised that the recommendations of this strategy are not dependant on the precise layouts for each individual development as detailed in the masterplan.

Some variations to the developments would be appropriate, provided that they do not significantly depart from proposals outlined herein in terms of size, position or usage.

1.4 Developer compliance with this strategy

Developers of individual plots within a Hereford Enterprise Zone mini-zone will be required to produce a written statement to demonstrate conformance with the flood risk and SuDS requirements of this strategy document, in support of their LDO permitted development application. Unless they intend to depart from this DFMS, this need only be a statement providing evidence of compliance with the strategy.

The supporting evidence should include information on design measures to mitigate risk from fluvial flooding in accordance with the recommendations in Section 3 of this strategy and the specific requirements for their respective mini-zone, as given in Sections 5 - 11. Relevant information will include:

- Site layout.
- Existing and proposed levels (slabs, car parks, landscaped areas etc).
- Access routes including emergency routes as necessary.
- Emergency response plan and emergency evacuation procedure where relevant.
- Design for exceedance and flood resilience.
- Management measures to mitigate flood risk including a draft 'Business Flood Plan'.

Site specific surface water drainage strategies will be required to evidence sustainable drainage design in accordance with Section 4 of this strategy and the specific requirements for their respective mini-zone, as given in Section 5 - 11.

Should a developer propose a scale or form of layout that significantly deviates from the masterplan layout assumed in this strategy, the Local Authority may require additional assessment to demonstrate that the proposals will accord with the aims of the strategy. An example may include proposals that involve a significantly higher building density. Specific mini-zone changes to layout and form that may have significant effect have been highlighted in the relevant sections of the strategy document.

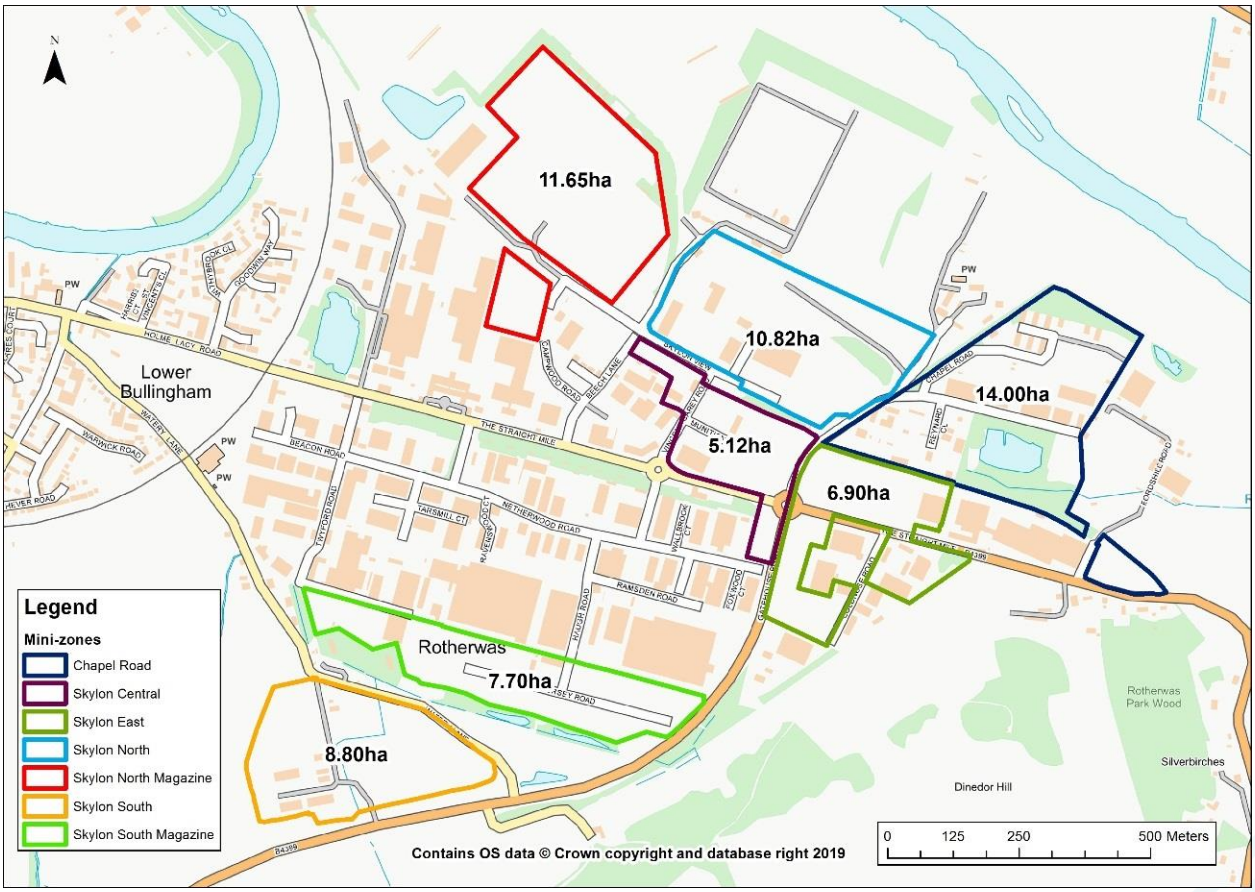
2 Background

2.1 Site location and mini-zones

Hereford Enterprise Zone (Skylon Park) refers to the 65-hectare site located within the Rotherwas Industrial Estate in the south-east of Hereford at grid reference SO 530382. Hereford Enterprise Zone comprises employment land that has undergone substantial development since being awarded Enterprise Zone status in 2011. As of 2019, approximately 50% of the site remains to be developed.

The Enterprise Zone has been divided into seven mini-zones as shown in Figure 2-1, each of which is discussed in detail within a separate section later in this strategy document (section 5-11).

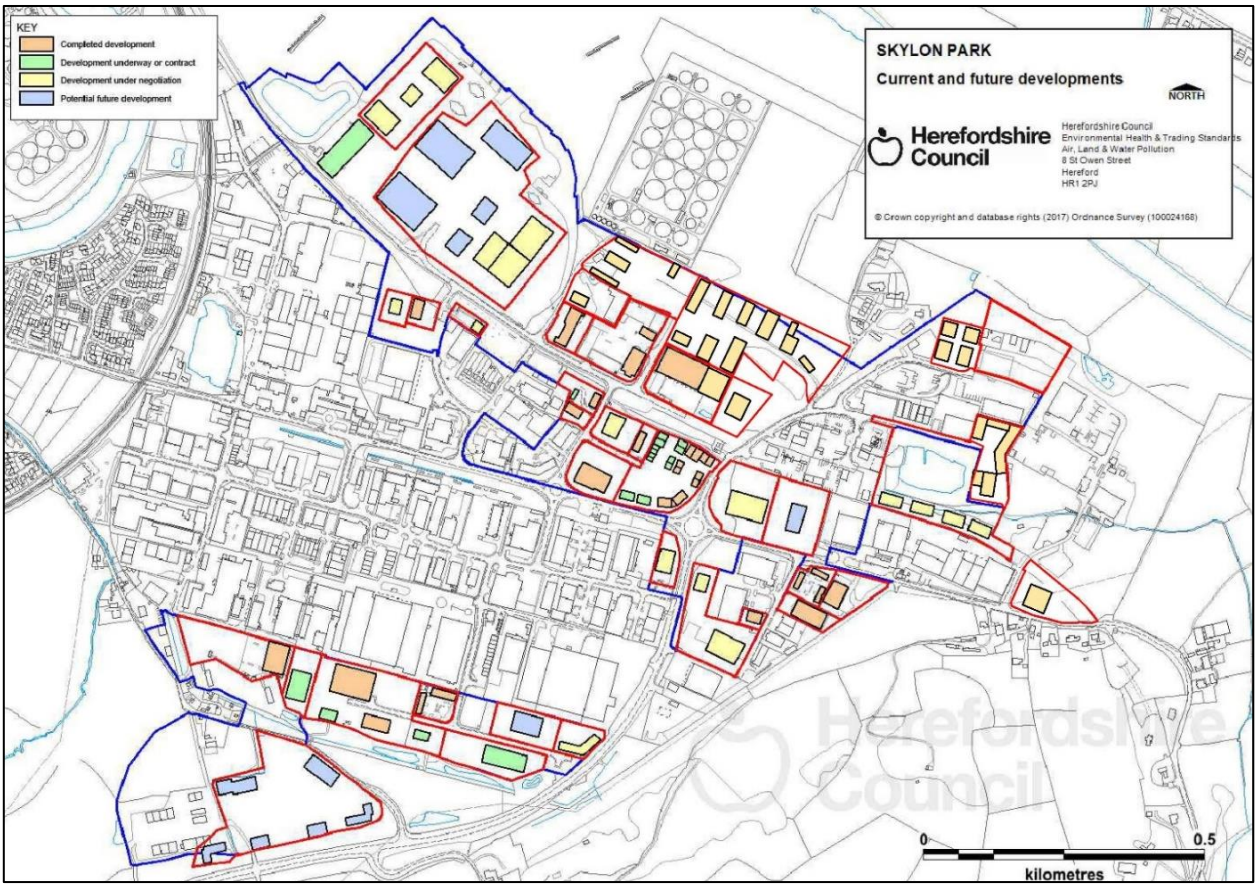
Figure 2-1 2019 mini-zone location plan



This strategy describes the flood risk and drainage requirements for the proposed future development parcels within the mini-zones. The development parcels are shown on the plan provided by Herefordshire Council, presented in Figure 2-2. The parcels considered within this strategy are denoted as 'development under negotiation' and 'potential future development'.

Developments denoted as 'completed development' and 'development underway or contract' have already been or are being constructed, together with the dedicated surface water drainage schemes. These parcels have not been included within the strategy but are accounted for in the technical assessments.

Figure 2-2 Completed and future developments (source: Herefordshire Council)



2.2 Drainage and Flood Management Strategy 2009

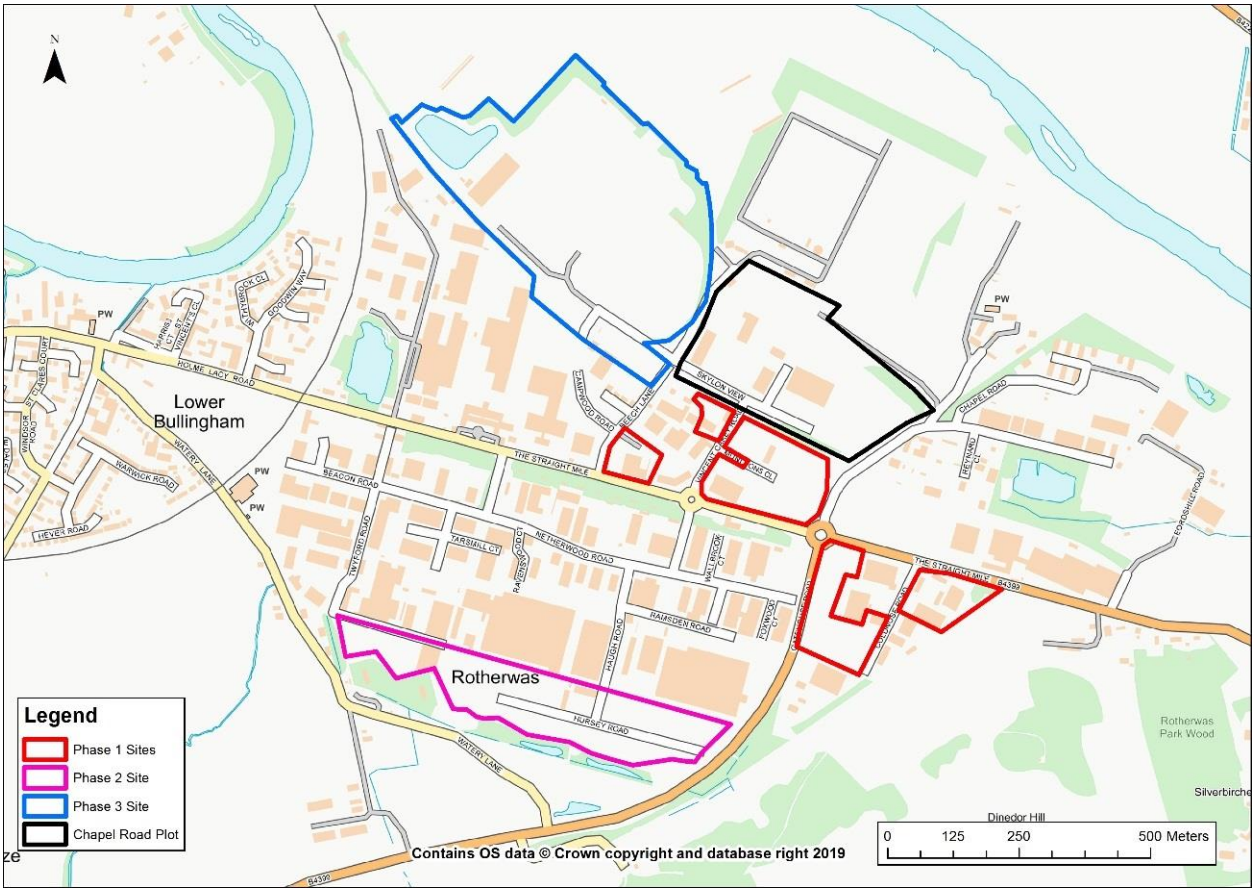
The 2009 Drainage and Flood Management Strategy for Hereford Enterprise Zone set out a plan and recommendations for how the Enterprise Zone could be safely and suitably developed with regards to the management of flood risk and drainage.

At that time, the development areas were divided into three phases as shown in Figure 2-3:

- Phase 1 included several individual plots distributed within the estate.
- Phase 2 located within the southern part of the estate.
- Phase 3 located in the northern part of the estate.
- Chapel Road plot located to the north eastern part of the estate.

Detailed 1D-2D flood modelling of the River Wye was undertaken to define flood risk across the site. This work showed that whilst the site generally did not flood during a 1% AEP flood event, extensive flooding of the site occurred during the 1% AEP event plus an allowance for climate change and the 0.1% AEP event. Consequently, a flood risk management scheme was required, of which the key components were recommended in the 2009 strategy.

Figure 2-3 2009 development phases location plan



2.3 Rotherwas Futures Flood Attenuation Scheme 2011

In response to the Drainage and Flood Management Strategy (2009) recommendations regarding flood risk, Herefordshire Council developed the Rotherwas Futures Flood Attenuation Scheme (2011)[1]. The scheme was developed to address the requirement for strategic compensation for the loss of floodplain storage that would result from the proposed development of the estate. The scheme was also designed to convey flood water through the site during extreme flood events.

The design of the Rotherwas Futures Flood Attenuation Scheme was informed by detailed assessment and development of a 1D-2D ISIS-TUFLOW hydraulic model by JBA Consulting in 2011 to assess and mitigate flood risk at the Rotherwas Industrial Estate[2].

The main features of the scheme are shown in Figure 2-4 and listed below:

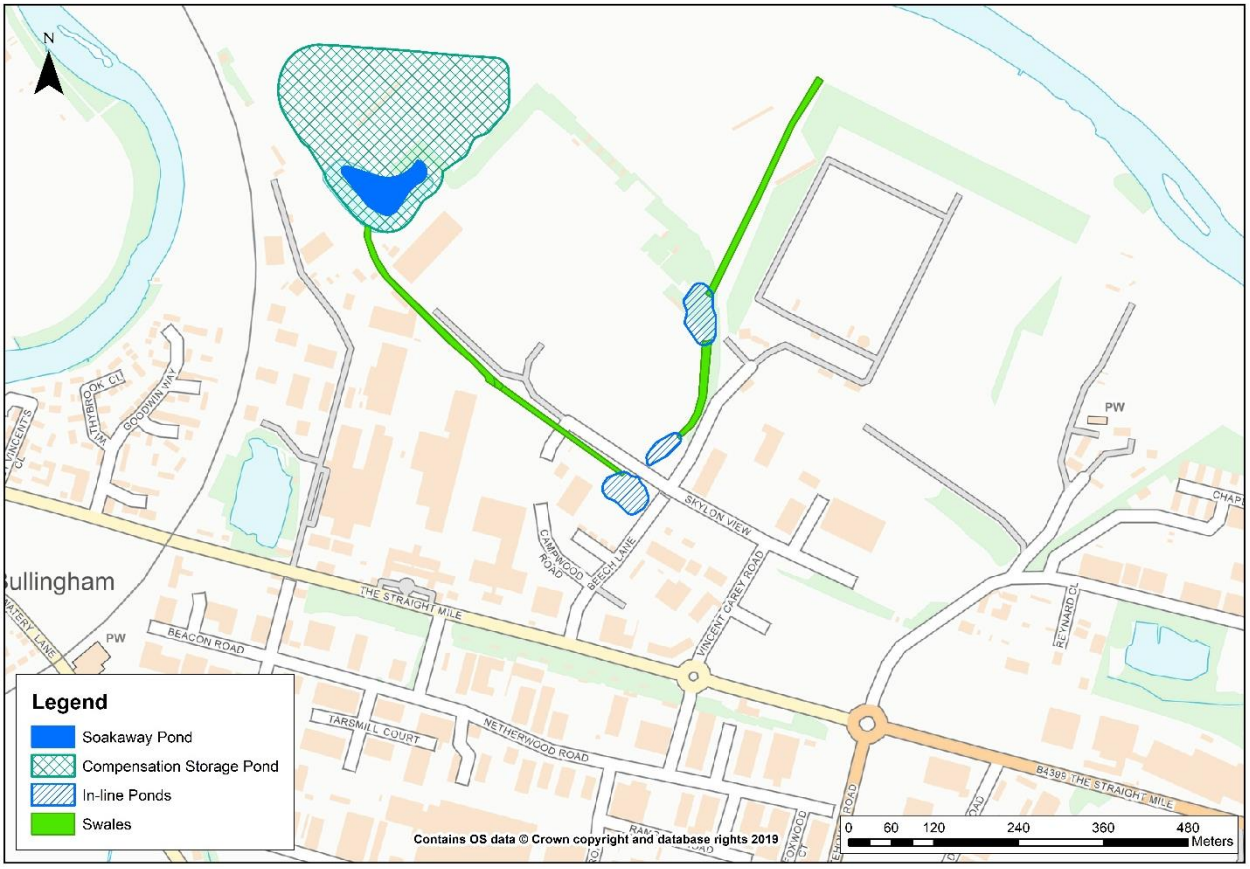
- A soakaway pond in the north-west of the site, storing floodwater during extreme events.
- A flood compensation area formed by lowering land between the attenuation pond and the River Wye floodplain by up to 1m to accommodate overflows from the pond.
- Three soakaway balancing ponds in the north of the estate, interconnected by shallow swales and an onward swale path flowing towards the floodplain and providing a natural flow path away from the site towards the River Wye. The balancing ponds have been designed to attenuate floodwater and provide additional SuDS benefit for future surface water drainage requirements.

1 Rotherwas Futures Flood Attenuation Scheme Flood Risk Assessment, August 2011, Herefordshire Council
2 Rotherwas Futures – Technical Modelling Report, JBA Consulting 2011.

- Additional swales between Vincent Carey Road and Chapel Road, designed to carry exceedance overland flow across the north-east of the estate, towards the existing pond in the east of Chapel Road.

These elements of the Rotherwas Futures Flood Attenuation Scheme have now been implemented.

Figure 2-4 Rotherwas Futures Flood Attenuation Scheme 2011



2.4 Access road developments

To enable the development of the Enterprise Zone, additional highway developments have been completed. These developments can influence flood risk and drainage arrangements and have therefore been considered during the development of this strategy.

The Phase 3 site access road is located in the northern part of the industrial estate, from the end of Vincent Carey Road. As part of the construction of the Phase 3 access road, a number of flood alleviation measures were included, such as:

- Ground raising of road levels above the 1% AEP plus climate change level.
- Flood relief pipes have been installed to the west of Fir Tree Lane to convey flood water via open swales providing a strategic flood storage area.
- Kerb drainage units installed along the highway to convey the surface water runoff through a filter drain located below a swale, discharging into a soakaway pond.
- The swale and the soakaway pond compensate for the storage lost due to the footprint of the access road.

In 2009, the Phase 3 access road was extended from Vincent Carey Road into the North Magazine site. The surface water runoff from the extended road is conveyed via a kerb drainage system into the swale along the southern boundary of the North Magazine site.

The highway and the drainage infrastructure for the road access in Phase 2 site was also constructed in 2009. The surface water runoff from the highway drains via an oil interceptor into an underground attenuation tank.

In 2016, the Hursey Road (providing access to the previous Phase 2 development) was extended to provide controlled access to the B4399 Gatehouse Road for abnormal loads only.

The Hereford Connect2 Greenway has been implemented within the Rotherwas Industrial Estate consisting of a shared use pedestrian and cycling path linking the centre of Hereford with the Rotherwas Industrial Estate. The cycle path runs alongside the North Magazine swale and under the railway embankment from the River Wye to the west of the industrial estate.

2.5 Site topography

The topography within Rotherwas Industrial Estate is shown in Figure 2-5 below. The estate is predominantly flat terrain located on the floodplain of the River Wye, gently sloping downwards in a northerly direction towards the river.

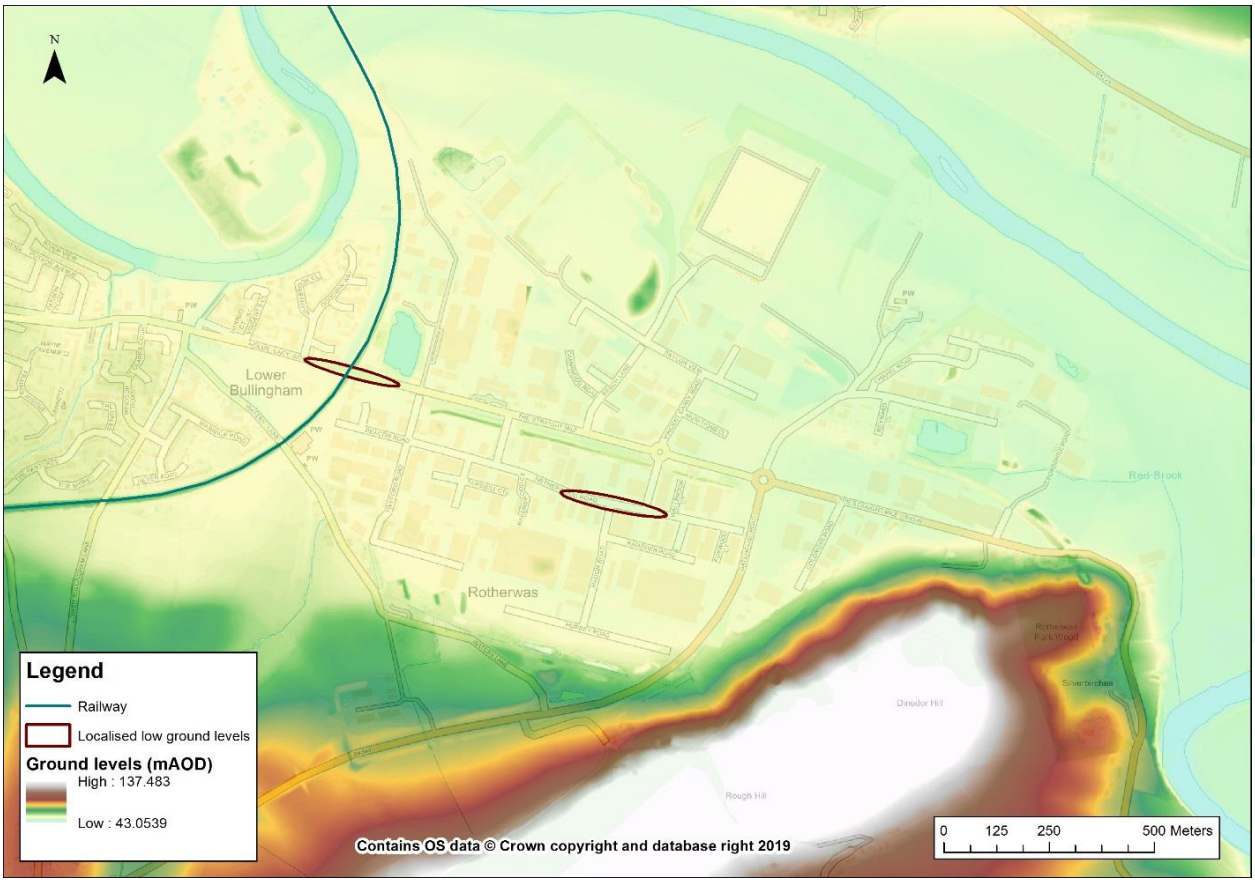
The ground levels within the Hereford Enterprise Zone vary from approximately 61.75mAOD in the southern mini-zones to approximately 49.12mAOD in the northern mini-zones.

The predominant topographic feature is Dinedor Hill to the south-west of the industrial estate and the River Wye to the north.

The Welsh Marches railway line (from Newport to Shrewsbury) is located along the western boundary of the estate. The railway is on an embankment with the crest level varying between 54.36mAOD and 52.64mAOD.

The main road through the site, 'the Straight Mile', is a continuation of Holme Lacy Road and underpasses the railway line on entry to the industrial estate.

Figure 2-5 Ground levels across Hereford Enterprise Zone



2.6 Watercourses and storm water sewers

Watercourses located in the vicinity of the Rotherwas Industrial Estate are listed below and shown in Figure 2-6.

- River Wye, a main watercourse flowing through Hereford City and meandering around the northern extent of the estate. The Hereford Enterprise Zone is located within the floodplain of the River Wye.
- Red Brook, a tributary of the River Wye, running to the west of the Skylon South and Skylon South Magazine plots before passing under the railway line.
- Red Brook, a tributary of the River Wye, running to the east of Chapel Road.
- Minor watercourses fed by land drains and groundwater springs within the southern part of the estate discharging into the Red Brook.

The Rotherwas Industrial Estate is served by public surface water sewers which discharge into the River Wye at two locations[3] as shown in Figure 2-6. A local storm sewer draining only the north-western part of the estate discharge into the River Wye to the west of the estate (passing under the railway line). A large diameter storm sewer draining most of the estate runs within Chapel Road before discharging into the River Wye via a 1500mm outfall pipe to the north east of the estate[4].

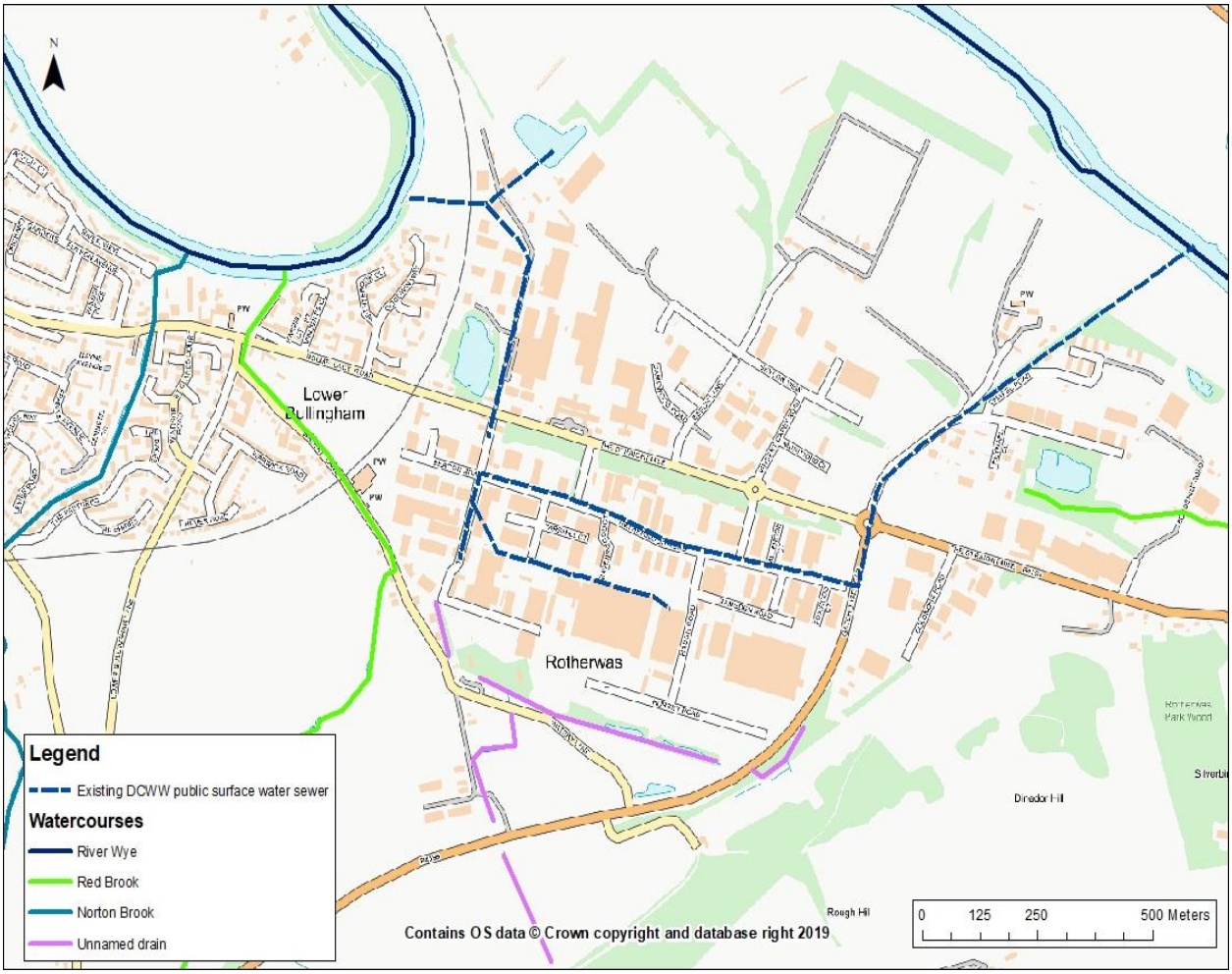
Much of the existing estate has impermeable surface due to roads, buildings and hardstanding, with associated drainage components.

Since the 2009 strategy was prepared, various land parcels within the mini-zones have been or are currently being constructed. Limited information is available regarding the constructed drainage arrangements for these areas.

3 Constraint plan, E000202954 - Rotherwas Ind Est V2 Rev03.dwg

4 DCWW Surface Water Sewer Long Section, drawing No. 551392-SK-115, Amey

Figure 2-6 Location of watercourses and public surface water sewers



2.7 Geology and hydrogeology

The British Geological Survey mapping[5] indicates that the area covered by Hereford Enterprise Zone is overlain by river terrace deposits consisting of sand and gravel. The bedrock comprises Raglan Mudstone Formation - siltstone and mudstone, interbedded.

Defra MAGIC mapping[6] shows that the estate is located within a Secondary A Aquifer for both bedrock and superficial drift. The groundwater vulnerability is classified as being within a Minor Aquifer and Intermediate Groundwater Vulnerability Zone. The site is also located within a Nitrate Vulnerable Zone.

Several ground investigations have been carried out within the Rotherwas Industrial Estate as part of the ongoing development of the estate. A summary of the available information is detailed in Table 2-1 below.

Table 2-1 Summary of ground investigation findings

Ground investigation	Findings
Ground Investigation at North Magazine Site, Rotherwas. Factual and	The results of the ground investigation, comprising cable percussive and rotary boreholes, showed the following general strata:

5 http://mapapps.bgs.ac.uk/geologyofbritain/home.html
6 https://magic.defra.gov.uk/MagicMap.aspx

Interpretive Report by Geotechnics Limited (February 2013, Project Number PC125103)	• Made Ground - encountered in all the boreholes with a thickness of between 0.30m and 5.30m. The composition of the Made Ground was variable across the site and was generally divided into clay-dominated soils (Cohesive Made Ground) or gravel-dominated soils (Granular Made Ground). • Superficial Deposits - the stratum was divided into two layers; an upper cohesive layer (thickness between 0.70m and 2.80m) recorded in the northern and south-eastern parts of the site, that may be alluvial in origin, or possibly form part of the River Wye River Terrace Deposits, and a lower granular layer found in all boreholes (at a depth between 1.60m and 3.40m bgl), which probably forms part of the River Wye River Terrace Deposits. • Raglan Mudstone Formation – found below the Superficial Deposits at depths between 5.30m and 7.00m bgl. The boreholes tentatively suggest that the surface of the Raglan Mudstone Formation slopes down from the northern corner and from the southern part of the site towards the central area of the site. The stratum was proved to maximum depth of 20.68m bgl in the northern part of the site. Groundwater was struck in majority of boreholes at varying depths between 1.80m and 3.80m bgl. Standpipes were installed in six of the boreholes, with water levels measured on four occasions in December 2012 and January 2013. The observations showed the maximum recorded water levels between 1.13m and 2.15m bgl. No soakaway testing was undertaken as part of the investigation. The results of the investigation have been incorporated into the relevant geology section for the North Magazine mini-zone.
Draft Factual Report CC Ground Investigation Ltd on behalf of Parsons Brinkerhoff Ltd. (15/09/2014, Report No. C4249)	The survey comprised three areas, namely Skylon Central, Skylon East and Skylon South Magazine, with 4 exploratory hole locations in each. The results of the survey are described within the relevant mini-zone geology sections later in the strategy.
Surface water management plan, Woodstock Trading (October 2015, Hydro-Logic Services)	Infiltration testing was undertaken at the Woodstock site and results show that the slowest rate of infiltration was 2.10^{-5} m/s.
Ground investigation for the Shell Store undertaken by Southern Ground Testing Ltd and Owen Pell in March 2016.	The findings were included within Appendix A of The Shell Store, Technology, Incubation & Development Centre report, Revision B, 27/09/18 (west of Skylon North Magazine) The results of ground investigations showed the following general strata: • Made Ground – reworked River Terrace Deposits, presumably placed during earthworks on adjacent sites. Local demolition material present (brick and concrete), however not clear if engineered fill or loosely placed.

	• Alluvium to 2mbgl – soft to firm, slightly gravelly, sandy, clayey silt. • River Terrace Deposits – 2mbgl and 3mbgl – upper surface of clay, sand and gravel, with clay content reducing with depth and not present approx. 0.5m into strata. Locally River Terrace Deposits encountered as medium dense sand. Groundwater was encountered at approximately 3mbgl. Infiltration tests were carried out within the Shell Store development and indicated varying infiltration rates between $1x10^{-5}$ m/s and $7.2x10^{-6}$ m/s.
Soil Infiltration tests (May 2016, Sutton Survey, Report reference: SS-16-2433)	Sutton Surveys have carried out soil infiltration tests off Vincent Carey Road for GB Electrical Ltd. 3 trial holes were excavated in the location of the anticipated SuDS area. No groundwater was encountered at 1.65m depth within the granular material but was expected that groundwater levels fluctuate within the floodplain gravels. Infiltration test was abandoned in one of the three holes due to the stabilised construction works as water didn't drain away. The infiltration rate was estimated to be 10^{-5}m/s which suggests a medium permeability value. The site is in a major floodplain and it is known that ground water levels can fluctuate significantly in winter and during periods of heavy rainfall, as there is a hydraulic continuity with river levels.

3 Flood risk

3.1 Introduction

This section outlines the national and local policy requirements for flood risk management at Hereford Enterprise Zone and provides a summary of existing flood risk. More detailed requirements for developers regarding flood risk mitigation in their mini-zone or development parcel is provided within the respective section later in the strategy document.

3.2 National policy and flood zones

The National Planning Policy Framework (NPPF) as updated in July 2018, sets strict requirements to protect people and property from flooding which all local planning authorities are expected to follow. The NPPF technical guidance applies a sequential characterisation of risk, based on flood zones as provided in the Environment Agency Flood Map for Planning. A principal planning requirement is to identify the flood zone at the location of the proposed development and review the appropriateness of the development type based on its vulnerability classification. The definition of the Environment Agency flood zones is provided in Table 3-1. Table 3-2 shows the compatibility of vulnerability classifications with the flood zones. The NPPF Sequential Test aims to promote development to the lowest flood risk zone. The Exception Test is used where no suitable development areas can be found in lower risk flood zones.

The NPPF requires a site-specific flood risk assessment to accompany planning applications in areas at risk of flooding or for sites of 1 hectare or more in size. The assessment should demonstrate the application of the Sequential and Exception Test where relevant. The assessment must show how flood risk will be managed now and over the development's lifetime, taking account of climate change and the vulnerability of its users.

Table 3-1 Definition of flood zones

		Probability of flooding	
Flood Zone	Zone 1	Low probability	Land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
	Zone 2	Medium probability	Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.
	Zone 3a	High probability	Land assessed as having a 1 in 100 or greater probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
	Zone 3b	Functional floodplain	Land where water will flow or be stored in times of flood.

The Environment Agency Flood Map for Planning covering Rotherwas Industrial Estate is shown in Figure 3-1. Hereford Enterprise Zone is located mostly within Flood Zone 2. Some isolated areas adjacent to the river are located within Flood Zone 3a at North Magazine and Chapel Road mini-zone. All proposed development within Hereford Enterprise Zone mini-zones constitutes commercial development and is classified as 'Less Vulnerable'. No part of the Enterprise Zone is located in

Table 3-2 Flood risk vulnerability and Flood Zone compatibility

Vulnerability Classification		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test	✓	✓
	Zone 3a	Exception Test	✓	X	Exception Test	✓
	Zone 3b	Exception Test	✓	X	X	X

✓ *Development is appropriate*

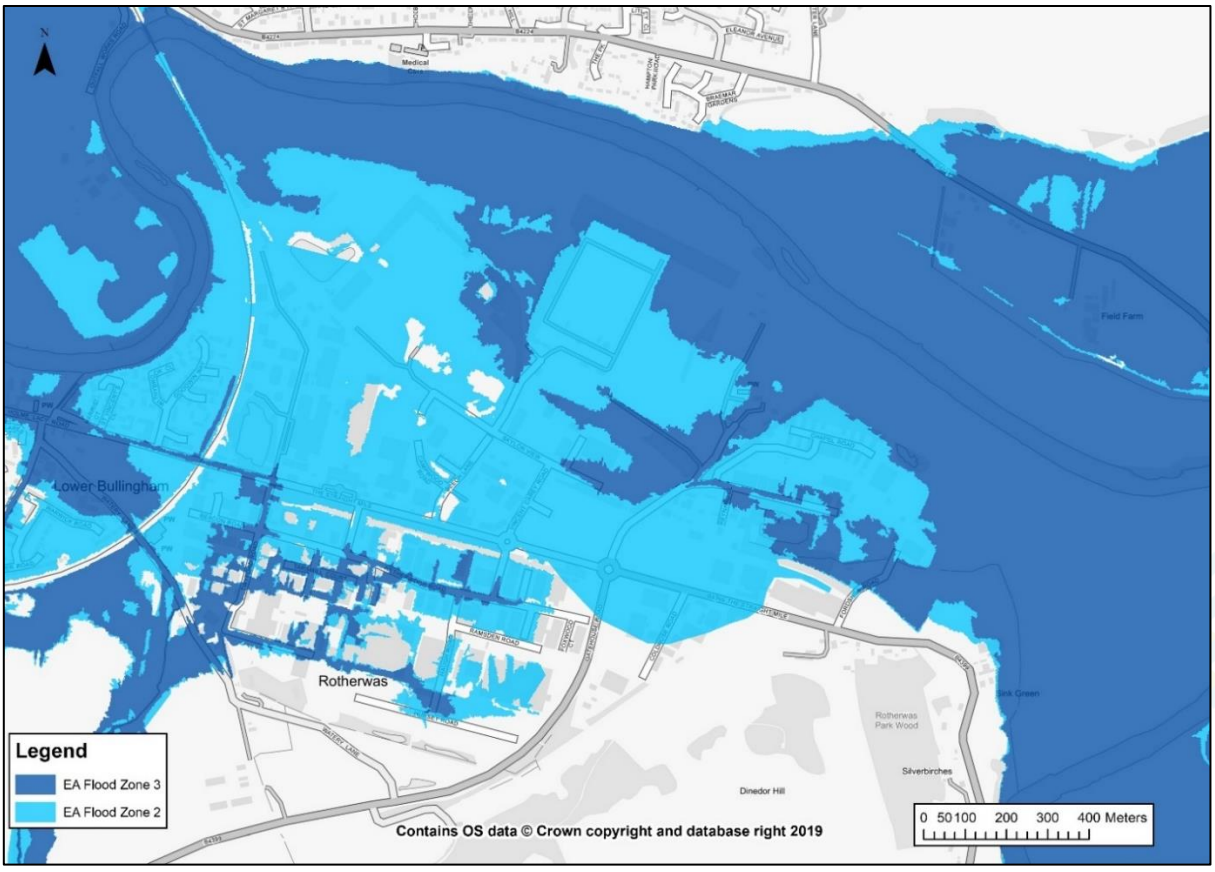
X *Development should not be permitted*

Notes:

This table does not show:

1. *The application of the sequential test which guides development to Flood Zone 1 first, then Zone 2, and then Zone 3;*
2. *Flood risk assessment requirements;*
3. *The policy aims for each flood zone.*

Figure 3-1 Existing EA Flood Zone Mapping



In accordance with Table 3-2, the proposed development of Hereford Enterprise Zone is therefore compliant with the NPPF, and the Sequential and Exception Test are not necessary. However, an assessment of flood risk is necessary on the basis of the size of development and

must consider the future risk of flooding, taking account of climate change. This assessment has been carried out as part of this DFMS and the findings detailed in the respective sections for each mini-zone later in the document.

3.3 Local policy and guidance documents

The Herefordshire Local Plan Core Strategy 2011 - 2031 clearly incorporates requirements for flood risk and climate change considerations for all new development. The key policy considerations are outlined below.

Policy SS7 – addressing climate change requires that development proposals include measures that will mitigate their impact on climate change and minimise the risk of flooding in the future.

Policy SD3 – sustainable water management and water resources requires new development to incorporate sustainable water management to reduce flood risk. Development proposals should be located in accordance with the NPPF guidance and have regard for the Herefordshire Strategic Flood Risk Assessment (SFRA). Further requirements include:

- Development must be designed to be safe, taking into account the lifetime of the development and the need to adapt to climate change by setting appropriate floor levels, providing safe pedestrian and vehicular access, where appropriate, implementation of a flood evacuation management plan and avoiding areas identified as being subject to Rapid Inundation from a breach of a Flood Defence.
- Where flooding is identified as an issue, new development should reduce flood risk through the inclusion of flood storage compensation measures or provide similar betterment to enhance the local flood risk regime.

More detail on the implementation of these policy requirements is provided in the Herefordshire Level 1 Strategic Flood Risk Assessment (April 2019)[7].

The guidance provided within these local policy documents has been used to inform the assessment and recommendations provided later in this section and for each mini-zone.

3.4 Climate change

Updated climate change recommendations were published by the Environment Agency (EA) in February 2016 and must be used when assessing and planning for future flood risk to new developments. A summary of the climate change recommendations for peak river flow within the Herefordshire area is provided in Table 3-3 below.

Table 3-3 Peak river flow allowances

Allowance category	Total potential anticipated for the '2020s' (2015 to 2039)	Total potential anticipated for the '2050s' (2040 to 2069)	Total potential anticipated for the '2080s' (2070 to 2115)
High++[8]	25%	45%	90%
Upper end	25%	40%	70%
Higher Central	15%	25%	35%
Central	10%	20%	25%

7 Herefordshire Level 1 SFRA April 2019 WSP.
8 The use of the High++ allowance category is generally reserved for schemes where the probability of flooding is rare but the consequences of flooding could be extreme (e.g. a nationally significant power station) or where the scheme will significantly change existing settlement patterns (e.g. new urban extensions).

At the time of developing this strategy, the EA guidance was being revised in line with the Met Office UK Climate Projections 2018[9]. Interim guidance was received from the EA[10] that recommends application of the February 2016 climate change allowance during the interim period, as the best national representation of how climate change affects peak river flow and peak rainfall intensity.

The proposed development for Hereford Enterprise Zone is categorised as commercial development. Herefordshire Council consider the lifetime of all non-residential developments as 60 years, except for agricultural developments with a design life of 50 years[11]. Consequently, development in Hereford Enterprise Zone is expected to extend into the '2080's' epoch.

The EA climate change allowance guidance states that development classified as Less Vulnerable, such as commercial development, should apply the central allowance category.

A 25% climate change allowances has therefore been applied for the purposes of fluvial flood risk assessment within this strategy, as agreed in consultation with the Environment Agency[12].

3.5 Principles of safe development

National and local flood risk policy requires that development proposals must address the issues of safe development and residual flood risk through site location, layout and design. It is a requirement that all new development in flood risk areas include safe access and egress routes. Furthermore, for development within areas identified to be at risk of flooding, appropriate resistance and resilience measures should be incorporated to adequately protect the development from flooding. Essential infrastructure and critical infrastructure should remain operational during flood events.

3.6 Flood hazard

The principle of flood hazard is that danger from flooding is not always a result of deep water, shallow but fast flowing water can easily knock people off their feet or transport damaging debris. Therefore, flood hazard applies the velocity of the flood waters, potential for debris and flood depths (recognising that deep water is generally more hazardous due to the ability to transport larger debris).

Guidance on the calculation of flood hazard is provided in the 2006 Defra Flood Risks to People Methodology[13] and 2008 Supplementary Note[14]. Factors that affect flood hazard and vulnerability are combined in a form of multi-criteria analysis that can be used to identify hot-spots and broadly estimate the probability of people being seriously harmed or fatalities during a flood. The Flood Hazard Ratings calculated using the methodology above can be translated into an assessment of likely Hazard to People Classification using the guidance provided in Table 3-4 below.

9 https://www.metoffice.gov.uk/research/collaboration/ukcp
10 Interim guidance. 1st March 2019.
11 Herefordshire Level 1 SFRA April 2019 WSP
12 As confirmed at a meeting between the EA, JBA and Hereford Enterprise Zone 28th June 2019
13 Defra and Agency (2006) The Flood Risks to People Methodology, Flood Risks to People Phase 2, FD2321 Technical Report 1, HR Wallingford et al. did the report for Defra/EA Flood and Coastal Defence R&D Programme, March 2006.
14 'Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1', Environment Agency and HR Wallingford, May 2008

Table 3-4 Hazard to people classification

Flood Hazard Code	Rating Colour	Hazard to People Classification
Less than 0.75		Very low hazard – Caution
0.75 to 1.25		Moderate - Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		High - Danger for most – includes the general public
More than 2.0		Very high - Danger for all – includes the emergency services

For development proposed in areas at risk of flooding, the use of the hazard rating is most applicable to the assessment of safe access and egress routes that people and the emergency services will be required to use should a flood event occur.

The hazard rating for primary access and egress route for each Hereford Enterprise Zone mini-zone has been provided within the relevant sections of this strategy document. This information is intended for use in developing appropriate mitigation measures in accordance with the vulnerability of the proposed development use.

3.7 Access, egress and emergency response

Herefordshire Council[15] define the following policy requirements for safe access and egress from Less Vulnerable developments in all Flood Zones below:

- Dry vehicular access should be provided above the 1% AEP fluvial flood level (including allowance for climate change) to a place of safety or the wider road network.
- Where this is not possible, safe access with no greater than 'moderate' flood hazard should be demonstrated up to the 0.1% AEP event.

It is considered by Herefordshire Council that for Less Vulnerable development in areas defined as Flood Zone 2, a *Site-Specific Emergency Response Plan* is unlikely to be necessary to support development.

In areas within Flood Zone 3, a *Site-Specific Emergency Response Plan* is likely to be required to support all habitable buildings and manned sites and must consider the needs of vulnerable and disabled users of the development. A *Site-Specific Emergency Evacuation Procedure* must also be in place to ensure that the risk to life is minimised should a flood event occur. Coordination with the emergency services will be required in the event of a flooding emergency.

The access/egress and emergency response arrangements for each mini-zone and development parcel has been considered separately within the respective sections of this strategy.

3.8 Ground levels, FFL's and freeboard

National and local policy recommend that finished floor levels for development are raised to a minimum elevation above flood levels (applying a freeboard), and where this is not possible appropriate resistance and resilience measures should be considered.

It is recognised that the impact of flooding on a site classified as Less Vulnerable may vary depending on the vulnerability of the use and function of that site. Therefore, the approach to flood mitigation may vary and more than one option is applicable for setting ground levels, FFL's and freeboard.

The Hereford Enterprise Zone mini-zones fall within the floodplain of the River Wye and experience widespread shallow flooding in the 1% AEP plus climate change and the 0.1% AEP

15 Herefordshire Level 1 SFRA April 2019 WSP .

event. Consequently, ground levels and finished floor levels (FFLs) of the proposed development must be set at an appropriate elevation to ensure safe development. Guidance for levels to be applied across the mini-zones at Hereford Enterprise Zone has been provided in the relevant sections for each mini-zone within this DFMS, the principles are outlined in the sections below.

National and local guidance

The Environment Agency Flood Risk Assessment Standing Advice[16] recommends a freeboard allowance for finished floor levels as a minimum of 600mm above the 1% AEP fluvial flood level, including an allowance for climate change. The 2019 Herefordshire SFRA also recommends the EA standing advice for typical floor levels.

The 2019 Herefordshire SFRA provides further guidance on the application of this freeboard (the height that the floor level is raised above the flood level) and states that freeboard is determined as a measure of the residual flood risks, confidence in the flood data and vulnerability of specific development. It is intended that all new development should strive to remain resilient to flood water ingress during the 0.1% AEP events.

It is also recommended that areas at risk of surface water flooding, should raise FFL's for new developments 150mm above the estimated surface water flood depth (taking the potential effects of climate change into account), or a minimum of 150mm above existing ground levels if this is more appropriate. The Environment Agency surface water flood map shows the majority of Hereford Enterprise Zone has a very low risk of surface water flooding. Consequently, surface water flooding has not been considered further with regards to recommended FFL's as flood mitigation in this DFMS.

Building regulations[17] recommend that that FFL's should be a minimum of 150mm above surrounding finished ground levels to prevent flooding from flowing or ponding stormwater near doorways and other ingress routes.

Recommended freeboard

Consideration has been given to the appropriate freeboard allowance for proposed development within Hereford Enterprise Zone based on the guidance outlined above, the flood mechanisms and the definition of freeboard provided in the 2019 Herefordshire SFRA and EA Fluvial Freeboard Guidance[18].

Freeboard is a safety margin that allows for uncertainties. These include the uncertainties associated with the estimation of the design water level, construction tolerances, and in the case of flood defences the long-term deterioration of a defence (such as settlement).

In the case of Hereford Enterprise Zone, detailed 1D-2D flood modelling has been undertaken and it is possible to evaluate the uncertainties in the model rather than apply a blanket application of 600mm freeboard to manage residual risk. The Rotherwas Industrial Estate is a large and flat site, across which flood water is able to spread out considerably, resulting in extensive flooding to lower depths. Consequently, a 600mm additional increase in flood levels would represent a physically improbable scenarios and an extreme assessment of freeboard.

The greatest uncertainty in the modelling comes from the estimation of the design peak flows and this can be used as a proxy for other model uncertainties. The 1% AEP peak flow at the upstream extent of the River Wye Hereford flood model is 808m^3/s and does not flood Hereford Enterprise Zone. The 1% AEP peak flow is increased by 25% to account for climate change and results in widespread shallow flooding of Hereford Enterprise Zone. The estimated 0.1% AEP peak flow represents a further 28% increase on the 1% AEP plus climate change peak flows.

---

16 https://www.gov.uk/guidance/flood-risk-assessment-standing-advice
17https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/431943/BR_PDF_AD_C_2013.pdf
18 Note3 R&D Technical Report W187 (Kirby and Ash, 2000).

Consequently, the 0.1% AEP flood level is considered a more appropriate measure of residual flood risk than a fix freeboard allowance (such as 300mm or 600mm). This provides a more realistic and physically relatable estimation of uncertainty. It is therefore recommended that 0.1% AEP flood level should be considered as part of the process of establishing recommended FFL for development.

Recommended ground levels and FFL

Ground levels relate to the level applied for the development plot including auxiliary areas, such as car parking. Landscaping areas are not considered within this definition and therefore minimum requirements for ground levels do not apply to these areas. FFL's refer to the floor levels of the plot buildings.

The criteria set out in Section 3.8 should be adhered to in relation to access, egress and emergency response. Consequently, it is recommended that ground levels for access routes are set above the 1% AEP level. Where this is not possible, it is recommended that ground levels should be raised as high as is reasonably practicable. The remaining minimum allowance should be comprised of flood resistant and resilient construction measures. Ground levels have been recommended for each mini-zone to ensure compliance with this recommendation in later sections of this strategy.

Finished floor levels should be a minimum of 150mm above surrounding ground level regardless of flood level to manage surface water flood risk. This measure is to guard against localised surface water flood risk.

It is recognised that the impact of flooding on a site will vary depending on the vulnerability of use and function of the site. Consequently, developers should give consideration to the level of residual flood risk that they are prepared to accept.

Minimum FFL's should be set to the higher of 1% AEP plus climate change level plus 300mm freeboard, or the 0.1% AEP flood level.

If it is not possible achieve the minimum recommended levels developer must provide robust justification for why this is not possible and set out appropriate resistance and resilience measures at will be implemented. This should follow the flood resilience guidance contained in the Herefordshire SFRA.

In some cases the nature of the proposed development may justify a more precautionary approach to flood risk management. An example of a higher vulnerability development includes technology focused manufacturing, high value machinery and data storage facilities that would incur considerable or uninsurable losses in the event of a flood. In such circumstances, consideration should be given to implementing additional freeboard to the 0.1% AEP flood level or the application of flood resistance/resilience measures.

Table 3-5 summaries the recommended approach for plot developers to apply when setting the building FFL. This is applicable across all Hereford Enterprise Zone mini-zones. The 1% AEP plus climate change and 0.1% AEP flood levels for each mini-zone have been provided in their respective section later in the DFMS, to enable the application of this guidance.

Table 3-5 Recommended approach for FFL

Type of development	FFL
Recommended approach to be applied to all forms of development (except in the specific cases listed below)	Set FFL to the higher of: - 1% AEP plus climate change flood level + 300mm - 0.1% AEP flood level Additionally, apply a minimum 150mm freeboard above surrounding ground levels.
For building types particularly vulnerable to flooding as result of the activities, materials or usage.	Apply the recommended approach to setting FFL **And** Consider application of additional freeboard (eg. +600mm)
For building types considered more flood resilient and of lower vulnerability to flood impacts due to activities, materials or usage. **And** Where the recommended minimum freeboard is not feasible.	Provide robust justification for why this is not possible and set out appropriate resistance and resilience measures at will be implemented. Incorporate flood resistance and resilience design methods as set out in 'Improving the Flood Performance of New Buildings (Flood Resilient Construction), CLG (2007)'.

3.9 Flood risk at Hereford Enterprise Zone

Historical flooding

Hereford and the Rotherwas area have a significant history of flooding, with major events occurring in 1960, 1998 and 2000. Historical flood events indicate that flooding in the estate is mainly fluvial and results from the River Wye and other watercourses exceeding capacity and overtopping into the surrounding area.

A summary of the eight largest flood events recorded for the Rotherwas Industrial Estate area are provided in Table 3-6 and show the estimated return periods and comparative levels at Wye Bridge upstream of Rotherwas. These values were calculated for the hydrological assessment and modelling that supported the 2009 DFMS.

The peak levels, peak flows and probabilities of these past flood events has been used to calibrate flood modelling of the Rotherwas Industrial Estate and inform the flood risk recommendations provided in this strategy.

Data has also been provided by the Environment Agency which shows the highest recorded levels in the river (as shown in Table 3-7). Despite unprecedented flooding in February 2020, the Hereford Enterprise Zone did not experience any flooding.

Table 3-6 Summary of historical events

Year	Date	Time to peak	Rank	Estimated flow	Event probability	Level at Wye Bridge
1795	February	Unknown	2	900	1 in 250	52.334
1960	4 December	Unknown	1	958	1 in 400	52.358

Year	Date	Time to peak	Rank	Estimated flow	Event probability	Level at Wye Bridge
1979	28 December	Unknown	4	663	1 in 25	51.650
1998	7 March	19:15	6	625	1 in 18	51.581
1998	28 October	21:45	3	706	1 in 40	52.054
2000	31 October	10:00	5	661	1 in 23	51.630
2002	2 February	23:30	5	661	1 in 23	51.730
2004	5 February	15:30	7	623	1 in 15	51.416

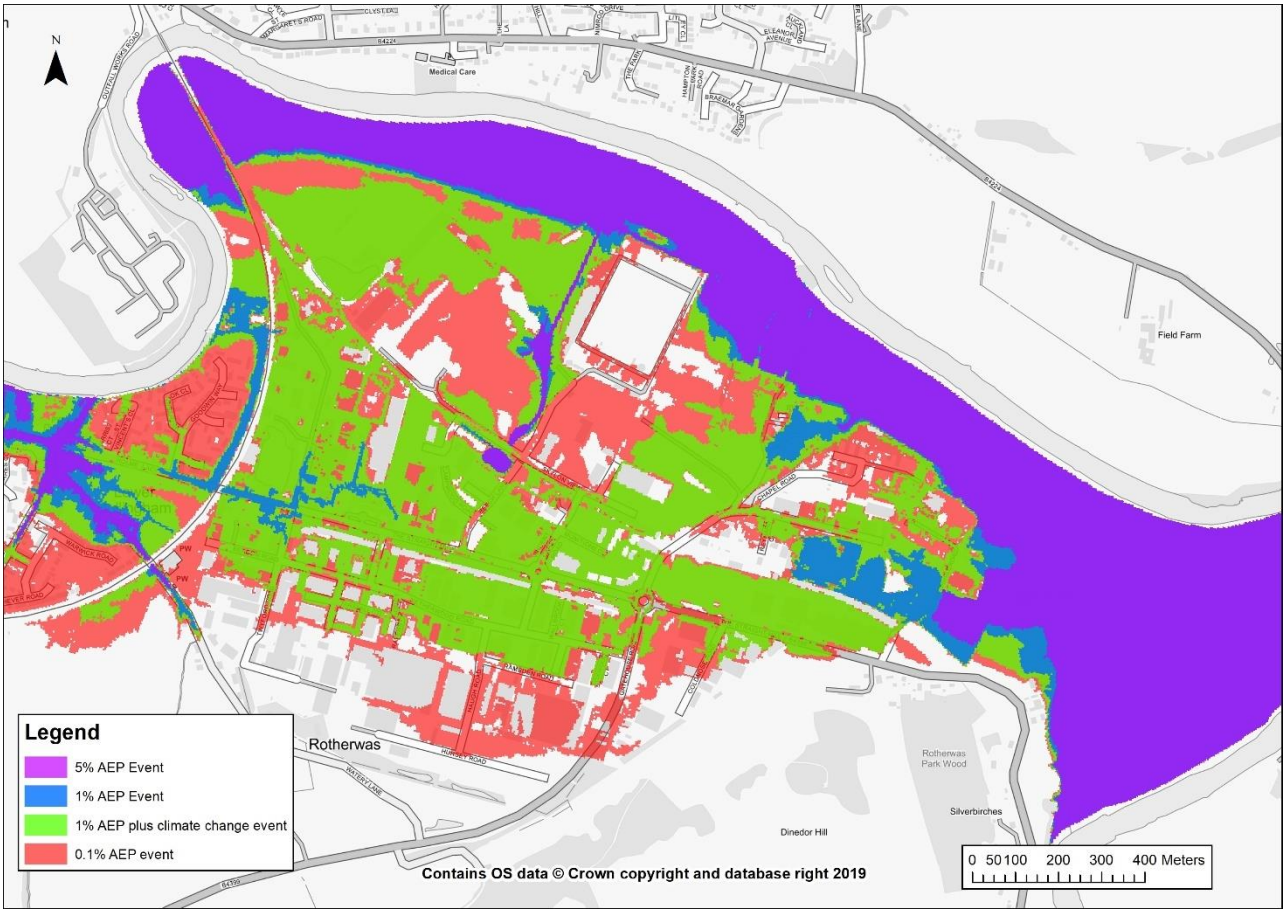
Table 3-7 Large floods at Old Wye Bridge- Data provided by the Environment Agency

Year	Date	Level at Old Wye Bridge (m)
1960	October	5.99
1998	29 October	5.66
2000	31 October	5.24
2002	3 February	5.34
2012	23 December	4.87
2013	25 December	4.88
2014	9 February	4.94
2015	1 December	4.94
2018	14 October	4.86
2019	17 March	4.45
2019	27 October	5.52
2020	1 March	4.74
2020	17 February	6.11

Fluvial flood risk

Hereford Enterprise Zone and the Rotherwas Industrial Estate is mostly flood free during the 5% AEP and the 1% AEP flood event (only experiencing flooding of flood storage ponds). However, the industrial estate experiences widespread flooding from the River Wye during the 1% AEP plus climate change and 0.1% AEP flood event due to its location on the River Wye floodplain. The extent of the modelled flood risk is shown in Figure 3-2.

Figure 3-2 Updated modelled flood outlines



There are two primary routes for fluvial flooding of Hereford Enterprise Zone from the River Wye, as detailed below:

- Holme Lacy Road Bridge – the bridge over Holme Lacy road becomes the main access for the floodwater from the River Wye to flow onto the north section of the estate.
- Network Rail Underpass - the railway embankment presents a barrier to floodwater overflowing the banks of the River Wye and approaching from the west of the estate. The underpass access to the north west of Thorn Business Park also provides an opening for floodwater impounded behind the railway embankment into the north section development sites.

Flood modelling of the Rotherwas Industrial Estate was used to understand the flood mechanisms and inform the recommendations within this DFMS. The flood modelling work undertaken for this study has been based on the 1D-2D linked model of the River Wye that was originally developed by JBA in 2008 for the 2009 strategy. The 1D component is from the EA 1D River Wye model and the 2D domain has been added to cover the Rotherwas Industrial Estate only. In summary the flood model is formed of the following components:

- 2012 EA 1D River Wye calibrated flood model
- 2012 EA inflow hydrology
- 2D TUFLOW component of the 2008 JBA Rotherwas Flood Model
- Latest versions of the flood modelling software (Flood Modeller and TUFLOW)

- 2009 LIDAR for the base DTM supplemented by various topographical surveys for individual posts.
- Schematisation of the 'Present-Day' scenario,
- Schematisation of the 'Future-Development' scenario,

The Hereford Enterprise Zone Modelling Technical Note found in Appendix A provides technical documentation of the flood modelling work undertaken including the model review process and findings, development of the different model scenarios, the flood modelling results, modelling uncertainties and conclusions.

A new baseline model was created for the analysis of present flood risk across the site that includes the operation of the implemented Rotherwas Futures Flood Attenuation Scheme (FAS). A future scenario was then modelled that includes the proposed development parcels to assess the risk to the development areas and assess the effectiveness of proposed mitigation options (such as ground raising and removal or earth bunds).

The flood modelling showed that the development of the remaining mini-zones with the proposed mitigation measures, does not cause unacceptable flood detriment to the existing developed areas. In some areas, the proposed measures cause a reduction in flood risk to existing developed areas.

These mitigation measures have been incorporated into the recommendations for each mini-zone within their respective section later in this strategy document.

The Red Brook, a tributary of the River Wye to the west of the Enterprise Zone, has a history of causing localised flooding to the west of the Rotherwas Industrial Estate, affecting several existing commercial premises. Independent of this strategy Herefordshire Council have been undertaking recent flood risk modelling work for the Red Brook. Although final results were not available for incorporation into the strategy, preliminary results show that the flood risk from the Red Brook would be limited in extent and limited to areas of existing development not of direct interest to the current Enterprise Zone plans. Consequently, the strategy does not specifically consider flood risk from the Red Brook.

Performance of Rotherwas Futures Flood Attenuation Scheme

As detailed in Section 2.3, the Rotherwas Futures FAS was developed in 2013 to provide strategic mitigation for the proposed development of Hereford Enterprise Zone. The mitigation measures included attenuation and infiltration features in addition to flood flow channels designed to effectively convey water through the northern section of the estate and back into the River Wye.

JBA Consulting were commissioned in 2013[19] to assess the implementation of the scheme using updated hydraulic modelling and to review the current status of the scheme in response to the proposed development of Hereford Enterprise Zone. The 2013 review found that the ponds and compensation area were performing well in the 1% AEP plus climate change event and 0.1% AEP event, providing significant attenuation of flood volumes (approximately 59,200m^3).

The review suggested a number of potential options to improve the performance of the scheme regarding the swales and ground levels. These options have been assessed as part of the hydraulic modelling used to inform this DFMS. Where relevant, these flood mitigation measures have been incorporated into the recommendations for each mini-zone, to ensure the continuing effectiveness of the FAS.

Flood storage compensation for the development of Hereford Enterprise Zone has been accommodated via the implemented Rotherwas Futures FAS. Therefore, the impact of ground raising outlined within this DFMS on flood storage availability do not require further flood storage compensation.

19 2013s7237_Rotherwas_Estate_FAS_Review v1 JBA Consulting, August 2013.

Surface water flood risk

The majority of the Hereford Enterprise Zone mini-zones shows a very low risk of flooding from surface water, with some isolated areas of low risk scattered across the site. A significant low spot that causes surface flood water accumulation is noted on Netherwood Road and underneath the railway bridge upon entering the Straight Mile. This has been discussed in detail regarding the surface water management of the respective mini-zone in later sections of the strategy.

Groundwater flood risk

The risk of flooding from groundwater sources at the Rotherwas Industrial Estate is considered to be low. Ground investigations and a programme of groundwater monitoring was undertaken to inform the development of Phase 1 and 2 (Skylon East and Skylon South Magazine mini-zone) in the 2009 DFMS. The monitoring showed that groundwater was between 2.7m and 3.4m from the existing ground level. Further anecdotal evidence from the industrial estate suggested that groundwater could rise to within 1.5m of the existing ground level. These levels were not considered to form a risk of surface flooding as a direct result of groundwater.

4 Surface water management

4.1 Introduction

The development of the remaining areas of Hereford Enterprise Zone will create additional hardstanding, resulting in an increase in runoff rates and volumes and potentially worsening flood risk elsewhere. To mitigate against this risk, Sustainable Drainage Systems (SuDS) will need to be incorporated within the future development, in line with the national and local policy and industry standards.

Herefordshire Council is the Lead Local Flood Authority (LLFA) for the area and responsible for the approval of sustainable drainage proposals through the planning process.

This section provides guidance and summarises requirements for the management of surface water arising from the development of Hereford Enterprise Zone. More detailed direction on drainage strategy requirements for the parcels to be developed within each mini-zone is provided within the respective sections later in the strategy.

For each mini-zone section of this strategy, the 'proposed surface water drainage strategy' sub-section is intended to identify the most appropriate drainage solution for the mini zone as a whole, and not for each of the individual development plots within the respective mini-zone. However, as some of the mini-zones are already partially developed, the drainage requirements have been assessed on a site-by-site basis. Sub-catchments for the proposed development parcels have been defined within the mini-zones and form the basis of the drainage strategy proposals. The drainage sub-catchments incorporate only the future development parcels and do not account for the areas already constructed or being currently under construction.

This strategy does not include a performance assessment of the existing surface water drainage systems within Hereford Enterprise Zone. For the purpose of this study it is assumed that they operate as originally designed and constructed.

4.2 National and local policy and guidance

Section 10 of the National Planning Policy Framework (the NPPF) sets out the expectation that Local Planning Authorities (LPAs), as part of their function of determining planning applications, should avoid flood risk to people and property and should manage any residual risk. Accordingly, the NPPF states that SuDS should be used in development projects and identifies a hierarchy of surface water disposal techniques.

The 2015 CIRIA SuDS Manual forms a basis for all SuDS design. DEFRA published 'Sustainable Drainage Systems: Non-statutory Technical Standards for Sustainable Drainage Systems in March 2015 to ensure a consistent approach to the design and enforcement of SuDS across the country. A Best Practice Guidance Document has been published by the Local Authority SuDS Officer Organisation (LASOO) which provides further interpretation and guidance in relation to the national standards.

Herefordshire's Local Plan Core Strategy (adopted in October 2015) Policy SD3 (Sustainable Water Management and Water Resources) requires development to include appropriate SuDS to manage surface water appropriate to the hydrological setting of the site.

LLFAs and Local Planning Authorities can develop local standards to complement the national guidance and prioritise local needs. As the Lead Local Flood Authority (LLFA), Herefordshire Council have developed a series of SuDS guidance documents that form the primary reference for surface water management requirements in Herefordshire. The key requirements have been set out in two core documents, listed below:

- *The Herefordshire Council Sustainable Drainage Systems (SuDS) Handbook (June 2018).*

  The handbook summarises the standard approaches which should be taken to meet criteria to discharge planning conditions in Herefordshire. The main design criteria are summarised in Section 4.2 of the handbook. The handbook provides guidance on

considerations for implementing different SuDS techniques, including soakaways, permeable paving, pumping stations, storage tanks and tank sewers.

- *Herefordshire Council SuDS Handbook – Arrangements for Maintenance and Adoption SuDS (April 2018).*

  This document provides a summary of potential parties that should assume responsibilities for long term management and maintenance of completed drainage/ SuDS schemes.

Herefordshire Council expects to see SuDS used in all developments as appropriate to the size and nature of development. The Council seeks to promote green SuDS, particularly at larger sites where an exemplar approach to SuDS design is expected. Sufficient space for attenuation features needs to be allocated at the start of the design process.

The recommendations given within this strategy have been developed in accordance with the national and local guidance. Future detailed design of surface water drainage solutions for individual plots should be carried out in line with this strategy and the local and national guidance.

4.3 Peak flow and volume control

Herefordshire Council follows national guidance for peak flow and volume control as outlined in the national standards for sustainable drainage. The design standards recommended are as follows:

- For greenfield sites, the post-development runoff rates to be limited to the existing runoff rates for all events between the 1-year and 100-year rainfall events. The volume of runoff in the 100-year 6-hour rainfall event should never exceed the greenfield runoff volume for the same event.
- For brownfield sites, the post-development runoff rates should be limited as far as practicable to the equivalent greenfield runoff rates for all events between the 1-year and 100-year rainfall events. A minimum of 20% betterment is expected for all return period events. The volume of runoff in the 100-year 6-hour rainfall event should be restricted as far as practicable to the greenfield runoff volume for the same event and should never exceed the runoff volume from the development prior to redevelopment.
- The post-development runoff rates should be calculated using FEH Methods and 2013 rainfall data.

Flow control sizes

The LLFA will promote the use of small orifices where it is considered that a maintenance regime can be practically implemented. For industrial or commercial premises, the discharge rate shall be limited to a minimum of 2 l/s in a 100-year plus climate change storm event, or the calculated greenfield runoff rate, if higher.

If the surface water drainage system is proposed for S104 adoption by Dŵr Cymru Welsh Water (DCWW) or Severn Trent Water, then advice regarding the discharge rate should be sought from the respective water company, as they will be adopting the flow control device. Note that DCWW do not adopt orifice plates but will adopt Hydrobrakes.

Runoff from S38 highway adoptions should be diverted to soakaways, where practical. Where discharge to ditches, watercourses, or existing highway drains has been agreed with Herefordshire Highways, the discharge rate shall be limited to 5 l/s in a 100-year plus climate change rainfall event or the greenfield runoff rate, if higher. Flow controls must be located in an area that can be safely accessed by operatives.

Adoptable systems

In line with the industry standards for adoptable systems, any flows up to the 30-year rainfall event should be accommodated underground (with no surface flooding), unless over ground storage facilities are provided as part of the design to cater for this event. Any flows beyond

the 30-year rainfall event and including the 100-year plus climate change storm event should be managed in a safe manner on site to reduce the risk of flooding to the development and elsewhere.

A dedicated overland flow route should be provided through the development to convey any exceedance flows beyond the 100-year plus climate change event in a safe manner.

4.4 Climate change

Peak rainfall intensities used in urban drainage design should take account of the impact of future climate change, in line with the February 2016 Environment Agency guidance on climate change allowances and the Herefordshire Council's Sustainable Drainage Systems Handbook 2018. The recommended climate change allowances are shown in Table 4-1.

Table 4-1 Peak rainfall intensity allowance in small and urban catchments

Applies across all of England	Total potential anticipated for the '2020s' (2015 to 2039)	Total potential anticipated for the '2050s' (2040 to 2069)	Total potential anticipated for the '2080s' (2070 to 2115)
Upper End projection	10%	20%	40%
Central projection	5%	10%	20%

Planned development of Hereford Enterprise Zone is expected to be designed for a lifespan of 60 - 100 years. Therefore, the '2080s' scenario has been used to determine the climate change allowances that apply in this strategy.

The 2018 Herefordshire Council's Sustainable Drainage Systems Handbook states that the 'Central' scenario should be used for design purposes (20% allowance).

Developers and their designers should also test the performance of their drainage system using the 'Upper End' scenario (40% allowance) to enable the performance of the system and any residual risk of flooding to be understood and managed adequately. It most cases this should be manged through consideration and design of exceedance conditions (eg. surface ponding and overland flow routes).

4.5 Impermeable areas

Detailed site layouts are not available for the mini-zones and therefore the following assumptions have been made in relation to the type of surfaces:

- Buildings – 40% of plot area.
- Car parking and other hardstanding areas – 40% of plot area.
- Soft landscaping – 20% of plot area.

The above assumptions will need to be confirmed by future developers in the design of their surface water management systems.

4.6 Design parameters and software

The greenfield runoff rates provided for each of the mini-zones in this strategy have been calculated using the FEH Method embedded in a web-based tool on www.uksuds.com, based on parameters extracted from the FEH website[20].

A quick storage estimate module within MicroDrainage software package has been used to estimate a range of the required 100-year plus 20% climate change attenuation volumes for the proposed mini-zones.

---

20 Flood Estimation Handbook Web Service https://fehweb.ceh.ac.uk/

Rainfall data used was derived from FEH catchment descriptors extracted from FEH website. Runoff coefficient (Cv) was calculated as 0.73 and 0.78 using the Wallingford procedure (winter and summer accordingly) and applied for all mini-zones.

Site specific parameters are noted in the individual mini-zone sections.

4.7 Long term management

It is currently envisaged that the long-term management and maintenance responsibilities for the strategic drainage components within the mini-zones will lie with Herefordshire Council, whereas the drainage infrastructure within the individual development plots will be the responsibility of the plot owners/occupiers.

4.8 Regulatory consents

Consents from Dŵr Cymru Welsh Water (DCWW) to connect to public sewers will be required under Section 106 of the Water Industry Act 1991. Pre-development enquiries must be submitted to the sewerage undertaker prior to the detailed design stage to confirm the capacity of the public sewerage system and any conditions that may be imposed on the discharges.

Any works to the public sewers (e.g. diversion of sewers, building over them) will require consents from DCWW under section 185 of the Water Industry Act 1991.

Furthermore, appropriate easements to the sewers will be required, where incorporation of buildings and trees will not be permitted.

Any works proposed to ordinary watercourse as part of the developments will require consents under the Land Drainage Act 1991.

Appropriate agreements with relevant landowners should be sought if any works associated with the development are to take place outside the development site boundary on third party land.

4.9 CDM requirements

Under the Construction (Design and Management) Regulations 2015 (CDM 2015) it is the designer's duty to:

- Eliminate foreseeable health and safety risks to anyone affected by the project;
- Take steps to reduce or control any risks that cannot be eliminated;
- Communicate, cooperate and coordinate with the client, other designers and contractors involved in the project so that designs are compatible, and health and safety risks are accounted for during the project and beyond.

The potential significant hazards and risks associated with the construction, operation and maintenance of the proposed drainage systems across the, have been identified during the preparation of this strategy. The findings are summarised in Table 4-2 below and should be applied to the development of drainage strategies for the individual mini-zones.

Table 4-2 Preliminary CDM Design Risk Assessment based on current site conditions

Project element	Hazard	Risk	Control measures
Health and Safety Considerations			
Plant/material delivery	Access to the mini-zones via existing estate roads.	1. Collisions and injury/ damage to people/vehicles 2. Denied access	Access agreements to be reached with relevant third parties for use of existing/ construction of new roads to facilitate the development. Traffic management to be prepared prior to construction activities commencing. Public to be notified of construction activities to take place.
Excavations	1. Services - public and private above-ground and underground– location of all existing services unknown at present. 2.UXO	1. Service strikes/ injury/death, damage to infrastructure 2.Low unexploded bomb risk in the Hereford region in line with www.zetica.com website	1. Detailed utility survey to be carried out prior to construction commencing to confirm the location and details of the existing services and check for any unidentified services. Care to be taken when excavating around existing services to minimise the risk of structural damage. Location of electrical cables to be confirmed using detection equipment before any excavation takes place. 2.Subject to the client's comfort and risk tolerance, works can proceed with no special precautions.
Excavations	1. Varying ground conditions across mini-zones 2. Groundwater conditions - locally shallow perched water 3. Archaeology	1. Falls into excavations/ overturning plant, trench collapse, confined space, injury, damage/ill health; pollution to surface water 2. Inundation 3. High archaeological sensitivity and value area (Skylon North development only)	1. Site specific ground investigation to be undertaken (including testing of geotechnical properties of soils and testing for ground and groundwater contamination, soakaway testing) prior to design and construction work. 2. Long term (seasonal) groundwater monitoring 3. Archaeological watch may be required during construction works.

Project element	Hazard	Risk	Control measures
Construction of outfalls to watercourses/ public surface water sewers	1. Water, working at height 2. No formal access along the whole route of the surface water outfalls laid in third party land (i.e. Skylon South development)	1. Inundation, pollution, falls/ drowning 2. Denied access	1. Work to be carried out during low flow conditions adhering to relevant pollution prevention measures. 2. Access agreements and long-term easements to be reached with relevant third parties prior to works commencing Consents to connect to be obtained prior to works commencing.
Maintenance of drainage systems	Water, working at height/ confined spaces/ inundation	Drowning, injury, suffocation	Maintenance work to be undertaken during low flow conditions in the system. Non-man entry inspection chambers should be used, where possible, to eliminate confined space entry.
Failure of drainage systems due to blockage or capacity exceedance	Water/ backing up flow	Site inundation	Site / building levels to be set appropriately to facilitate safe overland flow and long-term maintenance regime implemented.
General construction activities	1. Construction plant 2. Noise, dust	1. Collision of plant with public, injury 2. Impact on existing site occupiers	1. The site to be secured for the duration of the construction activities and public notified about the construction works. 2. Environmental management plan to be prepared prior to construction activities commencing and adhered to during construction. Working windows to be established.
Environmental Considerations			
Excavations/ topsoil strip, general construction activities	Sediment and other contaminants release	Pollution to water resources, including existing ponds/ swales and the River Wye and its tributaries	Environmental management plan to be prepared prior to construction activities commencing and adhered to during construction.
Maintenance of drainage systems	Sediment and other contaminants release	Pollution to water features and general environment	Any sediments removed from the drainage systems should be treated as contaminated and disposed of in a safe manner
General construction activities	Existing trees	Loss of habitat due to trees and other	Removal of trees should be minimised.

Project element	Hazard	Risk	Control measures
		natural vegetation removal. Increased runoff rates leading to erosion in the receiving watercourses.	Loss of existing trees/ green spaces to be compensated for as part of the development. Development not permitted within the Rotherwas House Green Space Buffer Zone (Skylon North development only).
Culverting of watercourses	Environmental quality reduction	Increased flood risk, impact on hydro-geomorphological conditions	Culverting should be avoided where possible. If no clear span bridges can be accommodated, the culvert base should be buried to sufficient depth below the existing bed level to mimic the existing channel conditions as much a practicable.
Operational stage	Flood risk and surface water / groundwater quality	Adverse impact on water flows and water chemistry in the existing streams	Site specific ground investigations/ hydrological assessments to be undertaken to allow for design of drainage systems to mimic existing conditions as much as practicable.

It should be noted that the above indicate potential significant hazards on and in the vicinity of Hereford Enterprise Zone based on a desk study of available information. This list therefore should not be considered as exhaustive and detailed site/services surveys should be undertaken prior to commencing construction activities.

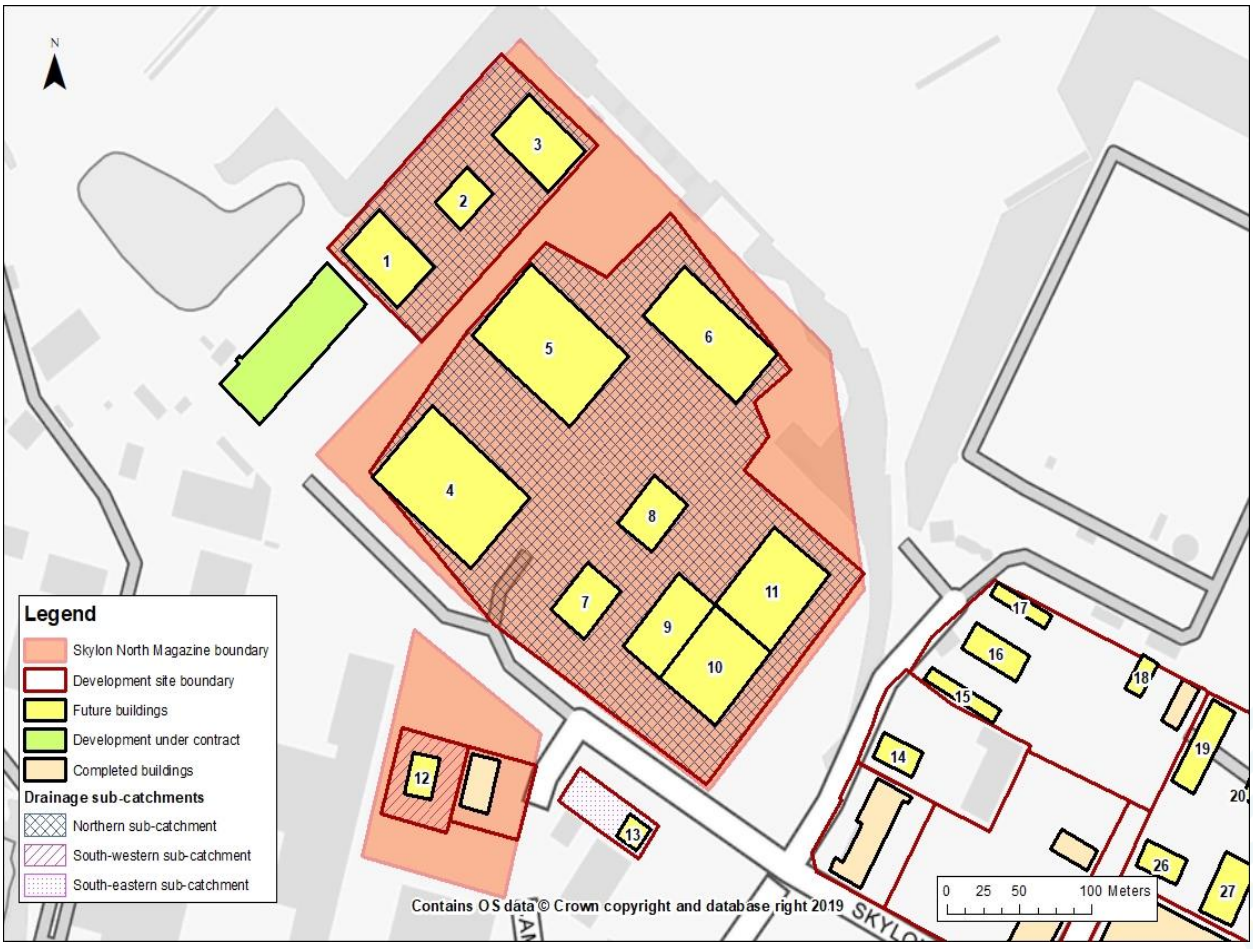
5 Skylon North Magazine development

5.1 Site description

Skylon North-Magazine mini-zone development plots are shown in Figure 5-1. The mini-zone comprises up to 11 future buildings and associated infrastructure within the northern part of the mini-zone (northern sub-catchment), and 2 future buildings and 1 completed building within the southern part of the mini-zone (south-western and south-eastern sub-catchments). The northern and southern sub-catchments are divided by Skylon View road.

Figure 5-1 reflects the likely indicative layout for Skylon North Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein. However, due regard must be given to ensuring that the additional flood mitigation measures outlined in Section 5.5 can be adequately implemented under an alternative layout.

Figure 5-1 Skylon North Magazine development and building numbers



All sub-catchments are largely greenfield (with minor areas of concrete surface located in the south-western part of the northern sub-catchment) and are relatively flat.

Based on the information contained in the topographical survey carried out for the area by Total Surveys Ltd in May 2018, the ground levels vary between 49.53mAOD and 51.15mAOD in the northern sub-catchment and between 49.16mAOD and 50.47mAOD in the south-western sub-catchment. The levels within the south-eastern sub-catchment are in the region of

50.50mAOD. This does not account for local earth bunds present in the northern sub-catchment which vary in height and extent.

5.2 Geology and hydrogeology

Site specific ground investigation was undertaken within the Skylon North Magazine site by Geotechnics Limited in 2013. The Geotechnics' report provides a detailed geology record from boreholes across the site and incorporates groundwater monitoring results from four site visits.

The site is overlain by Made Ground, underlain by Superficial Deposits and Raglan Mudstone Formation. The maximum recorded groundwater levels measured between December 2012 and January 2013 were between 1.13m and 2.15m bgl.

However, the monitoring did not include a long-term assessment of seasonal variability or hydro-geological correlation to levels in the River Wye. Soil infiltration testing was not carried out as part of the investigation. Further information is included in Table 2-1 of this report. No significant contamination was encountered at the site during the investigation.

Historic soil infiltration tests carried out for the GB Electrical Ltd development in May 2016 located to the east of Skylon North Magazine site showed infiltration rate as 10^{-5}m/s which is considered as medium permeability. Although no groundwater was encountered within the trial holes at the time, the site is located in the River Wye floodplain with the potential for significant ground water level fluctuations in winter and during periods of heavy rainfall.

5.3 Existing drainage conditions

The northern sub-catchment is bounded to the west by the Rotherwas Futures FAS pond and the Shell Store building, to the north by the River Wye floodplain and to the east by the Rotherwas Futures FAS conveyance swale and two soakaway ponds. The northern sub-catchment currently drains by a combination of infiltration to the ground and overland flow to the River Wye floodplain.

The south-western and south-eastern sub-catchments are bounded to the north by a conveyance swale from the Rotherwas Futures FAS scheme and currently drain by a combination of infiltration to the ground and overland flow in the direction of the conveyance swale, located along their northern boundary.

An approximately 1.3m deep triangular basin is located in the north-western corner of the south-western sub-catchment area. It is understood that this basin was strategically designed to serve the whole area of the south-western sub-catchment, including the proposed building.

Based on the information provided on topographic survey drawing BA26500418_01 by Bury Associates Ltd, dated April 2018 approximately 1.70m deep storage basin, associated with the existing flood mitigation measures, is located immediately to the south-east of the south-eastern sub-catchment.

5.4 Fluvial flood risk

The flood risk at North Magazine mini-zone is summarised in Table 5-1 below. The mini-zone experiences flooding in the 1% AEP plus climate change event to a depth of 1.10m and depths of up to 1.4m in the 0.1% AEP event at the locations of proposed development plots.

Table 5-1 North magazine flood risk summary

Flood risk	Northern sub-catchment	Southern sub-catchment
Flood Zone	FZ2 Building 6 and 11 partially located in FZ3	FZ2
Existing site levels	49.53mAOD to 51.15mAOD	49.16mAOD to 50.47mAOD
1% AEP plus climate change flood level	50.23mAOD	50.59mAOD
0.1% AEP flood level	50.78mAOD	50.87mAOD

The flood levels detailed above have been extracted from the updated flood modelling work undertaken for this study using the 'Present Day' model scenario.

5.5 Proposed flood mitigation

Flood mitigation measures are proposed in the sections below, designed to enable safe development of the plots for the lifetime of the property and in accordance with the requirements of local and national flood risk policy.

Site levels and FFL

It is recommended that ground levels are raised to the levels outlined in Table 5-2 and Figure 5-2 below. Ground levels relate to the entire development plot and include auxiliary areas such as car parking and emergency access/egress routes. Landscaping areas not required for emergency access/egress have no minimum requirements for ground levels.

FFL's for buildings should be set with a freeboard allowance as recommended in 3.8, with reference to either the 1% AEP plus climate change flood level or 0.1% AEP flood levels provided in Table 5-2.

The flood modelling work has assumed an average level for the main north magazine site that contains building footprints 4-11, the level chosen allows for the site elevations to tie in with the constructed Skylon View Road access road and ensures the site is flood free in the 1% plus climate change AEP event. The ground raising applied to building plots 1-3 in the north-west of the mini-zone has been set to ensure an acceptable flood depth of no greater than 300mm for car parking areas within the 1% plus climate change AEP event.

Hydraulic modelling was carried out to identify the ground levels recommended in Table 5-2 and confirm that the proposals do not cause detrimental impacts on flood mechanisms across Hereford Enterprise Zone. The results of the hydraulic modelling are provided in the Hereford Enterprise Zone Modelling Technical Note located in Appendix A.

Table 5-2 North magazine site levels for flood mitigation

Flood risk	Northern sub-catchment	South-western sub-catchment	South-eastern sub-catchment
Ground level for development	Buildings 1-3: Average ground level set to 50mAOD Buildings 4-11: 50.5mAOD average ground level across site.	Surrounding ground levels to remain as current. Groundworks undertaken during previous construction works.	Surrounding ground levels to remain as current. Groundworks undertaken during previous construction works.
Reference flood level for development			
Flood Level in 1% AEP plus climate change	Buildings 1-3: 50.23mAOD Buildings 4-11: 50.45mAOD*	Building 12: 50.60mAOD	Building 13: 50.58mAOD
Flood Level in 0.1% AEP	Buildings 1-3: 50.54mAOD Buildings 4-11: 50.78mAOD	Building 12: 50.87mAOD	Building 13: 50.85mAOD

* Buildings 4-11 are flood free in the 1% AEP plus climate change event, flood level shown above has been taken from site surroundings.

Figure 5-2 North Magazine ground levelling area

Additional flood mitigation measures

Specific requirements for flood management within the mini-zone are listed below:

- The northern sub-catchment currently contains several large temporary stockpiles. The safe flood management of the site requires removal of these stockpiles.
- The Fir Tree Swale that runs along the eastern boundary of the North Magazine mini-zone must be maintained, as this acts as an important flood management asset.

Safe access and egress

Herefordshire 2019 SFRA requires that the site maintains safe access and egress during a flood event, and that residual flood risk is safely managed, meeting the requirements specified in 3.7.

Table 5-3 below provides information on the access and egress for North Magazine mini-zone based on the outcome of flood modelling (as reported in Appendix A). The modelling results show that shallow flooding (up to 0.37m) and 'moderate' flood hazard occurs on the access and egress route during the 1% AEP plus climate change event. Flood hazard is classified as 'high' during the 0.1% AEP event, as a result of the maximum flood depth of 0.55m on Vincent Carey Road and a peak velocity of 1.9m/s on the Straight Mile roundabout.

Table 5-3 Flood risk for North Magazine access and egress

	Access and egress information
Primary access/egress route	The primary access route for the North Magazine mini-zone is through the new Skylon View access road. Access then feeds onto Vincent Carey Rd and on to the Straight Mile before leaving Rotherwas Industrial Estate.
Peak flood depth (on access route): 1% AEP plus climate change	Skylon View access road: 0.22m Vincent Carey road: 0.37m The Straight Mile: 0.34m
Flood hazard: 1% AEP plus climate change	Flood hazard along the access/egress route ranges between 0 and 1.23 and is therefore contained within the 'low' to 'moderate' hazard rating and classed as acceptable.
Flood hazard: 0.1% AEP	Flood hazard along the access/egress route extends to the 'high' category with a peak hazard classification value of 1.62. Further flood mitigation measures necessary.

The flood hazard rating on the primary access route for North Magazine mini-zone exceeds the guidance provided in the Herefordshire 2019 SFRA and consequently it is recommended that further mitigation measures are considered to ensure safe access and egress from the North Magazine mini-zone.

Recommended measures include:

- Sign up to EA flood alerts.
- Development of a Site-Specific Emergency Response Plan.
- A Site-Specific Emergency Evacuation Procedure. It is recommended that this is developed in consultation with the emergency planning department of Herefordshire Council.
- No overnight working during flood warnings, dissemination of flood information and testing flood evacuation procedures.
- Provision of areas where the floor level is above the 0.1% AEP event to provide a safe/dry zone for employees on site.

- Suitable emergency and welfare facilities on site in the event of prolonged flooding.

5.6 Surface water drainage strategy

Drainage scheme

Considering the permeability of soils within the area, discharge of surface water to the ground via infiltration could be viable. However, the geological investigation completed in 2013 by Geotechnics Limited showed relatively high groundwater levels that could impede drainage by infiltration to the ground.

The Geotechnics report should be reviewed in full and a site-specific long-term groundwater monitoring and infiltration testing completed to confirm the suitability of infiltration at specific locations across the site. If this shows that infiltration techniques are not suitable, the following should be considered:

Northern sub-catchment:

- Discharge to the existing Rotherwas Futures FAS pond to the west of the site. Discharge the unattenuated runoff into the FAS pond via a conveyance system[21].
- If connection to the FAS pond proves difficult to achieve, the sub-catchment could be split, and the eastern part of the area drained to either the ponds or the conveyance swale located to the east of the development. On-site attenuation may be required prior to any off-site connections if existing FAS features do not provide adequate storage capacity.

South-western sub-catchment:

- Discharge of unattenuated runoff into the existing triangular basin within the north-western corner via a conveyance system. The basin has been size and constructed by others to accommodate surface water runoff from Building 12.
- To account for exceedance overflow, a dedicated overland flow route from the basin to the FAS conveyance swale should be created/maintained by locally modifying the existing ground levels in the area.

South-eastern sub-catchment:

- Discharge the unattenuated runoff into the existing Rotherwas Futures FAS basin located to the south-east of the sub-catchment via a conveyance system.

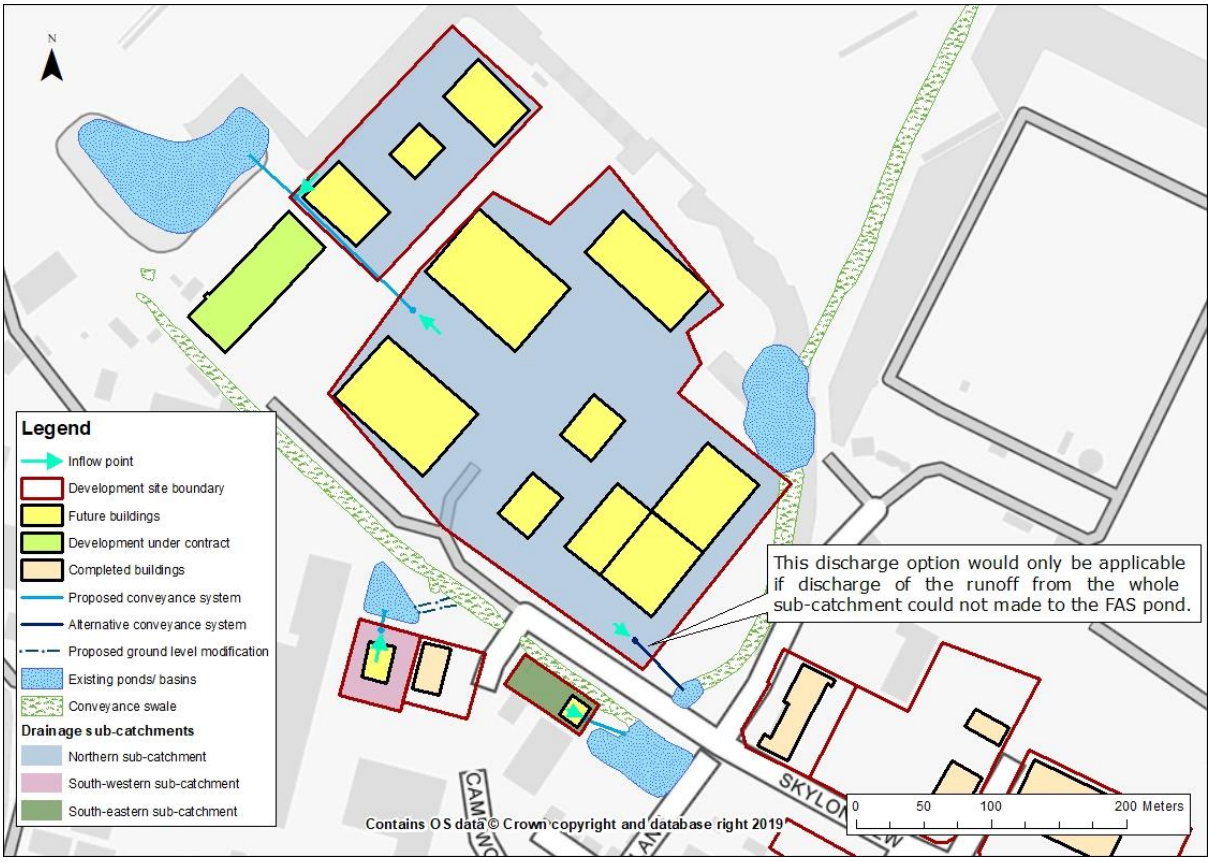
New surface water attenuation should be accommodated in an above ground facility unless technical/ spatial constraints preclude it.

To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. Additional measures, such as bioretention areas, swales and filter trenches should also be implemented. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

A conceptual proposal is shown in Figure 5-3.

[21] Hereford Enterprise Zone Flood Storage Pond Technical Note, JBA Consulting, September 2019

Figure 5-3 Proposed drainage scheme for North Magazine mini-zone



Discharge rates

If infiltration to ground is adopted as the main runoff disposal technique from the site, the discharge rates will be dictated by the permeability of the ground.

For discharges to surface water features, the greenfield runoff rates have been calculated for each sub-catchment as shown in Table 5-4. These calculations are provided for information only, as it is generally by the strategy that surface water will be discharge at an unattenuated rate to the existing strategic attenuation features.

Table 5-4 Skylon North Magazine greenfield runoff rates

	Development site area (ha)	Calculated Qbar (l/s)	Minimum discharge rate (l/s)
Northern sub-catchment	8.44	9.1	9.1
South-western sub-catchment	0.27	0.29	2
South-eastern sub-catchment	0.18	0.19	2

Attenuation requirements

The following site-specific parameters have been used in the calculation of attenuation requirements:

- Impermeable area – assumed 80% of total area.
- Infiltration rate – the lowest infiltration rate derived within Shell Store development.

The attenuation requirements for the northern and southern sub-catchments are given in Table 5-5 below. These calculations are provided for information only, as it is generally by the strategy that surface water will be discharge at an unattenuated rate to the existing strategic attenuation features.

Table 5-5 Attenuation volume for Skylon North Magazine mini-zone

	Impermeable area (ha)	Infiltration rate (m/s)	Attenuation volume required (based on infiltration) (m^3)	Attenuation volume required (no infiltration) (m^3)
Northern sub-catchment	6.75	$7.2x10^{-6}$	1858 - 4791	4763 - 6362
South-western sub-catchment	0.22	$7.2x10^{-6}$	61 - 156	84 - 122
South-eastern sub-catchment	0.15	$7.2x10^{-6}$	41 - 106	51 - 73

The SuDS calculations for North Magazine mini-zone are provided in Appendix B.

6 Skylon North

6.1 Site description

Skylon North mini-zone development plots are shown in Figure 6-1. The mini-zone is currently occupied by GB Electrical Ltd, Western Power Distribution and Woodstock Trading developments.

The development proposal for Skylon North mini-zone comprises up to 5 future buildings, 1 completed building within the western part of the site (western sub-catchment), 10 future buildings and associated infrastructure within the north-eastern part of the site (north-eastern sub-catchment) and 1 future building within the south-eastern part of the site (south-eastern sub-catchment).

The Woodstock Trading development is a phased development, only Phase 1 has been constructed to date. Figure 6-1 reflects the likely indicative layout for Skylon North Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein.

Part of the site falls within an area of high archaeological sensitivity and value.

Figure 6-1 Skylon North development and building numbers

6.2 Geology and hydrogeology

Historic soil infiltration tests carried out for the GB Electrical Ltd development in May 2016 located to the south-western corner of the Skylon North site showed infiltration rate as 10-5m/s which is considered as medium permeability. Although no groundwater was encountered

within the trial holes at the time, the site is located in the River Wye floodplain with the potential for significant ground water level fluctuations in winter and during periods of heavy rainfall.

6.3 Existing drainage

The surface water runoff from GB Electrical Ltd development is conveyed via a combination of a swale and porous paving into a soakaway pond within the rear service yard area[22].

The surface water runoff from the Woodstock Trading site is conveyed via surface water drains into an infiltration basin located in the south eastern corner of the site. There is an overflow pipe connecting to the local surface water sewer, facilitating safe passage of flow in case of capacity exceedance from the infiltration basin[23].

The surface water runoff from the Western Power Distribution development is conveyed via a combination of surface water drains, drainage channel and porous paving into two soakaway tanks located within the car park[24].

There is an existing pond located in the north-eastern corner of the Skylon North. It is understood that the pond area falls within the Rotherwas House Green Space Buffer Zone.

6.4 Fluvial flood risk

The flood risk at Skylon North mini-zone is summarised in Table 6-1 below. The western sub-catchment comprises of a single standalone proposed development at plot 14 and four proposed development plots within the 'Beyond Storage' site. The north-eastern sub-catchment encompasses the proposed development known as Woodstock North, this comprises of buildings 19-28. The south-eastern sub-catchment has a single proposed development site, building 29. The mini-zone experiences flooding with flood depths up to 0.8m in the 1% AEP plus climate change event with depths up to 1.15m in the 0.1% AEP event at the locations of proposed development.

Table 6-1 Skylon North flood risk summary

Flood risk	Western sub-catchment	North-Eastern sub-catchment	South-Eastern sub-catchment
Flood Zone	FZ3	FZ3	FZ3
Existing site levels	48.67mAOD to 50.17mAOD	48.45mAOD to 49.62mAOD (not including pond depression)	49mAOD*
1% AEP plus climate change flood level	Flood free	49.29mAOD	49.29mAOD
0.1% AEP flood level	50.30mAOD	49.65mAOD	49.65mAOD

* Note: Assumed natural level, due to temporary ground depression currently on the site.

The flood levels detailed above have been extracted from the updated flood modelling work undertaken for this study using the 'Present Day' model scenario.

22 GB Electrical Development, SUDS Management Strategy, Application No. 151853, December 2015, Nolan Associates
23 Woodstock Site Plan, Drawing No. SA004, 01/10/15, Collins Design and Build Ltd
24 Western Power Distribution Plan, Drawing 'WPD Levels'

6.5 Proposed flood mitigation

Flood mitigation measures are proposed in the sections below, designed to enable safe development of the plots for the lifetime of the property and in accordance with the requirements of local and national flood risk policy.

Site levels and FFL

It is recommended that ground levels are raised to the levels outlined in Table 6-2 below. Ground levels relate to the entire development plot and include auxiliary areas such as car parking and emergency access/egress routes. Landscaping areas not required for emergency access/egress have no minimum requirements for ground levels.

FFL's for buildings should be set with a freeboard allowance as recommended in 3.8, with reference to either the 1% AEP plus climate change flood level or 0.1% AEP flood levels provided in Table 6-2 below.

The majority of the 'Beyond Storage' site has received ground raising works at a previous stage, for the purpose of the flood modelling work a ground level of 49.85mAOD has been assumed for the western section of development to tie in with surrounding ground level to the east. For the Woodstock site, the ground levels have been set to an average level of 49.5mAOD. This level has been chosen to align with elevations provided on Hereford's planning portal for the constructed Woodstock Trading Warehouse. The location of the modelled ground levelling/raising is shown in Figure 6-2.

Hydraulic modelling was carried out to identify the ground levels recommended in Table 6-2 and confirm that the proposals do not cause detrimental impacts on flood mechanisms across Hereford Enterprise Zone Enterprise Zone. The results of the hydraulic modelling are provided in the Hereford Enterprise Zone Modelling Technical Note located in Appendix A).

Table 6-2 Skylon North site levels for flood mitigation

Flood risk	Western sub-catchment	North-eastern sub-catchment	South-eastern sub-catchment
Ground level for development	Building 14: Set average ground level to 49.6mAOD. Building 15-18: Set average ground level to 49.85mAOD	Building 19-28: Set average ground level to 49.5mAOD.	Building 29: Set average ground level to 49.5mAOD
Reference floor level for development			
Flood Level in 1% AEP plus climate change	Building 14: 50.0mAOD* Building 15-18: 50.0mAOD*	Building 19: 49.52mAOD Building 20-28: 49.54mAOD	Building 29: 49.55mAOD
Flood Level in 0.1% AEP	Building 14: 50.31mAOD Building 15-18: 50.30mAOD	Building 19: 50.27mAOD Building 20-28: 49.80mAOD	Building 29: 49.80mAOD

* Buildings 14 -18 are flood free in the 1% plus climate change event, flood level shown above has been taken from site surroundings.

Figure 6-2 Skylon North ground raising

Safe access and egress

Herefordshire 2019 SFRA requires that the site maintains safe access and egress during a flood event, and that residual flood risk is safely managed, meeting the requirements specified in 3.7.

Table 6-3 below provides information on the access and egress for Skylon North mini-zone based on the outcome of flood modelling (as provided in Appendix A). The modelling results show that shallow flooding (up to 0.37m) and 'moderate' flood hazard occurs during the 1% AEP plus climate change event on the access and egress route. Flood hazard is classified as 'high' during the 0.1% AEP event as a result of the maximum flood depth of 0.55m on Vincent Carey road and peak velocity of 1.9m/s on the Straight mile roundabout.

Table 6-3 Flood risk for Skylon North access and egress

	Access and egress information
Primary access/egress route	For the Skylon North mini-zone there are two primary access routes that both feed onto the new Skylon View access road. Depending on the development, access will be either via Fir Tree Lane or the Woodstock access road. Access then feeds onto Vincent Carey Rd and the Straight Mile before leaving Rotherwas Industrial Estate.
Peak flood depth (on access route): 1% AEP plus climate change	Fir Tree Lane: Flood Free Skylon View access road: 0.09m Vincent Carey road: 0.37m The Straight Mile: 0.34m

Flood hazard: 1% AEP plus climate change	Flood hazard along the access/egress route ranges between 0 and 1.23 and is therefore contained within the 'low' to 'moderate' hazard rating and classed as acceptable.
Flood hazard: 0.1% AEP	Flood hazard along the access/egress route extends to the 'high' category with a peak hazard classification value of 1.62. Further mitigation measures required.

The flood hazard rating on the primary access route for Skylon North mini-zone exceeds the guidance provided in the Herefordshire 2019 SFRA and consequently it is recommended that further mitigation measures are considered to ensure safe access and egress from the Skylon North mini-zone.

Recommended measures include:

- Sign up to EA flood alerts.
- Development of a Site-Specific Emergency Response Plan.
- A Site-Specific Emergency Evacuation Procedure. It is recommended that this is developed in consultation with the emergency planning department of Herefordshire Council.
- No overnight working during flood warnings, dissemination of flood information and testing flood evacuation procedures.
- Provision of areas where the floor level is above the 0.1% AEP event to provide a safe/dry zone for employees on site.
- Suitable emergency and welfare facilities on site in the event of prolonged flooding.

6.6 Surface water drainage strategy

Drainage scheme

No site-specific ground investigation results are available for this site. However, considering the likelihood of the permeability within the area, discharge of surface water to the ground via infiltration could be viable at this location. However, the potential for high groundwater levels that could preclude infiltration techniques would need to be assessed in more detail prior to designing an infiltration-based system.

If a site-specific ground investigation and long-term groundwater monitoring show that infiltration techniques are not suitable at this location, the following should be considered.

The drainage options for the north-eastern and south-eastern sub-catchments have been based on the proposed site layout plan entitled 'Proposed development at land north of Woodstock Trading, Rotherwas Ind. Est.'[25], which shows two proposed storage ponds.

Western sub-catchment (options based on potential phasing of the development parcels):

- Option 1 - Discharge the attenuated flow into the proposed pond located to the north-east of the south-eastern sub-catchment. Attenuation storage will need to be provided within the sub-catchment prior to connection to the pond. The flow control at the downstream end of the pond will need to account for the additional drained catchment.
- Option 2 - Discharge the attenuated flow directly to the public surface water sewer located within Chapel Road – subject to DCWW approval. Attenuation storage will need to be provided within the sub-catchment prior to making the connection.

[25] 'Proposed development at land north of Woodstock Trading, Rotherwas Ind. Est.', Drawing no. 'EZ-002-d' dated 03/05/19 by Collins

North-eastern sub-catchment:

- Discharge of the unattenuated runoff into the proposed pond located in the north-eastern corner of the sub-catchment, which will provide the required attenuation storage. The pond would discharge to the public surface water sewer located within Chapel Road – subject to DCWW approval. A safe overland flow route will need to be provided to cater for exceedance flows from the pond.

South-eastern sub-catchment:

- Discharge of the unattenuated runoff into the proposed pond located in the north-east of the sub-catchment. The pond would discharge to the public surface water sewer located within Chapel Road – subject to DCWW approval. A safe overland flow route will need to be provided to cater for exceedance flows from the pond.

The surface water attenuation should be accommodated in above-ground facilities unless technical/spatial constraints preclude it.

To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. Additional measures, such as bioretention areas, swales and filter trenches should also be implemented. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

The conceptual proposal is shown in Figure 6-3 below.

Figure 6-3 Proposed drainage scheme for North mini-zone

Discharge rates

If infiltration to ground is adopted as the main runoff disposal technique from the site, the discharge rates will be dictated by the permeability of the ground.

For discharges to surface water features, the greenfield runoff rates have been calculated for each sub-catchment as shown in Table 6-4. If practical, the discharges of north-eastern sub-catchment and south-eastern sub-catchment should be combined to achieve a combined Qbar based minimum greenfield discharge rate that is not constrained by the minimum practical discharge rate of 2l/s.

Table 6-4 Skylon North greenfield runoff rates

	Development site area (ha)	Calculated Qbar (l/s)	Minimum discharge rate (l/s)
Western sub-catchment	2.22	2.39	2.40
North-eastern sub-catchment	3.28	3.53	3.50
South-eastern sub-catchment	0.62	0.67	2.00

Attenuation requirements

The following site-specific parameters have been used in the calculation of attenuation requirements:

- Impermeable area:
- For the north-eastern sub-catchment using the site layout 'Proposed development at land north of Woodstock Trading, Rotherwas Ind. Est.', drawing no. 'EZ-002-d' dated 03/05/19 by Collins.
- Assumed 80% of the area for the other sub-catchments.
- Infiltration rate – the lowest infiltration rate derived within GB Electrical Ltd development.

The attenuation requirements for the sub-catchments are given in Table 6-5.

Table 6-5 Attenuation volume for Skylon North mini-zone

	Impermeable area (ha)	Infiltration rate (m/s)	Attenuation volume required (based on infiltration) (m^3)	Attenuation volume required (no infiltration) (m^3)
Western sub-catchment	1.78	$1.0x10^{-5}$	451 - 1166	1256 - 1678
North-eastern sub-catchment	2.71	$1.0x10^{-5}$	686 - 1775	1936 - 2581
South-eastern sub-catchment	0.50	$1.0x10^{-5}$	127 - 327	244 - 365

The SuDS calculations for Skylon North mini-zone are provided in Appendix C.

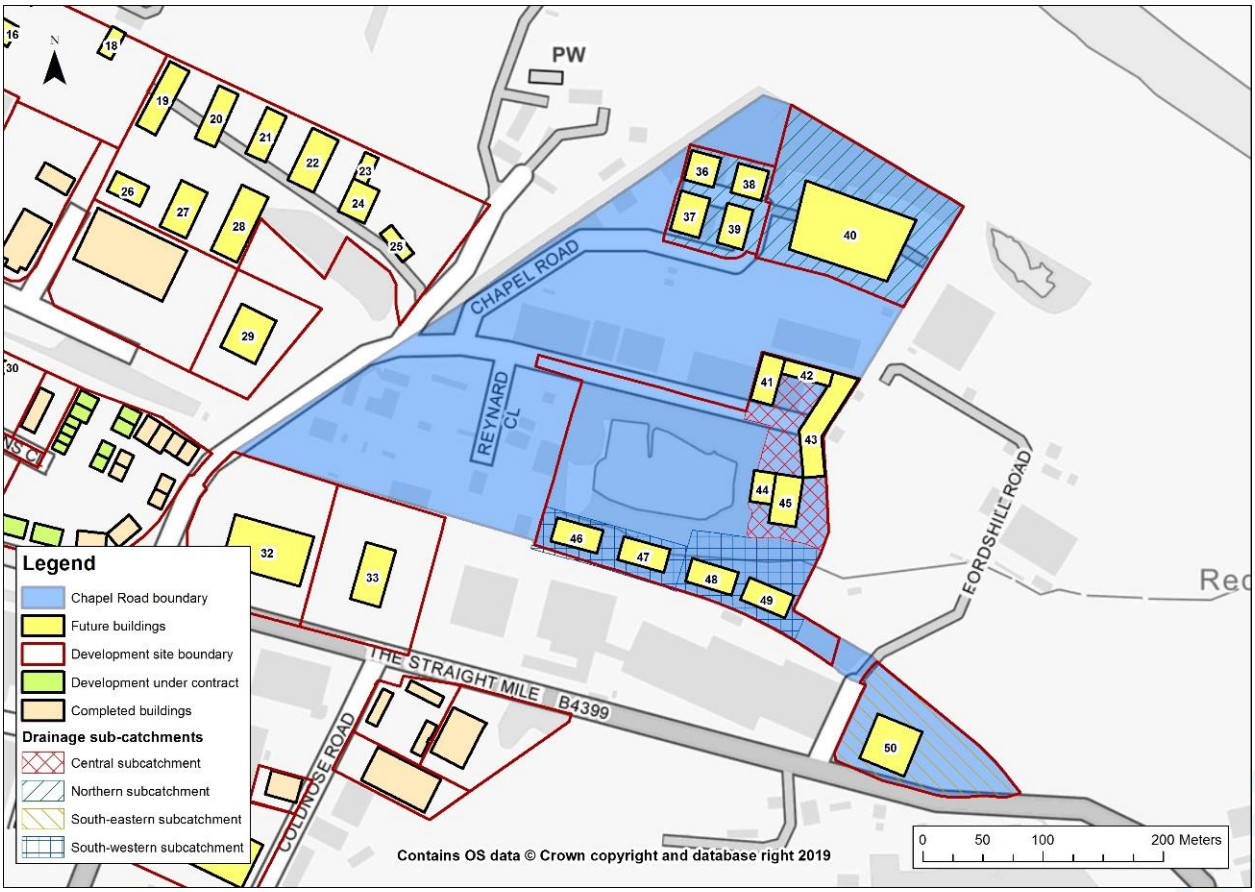
7 Chapel Road

7.1 Site description

The development proposal for Chapel Road mini-zone comprises up to 5 future buildings within the northern sub-catchment, 5 future buildings within the central sub-catchment, 4 future buildings within the south-western sub-catchment and 1 future building within the south-eastern sub-catchment, as shown in Figure 7-1.

Figure 7-1 reflects the likely indicative layout for Skylon North Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein.

Figure 7-1 Chapel Road mini-zone development and building numbers



The Chapel Road development site is currently brownfield land, occupied by a variety of developments. Site-specific topographical survey of the area was not available to support this study. However, the publicly available LiDAR data suggests that ground levels within the site vary between 46.60mAOD and 56.05mAOD. The ground generally falls in a north-easterly direction in the northern part of the site, whereas the southern part falls in a south-easterly direction.

7.2 Existing geology and hydrogeology

No site-specific ground investigation was undertaken within the Chapel Road development to date.

The nearest historic borehole information available from the British Geological Survey (BGS) website is dated 1973 and located approximately 50m west of the south-western corner of the mini-zone (BGS reference: SO53NW41). The ground strata are described as follows:

- Topsoil – fill, ash gravel – 0.60m
- Firm gravelly clay – thickness 0.3m
- Silty clayey gravel – thickness 0.9m
- Grit, sand, gravel, loose granular deposit material round to sub-round. Material becomes coarser with depth with very few fines mainly grey in colour. Cobbles with occasional boulders. Between 1.83m and 5.14m bgl
- Red/Brown orange mudstone between 5.14m and 7.92m becoming stiffer with depth.

Slight groundwater seepages were encountered at approximatively 2mbgl.

7.3 Existing drainage conditions

The area is mainly brownfield land, limited information is available about the site-specific drainage systems for the existing parcels.

An existing pond is located in the centre of the southern part of the mini-zone, however the designation of the pond is unknown. The OS mapping shows the Red Brook originating within the southern part of the mini-zone and running in an easterly direction towards the River Wye. It is currently unknown if connectivity between the pond and the Red Brook exists.

A Dwr Cymru Welsh Water (DCWW) surface water sewer is located in Chapel Road and discharges into the River Wye.

7.4 Fluvial flood risk

The flood risk at Chapel Road mini-zone is summarised in Table 7-1 below. The northern sub-catchment contains the proposed building footprints 36-40. The central sub-catchment contains building footprints 41-45. The south-western sub-catchment contains the proposed building footprints 46-49 and the south-western sub-catchment contains a single standalone development, building 50. The mini-zone currently experiences flooding in the 1% AEP plus climate change up to a depth of 1.38m at a location where development is proposed. Flood depths increase up to 1.75m in the 0.1% AEP event.

Table 7-1 Chapel Road flood risk summary

Flood risk	Northern sub-catchment	Central sub-catchment	South-eastern sub-catchment	South-western sub-catchment
Flood Zone	FZ2	FZ3	FZ2	FZ2
Existing site levels	48.86mAOD to 49.92mAOD.	48.41mAOD to 49.80mAOD.	48.41mAOD to 49.80mAOD.	47.50mAOD to 51.97mAOD.
1% AEP plus climate change flood level	49.20mAOD	49.06mAOD	Flood Free	49.51mAOD
0.1% AEP flood level	49.60mAOD	49.38mAOD	49.75mAOD	49.84mAOD

The flood levels detailed above have been extracted from the updated flood modelling work undertaken for this study using the 'Present Day' model scenario.

7.5 Proposed flood mitigation

Flood mitigation measures are proposed in the sections below, designed to enable safe development of the plots for the lifetime of the property and in accordance with the requirements of local and national flood risk policy.

Site levels and FFL

It is recommended that ground levels are raised to the levels outlined in Table 7-2. Ground levels relate to the entire development plot and include auxiliary areas such as car parking and emergency access/egress routes. Landscaping areas not required for emergency access/egress have no minimum requirements for ground levels.

FFL's for buildings should be set with a freeboard allowance as recommended in 3.8, with reference to either the 1% AEP plus climate change flood level or 0.1% AEP flood levels provided in Table 7-2 below.

The location of required ground levels across the Chapel Road mini-zone are shown in Figure 7-2. The proposed buildings 46-49 currently reside on a raised embankment which will require lowering, the flood modelling work undertaken indicates that a level of 49mAOD is required in order to ensure ground elevations are acceptable for flooding of car parking areas. For buildings 41-45, surrounding ground elevations have been set to 48.85mAOD to ensure ground elevations are acceptable for flooding of car parking areas. All of the other buildings within the Chapel Rd mini-zone can utilise existing ground levels.

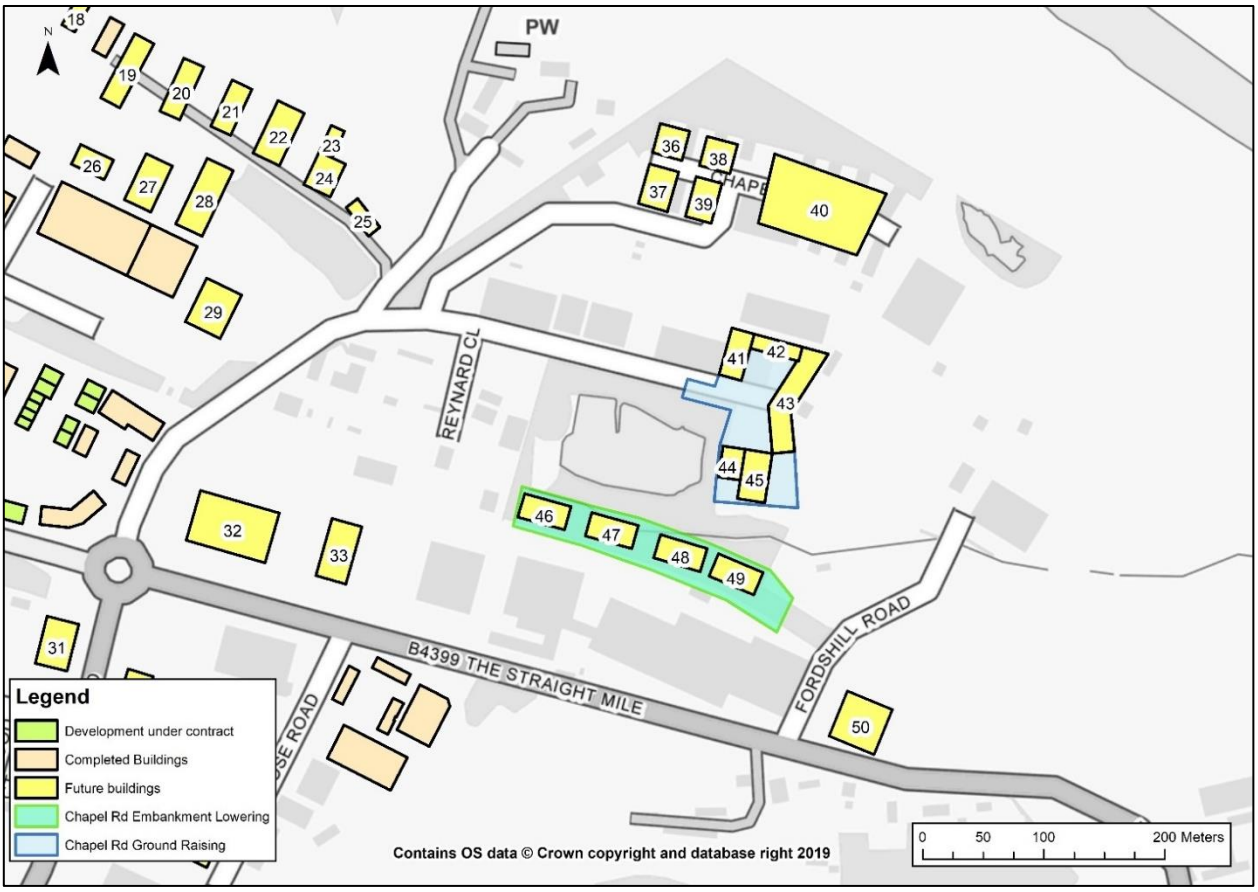
Hydraulic modelling was carried out to identify the ground levels recommended in Table 7-2 and confirm that the proposals do not cause detrimental impacts on flood mechanisms across Hereford Enterprise Zone. The results of the hydraulic modelling are provided in the Hereford Enterprise Zone Technical Modelling Note located in Appendix A.

Table 7-2 Chapel Road site levels for flood mitigation

Flood risk	Northern sub-catchment	Central sub-catchment	South-eastern sub-catchment	South-western sub-catchment
Ground level for development	Use existing ground levels	48.85mAOD	Use existing ground levels	49mAOD
Finished Floor Level for development				
Flood Level in 1% AEP plus climate change	Buildings 36-40: 49.20mAOD	Buildings 41-45: 49.06mAOD	Building 50: 49.06mAOD*	Buildings 46-49: 49.17mAOD
Flood Level in 0.1% AEP	Buildings 36-40: 49.62mAOD	Buildings 41-45: 49.40mAOD	Building 50: 49.42mAOD*	Buildings 46-49: 49.48mAOD

* Plot 50 is flood free for both the 1% plus climate change AEP and the 0.1% AEP, flood level shown above has been taken from site surroundings on Fordshill Rd.

Figure 7-2 Chapel Road site level changes



Additional flood mitigation measures

No additional site-specific measures are required other than the ground levels specified in the sections above.

Safe access and egress

Herefordshire 2019 SFRA requires that the site maintains safe access and egress during a flood event, and that residual flood risk is safely managed, meeting the requirements specified in 3.7.

Table 7-3 below provides information on the access and egress for Chapel Road mini-zone based on the outcome of flood modelling (as provided in Appendix A). The modelling results show that shallow flooding (up to 0.35m) and moderate flood hazard occurs during the 1% AEP plus climate change. Flood hazard is classified as 'high' during the 0.1% AEP as a result of the maximum flood depths of 0.65m on Chapel Rd and 0.7m on the Luck Trading estate access road. The model indicates a peak velocity of 1.7m/s on Chapel Rd.

Table 7-3 Flood risk for Chapel Rd access and egress

	Access and egress information
Primary access/egress route	For the Chapel Rd mini-zone, there are two primary access routes. For buildings 36-45 located within the northern and central sub-catchments, access is via Chapel Rd. This route feeds onto the Straight Mile roundabout and onto the B4399. For buildings 46-50, the best access and egress route is to use the Straight Mile and leave the Rotherwas estate to the east. This can be

	directly accessed for building 50 as this is not at flood risk in any of the model simulations. For buildings 46-49, access will need to occur via the Luck Trading estate access road and onto Fordshill Rd before entering the Straight Mile.
Peak flood depth (on access route): 1% AEP plus climate change	Chapel Rd: 0.37m The Straight Mile: 0.10m Luck Trading estate access / Fordshill Rd: 0.17m
Flood hazard: 1% AEP plus climate change	Flood hazard along the access/egress route ranges between 0 and 0.61 and is therefore contained within the 'low' to 'moderate' hazard rating and classed as acceptable.
Flood hazard: 0.1% AEP	Flood hazard along the access/egress route extends to the 'high' category with a peak hazard classification value of 1.43.

The flood hazard rating on the primary access route for Chapel Road mini-zone exceeds the guidance provided in the Herefordshire 2019 SFRA and consequently it is recommended that further mitigation measures are considered to ensure safe access and egress from the Chapel Road mini-zone.

Recommended measures include:

- Sign up to EA flood alerts.
- Development of a Site-Specific Emergency Response Plan.
- A Site-Specific Emergency Evacuation Procedure. It is recommended that this is developed in consultation with the emergency planning department of Herefordshire Council.
- No overnight working during flood warnings, dissemination of flood information and testing flood evacuation procedures.
- Consideration of finished floor levels above the 0.1% AEP event to ensure safe/dry zone for employees on site.
- Suitable emergency and welfare facilities on site in the event of prolonged flooding.

7.6 Proposed surface water drainage strategy

Drainage scheme

Site-specific ground investigation will be required to determine the ground conditions across the mini-zone and the potential for infiltration techniques. The existing ponds located within Chapel Road mini-zone and to the east of the northern sub-catchment, and their connectivity with the Red Brook and the River Wye respectively, should also be investigated.

The surface water runoff from the car park areas and yards should drain to the pond or the watercourse. To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. In accordance with section 7.8 of the Herefordshire SuDS Handbook, additional measures, such as bioretention areas, swales and filter trenches should also be used, where practicable. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

If a site-specific ground investigation and long-term groundwater monitoring indicate that infiltration techniques are not suitable at this location, the following options should be considered:

Northern sub-catchment

Discharge to the existing pond located to the east of the sub-catchment. The potential options would be as follows:

- Discharge the unattenuated runoff into the pond via a conveyance system – subject to spare capacity in the pond, its ownership and confirmation from the LLFA.
- If the capacity of the pond is restricted, discharge the attenuated runoff from the sub-catchment into the pond. Attenuation storage will need to be provided within the sub-catchment prior connection to the pond.
- If connection to the pond proves difficult, a discharge of attenuated flow into the public surface water sewer located along the north-western boundary of the sub-catchment could be considered– subject to DCWW approval. Attenuation storage will need to be provided within the sub-catchment prior to connection to the drain.

The conceptual proposal is shown in Figure 7-3.

Central and south-western sub-catchments

Option 1 - Discharge to the existing pond located in the centre of the site. The potential options would be as follows:

- Discharge the unattenuated runoff into the pond via a conveyance system - subject to the spare capacity in the pond and its ownership.
- If the capacity of the pond is restricted, discharge the attenuated runoff from the parcels to the pond. Attenuation storage will need to be provided within the sub-catchments prior to connection to the pond.

The conceptual proposal for Option 1 is shown in Figure 7-4.

Option 2 - Discharge the attenuated runoff from the parcels into the Red Brook watercourse. Attenuation storage will need to be provided by use of dedicated flow controls within each sub-catchment prior to connection to the watercourse. Alternatively, one attenuation system may be applied for both sub-catchments and the runoff drained via a combined outfall to the watercourse. This assumes that a section of the watercourse within the red line boundary will be abandoned post-development, instead of being culverted or diverted within the site – subject to confirmation that no external catchment drains to the said watercourse.

The attenuation should be accommodated in an above ground facility unless technical/ spatial constraints preclude it.

The conceptual proposal for Option 2 is shown in Figure 7-5.

South-eastern sub-catchment

- Discharge the attenuated runoff from the sub-catchment into the Red Brook located to the north of the site via a conveyance system located within Fordshill Road or adjacent land - subject to the relevant ownership agreement and land drainage consent. Attenuation will need to be provided within the sub-catchments prior to connection to the watercourse.

The conceptual proposal is shown in Figure 7-3.

Figure 7-3 Drainage scheme for Chapel Road mini-zone

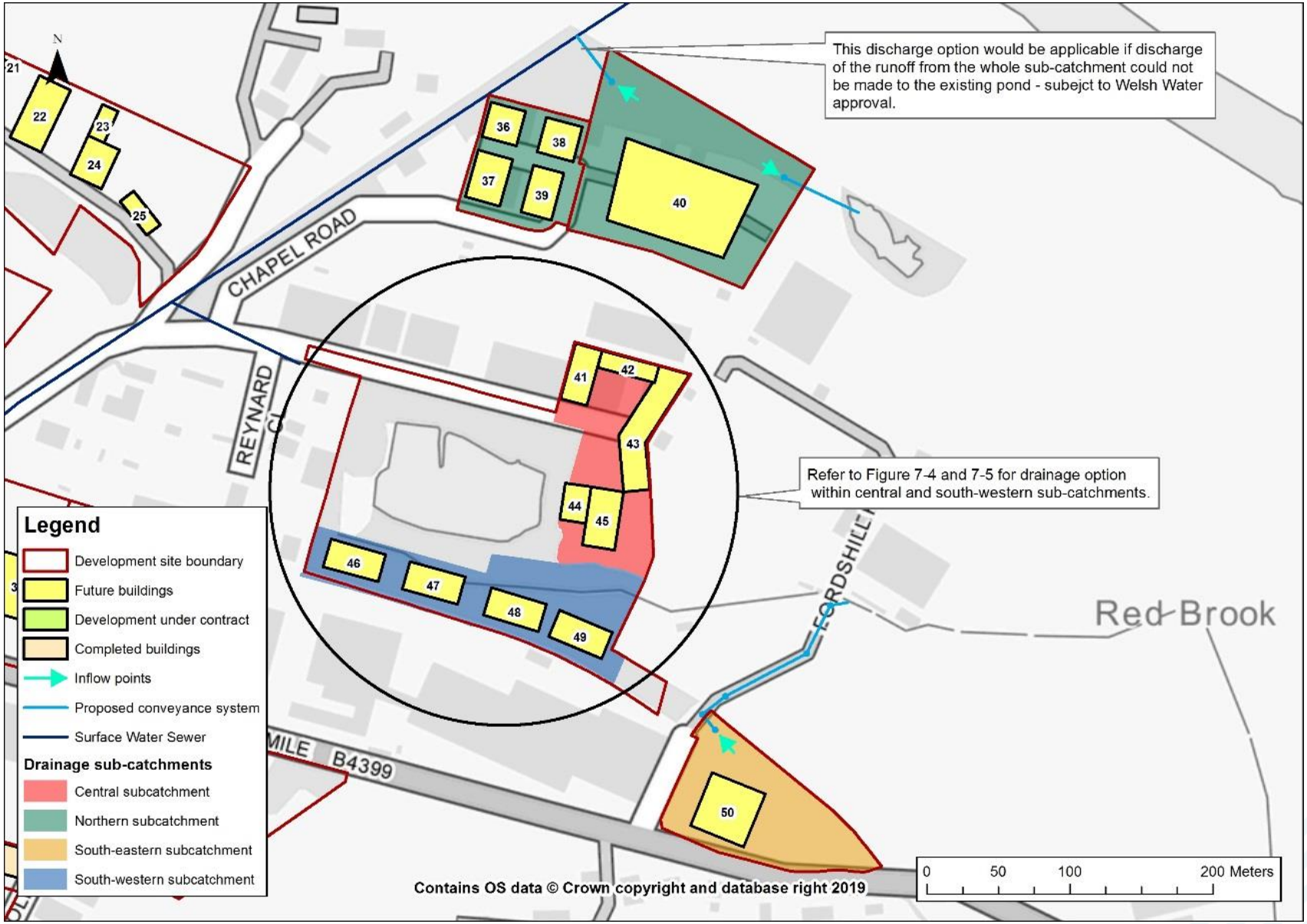


Figure 7-4 Option 1 scheme for central and south-western sub-catchments

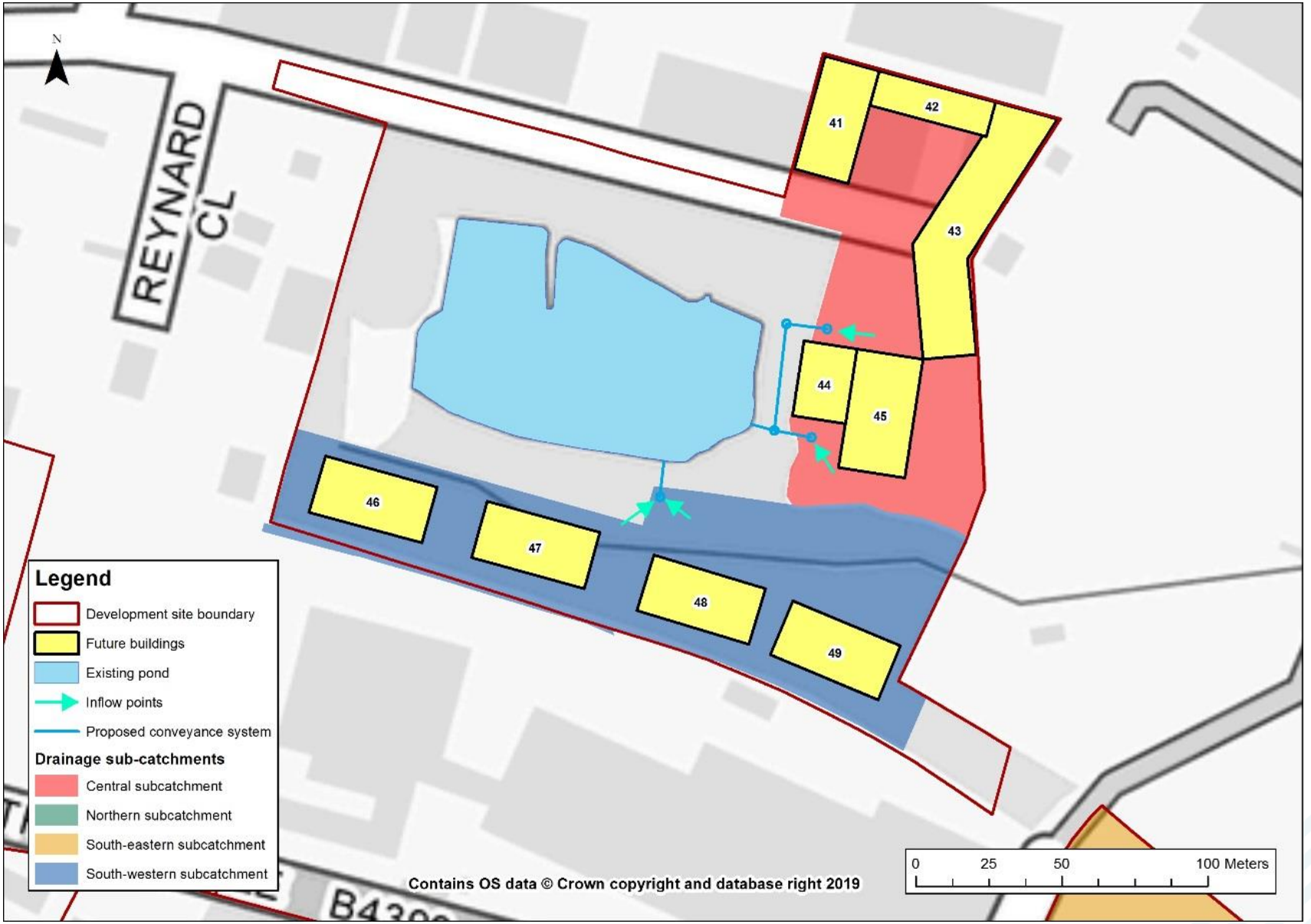
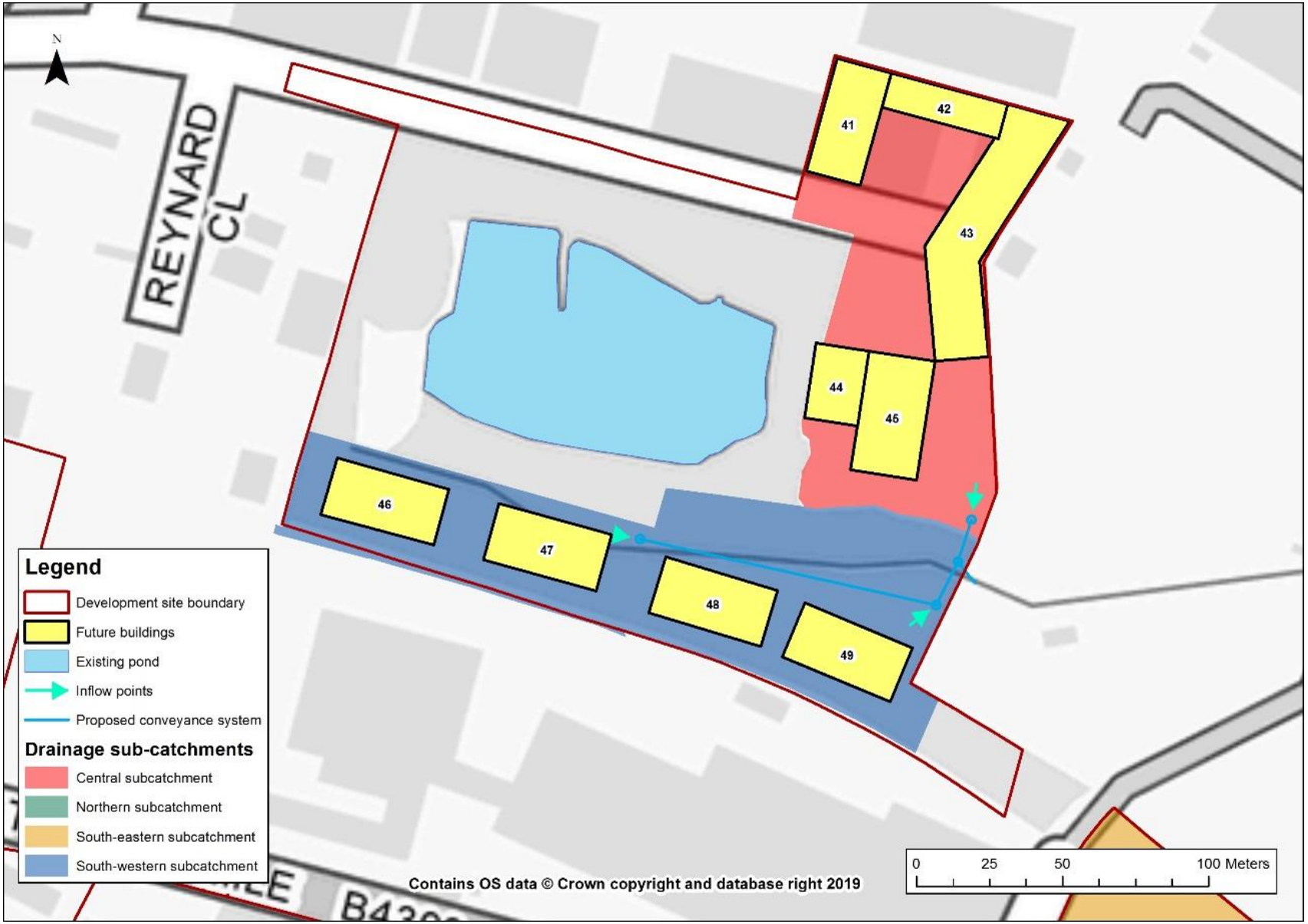


Figure 7-5 Option 2 scheme for central and south-western sub-catchments



Discharge rates

The greenfield runoff rate has been calculated for each sub-catchment as shown in Table 7-4. If practical, the discharges of sub-catchments should be combined to achieve a combined Qbar based minimum greenfield discharge rate that is not constrained by the minimum practical discharge rate of 2l/s.

Table 7-4 Chapel Road Greenfield runoff rates

	Development site area (ha)	Calculated Qbar (l/s)	Minimum discharge rate (l/s)
Northern sub-catchment	2.25	2.45	2.5
Central sub-catchment	0.97	1.06	2.0
South-western sub-catchment	1.12	1.25	2.0
South-eastern sub-catchment	0.89	0.99	2.0

Attenuation requirements

The following site-specific parameters have been used and the attenuation requirements are shown in Table 7-5.

- Impermeable area - Assumed 80% of total area.

Table 7-5 Attenuation volume required within Chapel Road mini-zone

	Impermeable area (ha)	Attenuation volume required (no infiltration) (m^3)
Northern sub-catchment	1.80	1259 - 1685
Central sub-catchment	0.78	443 - 633
South-western sub-catchment	0.90	535 - 754
South-eastern sub-catchment	0.71	389 - 563

The SuDS calculations for Chapel Road mini-zone are provided in Appendix D.

8 Skylon East

8.1 Site description

The development proposal for Skylon East mini-zone comprises up to 2 future buildings and associated infrastructure within the northern part of the site (northern sub-catchment) and 2 future buildings and 1 completed building within the south-western part of the site (south-western sub-catchment).

The development of 5 buildings within the south-eastern part of the site (south-eastern sub-catchment) has already been completed as shown in Figure 8-1. The three sub-catchments are separated by The Straight Mile and Coldnose Road.

Figure 8-1 reflects the likely indicative layout for Skylon North Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein. However, due regard must be given to ensuring that the additional flood mitigation measures outlined in Section 8.5 can be adequately implemented under an alternative layout.

Figure 8-1 Skylon East development and building numbers

The northern and south-western sub-catchments are currently greenfield.

Based on the information contained in the topographical survey carried out for the area by Severn Partnership in August 2014[26] the ground levels vary between approximately

26 'Topographical Survey, Hereford Enterprise Zone – C1, C19 and C20', Severn Partnership, 11/08/2014

48.50mAOD and 49.75mAOD in the northern sub-catchment. This does not account for local temporary earthwork stockpiles present at that time in the northern sub-catchment, which vary in height and extent. The ground within the southern sub-catchment slopes in a northerly direction from approximately 50.73mAOD to 49.30mAOD.

8.2 Existing geology and hydrogeology

Ground investigation was carried out in 2014 by CC Ground Investigation Ltd[27] within the northern and south-western sub-catchments. The results showed that the soil is relatively permeable with infiltration rates between $2.87x10^{-4}$ and $6.10x10^{-5}$ m/s within the northern sub-catchment. The soil within the south-western sub-catchment was shown as impermeable. Groundwater was struck at 2.90mbgl with levels rising during the investigation.

The survey shows the following general strata within the northern sub-catchment:

- Made Ground – Grey and reddish-brown sandy gravel. Gravel is angular and subangular to rounded to sub-rounded fine to coarse sandstone, siliceous material and concrete and coarse clinker sandstone and concrete with average thickness of 0.3m and presence of a concrete slab at 0.05mbgl.
- Made Ground – became soft greyish brown very gravelly silty clay with low cobble content. Gravel is angular to sub-rounded fine to coarse brick, concrete and clinker. Cobbles are angular to subangular brick and concrete with depths between 0.35 mbgl and 0.5mbgl.
- Firm reddish brown mottled yellowish brown and grey slightly sandy gravelly clay with low cobble content. Gravel is sub-rounded and rounded fine to coarse sandstone and siliceous material. Cobbles are sub-rounded sandstone with depths between 0.3mbgl and 1.5mbgl.
- Greyish brown mottled reddish brown and brown sandy gravel locally tending to gravelly sand with medium cobble content. Gravel is rounded to sub-rounded fine to coarse sandstone and siliceous material. Cobbles are sub-rounded to rounded sandstone and siliceous material with depths between 1.4mbgl and 2mbgl.

The survey shows the following general strata within the south-western sub-catchment:

- Made Ground – Rough vegetation over grey and black very gravelly sand locally trending to sandy gravel with frequent roots and rootlets. Gravel is angular to subangular fine to coarse sandstone concrete and brick from the surface to a maximum depth of 0.15m.
- Firm friable orangish brown slightly gravelly silty clay with low cobble content. Gravel is sub-rounded and rounded fine to coarse sandstone and siliceous material. Cobbles are sub-rounded sandstone with depths between 0.15mbgl and 1.80mbgl.
- Greyish brown mottled orangish brown very sandy gravel with medium cobble content. Gravel is rounded to sub-rounded fine to coarse sandstone and siliceous material. Cobbles are sub-rounded and rounded sandstone and siliceous material with depths between 1.80m and 3.0mbgl.

8.3 Existing drainage

Dŵr Cymru Welsh Water (DCWW) surface water sewer is located within the Gatehouse Road and Chapel Road and discharges to the River Wye.

The Surface Water Sewer at Rotherwas Industrial Estate drawing[28] shows existing private drainage running along Coldnose Road and The Straight Mile, and discharging into the DCWW surface water sewer at the intersection of Chapel Road and The Straight Mile.

27 'Draft Factual Report', CC Ground Investigations Ltd, Report No. C4249, 15/09/14
28 'Surface Water Sewer at Rotherwas Industrial Estate', Drawing Number: 551392-SK-107, Amey

It is understood that two 600mm pipes cross under The Straight Mile road north to south near the roundabout junction of The Straight Mile Road and Gatehouse Road. A gully positioned within the headwalled concrete base is located at the outfall of the pipes to the south of The Straight Mile road. The local ground levels show that the south-western sub-catchment is draining towards the gully. The exact purpose of this drainage arrangement and the discharge environment are currently unknown.

8.4 Fluvial flood risk

The flood risk at Skylon East mini-zone is summarised in Table 8-1 below. The mini-zone experiences flooding in the 1% AEP plus climate change event to a depth of 1.05m and depths up to 1.39m in the 0.1% AEP event at locations of the proposed development plots.

Table 8-1 Skylon East flood risk summary

Flood risk	Northern sub-catchment	South-eastern sub-catchment	South-western sub-catchment
Flood Zone	FZ2	FZ2	FZ2
Existing site levels	47.94mAOD to 50.02mAOD	48.64mAOD to 52.68mAOD	48.32mAOD to 51.97mAOD
1% AEP plus climate change flood level	49.53mAOD	49.51mAOD	49.54mAOD
0.1% AEP flood level	49.85mAOD	49.84mAOD	49.85mAOD

The flood levels detailed above have been extracted from the updated flood modelling work undertaken for this study using the 'Present Day' model scenario.

8.5 Proposed flood mitigation

Flood mitigation measures are proposed in the sections below, designed to enable safe development of the plots for the lifetime of the property and in accordance with the requirements of local and national flood risk policy.

Site levels and FFL

It is recommended that ground levels are raised to the levels outlined in Table 8-2 below. Ground levels relate to the entire development plot and include auxiliary areas such as car parking and emergency access/egress routes. Landscaping areas not required for emergency access/egress have no minimum requirements for ground levels.

FFL's for buildings should be set with a freeboard allowance as recommended in 3.8, with reference to either the 1% AEP plus climate change flood level or 0.1% AEP flood levels provided in Table 8-2.

There are no new development plots proposed for the south-eastern sub catchment and therefore, updated ground levels and flood levels have not been provided for this location in Table 8-2.

The location of the required topographic modifications for the Skylon East mini-zone are shown in Figure 8-2. Plots 32 and 33 currently lie in a slight depression, for flood depths to be acceptable in the surrounding car parking areas, the ground level needs to be raised to a level of 49.3mAOD. Topographic modifications were not required for proposed building plot 35 and

therefore existing ground levels can be adopted. An average surrounding ground level of 49.4mAOD has been used for proposed building plot 34 in order to achieve an acceptable car parking level.

Hydraulic modelling was carried out to identify the ground levels recommended in Table 8-2 and confirm that the proposals do not cause detrimental impacts on flood mechanisms across Hereford Enterprise Zone. The results of the hydraulic modelling are provided in the Hereford Enterprise Zone Technical Modelling Note located in Appendix A.

Table 8-2 Skylon East site levels for flood mitigation

Flood risk	Northern sub-catchment	South-western sub-catchment
Ground level for development	Buildings 32-33: 49.3mAOD	Building 34: 49.4mAOD Building 35: Use existing ground levels
Finished Floor Level for development		
1% AEP plus climate change flood level	Buildings 32-33: 49.51mAOD	Flood Free*
0.1% AEP flood level	Buildings 32-33: 49.76mAOD	Building 34: 49.75mAOD Building 35: 49.91mAOD

* For buildings 34-35 there is no flooding in the 1% plus climate change event. We are unable to take a sensible flood level from the surrounding area for this event so the 0.1% AEP flood level should be adopted for these plots.

Figure 8-2 Skylon East ground raising and bund location

Additional flood mitigation measures

Specific requirements for flood management of the mini-zone are listed below:

- The flood modelling work highlighted that the proposed development throughout the Rotherwas estate could cause a slight increase in conveyance entering the Skylon East mini-zone. In order to ensure no third-party detriment to existing businesses within this mini-zone, a small bund is necessary that will run alongside the edge of the B4399 road. An elevation of 50.3mAOD is required. The location of the proposed bund is shown in Figure 8-2.

Safe access and egress

Herefordshire 2019 SFRA requires that the site maintains safe access and egress during a flood event, and that residual flood risk is safely managed, meeting the requirements specified in 3.7.

Table 8-3 below provides information on the access and egress for the Skylon East mini-zone based on the outcome of flood modelling (as provided in Appendix A). The modelling results show that flooding (up to 0.68m) and high flood hazard occurs during the 1% AEP plus climate change event. Flood hazard is classified as 'high' during the 0.1% AEP event as a result of maximum flood depths of 0.96m on the Luck Trading estate access road. The model indicates a peak velocity of 0.8m/s on the Straight Mile.

Table 8-3 Flood risk for Skylon East access and egress

	Access and egress information
Primary access/egress route	For the Skylon East min-zone, there are two primary access/egress routes. Buildings 32-33: Access will need to occur via the Luck Trading estate access road and onto Fordshill Rd before entering the Straight Mile. Buildings 34-35: Access via Coldnose Rd and onto the Straight Mile.
Peak flood depth (on access route): 1% AEP plus climate change	Buildings 32-33: 0.68m Buildings 34-35: Access is flood free
Flood hazard: 1% AEP plus climate change	Buildings 32-33: Flood hazard value of 1.41 for the Luck Trading Estate access route. This falls within the 'high' category band. Buildings 34-35: No flood hazard on access route.
Flood hazard: 0.1% AEP	Buildings 32-33: Flood hazard value of 1.77 for the Luck Trading Estate access route. This falls within the 'high' category band. Buildings 34-35: Flood hazard value of 1.38 exhibited on Coldnose Rd access route. This falls within the 'high' category band.

The flood hazard rating on the primary access routes for the Skylon East mini-zone exceeds the guidance provided in the Herefordshire 2019 SFRA and consequently it is recommended that further mitigation measures are considered to ensure safe access and egress from the Skylon East mini-zone.

Recommended measures include:

- Sign up to EA flood alerts.
- Development of a Site-Specific Emergency Response Plan.
- A Site-Specific Emergency Evacuation Procedure. It is recommended that this is developed in consultation with the emergency planning department of Herefordshire Council.

- No overnight working during flood warnings, dissemination of flood information and testing flood evacuation procedures.
- Provision of areas where the floor level is above the 0.1% AEP event to provide a safe/dry zone for employees on site.
- Suitable emergency and welfare facilities on site in the event of prolonged flooding

8.6 Proposed surface water drainage strategy

Drainage scheme

Considering the likelihood of the permeability of soils within the area, discharge to the ground via infiltration could be a viable option. However, groundwater was encountered at 2.90mbgl within the south-western sub-catchment during historic ground investigation. Therefore, there is potential for high groundwater levels which could preclude infiltration techniques and would need to be assessed in more detail prior to designing an infiltration-based system.

If more detailed site-specific ground investigation and long-term groundwater monitoring show that infiltration techniques are not suitable at this location, the following should be considered:

Northern sub-catchment

Discharge to the public surface water sewer along Chapel Road or to the private drainage system along The Straight Mile. The potential options would be as follows:

- Discharge the attenuated flow into the public surface water sewer located in Chapel Road. Attenuation storage will need to be provided within the sub-catchment prior to connection to the public sewer – subject to DCWW approval.
- If connection to the public surface water sewer proves difficult, the sub-catchment could be split, and the eastern part of the area drained to the private surface water sewer located along The Straight Mile - subject to the capacity and ownership of the drain.

South-western sub-catchment

Discharge to the public surface water sewer along Gatehouse Road or to the private drainage system along Coldnose Road. The potential options would be as follows:

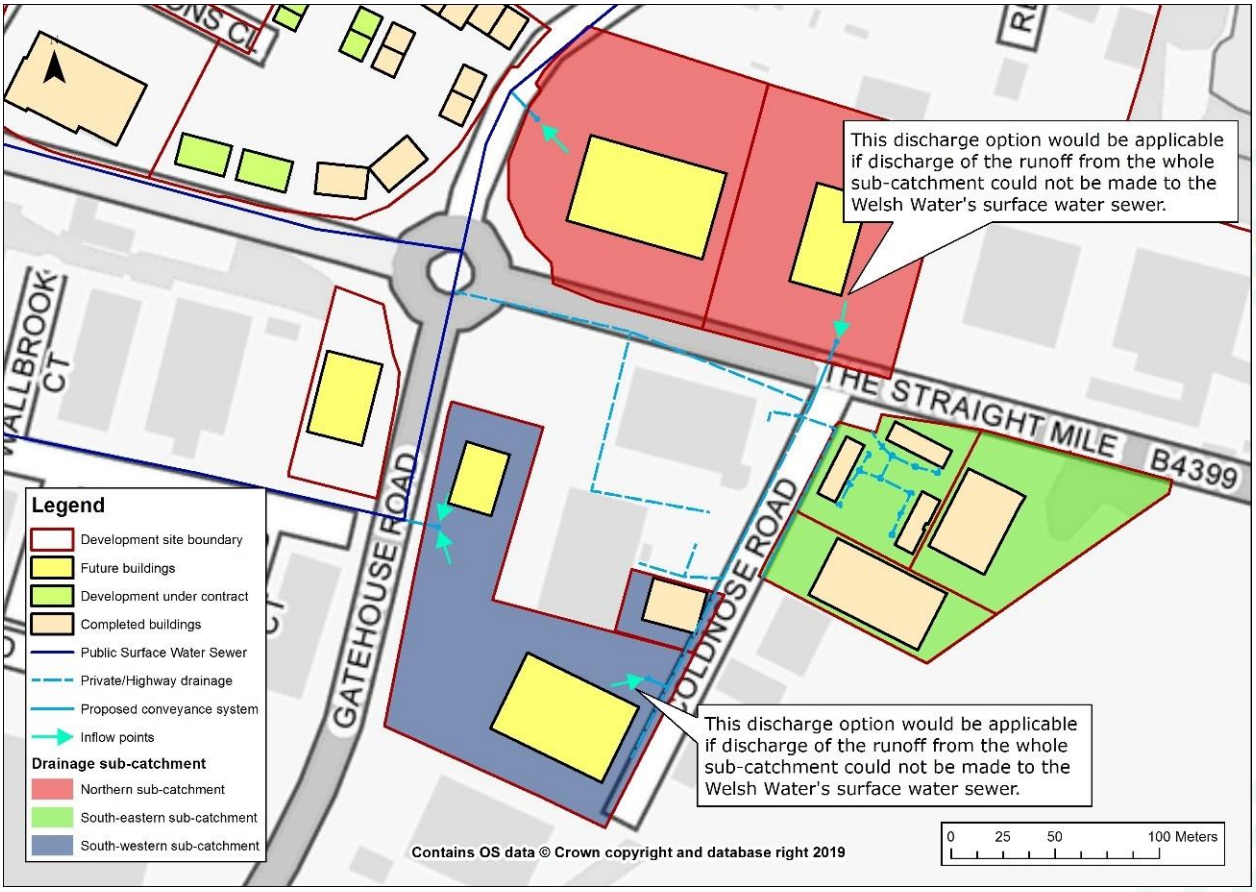
- Discharge the attenuated flow into the public surface water sewer located in Gatehouse Road. Attenuation storage will need to be provided within the sub-catchment prior to connection to the public sewer - subject to DCWW approval.
- If connection to the public surface water sewer proves difficult, the sub-catchment could be split, and the eastern part of the area drained to the private surface water drain located along Coldnose Road - subject to the capacity and ownership of the drain.

The attenuation should be accommodated in an above-ground facility unless technical/ spatial constraints preclude it.

The surface water runoff from the car park areas and yards should drain to the pond. To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. Additional measures, such as bioretention areas, swales and filter trenches should also be used. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

The conceptual proposal is shown in Figure 8-3.

Figure 8-3 Proposed drainage scheme within Skylon East



Discharge rates

If infiltration to ground is adopted as the main runoff disposal technique from the site, the discharge rates will be dictated by the permeability of the ground.

For discharges to surface water features the greenfield runoff rates have been calculated for each sub-catchment as shown in Table 8-4.

Table 8-4 Skylon East greenfield runoff rates

	Development site area (ha)	Qbar calculated (l/s)	Minimum discharge rate (l/s)
Northern sub-catchment	2.37	2.6	2.6
Southern sub-catchment	1.42	1.5	2

Attenuation requirements

The following site-specific parameters have been used in the calculation and the attenuation requirements are shown in Table 8-5.

- Impermeable area – assumed 80% of total area.
- Infiltration rate – worst infiltration rate measured within the site.

Table 8-5 Attenuation volume required within Skylon East site

	Assumed impermeable area (ha)	Infiltration rate (m/s)	Attenuation volume required (based on infiltration) (m3)	Attenuation volume required (no infiltration) (m3)
Northern sub-catchment	1.90	6.39x10-5	266 - 788	1335 - 1785
Southern sub-catchment	1.13	N/A	N/A	728 - 999

The SuDS calculations for Skylon East mini-zone are provided in Appendix E.

9 Skylon Central

9.1 Site description

The development proposals for Skylon Central mini-zone comprises 1 future building and associated infrastructure in the southern part of the mini-zone (southern sub-catchment) and 1 future building to the north of Munitions Close (northern sub-catchment) as shown in Figure 9-1. The remainder of the mini-zone has either already been completed or is currently under construction.

Figure 9-1 reflects the likely indicative layout for Skylon North Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein.

Figure 9-1 Skylon Central development and building numbers

The northern sub-catchment is brownfield, covered by tarmac, and the southern sub-catchment is largely greenfield with an area of car park located in the southern part of the plot.

Based on the information contained in the topographical survey carried out within the northern sub-catchment by Monument Geomatics Ltd in September 2016[29], the site is relatively flat with ground levels varying between approximately 50.01mAOD and 50.10mAOD.

29‘ Existing layout 3D Annotated topographical survey’, Monument Geomatics Ltd, September 2016, Drawing Number ‘MG0931 S1’

The information contained in the topographical survey carried out within the southern sub-catchment by Severn Partnership in August 2014[30] indicates that the ground levels vary between approximately 49.98mAOD and 50.45mAOD.

9.2 Existing geology and hydrogeology

Ground investigation was carried out in 2014 by CC Ground Investigation Ltd[28] within all drainage sub-catchments. The results show that the soil is permeable with the infiltration rates shown in Table 9-1 Infiltration rates from ground investigation.

Table 9-1 Infiltration rates from ground investigation

	Infiltration rates (m/s)
North-western sub-catchment	1.16×10^{-5} m/s
Northern sub-catchment	between 2.3×10^{-4} and 4.0×10^{-4} m/s
Central sub-catchment	between 1.89×10^{-5} and 3.59×10^{-5} m/s
Southern sub-catchment	between 7.32×10^{-5} and 1.35×10^{-4} m/s

Since 2014, ground modifications have been carried out within the northern sub-catchment as suggested on the 2016 topographical survey. The 2014 ground investigation survey shows that the topsoil comprised rough vegetation over soft orangish brown gravelly clay with frequent roots and rootlets, whereas the 2016 topographical survey showed the whole site area covered by tarmac surfacing. The ground investigation survey showed groundwater seepage encountered at 3.0mbgl without any rise recorded during the survey.

The 2014 ground investigation survey showed the following strata within the southern sub-catchment:

- Made Ground: grass over soft brown mottled orangish brown slightly gravelly silty clay with low cobble content and frequent rootlets. Encountered from the surface to a depth of 0.5mbgl.
- Made Ground: Black mottled ashy sandy gravel with medium cobble content and metal fragments. Gravel is angular to sub-rounded clinker, charcoal, concrete and brick. Encountered to depths between 0.50mbgl and 0.80mbgl.
- Firm orangish brown mottled reddish brown slightly gravelly silty clay with low cobble content. Encountered to depths between 0.80mbgl and 2.10mbgl.
- Greyish brown mottled reddish brown and orangish brown sandy gravel locally tending to gravelly sand. Encountered to depths between 2.10mbgl and 3.0mbgl.

No groundwater was encountered at that time.

9.3 Existing drainage conditions

Based on the information contained in the topographical surveys, it is understood that a surface water drain is running along the Vincent Carey Road in a north to south direction and along Munitions Close. The surface water drain conveys surface water runoff from Vincent Carey Road and possibly from the adjacent development. However, this has not been confirmed. The surface water drain then runs through the central sub-catchment and discharges into the public surface water sewer located in The Straight Mile.

It is currently unknown if the existing tarmac surface in the northern sub-catchment is positively drained. It is assumed however that the runoff from the area drains towards road gullies and discharge into the surface water drain within Munitions Close.

[30] 'Topographical Survey, Hereford Enterprise Zone – C1, C19 and C20', Severn Partnership, 11/08/2014

To the north of the northern sub-catchment and south to Skylon View road, a soakaway pond storing surface water runoff from the Phase 3 Access Road is present, as described in section 2.4.

Based on the information contained in the topographical surveys it is understood that the car park within the southern sub-catchment currently drains via gullies towards the public surface water sewer located in Netherwood Road.

9.4 Fluvial flood risk

The flood risk at Skylon Central mini-zone is summarised in Table 9-2 below. The mini-zone experiences shallow flooding in the 1% AEP plus climate change event to a depth of 0.24m and depths up to 0.38m in the 0.1% AEP event at locations of the proposed development plots.

Table 9-2 Skylon Central flood risk summary

Flood risk	Northern sub-catchment	North-western sub-catchment	Central sub-catchment	Southern sub-catchment
Flood Zone	FZ2	FZ2	FZ2	FZ2
Existing site levels	50mAOD	49.95mAOD to 50.51mAOD	49.95mAOD to 50.18mAOD	49.45mAOD to 50.35mAOD
1% AEP plus climate change flood level	50.15mAOD	50.37mAOD	50.43mAOD	50.36mAOD
0.1% AEP flood level	50.36mAOD	50.60mAOD	50.62mAOD	50.53mAOD

The flood levels detailed above have been extracted from the updated flood modelling work undertaken for this study using the 'Present Day' model scenario.

9.5 Proposed flood mitigation

Flood mitigation measures are proposed in the sections below, designed to enable safe development of the plots for the lifetime of the property and in accordance with the requirements of local and national flood risk policy.

Site levels and FFL

It is recommended that ground levels are set to the levels outlined in Table 9-3 below. Ground levels relate to the entire development plot and include auxiliary areas such as car parking and emergency access/egress routes. Landscaping areas not required for emergency access/egress have no minimum requirements for ground levels.

FFL's for buildings should be set with a freeboard allowance as recommended in 3.8, with reference to either the 1% AEP plus climate change flood level or 0.1% AEP flood levels provided in Table 9-3 below.

There are only two proposed buildings located within the Skylon Central mini-zone. Building 30 is located in the northern sub-catchment and building 31 is located in the southern sub-catchment. The other sub-catchments have not been mentioned Table 9-3 as no proposed development is scheduled here.

Hydraulic modelling was carried out to identify the ground levels recommended in Table 9-3 and confirm that the proposals do not cause detrimental impacts on flood mechanisms across Hereford Enterprise Zone. The results of the hydraulic modelling are provided in the Hereford Enterprise Zone Technical Modelling Note located in Appendix A.

Table 9-3 Skylon Central site levels for flood mitigation

Flood risk	Northern sub-catchment	South-western sub-catchment
Ground level for development	Building 30: 50.0mAOD	Building 31: 50.15mAOD
Finished Floor Level for development		
1% AEP plus climate change flood level	Building 30: 50.16mAOD	Building 31: 50.38mAOD
0.1% AEP flood level	Building 30: 50.36mAOD	Building 31: 50.54mAOD

Safe access and egress

Herefordshire 2019 SFRA requires that the site maintains safe access and egress during a flood event, and that residual flood risk is safely managed, meeting the requirements specified in 3.7.

Table 9-4 below provides information on the access and egress for the Skylon Central mini-zone based on the outcome of flood modelling (as provided in Appendix A). The modelling results show that flooding (up to 1.23m) and 'high' flood hazard occurs during the 1% AEP plus climate change event. Flood hazard is classified as 'high' during the 0.1% AEP event as a result of maximum flood depths of 1.46m on Netherwood road which is the primary access for plot 31. The model indicates a peak velocity of 1.52m/s on Netherwood Rd.

Table 9-4 Flood risk for Skylon Central access and egress

	Access and egress information
Primary access/egress route	For the Skylon Central mini-zone there are two primary access and egress routes, one for each of the separate proposed development plots. For building 30 located in the northern sub-catchment, access will need to occur via Vincent Carey Rd, onto the Straight Mile and out of the Rotherwas estate via the B4399. For building 31 located in the southern sub-catchment access route is via Netherwood Rd, onto the Straight Mile and out of the Rotherwas estate via the B4399.
Peak flood depth (on access route): 1% AEP plus climate change	Building 30 access route: 0.47m Building 31 access route: 1.23m
Flood hazard: 1% AEP plus climate change	Building 30: Flood hazard value of 1.23m for Vincent Carey Rd access route. This falls within the 'moderate' hazard classification. Building 31: Flood hazard value of 1.63 for Netherwood Road access route. This falls within the 'high' hazard classification.
Flood hazard: 0.1% AEP	Building 30: Flood hazard value of 1.56 for Vincent Carey Rd access route. This falls within the 'high' hazard classification. Building 31: Flood hazard value of 1.91 for Netherwood Road access route. This falls within the 'high' hazard classification.

The flood hazard rating on the primary access routes for the Skylon Central mini-zone exceeds the guidance provided in the Herefordshire 2019 SFRA and consequently it is recommended

that further mitigation measures are considered to ensure safe access and egress from the North Magazine mini-zone.

Recommended measures include:

- Sign up to EA flood alerts.
- Development of a Site-Specific Emergency Response Plan.
- A Site-Specific Emergency Evacuation Procedure. It is recommended that this is developed in consultation with the emergency planning department of Herefordshire Council.
- No overnight working during flood warnings, dissemination of flood information and testing flood evacuation procedures.
- Provision of areas where the floor level is above the 0.1% AEP event to provide a safe/dry zone for employees on site.
- Suitable emergency and welfare facilities on site in the event of prolonged flooding

9.6 Proposed surface water drainage strategy

Drainage Scheme

Considering the likelihood of the permeability of soils within the area, discharge to the ground via infiltration could be viable. However, the potential for high groundwater levels that could preclude infiltration techniques would need to be assessed in more detail prior to designing an infiltration-based system.

If a site-specific ground investigation and long-term groundwater monitoring show that infiltration technique are not suitable, the following should be considered:

Northern sub-catchment:

Discharge to the existing pond located to the north of the sub-catchment (subject to ownership of the pond). The potential options are as follows:

- Discharge the unattenuated runoff into the pond via a conveyance system – subject to increasing the storage capacity of the pond to accommodate the additional runoff volume.
- If the capacity of the pond cannot be increased, and if viable, discharge attenuated runoff from the sub-catchment into the pond. Attenuation storage will need to be provided within the sub-catchment prior connection to the pond.
- If connection to the pond proves difficult, discharge the attenuated flow into the surface water drain located within Munitions Close - subject to the capacity and ownership of the drain. Attenuation storage will need to be provided within the sub-catchment prior to connection to the drain.

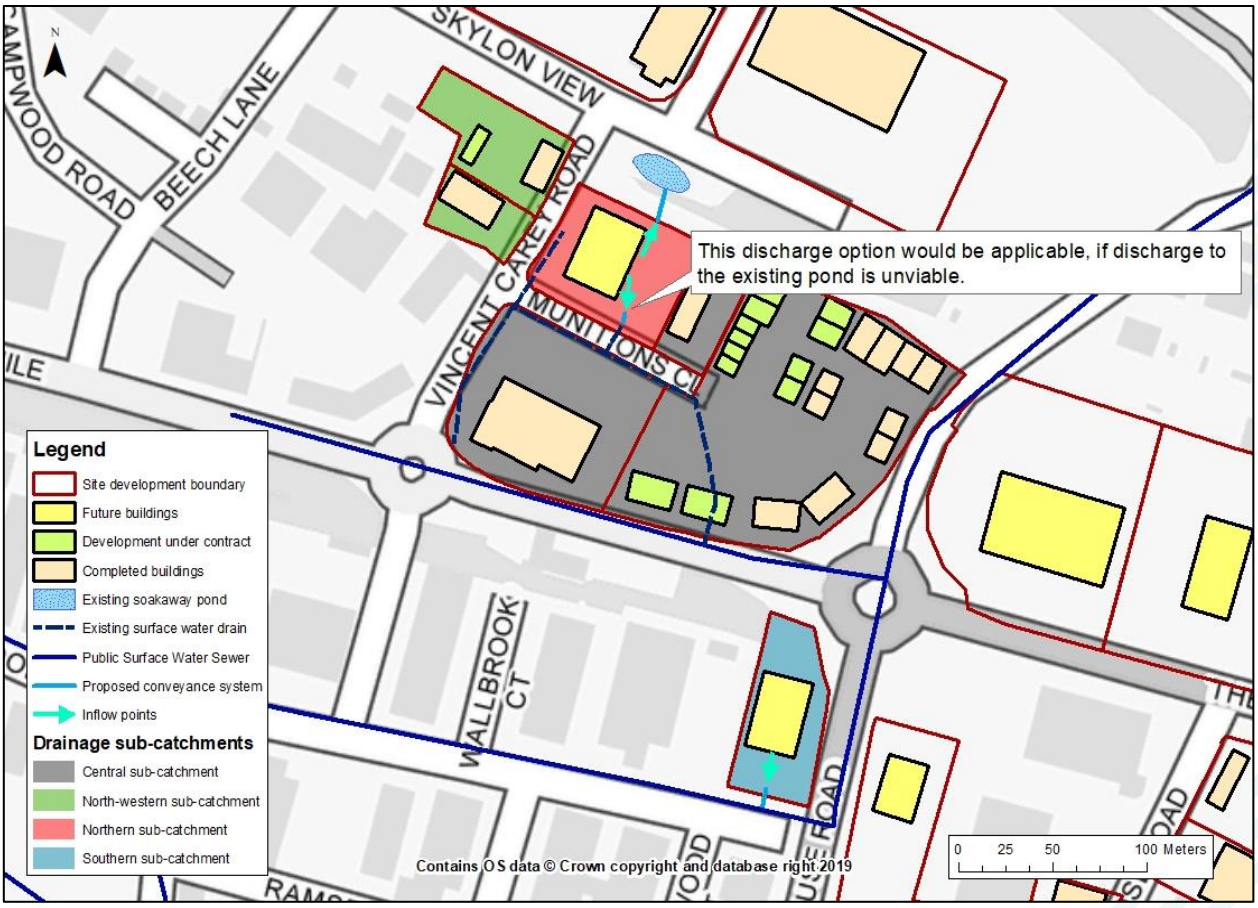
Southern sub-catchment:

- Discharge the attenuated flow into the public surface water sewer located within Netherwood Close – subject to DCWW approval. Attenuation storage will need to be provided within the sub-catchment prior to connection to the sewer.

The surface water runoff from the car park areas and yards should drain to the pond. To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. Additional measures, such as bioretention areas, swales and filter trenches should also be used. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

The conceptual proposal is shown in Figure 9-2.

Figure 9-2 Proposed drainage scheme within Skylon Central



Discharge rates

If infiltration to ground is adopted as the main runoff disposal technique from the site, the discharge rates will be dictated by the permeability of the ground.

For discharges to surface water features the greenfield runoff rates have been calculated for each sub-catchment as shown in Table 9-5.

Table 9-5 Skylon Central greenfield runoff rates

	Development site area (ha)	Calculated Qbar (l/s)	Minimum discharge rate (l/s)
Northern sub-catchment	0.46	0.49	2
Southern sub-catchment	0.36	0.39	2

Attenuation requirements

The following site-specific parameters have been used in the calculation and the attenuation requirements are shown in Table 9-6.

- Impermeable area – assumed 80% of total area
- Infiltration rate – worst infiltration rate measured within the site

Table 9-6 Attenuation volume required within Skylon Central development

	Impermeable area (ha)	Infiltration rate (m/s)	Attenuation volume required (based on infiltration) (m^3)	Attenuation volume required (no infiltration) (m^3)
Northern sub-catchment	0.37	$2.30x10^{-4}$	26 - 113	165 - 245
Southern sub-catchment	0.29	$7.32x10^{-5}$	38 - 116	120 - 177

The SuDS calculations for Skylon South mini-zone are provided in Appendix F.

10 Skylon South Magazine

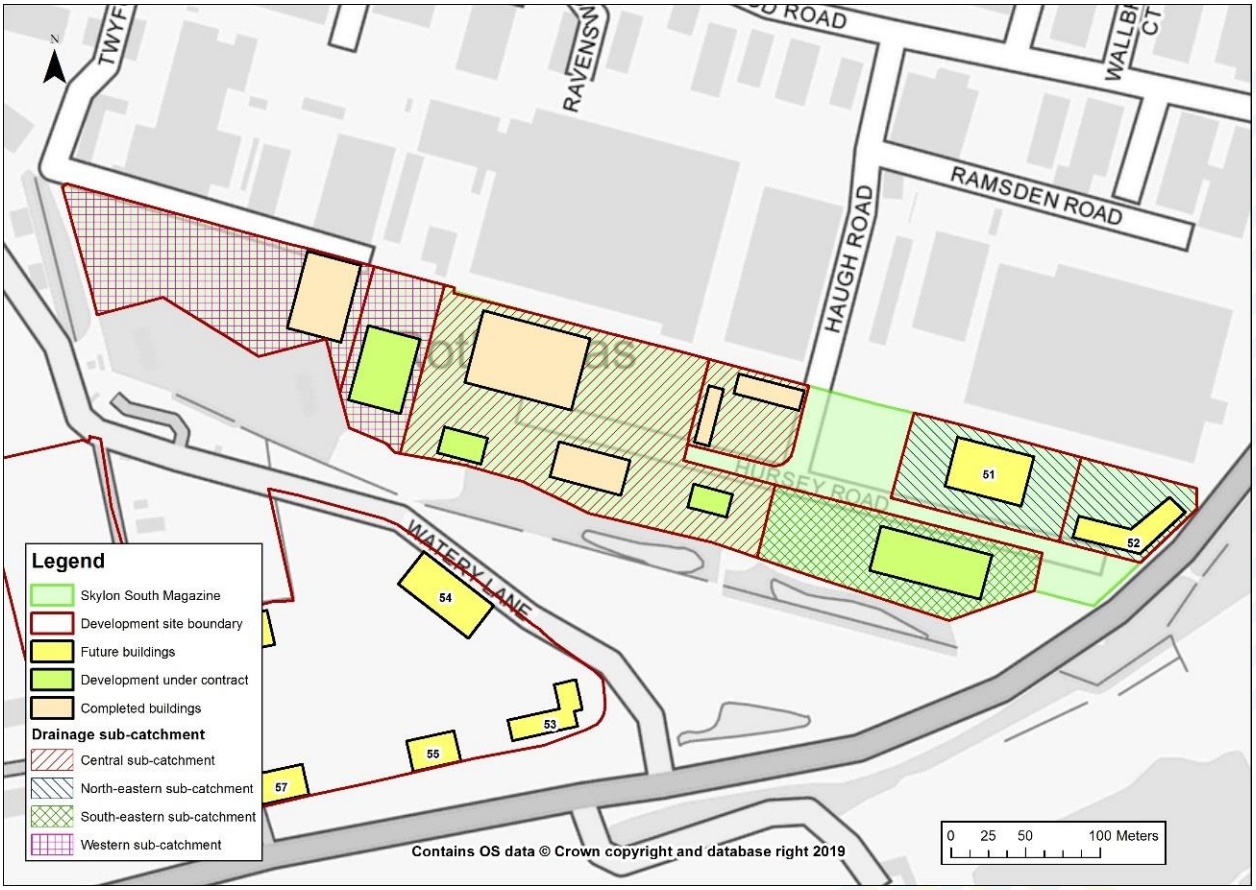
10.1 Site description

Skylon South Magazine forms the area formerly referred to as Phase 2 of the Hereford Enterprise Zone. The development proposal for the mini-zone are shown in Figure 10-1Figure 10-1 and comprise the following:

- Up to two future buildings and associated infrastructure within the north-western sub-catchment.
- Development underway or contract within the south-eastern sub-catchment.
- Four completed buildings and two developments underway or contract within the central sub-catchment.
- One completed building and development underway or contract within the western sub-catchment.

Figure 10-1 reflects the likely indicative layout for Skylon North Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein.

Figure 10-1 Skylon South Magazine development and building numbers



Based on the information contained in the topographical survey carried out in January 2014 by Severn Partnership[31] the ground levels within the site vary between 50.46mAOD and 53.21mAOD. The general ground falls in an easterly direction in the western part of the site, and a north-westerly direction in the eastern part of the site. The topographical survey carried out in August 2018 by Total Surveys Ltd[32] shows a local sunken area located within the eastern part of the north-eastern sub-catchment. The central and eastern sub-catchments were predominantly greenfield prior to the recently completed or underway developments. Hursey Road splits the central and eastern sub-catchment into northern and southern areas.

A series of ponds and ditches is located immediately to the south of the development zone.

10.2 Existing geology and hydrogeology

Ground investigation in the area was carried out in 2014 by CC Ground Investigation Ltd[28].

The survey shows the following general strata within the north-eastern sub-catchment:

- Made Ground: grass over soft dark brown mottled grey and black slightly sandy gravelly clay with low cobble content and frequent rootlets from the surface to depths of 0.50mbgl. Gravel is angular to sub-rounded fine to coarse brick, concrete, sandstone and charcoal. Cobbles are angular to subangular brick and concrete.
- Made Ground: firm orangish brown locally discoloured black and brown slightly sandy slightly gravelly clay with low cobble content with depths between 0.50m and 1.50mbgl. Gravel is angular to sub-rounded fine to coarse brick, concrete, sandstone and siliceous material. Cobbles are angular to subangular brick.
- Firm orangish brown mottled yellowish brown locally slightly gravelly silty clay with low cobble content with depths between 1.50mbgl and 2.10mbgl. Gravel is sub-rounded to rounded fine to coarse sandstone and siliceous material. Cobbles are sub-rounded sandstone. There are frequent roots and roots fragments between 1.50 and 1.80mbgl.
- Reddish brown slightly gravelly locally gravelly clayey sand with depths between 2.10mbgl and 3.0mbgl. Gravel is sub-rounded to rounded fine to coarse sandstone and siliceous material.

Groundwater seepages were encountered at 3.0mbgl within the north-eastern sub-catchment.

The survey showed that the soil is not suitable for infiltration at this location.

10.3 Existing drainage conditions

The proposed future buildings are located within the greenfield area.

There is a Dŵr Cymru Welsh Water (DCWW) surface water sewer located along Haugh Road which conveys surface water runoff into the River Wye.

It is understood that Hursey Road currently drains into a road drainage system, which discharges surface water runoff into an underground attenuation tank located to the west of the north-eastern sub-catchment. The attenuated flow is then discharged into the public sewer located within Haugh Road.

Based on the design drawing 3512463A-HHC_010D[33] two interconnected cellular attenuation tanks are likely to be present within the considered catchment, one to the south (approximate dimensions 73mx26mx1.2m) and one to the north (approximate dimensions 30mx44mx1.2m) of Hursey Road. A flow control chamber restricting discharge to 5l/s is present immediately

———————————————————————————————————

31 'Topographical survey of the South magazine areas S1 to S11', Drawing Number: '13099-P-1-1' to '13099-P-1-5', Severn Partnership, 22/01/2014
32 'Topographical survey, Land adjacent to Hursey Road, Rotherwas Industrial Estate, Hereford, HR2 6NX', Drawing Number: 'OPL/TS/438233/1D' revision D, Total Surveys Ltd, 07/08/2018
33 3512463A-HHC_010D Enterprise Zone Hereford, South Magazine Access Road by WSP/Parsons Brinckerhoff, dated March 2017

upstream of the connection to the public surface water sewer located in Haugh Road. These tanks have been designed to accommodate all runoff from the north-eastern and south-eastern sub-catchments[34].

The topographical survey carried out in August 2018 by Total Surveys Ltd suggests that there is an underground attenuation tank approximatively 73m long and 27m wide located in the western part of the south-eastern sub-catchment. There is no indication about the northern tank on the said survey.

10.4 Fluvial flood risk

The flood risk at Skylon South Magazine mini-zone is summarised in Table 10-1 below. The mini-zone experiences no flooding in the 1% AEP plus climate change event but does experience some shallow flooding in the 0.1% AEP event of depths up to 0.32m at locations of the proposed development plots.

Table 10-1 Skylon South Magazine flood risk summary

Flood risk	Central sub-catchment	North-eastern sub-catchment	South-eastern sub-catchment	Western sub-catchment
Flood Zone	FZ2	FZ2	FZ2	FZ2
Existing site levels	50.49mAOD to 52.36mAOD	50.5mAOD to 52.62mAOD	51.21mAOD to 52.74mAOD	50.97mAOD to 51.77mAOD
1% AEP plus climate change flood level	Flood Free	Flood Free	Flood Free	Flood Free
0.1% AEP flood level	50.84mAOD	50.84mAOD	Flood Free	Flood Free

The flood levels detailed above have been extracted from the updated flood modelling work undertaken for this study using the 'Present Day' model scenario. The Skylon South Magazine mini-zone doesn't experience any flooding in the 1% plus climate change AEP. Only the central and North-eastern sub-catchments experience flooding in the 0.1% AEP event.

The Red Brook, a tributary of the River Wye to the west of the Enterprise Zone, has a history of causing localised flooding to the west of the Rotherwas Industrial Estate, affecting several existing commercial premises. Independent of this strategy Herefordshire Council have been undertaking recent flood risk modelling work for the Red Brook. Although final results were not available for incorporation into the strategy, preliminary results show that the flood risk from the Red Brook would be limited in extent and limited to areas of existing development not of direct interest to the current Enterprise Zone plans. Consequently, the strategy does not specifically consider flood risk from the Red Brook. Should new development plans be proposed for the western half of Skylon South Magazine the flood risk from the Red Brook should be assessed and additional flood risk management measures may be required.

10.5 Proposed flood mitigation

Flood mitigation measures are proposed in the sections below, designed to enable safe development of the plots for the lifetime of the property and in accordance with the requirements of local and national flood risk policy.

34 South Magazine – Surface Water Design Evolution Rev B. Memo prepared by WPS for Herefordshire Council. 5th April 2017

Site levels and FFL

Recommended ground levels and Finished Floor Levels (FFL) are provided in Table 10-2. Ground levels relate to the entire development plot and include auxiliary areas such as car parking and emergency access/egress routes. Landscaping areas not required for emergency access/egress have no minimum requirements for ground levels.

FFL's for buildings should be set with a freeboard allowance as recommended in 3.8, with reference to either the 1% AEP plus climate change flood level or 0.1% AEP flood levels provided in Table 10-2 below.

There are only two proposed buildings located within the Skylon South Magazine mini-zone. Buildings 51 and 52 are located in the north-eastern sub-catchment. The other sub-catchments have not been mentioned Table 10-2 as no further proposed development is planned at this location.

Hydraulic modelling was carried out to identify the ground levels recommended in Table 10-2 and confirm that the proposals do not cause detrimental impacts on flood mechanisms across Hereford Enterprise Zone Enterprise Zone. The results of the hydraulic modelling are provided in the Hereford Enterprise Zone Technical Modelling Note located in Appendix A.

Table 10-2 Skylon South Magazine site levels for flood mitigation

Flood risk	Northern sub-catchment
Ground level for development	Building 51: 50.65mAOD Building 52: 51.10mAOD
Finished Floor Level for development	
1% AEP plus climate change flood level	Building 51 & 52: Flood Free*
0.1% AEP flood level	Building 51 & 52: 50.84mAOD*

* For buildings 51 and 52 there is no flooding in the 1% plus climate change event. We are unable to take a sensible flood level from the surrounding area for this event so the 0.1% AEP flood level should be adopted for these buildings. Building 52 is also flood free for the 0.1% AEP event so the flood level has been taken from building 51.

Safe access and egress

Herefordshire 2019 SFRA requires that the site maintains safe access and egress during a flood event, and that residual flood risk is safely managed, meeting the requirements specified in 3.7.

Table 10-3 below provides information on the access and egress for the Skylon South Magazine mini-zone based on the outcome of flood modelling (as provided in Appendix A). The modelling results show no flooding impacts this mini-zone or the access and egress routes during the 1% AEP plus climate change event. Building 51 is surrounded by a peak hazard value of 1.17 which is classified as 'moderate' hazard. The main access is via Hursey Road and onto the B4399, which experience no flooding during either event.

Table 10-3 Flood risk for Skylon South Magazine access and egress

	Access and egress information
Primary access/egress route	For the Skylon Central mini-zone there is one primary access route is via Hursey Road and onto the B4399.
Peak flood depth (on access route): 1% AEP plus climate change	Access is flood free.

Flood hazard: 1% AEP plus climate change	No flood hazard on this access route.
Flood hazard: 0.1% AEP	No flood hazard on this access route.

The flood hazard rating on the primary access routes for the Skylon South Magazine is considered acceptable and in accordance with the guidance provided in the Herefordshire 2019 SFRA. Consequently, no additional measures are required.

10.6 Proposed surface water drainage strategy

Drainage scheme

Considering the likelihood of low soil permeability within the area, discharge to the ground via infiltration is not considered a viable option. If more detailed site-specific ground investigation and long-term groundwater monitoring confirm that infiltration techniques are indeed not suitable, the following strategy should be considered:

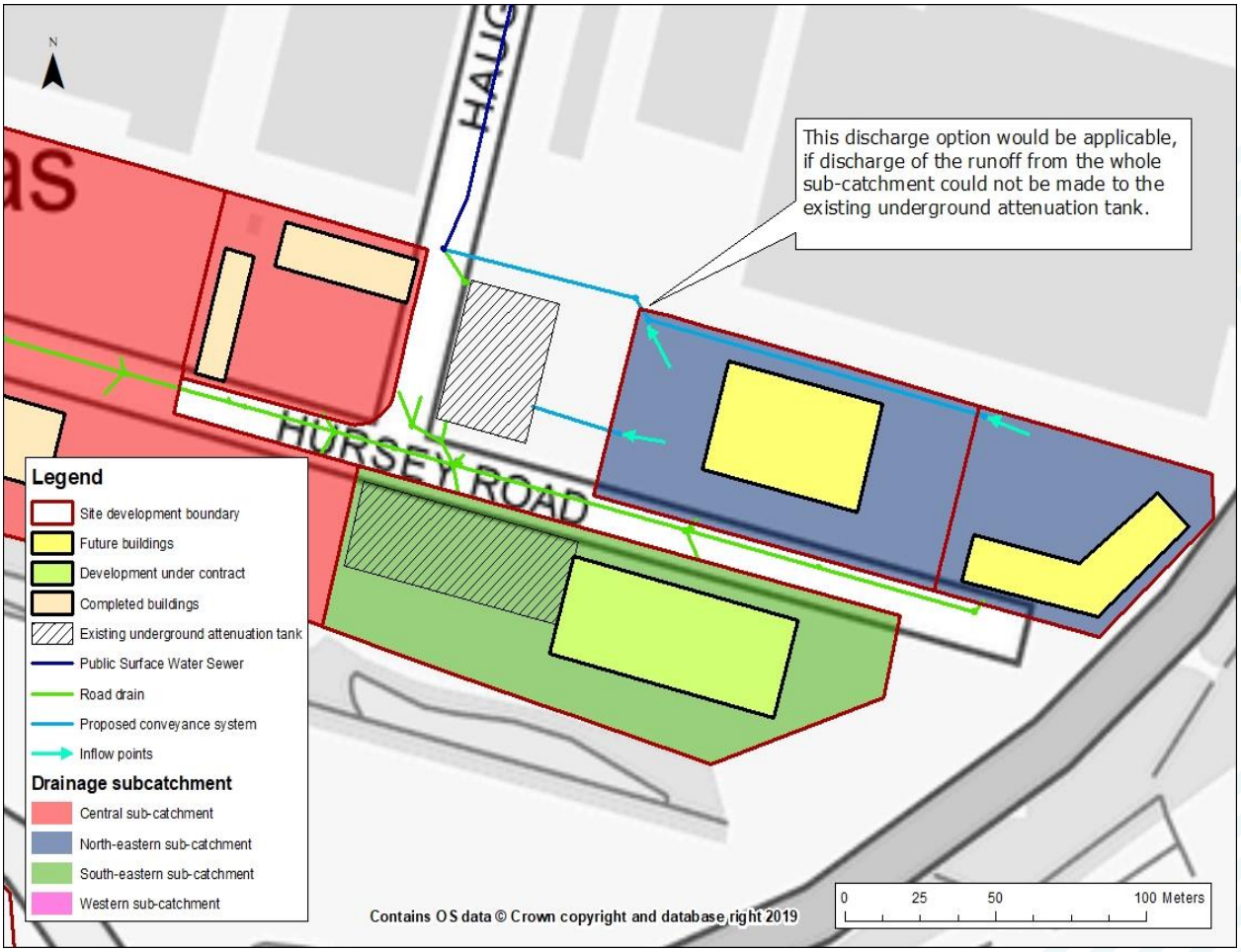
- Discharge the unattenuated surface water runoff into the existing underground attenuation tanks via a conveyance system. Although, it is understood that these tanks were designed to accommodate all flows from the north-eastern and south-eastern sub-catchments, it is currently uncertain if the flow control device located downstream of the northern tank would need to be upgraded on completion of the development to minimise the impact of the additional flow on the existing tank capacity. This would need to be confirmed prior to making a connection.
- Discharge the attenuated surface water runoff from the north-eastern sub-catchment into the existing tanks to minimise impact on the existing flow control device.
- If connection to the tanks proves difficult, discharge of the attenuated surface water runoff via a new conveyance system along the northern boundary of the site discharging directly to public sewer is Haugh Road - subject to DCWW and third-party owner approval.

On site attenuation storage would need to be provided within the sub-catchment prior to off-site connections for the two latter options. The attenuation should be accommodated in an above-ground facility, unless technical/spatial constraints preclude it.

The surface water runoff from the car park areas and yards should drain into the existing underground attenuation tank or the proposed conveyance system. The surface water runoff from the car park areas and yards should drain to the pond. To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. Additional measures, such as bioretention areas, swales and filter trenches should also be used. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

The conceptual proposal is shown in Figure 10-2.

Figure 10-2 Proposed drainage scheme within Skylon South Magazine



Discharge rates

The greenfield runoff rate has been calculated for the sub-catchment to be developed as shown in Table 10-4.

Table 10-4 Skylon South Magazine greenfield runoff rates

	Development site area (ha)	Calculated Qbar (l/s)	Minimum discharge rate (l/s)
North-eastern sub-catchment	1.11ha	1.19	2

Attenuation sizing

The impermeable area has been estimated as 0.89ha (assumed 80% of total area).

The required 100-year + 10%CC attenuation volume has been estimated between 527m^3 and 744m^3.

The SuDS calculations for Skylon South Magazine mini-zone are provided in Appendix G.

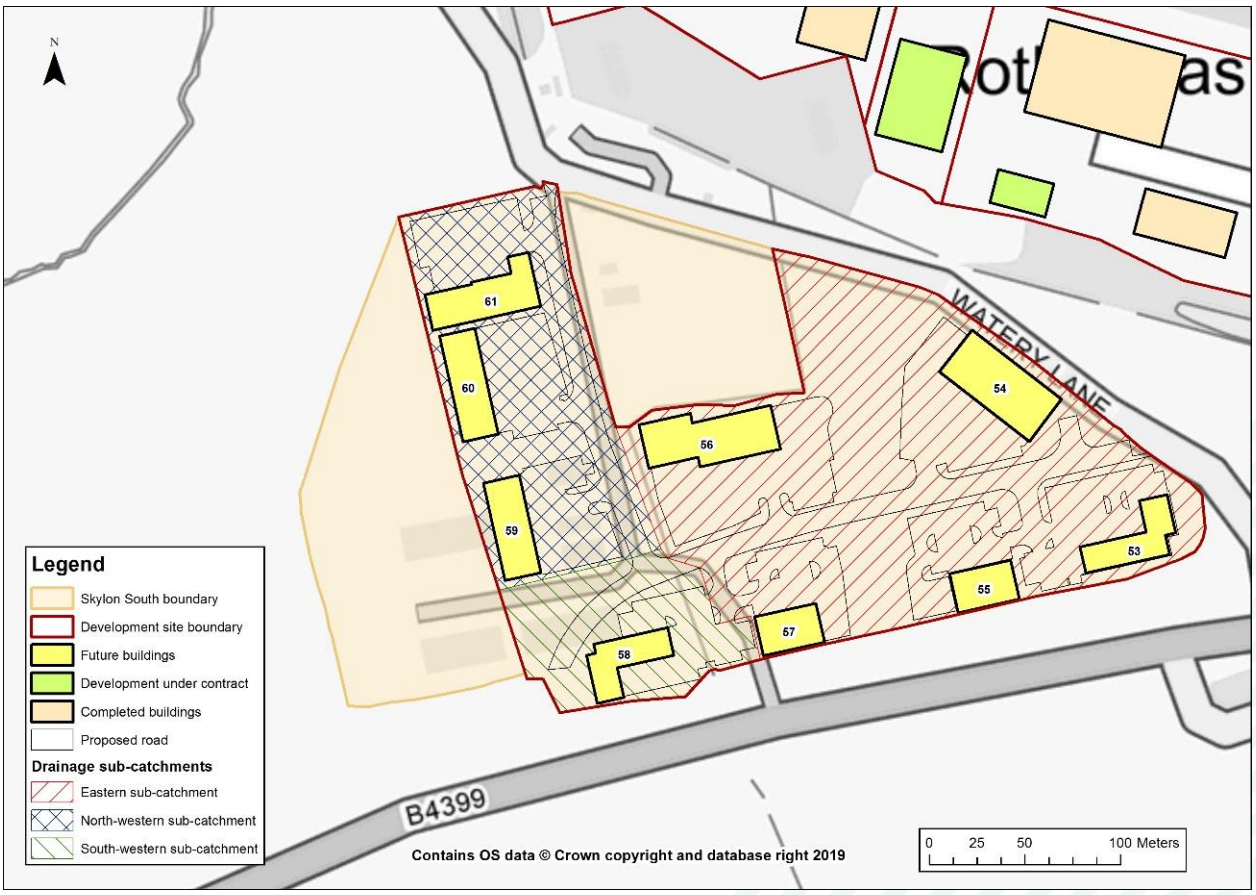
11 Skylon South

11.1 Site description

The development proposal for Skylon South mini-zone comprises up to 9 future buildings divided between 3 sub-catchments as shown in Figure 11-1.

Figure 11-1 reflects the indicative layout for Skylon South Magazine, as provided in June 2019 and derived from the outputs of a third-party master planning exercise managed by Hereford Enterprise Zone. As described in Section 1.3, the strategy recommendations for this mini-zone are not dependant on these precise layouts. Some variations to the developments would be applicable, provided that they do not significantly depart from proposals outlined herein.

Figure 11-1 Skylon South development and building numbers



The western sub-catchment is predominantly greenfield with individual agricultural buildings and associated hardstanding present in the most southern part of the site. The remaining sub-catchments are entirely greenfield. No site-specific topographical survey is available for the area. The publicly available LiDAR data suggests that the ground levels within the site vary between 53.73mAOD and 65.42mAOD with general ground fall in a northerly direction.

11.2 Existing geology and hydrogeology

Site-specific ground investigation has not been undertaken to date within the Skylon South development. The nearest historic borehole information available on the British Geological Survey (BGS) website is from 1989 and located 110m south of the site (BGS Reference: S053NW81).

The ground strata are described as follows:

- Firm dark brown slightly sandy silty clay with rootlets from the surface to depths of 0.50mbgl.
- Weathered mudstone - stiff red brown silty clay with occasional rootlets with depths between 0.50m and 1.20mbgl.
- Weathered mudstone and sandstone – stiff red brown silty clay interbedded with clayey silty sand with occasional lithorelicts of sandstone with depths between 1.20m and 3.70mbgl.
- Weathered silty mudstone – firm to stiff brown silty clay with lithorelicts of mudstone with depths between 3.70m and 6.0mbgl.

No groundwater was encountered during the investigation.

11.3 Existing drainage conditions

The Red Brook is located approximately 130m to the north-west of the site.

An unnamed watercourse crosses the development site from south to north. It is believed that this watercourse continues to run to the north of the site and to the west of the Skylon South Magazine development. The watercourse either discharges into the Red Brook or directly to the River Wye. However, this has not been confirmed.

There is currently no information available on whether the existing buildings in the north-western sub-catchment are served by a positive drainage system.

The site currently drains via natural infiltration to ground and overland flow following local topography towards the unnamed watercourse.

11.4 Fluvial flood risk

The Skylon south min-zone is located within Flood Zone 1 and is therefore not at risk of fluvial flooding. There is a small unnamed watercourse that flows through the site from the south in a northerly direction. There is no information to suggest that this watercourse provides any flood risk to the site. A review of the EA historical flood map, and long-term flood maps for both fluvial and surface water flooding does not indicate any risk to the site.

Site specific flood mitigation requirements are not necessary for this mini-zone. Ground levels for the proposed development should align with existing ground levels.

Access and egress for the Skylon South min zone is via Watery Lane and onto the B4399. Both roads do not experience flooding in either the 1% plus climate change event or 0.1% AEP event, providing access is from the south. Watery Lane becomes flooded if travelling in a north-westerly direction towards Hereford town centre.

11.5 Proposed surface water drainage strategy

Drainage scheme

A site-specific ground investigation and long-term groundwater monitoring will be required to determine the ground conditions on site and the potential for infiltration techniques.

If a site-specific ground investigation and long-term groundwater monitoring show that infiltration techniques are not suitable, the following should be considered:

North-western sub-catchment:

Discharge to the nearby water features. The potential options would be as follows:

- Discharge the attenuated runoff to the unnamed watercourse located to the north of the site via a conveyance system within the proposed access road and crossing Watery Lane, subject to the ownership, capacity and discharge conditions of the watercourse to the north. Connection to this culvert may require third party landowner agreement.

- Discharge the attenuated runoff to the Red Brook located to the west of the site via a conveyance system crossing third-party land, subject to third-party approvals.

For both options', attenuation storage will need to be provided within the sub-catchment prior to off-site connections. The attenuation should be accommodated in an above-ground facility, unless technical/spatial constraints preclude it.

The surface water runoff from the car park areas and yards should drain to the conveyance system. To satisfy water quality requirements and following technical considerations, permeable paving may be adopted for these areas to provide pre-treatment. Additional measures, such as bioretention areas, swales and filter trenches should also be used. In accordance with Herefordshire SuDS Handbook the use of oil interceptors should be avoided if possible.

South-western sub-catchment:

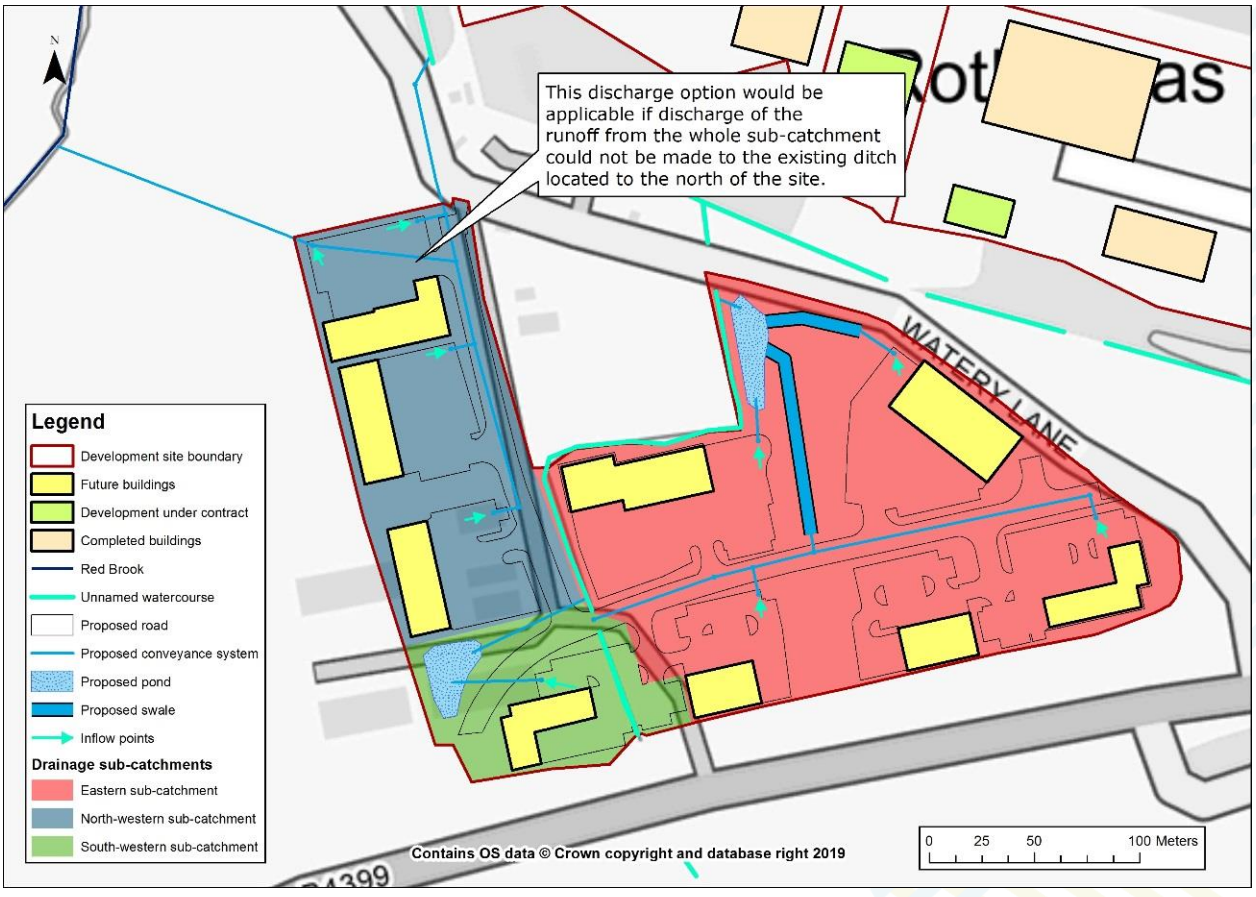
Discharge the attenuated runoff into the unnamed watercourse crossing the site. If dictated by spatial constraints the attenuation up to the 30-year storm event could be provided in an underground drainage system and remaining storage up to the 100-year plus climate change storm event in an above-ground facility, such as pond or basin.

Eastern sub-catchment:

Discharge the attenuated runoff into the unnamed watercourse crossing the site. A combination of swales and above-ground storage facilities could be used for the purpose of runoff conveyance and storage prior to discharge to the watercourse.

The conceptual proposal is shown in Figure 11-2.

Figure 11-2 Proposed drainage strategy at Skylon South site



Discharge rates

The greenfield runoff rates have been calculated for each sub-catchment as shown in Table 11-1. If practical, the discharges of sub-catchments should be combined to achieve a combined Qbar based minimum greenfield discharge rate that is not constrained by the minimum practical discharge rate of 2l/s.

Table 11-1 Skylon South greenfield runoff rates

	Development site area (ha)	Calculated Qbar (l/s)	Minimum discharge rate (l/s)
North-western sub-catchment	1.68	1.81	2.0
South-western sub-catchment	0.75	0.81	2.0
Eastern sub-catchment	3.71	3.99	4.0

Attenuation requirements

The impermeable areas have been derived from proposed site layout 'Site Layout – Masterplan – Option 2' by Ancer Spa Ltd, 29/03/2017. The required attenuation storage is summarised in Table 11-2.

Table 11-2 Attenuation volume required within Skylon South development

	Impermeable area (ha)	Attenuation volume required (m^3)
North-western sub-catchment	1.21	797 - 1088
South-western sub-catchment	0.41	188 - 282
Eastern sub-catchment	2.21	1413 - 1944

The SuDS calculations for Skylon South mini-zone are provided in Appendix H.

Appendix A - Hereford Enterprise Zone Modelling Technical Note

NOTE TO FILE

JBA Project Code	2018s1555
Contract	Flood Management and Drainage Strategy for Rotherwas
Client	Herefordshire Enterprise Zone
Day, Date and Time	26 September 2019
Author	Paul Redbourne
Reviewer / Sign-off	George Baker
Subject	Hereford Enterprise Zone Modelling Technical Note

1 Introduction

JBA Consulting have been commissioned by Herefordshire Enterprise Zone (HEZ) to provide an updated Drainage and Flood Management Strategy to support the continued development of the Enterprise Zone at Rotherwas Industrial Estate, Hereford.

Herefordshire Council published the first drainage and flood management strategy in 2009 to support the Hereford Enterprise Zone Local Development Order (LDO). This LDO expired in November 2018, hence the requirement for the updated flood management and drainage strategy.

This technical note has been prepared to document the flood modelling work that has been undertaken to aid with the production of the new Hereford Enterprise Zone Drainage and Flood Management Strategy.

1.1 Project objectives

The primary objective of the flood modelling work is to determine site specific flood management requirements for each of the mini-zones located within the HEZ, whilst developing a scheme that will not increase the flood risk to others.

The note to file provides a technical overview of the modelling process used for the development of the flood management aspect of the strategy. The general approach taken for the flood modelling work was as follows:

- Technical review of previous flood modelling within the study area.
- Liaison with the Environment Agency to agree the hydraulic and hydrological approach.
- Update the existing model to include best available data, and applying most recent methods and software.
- Development of a 'Present-Day' Model scenario to best represent the HEZ current conditions.
- Development of a 'Future-Development' Model scenario to represent development at the HEZ as best as is reasonably practicable.

1.2 Study Area

The modelled study area showing the 2D model extent covering the Hereford Enterprise Zone is shown in Figure 1-1.

Figure 1-1: Modelled study area

2 Model Review

The model review process focused on the updated version of the 1D-2D linked model originally developed for the 2009 strategy, this model was produced by JBA Consulting in 2008. The model is an amalgamation of the Environment Agency's 1D model of the River Wye combined with the 2D domain used to better represent overland flood risk to the Rotherwas Industrial Estate.

The 2D domain had been updated at numerous stages since the production of the 2009 strategy when additional site specific information was required to aid with development designs on the Rotherwas Estate.

The process of the model review focused on two main areas;

- EA 1D River Wye Model
- JBA 2D Model Domain

2.1 EA 1D River Wye Model

The underlying EA 1D model has remained largely unchanged since the development of the original management strategy in 2009. However, in 2012 Halcrow produced the River Wye Modelling, Forecasting and Review Study under the SFRM2 framework[1].

The two primary updates undertaken by Halcrow for the 2012 River Wye modelling work are the calibration work undertaken and the new hydrological assessment. The calibration work looked at three observed events including:

- October 2000
- February 2004
- September 2008

The modelling of these observed events was checked against five hydrometric gauges located throughout the model extent including Brewardaline, Belmont, Old Wye Bridge, Mordiford, and Ross on Wye. The model results were compared to the observed readings for these gauges with respect to hydrograph volumes, peak flow/level, and hydrograph timing. The calibration process focused primarily on the adjustments to hydraulic roughness values as well as structure loss coefficients at the various structures located at the gauges. Given the wide range of observed data and good calibration results, their there was a good level of confidence in the outputs from the updated model.

The new hydrological assessment has used the FEH statistical methodology to derive a series of design flow estimates for a range of return periods. Even though the datasets and methodology used are not the latest available, the EA have specified that it is their preference for these flows to be adopted for any flood modelling work on the River Wye.

[1] River Wye Modelling, Forecasting and Review Study SFRM2. 2012. Halcrow.

Table 2-1 provides a comparison between the model inflows for the River Wye model at Hereford. This shows that there has been a small increase in flows compared to those used in the 2009 modelling work for original Rotherwas flood management strategy.

Table 2-1: Peak inflow comparison between 2009 and 2012

	1% AEP	0.1% AEP
2009	808m3/s	1293m3/s
2012	846m3/s	1337m3/s
Difference (%)	+4.7%	+3.4%

The EA River Wye model provided for this study as part of a Product 7 data request showed that the model had been simulated using ISIS version 6.5. This is an outdated version of the software with FloodModeller v4.4 available at the outset of this project commission.

The review concluded that the 1D River Wye model updated by Halcrow in 2012 should be adopted for the flood modelling work in this study including the incorporation of the new model inflows and roughness coefficients.

2.2 JBA 2D domain

The 2D domain that had been bolted onto the EA 1D River Wye model in 2008 was developed specially to represent overland flood risk for the Rotherwas Industrial estate. This has been updated at numerous times since 2009 to reflect site specific investigation for development plots in the enterprise zone.

The review of this flood modelling highlighted the following:

- A number of the layers that have been incorporated into the model were 2D z-shape and Triangular Irregular Network (TIN) layers whose purpose was to specify the 2D surface topography. The source of these datasets could not all be verified, therefore reducing confidence that the model was correctly representing the current site elevations across the enterprise zone.
- TUFLOW executable version was outdated and should be updated.
- Base LIDAR and OS MasterMap datasets were outdated and should be updated.

The review highlighted that new data including topographical survey, LIDAR, and OS MasterMap should be added to the model along with updating the TUFLOW executable version for the new flood modelling work.

3 Data Review

The flood modelling work required the development of two model scenarios, one that represented the "Present-Day" site conditions and the second that represented the "Future-Development" site conditions. The data review focused on ensuring that these two model scenarios could be developed from the data available for the project.

The flood management strategy has split the HEZ into seven mini-zones to enable development and reporting of the site specific flood risk management requirements. Where available, the client provided a range of datasets for each of these mini-zones including:

- Topographical survey
- Site Masterplans (existing and proposed)
- Finished Floor Levels of constructed plots
- OS Datasets

The review process took a traffic light system approach which classified each of the mini-zones into a colour coded data quality grading to clearly show which mini-zone had a sufficient level data and which mini-zones required additional information.

The map shown in Figure 3-1 provides an overview of the findings of the data review process with the colour coding used to represent the quality of the data with Green providing a good quality dataset. Orange classified as acceptable and provides an improvement on the base LIDAR data but additional data / amendments may be required. Red is classified as unusable and providing no real benefit in its current state.

The primary outcomes of the data review were as followed for each of the mini-zones:

Chapel Road

- Data provided appeared to only reflect future site conditions
- No topographical data so LIDAR would be used to represent 2D topography.

Skylon Central

- Topographical survey collected in 2018. Comparison to LIDAR data indicates survey is the better dataset to use.
- Survey CAD file represented elevations as annotation only, therefore the CAD file needed to be updated so that elevations were represented within point date for inclusion into the hydraulic model.
- No information provided regarding as-built or finished floor levels for the plots already constructed on the Skylon Central mini-zone.

Skylon East

- Topographical survey was collected in 2014 which raised some concerns regarding its representation of current ground conditions. This was compared to LIDAR which showed that elevations were sufficiently different to warrant using the 2014 topographical survey.
- The topographical survey didn't cover the full extent of the Skylon East min-zone. For these areas LIDAR would be required to set ground elevations within the hydraulic model.
- Insufficient information to confirm the current level of recent development.

Figure 3-1: Map derived from data review

KEY

Legend

- Skylon South
- North Magazine
- Skylon north
- Chapel Rd
- Skylon East
- South Magazine
- Skylon Central

KEYPLAN

Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

Herefordshire Council

Hereford Enterprise Zone
Flood Management
Data Review Map

Scale: 1:7,000	Drawn	PR	22/01/2019
	Checked	GB	22/01/2019
Original @ A3	Approved	GB	22/01/2019
Digital File Name: 2018s1555_Hereford_001.MXD			
Drawing 2018s1555_Hereford_001	Sheet No.: 1 of 1		Rev.: A

Skylon North

- Multiple topographical survey datasets covered this mini-zone, these were collected in 2015 and 2018. Comparison to the LIDAR indicates that the survey is the better dataset to use.
- Survey CAD file represented elevations as annotation only, therefore the CAD file needed to be updated so that elevations were represented within point date for inclusion into the hydraulic model.
- Survey didn't cover full extent of Skylon North min-zone. Additional information was required for the Woodstock Trading site area.

Skylon North Magazine

- Topographical survey collected in 2018. Comparison to LIDAR data indicates survey is the better dataset to use.
- Survey CAD file represented elevations as annotation only, therefore the CAD file needed to be updated so that elevations were represented within point date for inclusion into the hydraulic model.

Skylon South

- Data provided included future-development information only, including proposed site masterplan. CAD drawing file was not geo-referenced so could not be easily incorporated into GIS.
- No topographical data provided so LIDAR elevations to be used within the hydraulic model.

Skylon South Magazine

- Topographical survey collected in 2018 and provided with elevations in the correct format within the CAD drawings. This is more recent that the LIDAR data as therefore taken forward for use within the hydraulic model.
- The topographical survey only covered the Eastern portion of the South Magazine mini-zone site. If no additional survey exists then LIDAR data will be utilised to represent the ground elevations.
- Additional information required to inform plots that have been constructed including building locations and finished floor levels.

The findings of the data review were shared with the client during an interim project meeting with all outstanding data issues addressed for the final model simulations. An updated site masterplan was provided which gave a clear delineation between proposed and already constructed building plots along with any finished floor level information.

4 General Model Updates

4.1 Software

The model review process highlighted that EA's River Wye model had been simulated with ISIS version 6.5. Since this modelling was undertaken, FloodModeller has been released (updated model package of ISIS). FloodModeller version 4.4 has been used for the flood modelling work.

The TUFLOW executable has also been updated to use the latest available version; 2018-03-AE-iSP-w64.

4.2 1D Domain

4.2.1 River Wye 1D model

The EA River Wye model provided under the product 7 data request extends a significant distance beyond the required model extent for the HEZ study. In the previous modelling the upstream node of the Hereford model was section 1.072. This section no longer existed in the updated 2012 Halcrow model and has been replaced by the more recently surveyed section "WYE67840" which now forms the new upstream extent of the Hereford model. The 2012 1D Halcrow model has been cut back at both the upstream and downstream extent to focus specifically on the Hereford region. The most upstream node "WYE67840" is located just upstream of the urbanised area of Hunderton. The downstream extent of the model is at node "CS1.01" which is located at Bullingham Hill.

4.2.2 Model Inflows

The model inflows have been updated from the 2009 HEZ modelling to make use of the Halcrow derived flows from the 2012 SFRM2 study. The hydrology study undertaken did not provide model input hydrographs directly for the upstream extent of the Hereford model. Flow hydrographs have been extracted from the River Wye model at the 1D node "WYE67840".

The product 7 dataset provided by the EA showed that two storm durations had been simulated. Section 5.2 of the Halcrow report[2] has stated that the reconciliation process of the design flows highlighted that adopting the larger 91 hour duration resulted in peak flows for each return period that closer represented the return period greater. It was therefore decided that the 57 hour storm duration which provided a closer match to the recorded storm durations over the Wye catchment should be used within the flood model for areas upstream of the Mordiford which the Rotherwas trading estate is. Therefore the flows for the updated HEZ modelling have been extracted form the 57 hour storm duration simulations.

The application of climate change required updating from the previous modelling studies. The River Wye is located within the Severn River Basin district map[3] and therefore requires a 25% increase to fluvial flows to represent the impact of climate change for the 2080's epoch.

4.3 2D Domain

4.3.1 LIDAR

[2] River Wye Modelling, forecasting, and Review Study SFRM2. 2012. Halcrow.

[3] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

The most recent LIDAR data has been incorporated into the flood model to represent the base topography cross the 2D domain of the model. A data request was raised with the EA at the project outset to check whether any new LIDAR had been flown compared to the open source dataset. The most recent LIDAR available was flown in 2009 and this has therefore been incorporated into the model.

The LIDAR was found to be a more recent representation of the site elevations when compared to the JBA 2D domain derived in the 2008 modelling as it included the newly constructed B4399 bypass road. The EA have indicated that new LIDAR will be flown for the River Wye but it was not undertaken in time for this study.

4.3.2 OS MasterMap

The OS MasterMap data is used within the hydraulic model to delineate the different land use types across the 2D domain and allow for 2D roughness coefficients to be specified for those given land use types. The client has provided the most recent OS MasterMap data which has been incorporated into the model. The roughness coefficients for the different land use types have been retained from the previous JBA modelling work.

4.4 1D-2D Linkage

The 2012 Halcrow model of the River Wye is a 1D model only, therefore the floodplain is being represented by a series of extended cross sections and lateral reservoir units. In order to successfully align the JBA 2D domain with the 2012 EA ISIS model, a number of amendments were required to the 1D model;

- The 1D cross sections between 1.043 to CS1.040 were trimmed back to their respective right bank locations, removing the floodplain storage through this reach that had previously represented the Rotherwas estate.
- One Lateral reservoir unit has been removed "S1.040RR", along with the lateral spills of S1.040RW, S1.039RW, and S1.037RW.

The 1D-2D HX linkage elevations have been specified using the base LIDAR DTM. This is generally the preferred approach for specifying the 1D-2D linkage elevations as it prevents artificially increasing or lowering the bank heights which can occur when you use the 1D cross section bank elevations and interpolate the heights between cross sections.

5 Present Day Model Updates

The 'present day' model scenario has focused on ensuring that the current ground conditions are being represented as accurately as practical. To this end, the primary updates have been to incorporate the topographical survey and include finished floor levels for development plots that have been constructed or approved for construction since the previous flood management strategy was produced in 2009.

5.1 Topographical survey

The data review process found that the topographical survey data was sufficient to update the base LIDAR ground conditions for the separate mini-zones without the need for additional survey. There were two methods for incorporating this survey data within the hydraulic model;

- Use Triangular Irregular Networks (TIN's) directly within the TUFLOW software which will create 2D triangulated DTM based of the surveyed elevations. This is usually preferred for small scale, site specific analysis as it can involve multiple iterations for it to be produced correctly.
- Alternatively, the surveyed elevations can be used to generate an Ascii grid Digital Terrain Model (DTM). This is generally a more user friendly automated approach with the output being read directly into TUFLOW. This was the approach taken forward.

There are a total of nine ASCII grid files being read into the model after the base LIDAR DTM, these have been read into the model in a particular order of most recent topographical survey being read in last to ensure that at any locations where they overlap the most recent survey is being utilised to set the model ground elevations. The different Ascii and their source topographical survey are detailed in Table 5-1.

Table 5-1: TUFLOW Ascii grid source files

TUFLOW ASCII Grid	Source Topographical Survey
TopoGrey.asc	Skylon North Topo Bury Assoc 2015.dwg
TopoSurvey.asc	Skylon North Topo Bury Assoc 2015.dwg
TopoFloodplainComp.asc	Skylon North Topo Bury Assoc 2015.dwg
SouthTopoSurvey.asc	13099-P-1 South Magazine S1-S11.dwg
South2018TopoSurvey.asc	South Magazine Topo Survey.dwg
SkylonEast.asc	HEZ-RWC-SC-XX-DR-Z-0001.dwg
BeyondStorage.asc	BA26500418_01-Topographcial-Survey.dwg
Woodstock_North.asc	T_MG1538.dwg
NorthTopoSurvey.asc	OP-438233-1A-3D.DWG

5.2 Building representation

The client has provided details of the building plots that have been constructed or approved for construction at the time of this project commission award. The masterplan in Figure 5-1 shows that the building footprints coloured in orange and green are to be included within the present day model scenario.

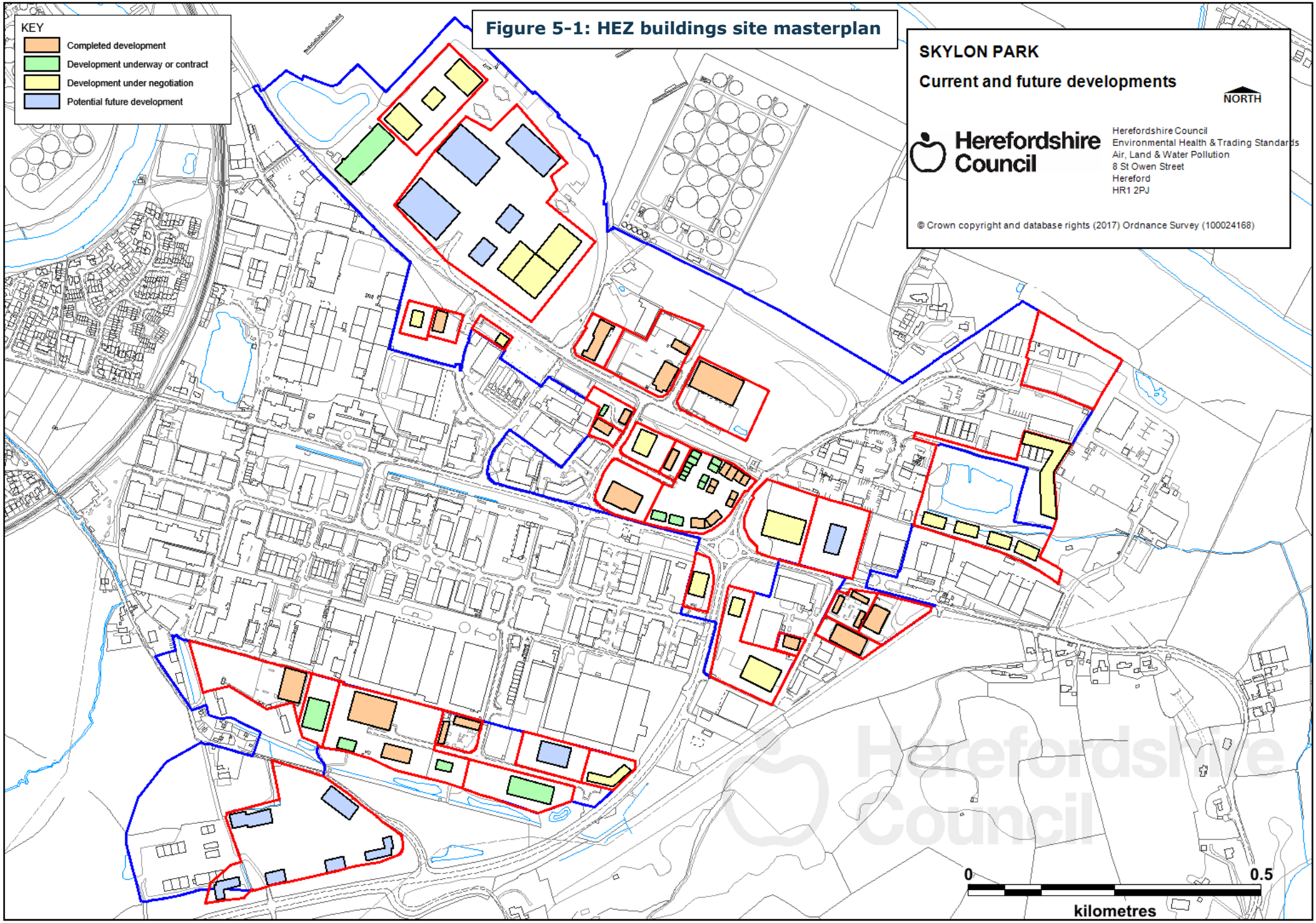


Figure 5-1: HEZ buildings site masterplan

For the majority of these buildings the client provided finished floor levels that have been read directly into the model. Where finished floor levels were not provided, the building footprints were raised to 100mAOD to represent finished floor levels above the flood level. This approach was discussed and agreed with the EA at an interim stakeholder meeting.

Figure 5-2 shows the model schematic for the present-day model scenario with the inclusion of the flood storage pond, flood management swales and the building footprints added to the model that have been constructed or approved for construction along with their respective elevations within the model.

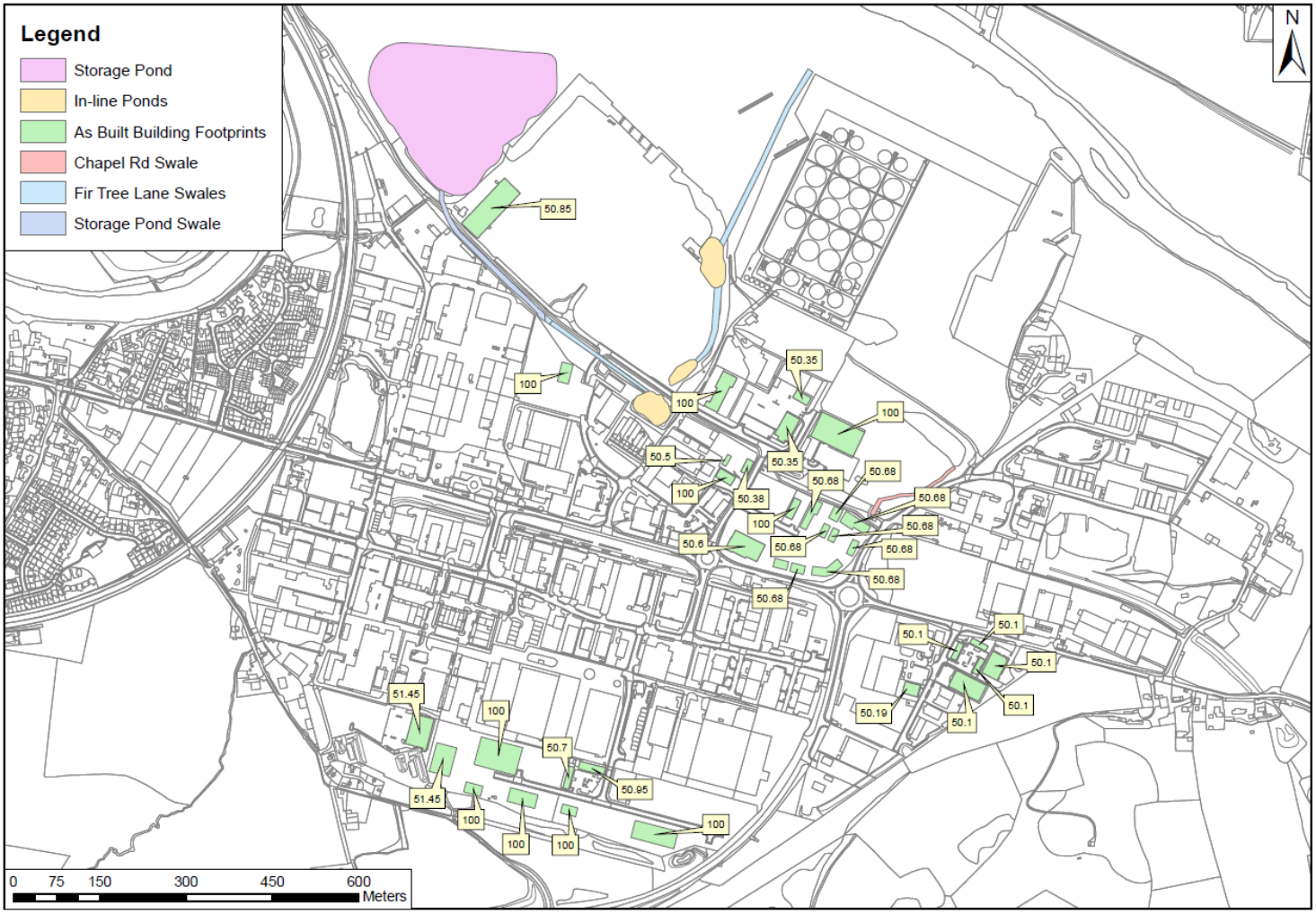


Figure 5-2: Present day model schematic

The inclusion of the topographical survey and existing building footprints has resulted in a noticeable change to the model topography of the Rotherwas estate mini-zones as shown in Figure 5-3 which compares the 2009 base LIDAR DTM against the present-day modelled DTM. It should be noted that the topographical survey included a series of temporary material heaps across the study area, these have been removed from both the present-day and future-development model scenarios as they are only temporary fixtures.

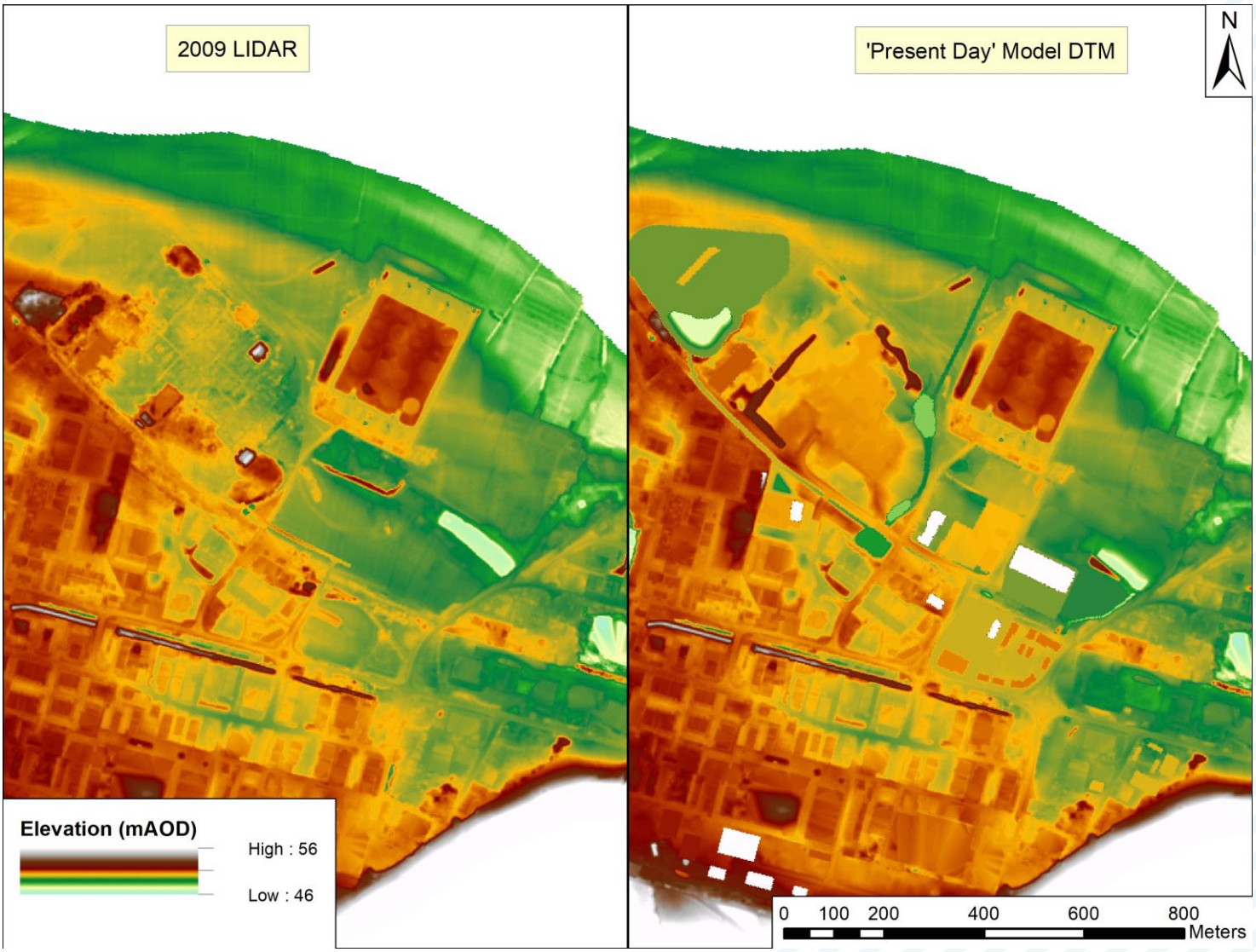


Figure 5-3: DTM comparison between 2009 LIDAR and present-day model DTM

6 Future Development Model Updates

The purpose of the future development scenario is to derive site specific flood risk management including finished floor levels for the proposed development plots along with any site specific flood management such as ground raising or lowering.

The client provided a detailed masterplan for the building plots that are proposed for construction which have been represented within the future development model scenario. It was decided that all building footprints would be raised to an elevation of 100mAOD to enable their maximum potential impact of third party detriment to be assessed. This approach also enables the proposed finished floor levels to be derived by assessing the maximum water level that surrounds the building footprint.

A selection of model layers have been used to specify the topographical modifications in the future development model scenario, details of these layers and how they have schematised is provided in Table 6-1.

Table 6-1: Future-development model layers

TUFLOW Layer	Elevation (mAOD)	Comment
2d_zsh_HFD_Post_Dev_096	100mAOD	Proposed building footprints, raised to 100mAOD so that they remain flood free.
2d_zsh_HFD_North_Mag_Site_107	50.5mAOD and 50mAOD	Ground raising located in the North Magazine site to account for surrounding car parking elevations.
2d_zsh_HFD_Beyond_Storage_Post_Dev_102	49.85mAOD	Surrounding ground levels for Beyond Storage site.
2d_zsh_HFD_Woodstock_Post_Dev_107	49.5mAOD	Site elevations set to 49.5mAOD to correlate to the already developed Woodstock site.
2d_zsh_HFD_C1_Post_Dev_Ground_102	49.3mAOD	Surrounding ground elevations for the building plots in Skylon East mini-zone located to the north of The Straight Mile.
2d_zsh_HFD_Chapel_Rd_Post_Dev_Level_107	48.85mAOD	Surrounding ground elevations for a section of the Chapel Rd mini-zone.
2d_zsh_HFD_Skylon_East_Ground_Levels_103	49.4mAOD	Ground levelling for a single development plot in the Skylon East mini-zone.
2d_zsh_HFD_Skylon_East_Bund_103	50.3mAOD	A small flood bund is required in the Skylon East mini-zone that runs along the eastern side of the B4399 to address third party detriment issues.

7 Model Results

7.1 Present Day Flood Risk

The present day model updates applied to the model have accounted for the EA's preferred input hydrology, made use of the best available data and utilise the most recent flood modelling software.

The impact of these changes have been compared to the existing EA flood zone mapping of the Rotherwas industrial estate as shown in Figure 7-1 which highlights a slight reduction in flood outline for the present day 1% AEP event in comparison to the flood zone 3 outline across the Rotherwas estate. For the 0.1% AEP event the outlines are more similar.

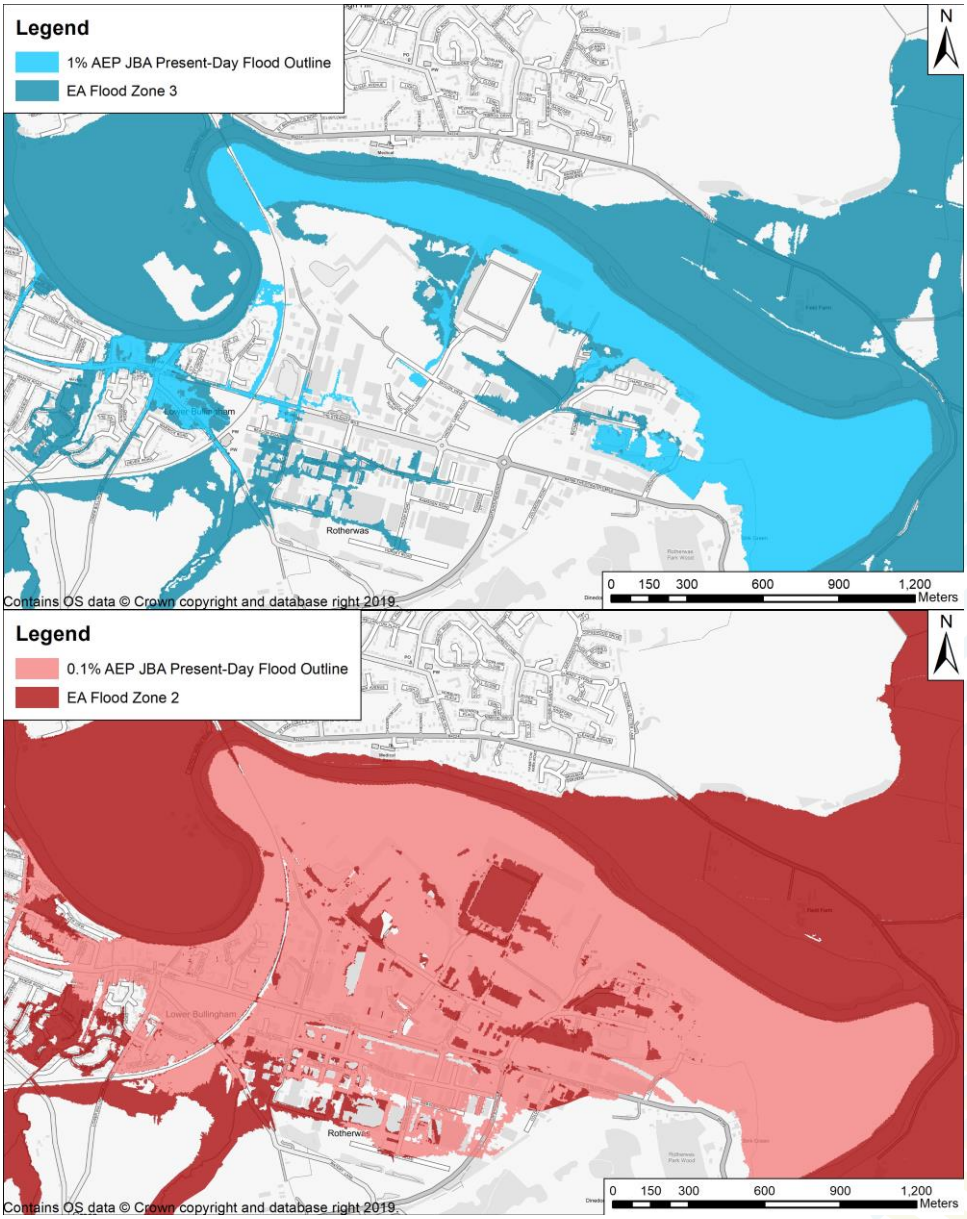


Figure 7-1: EA flood zone comparison

The primary flood mechanism impacting the Hereford Enterprise Zone is due to the exceedance of channel capacity along the right bank of the River Wye to the West of the raised railway line, floodwater spreads eastwards and through the two underpasses that allow access into the industrial estate at The Straight Mile Rd and the Greenway access lane. Floodwater also enters the HEZ from the River Wye at the north eastern corner of the industrial estate.

Once into the industrial estate the floodwater spreads laterally across the industrial estate in a predominately east to west direction. Figure 7-2 shows the 0.1% AEP event depth grid for the present-day model scenario. Arrows have been used to show the overland flow routes from the River Wye entering into the industrial estate.

Flood depths differ significantly across the industrial estate, with localised depressions experiencing high depths (>3m). The main roads act as primary flow routes for the conveyance across the site with the majority of the Straight Mile Road underwater during the 0.1% AEP event with depths ranging from relatively shallow depths of 0.1m up to 3m at the underpass location.

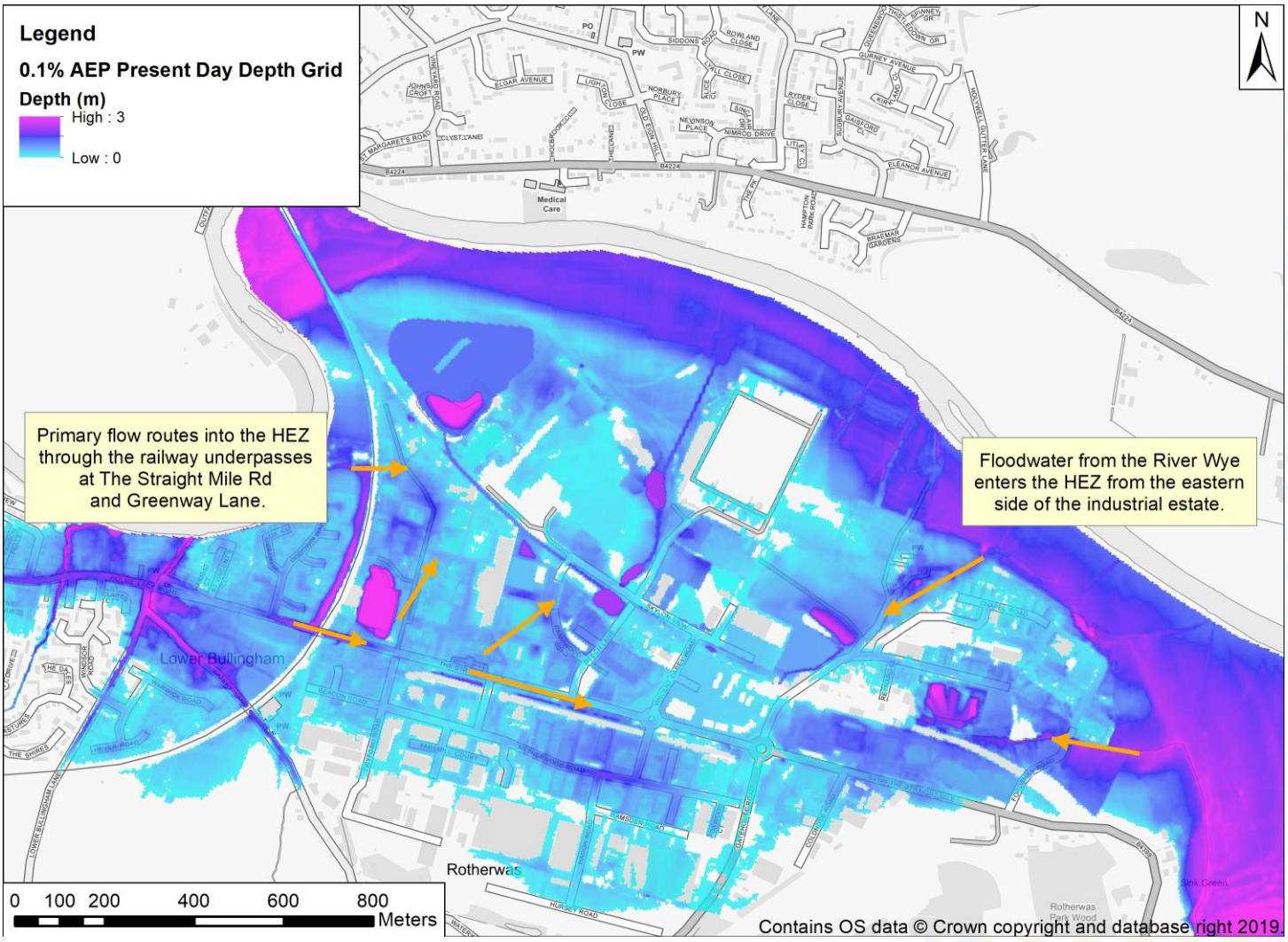


Figure 7-2: 0.1% AEP depth grid for the present day model scenario

7.2 Future development flood risk

The amendments made to the future-development model scenario have been included to simulate an acceptable level of flood risk for the proposed mini-zone developments. This has been assessed not only in terms of flood depths and hazard but also in respect to third party detriment to existing site users/owners.

Figure 7-3 shows the 0.1% AEP event depth grid for the future-development model scenario. In comparison to Figure 7-2 there are a number of blanked out areas which represent where the future-development building plots have been raised above the flood level. Other than where site specific modifications have been applied, such as raised building footprints and their surrounding car park grounds, the flood depths have remained largely unchanged when compared to the present day model scenario as shown in Figure 7-4.

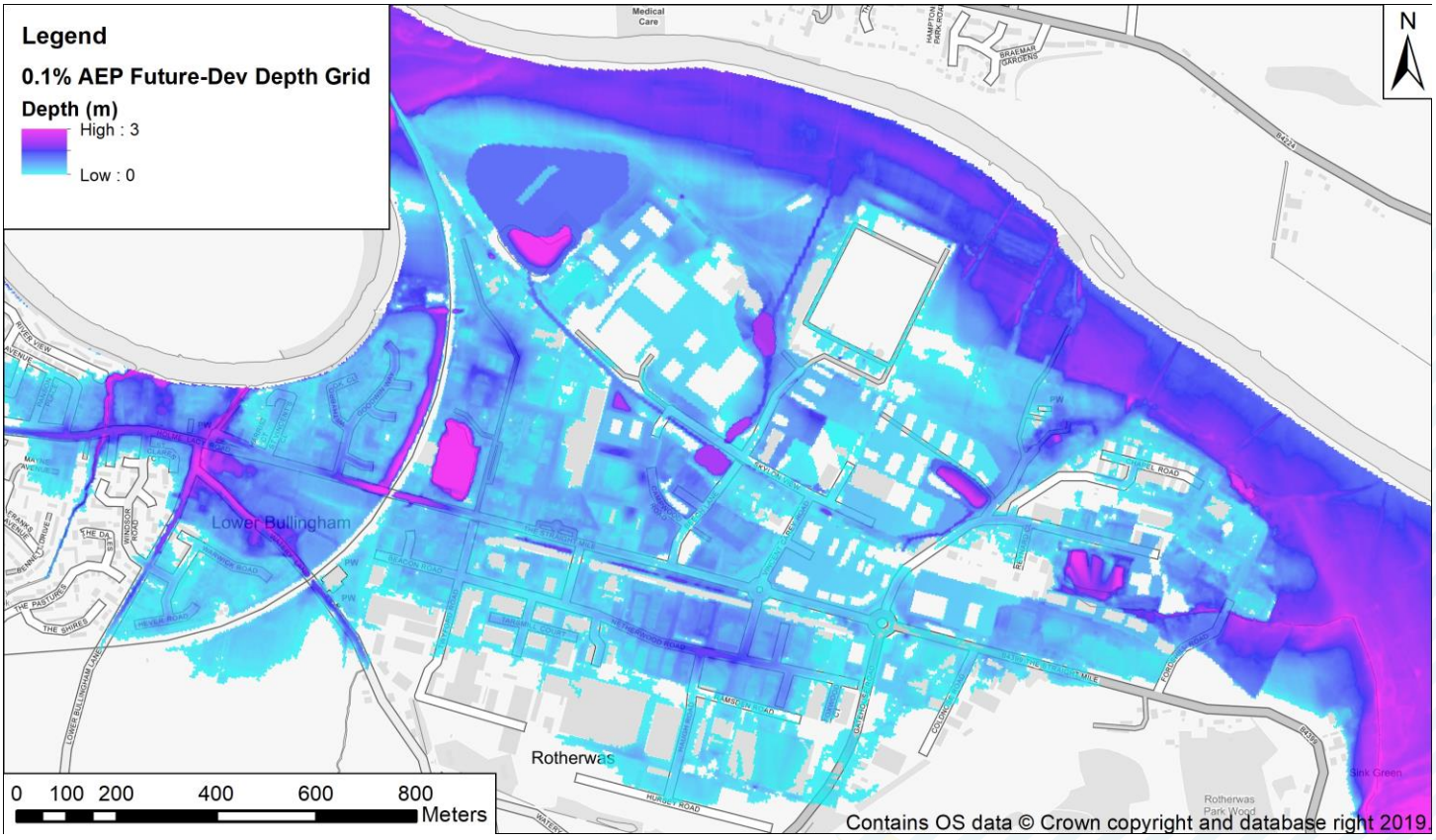


Figure 7-3: 0.1% AEP event future-development depth grid

Figure 7-4 shows a flood depth grid comparison for the 0.1% AEP event between the present day and future-development model scenarios. As can be seen there is no change in flood depths across the majority of the HEZ as a result of the proposed development works. There are some small pockets of localised increases in flood depths but these are contained to below a 10cm increase.

It is worth noting that there are a number of areas that have resulted in a reduction in flood depths as a result of topographical modifications made for the future-development model scenario. These flood risk improvements are not only benefitting the proposed developments but also some of the existing business units.

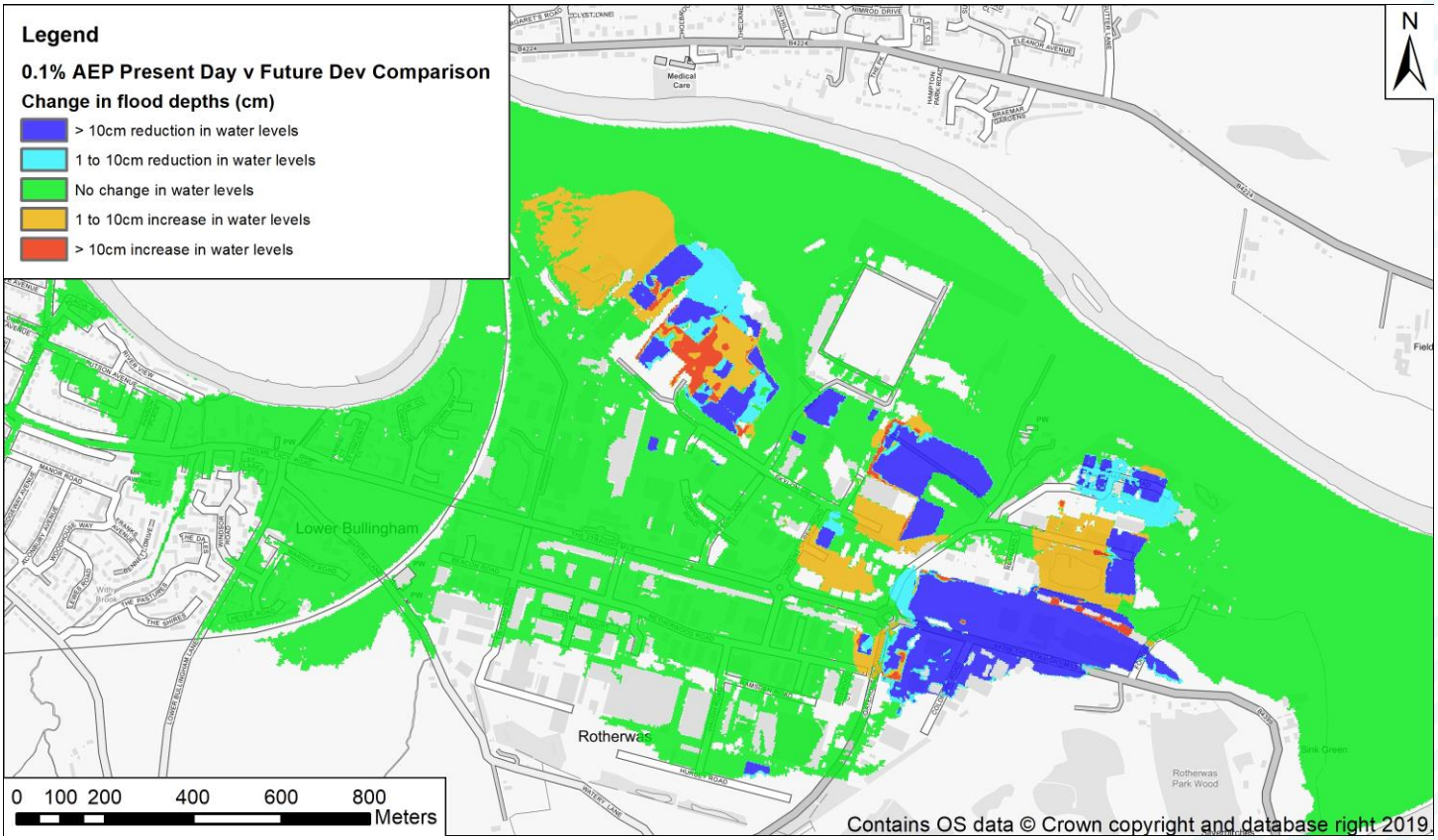


Figure 7-4: 0.1% AEP event depth comparison between present day and future-development model scenarios

Along with flood depth, the flood hazard classification is an important model result output for accessing the suitability of the potential development within the HEZ. One of the aspects of the flood management strategy is to provide guidance on the safe access and egress routes for the mini-zone developments. Table 7-1 provides an overview of the different hazard classifications.

Table 7-1: Hazard to people classification

Flood Hazard Code	Rating Colour	Hazard to People Classification
Less than 0.75		Very low hazard – Caution
0.75 to 1.25		Moderate - Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		High - Danger for most – includes the general public
More than 2.0		Very high - Danger for all – includes the emergency services

Figure 7-5 shows the hazard grid classifications for the 0.1% AEP event for the future development scenario. For the most part, the proposed development plots and their associated ground raising have meant that the level of hazard is between low and moderate.

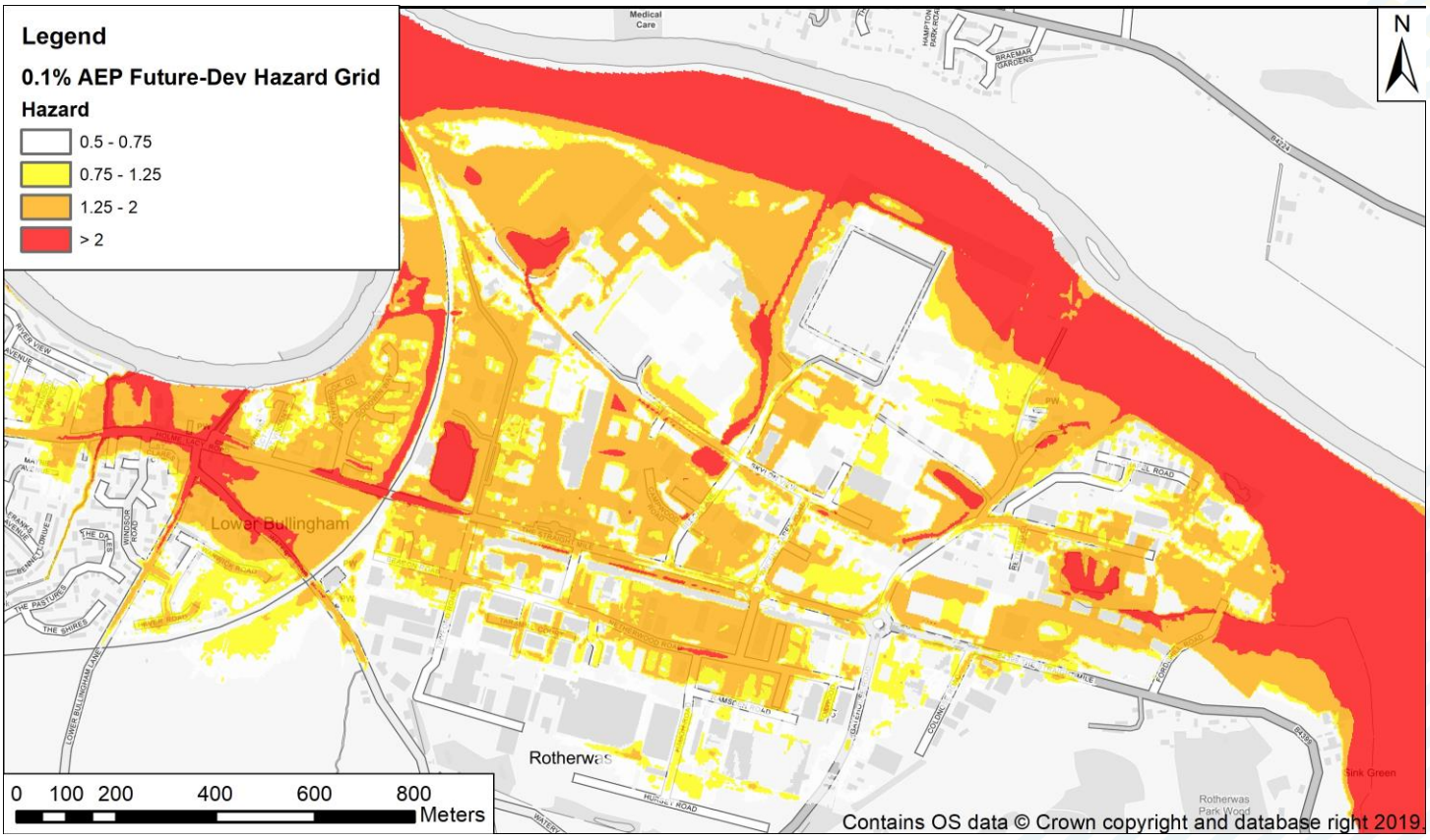


Figure 7-5: 0.1% AEP event future-development hazard grid

8 Assumptions, uncertainties, and limitations

Developing a hydraulic model requires the application of simplifications and generalisations. As such a number of assumptions are made when building the model. This can lead to model uncertainties and subsequent limitations in the results.

The model inflows have been extracted from the 2012 Halcrow model of the River Wye. These flows have been included at the request of the EA as these have been preferred to any subsequent hydrological assessments that have been undertaken. These flow estimates are now becoming outdated both in terms of the software and data used to derive them. The flows have increased slightly compared to those used for the flood modelling used to inform the 2009 flood management strategy for the HEZ and are therefore deemed to be acceptable. However, there is some uncertainty with these inflows and if a new hydrological assessment was undertaken the peak flow estimates could change.

The base LIDAR DTM is a source of uncertainty, this was flown back in 2009 and doesn't correctly reflect the entirety of the ground conditions across the HEZ. The uncertainty surrounding the base LIDAR DTM ground elevations has been improved as much practicably possible with the inclusion of a range of topographical survey data however this is sourced from different time periods and is not a perfect substitute for current up to date LIDAR.

The general model performance is very good as there are no negative depths present but the peak mass balance error extends beyond the recommended +/-1% range for all of the simulated design events. This occurs between 23-25 hours into the model simulation. The peak water levels across the Skylon business park do not occur until occur approximately 66 hours into the simulation. This shows that the peak MB error is having no bearing on the results at the time of maximum flooding. The spike in MB error that occurs at 23-25 hours can be traced to the initial wetting of 2D cells. Although it would be preferable for the MB error to remain within the recommended +/-1% range, the high MB error is not impacting peak model results and returns to acceptable conditions within 15 minutes. Therefore, this is deemed to be an acceptable limitation.

The future development scenario is based on assumed building footprints, it is possible that building locations and footprints may differ slightly for construction purposes. Providing the building footprint sizes don't change significantly then this shouldn't have a significant impact on the modelled flood risk across the HEZ.

9 Model References

9.1 Present Day Model Scenario

Run Reference:	HFD_~e1~_108 (e1 = design event)	
Purpose of Runs:	To model a range of fluvial flood events for the present-day scenario	
TUFLOW file and Version: 2018_03_AE_iSP_w64 FM Version: 4.4	File Names:	
	HFD_~e1~_108.tcf	HFD_002.tmf
	HFD_~e1~_108.ecf	HFD_JBA_2019_051.DAT
	HFD_108.tgc	HFD_066.tbc
Model timesteps:	A 2 second timestep has been applied within the 2D TUFLOW model and a 1 second timestep has been applied within the 1D domain in FloodModeller.	
Run Time:	Model event duration: 100 hours for design events, simulation time: 6 hours.	
AEP event(s)	1% AEP, 0.1% AEP, and 1% AEP + 25% climate change factor	
Comments on results:	Peak 1% AEP MB Error = -2.49% Final Cumulative 1% AEP MB Error = -0.03% 0.1% AEP MB Error = -2.38% Final Cumulative 1% AEP MB Error = 0.00%	

9.2 Future Development Model Scenario

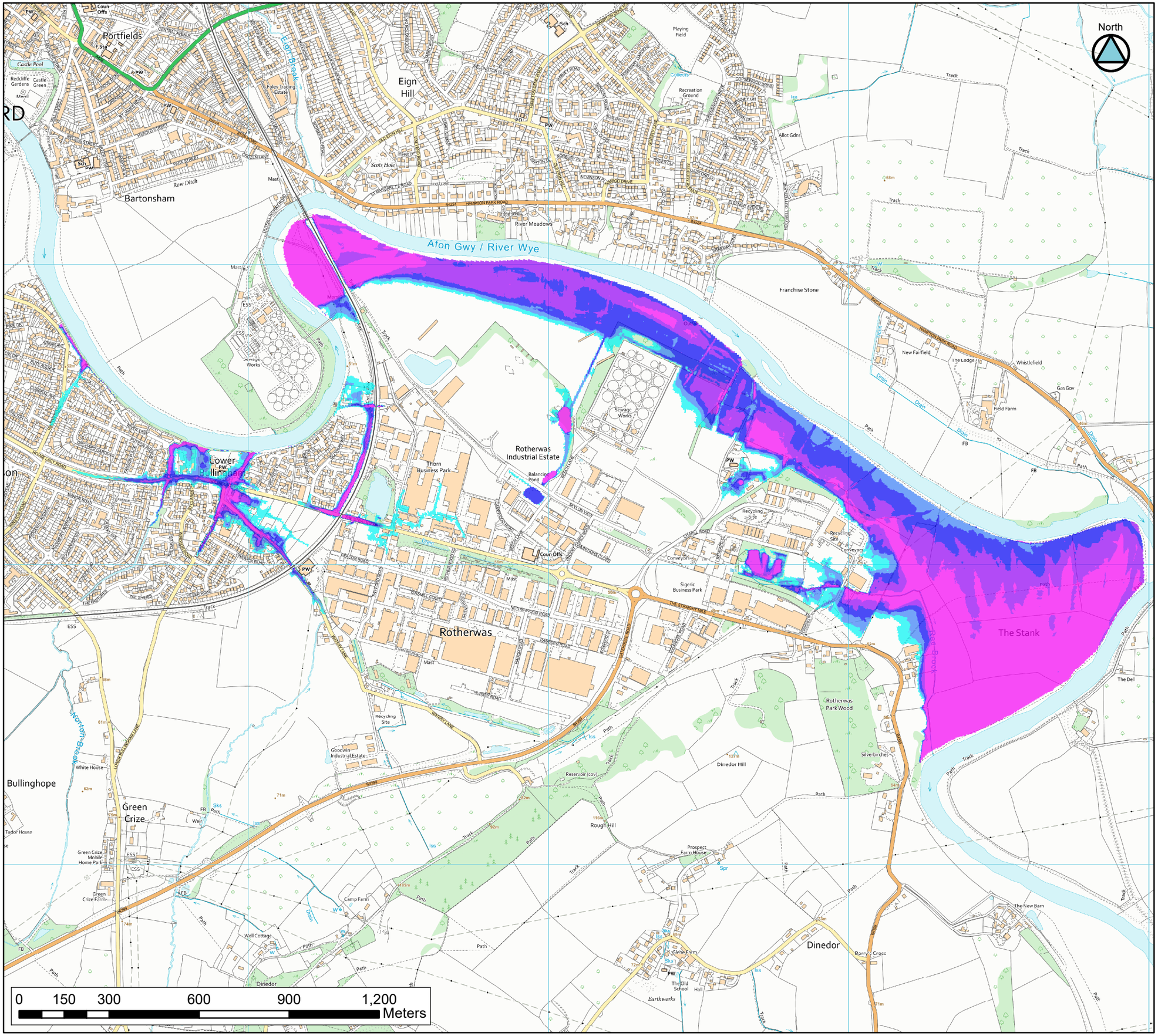
Run Reference:	HFD_~e1~_109 (e1 = design event)	
Purpose of Runs:	To model a range of fluvial flood events for the present-day scenario	
TUFLOW file and Version: 2018_03_AE_iSP_w64 FM Version: 4.4	File Names:	
	HFD_~e1~_109.tcf	HFD_002.tmf
	HFD_~e1~_109.ecf	HFD_JBA_2019_051.DAT
	HFD_109.tgc	HFD_066.tbc
Model timesteps:	A 2 second timestep has been applied within the 2D TUFLOW model and a 1 second timestep has been applied within the 1D domain in FloodModeller.	
Run Time:	Model event duration: 100 hours for design events, simulation time: 6 hours.	
AEP event(s)	1% AEP, 0.1% AEP, and 1% AEP + 25% climate change factor	
Comments on results:	Peak 1% AEP MB Error = -2.49% Final Cumulative 1% AEP MB Error = -0.03% 0.1% AEP MB Error = -2.38% Final Cumulative 1% AEP MB Error = 0.00%	

10 Conclusions

The updated 1D-2D linked River Wye model for the Herefordshire Enterprise Zone has incorporated the best available data and uses the most recent software versions. The project has involved input from the EA to ensure that the modelling approach is appropriate and acceptable for the needs of the HEZ flood management strategy.

The flood modelling work has enabled two model scenarios to be developed looking at the present-day site conditions and the future-development conditions. The two model scenarios have been simulated for the 1%, 0.1%, and 1% AEP plus climate change (+25%) events.

Site specific flood management including finished floor levels and surrounding car parking ground levels has been achieved and detailed in the main flood management strategy report for the all of the mini-zones. The flood modelling work has shown that the proposed development will not result in any significant third party detriment to the existing users/owners in the Rotherwas industrial estate.

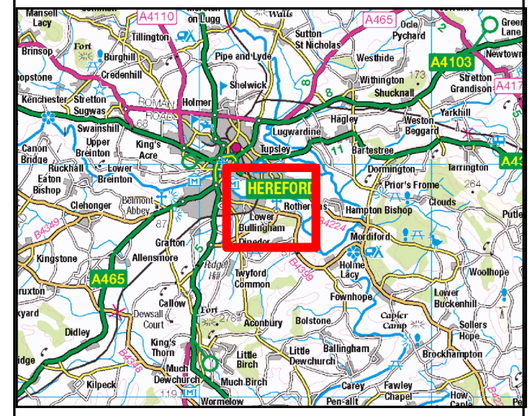


KEY

Depth (m)

- <0.3m
- 0.3 - 0.6m
- 0.6 - 0.9m
- 0.9 - 1.2m
- >1.2m

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

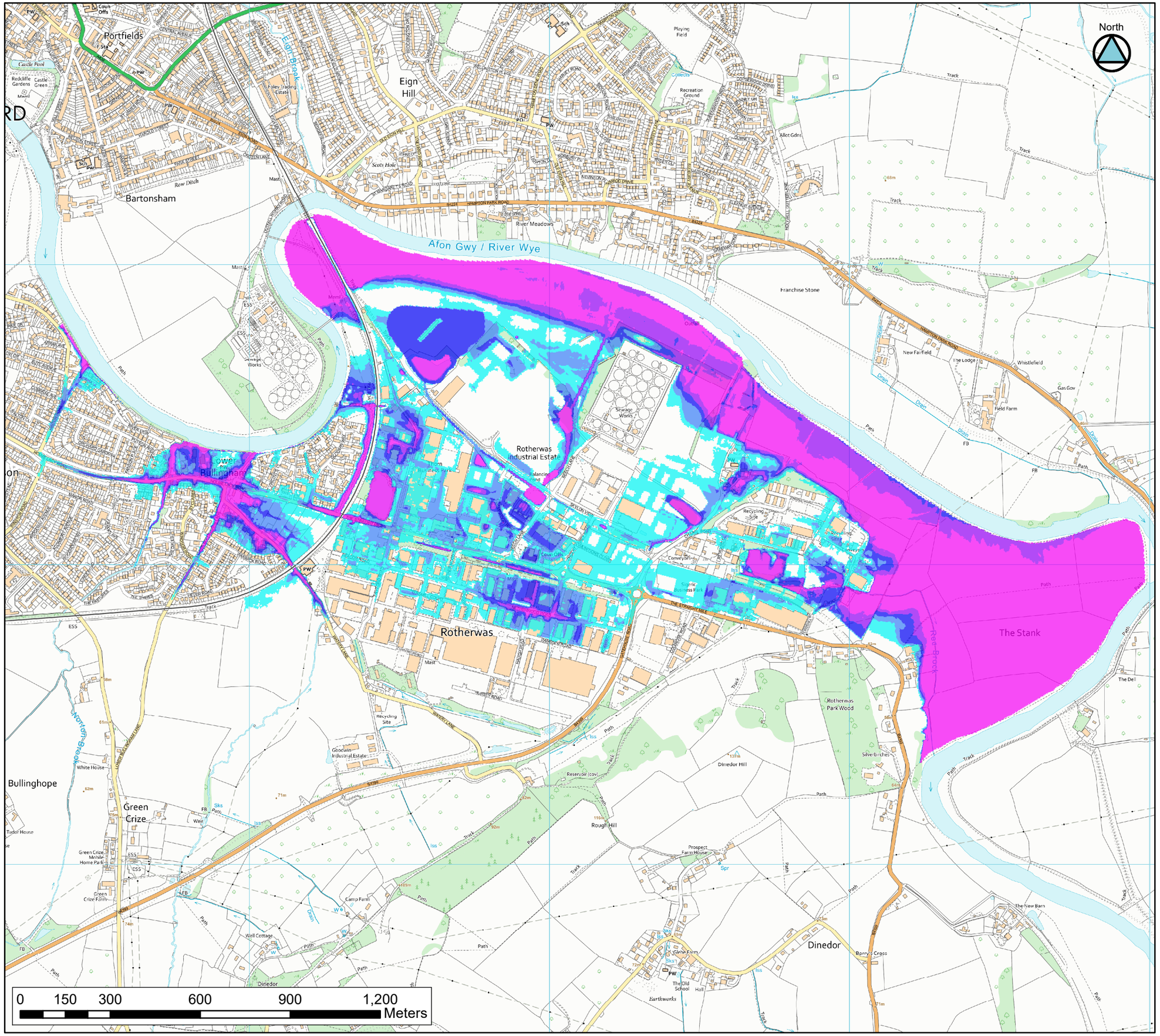
Hereford Enterprise Zone

River Wye Hereford Model
1% AEP event
Future-Development
Flood Depth Map

Scale: 1:12,000	Drawn	PR	27/09/2019
	Checked	GB	27/09/2019
Original @ A3	Approved	GB	27/09/2019

Digital File Name: 2018s1555_Depth_Maps.MXD

Drawing 2018s1555_001	Sheet No.: 1 of 1	Rev.: A

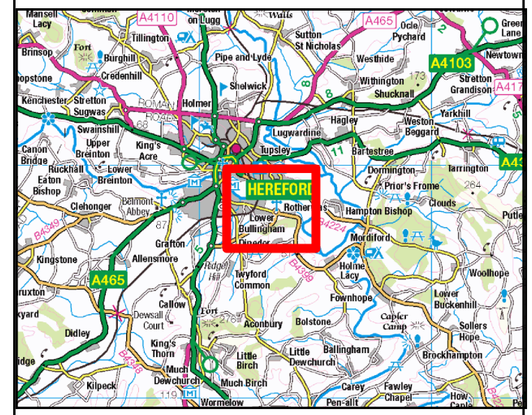


KEY

Depth (m)

- <0.3m
- 0.3 - 0.6m
- 0.6 - 0.9m
- 0.9 - 1.2m
- >1.2m

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

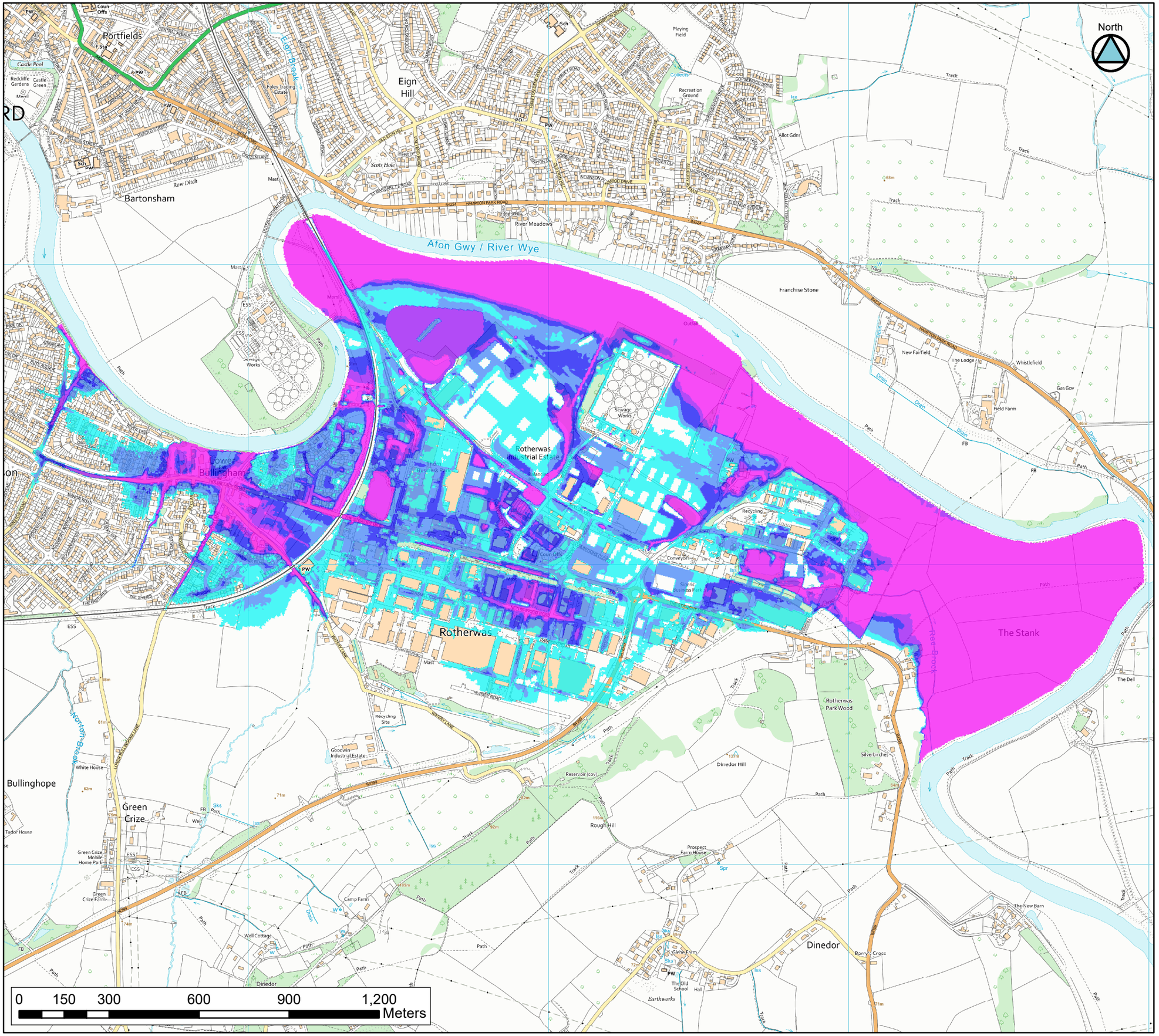
Hereford Enterprise Zone

River Wye Hereford Model
1% AEP + Climate Change (25%) event
Future-Development
Flood Depth Map

Scale: 1:12,000	Drawn	PR	27/09/2019
	Checked	GB	27/09/2019
Original @ A3	Approved	GB	27/09/2019

Digital File Name: 2018s1555_Depth_Maps.MXD

Drawing 2018s1555_002	Sheet No.: 1 of 1	Rev.: A

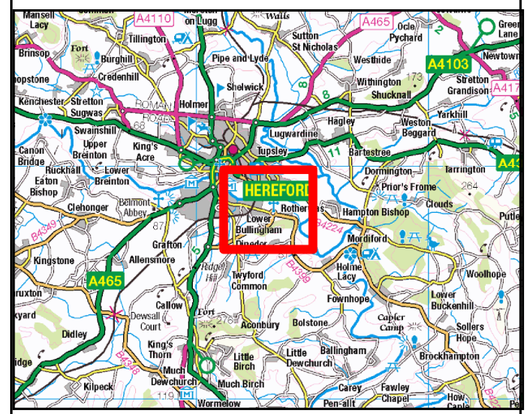


KEY

Depth (m)

- <0.3m
- 0.3 - 0.6m
- 0.6 - 0.9m
- 0.9 - 1.2m
- >1.2m

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

Hereford Enterprise Zone

River Wye Hereford Model
0.1% AEP event
Future-Development
Flood Depth Map

Scale: 1:12,000	Drawn	PR	27/09/2019
	Checked	GB	27/09/2019
Original @ A3	Approved	GB	27/09/2019

Digital File Name: 2018s1555_Depth_Maps.MXD

Drawing 2018s1555_003	Sheet No.: 1 of 1	Rev.: A

North

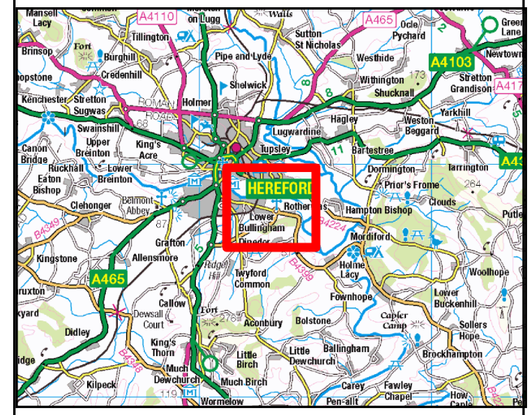
0 150 300 600 900 1,200 Meters

KEY

Flood Hazard

- 0.5 - 0.75
- 0.75 - 1.25
- 1.25 - 2
- > 2

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

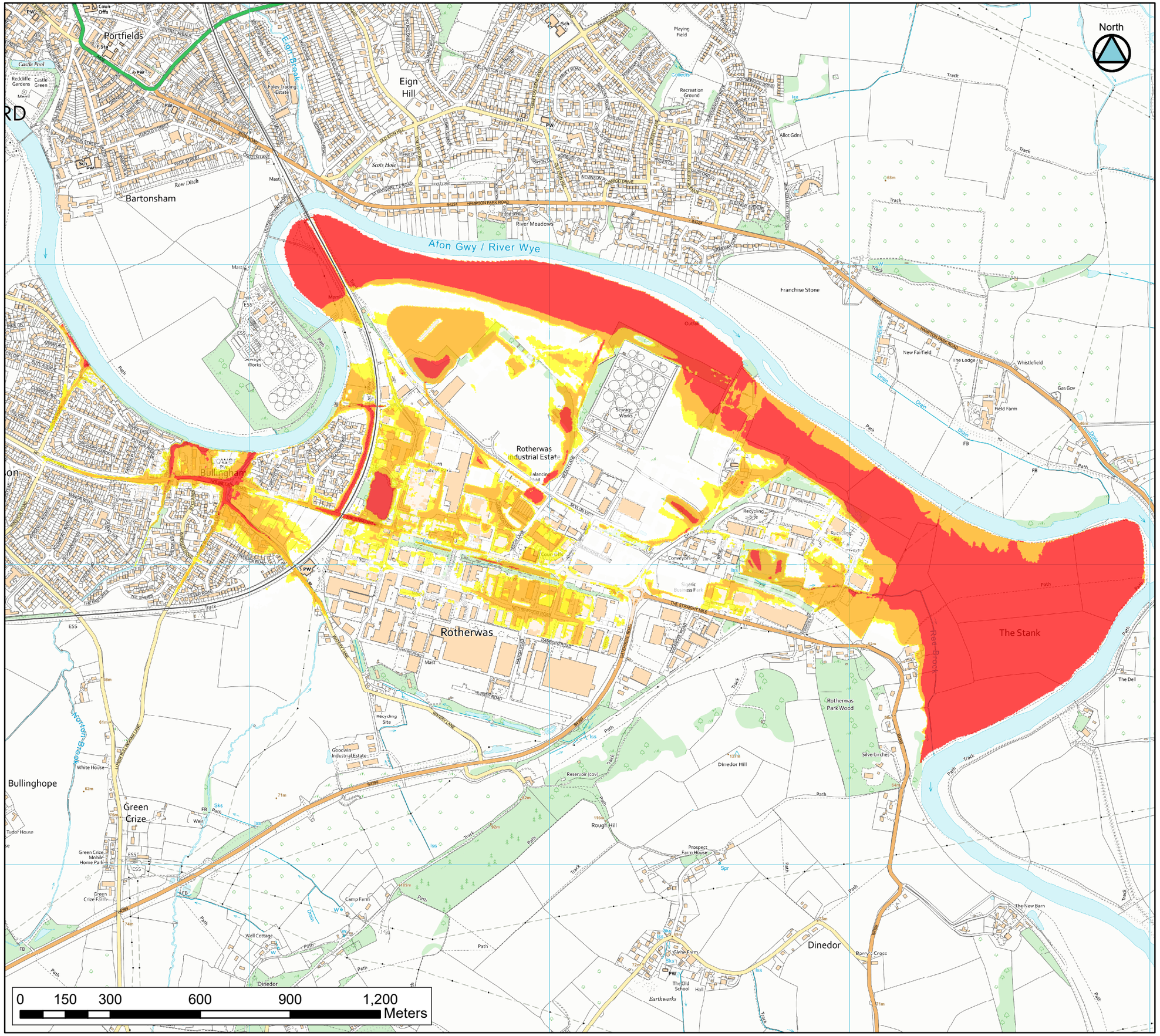
Hereford Enterprise Zone

River Wye Hereford Model
1% AEP event
Future-Development
Flood Hazard Map

Scale: 1:12,000	Drawn	PR	27/09/2019
	Checked	GB	27/09/2019
Original @ A3	Approved	GB	27/09/2019

Digital File Name: 2018s1555_Hazard_Maps.MXD

Drawing 2018s1555_004	Sheet No.: 1 of 1	Rev.: A

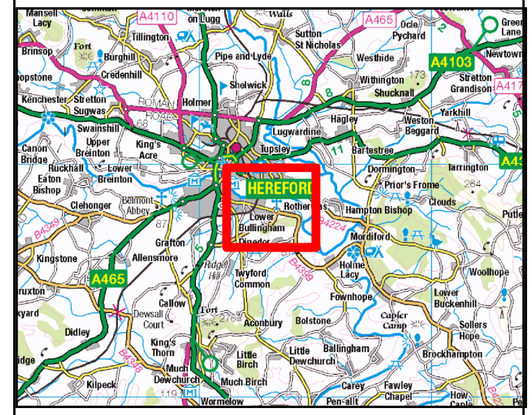


KEY

Flood Hazard

- 0.5 - 0.75
- 0.75 - 1.25
- 1.25 - 2
- > 2

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

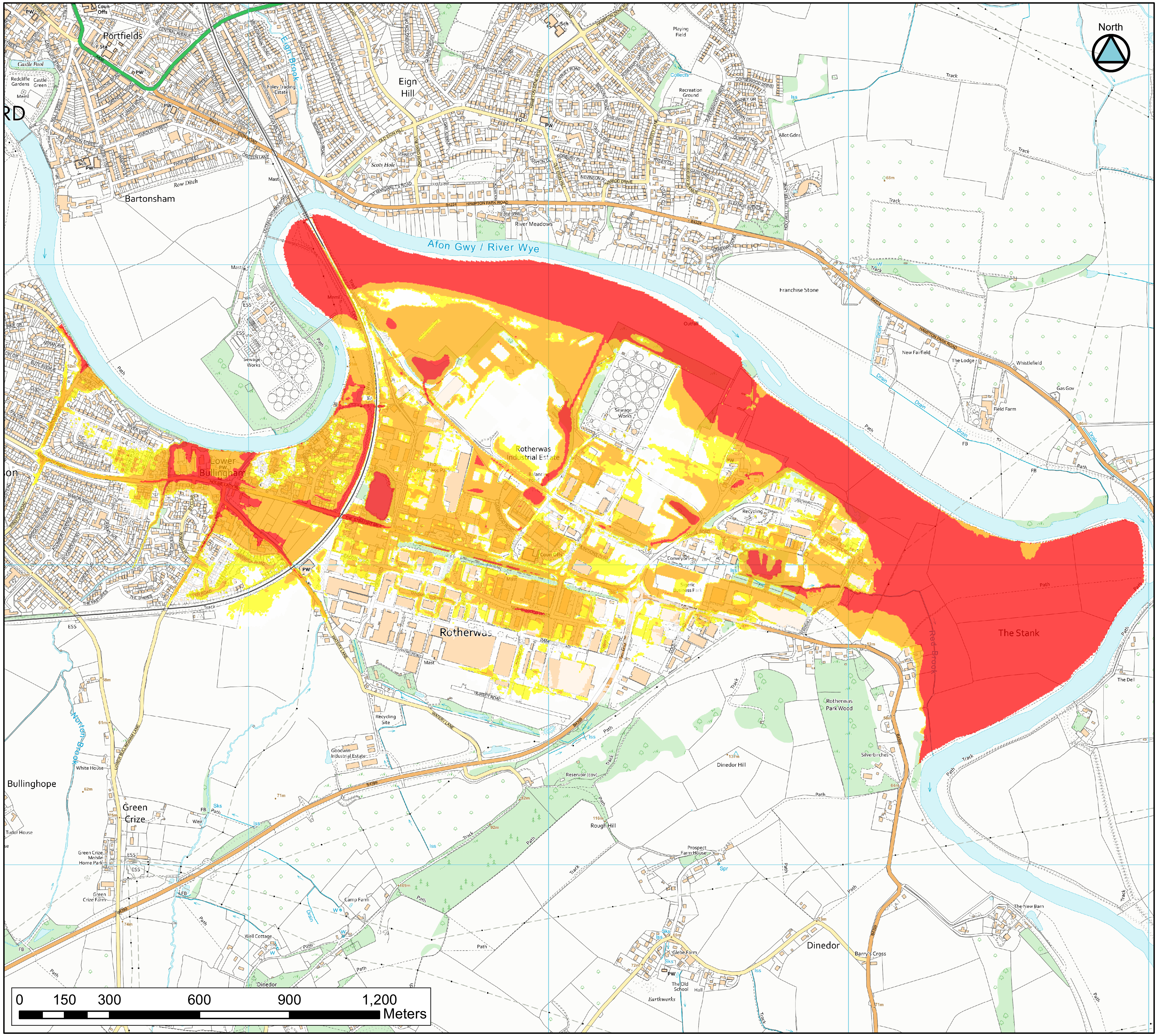
Hereford Enterprise Zone

River Wye Hereford Model
1% AEP + Climate Change (25%) event
Future-Development
Flood Hazard Map

Scale: 1:12,000	Drawn	PR	27/09/2019
	Checked	GB	27/09/2019
Original @ A3	Approved	GB	27/09/2019

Digital File Name: 2018s1555_Hazard_Maps.MXD

Drawing 2018s1555_005	Sheet No.: 1 of 1	Rev.: A

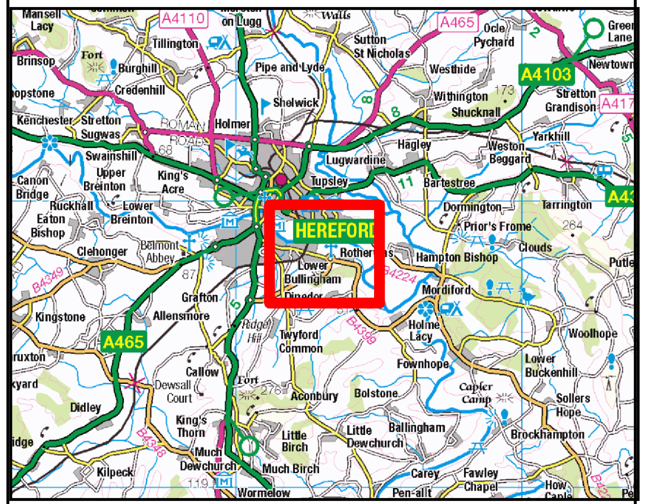


KEY

Flood Hazard

- 0.5 - 0.75
- 0.75 - 1.25
- 1.25 - 2
- > 2

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

JBA consulting

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

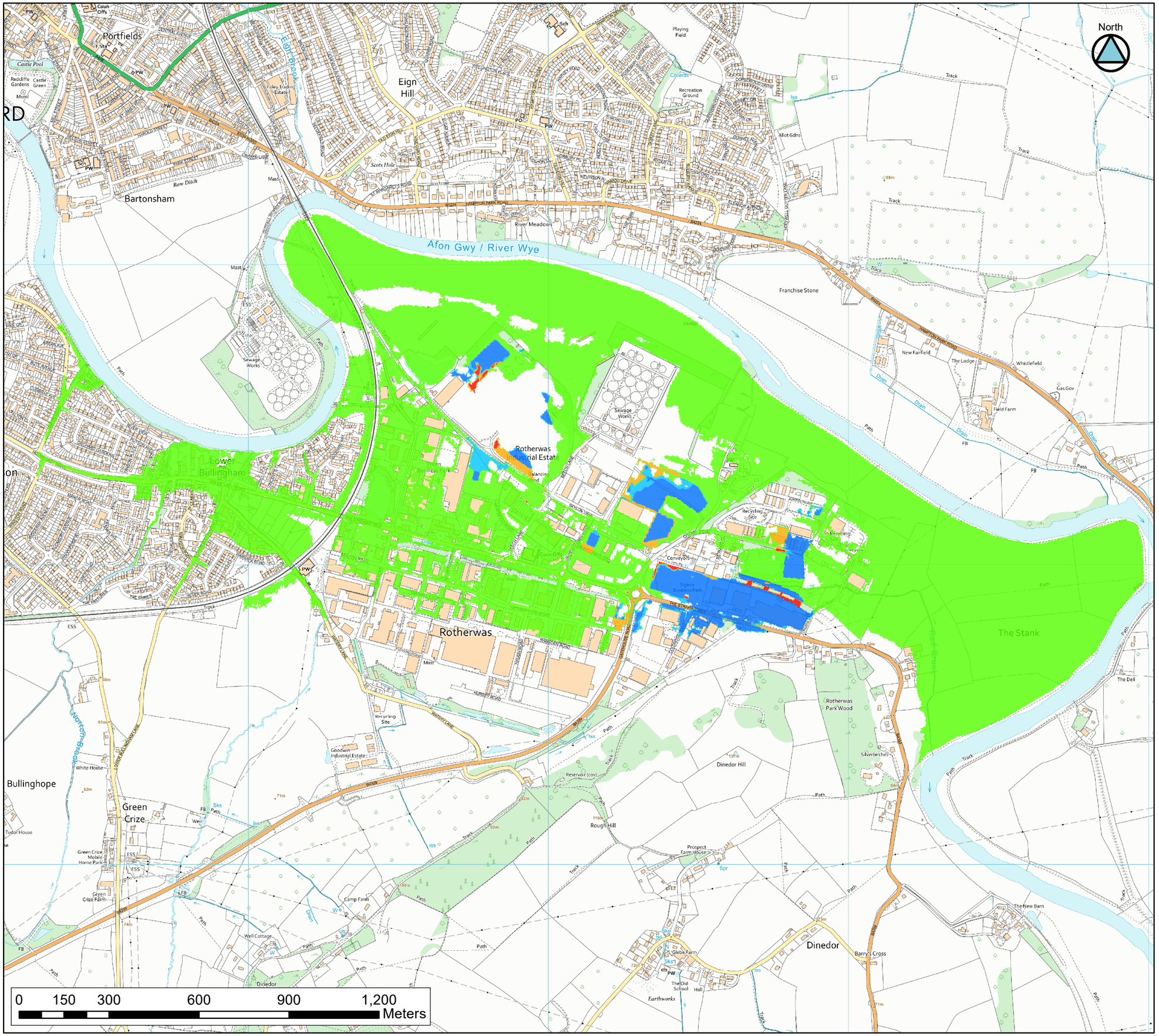
Hereford Enterprise Zone

River Wye Hereford Model
0.1% AEP event
Future-Development
Flood Hazard Map

Scale: 1:12,000	Drawn	PR	27/09/2019
	Checked	GB	27/09/2019
Original @ A3	Approved	GB	27/09/2019

Digital File Name: 2018s1555_Hazard_Maps.MXD

Drawing 2018s1555_006	Sheet No.: 1 of 1	Rev.: A

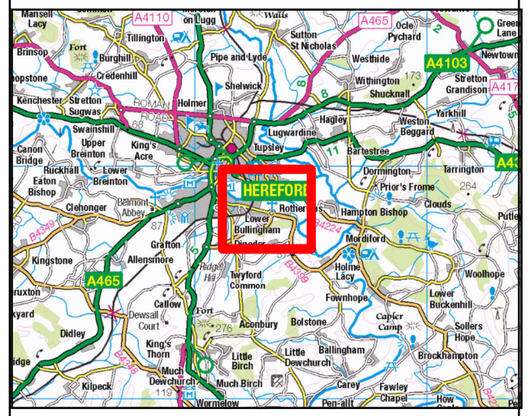


KEY

Change in water levels (cm)

- > 10cm reduction in water levels
- 1 to 10cm reduction in water levels
- No change in water levels
- 1 to 10cm increase in water levels
- > 10cm increase in water levels

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

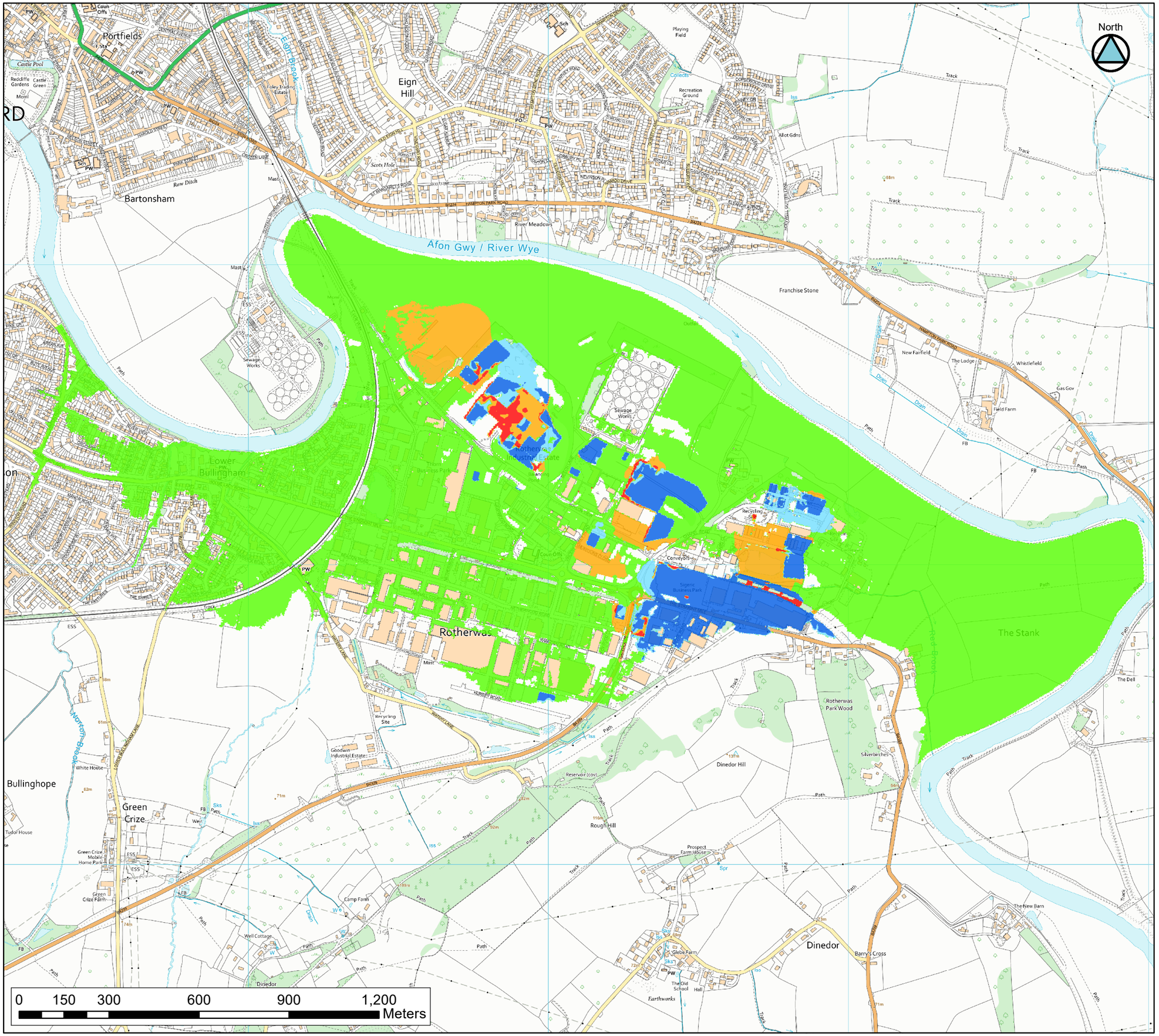
Hereford Enterprise Zone

River Wye Hereford Model
1% AEP plus climate change event
Future-Development
Flood Depth Comparison Map

Scale: 1:12,000	Drawn	HB	04/11/20
	Checked	GB	
Original @ A3	Approved	GB	

Digital File Name: 2018s1555_Depth_Maps.MXD

Drawing 2018s1555_008	Sheet No.: 1 of 1	Rev.: A

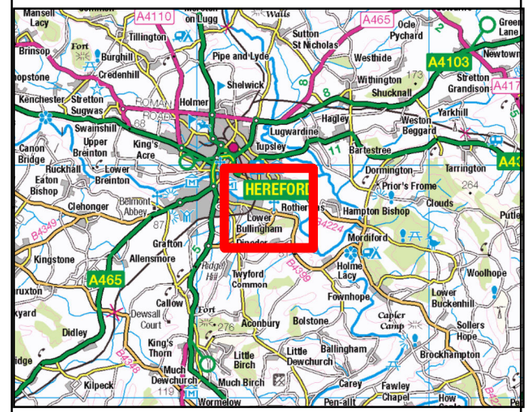


KEY

Change in water levels (cm)

- > 10cm reduction in water levels
- 1 to 10cm reduction in water levels
- No change in water levels
- 1 to 10cm increase in water levels
- > 10cm increase in water levels

KEYPLAN



Kings Chambers
7 - 8 High Street
Newport
South Wales
NP20 1FQ
United Kingdom

+44 (0)1633 413 514
+44 (0)8458 627 772
info@jbaconsulting.co.uk

Other offices at Coleshill, Doncaster, Edinburgh, Haywards Heath, Newcastle upon Tyne, Northallerton, Saltaire, Skipton, Tadcaster, Wallingford & Warrington www.jbaconsulting.co.uk

for

Hereford Enterprise Zone

River Wye Hereford Model
0.1% AEP event
Future-Development
Flood Depth Comparison Map

Scale: 1:12,000	Drawn	HB	17/11/20
	Checked	GB	
Original @ A3	Approved	GB	

Digital File Name: 2018s1555_Depth_Maps.MXD

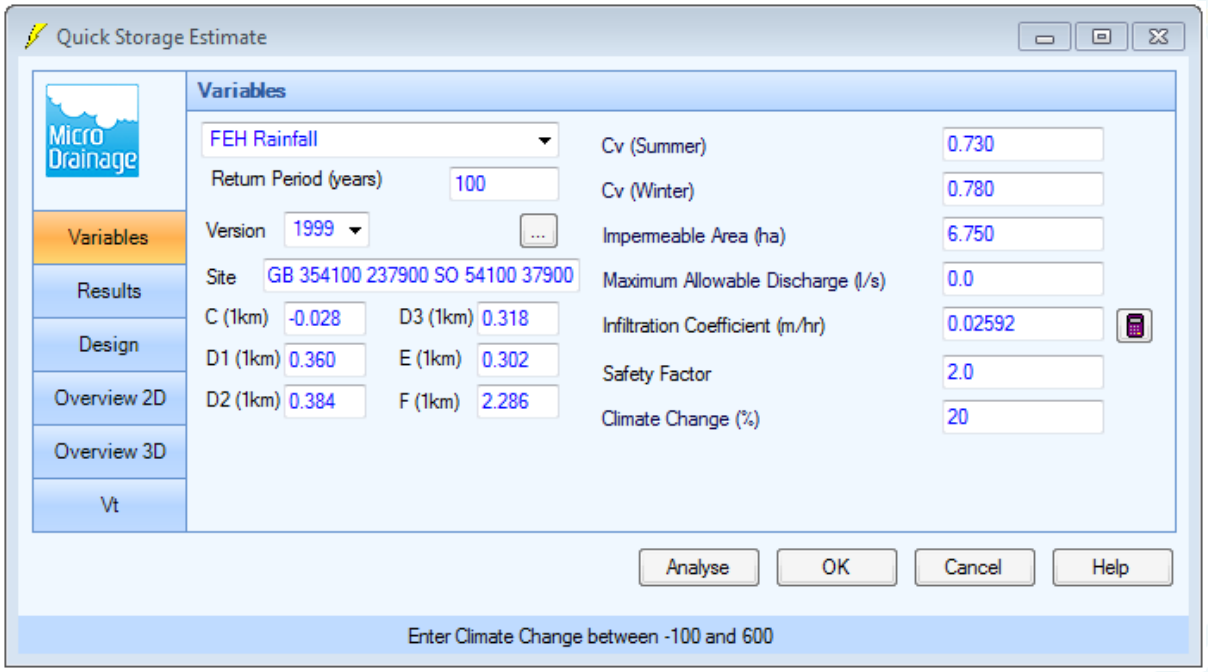
Drawing 2018s1555_008	Sheet No.: 1 of 1	Rev.: A

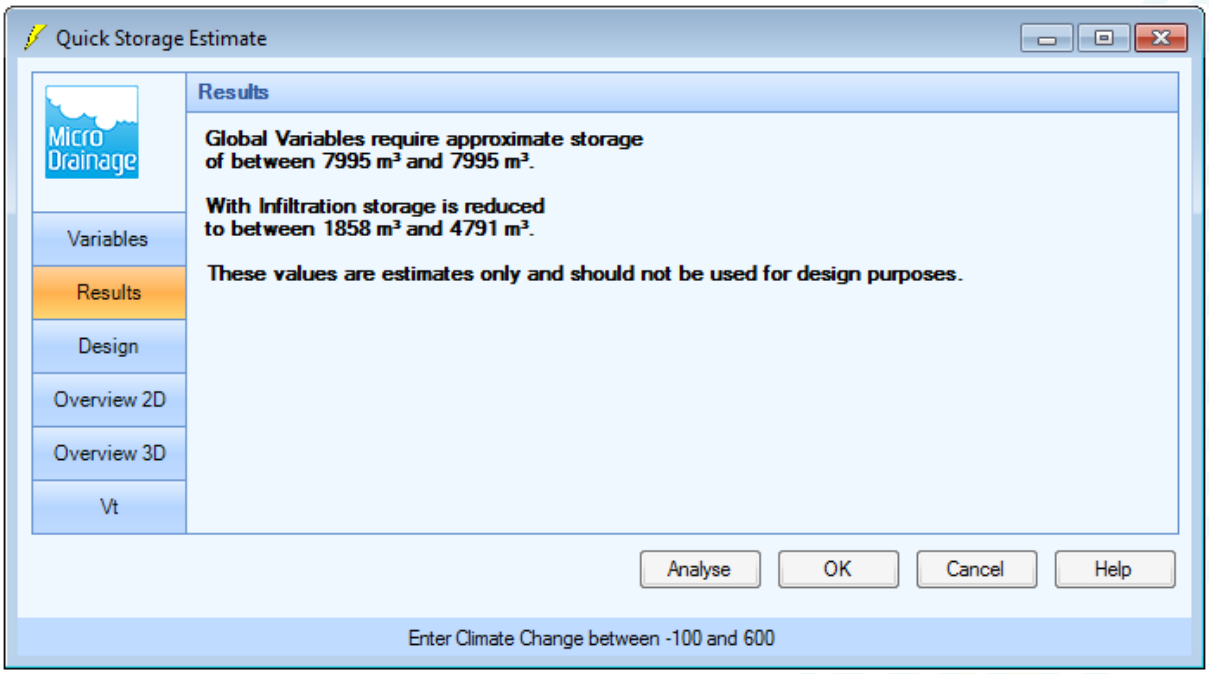
Appendix B – SuDS calculations North Magazine

Skylon North Magazine

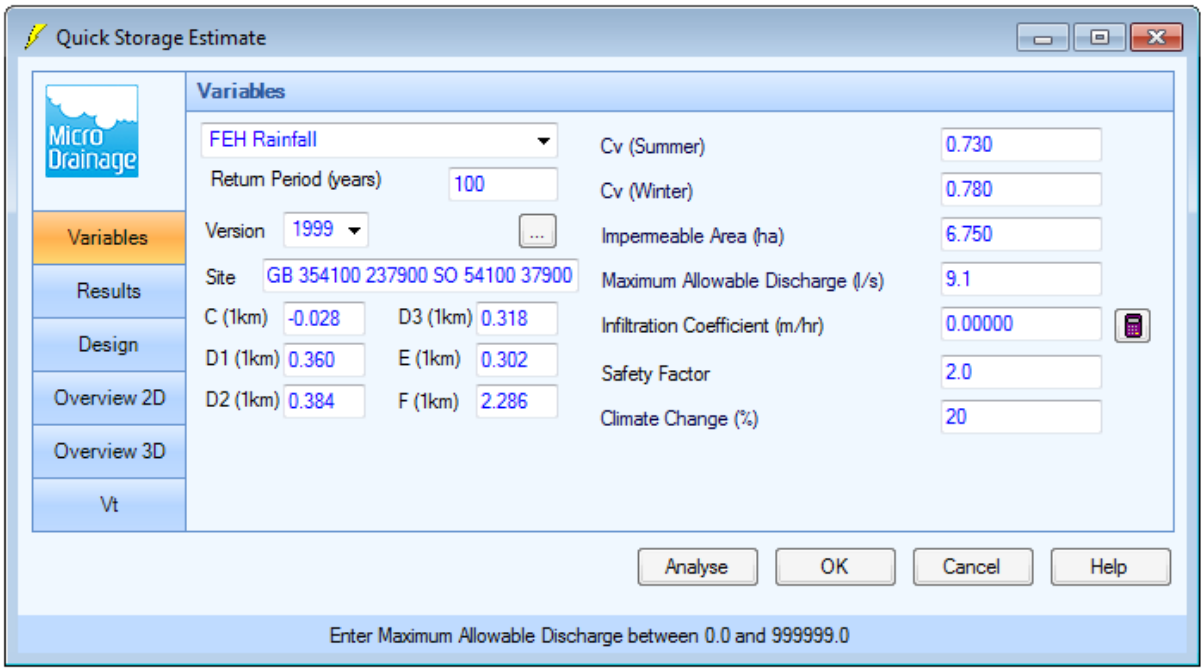
A Northern sub-catchment

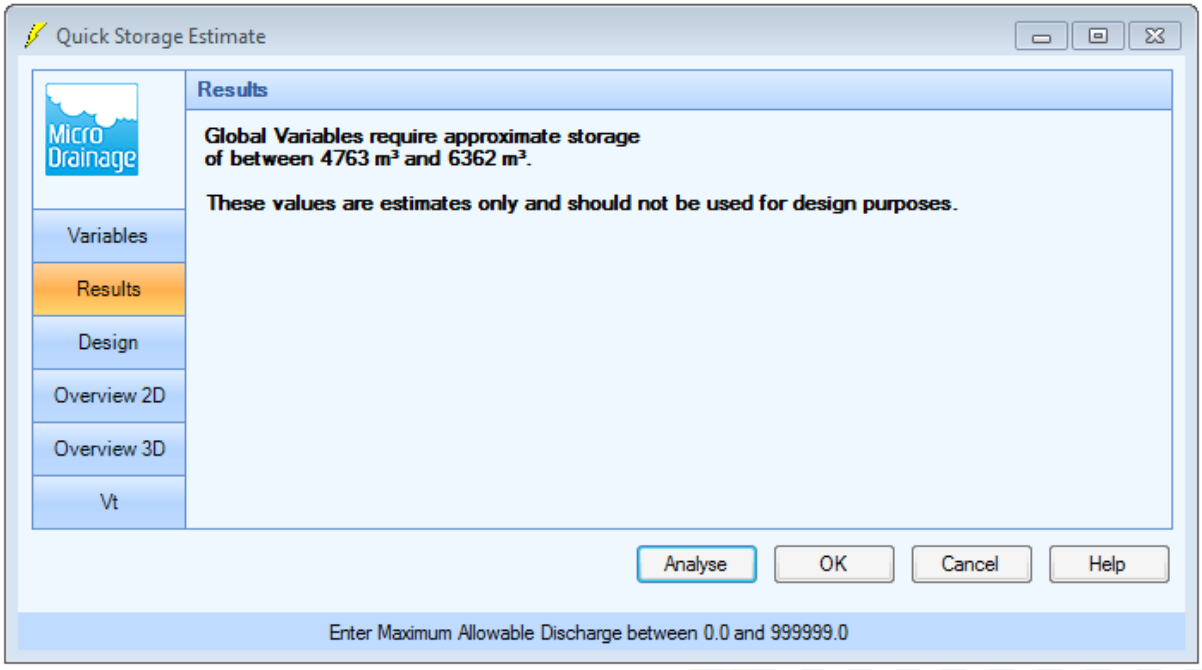
If infiltration to the ground is suitable





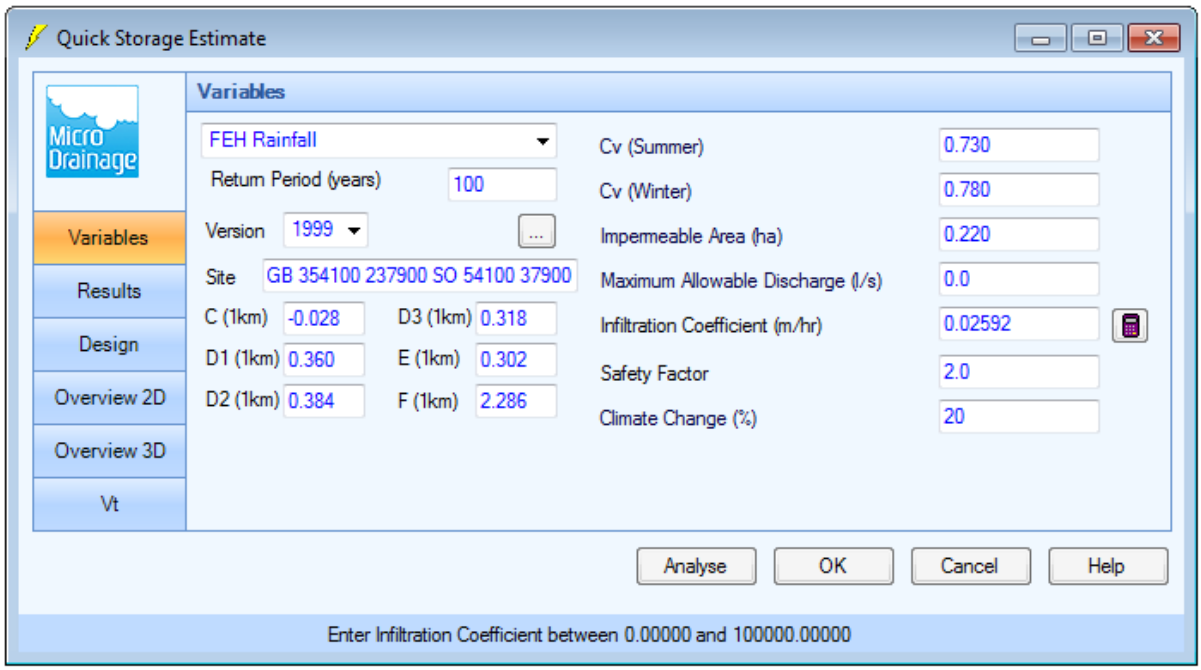
If infiltration to the ground is not viable

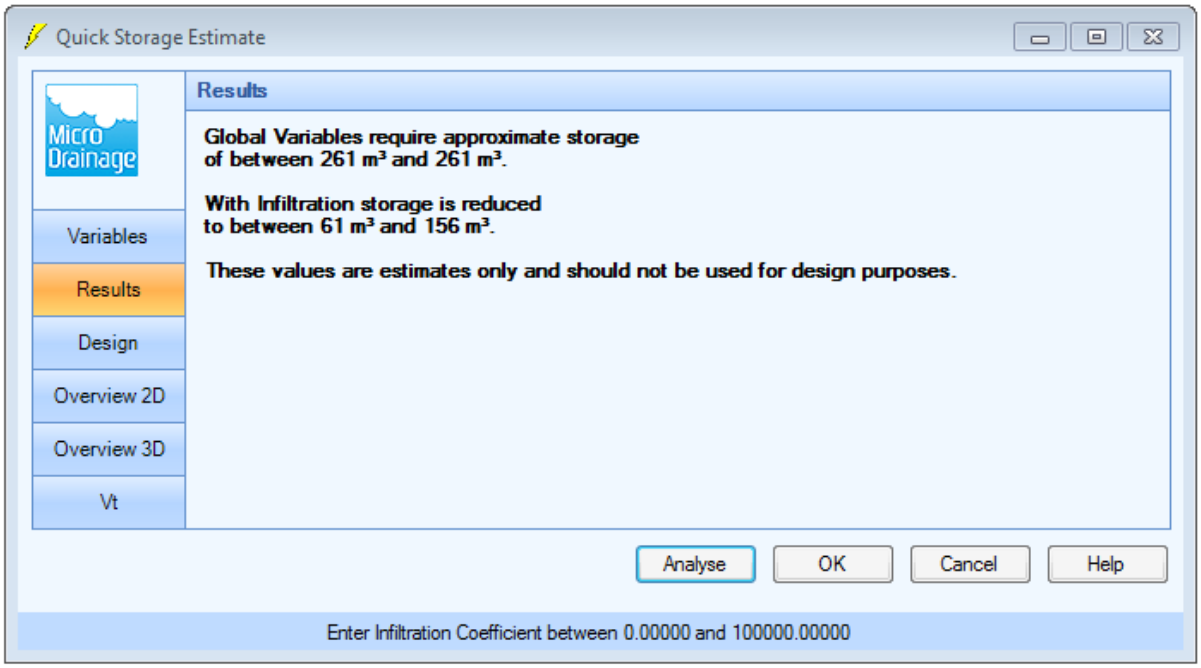




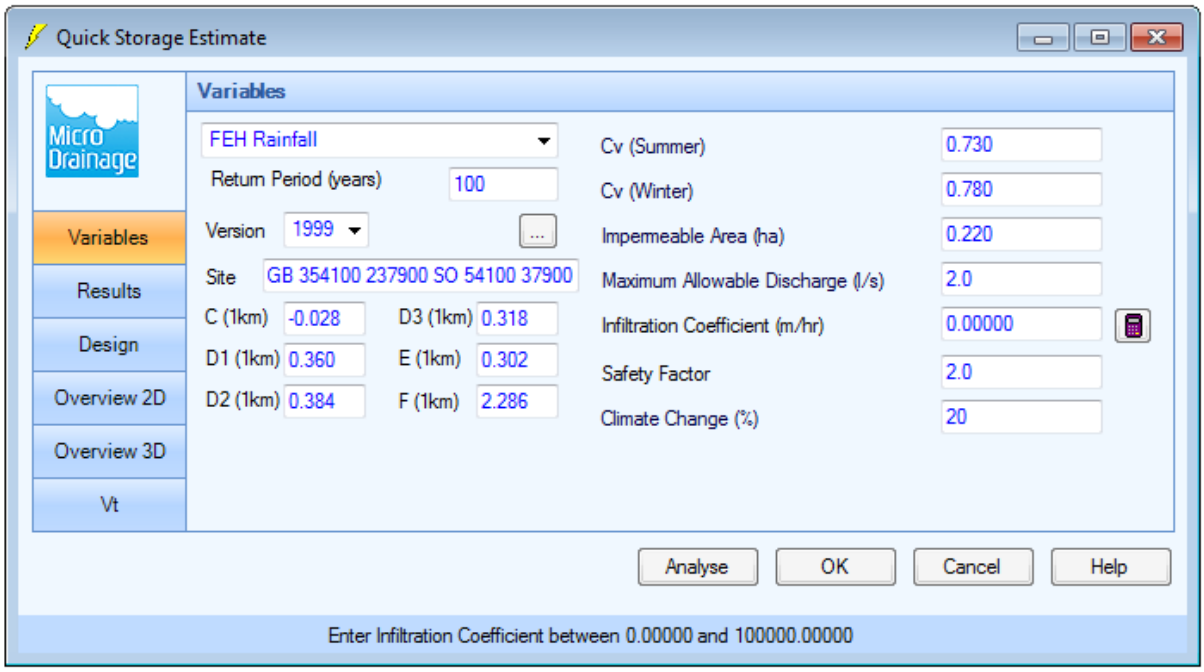
B South-western sub-catchment

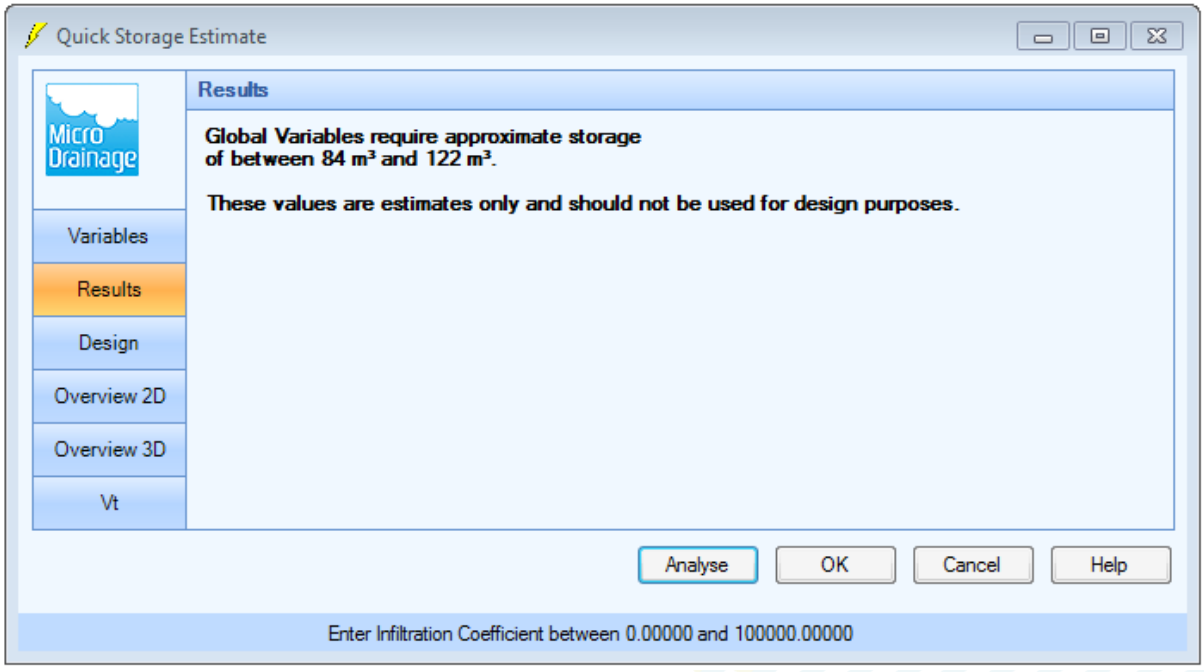
If discharge to the ground is suitable





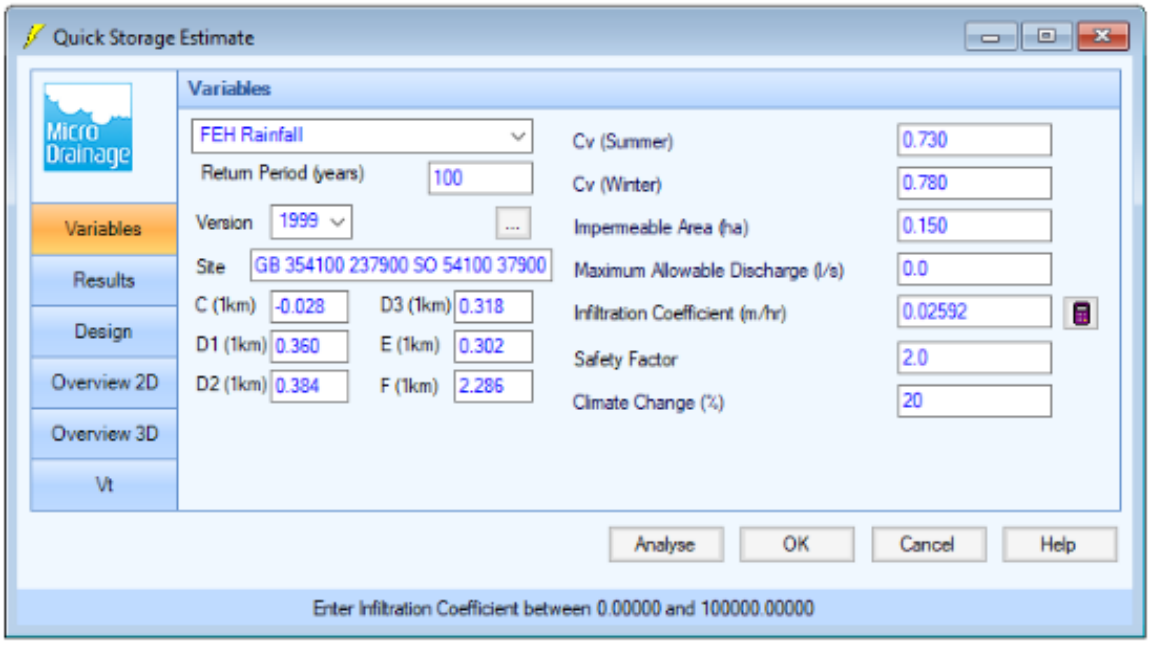
If discharge to the ground is not viable

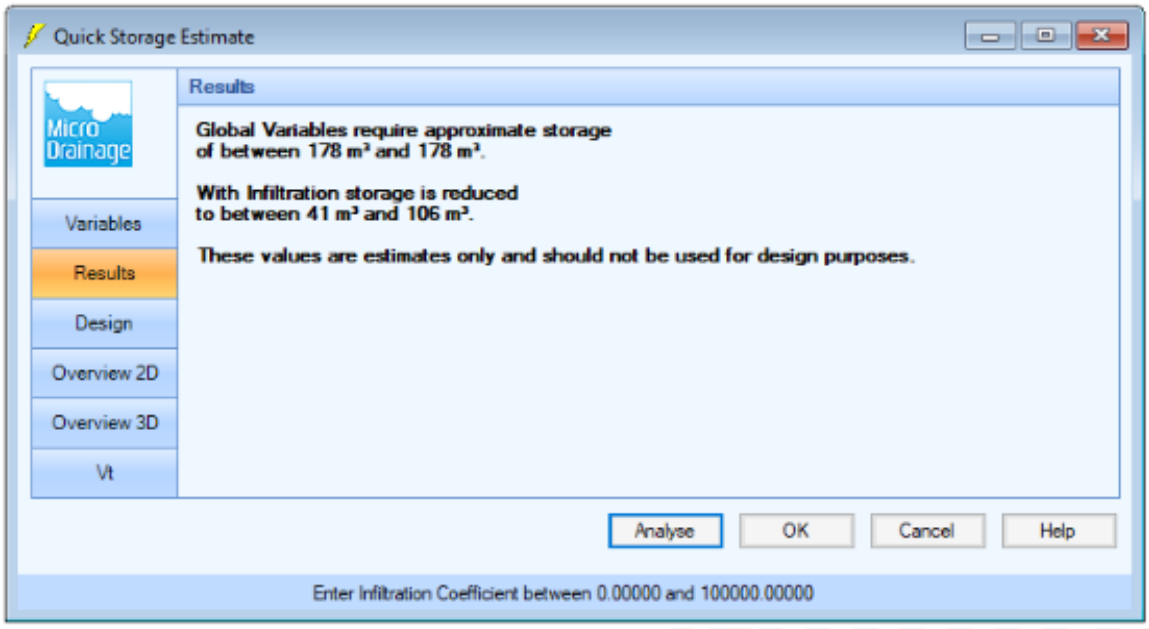




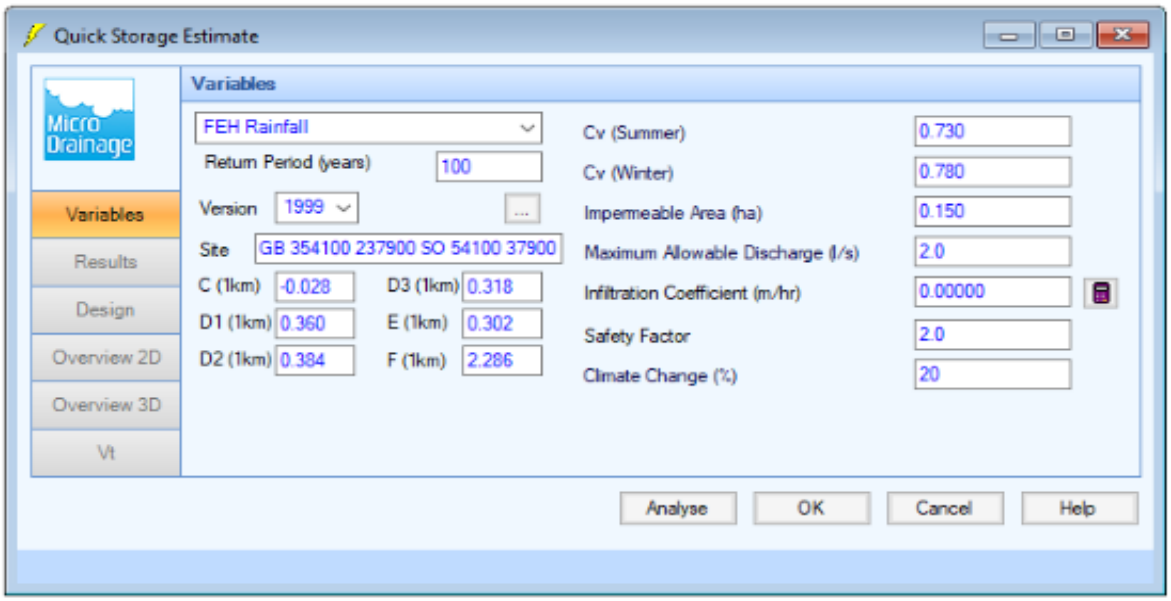
C South-eastern sub-catchment

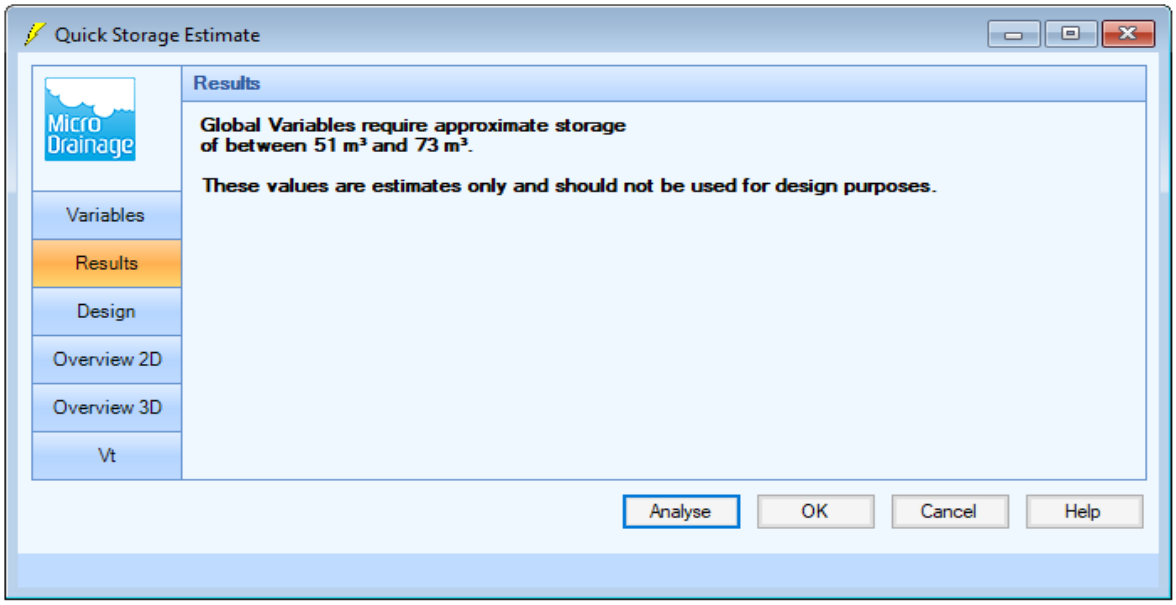
If discharge to the ground is suitable





If discharge to the ground is not viable





HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon North Magazine
Site location:	Northern subcatchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.04265° N
Longitude:	2.68904° W

Reference:	
Date:	2019-05-20 12:43

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	8.44

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	12.55
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	13.5	9.07
1 in 1 year (l/s)	11.88	7.98
1 in 30 years (l/s)	24.02	16.15
1 in 100 years (l/s)	29.42	19.77

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:

Site name: Skylon North Magazine

Site location: South-eastern part

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude: 52.04071° N

Longitude: 2.68757° W

Reference: 2888900294

Date: Sep 23 2019 10:45

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 0.18

Methodology

Q_{MED} estimation method: Calculate from BFI and SAAR

BFI and SPR method: Specify BFI manually

HOST class: 6

BFI / BFIHOST: 0.731

Q_{MED} (l/s): 0.27

Q_{BAR} / Q_{MED} factor: 1.08

Hydrological characteristics

	Default	Edited
SAAR (mm):	654	651
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	0.29	0.19
1 in 1 year (l/s):	0.25	0.17
1 in 30 years (l/s):	0.51	0.34
1 in 100 year (l/s):	0.63	0.42
1 in 200 years (l/s):	0.71	0.48

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:

Site name: Skylon North Magazine

Site location: South-western part

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013) , the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site Details

Latitude: 52.04081° N

Longitude: 2.6886° W

Reference: 2719387281

Date: Sep 23 2019 10:34

Runoff estimation approach

FEH Statistical

Site characteristics

Total site area (ha): 0.27

Methodology

Q_{MED} estimation method: Calculate from BFI and SAAR

BFI and SPR method: Specify BFI manually

HOST class: 6

BFI / BFIHOST: 0.731

Q_{MED} (l/s): 0.4

Q_{BAR} / Q_{MED} factor: 1.08

Hydrological characteristics

	Default	Edited
SAAR (mm):	654	651
Hydrological region:	9	9
Growth curve factor 1 year:	0.88	0.88
Growth curve factor 30 years:	1.78	1.78
Growth curve factor 100 years:	2.18	2.18
Growth curve factor 200 years:	2.46	2.46

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	0.43	0.29
1 in 1 year (l/s):	0.38	0.26
1 in 30 years (l/s):	0.77	0.52
1 in 100 year (l/s):	0.94	0.63
1 in 200 years (l/s):	1.06	0.71

Appendix C – SuDS calculations Skylon North

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon North
Site location:	North-eastern sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.04048° N
Longitude:	2.68182° W

Reference:	
Date:	2019-07-30 13:18

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	3.28

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	4.88
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	5.25	3.53
1 in 1 year (l/s)	4.62	3.1
1 in 30 years (l/s)	9.34	6.27
1 in 100 years (l/s)	11.43	7.68

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon North
Site location:	South-eastern sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03964° N
Longitude:	2.68188° W

Reference:	
Date:	2019-07-30 13:17

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	0.62

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	0.92
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	0.99	0.67
1 in 1 year (l/s)	0.87	0.59
1 in 30 years (l/s)	1.76	1.19
1 in 100 years (l/s)	2.16	1.45

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon North
Site location:	Western sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.04173° N
Longitude:	2.68454° W

Reference:	
Date:	2019-07-30 13:19

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	2.22

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	3.3
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

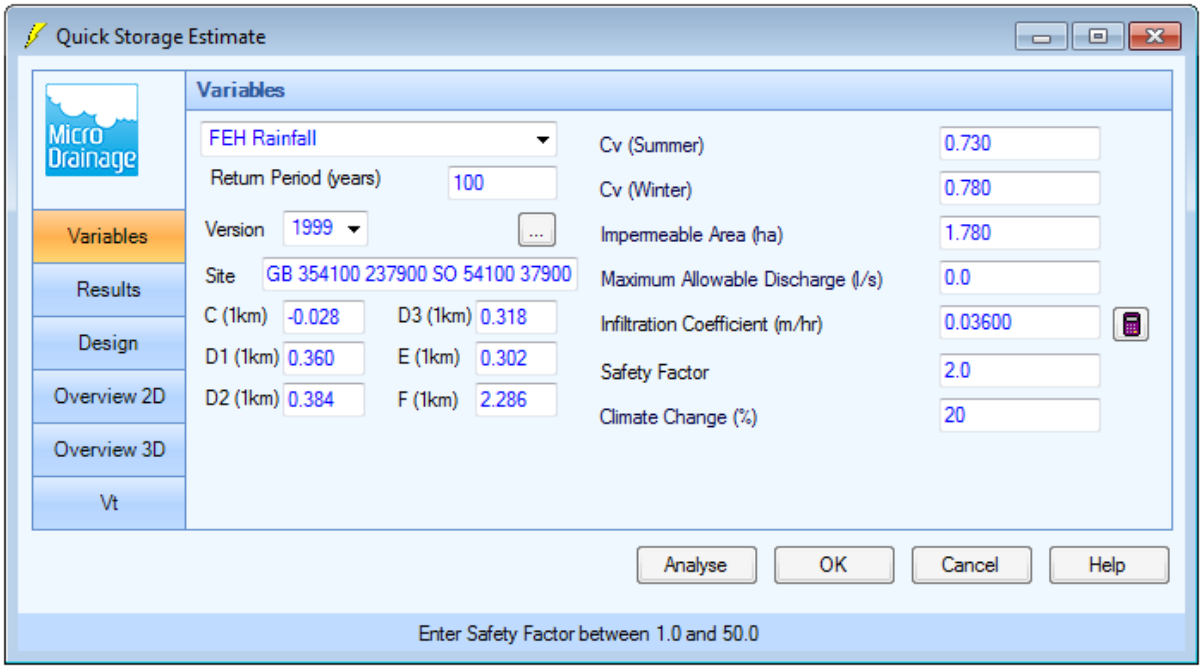
Greenfield runoff rates

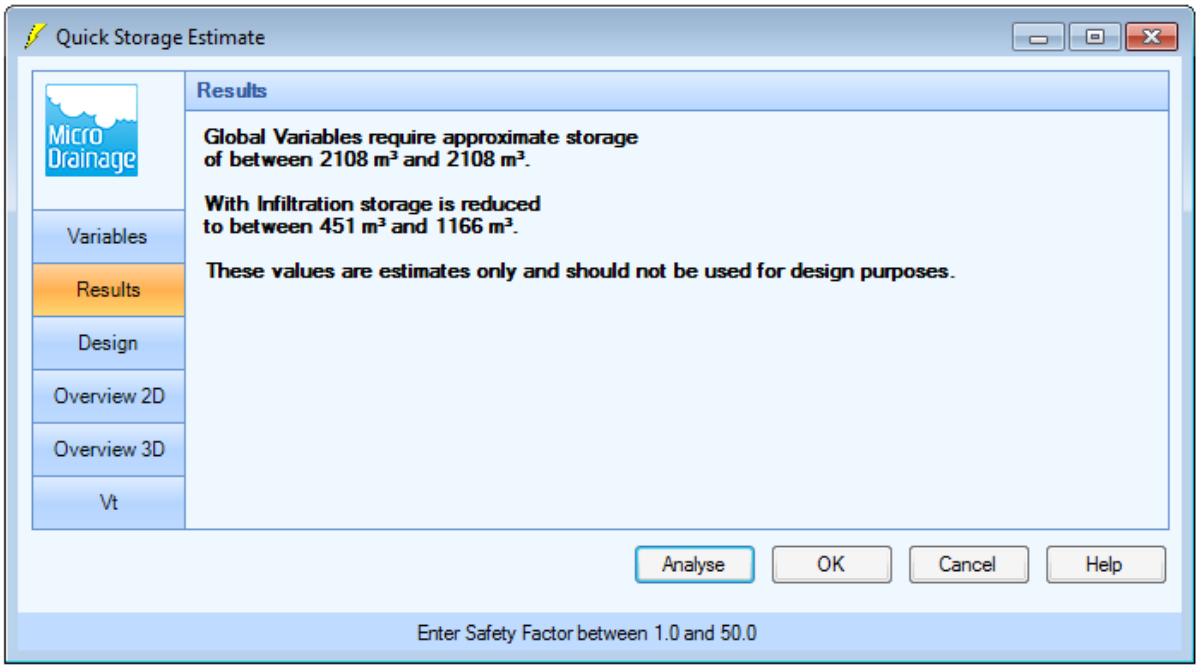
	Default	Edited
Qbar (l/s)	3.55	2.39
1 in 1 year (l/s)	3.12	2.1
1 in 30 years (l/s)	6.32	4.25
1 in 100 years (l/s)	7.74	5.2

Skylon North

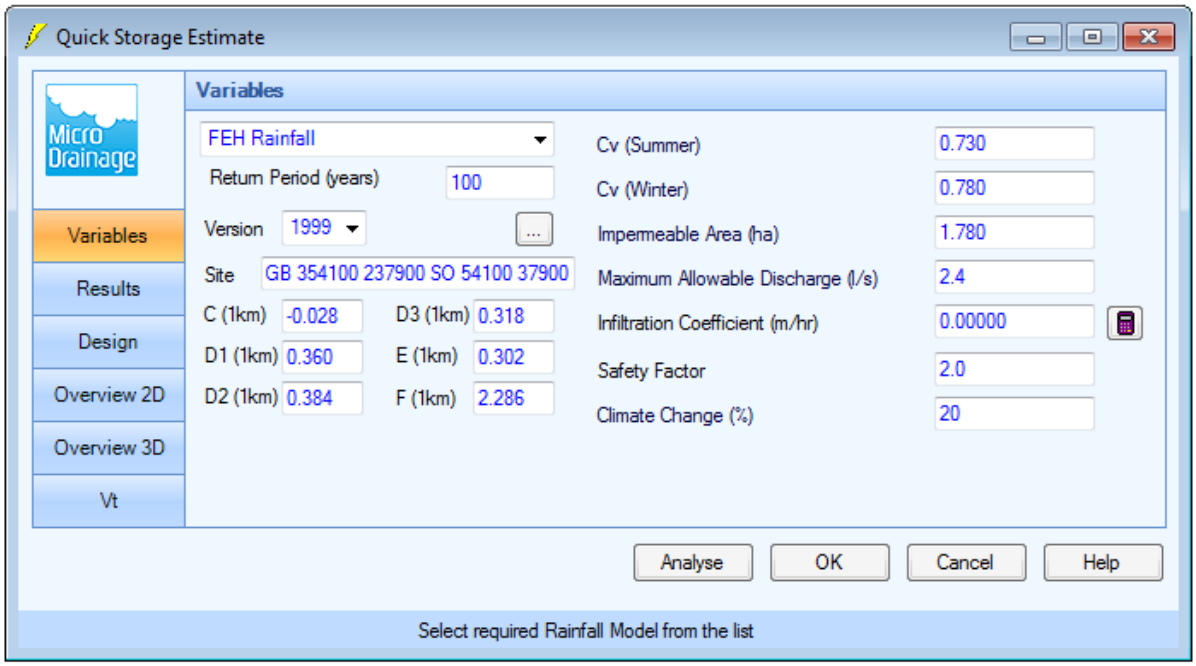
A Western sub-catchment

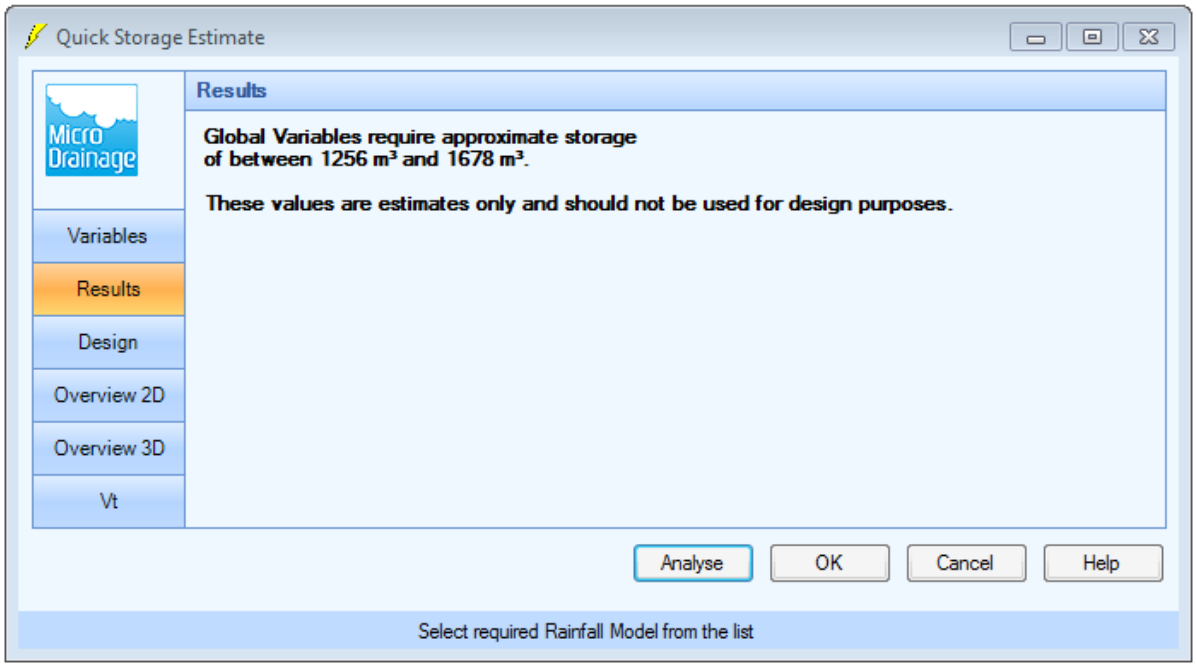
If infiltration to the ground is suitable





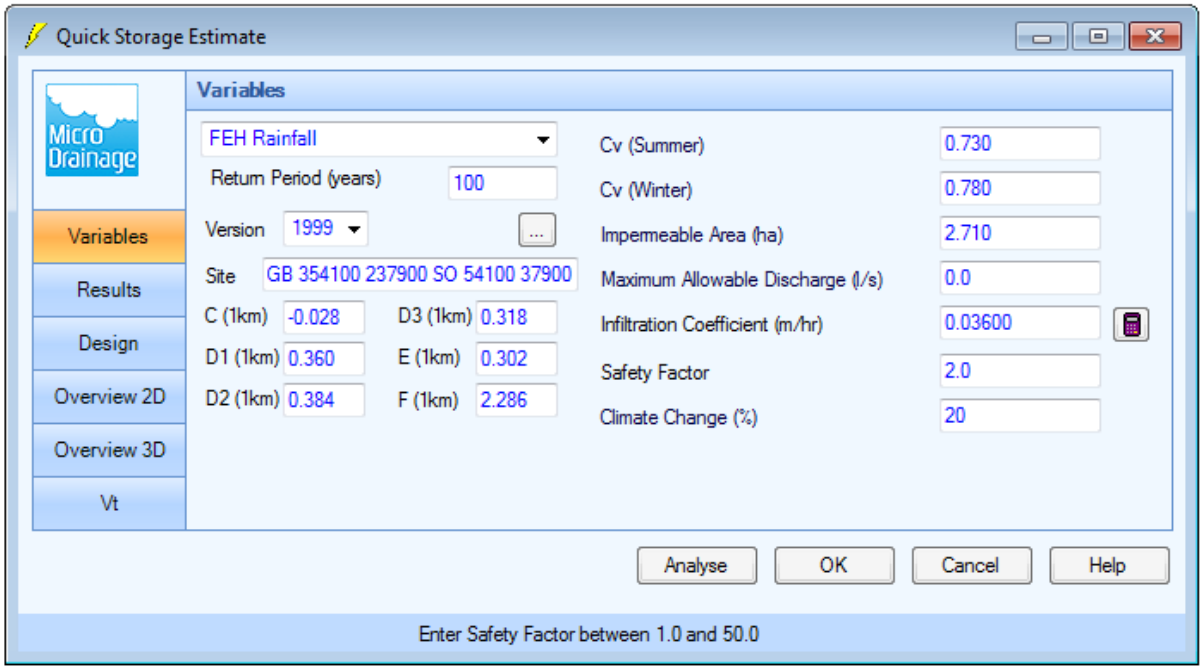
If infiltration to the ground is not viable

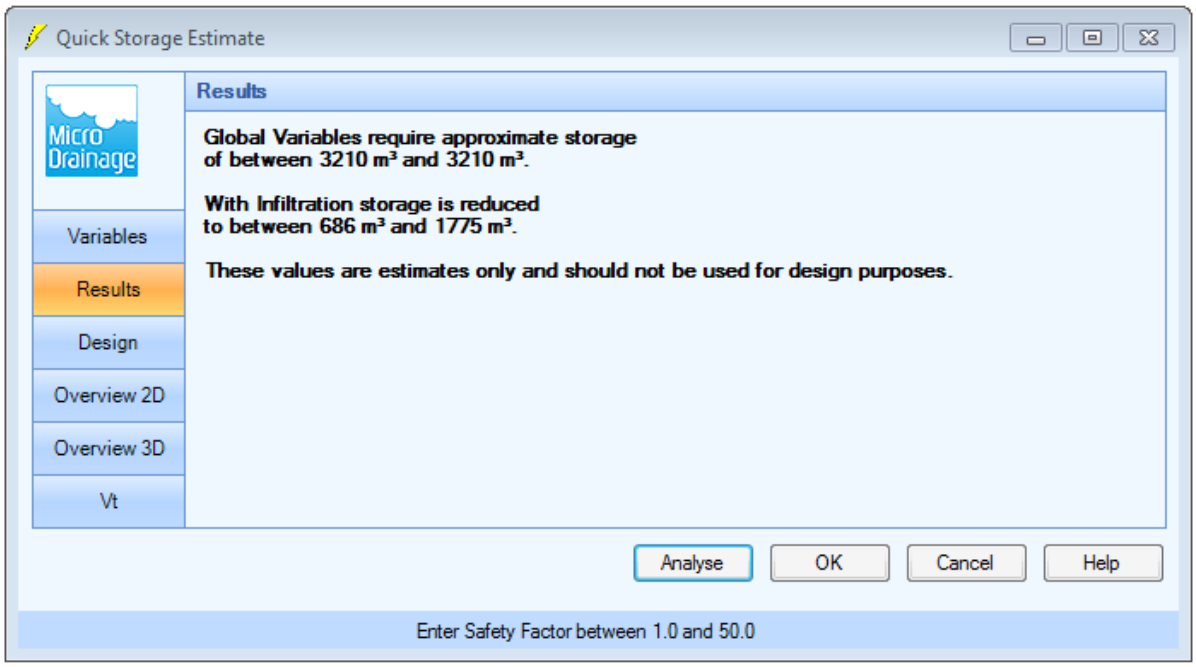




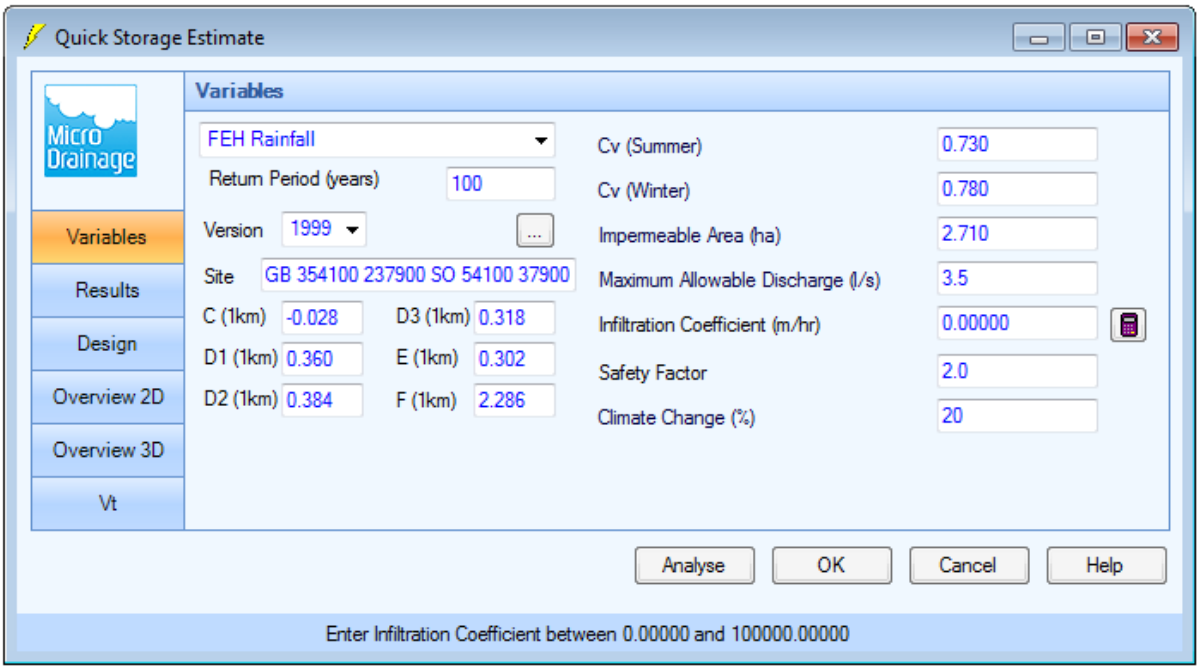
B North-eastern sub-catchment

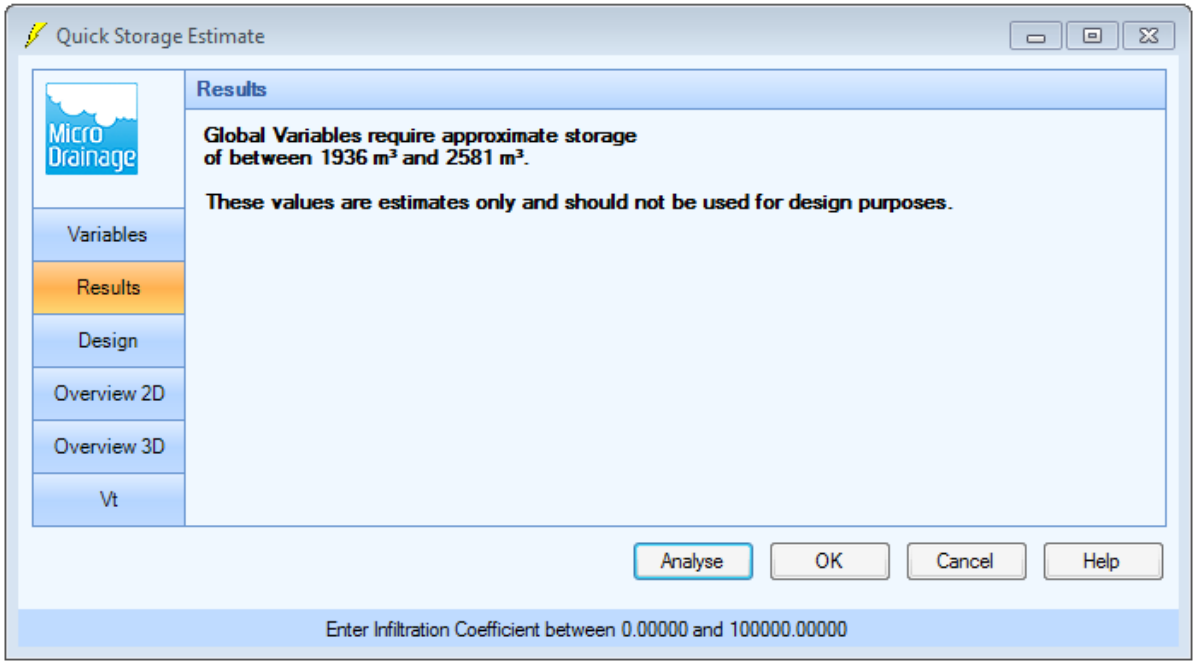
If discharge to the ground is suitable





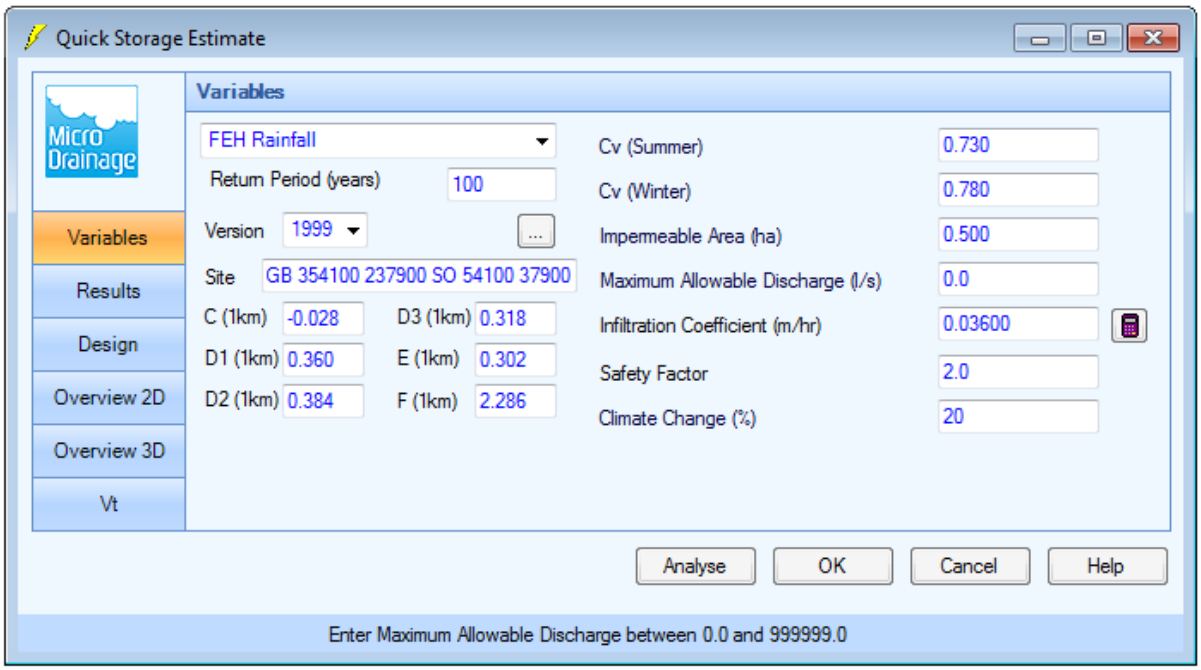
If discharge to the ground is not viable

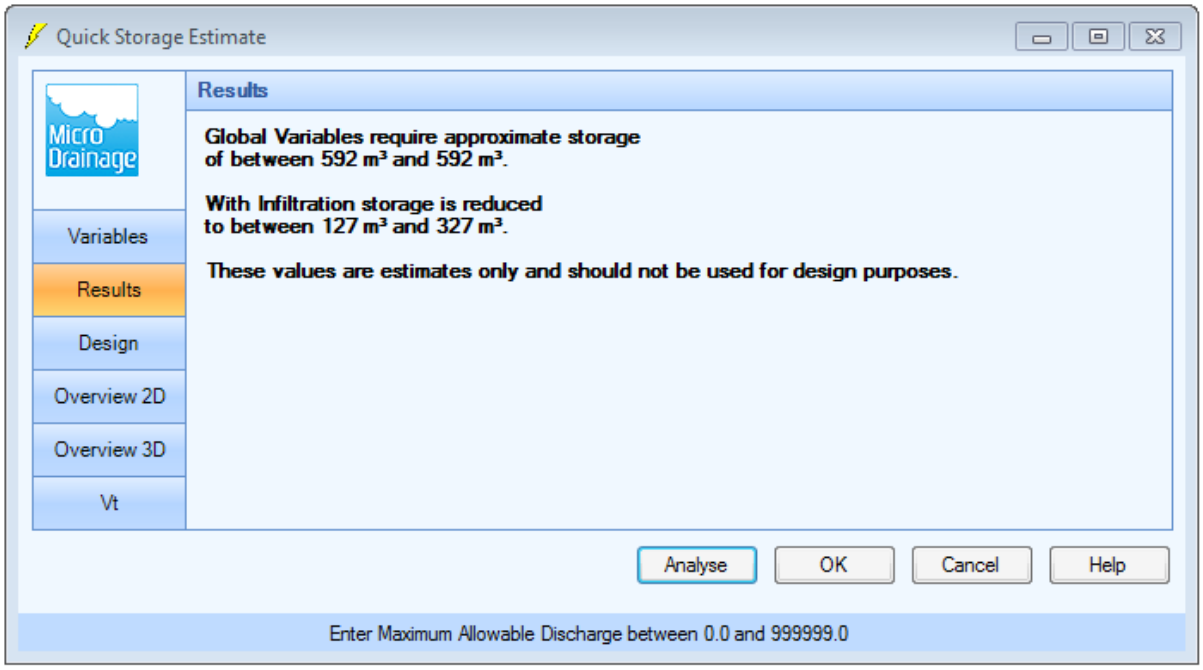




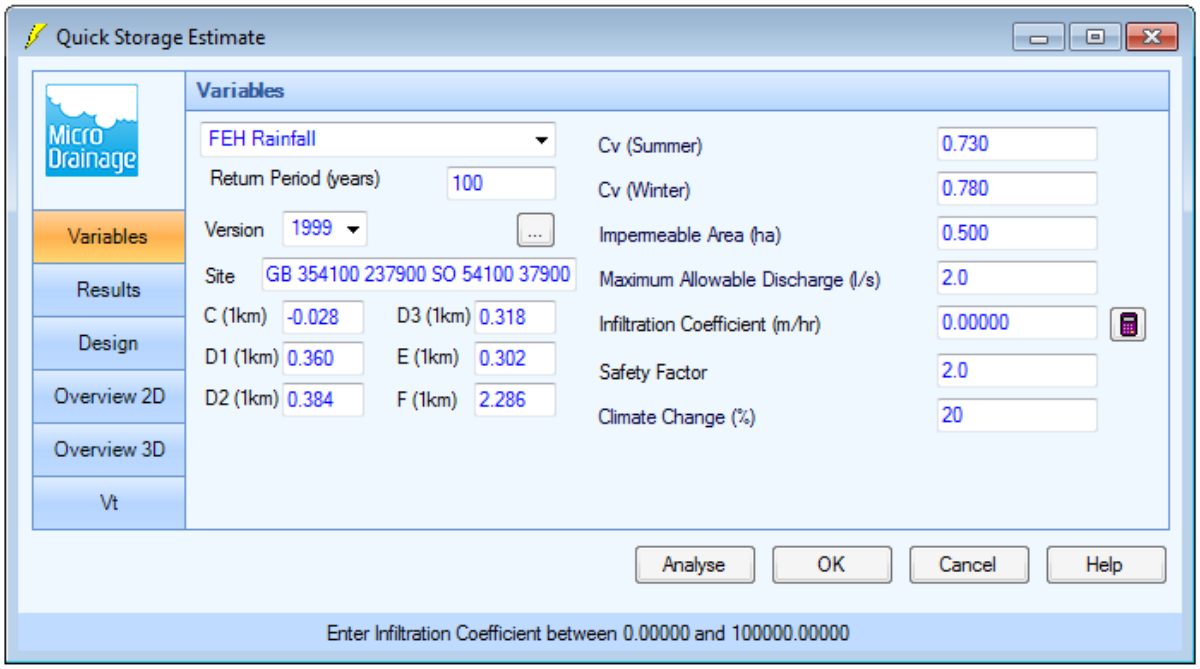
C South-eastern sub-catchment

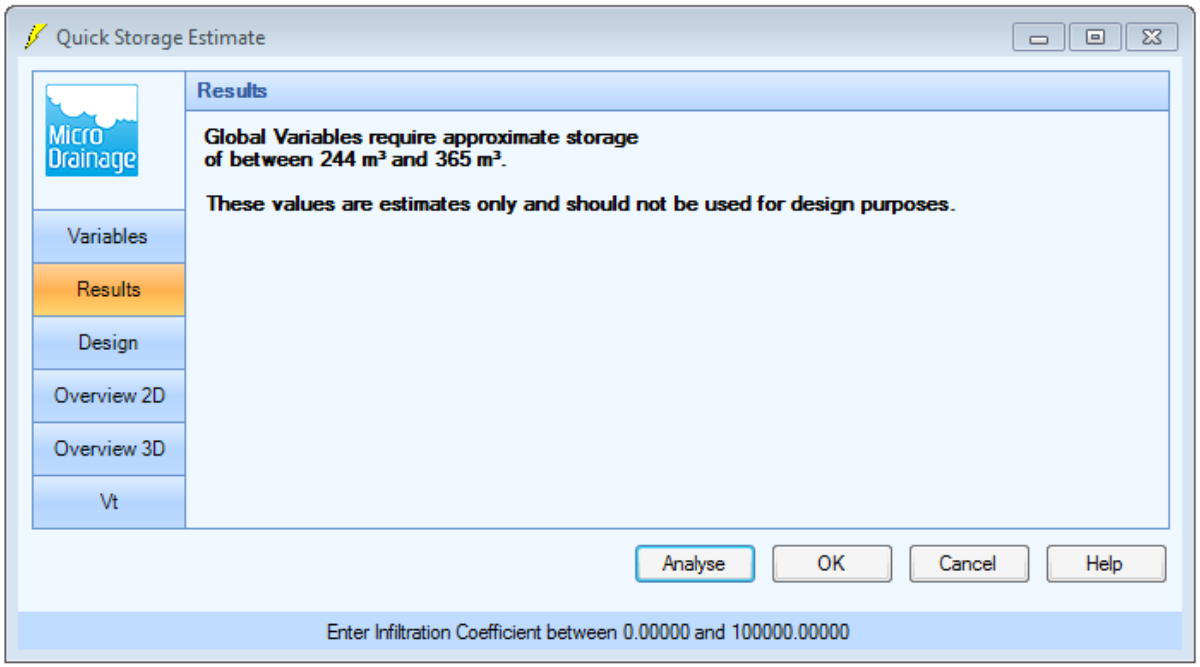
If discharge to the ground is suitable





If discharge to the ground is not viable

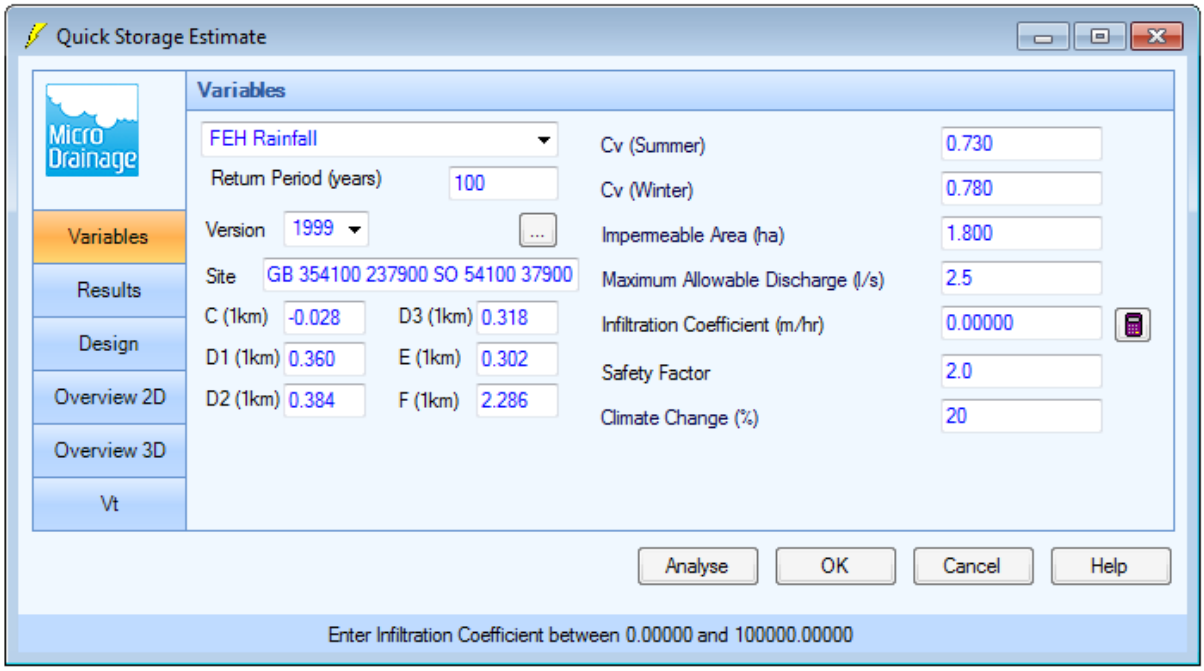


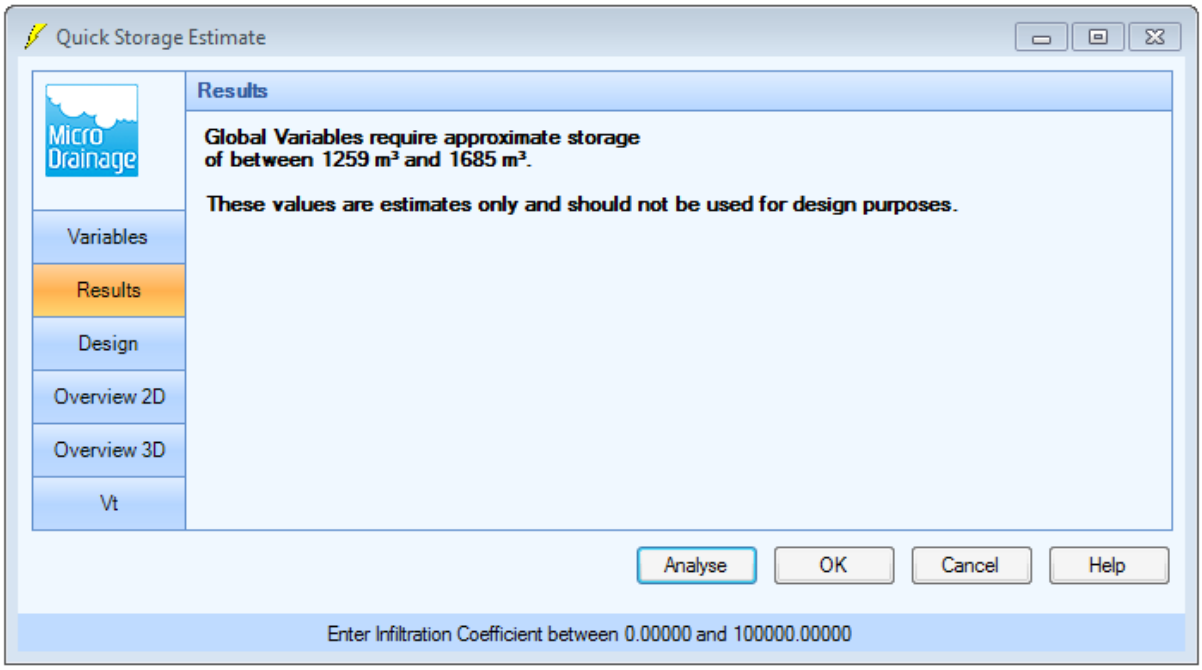


Appendix D – SuDS calculations Chapel Road

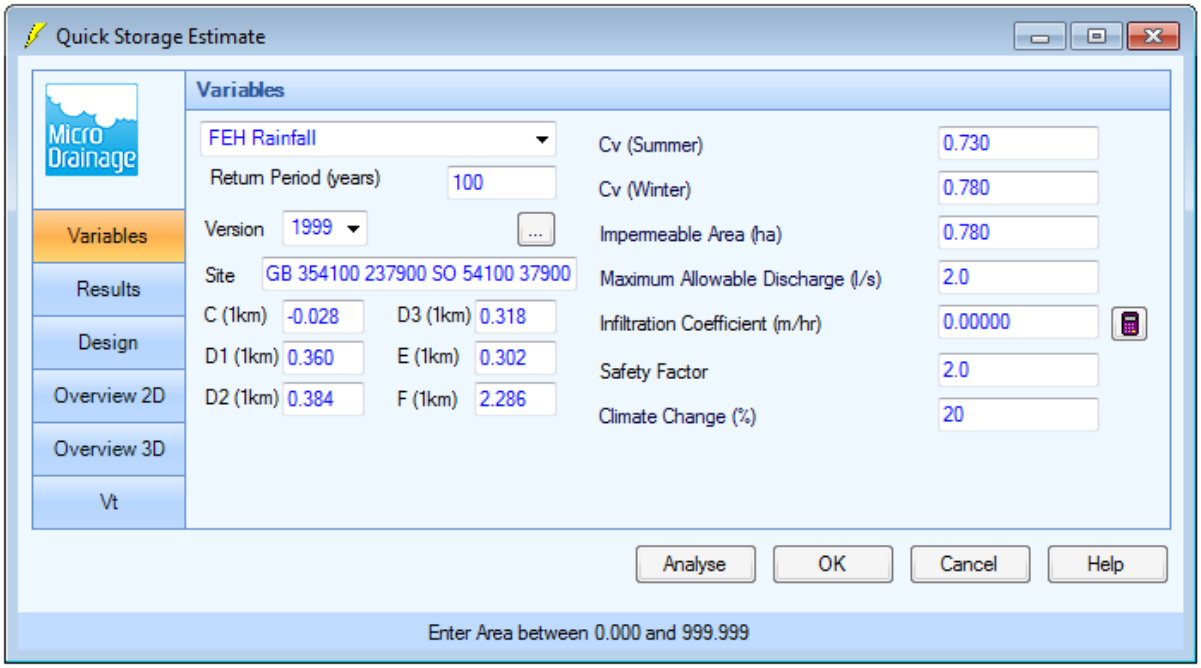
Chapel Road

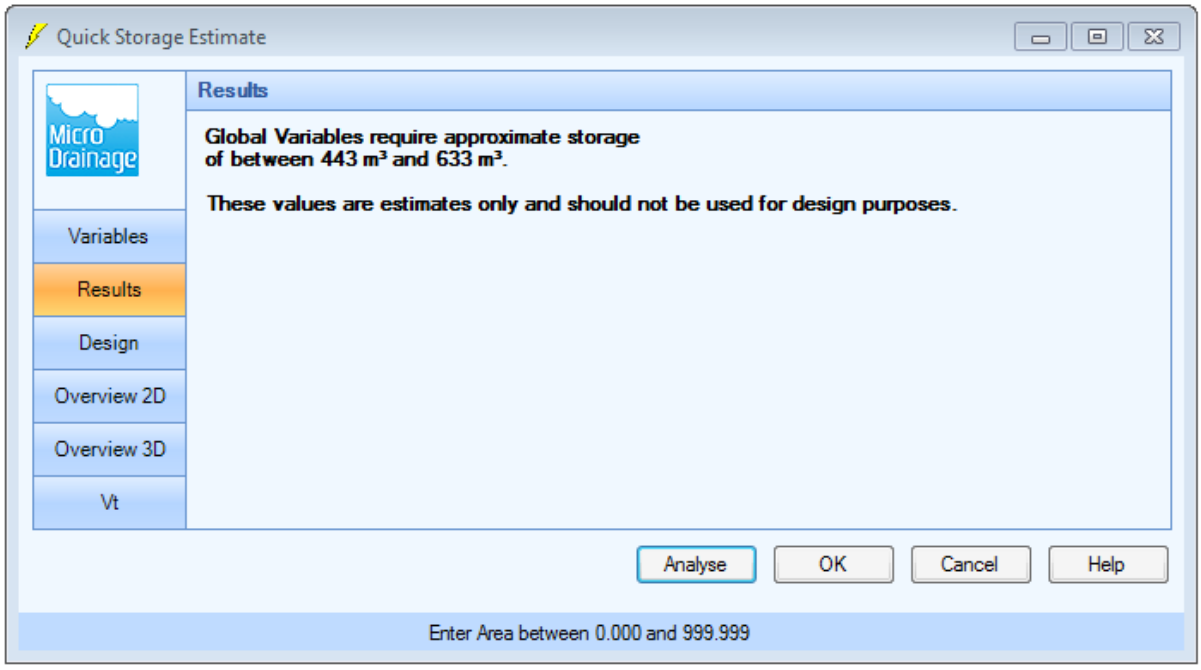
A Northern sub-catchment



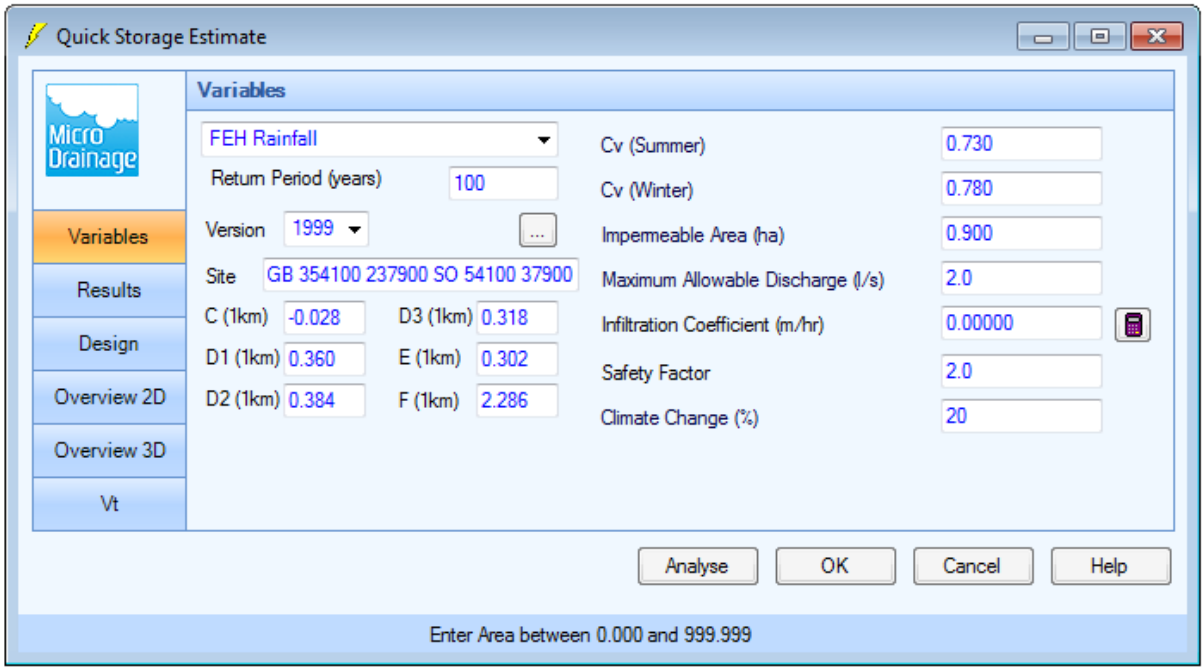


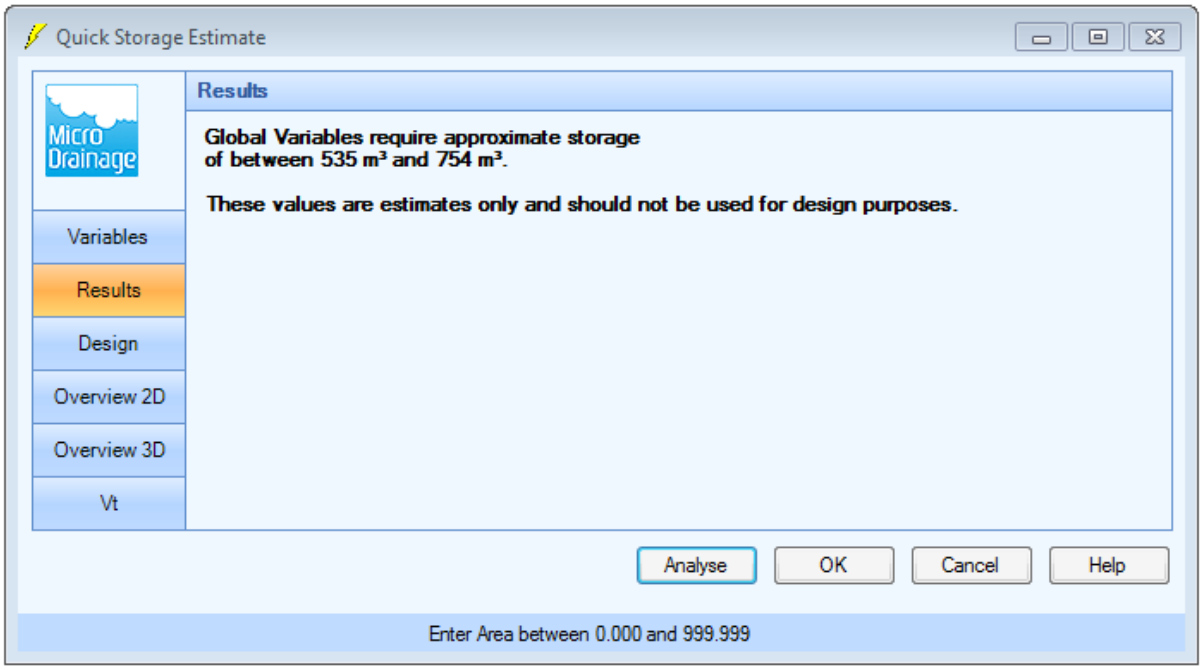
B Central sub-catchment



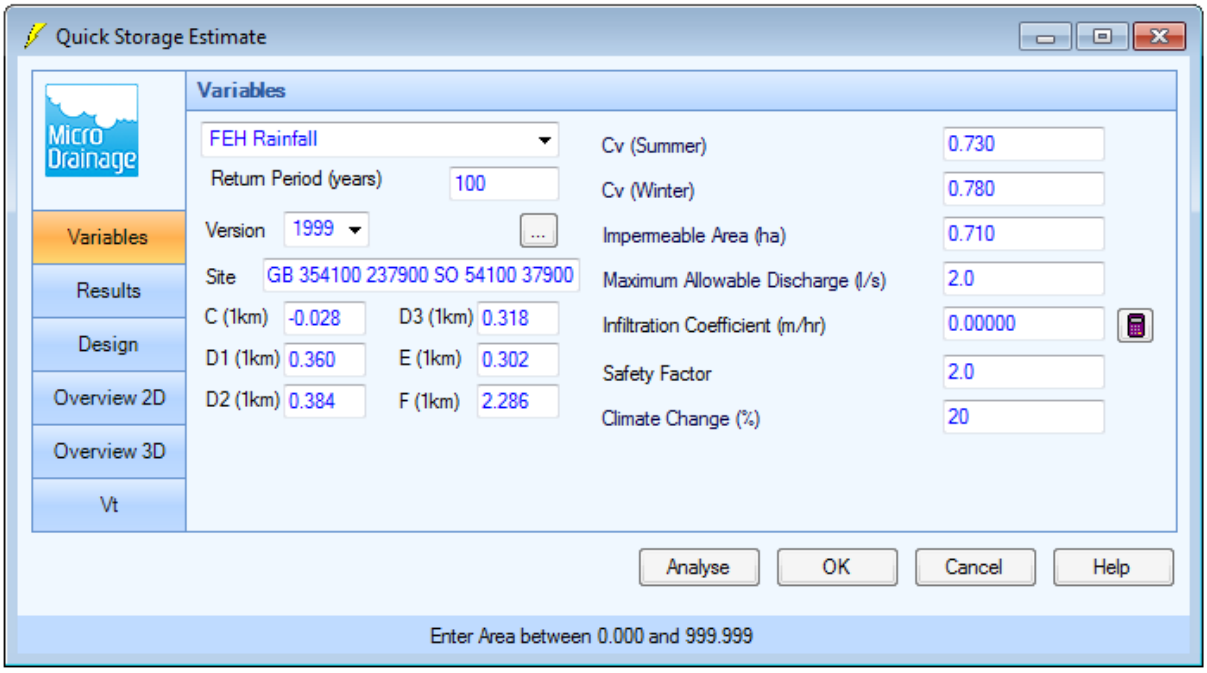


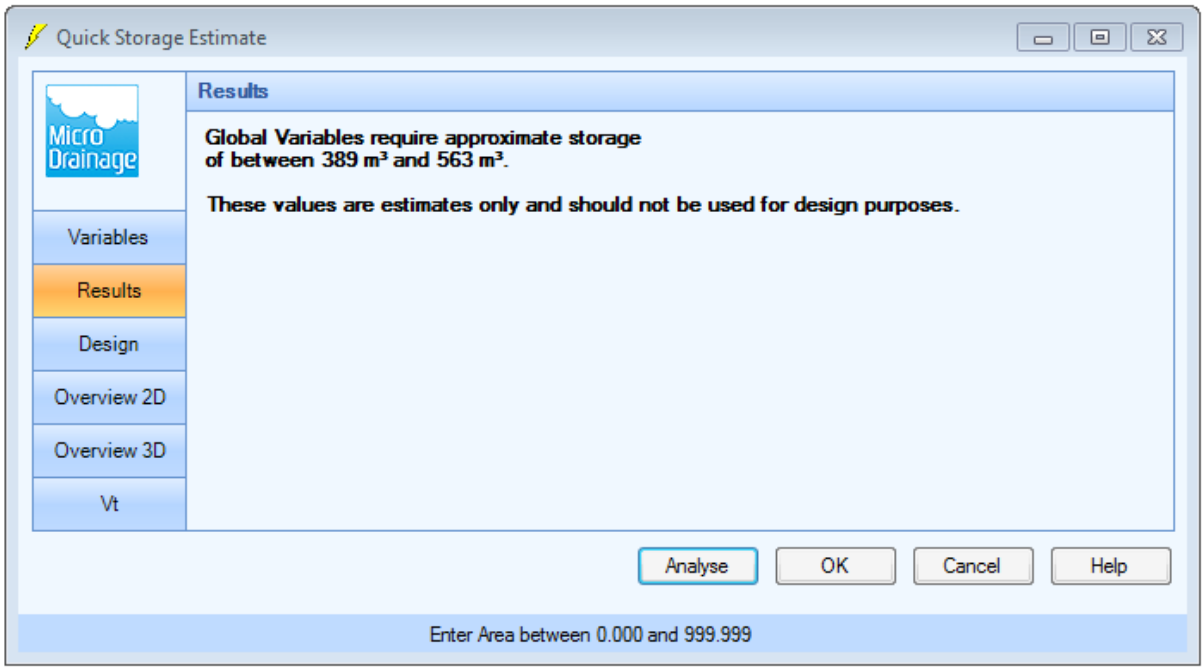
C South-western sub-catchment





D South-eastern sub-catchment





HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Chapel Road
Site location:	South-eastern sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03645° N
Longitude:	2.67355° W

Reference:	
Date:	2019-07-29 15:34

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	0.89

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	1.36
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	660
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	1.46	0.99
1 in 1 year (l/s)	1.29	0.88
1 in 30 years (l/s)	2.6	1.77
1 in 100 years (l/s)	3.18	2.17

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Chapel Road
Site location:	South-western sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03785° N
Longitude:	2.67592° W

Reference:	
Date:	2019-07-29 15:33

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	1.12

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	1.71
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	660
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	1.84	1.25
1 in 1 year (l/s)	1.62	1.1
1 in 30 years (l/s)	3.27	2.23
1 in 100 years (l/s)	4.01	2.73

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Chapel Road
Site location:	Central sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03841° N
Longitude:	2.67464° W

Reference:	
Date:	2019-07-29 15:31

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	0.97

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	1.44
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	654
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	1.55	1.06
1 in 1 year (l/s)	1.37	0.93
1 in 30 years (l/s)	2.76	1.88
1 in 100 years (l/s)	3.38	2.3

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Chapel Road
Site location:	Northern sub-catchment

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.04047° N
Longitude:	2.67487° W

Reference:	
Date:	2019-07-29 15:29

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	2.25

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	3.35
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	654
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

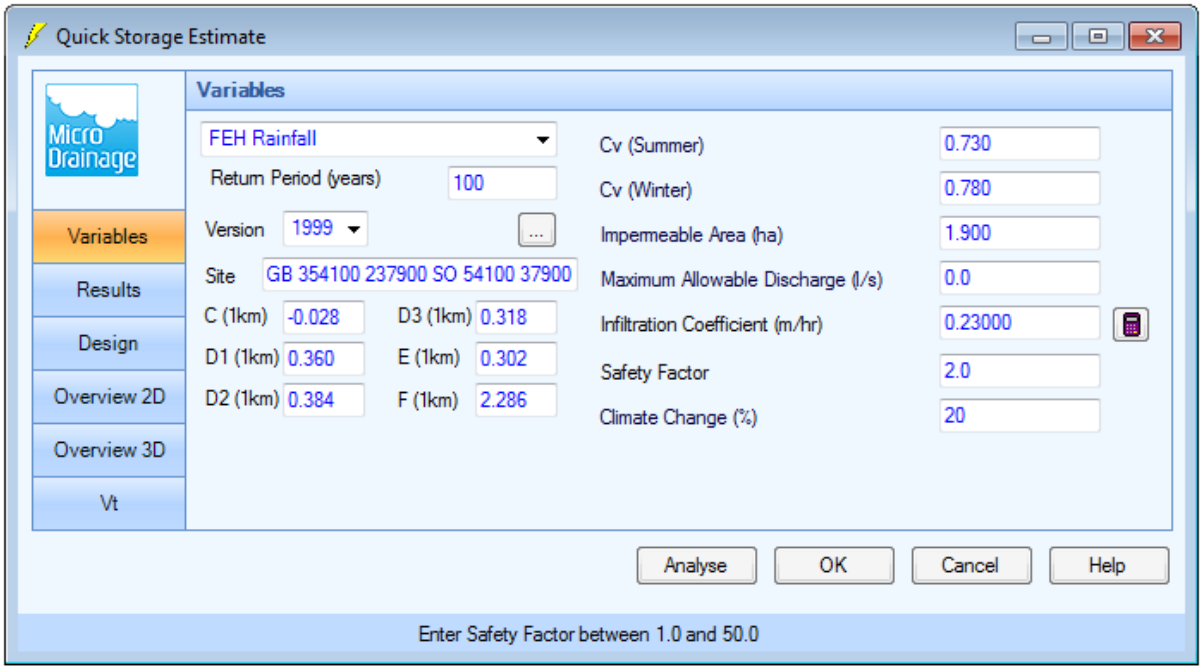
	Default	Edited
Qbar (l/s)	3.6	2.45
1 in 1 year (l/s)	3.17	2.16
1 in 30 years (l/s)	6.4	4.36
1 in 100 years (l/s)	7.84	5.34

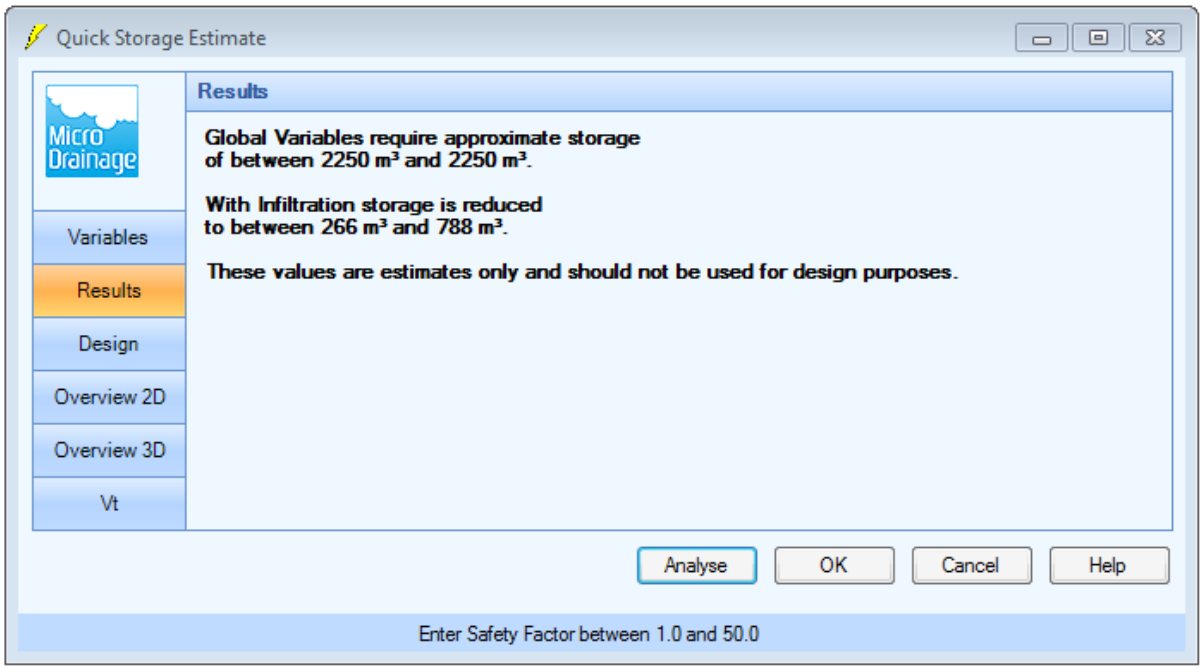
Appendix E – SuDS calculations Skylon East

Skylon East

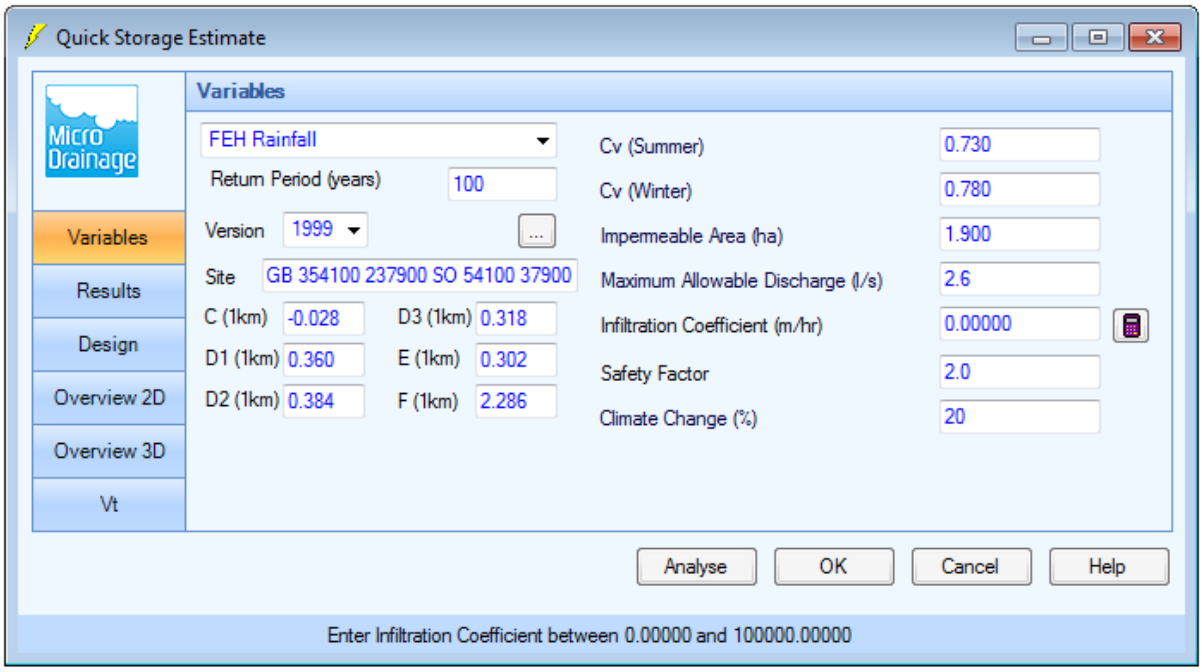
A Northern sub-catchment

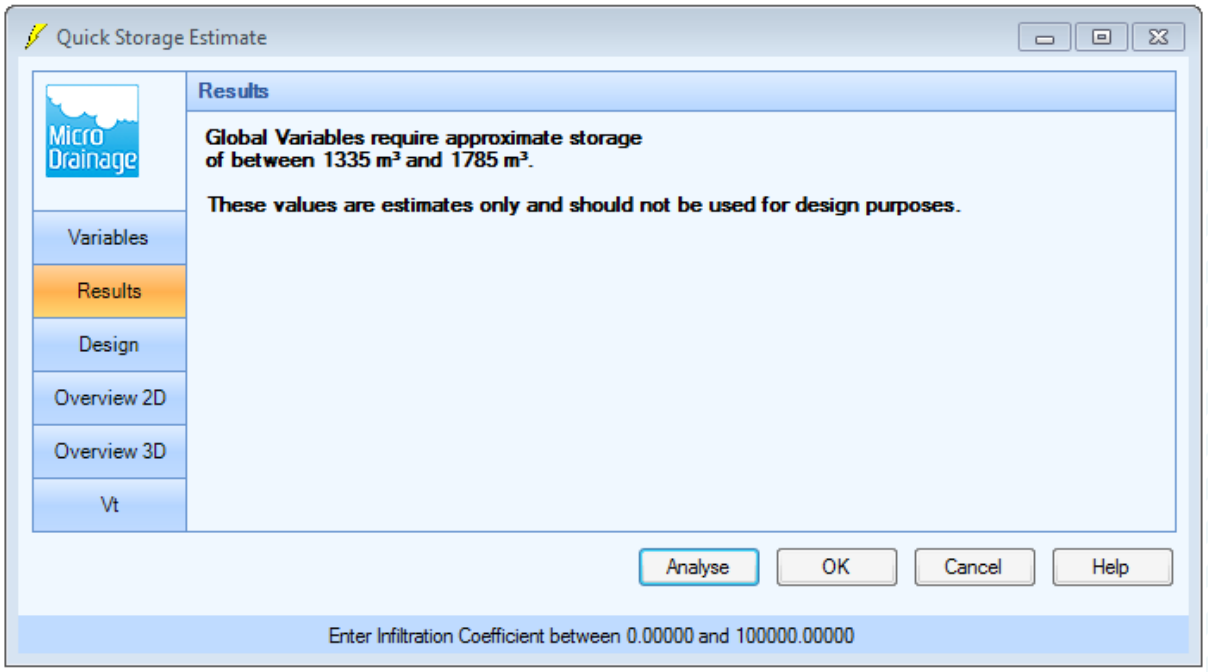
If discharge to the ground is suitable



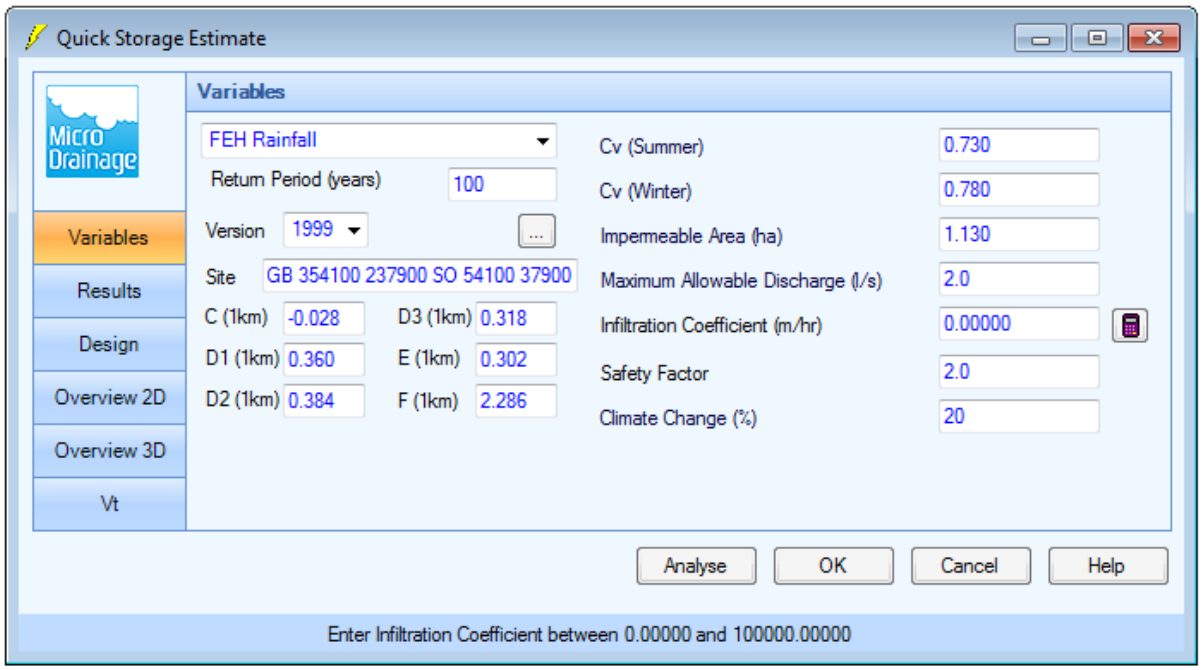


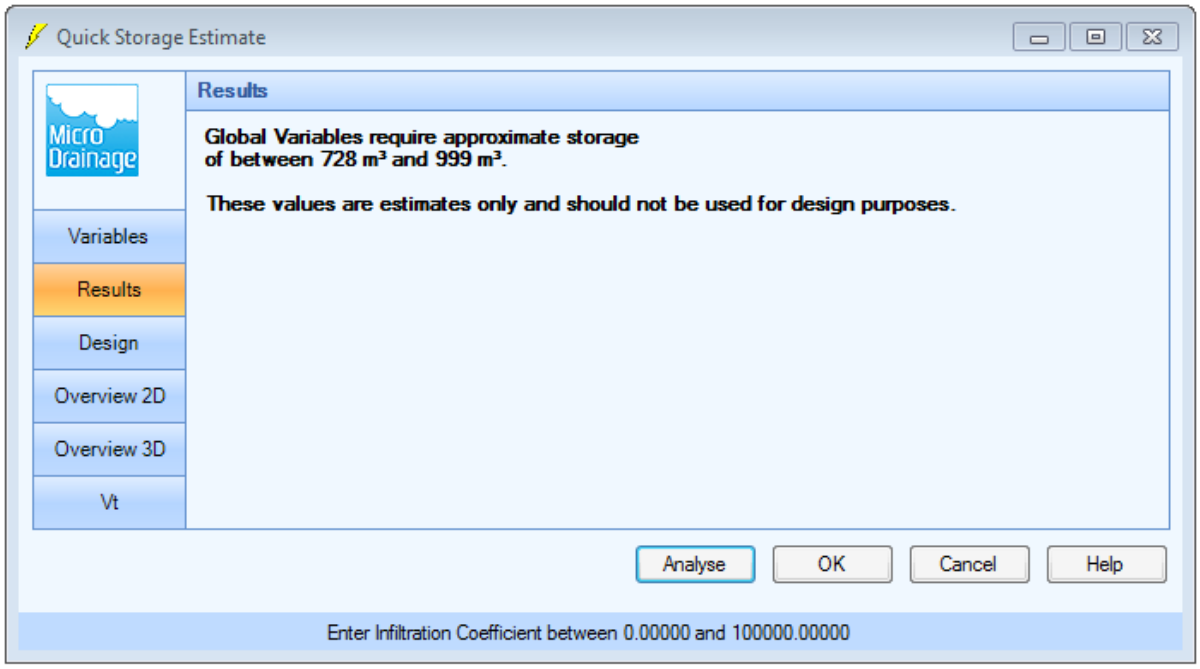
If discharge to the ground is not viable





B Southern sub-catchment





HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon East
Site location:	Southern part

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03649° N
Longitude:	2.68213° W

Reference:	
Date:	2019-05-16 12:07

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	1.42

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	2.17
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	2.33	1.53
1 in 1 year (l/s)	2.05	1.34
1 in 30 years (l/s)	4.15	2.72
1 in 100 years (l/s)	5.08	3.33

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon East
Site location:	Northern part

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03777° N
Longitude:	2.68081° W

Reference:	
Date:	2019-05-16 12:16

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	2.37

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	3.62
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

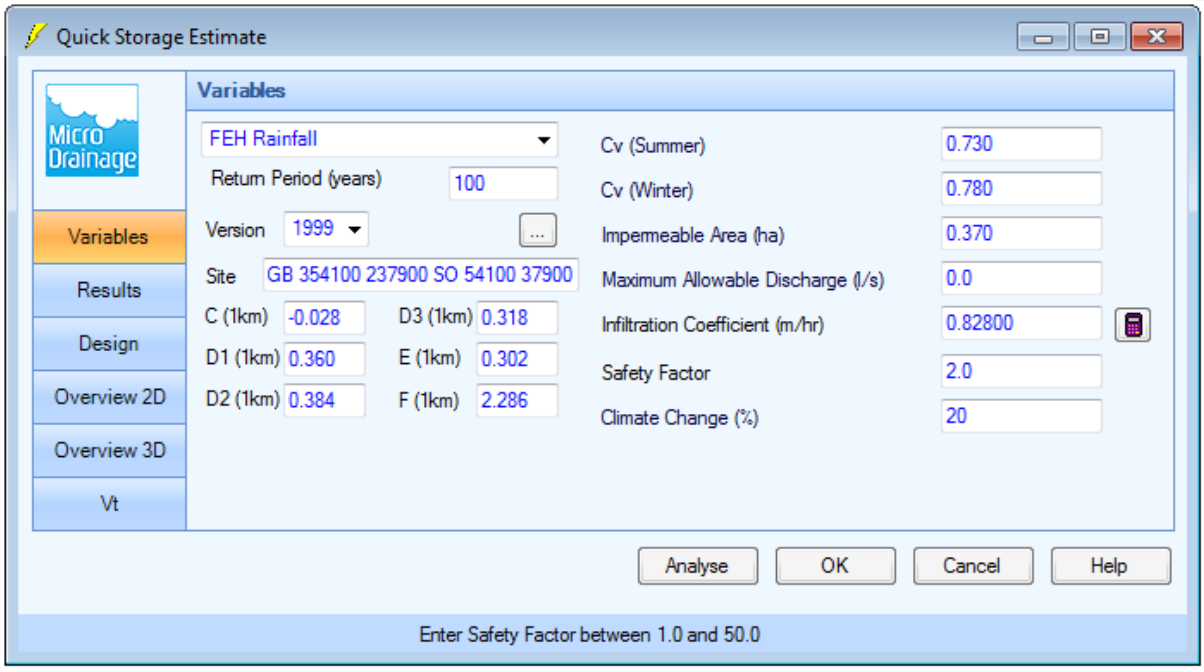
	Default	Edited
Qbar (l/s)	3.89	2.55
1 in 1 year (l/s)	3.42	2.24
1 in 30 years (l/s)	6.92	4.53
1 in 100 years (l/s)	8.48	5.55

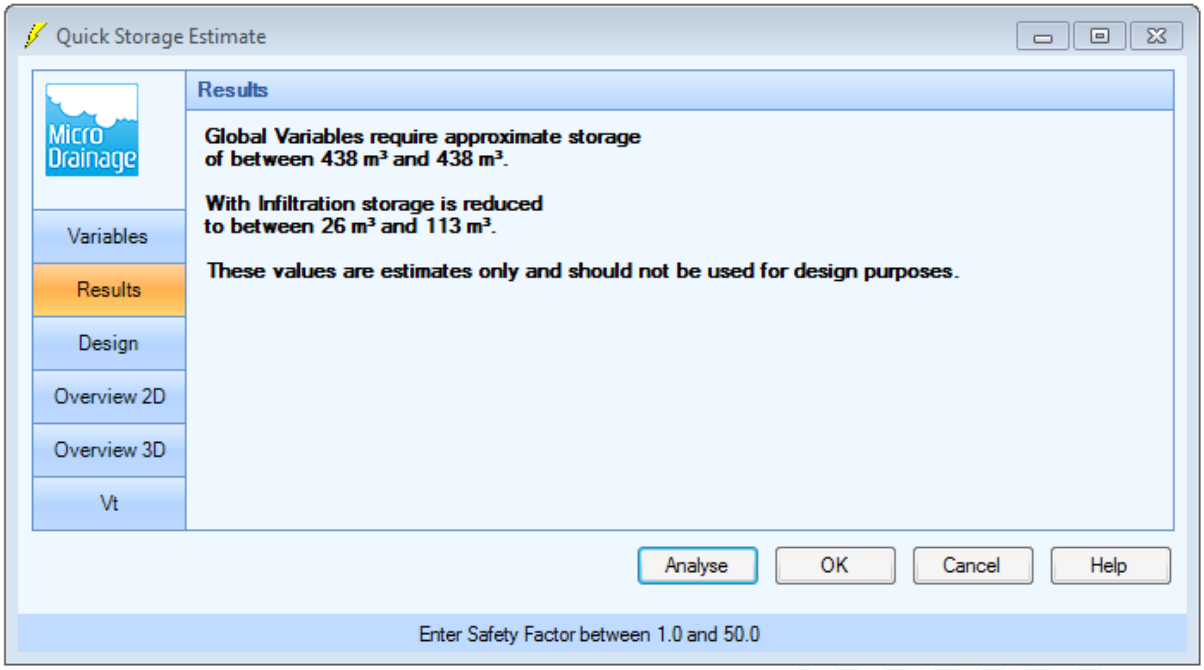
Appendix F – SuDS calculations Skylon Central

Skylon Central

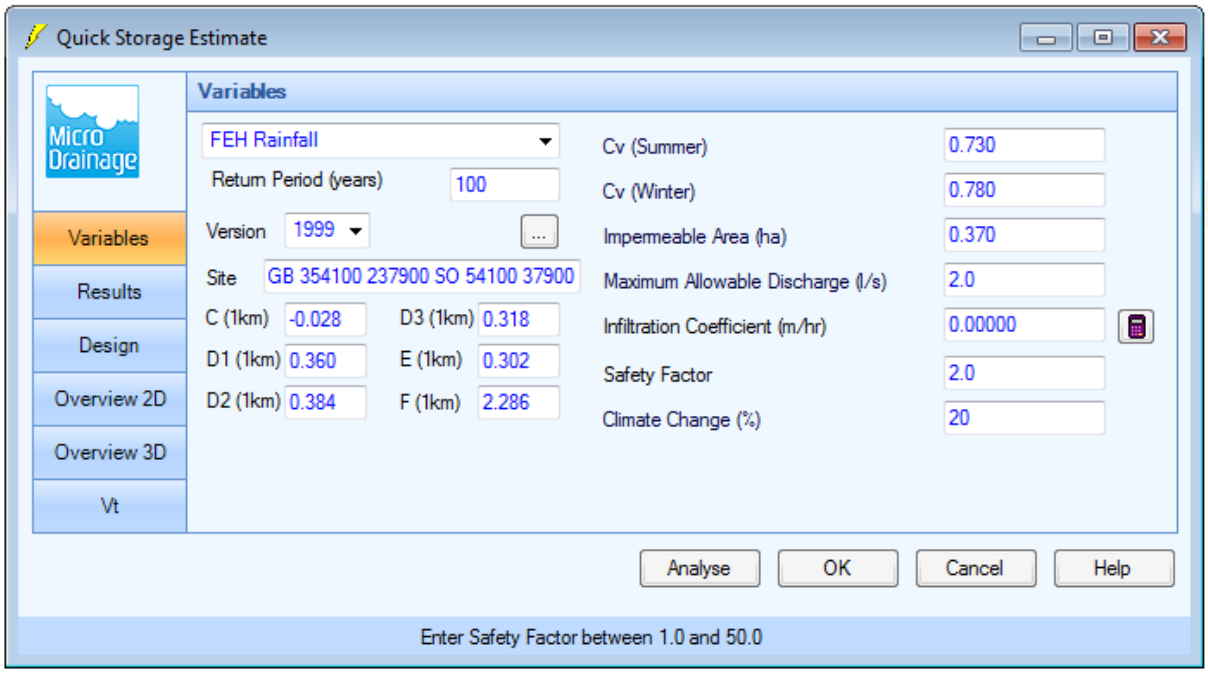
A Northern sub-catchment

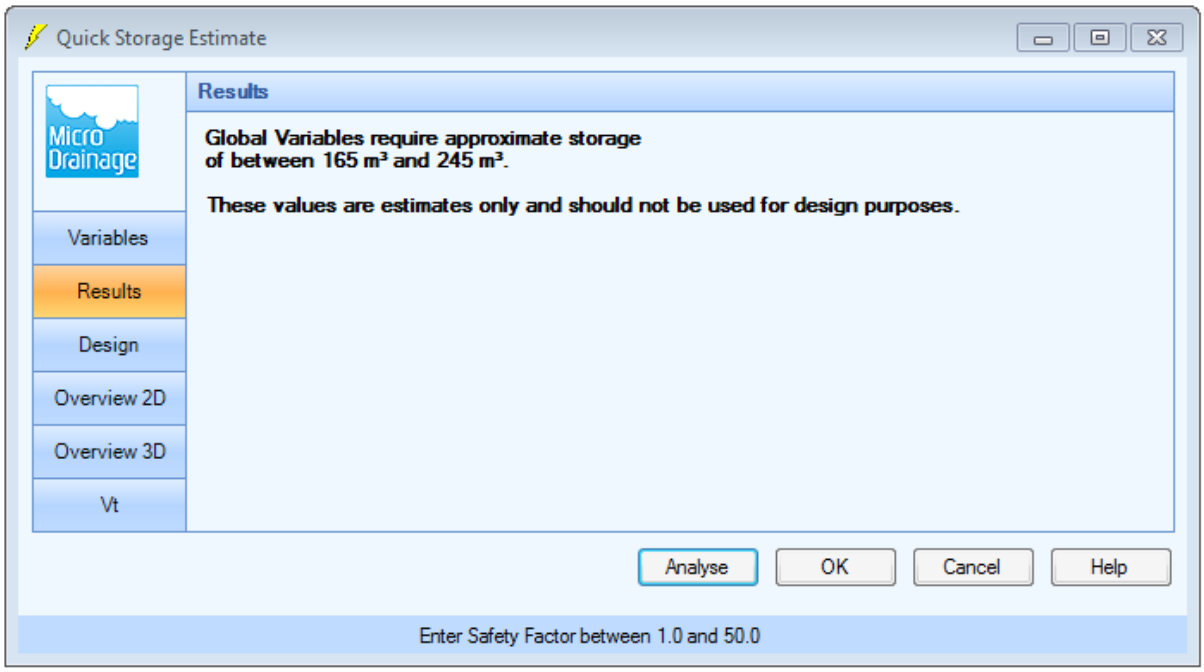
If discharge to the ground is suitable





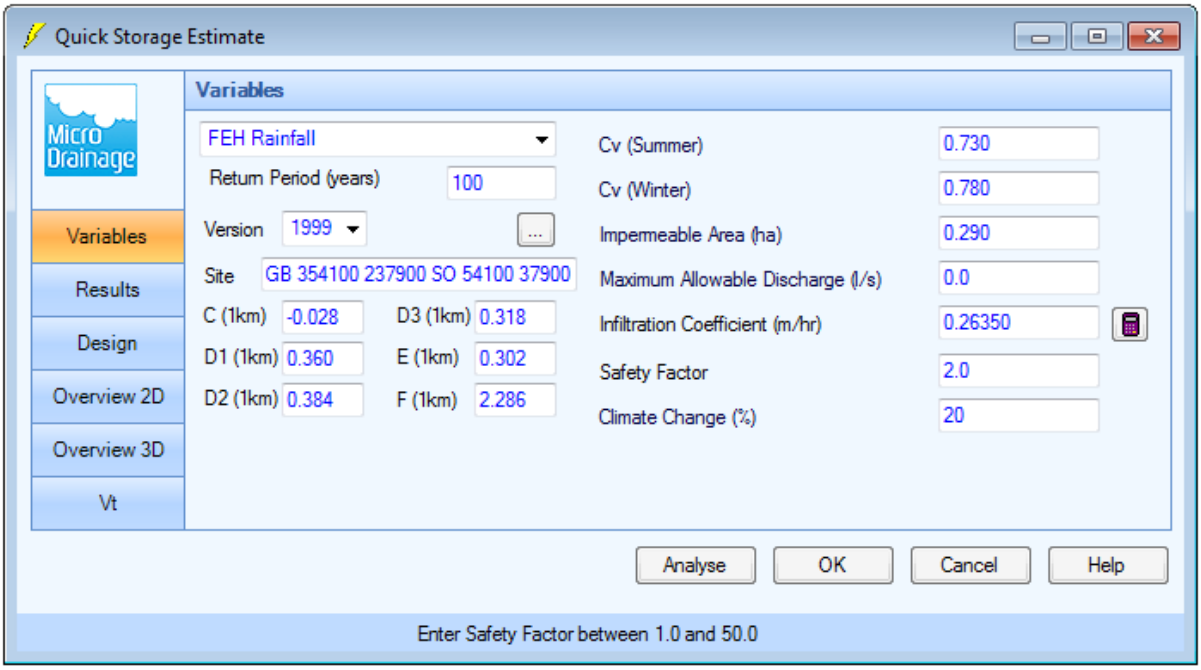
If discharge to the ground is not viable

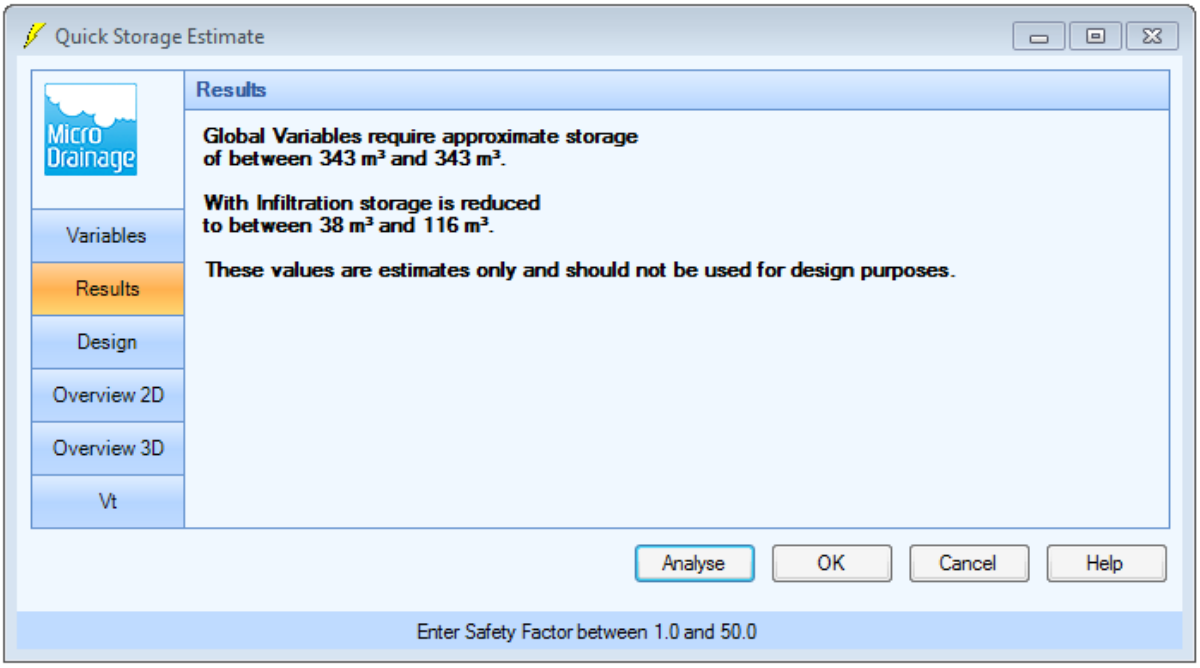




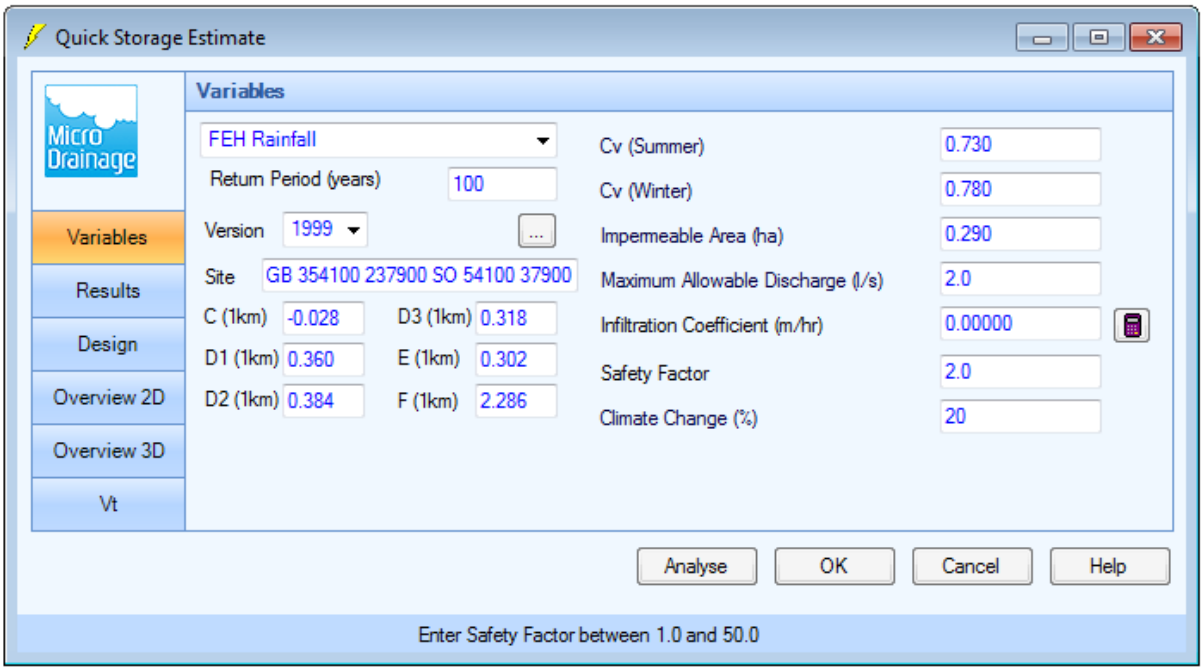
B Southern sub-catchment

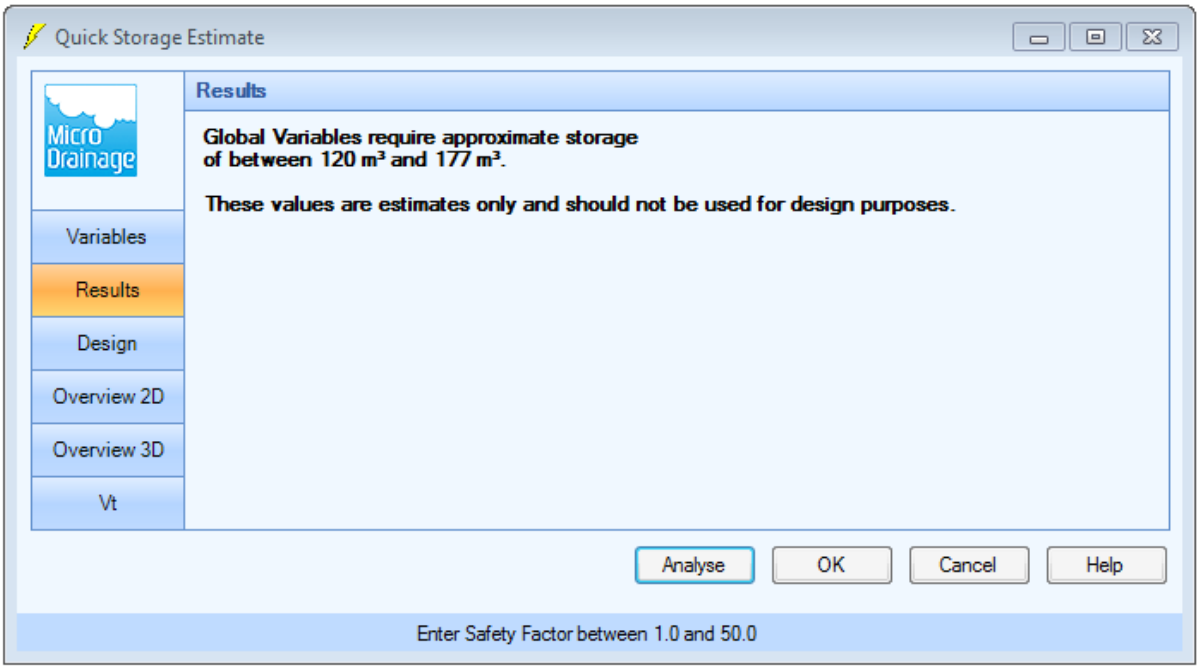
If discharge to the ground is suitable





If discharge to the ground is not viable





HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon Central
Site location:	Central part

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03861° N
Longitude:	2.68279° W

Reference:	
Date:	2019-05-16 11:23

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	1.61

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	2.39
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	2.57	1.73
1 in 1 year (l/s)	2.27	1.52
1 in 30 years (l/s)	4.58	3.08
1 in 100 years (l/s)	5.61	3.77

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon Central
Site location:	Western part

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03981° N
Longitude:	2.68523° W

Reference:	
Date:	2019-05-16 11:11

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	0.31

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	0.46
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	654	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	0.5	0.33
1 in 1 year (l/s)	0.44	0.29
1 in 30 years (l/s)	0.88	0.59
1 in 100 years (l/s)	1.08	0.73

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon Central
Site location:	Southern part

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03717° N
Longitude:	2.68308° W

Reference:	
Date:	2019-05-16 11:34

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	0.36

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	0.55
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

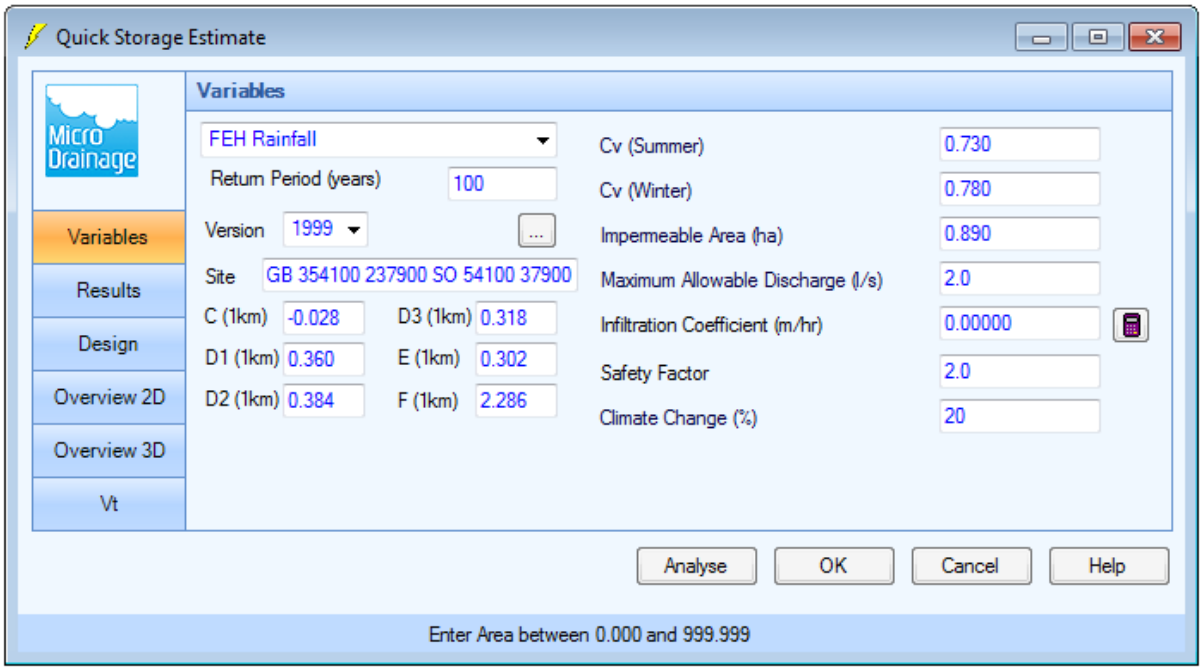
(3) Is SPR/SPRHOST ≤ 0.3?

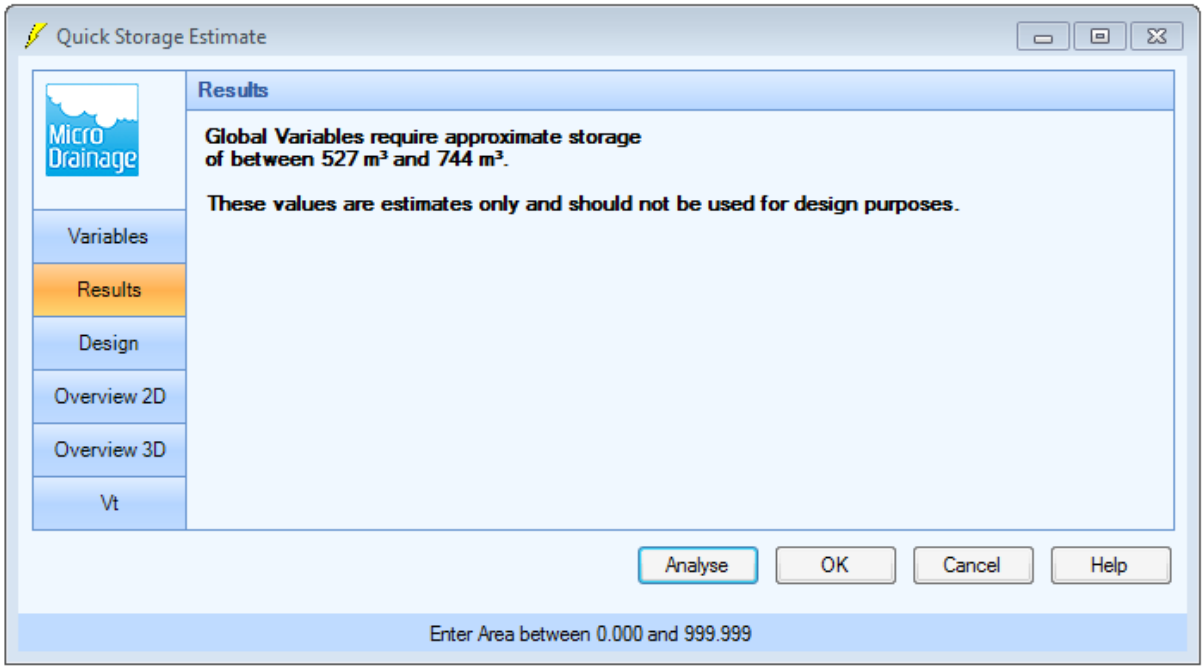
Greenfield runoff rates

	Default	Edited
Qbar (l/s)	0.59	0.39
1 in 1 year (l/s)	0.52	0.34
1 in 30 years (l/s)	1.05	0.69
1 in 100 years (l/s)	1.29	0.84

Appendix G – SuDS calculations Skylon South Magazine

Skylon South Magazine





HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon South Magazine
Site location:	Rotherwas Industrial Estate

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03428° N
Longitude:	2.6863° W

Reference:	
Date:	2019-05-22 16:30

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	1.11

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	9
BFI / BFIHOST	0.731
Qmed (l/s)	1.16
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

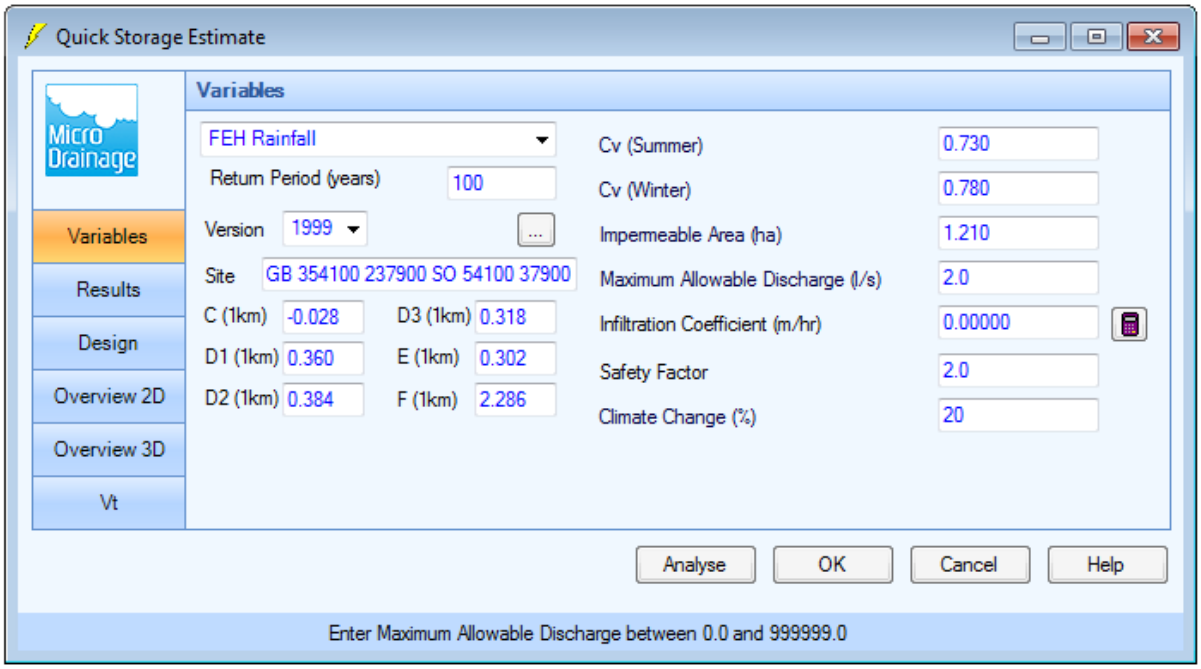
Greenfield runoff rates

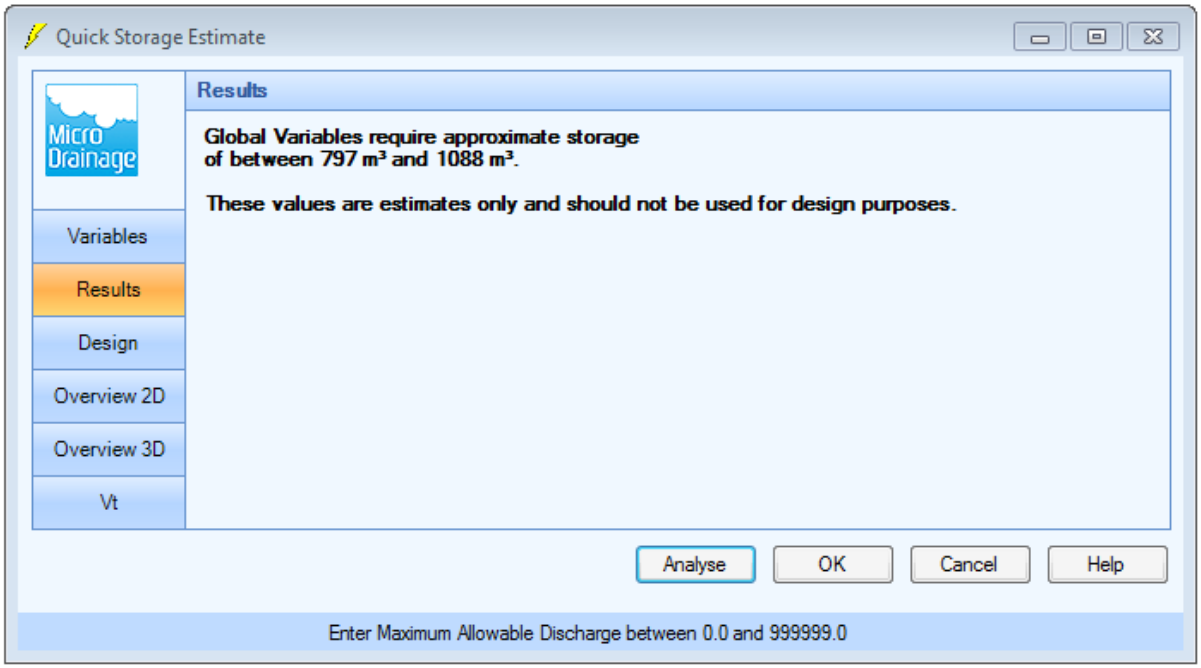
	Default	Edited
Qbar (l/s)	1.25	1.19
1 in 1 year (l/s)	1.1	1.05
1 in 30 years (l/s)	2.22	2.12
1 in 100 years (l/s)	2.72	2.6

Appendix H – SuDS calculations Skylon South

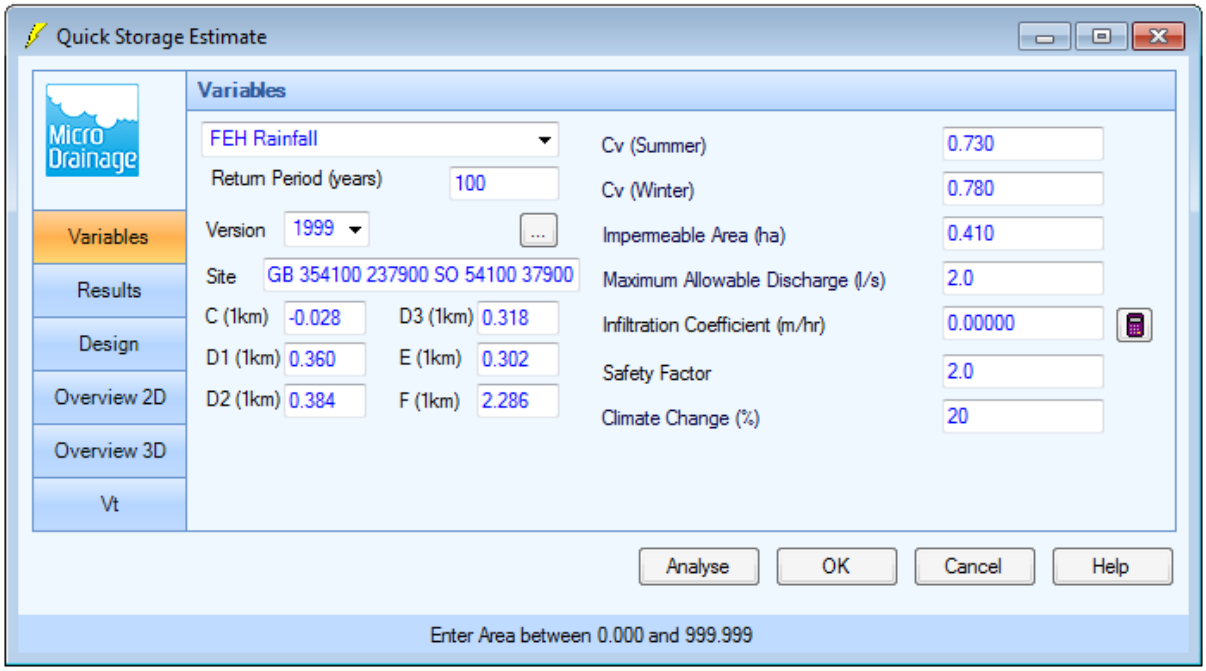
Skylon South

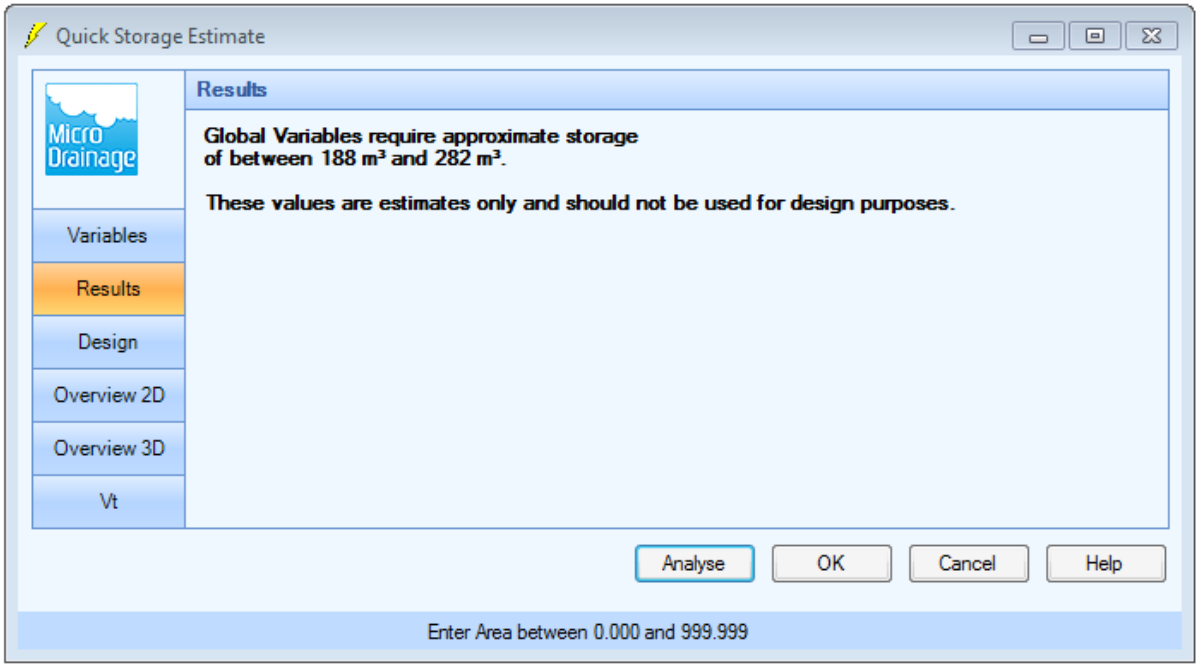
A North-western sub-catchment



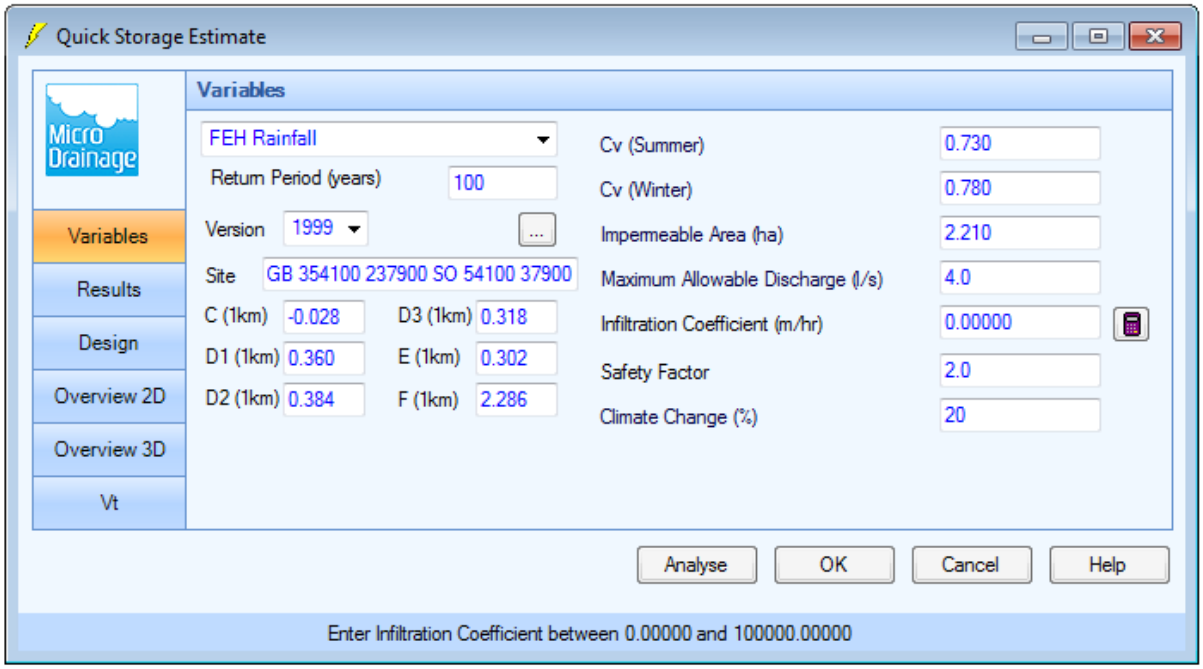


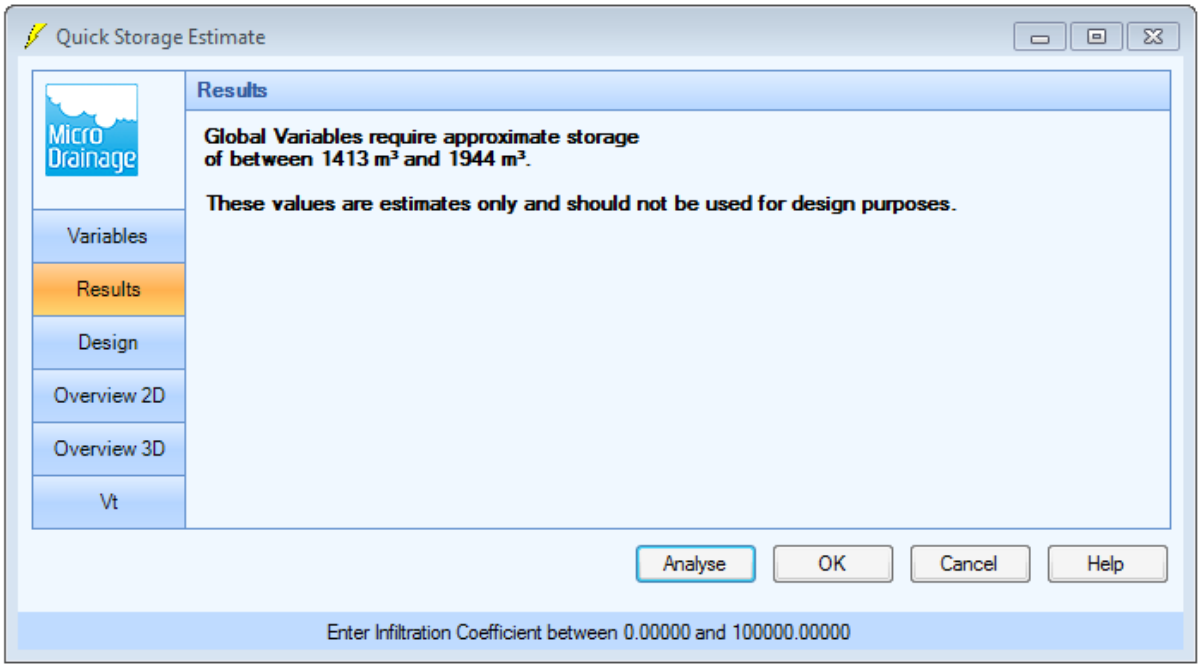
B South-western sub-catchment





C Eastern sub-catchment





HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon South
Site location:	North-western

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03363° N
Longitude:	2.69575° W

Reference:	
Date:	2019-05-28 16:41

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	1.68

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	2.57
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	2.76	1.81
1 in 1 year (l/s)	2.43	1.59
1 in 30 years (l/s)	4.91	3.21
1 in 100 years (l/s)	6.01	3.94

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon South
Site location:	South-western

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03231° N
Longitude:	2.69414° W

Reference:	
Date:	2019-05-28 16:42

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	0.75

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	1.15
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	1.23	0.81
1 in 1 year (l/s)	1.08	0.71
1 in 30 years (l/s)	2.19	1.43
1 in 100 years (l/s)	2.68	1.76

HR Wallingford
Working with water

Greenfield runoff estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	
Site name:	Skylon South
Site location:	Eastern

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	52.03279° N
Longitude:	2.69216° W

Reference:	
Date:	2019-05-28 16:43

Methodology	FEH Statistical

Site characteristics

Total site area (ha)	3.71

Methodology

Qmed estimation method	Calculate from BFI and SAAR
BFI and SPR estimation method	Specify BFI manually
HOST class	6
BFI / BFIHOST	0.731
Qmed (l/s)	5.66
Qbar / Qmed Conversion Factor	1.08

Hydrological characteristics

	Default	Edited
SAAR (mm)	660	651
Hydrological region	9	9
Growth curve factor: 1 year	0.88	0.88
Growth curve factor: 30 year	1.78	1.78
Growth curve factor: 100 year	2.18	2.18

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consents are usually set at 5.0l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set in which case blockage work must be addressed by using appropriate drainage elements

(3) Is SPR/SPRHOST ≤ 0.3?

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	6.09	3.99
1 in 1 year (l/s)	5.36	3.51
1 in 30 years (l/s)	10.84	7.1
1 in 100 years (l/s)	13.27	8.69

References

Amey UK, 2009. Drainage and Flood Management Strategy, Herefordshire Council Rotherwas Futures. September 2009.

Amey, 2011. Rotherwas Futures Flood Attenuation Scheme Flood Risk Assessment, Final. Herefordshire Council. August 2011.

CC Ground Investigation on behalf of Parsons Brinckergoff Ltd., 2014. Draft Factual Report, Report C4249 15th September 2014.

Communities and Local Government, 2007. Improving the Flood Performance of New Buildings. Flood Resilient Construction. May 2007.

Defra and Agency, 2006. The Flood Risks to People Methodology, Flood Risks to People Phase 2, FD2321 Technical Report 1, HR Wallingford et al. for Defra/EA Flood and Coastal Defence R&D Programme. March 2006

Environment Agency and HR Wallingford, 2008. Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1'. May 2008.

Geotechnics Ltd, February 2013. Ground Investigation at North Magazine Site, Rotherwas. Factual and Interpretive Report. Project Number PC125103.

Nolan Associates, 2015. GB Electrical Development SUDS Management Strategy, Application No. 151853, December 2015.

Hydro-Logic, 2015. Surface Water Management Plan, Woodstrock Trading. October 2015.

JBA Consulting, 2011. Rotherwas Futures – Technical Modelling Report. June 2011.

JBA Consulting, 2014. Hereford Enterprise Zone – Additional Flood Zone (new development plots), Note to File. May 2014.

JBA Consulting, 2013. Rotherwas Estate Hydraulic Modelling: Investigation of the impact on flood risk from the installation of culverts underneath the Chapel Road Plot Access Road, Note to File. June 2013.

JBA Consulting, 2017. Rotherwas Drainage and Flood Risk Management Strategy 2017 Update, Note to File. October 2017.

JBA Consulting, 2018. Rotherwas Industrial Estate: Review of Flood Mitigation Strategy, Report. August 2018.

JBA Consulting, 2019. Hereford Enterprise Zone Flood Storage Pond Technical Note. September 2019

Sutton Survey, 2016. Soil Infiltration Testing Report SS-16-2433, North Magazine. May 2016.

WSP, 2019. Herefordshire Strategic Flood Risk Assessment Level 1 for Herefordshire Council.

Offices at

Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Isle of Man
Limerick
Newcastle upon Tyne
Newport
Peterborough
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

+44(0)1756 799919
info@jbaconsulting.com
www.jbaconsulting.com
Follow us:

Jeremy Benn Associates Limited

Registered in England 3246693

JBA Group Ltd is certified to:
ISO 9001:2015
ISO 14001:2015
OHSAS 18001:2007