Greater Cambridge Partnership

CAMBOURNE TO CAMBRIDGE

Appendix TR13.1: Flood Risk Assessment

AUGUST 2023

PUBLIC

Greater Cambridge Partnership

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CONTENTS

1. INTRODUCTION 1

1.1. SCHEME OVERVIEW 1
1.2. LOCATION 1
1.3. CONSULTATION 3

2. ASSESSMENT METHODOLOGY 4

2.1. OVERVIEW 4
2.2. DEFINITION OF FLOOD RISK 4
2.3. POTENTIAL SOURCES OF FLOODING 5
2.4. POTENTIAL EFFECTS OF CLIMATE CHANGE 5
2.5. LEGISLATIVE FRAMEWORK AND GUIDANCE 6

3. SITE DESCRIPTION 11

3.2. EXISTING SURFACE WATER FEATURES 11
3.3. GEOLOGY AND HYDROGEOLOGY 15

4. EXISTING FLOOD RISK 17

4.1. HISTORIC FLOOD RECORDS 17
4.2. FLUVIAL FLOOD RISK 18
4.3. TIDAL FLOOD RISK 22
4.4. SURFACE WATER FLOOD RISK 22
4.5. GROUNDWATER FLOOD RISK 25
4.6. SEWER FLOOD RISK 26
4.7. ARTIFICIAL SOURCES 26
4.8. OTHER SOURCES OF FLOOD RISK 27
4.9. EXISTING FLOOD RISK SUMMARY 28

5. POST DEVELOPMENT FLOOD RISK 29

5.1. PROPOSED WORKS 29
5.2. BIN BROOK CROSSING 29
5.3. ORDINARY WATERCOURSE CROSSINGS 31
5.4. INCREASE IN SURFACE WATER RUNOFF 33
5.5. FLOOD RISK DURING CONSTRUCTION 33
5.6. RESIDUAL FLOOD RISK AND OFFSITE EFFECTS 34
6. CONCLUSION 35
6.1. EXISTING FLOOD RISK 35
6.2. POST DEVELOPMENT FLOOD RISK 35
6.3. SEQUENTIAL AND EXCEPTION TEST 36
7. REFERENCES 38

TABLES

Table TR13.1-2-1 Flood Probability Conversion Table 4
Table TR13.1-2-2 Flood Zones 5
Table TR13.1-2-3 - Flood Risk Vulnerability Classification 8
Table TR13.1-4-1 - Flood risk summary 28
Table TR13.1-5-1 - Proposed Bin Brook Structure 29
Table TR13.1-5-2 - Summary of ordinary watercourse crossings 32
Table TR13.1-6-1 - Summary of baseline and post-development flood risk 36

FIGURES

Plate TR13.1-1-1 – Scheme Location and Extents 2
Plate TR13.1-3-1 – Watercourses found in proximity to the C2C Scheme 12
Plate TR13.1-3-2 – Bin Brook location 13
Plate TR13.1-3-3 – Bin Brook and tributaries 14
Plate TR13.1-3-4 – Callow Brook and tributaries 15

Plate TR13.1-4-1 – Bar Hill and Caldecote 17
Plate TR13.1-4-2 – Environment Agency historic flood outline 18
Plate TR13.1-4-3 – Environment Agency Flood Map for Planning 19
Plate TR13.1-4-4 – The Bin Brook Section of the Environment Agency's Flood Map for Planning (April 2022) for the C2C Scheme 20
Plate TR13.1-4-5 – Modelled baseline 1% and 0.1% AEP flood extents 21
Plate TR13.1-4-6 – 1% AEP + 19%CC modelled baseline flood depths 21
Plate TR13.1-4-7 – Surface water flooding probility 22
Plate TR13.1-4-8 – Section A surface water flood risk 23
Plate TR13.1-4-9 – Section B surface water flood risk 24
Plate TR13.1-4-10 – Section C surface water flood risk 25
Plate TR13.1-4-11 – Environment Agency Reservoir Flood Extent 27
Plate TR13.1-5-1 – Comparison of baseline and proposed flood extents (1% AEP +19%CC) 30
Plate TR13.1-5-2 – Depth Comparison between baseline and proposed model (1% AEP + 19%CC) 31
Plate TR13.1-5-3 – Depth Comparison between baseline and proposed model (0.1% AEP + 19%CC) 34

APPENDICES

ANNEX TR13.1.1 ENVIRONMENT AGENCY ADVISORY NOTE
ANNEX TR13.1.2 MODELLING TECHNICAL NOTE
ANNEX TR13.1.3 HYDROLOGY
ANNEX TR13.1.4 SURFACE WATER DRAINAGE STRATEGY

1. INTRODUCTION

1.1. SCHEME OVERVIEW

1.1.1. WSP UK Ltd (WSP) have been commissioned by the Greater Cambridge Partnership (GCP) to undertake a Flood Risk Assessment (FRA) which will form a Technical Appendix to the Environmental Impact Assessment (EIA) to support the planning application for the proposed Cambourne to Cambridge (C2C) Scheme in South Cambridgeshire.

1.1.2. The assessment has been conducted in accordance with the National Planning Policy Framework (NPPF) (Ministry of Housing, Communities & Local Government, 2021) and Planning Practice Guidance (PPG) (Ministry of Housing, Communities & Local Government, 2022), local planning policy, as well as other relevant standards as agreed through consultation with the Environment Agency and Cambridgeshire City Council (CCC).

1.1.3. A review of the Environment Agency's Flood Map for Planning indicates that the majority of the C2C Scheme is located in Flood Zone 1, areas of Low Risk. However, within the Order Limits of the C2C Scheme there is a small area in the eastern extent of the scheme located within Flood Zone 3, areas of High Risk. The identified high risk areas of fluvial flood risk is associated with the Bin Brook.

1.1.4. The assessment includes the following:

- Confirmation of the sources of flooding which may affect the C2C Scheme;
- A quantitative assessment of the risk of flooding to the C2C Scheme, including use of a detailed hydraulic model;
- Identification of possible measures which could reduce flood risk to acceptable levels and a summary of residual risks; and
- A summary of the proposed surface water drainage strategy.

1.2. LOCATION

1.2.1. The C2C Scheme is located west of Cambridge, within the County of Cambridgeshire, the location of the scheme can be seen in **Plate TR13.1-1-1**.

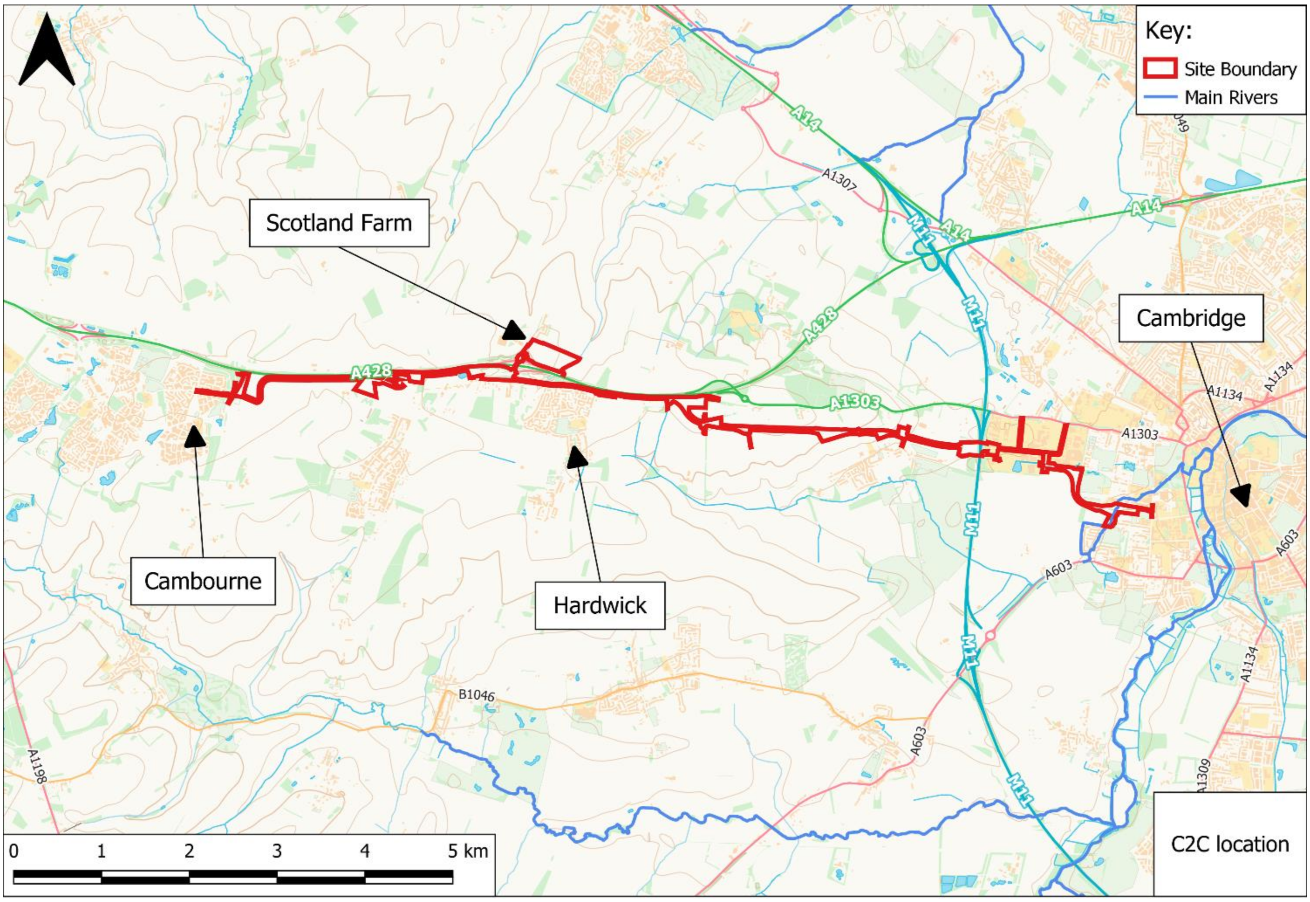

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Plate TR13.1-1-1 – Scheme Location and Extents

1.2.2. The C2C Scheme will include a 13.6km long mainly dedicated busway connecting Cambourne in the west with Cambridge in the east. A service road and maintenance track, to be used as an active travel path, will run alongside the segregated sections of busway. The C2C Scheme will use hybrid vehicles (and in due course, electric vehicles), providing a service of around 10 buses per hour each way. The Scotland Farm travel hub (a park and ride facility) will be situated along the route, just north of the A428, approximately 5km west of Cambridge. Further details about the Scheme proposal are set out in Chapter 3 of the ES[1].

1.2.3. The scheme is comprised of three main elements:

- A new, largely segregated, roadway for High Quality Public Transport (HQPT) use, with public transport priority measures between Cambourne and Cambridge where the route joins the existing road network;
- A new Travel Hub at Scotland Farm; and
- New high-quality non-motorised user facilities (referred to as the Shared Use Path).

[1] Environmental Statement (Document reference: C2C-10-00-Environmental Statement (Volume 1)).

1.3. CONSULTATION

1.3.1. Consultation with the Environment Agency regarding the crossing of the Bin Brook was undertaken via emails.

1.3.2. The design soffit level for the Bin Brook crossing was agreed to be set at the 1%Annual Exceedance Probability (AEP) with 19% climate change plus a 300mm freeboard, equating to a height of 9.67mAOD. As such the proposed crossing would meet the design requirements set out by the Environment Agency and section LA 113 - Road drainage and the water environment of the Design Manual for Roads and Bridges (DMRB) (National Highways, 2020).

1.3.3. Following completion of the hydraulic modelling a technical memo was submitted to the Environment Agency for consultation to agree the findings. The technical memo is found in **Annex A**. This is described in more detail in **Section 5.2**.

2. ASSESSMENT METHODOLOGY

2.1. OVERVIEW

2.1.1. The tasks involved in the completion of this FRA are as follows:

- Site walkover completed in relation to the wider scheme works in July 2021 and January 2022;
- Review of available relevant flood risk information to identify existing risks from all sources. The information reviewed includes:
  - The Environment Agency's online maps for flood risk (Flood Map for Planning);
  - Environment Agency Long-Term Flood Risk Maps; and
  - Groundwater mapping (Environment Agency groundwater data is hosted on The Multi-Agency Geographic Information for the Countryside (MAGIC)2 online map).
- Summary of the proposed drainage strategy for the C2C Scheme; and
- Hydraulic modelling of the Bin Brook in order to inform the understanding of flood mechanisms and potential impacts.

2.2. DEFINITION OF FLOOD RISK

2.2.1. Flood risk is the product of the likelihood or chance of a flood occurring (flood frequency) and the consequence or impact of the flooding (flood consequence).

FLOOD FREQUENCY

2.2.2. Flood frequency is identified in terms of the return period and annual probability. For example, a 1 in 100 year flood event has a 1% annual exceedance probability (AEP) of occurring. **Table TR13.1-2-1** provides a conversion between return periods and annual flood probabilities.

Table TR13.1-2-1 Flood Probability Conversion Table

Return Period (Years)	2	5	10	30	50	100	200	1000
Annual Exceedance Probability %	50	20	10	3.33	2	1	0.5	0.1

2.2.3. The Flood Risk and Coastal Change PPG (Ministry of Housing, Communities & Local Government, 2022) identifies Flood Zones in relation to flood frequency. The zones refer to the probability of river (fluvial) and sea (tidal) flooding, whilst ignoring the presence of defences.

2.2.5. **Table TR13.1-2-2** summarises the relationship between Flood Zone category and the identified flood probability (as defined in the PPG).

[2] DEFRA Magic Map (2022). Available online: https://magic.defra.gov.uk/MagicMap.aspx

Table TR13.1-2-2 Flood Zones

Flood Risk Area	Identification	Annual Probability of Fluvial Flooding	Annual Probability of Tidal Flooding
Zone 1	Low probability	< 0.1 %	< 0.1 %
Zone 2	Medium probability	1 % - 0.1 %	0.5 % - 0.1 %
Zone 3a	High probability	> 1 %	> 0.5 %
Zone 3b	Functional Floodplain	> 3.3 %	> 3.3 %

FLOOD CONSEQUENCES

2.2.6. The consequence of a flood event describes the potential damage, danger and disruption caused by flooding. This is dependent on the mechanism and characteristics of the flood event and the vulnerability of the affected land and the land use.

2.2.7. The NPPF (Ministry of Housing, Communities & Local Government, 2021) identifies five classifications of flood risk vulnerability and provides recommendations on the compatibility of each vulnerability classification with the Flood Zones. Full details of the Flood Zones and flood risk vulnerability classifications can be found in the PPG (Ministry of Housing, Communities & Local Government, 2022) and Annex 3 of the NPPF (Ministry of Housing, Communities & Local Government, 2022) respectively and are discussed in **Section 2.5** below.

2.3. POTENTIAL SOURCES OF FLOODING

2.3.1. All sources of flooding have been considered in this assessment, these are:

- Fluvial flood risk;
- Surface water flooding from within the Order Limits of the C2C Scheme and adjacent land;
- Tidal flood risk;
- Surcharging of sewers and other infrastructure;
- Groundwater flooding; and
- Flood risk from other artificial sources such as impounded reservoirs.

2.4. POTENTIAL EFFECTS OF CLIMATE CHANGE

2.4.1. Scientific consensus is that the global climate is warming, predominantly due to anthropogenic greenhouse gas emissions. While there remain uncertainties as to how a changing climate will affect flooding in the UK, the UKCP18 climate projections show a strong trend of short-duration, high-intensity rainfall events increasing alongside an increase of long-duration rainfall events. Sea level rise is also projected to continue. These increases will most likely lead to an increase in the likelihood of flooding over the long term.

2.4.2. The Environment Agency guidance “Flood risk assessments: climate change allowances” (Environment Agency, 2022), published in 2022, provides climate change allowances which are predictions of anticipated changes for peak river flow, peak rainfall intensity and sea level rise. Sea level rise allowances are available on a river basin district; peak river flow and peak rainfall intensity are available on a management catchment level. Management catchments are sub-catchments of river basin districts.

2.4.3. The precise extent of the impacts of climate change is unknown. This is reflected in the Environment Agency's guidance which provides 'Central', 'Higher Central' and 'Upper End' estimates that are based on the 50th, 70th and 95th percentile predictions for climate change.

IMPACT OF CLIMATE CHANGE ON THE DEVELOPMENT

2.4.4. The design life of the C2C Scheme is 100 years and is also classified as essential infrastructure. In accordance with the guidance the higher central band is required to be used for peak river flow and the upper band for peak rainfall allowances. The climate change allowances are from DEFRA's climate change allowances (Department for Environment Food & Rural Affairs, 2021).

- 19% increase in peak river flow for the assessment of flood risk to the C2C Scheme, assessment of flood risk to third parties, design of the large watercourse crossing and design of other required fluvial mitigation as required and
- 35% increase in the 3.33% AEP rainfall event and a 40% increase in the 1% AEP rainfall event to be used to inform the drainage design for the assessment of surface water risk to the C2C Scheme and third parties, including the crossings of the small watercourses (i.e. those with a catchment smaller than 5km^2).

2.5. LEGISLATIVE FRAMEWORK AND GUIDANCE

2.5.1. The coordination of policies for the water environment is managed by the UK Government and is split into the following jurisdictions:

- The Environment Agency has a strategic overview regarding the management of all of sources of flooding and an operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and tidal sources;
- Lead Local Flood Authorities (LLFAs) are responsible for managing the risk of flooding from local sources, including surface water, groundwater and ordinary watercourses. The LLFA relevant to the C2C Scheme is Cambridgeshire County Council; and
- The applicable legislative frameworks are summarised below.

EUROPEAN LEGISLATION

Floods Directive (2007/60/EC)

2.5.2. The key objective of the Floods Directive (UK Government, 2007) is to coordinate the assessment and management of flood risks. Specifically, it requires the assessment of all watercourses and coastlines that are at risk of flooding, to map the flood extent, assess the flood assets and the humans at risk in these areas, and to take adequate and coordinated measures to reduce this risk.

NATIONAL LEGISLATION

The Flood Risk Regulations 2009

2.5.3. The Floods Directive (UK Government, 2007) has formalised flood risk management planning. The Flood Risk Regulations 2009 (UK Government, 2009) implements the Directive and requires LLFAs, and the Environment Agency to prepare and publish Flood Risk Management Plans (FRMPs) on a six year cycle.

Land Drainage Act 1991

2.5.4. Local Authorities and Internal Drainage Boards (IDB) have additional duties and powers associated with the management of flood risk under the Land Drainage Act 1991 (UK Government, 1991). As Land Drainage Authorities, consent must be given for any permanent or temporary works that could affect the flow within an ordinary watercourse under their jurisdiction, in order to ensure that local flood risk is not increased.

2.5.5. The Land Drainage Act (UK Government, 1991) specifies that the following works would require formal consent from the appropriate authority:

- Construction, raising or alteration of any mill dam, weir, or other like obstructions to the flow of a watercourse;
- Construction of a new culvert; and
- Any alterations to an existing culvert that would affect the flow of water within a watercourse.

2.5.6. The Land Drainage Act (UK Government, 1991) also sets out the maintenance responsibilities riparian owners have in order to reduce local flood risks. Riparian owners, who are landowners with a watercourse either running through their land or adjacent to, have the responsibility to ensure that the free flow of water is not impeded by any obstruction or build-up of material within the watercourse.

Flood and Water Management Act 2010

2.5.7. The Flood and Water Management Act 2010 (UK Government, 2010) extended the role of the LLFA (CCC) set out in the Flood Risk Regulations (2009) (UK Government, 2009) to take responsibility for leading the co-ordination of local flood risk management in their areas. In accordance with the Act the Environment Agency is responsible for the management of risks associated with main rivers, the sea and reservoirs. LLFAs are responsible for the management of risks associated with local sources of flooding such as ordinary watercourses, surface water and groundwater.

2.5.8. The Act is also guiding the role of the LLFA in the review and approval of surface water management systems.

2.5.9. Schedule 3 of the Flood and Water Management Act introduces National Standards for SuDS against which proposed drainage systems should comply. Schedule 3 proposes to establish a SuDS approving body (SAB) at the county and unitary level.

Environmental Permitting (England and Wales) Regulations 2016

2.5.10. The Environmental Permitting (England and Wales) Regulations 2016 (UK Government, 2016) aim to protect groundwater and surface waters from pollution by controlling the inputs of potentially harmful and polluting substances.

2.5.11. Additionally, under the Environmental Permitting Regulations (UK Government, 2016), any works in, under or near a main river requires permission from the Environment Agency to ensure no detrimental impacts on the watercourse.

NATIONAL POLICY

National Planning Policy Framework (NPPF) 2021

2.5.12. The NPPF (Ministry of Housing, Communities & Local Government, 2021) sets out the Government's planning policies for England, providing a framework within which local councils can produce their own plans that better reflect the specific needs of their communities. PPG has been published alongside the NPPF to set out how certain policies, including those relating to flood risk, should be implemented. The PPG for Flood Risk and Coastal Change (Ministry of Housing, Communities & Local Government, 2022) is updated regularly to respond to changes in guidance and best practice.

2.5.13. The NPPF (Ministry of Housing, Communities & Local Government, 2021) and relevant PPG identify how new developments must take flood risk into account, including making an allowance for climate change impacts, and steer development to those areas at lowest risk. Under Annex 3 of the NPPF (Ministry of Housing, Communities & Local Government, 2021) the C2C Scheme is classified as 'Essential Infrastructure' using the flood risk vulnerability classification. Essential Infrastructure' developments in Flood Zone 3a or 3b require an Exception Test, as shown in **Table TR13.1-2-3**.

Table TR13.1-2-3 - Flood Risk Vulnerability Classification

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Fluvial Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test Required	✓	✓
	Zone 3a	Exception Test Required	✓	✗	Exception Test Required	✓
	Zone 3b	Exception Test Required	✓	✗	✗	✗

The Sequential Test

2.5.14. The Sequential Test, as defined in the NPPF (Ministry of Housing, Communities & Local Government, 2021), ensures that a sequential approach is followed to steer new development to areas with the lowest probability of flooding.

The Exception Test

2.5.15. The Exception Test is a method to demonstrate and help ensure that flood risk to people and property would be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available. Essentially, the two parts to the test require the proposed development to show that it would provide wider sustainability benefits to the community that outweigh flood risk, and that it would be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

2.5.16. The PPG (Ministry of Housing, Communities & Local Government, 2022) also sets out the requirement to consider Sustainable Drainage Systems (SuDS) within all new development where appropriate. It states that developments should aim to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable:

- Into the ground (infiltration);
- To a surface water body;

- To a surface water sewer, highway drain, or another drainage system; and
- To a combined sewer.

Non-Statutory Technical Standards for Sustainable Drainage Systems 2015

2.5.17. The Non-Statutory Technical Standard for SuDS (Department for Environment, Food & Rural Affairs, 2015), published in March 2015, sets out the core technical standards for SuDS proposed within England. These standards should be used in accordance with the NPPF and PPG. The standards include guidance on controlling flood risk within a development boundary and elsewhere, peak flow and runoff volume control, and the structural integrity of SuDS.

LOCAL POLICY

Greater Cambridge Level 1 Strategic Flood Risk Assessment (2021)

2.5.18. The Level 1 Strategic Flood Risk Assessment (SFRA) (Greater Cambridge Shared Planning, 2021) has been prepared based on Government set requirements, the aims and objectives are as follows:

- To map flood risk from all sources, identifying the extent and severity of flood risk throughout the study area, delineating Flood Zones and the Functional Floodplain. The study area includes the location of the C2C Scheme;
- To identify the potential effects of climate change and development on future flood risk;
- To identify measures proposed or underway in Greater Cambridge to address flooding issues, and the land required for current and future flood management that should be safeguarded from development;
- To form part of the evidence base and inform the Sustainability Appraisal for the new Local Plan, including recommendations for planning policy relating to flood risk;
- To provide information to support the selection of development sites through the application of the Sequential Test and Exception Test, enabling the councils to meet their obligations under the National Planning Policy Framework; and
- To provide advice for site-specific flood risk assessments, including guidance on the application and suitability of mitigation measures, and opportunities to reduce flood risk for existing communities.

2.5.19. Based upon the review of the Level 1 SFRA, there are no additional requirements for the FRA to abide to beyond those outlined in the NPPF.

Cambridge City Council Local Plan and South Cambridgeshire local plan (2018)

2.5.20. The current local planning policy and guidance to the water environment is contained in the adopted (2018) South Cambridgeshire and Cambridge City Local Plans.

2.5.21. The South Cambridgeshire Local Plan (South Cambridgeshire District Council, 2018) contains three policies relevant to this scheme:

- Policy CC/7: Water quality references the need for proposals to have adequate water supply, sewerage and land drainage systems for the whole development. The proposal also needs to demonstrate that the quality of the ground, surface water and waterbodies will not be harmed, and that sources of pollution and SuDS measures are considered;
- Policy CC/8: SuDS refers to the needs for proposals to incorporate appropriate Suds; and
- Policy CC/9: Managing flood risk describes the need to minimise flood risk associated with the proposed development by incorporating sustainable flood protection/mitigation measures to the level and nature of the flood risk and ensuring there is no increase in flood risk. The policy also

refers to the need to undertake a site-specific FRA depending on the size of the proposed development and the Flood Zone it is located in.

2.5.22. Two policies from the Cambridge Local Plan (Cambridge CIty Council, 2018) are relevant to the water environment for this Scheme:

- Policy 31: Integrated water management and the water cycle – suggests that surface water management features are multi-functional wherever possible in their land use and measures need to be implemented to contain the runoff from all hard surfaces. It also refers to the need for all hard surfaces to be permeable surfaces where reasonably practicable and having regard to groundwater protection; and
- Policy 32: Flood Risk – describes the need for proposals to address the potential flood risk following the principles of the NPPF.

2.5.23. Based upon the review of the local plans, no additional requirements for the FRA are identified beyond those outlined in the NPPF.

3. SITE DESCRIPTION

3.1.1. This section provides a description of the current baseline conditions with respect to the water environment.

3.1.2. As illustrated in **Plate TR13.1-1-1** the C2C Scheme starts in the civil parish of Cambourne and then heads east towards the city of Cambridge, predominantly running through agricultural land adjacent to the A428 and A1303.

3.2. EXISTING SURFACE WATER FEATURES

3.2.1. Within 1km of the C2C Scheme's Order Limits there are numerous watercourses. In the east of the C2C Scheme the Bin Brook and River Cam can be found, both of which are classified as main rivers by the Environment Agency. The scheme itself only crosses the Bin Brook, making it the only main river that the scheme crosses.

3.2.2. In the central area of the scheme the Callow Brook Runs from south to north, adjacent to Scotland Road. Furthermore, there is an unnamed watercourse (noted as Scotland Road Ditch on **Plate TR13.1-3-1**) within close proximity to the Callow Brook located on the west side of Scotland Road. The discussed watercourses can be seen in **Plate TR13.1-3-1**.

3.2.3. There are also numerous ditches and land drains across the C2C Scheme area, tending to follow outlines of agricultural fields, this can be seen in **Plate TR13.1-3-1**.

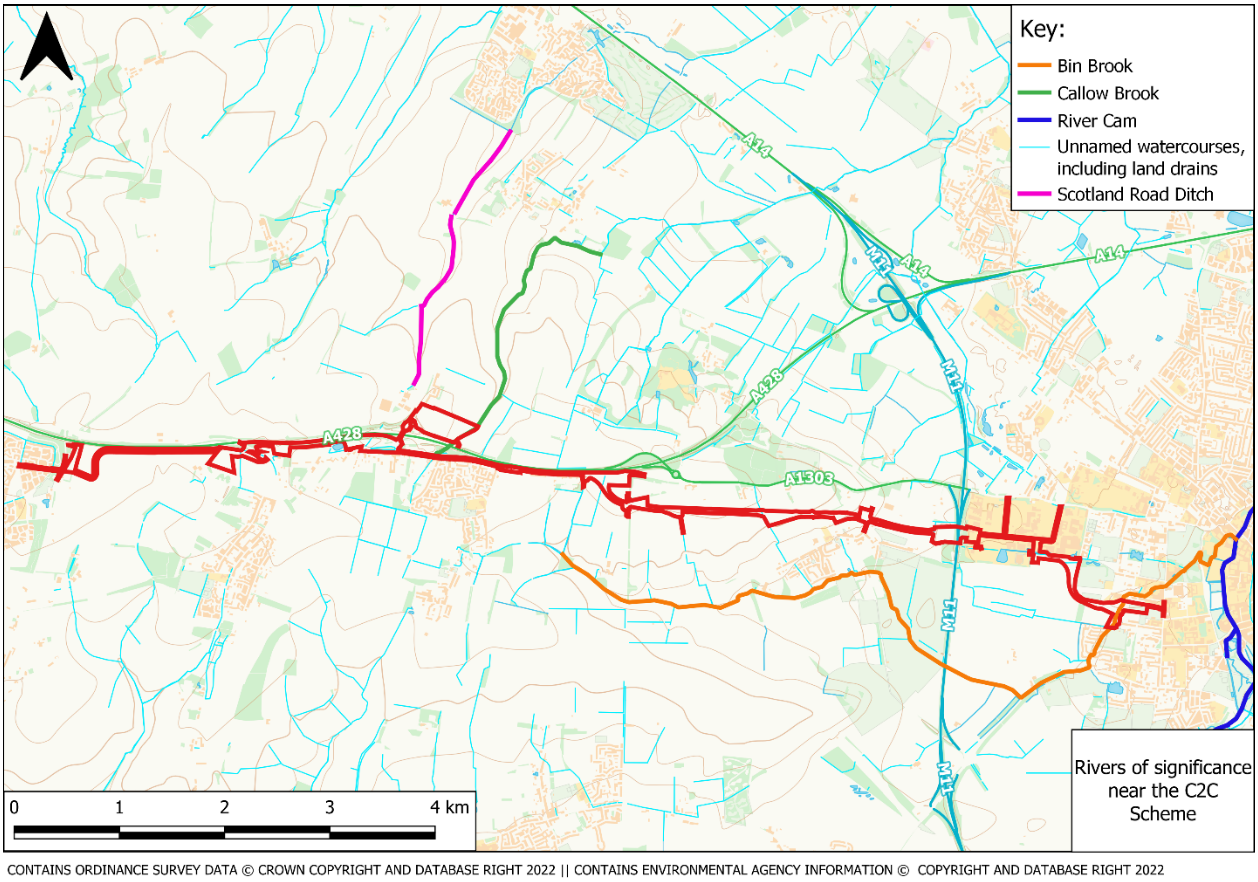

Plate TR13.1-3-1 – Watercourses found in proximity to the C2C Scheme

BIN BROOK

3.2.4. Bin Brook flows in an east to west direction, starting approximately 750m east of Hardwick. At the eastern end the C2C Scheme crosses Bin Brook, just south of Herschel Road. The location of the brook in relation to the C2C Scheme can be seen in **Plate TR13.1-3-2**.

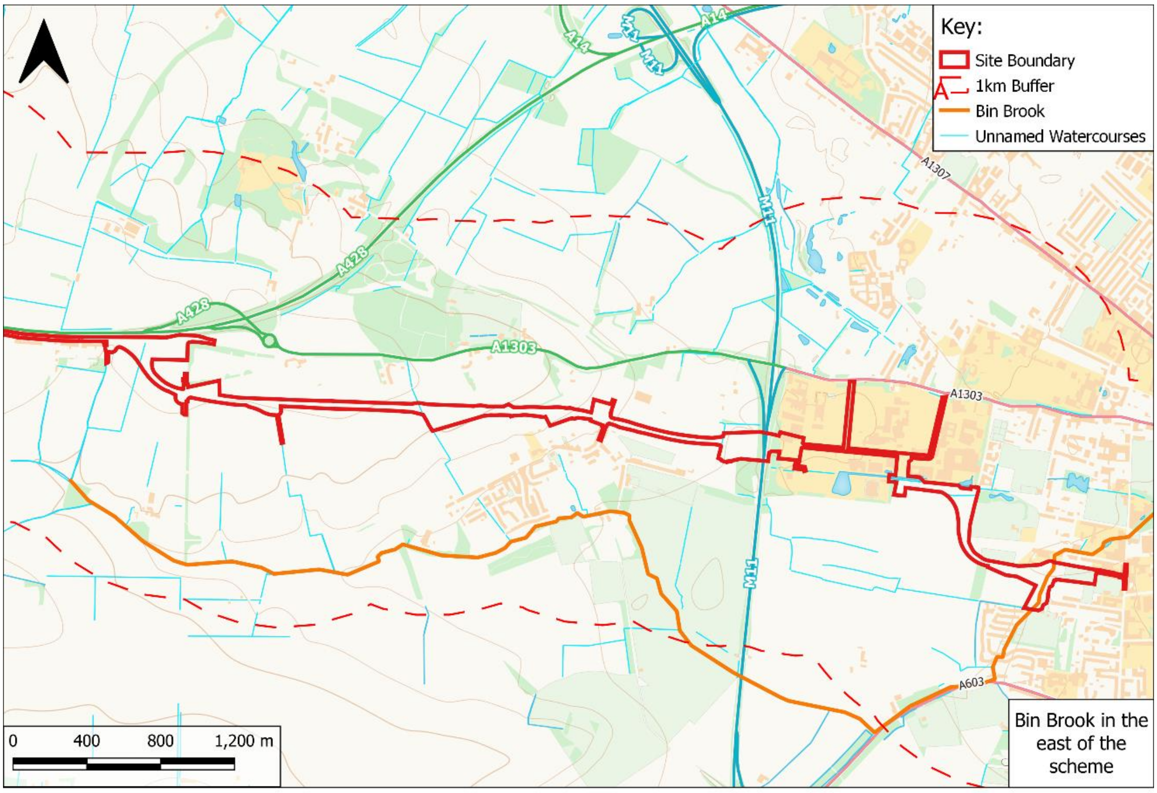

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Plate TR13.1-3-2 – Bin Brook location

3.2.5. There are numerous tributaries of Bin Brook consisting of surface water land drains from the surrounding fields. These flow predominantly in a north to south direction. There are two tributaries that flow through the Order Limits, firstly, one west of Long Road (Tributary A) and secondly, a tributary east of Long Road (Tributary B). Both noted tributaries can be seen in **Plate TR13.1-3-3**.

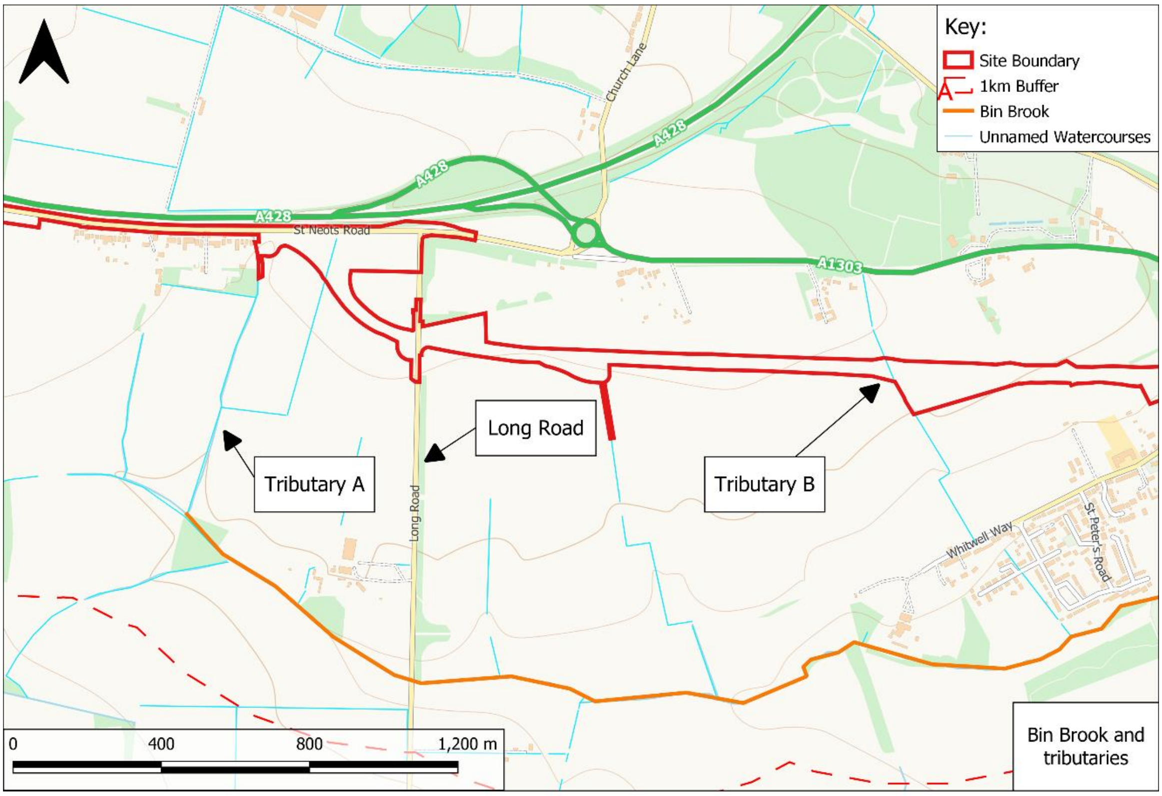

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Plate TR13.1-3-3 – Bin Brook and tributaries

CALLOW BROOK AND UNAMMED TRIBUTARY

3.2.6. Callow Brook flows from south to north, starting just south of the A428 in the village of Hardwick. It is culverted under the A428 and St Neots Road and flows adjacent to Scotland Road, this can be seen in **Plate TR13.1-3-4**. Callow Brook is classified as an ordinary watercourse under the jurisdiction of the CCC as the LLFA.

3.2.7. The unnamed tributary, denoted as Scotland Road ditch in **Plate TR13.1-3-4**, runs adjacent to Callow Brook, west of Scotland Road. Like Callow Brook it is most likely also culverted under the A428 and St Neots Road.

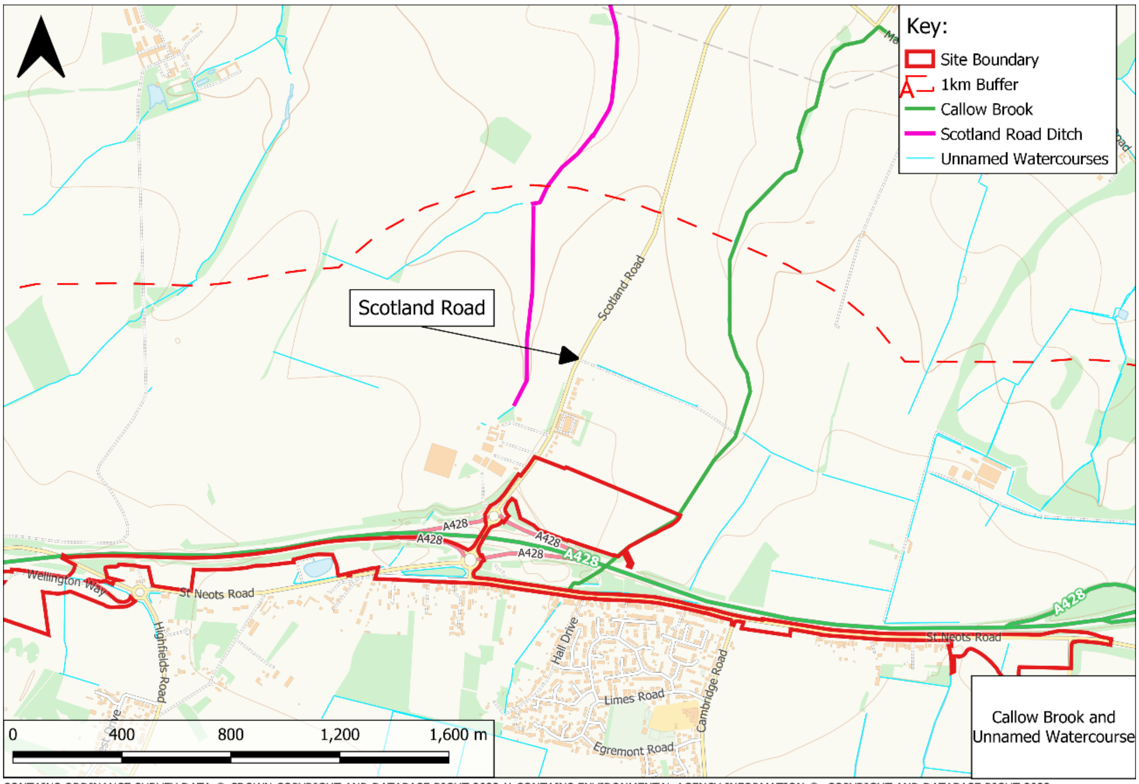

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Plate TR13.1-3-4 – Callow Brook and tributaries

3.3. GEOLOGY AND HYDROGEOLOGY

3.3.1. A review of the British Geological Survey (BGS) 1:50,000[3] data indicate that the site area is underlain by several different types of bedrock.

3.3.2. The western most point of the scheme is underlain by the Kimmerage Clay Formation (Mudstone). The Kimmerage Clay Formation ends just east of Cambourne and is followed by approximately 1.5km of the Woburn Sands Formation (Sandsatone). The majority of the remaining C2C Scheme is underlain by the Gualt Formation (Mudstone), however, there is an outcrop of the West Melbury Marly Chalk formation (Chalk) towards the east of the C2C Scheme.

3.3.3. DEFRA Magic Map aquifer designations, designates the Woburn Sands formation and the outcrop of the Melbury Chalk formation as principal aquifers. This formation is identified as being part of the Cam and Ely Ouse Woburn Sands groundwater body.

3.3.4. Despite the Melbury Chalk formation being defined as a principal aquifer the formation is above the underlying Gault Formation and is likely to be relatively thin. Additionally, OS mapping shows there are no springs visible around the edge of the chalk formation which indicates that the chalk is likely to have limited water within it. The Environment Agency has not included this outcrop within any

[3] British Geological Survey Mapping (2022). Available online: https://mapapps.bgs.ac.uk/geologyofbritain/home.html?&_ga=2.145945713.41395624.1649687684-1610241980.1649687684

designated groundwater body (under the Water Framework Directive), reinforcing the interpretation that the outcrop is a small, isolated outcrop that is not likely to hold any significant quantity of groundwater but there remains the potential for small scale perched water tables.

3.3.5. A review of BGS 1:50,000 superficial deposit[3] data indicate that superficial deposits across the C2C Scheme are predominantly made up of the Oadby Member (Diamiction Till). The Oadby Member is classified as a Secondary (Undifferentiated) aquifer. However, the Oadby Member is a low permeability formation that has limited groundwater present within it. Furthermore, for the eastern most 3km of the C2C Scheme, there is no recorded superficial geology.

3.3.6. A review of the DEFRA Groundwater data available on MAGIC online mapping indicates that there are no Source Protection Zones located within the C2C Scheme. However, 1km away from the western end of the C2C Scheme there is a Zone III – Total Catchment. This is defined as the total area needed to support the abstraction or discharge from the protected groundwater source. It is noted however that due to the distance from the scheme this zone is unlikely to be impacted by the proposed works.

3.3.7. A review of the Cranfield University Soilscapes[4] mapping indicates that the soils within the C2C Scheme area are lime-rock loamy and clayey soils with impeded drainage.

3.3.8. The C2C Scheme is not located within the Coal Authority's (CA)[5] reporting area. The online CA's screening tool indicates that the C2C Scheme is not located within a constraint area with regards to groundwater.

[4] Cranfield Soil and Agrifood Institute Soilscapes (2022). Available online: http://www.landis.org.uk/soilscapes/

[5] The Coal Authority Interactive Map (2022). Available online: https://mapapps2.bgs.ac.uk/coalauthority/home.html.

4. EXISTING FLOOD RISK

4.1. HISTORIC FLOOD RECORDS

4.1.1. The Greater Cambridge Level 1 SFRA (2021) (Greater Cambridge Shared Planning, 2021) notes multiple areas where flooding occurred in 2014 after intense rainfall. Within the C2C Scheme, 12 properties within Caldecote were affected internally by the flooding, the area is outlined in **Plate TR13.1-4-1**.

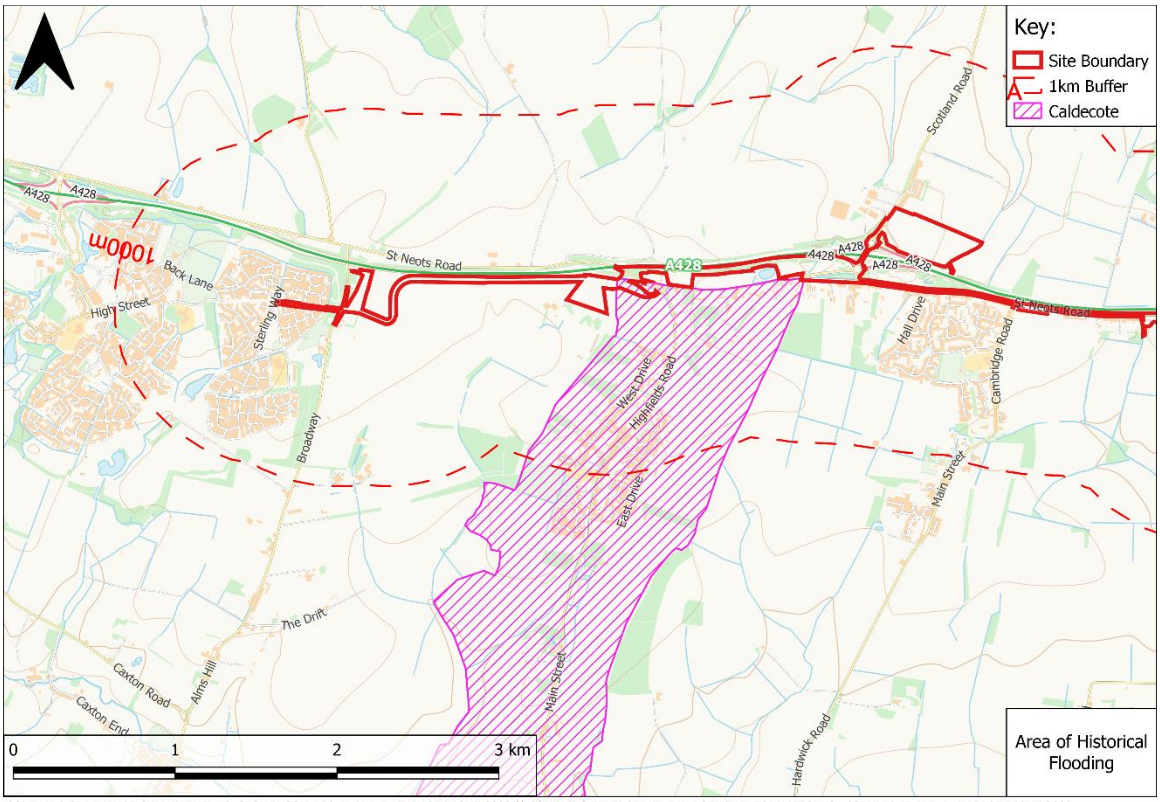

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Plate TR13.1-4-1 – Bar Hill and Caldecote

4.1.2. The Level 1 SFRA (2021) (Greater Cambridge Shared Planning, 2021) notes there have been over 15 recorded sewer flooding incidents recorded in the DG5 register within an area that includes the majority of the C2C Scheme. As the scheme enters Cambridge this number drops to between 2 and 5. It goes on to specifically note that the village of Hardwick, which is within the vicinity of the C2C Scheme has recorded sewer flood events in 2013 and 2015.

4.1.3. The Environment Agency's historical flood outline is shown in **Plate TR13.1-4-2**. This outline covers an area of the Bin Brook just downstream of the C2C Scheme area near the proposed crossing of Bin Brook. This suggests that there is historical flooding in the area associated with Bin Brook.

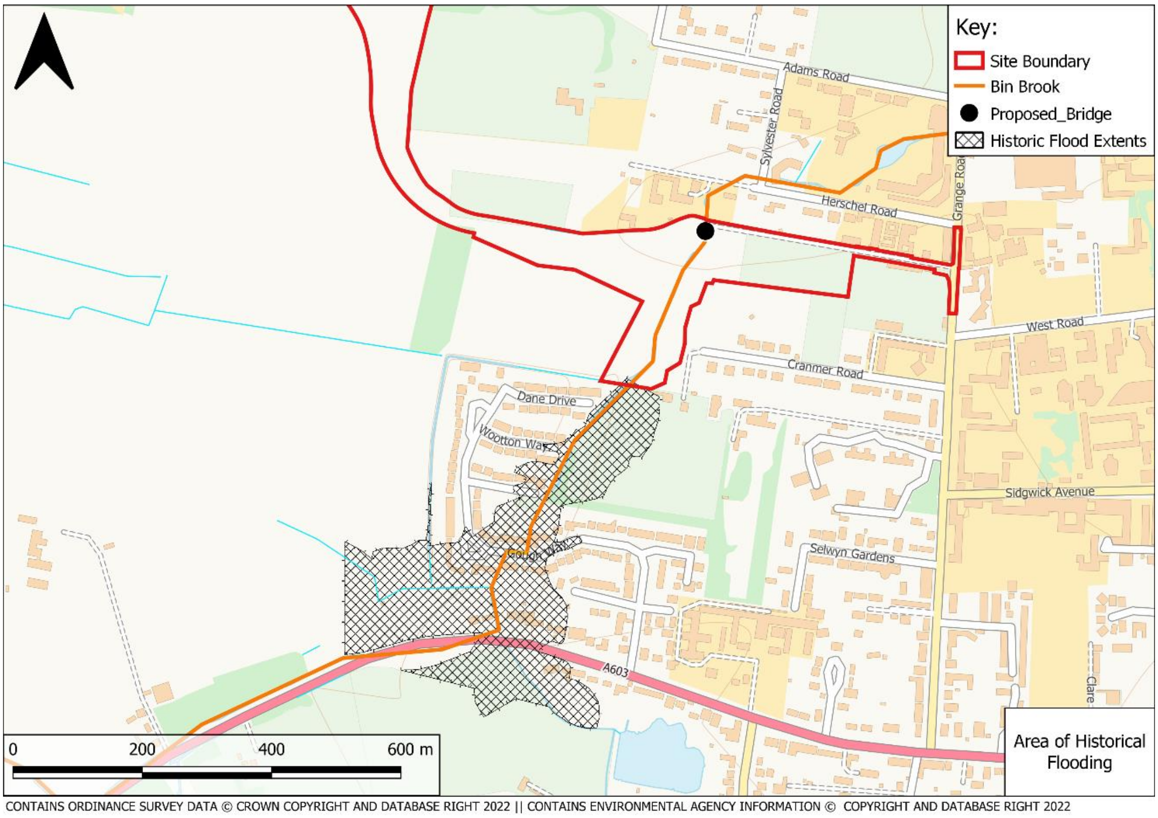

Plate TR13.1-4-2 – Environment Agency historic flood outline

4.2. FLUVIAL FLOOD RISK

4.2.1. The Environment Agency's Flood Map for Planning (see **Plate TR13.1-4-3** below) shows the risk of fluvial or tidal flooding with the following risk categories:

- Flood Zone 1 – Land assessed as having a less than 0.1% AEP of river or sea flooding;
- Flood Zone 2 – Land assessed as having between a 1% AEP and 0.1% AEP of river flooding or between a 0.5% AEP and 0.1% AEP of sea flooding;
- Flood Zone 3 – Land assessed as having a greater than 1% AEP of river flooding or a greater than 0.5% AEP of sea flooding; and
- Flood Zone 3b – Land where water has to flow or be stored in time of flood, i.e., the functional floodplain.

4.2.2. A review of the Environment Agency's Flood Map for Planning (**Plate TR13.1-4-3**) indicates that the C2C Scheme is predominantly located in the Low Risk Flood Zone 1.

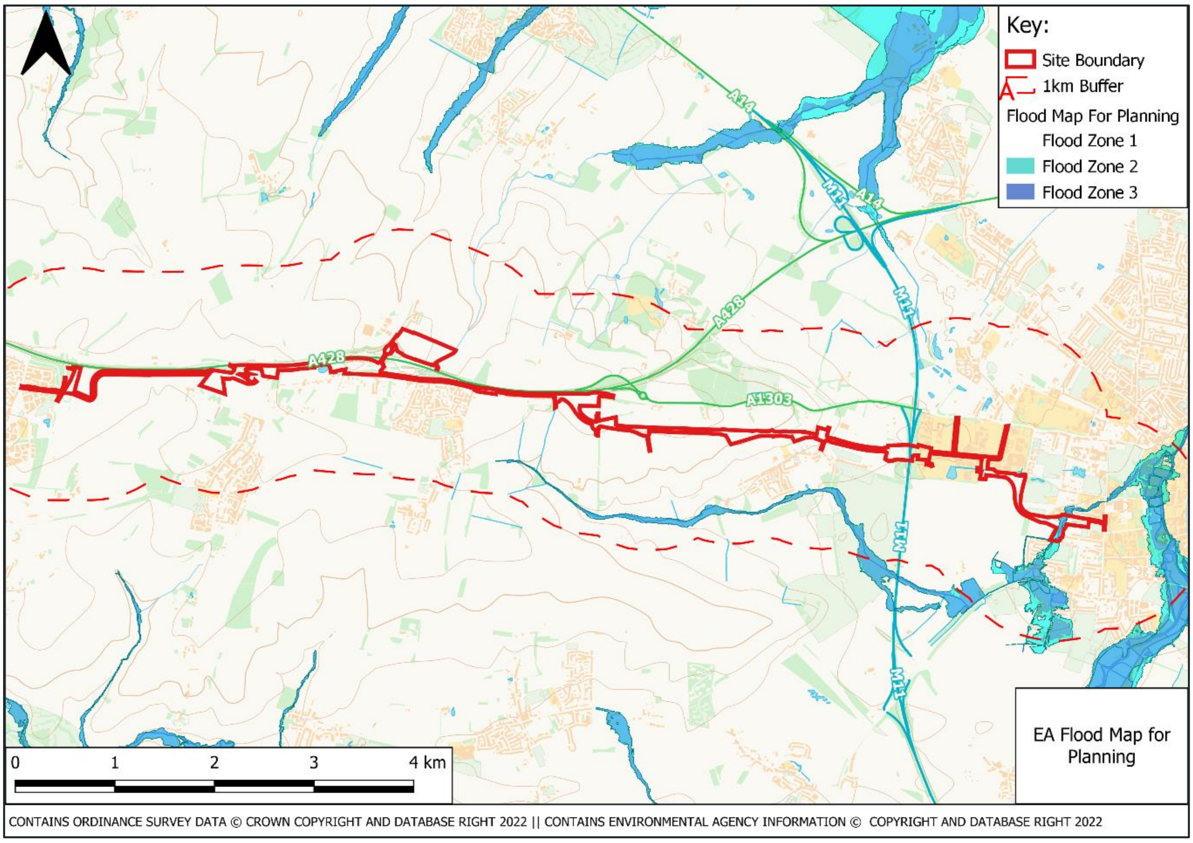

Plate TR13.1-4-3 – Environment Agency Flood Map for Planning

4.2.3. However, within the Order Limits of the C2C Scheme there is an area located within the High Risk Flood Zone 3 associated with the Bin Brook. This can be seen in **Plate TR13.1-4-4**.

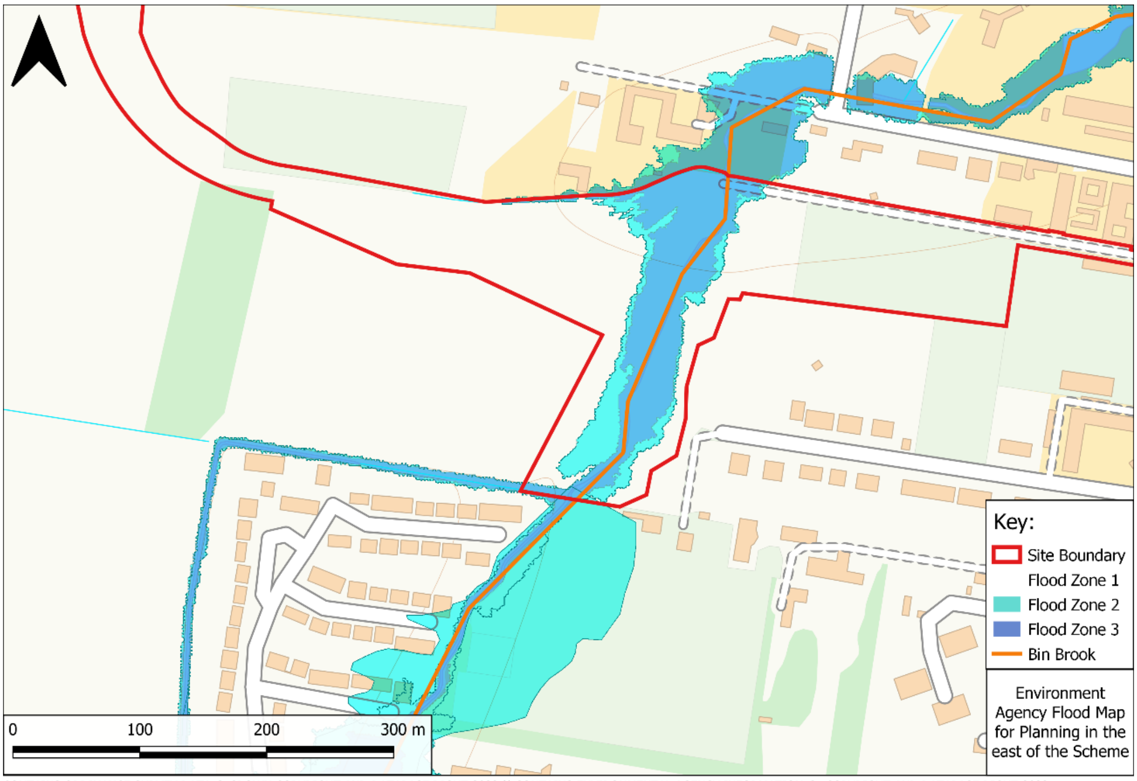

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Plate TR13.1-4-4 – The Bin Brook Section of the Environment Agency's Flood Map for Planning (April 2022) for the C2C Scheme

BASELINE FLUVIAL HYDRAULIC MODELLING

4.2.4. In order to improve the understanding of flood mechanisms along Bin Brook, hydraulic modelling was undertaken by WSP to support the FRA. The modelling is centred around the Scheme's proposed crossing of the Bin Brook.

4.2.5. Relevant information from the existing Environment Agency 1D/2D model of Bin Brook was used to create a site specific hydraulic model with up-to-date topographic survey of the watercourse.

4.2.6. The hydraulic model was tested for a range of baseline (pre-development) scenarios including a 1% AEP and the 0.1% AEP fluvial flood events with a 19% increase to account for the impact of climate change. The 1% AEP + 19% climate change (the design event) and 0.1% AEP +19% climate change modelled events have similar flood extents as shown in **Plate TR13.1-4-5**.

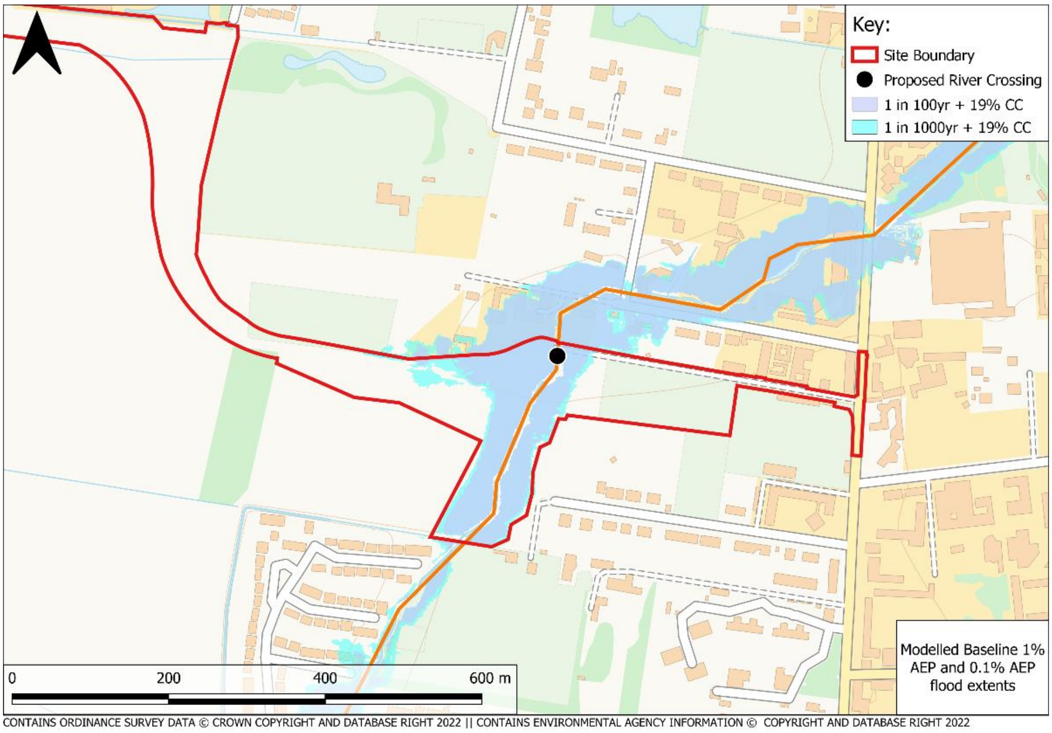

Plate TR13.1-4-5 – Modelled baseline 1% and 0.1% AEP flood extents

4.2.7. During the baseline 1% AEP + 19% climate change event, flood depths within the Order Limits are modelled to be in exceedance of 0.5m. Downstream of the Order Limits depths in some areas are modelled to be in excess of 1.5m, this can be seen in **Plate TR13.1-4-6**.

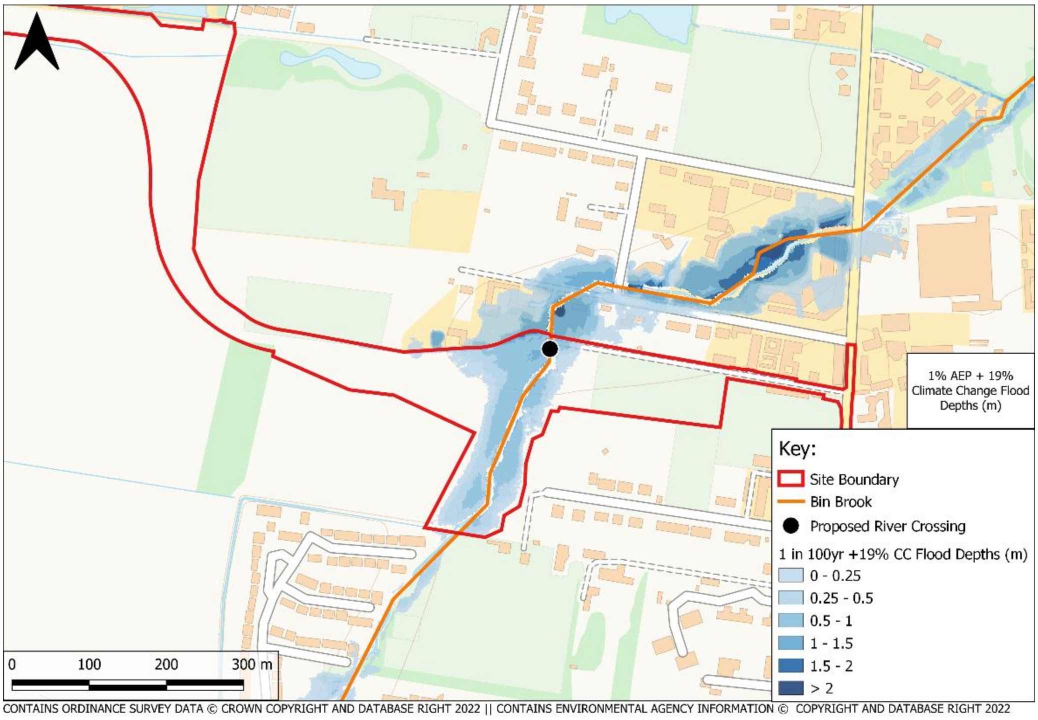

Plate TR13.1-4-6 – 1% AEP + 19%CC modelled baseline flood depths

4.3. TIDAL FLOOD RISK

4.3.1. The 2021 Level 1 SFRA (Greater Cambridge Shared Planning, 2021) states that Cambridge is outside the area of tidal flood risk, therefore, there is **No Risk** of tidal flooding.

4.4. SURFACE WATER FLOOD RISK

4.4.1. Surface water occurs when rainwater does not drain away through the normal drainage systems or when rainfall cannot soak into the ground, due to ground being fully saturated or that drainage channels or infrastructure does not have sufficient capacity, and subsequently water lies ponded on or flows over the ground. This form of flooding is usually associated with high intensity rainfall events but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, or otherwise has a low permeability.

4.4.2. The Environment Agency's Risk of Flooding from Surface Water Mapping is shown in **Plate TR13.1-4-7**. This mapping shows the risk of flooding from surface water or smaller watercourses not covered by the Environment Agency's flood map for planning in proximity to the C2C Scheme. The risk categories are as follows:

- Very Low Risk means that land has a less than 0.1% AEP of flooding;
- Low Risk means that land has between a 1% AEP and 0.1% AEP of flooding;
- Medium risk means that land has between a 3.33% AEP and 1% AEP of flooding; and
- High Risk means that land has greater than a 3.33% AEP of flooding.

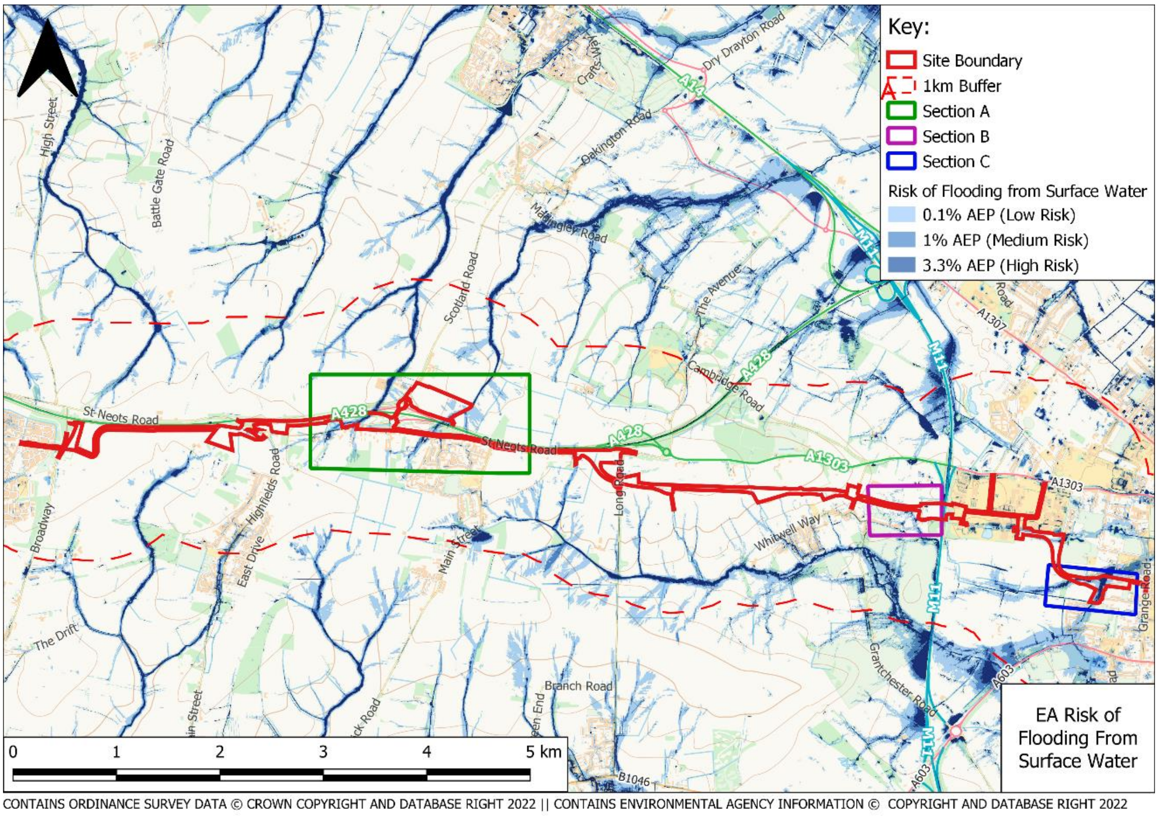

Plate TR13.1-4-7 – Surface water flooding probility

4.4.3. A review of the Environment Agency's Flood Risk from Surface Water Map indicates that several sections of the C2C Scheme are at High, Medium and Low Risk of surface water flooding. The C2C

Scheme predominantly runs along a ridgeline, limiting the possibility of surface water occurring in large volumes that would cause risk to the site. The different sections of varying risk to surface water flooding can be seen in **Plate TR13.1-4-7**.

4.4.4. The first section, denoted as Section A in **Plate TR13.1-4-7**, is the surface water risk associated with Callow Brook and an unnamed watercourse, both areas running adjacent to Scotland Road, with Callow Brook on Scotland Road's east and the unnamed watercourse on its west. The High Risk areas are generally confined to the constraint of the channels. However, there are areas of High Risk on the A428 and St Neots Road, within the extent of the Order Limits. This can be seen in **Plate TR13.1-4-8**.

4.4.5. Within the Order Limits in Section A, depths of High Risk and Medium Risk zones are modelled to generally be below 150mm with some very small areas with modelled depths between 150 and 300mm. Within the Low Risk areas, depths between 150 and 300mm are more wide spread, with small areas being between 300 and 600mm.

4.4.6. Section A has areas that are at High Risk to surface water flooding, however, the depths modelled for this extent are predominantly under 150mm. Due to this and similar being true for the Medium Risk event, the risk of surface water flooding has been assessed as **Medium**.

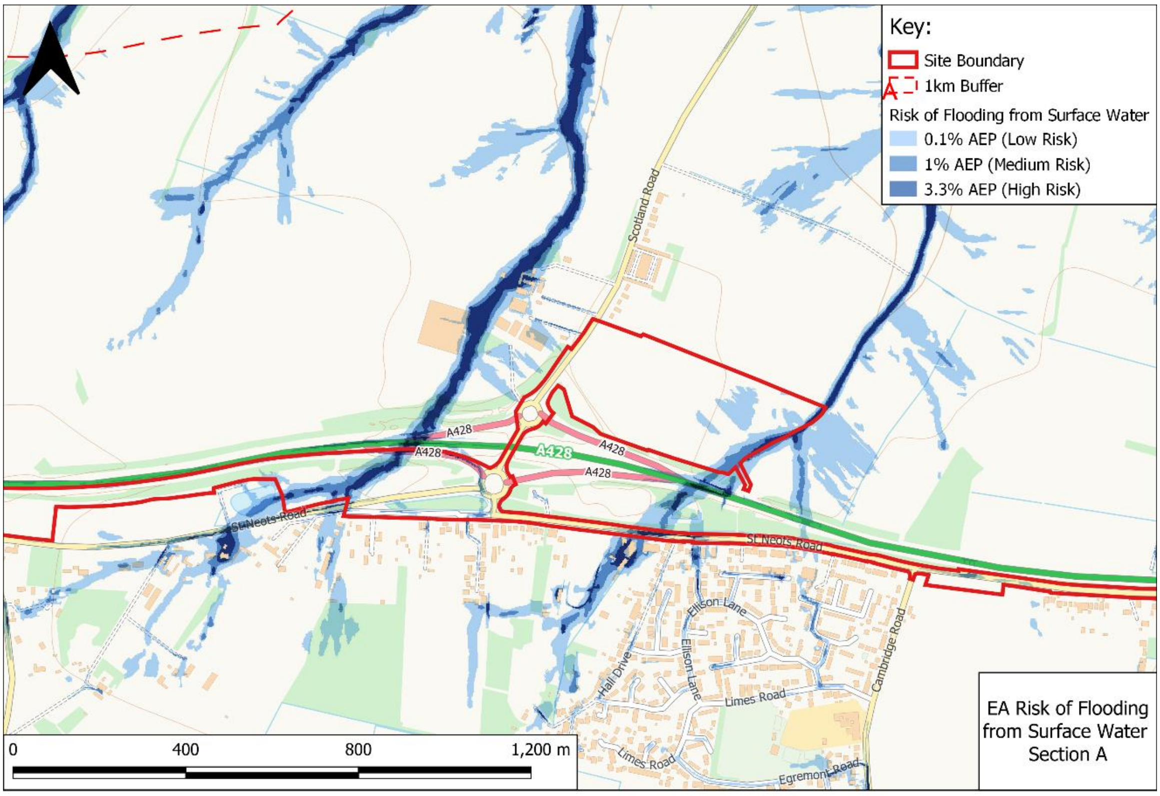

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Plate TR13.1-4-8 – Section A surface water flood risk

4.4.7. Small Low Risk areas of surface water flood risk can be found east of Cambridge Road in Section B (**Plate TR13.1-4-9**). During a Low Risk event the inundated extent modelled flood depths are below 300mm for the majority of the area.

4.4.8. Due to the low modelled depths and the small flood extents, the risk to surface water flooding for section B is assessed to be Low.

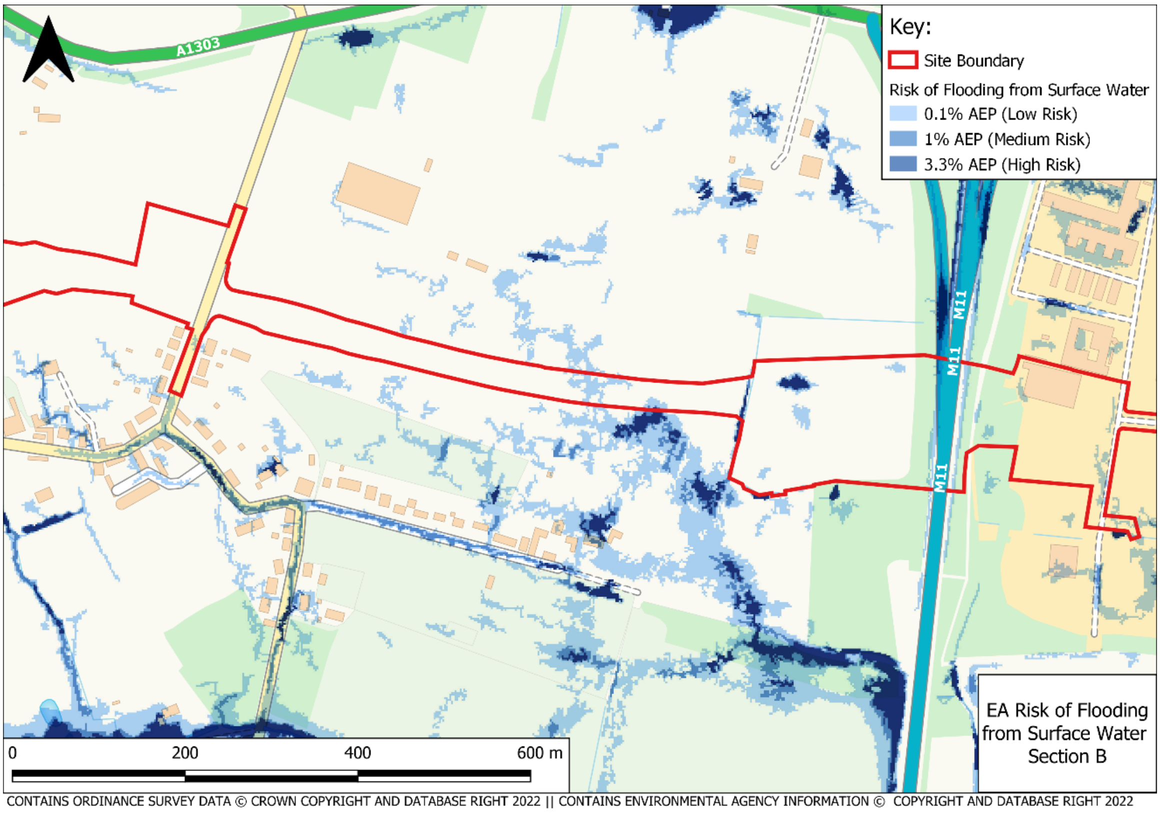

Plate TR13.1-4-9 – Section B surface water flood risk

4.4.9. Other areas of varying risk to surface water can be found in the east of the C2C Scheme, near the scheme's crossing of Bin Brook. This area has been denoted as Section C and can be seen in **Plate TR13.1-4-10**. Section C has extensive areas that are defined as High Risk.

4.4.10. Modelled depths of a High Risk surface water flood event are predominantly between 300-600mm, with smaller areas of 600-900mm levels present. During a Medium Risk flood event, flood depths are modelled to be similar to the High Risk event.

4.4.11. Due to the extent and the high modelled depths, Section C has been assessed to be at **High Risk** to surface water flooding. It is noted however that the majority of these areas are centred around Bin Brook itself. As such, it is expected that these areas of risk are associated more with fluvial flood influences than surface water flooding.

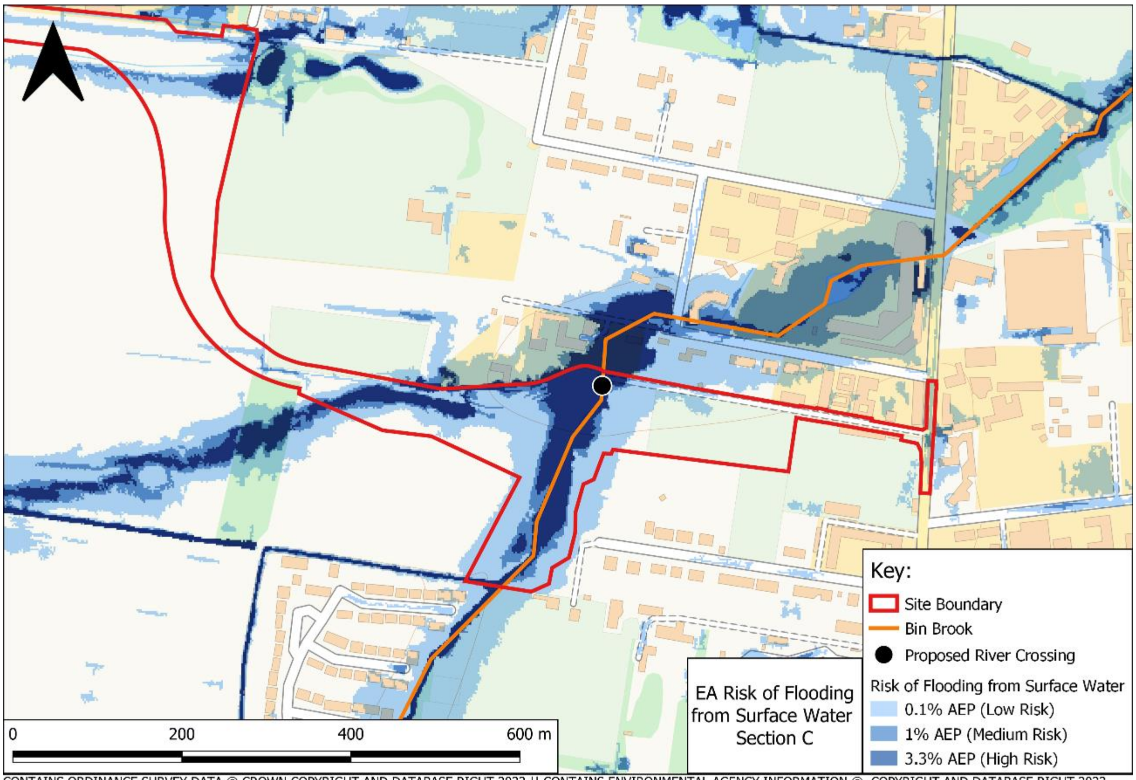

Plate TR13.1-4-10 – Section C surface water flood risk

4.5. GROUNDWATER FLOOD RISK

4.5.1. Groundwater flooding occurs when water stored below ground reaches the surface. It is commonly associated with porous underlying geology, such as chalk, limestone and gravels.

4.5.2. Based on BGS groundwater vulnerability mapping, the C2C Scheme extent passes through multiple different risk areas. The area of Sandstone located at the western end of the C2C Scheme extent, just east of Cambourne has a high permeability, enabling the potential of groundwater flooding. Additionally, there is a small area of chalk located to the northwest of Coton which has a high permeability and therefore may experience groundwater flooding. Both these areas are designated as principal aquifers. The remaining area is specified as either unproductive or at Low Risk groundwater vulnerability.

4.5.3. Due to the high groundwater vulnerability associated with the principle aquifers, it has been assessed that the areas of the C2C Scheme associated with the principle aquifers mentioned above are at **Medium Risk** to groundwater flooding.

4.5.4. There is only one instance of recorded groundwater flooding within the 2021 SFRA (Greater Cambridge Shared Planning, 2021), which is not within the C2C Scheme area. Due to this, coupled with embedded drainage features in the design, the remaining and majority of the C2C Scheme, is considered to be at **Low Risk** to groundwater flooding.

4.6. SEWER FLOOD RISK

4.6.1. Sewer flooding occurs as a result of a number of influencing factors. It is most likely to occur during storms when large volumes of rainwater enter the sewers. However, it can also occur when pipes become blocked or damaged.

4.6.2. An exert from the DG5 register within the 2021 Level 1 SFRA (Greater Cambridge Shared Planning, 2021) shows that between 2001 and 2018 there have been a combined total of 73 internal and external sewer flood events in Greater Cambridge. The exert does not include any postcode information. However, it does note that a large number of properties within Comberton and Hardwick were affected by sewer flooding in 2013 and 2015. Both of these areas are situated within the C2C Scheme's vicinity.

4.6.3. The Level 1 SFRA (Greater Cambridge Shared Planning, 2021) goes on to note that these events do not correlate with any flood incident reports and so no further information is available.

4.6.4. The majority of the C2C Scheme passes through greenfield land and is unlikely to be sewered, therefore, for these areas the risk of sewer flooding has been assessed to be **Low**.

4.6.5. Where the C2C Scheme passes through urban or semi urban areas, the large number of recorded events within Greater Cambridge, including areas within the C2C Scheme vicinity, risk of sewer flooding has been assessed to be **Medium**.

4.7. ARTIFICIAL SOURCES

4.7.1. A review of the Environment Agency's Reservoir Flood Extent Map shown in **Plate TR13.1-4-11** indicates that the C2C Scheme is not at risk of flooding from potential failure of reservoirs located upstream of the Study Area. The eastern most point of the scheme is approximately 175m south of the wet day extent. The wet day extent is defined by the Environment Agency as a day where local rivers have already overflowed their banks.

4.7.2. There is a heritage section of a small-scale canal and feeder reservoir, but this has been assessed to be limited in scope and additionally the flood risk is throttled by a bridge.

4.7.3. Therefore, the risk of flooding form artificial sources has been assessed to be **Low**.

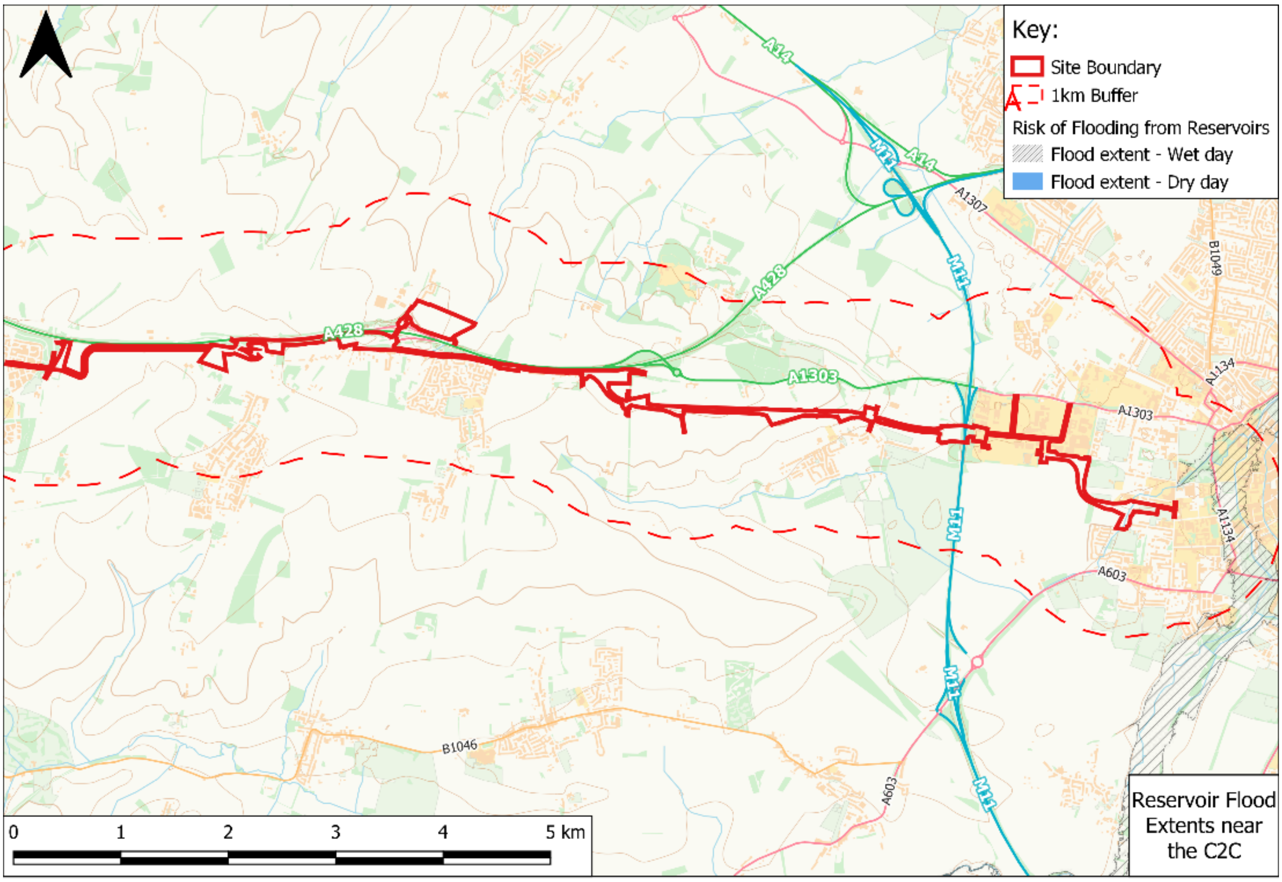

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Plate TR13.1-4-11 – Environment Agency Reservoir Flood Extent

4.8. OTHER SOURCES OF FLOOD RISK

4.8.1. No other sources of flood risk have been identified.

4.9. EXISTING FLOOD RISK SUMMARY

4.9.1. **Table TR13.1-4-1** provides a summary of the existing risk of flooding to the C2C Scheme from all sources of flooding.

Table TR13.1-4-1 - Flood risk summary

Flood Risk	Area	Assessed risk
Fluvial flooding	Near the Bin Brook crossing	High
	Remainder of the scheme	Low
Surface water flooding	Near Callow Brook	Medium
	Near the Bin Brook crossing	High
	Remainder of the scheme	Low
Reservoir flooding	Entire scheme	Low
Tidal flooding	Entire scheme	Low
Flood risk from other artificial sources	Entire scheme	Low
Flood risk from groundwater	Areas within principal aquifers	Medium
	Remainder of the scheme	Low
Sewage flooding	Urban and semi urban areas	Medium
	Greenfield/rural areas	Low

5. POST DEVELOPMENT FLOOD RISK

5.1. PROPOSED WORKS

5.1.1. As stated, the C2C Scheme involves construction of a new, largely segregated, roadway for HQPT use, with public transport priority measures between Cambourne and Cambridge where the route joins the existing road network. The C2C Scheme will also include a new transport hub at Scotland Farm and a new Shared-Use path. Based upon an assessment of the C2C Scheme the following potential impacts to flood risk have been noted:

- Bin Brook Crossing – The crossing of Bin Brook has the potential to impact fluvial flood risk upstream and downstream of the proposed crossing point, potentially impacting third parties;
- Smaller watercourse crossings – Where the scheme crosses smaller watercourses there is potential for the works to impact fluvial and surface water flooding in the area; and
- Increased Surface Water runoff – Increase in hardstanding and impermeable areas throughout the scheme will likely lead to increases in surface water runoff, potentially increasing local surface water flood risk.

5.1.2. In addition to the potential impacts outlined above there is also potential for the various works required during the construction phase to have a temporary impact on flood risk.

5.1.3. The assessment of these potential influences on flood risk are detailed in the sections below.

5.2. BIN BROOK CROSSING

5.2.1. The Bin Brook crossing consists of a clear span bridge structure intended to accommodate the busway as part of the HQPT. This will bridge the watercourse just upstream of Herschel Road. This work will also include the removal of an existing farm access / footbridge at the same location. (See **Plate TR13.1-5-1**).

5.2.2. To provide a better understanding of the potential impact on flood risk, variations of the Bin Brook crossing were tested within the hydraulic model. Further details of the series of tests conducted and how the crossing was incorporated into the model can be found in the hydraulic modelling report in **Annex B** and the associated hydrology calculations in **Annex C**.

5.2.3. The details of the final bridge design tested are summarised in **Table TR13.1-5-1**.

Table TR13.1-5-1 - Proposed Bin Brook Structure

Structure Type	Span Length (m)	Required minimum soffit height (mAOD)
Clear span Bridge	10	9.67mAOD (defined as a 300mm freeboard above the peak water level for the 1% AEP event with a 19% climate change allowance)
Bridge embankments	N/A	Maximum height of 9.67mAOD

5.2.4. The proposed bridge was tested in the model for the 1% AEP event with 19% climate change allowance. A comparison of the baseline and proposed flood extent can be seen in **Plate TR13.1-5-1**.

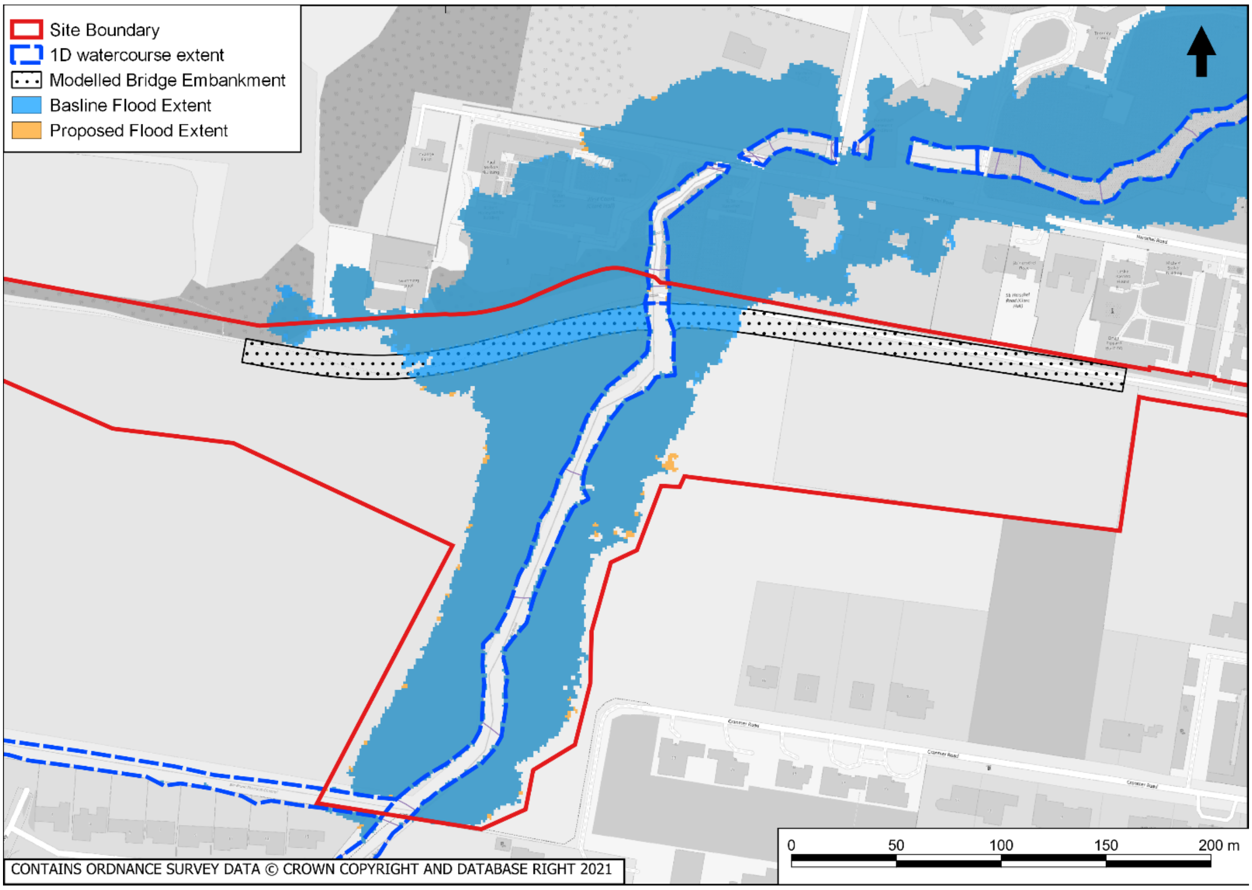

Plate TR13.1-5-1 – Comparison of baseline and proposed flood extents (1% AEP +19%CC)

5.2.5. **Plate TR13.1-5-1** shows that there is minimal change in peak flood extent between the baseline and proposed. **Plate TR13.1-5-2** shows the difference in modelled peak flood depths between the baseline and proposed model for the 1% AEP event with 19% climate change allowance.

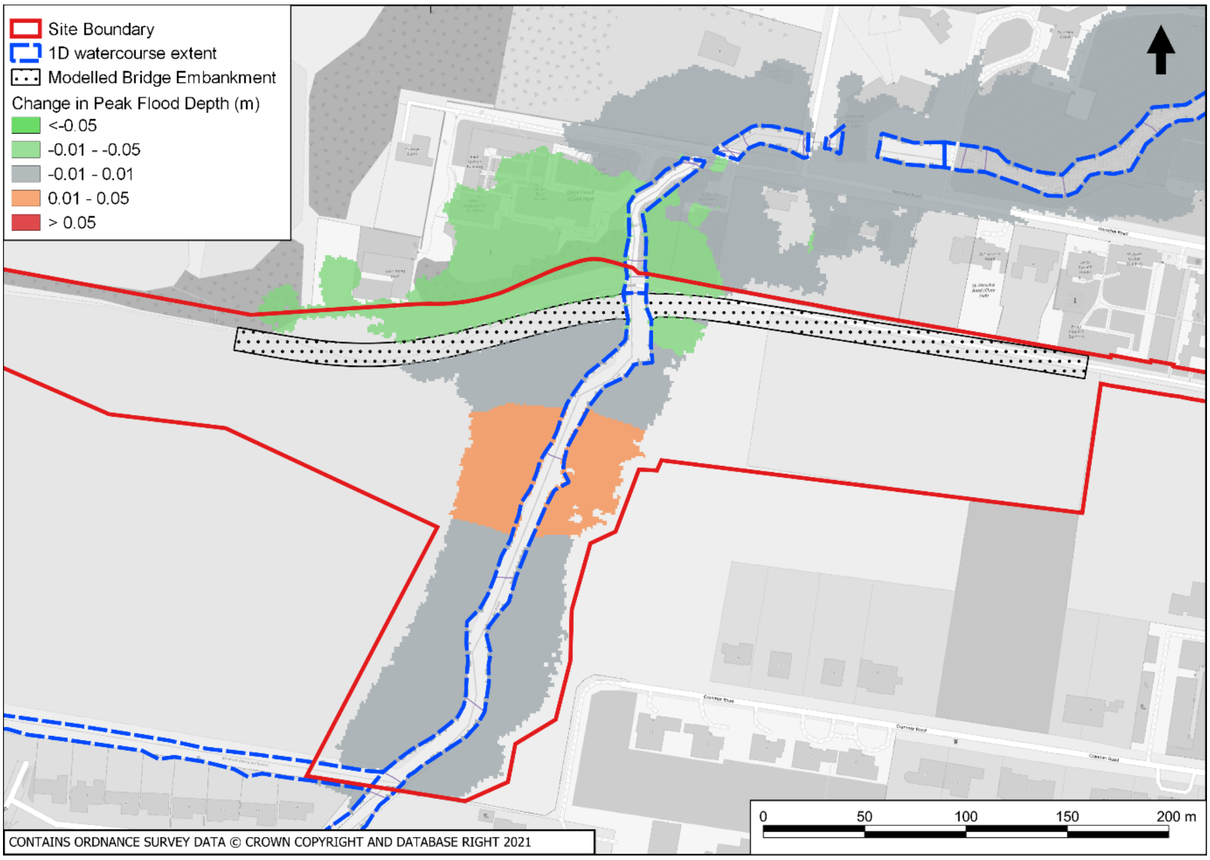

Plate TR13.1-5-2 – Depth Comparison between baseline and proposed model (1% AEP + 19%CC)

5.2.6. **Plate TR13.1-5-2** indicates that there will be a slight increase in flood depth of between 10-50mm within the area of open field immediately upstream of the proposed bridge location. It also shows a slight decrease in peak flood depths (approximately between 10-50mm) downstream of the proposed bridge.

5.2.7. It is noted that in comparison with the existing flood depth of approximately 900mm the increases in peak flood depth shown in the field are considered to be negligible. As these changes are within the redline boundary there are no impacts of increased flood risk to third parties and no requirement for mitigation measures.

5.3. ORDINARY WATERCOURSE CROSSINGS

5.3.1. The C2C Scheme will include nine ordinary watercourses crossings. To ensure that these crossings do not lead to an increase in flood risk, the design of the scheme ensures that the 0.1% AEP flows can be conveyed (these flows are greater than the 1%+40% AEP flows in pipes through the scheme. **Table TR13.1-5-2** below provides a summary of the ordinary watercourse crossings including the dimensions of the structures and the . The pipes have been sized based upon the following conservative principles:

- The pipes will be laid flat and not at a gradient;
- No allowances for headwater impacts;

- The 0.1% AEP peak flows, are detailed in **Annex C**. As the 0.1% AEP peak flows are greater than the 1% AEP + 40% CC peak flows, therefore, the crossings are sufficiently sized to convey the flows, without the need for additional freeboard; and
- It has assumed that the C2C Scheme will have a lifetime beyond 2100, and as the areas draining to each of the crossings is less than 5km^2 the upper end peak rainfall climate change allowance of 40% has been used.

5.3.2. The C2C Scheme will also result in a new crossing over the West Cambridge Canal, located to the south of Charles Babbage Road. This crossing has not been assessed within this FRA as it will be designed during the detailed design phase by Cambridge University, due to the complex interactions with the University's surface water drainage systems. As the canal is now largely an aesthetic feature with the flows controlled by a penstock beneath a footbridge upstream of the stream crossing, limiting the flows largely to a baseflow limit, it is considered that a new crossing can robustly be designed during the detailed design phase without increasing the risk of flooding to the scheme or third parties.

Table TR13.1-5-2 - Summary of ordinary watercourse crossings

Culvert Crossing	QMED (m^3/s)	3.3% AEP + 35% CC (m^3/s)	1% AEP + 40% CC (m^3/s)	0.1% AEP (m^3/s)	Culvert Diameter (m)	Culvert Length (m)
2	0.02	0.05	0.07	0.09	600	30
3	0.01	0.03	0.04	0.06	600	34
4a	0.01	0.02	0.03	0.04	600	35
4b	0.01	0.02	0.03	0.04	600	47
6	0.03	0.08	0.12	0.16	600	11 (This includes the extension to the existing culvert)
7	0.28	0.82	1.19	1.53	1200	10
8	0.18	0.54	0.79	1.01	The existing culvert is of sufficient length and won't be changed as a result of the C2C Scheme	
9	0.28	0.84	1.22	1.57	1200	20 (This is the length of the culvert extension, the existing culvert is approximately 100m in length
11	0.01	0.02	0.03	0.04	600	36

5.4. INCREASE IN SURFACE WATER RUNOFF

5.4.1. A detailed description of the detailed surface drainage strategy is provided in **Annex D**. The strategy includes the following measures and assumptions:

- Surface water runoff will be conveyed within a network of swales, filter strips before discharging into detention basins/ponds;
- Where there is not sufficient space for swales and detention basins it is proposed discharged to underground geocellular attenuation systems;
- No infiltration features are included within the drainage strategy and all attenuation features will be lined;
- The drainage strategy has been designed to accommodate the 3.33% AEP design flow, with a 100mm freeboard allowance;
- In the 1% AEP + 40% climate change design event some short term flooding is expected, this will be managed by providing additional storage through oversized detention basins and ponds; and
- The surface water drainage strategy includes filter strips, swales, detention basins and attenuation ponds. The Simple Index Approach (SIA) has been applied to the treatment train and provides sufficient mitigation as detailed in **Annex D**.

5.4.2. Based upon the measures above it is considered that there will be no increase in surface water flood risk to the surrounding areas or the scheme itself.

5.5. FLOOD RISK DURING CONSTRUCTION

5.5.1. The Code of Construction Practice[6] (CoCP) will set out the measures for managing flood risks during construction. Measures would include:

- Ensuring that flood conveyance routes are maintained during construction;
- Moving any plant away from the banks of watercourses following heavy rainfall events;
- Monitoring of the Environment Agency's flood warnings;
- Creating safe working areas for the storage of plant and materials if a flood warning is received during construction; and
- Ensuring that there are construction phase drainage strategies available for large areas as required.

5.5.2. Based upon the measures above it is considered that the construction stage will not have a significant impact on flood risk to the surrounding area or the scheme itself.

[6] Code of Construction Practice (Document reference: C2C-26-00-Code of Construction Practice)

5.6. RESIDUAL FLOOD RISK AND OFFSITE EFFECTS

5.6.1. The majority of the C2C Scheme is within the Low Risk Flood Zone 1, which will continue to remain post development. Modelling has shown that the proposed bridge will have a negligible affect upstream and downstream of the C2C Scheme during a 1%+CC AEP fluvial event. **Plate TR13.1-5-3** shows that during a 0.1% AEP fluvial event, changes in maximum flood depths pre and post development will continue to be negligible, with a maximum increase of 0.05m upstream of the proposed crossing.

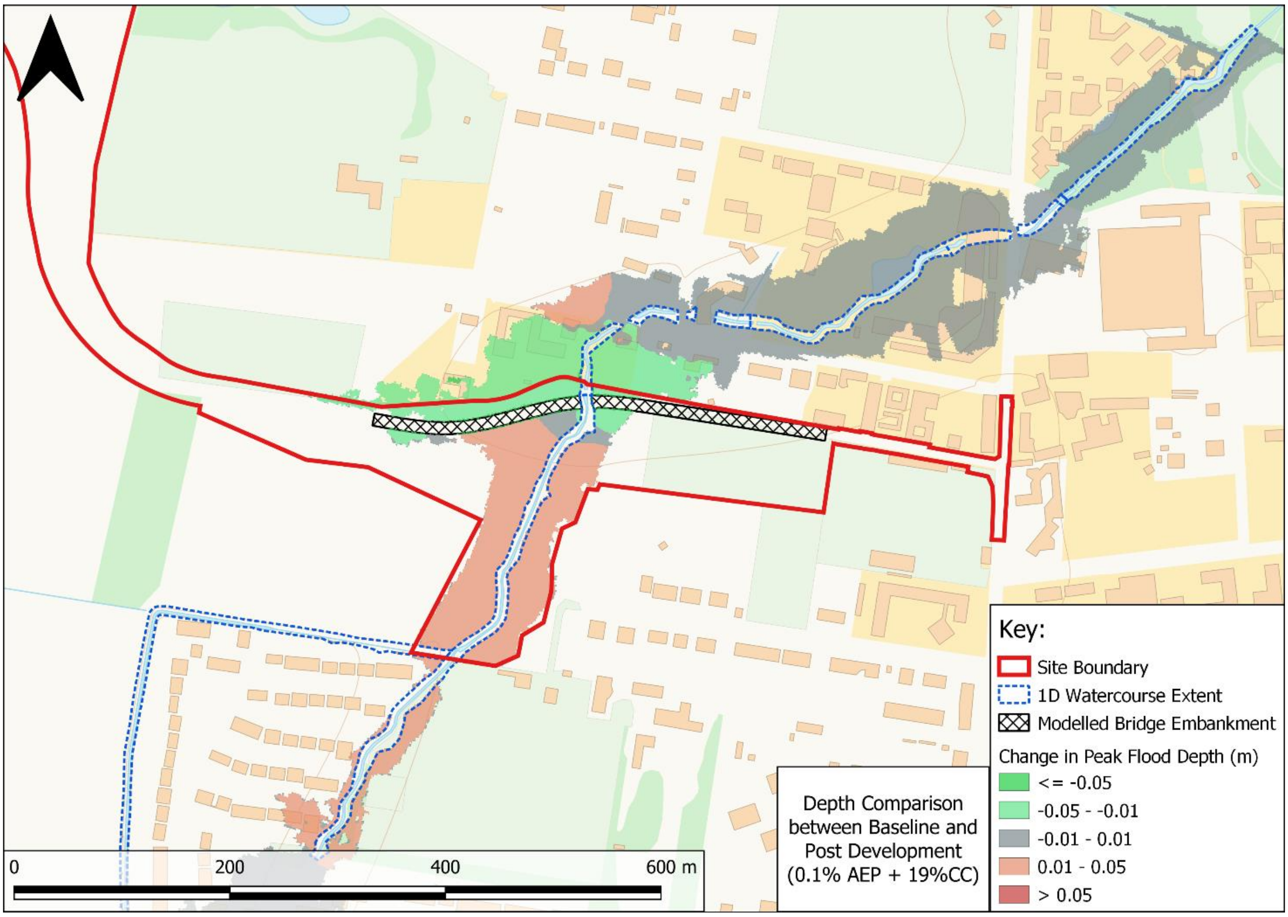

Plate TR13.1-5-3 – Depth Comparison between baseline and proposed model (0.1% AEP + 19%CC)

5.6.2. The C2C Scheme is predominantly at low risk to surface water flooding and will have minimal residual risk post development. Despite the increase in impermeable area, areas on and offsite that are risk to surface water flooding currently, will in most cases remain unchanged, due to the surface water drainage strategy (refer to **Annex D**).

5.6.3. Risk of sewer flooding across the C2C Scheme and its surrounding area will remain unchanged post development, as such there will remain a residual risk.

6. CONCLUSION

6.1. EXISTING FLOOD RISK

6.1.1. The majority of the C2C Scheme is within Flood Zone 1, indicating a Low Risk to fluvial flooding, with only a small area of the eastern end of the scheme located in the areas of Flood Zone 2 and 3 associated with the Bin Brook. Hydraulic modelling of the Bin Brook showed significant out of bank flood extents along the Bin Brook for the 1% AEP event with 19% climate change. This correlates with historic flood maps of areas along the Bin Brook.

6.1.2. Surface water flood risk varies across the C2C Scheme with a High Risk zone being found near the C2C Scheme's Bin Brook crossing, a Medium Risk area found near the Callow Brook and the remainder of the scheme being at Low Risk.

6.1.3. The risk of sewer flooding across the C2C Scheme has been assessed as Medium Risk predevelopment due to the number of recorded sewer flooding events.

6.1.4. Despite the C2C Scheme crossing principal aquifers, the absence of any recorded groundwater flood events has led the scheme to be assessed as having a Low Risk of groundwater flooding.

6.1.5. Artificial sources including reservoir flooding and tidal flooding have been assessed to be Low Risk.

6.2. POST DEVELOPMENT FLOOD RISK

6.2.1. The primary influences of the proposed works on flood risk are expected to be the following:

- The Bin Brook Crossing;
- Crossing of smaller watercourses; and
- Increases in surface water runoff as a result of the scheme.

6.2.2. Hydraulic modelling of the Bin Brook crossing has indicated that the introduction to the crossing will have a minimal impact on the flood risk, showing minimal change in predicted flood extents for the 1% AEP event with 19% climate change allowance and showing increases of between 10 to 50mm in peak flood depth over an existing flood depth of approximately 900mm. This potential increase in risk is within the Order Limits, i.e. there is no change in risk to third parties. As the proposed HQPT in the area will be raised above the peak flood level it is considered that the scheme will be safe from flooding for its design life.

6.2.3. The small watercourse crossings have been sized using the 0.1% AEP peak flows, which is greater than the 1%AEP +40%CC peak flows, ensuring that the crossings are sufficiently sized for the lifetime of the C2C Scheme.

An increase in impermeable surfaces will not lead to an increase in surface water flood risk, with the implementation of the surface water strategy.

6.2.7. **Table TR13.1-6-1** provides a summary of the baseline and post-development flood risk.

Table TR13.1-6-1 - Summary of baseline and post-development flood risk

Source of flooding	Assessed Risk	
	Baseline	Post Development
Fluvial	High – Near Bin Brook crossing Low – Remainder of the scheme	Near Bin Brook Crossing - Changes in flood risk are effectively mitigated Remainder of the scheme – no change
Surface water	High - Near Bin Brook crossing Medium - Near Callow Brook Low – Remainder of the scheme	No change
Sewer	Medium – Urban and semi urban areas Low – Greenfield/rural areas	No change
Groundwater	Medium – Areas within principal aquifers Low - Remainder of the scheme	No change
Artificial	Low	No change
Tidal	Low	No change

6.3. SEQUENTIAL AND EXCEPTION TEST

SEQUENTIAL TEST

6.3.1. The PPG (Ministry of Housing, Communities & Local Government, 2022) and NPPF (Ministry of Housing, Communities & Local Government, 2021) states that Planning Authorities should complete a risk based "Sequential Test" which is to "steer new developments to areas with the lowest probability of flooding" (Paragraph 158 of the NPPF). However, based upon the requirements of the transport route to connect certain areas the scheme cannot completely avoid areas of potential flooding. As a result, the C2C Scheme is partly located within Flood Zone 3 and an Exception Test is required.

EXCEPTION TEST

6.3.2. As stated, the Exception Test is a method to help ensure that flood risk to people and property would be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available. This is done in combination by showing that the proposed development would provide wider sustainability benefits to the community, that outweigh flood risk, and that potential flood risk to the scheme and third parties as a result of the scheme can be managed. It is our consideration that the evidence provided in this FRA demonstrates that the scheme will be safe from flooding while not increasing flood risk to others. The wider sustainability benefits of the scheme are outlined elsewhere in the planning application that this FRA supports.

7. REFERENCES

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Annex TR13.1.1

ENVIRONMENT AGENCY ADVISORY NOTE

Public

1. INTRODUCTION

BACKGROUND

1.1.1 WSP has been commissioned to develop the design for the proposed bus route connecting Cambridge to Cambourne. To inform the design of the proposed bridge structure across the Bin Brook a 1D/2D hydraulic model of the relevant reach of Bin Brook has been developed. The proposed bridge structure passes over the Bin Brook in the area immediately south of Herschel Road within the University of Cambridge.

1.1.2 This model was created using an existing Environment Agency 1D/2D model of the Bin Brook that has been enhanced with up-to-date topographic survey of the watercourse. This memo summarises the main points discussed and agreed during a consultation call between WSP and Greater Cambridge Partnership (GCP) held on the 23rd of September 2022. It also outlines the main actions moving forward with the intent on receiving the Environment Agency's approval on the proposed methodology for addressing a potential slight increase in flood risk produced by the proposed works.

MODELLING EXERCISE

1.1.3 To optimise the bridge design, three different bridge spans (20m, 16m and 10m) were modelled. The modelling of the bridge structure was made with the following assumptions:

- The bridge would be a clear span structure, to help mitigate the impacts from a Water Framework Directive (WFD) perspective;
- The soffit level of the structure would be set at a height above the peak water level, and as such would not need to be represented within the hydraulic model; and
- No additional flow structures or overflows are to be provided through the embankment leading up to the bridge crossing or within the abutments for the bridge.

1.1.4 Based upon the above assumptions the representation of the bridge structure within the model has been created using a uniform embankment height of 10.5mAOD to block all flows passing along the floodplain outside of the watercourse. A gap over the watercourse has been left to allow for flows passing through the tested bridge spans. When it comes to the design of the bridge structure / embankment, this will be derived from the **1 in 100 Annual Exceedance Probability (AEP) plus 19% climate change and a freeboard of 300mm.**

1.1.5 Immediately downstream of the proposed bridge location there is an existing farm access bridge. As this bridge will no longer be accessible once the proposed bridge is constructed additional model runs were performed to assess the impact of removing this structure on the predicted flood risk in the area.

1.1.6 Each model scenario was run for the 1 in 100 AEP event with 19% allowance for climate change (design event).

MODELLING RESULTS

1.1.7 Baseline modelling of the area showed significant areas of flooding for the design event, with large extents of flooding within the fields upstream of the proposed bridge structure. Flooding was also shown downstream within the university buildings to the north of the proposed bridge location (see **Plate TR13.1-1-1-1**).

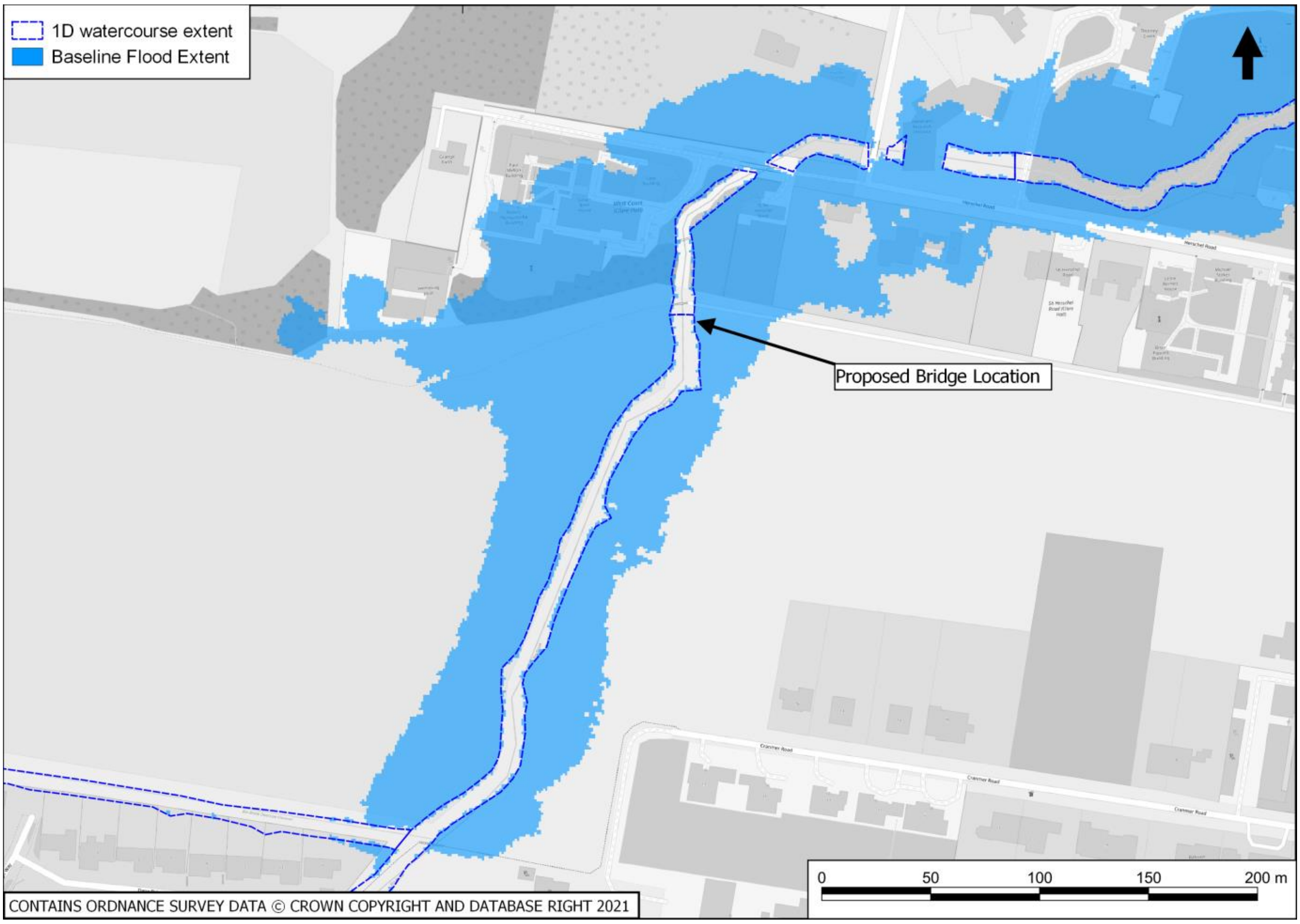


Plate TR13.1-1-1-1 – Baseline Flood Extent 1 in 100 AEP with 19% climate change allowance

1.1.8 During the consultation call GCP indicated that a smaller bridge span was preferrable. It was also confirmed by GCP that the existing footbridge structure would be removed. Examination of the 10m span bridge with the downstream footbridge removed showed minimal change in the predicted flood extent (see **Plate TR13.1-1-1-2** and **Plate TR13.1-1-1-3**).

1.1.9 **Plate TR13.1-1-1-2** and **Plate TR13.1-1-1-3** show that there is negligible change in the predicted flood extent upstream of the proposed bridge, with only minimal increases in peak flood water level (an average of 10 to 15mm over an existing flood depth of approximately 900mm at its deepest point immediately adjacent the river bank at the proposed bridge). It is also shown that there is a slight reduction (approximately 20mm over an existing depth of 900mm) in the peak flood level around existing university buildings immediately downstream of the proposed bridge.

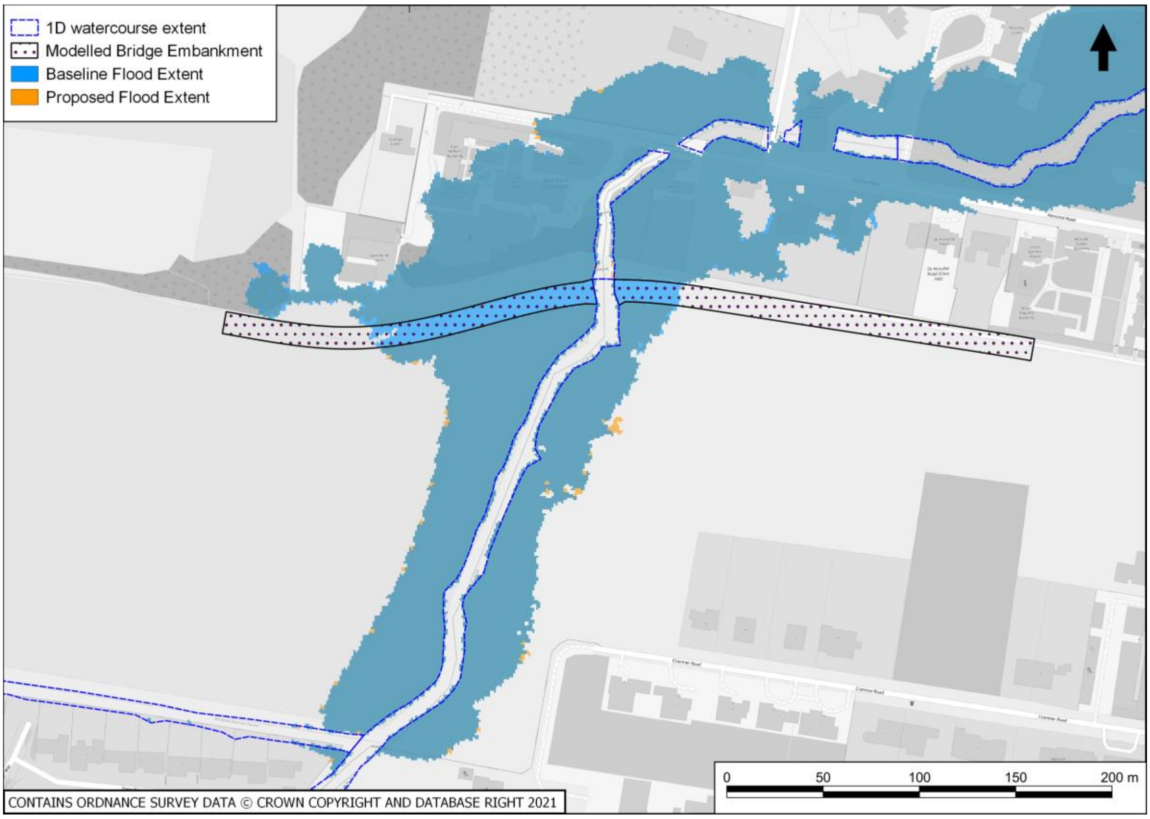


Plate TR13.1-1-1-2 – Baseline vs Proposed (10m span with existing footbridge removed) flood extent for the 1 in 100 AEP with 19% climate change allowance

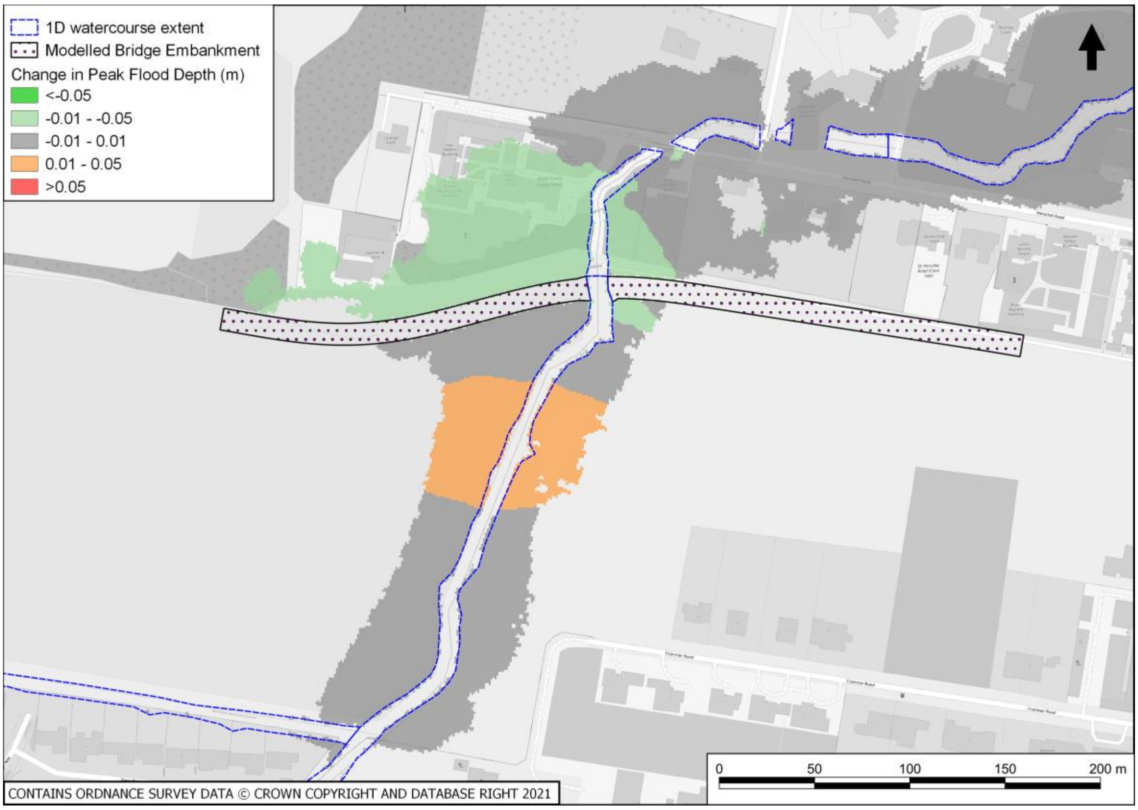


Plate TR13.1-1-1-3 – Baseline vs Proposed (10m span with existing footbridge removed) change in peak flood water level for the 1 in 100 AEP with 19% climate change allowance

MEETING TAKEAWAYS AND ACTIONS

1.1.10 Based upon the minimal impact shown in the flood modelling it was decided that the 10m span bridge would be taken forward as the proposed design span. This was agreed with GCP during the call.

1.1.11 To manage the slight increase in peak water level upstream from a planning and permissions perspective it was decided that an agreement could be reached between GCP and Cambridge University regarding the potential impact. This would usually take the form of a formal letter from the university saying they agree to the increase in flood risk. It is intended that GCP will outline the potential change in flood risk to Cambridge University and receive agreement in principle to the additional risk prior to submission of an FRA for the proposed works.

1.1.12 As stated, it was agreed that the bridge would have a 10m span. The design soffit level for the bridge was agreed to be set at the 1 in 100 AEP with 19% climate change plus a 300mm freeboard. As such the Proposed Bridge would meet the design requirements set out by the Environment Agency (as advised by N Benn via email on 23rd August 2022) and section LA 113 of the DMRB. It is noted however that section CD 356 (para 4.16) requires a 600mm freeboard above the 1 in 200 AEP plus climate change event. It was proposed to depart from this requirement to design to / provide a 300mm freeboard above the 1 in 100 AEP with 19% climate change adjustment.

Annex TR13.1.2

MODELLING TECHNICAL NOTE

Public

1 INTRODUCTION

1.1 PROJECT REQUIREMENTS

1.1.1. WSP has been commissioned by the Greater Cambridge Partnership (GCP) to develop the design for the proposed bus route connecting Cambridge to Cambourne. To inform the design of the proposed bridge structure across the Bin Brook a 1D/2D hydraulic model of the relevant reach of Bin Brook has been developed. The proposed bridge structure passes over the Bin Brook in the area immediately south of Herschel Road within the University of Cambridge.

1.1.2. The Bin Brook is a tributary to the River Cam that flows south-north towards the city of Cambridge. The hydraulic model has been constructed as a 1D/2D FMP Tuflow model to allow for modelling of the watercourse, floodplain and road. This modelling report forms an Annex to the Flood Risk Assessment (FRA).

1.2 SITE OVERVIEW

1.2.1. The Bin Brook rises in Hardwick to the west of Cambridge. It flows in an easterly direction before entering Cambridge and discharging to the River Cam.

1.2.2. The extent of the hydraulic model is shown in **Plate TR13.1-1-2-1**.

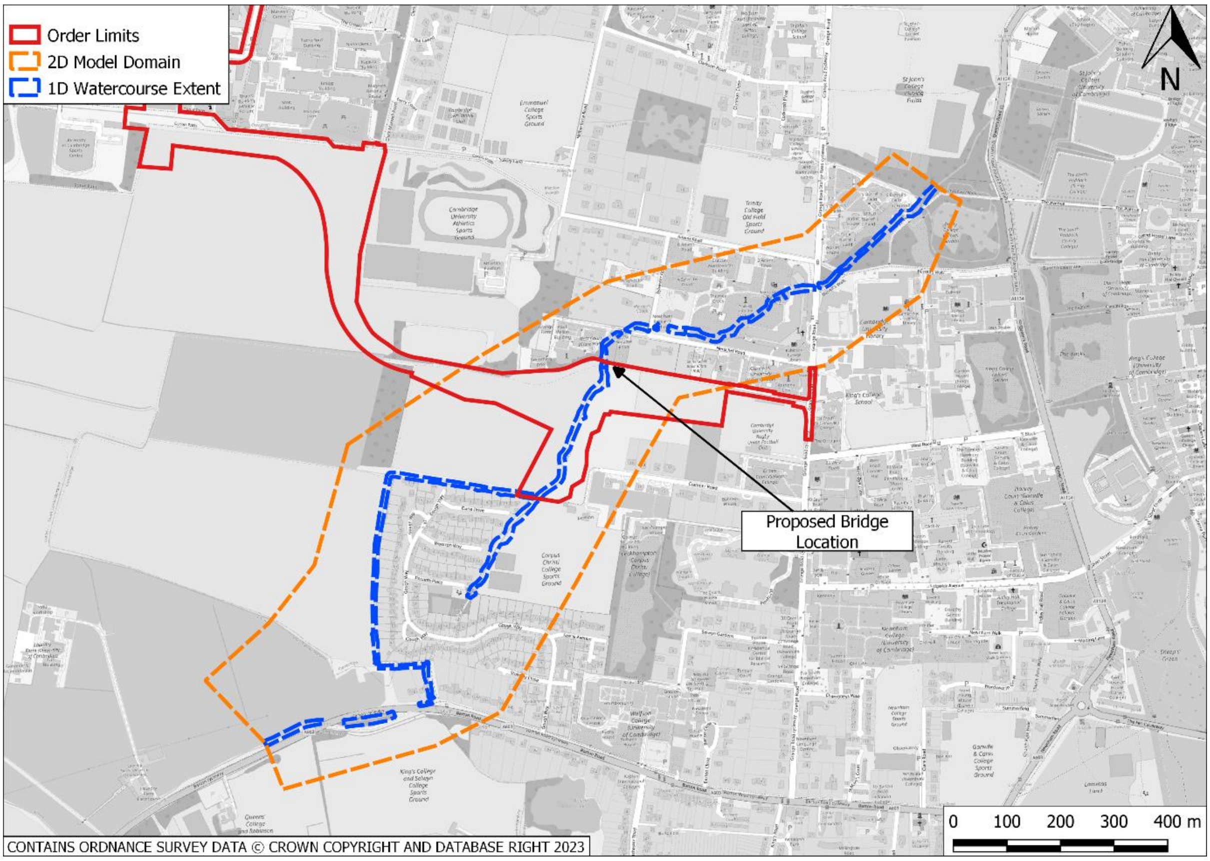


Plate TR13.1-1-2-1 – Hydraulic model extents

1.3 BACKGROUND DATA

HYDRAULIC MODELLING STUDIES

1.3.1. This model was created using an existing Environment Agency 1D/2D model of the Bin Brook that has been enhanced with up-to-date topographic survey of the watercourse.

SURVEYED DATA

1.3.2. Cross section survey of the Bin Brook was collected by GCP in May of 2022. Cross sections and structure details were collected for use in the 1D hydraulic model domain.

1.3.3. The survey can be found at the link below:

\\uk.wspgroup.com\central data\Projects\70086xxx\70086660 - C2C TWAO Stage\03 WIP\Water\Watercourse Survey

1.3.4. This survey will also be packaged with the hydraulic model upon submission.

1.3.5. The floodplain was defined using 1m LiDAR which was downloaded from the Environment Agency webpage in May 2022 to represent the 2D domain. **Table TR13.1.1-1-2-1** provides a summary of the survey information used.

Table TR13.1.1-1-2-1 Survey information

Title	Type	Notes
1m_LiDAR	Lidar Survey	1m DTM LiDAR downloaded from the EA webpage: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey
Bin Brook survey CSVs and cross section drawings	River cross-sections	River section survey along the Bin Brook and adjoining ditch. They have been used to add to the existing hydraulic model in the 1D model domain.

GAUGE DATA

1.3.6. There are no flow gauges on the watercourse in the Study Area.

HISTORICAL DATA

1.3.7. No flow or historical flood data was available for model calibration.

2 MODELLING APPROACH

2.1.1. A hydraulically linked 1D-2D FMP TUFLOW model has been used for the purpose of the study. The choice of software reflects the need to accurately represent the interaction between the channel and floodplain in the area of interest whilst maintaining a stable model.

2.1.2. The fluvial inflow into the model was added as a QTBDY inflow at the upstream end of the model. The modelled reach is small (~ 1.8km) with a mix of urban and rural catchment. The derived hydrograph was added at the upstream inflow point.

2.1.3. The downstream boundary in the 1D domain was set as a normal depth boundary using a user defined slope of 0.002 based upon the preceding river sections. The downstream boundary in the 2D domain was set as a HQ boundary in order to manage overland flows in the downstream end of the model. The slope for this boundary was set using surrounding Lidar survey levels.

2.1.4. The roughness for the 2D domain was set based on OS mastermap with standard roughness values.

2.1.5. The 2D domain surface was completed using 1m LiDAR survey obtained from LLE.

2.2 BASELINE MODELLING

1D BASELINE MODEL REPRESENTATION

2.2.1. All channel sections are prefixed by BB01 for Bin Brook. This is followed by a number which corresponds with the chainage starting from the downstream limit of the model.

2.2.2. **Table TR13.1.1-1-2-2** provides a summary of the roughness values used in the 1D domain.

Table TR13.1.1-1-2-2 1D model roughness

Type	Mannings
River cross sections Invert	0.035
River cross sections Bank	0.05
Culvert	0.02

2.2.3. The above roughness values have been referenced from Manning's n for Channels (Chow, 1959).

1D Model Boundaries

2.2.4. As stated above, one main hydrological inflow boundary has been schematised for the model based on the key drainage catchment for the study area. The main catchment is applied as 1D model flow versus time (QT) boundary at the upstream extent of the 1D model.

2D BASELINE MODEL REPRESENTATION

Labelling Convention

2.2.5. The standard labelling convention and folder structure for TUFLOW models has been applied. The primary control files (.tcf, .ecf, .tgc etc) have been prefixed with BBK and a 3 digit version number. GIS files are saved in the model/SHP folder and prefixed with the TUFLOW ascribed codes and suffixed with a general description of the file.

2.2.6. Scenario identifiers have been used for the running of different scenarios in Tuflow. These scenario identifiers are outlined in **Table TR13.1.1-1-2-3**.

Table TR13.1.1-1-2-3 Scenario identifiers

Scenario	Identifier
Baseline	BSC
10m bridge span	10m
16m bridge span	16m
21m bridge span	21m
Removal of downstream footbridge	FBRem
Retainment of downstream footbridge	FBRet
Floodplain compensation area 1	Comp1
Floodplain compensation area 2	Comp2
20% increase in roughness sensitivity test	R20in
20% decrease in roughness sensitivity test	R20de
20% decrease in DS boundary event scenario	100YR19CCDSde
20% increase in DS boundary event scenario	100YR19CCDSin

Model Grid Resolution and Modifications

2.2.7. The LIDAR data has been sampled at a 2m grid cell size to represent the floodplain.

2.2.8. Bank top levels have been applied separately and are based on the available topographic survey data. Bank top levels are applied at surveyed cross sections and linearly interpolated between these points.

2.2.9. A line has been added in the area around the culvert in order to raise the levels of the bank to the level of the wall in this area. The levels for this wall have been based upon topographic survey.

Floodplain Roughness

2.2.10. OS Mastermap data has been used to determine floodplain surface types. A spatially varying roughness has been applied across the 2D domain using this data and the roughness values linked to the different surface types as shown in **Table TR13.1.1-1-2-4**.

Table TR13.1.1-1-2-4 2D domain roughness

Description	Manning's 'n' value
Buildings	0.500
Roads or hardstanding	0.020
Gardens	0.060
General Green Areas/ Natural Roadside	0.060
Natural environment (Trees)	0.045

Description	Manning's 'n' value
Water	0.020

2.2.11. These values have been referenced from Chow 1959.

2D Model Boundaries

2.2.12. The TUFLOW 2D domain is linked to the FMP 1D channels using a HX boundary along the left and right bank top of the channels and 1D nodes corresponding to FMP river sections. This boundary coincides with the bank top levels stamped into the 2D domains based on the cross section survey.

2.2.13. As stated above a HQ boundary has been placed at the downstream end of the model in order to manage overland flows passing out of the model domain. The slope for this boundary has been estimated based upon Lidar survey data.

2.3 PROPOSED MODELLING

PROPOSED MODEL SETUP

2.3.1. To optimise the bridge design, three different bridge spans (20m, 16m and 10m) were modelled. The modelling of the bridge structure was made with the following assumptions:

- The bridge would be a clear span structure, to help mitigate the impacts from a Water Framework Directive (WFD) perspective;
- The soffit level of the structure would be set at a height above the peak water level, and as such would not need to be represented within the hydraulic model; and
- No additional flow structures or overflows are to be provided through the embankment leading up to the bridge crossing or within the abutments for the bridge.

2.3.2. Based upon the above assumptions the representation of the bridge structure within the model has been created using a uniform embankment height of 10.5mAOD to block all flows passing along the floodplain outside of the watercourse. This has been created using a no merge shape to cover the area of the embankment. A gap over the watercourse has been left to allow for flows passing through the tested bridge spans. When it comes to the design of the bridge structure / embankment, this will be derived from the **1 in 100 Annual Exceedance Probability (AEP) plus 19% climate change and a freeboard of 300mm.**

2.3.3. Immediately downstream of the proposed bridge location there is an existing farm access bridge. As this bridge will no longer be accessible once the proposed bridge is constructed additional model runs were performed to assess the impact of removing this structure on the predicted flood risk in the area. This was done by removing the bridge structure form the 1D FMP .dat file.

2.3.4. Each model scenario was run for the 1 in 100 AEP event with 19% allowance for climate change (design event).

3 MODEL RESULTS

3.1 BASELINE RESULTS

3.1.1. Baseline modelling of the area showed significant areas of flooding for the design event, with large extents of flooding within the fields upstream of the proposed bridge structure. Flooding was also shown downstream within the university buildings to the north of the proposed bridge location (see **Plate TR13.1-1-2-2**).

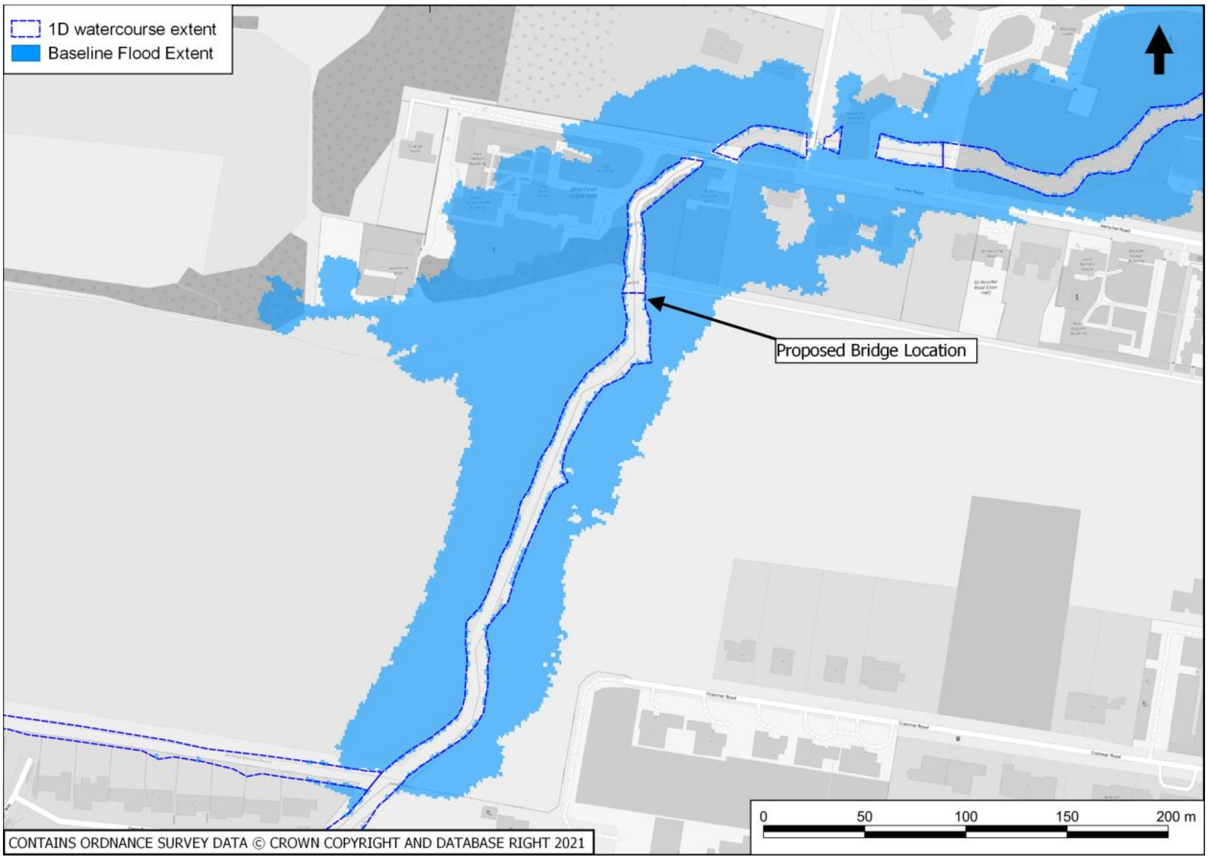


Plate TR13.1-1-2-2 – Baseline Flood Extent 1% AEP with 19% climate change allowance

3.2 PROPOSED RESULTS

3.2.1. During consultation with GCP they indicated that a smaller bridge span was preferrable. It was also confirmed by GCP that the existing footbridge structure would be removed. Examination of the 10m span bridge with the downstream footbridge removed showed minimal change in the predicted flood extent (see **Plate TR13.1-1-2-3** and **Plate TR13.1-1-2-4**).

3.2.2. **Plate TR13.1-1-2-3** and **Plate TR13.1-1-2-4** show that there is negligible change in the predicted flood extent upstream of the proposed bridge, with only minimal increases in peak flood water level (an average of 10 to 15mm over an existing flood depth of approximately 900mm at its deepest point immediately adjacent the river bank at the proposed bridge). It is also shown that there is a slight reduction (approximately 20mm over an existing depth of

900mm) in the peak flood level around existing university buildings immediately downstream of the proposed bridge.

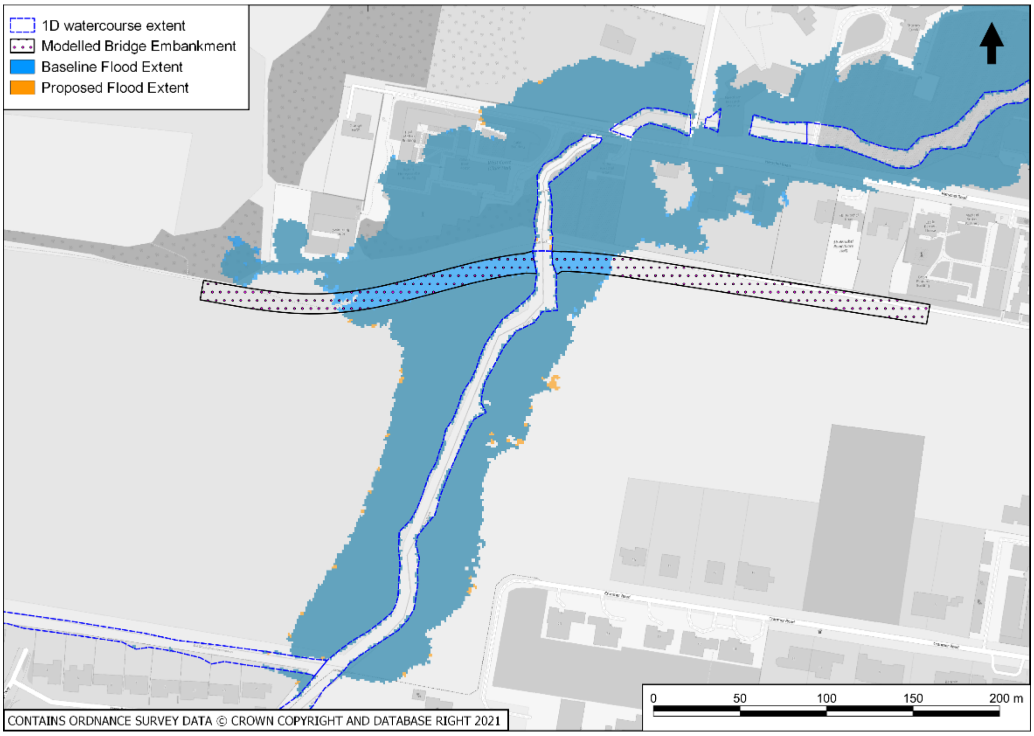


Plate TR13.1-1-2-3 – Baseline vs Proposed (10m span with existing footbridge removed) flood extent for the 1% AEP with 19% climate change allowance

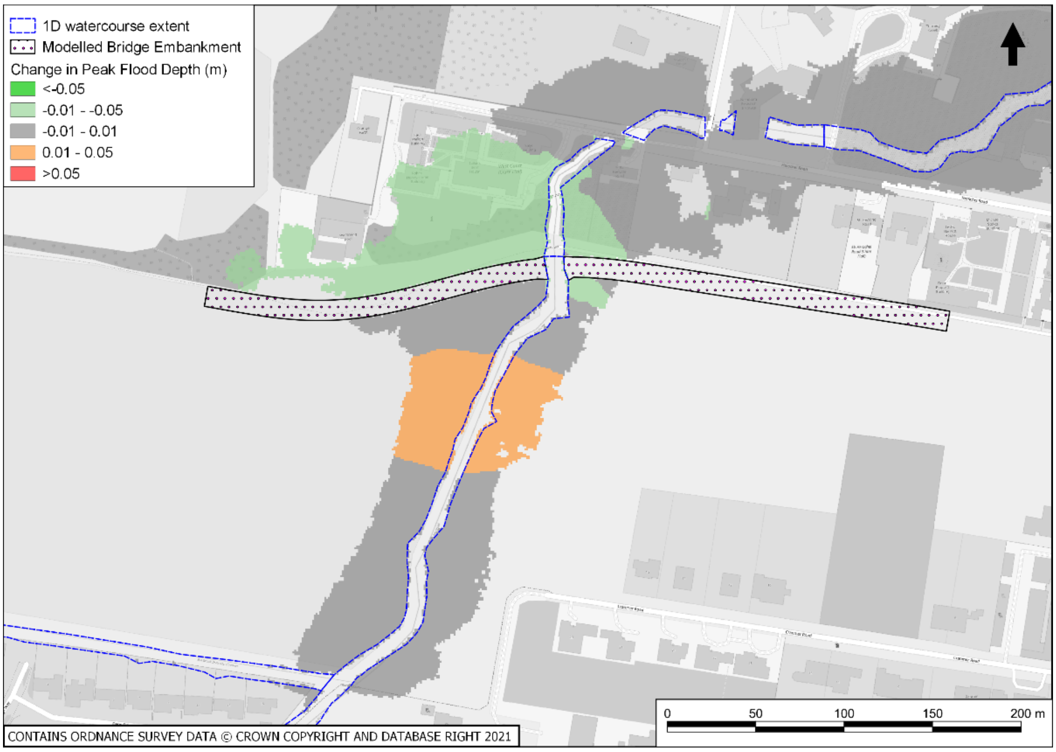


Plate TR13.1-1-2-4 – Baseline vs Proposed (10m span with existing footbridge removed) change in peak flood water level for the 1% AEP with 19% climate change allowance

3.3 SENSITIVITY TESTS

3.3.1. A series of tests were run to test the sensitivity of the hydraulic model to changes in certain model attributes. These are outlined below:

- 20% increase and decrease in roughness; and
- 20% increase and decrease in the channel and overland slope at the downstream boundary.

3.3.2. Each of these tests was run for the 1% AEP event with 19% climate change. The results of these sensitivity tests are summarised below.

ROUGHNESS TEST

3.3.3. Overall the test of a 20% increase and decrease in channel and floodplain roughness had minimal impact on the peak flood depths. As expected, there was an increase and decrease in the peak water level throughout the model, corresponding to the relevant test. This change in peak water level was generally only ever approximately 10 to 15mm. In comparison to existing peak flood depths that range between 350mm to 1.2m these changes in depth are considered to be negligible, indicating that the hydraulic model is not overly sensitive to changes in roughness.

DOWNSTREAM BOUNDARY TEST

3.3.4. The test of a 20% increase and decrease in the channel and overland flow slope at the downstream boundary had minimal impact on predicted flood depths, only leading to a 4 to 6mm change in depth at different points within the hydraulic model. In comparison with the existing peak flood depths that range between 350mm to 1.2m these changes in depth are considered to be negligible, indicating that the hydraulic model is not overly sensitive to changes the downstream boundary of the model.

Annex TR13.1.3

HYDROLOGY

Public

Flood estimation calculation record

Introduction

This document is a supporting document to the Environment Agency's flood estimation guidelines. It provides a record of the calculations and decisions made during flood estimation. It will often be complemented by more general hydrological information given in a project report. The information given here should enable the work to be reproduced in the future. This version of the record is for studies where flood estimates are needed at multiple locations.

Contents

Page

1 METHOD STATEMENT ---------- 3

2 LOCATIONS WHERE FLOOD ESTIMATES REQUIRED ---------- 7

3 STATISTICAL METHOD ---------- 9

4 REVITALISED FLOOD HYDROGRAPH (REFH) METHOD ---------- 13

5 FEH RAINFALL-RUNOFF METHOD ---------- 14

6 DISCUSSION AND SUMMARY OF RESULTS ---------- 15

7 ANNEX - SUPPORTING INFORMATION ---------- 18

Approval

	Signature	Name and qualifications	For Environment Agency staff: Competence level (see below)
Calculations prepared by:		Stephanie Haberfield MSc BSc (Hons) MCIWEM	
Calculations checked by:		Tim Jolley PhD MSc BEng C.ENG	
Calculations approved by:		Tim Jolley PhD MSc BEng C.ENG	

Environment Agency competence levels are covered in Section 2.1 of the flood estimation guidelines:

- Level 1 – Hydrologist with minimum approved experience in flood estimation
- Level 2 – Senior Hydrologist
- Level 3 – Senior Hydrologist with extensive experience of flood estimation

ABBREVIATIONS

AM	Annual Maximum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FSR	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp(0)	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

1 Method statement

1.1 Overview of requirements for flood estimates

Item	Comments
Give an overview which includes: • Purpose of study • Approx. no. of flood estimates required • Peak flows or hydrographs? • Range of return periods and locations • Approx. time available	WSP has been commissioned to undertake a Flood Risk Assessment (FRA) for the Cambridge to Cambourne scheme. The scheme includes a replacement bridge crossing across the Bin Brook which will be assessed using a hydraulic model to understand local flooding mechanisms and the impact of the scheme. The purpose of the study is to generate hydrographs and peak flow estimates. Peak flow estimates are required at four locations along the Bin Brook and its tributaries. Plate TR13.1-1-3-1 below provides an overview of the study area. The following return period events were assessed: 2 year, 5 year, 10 year, 20 year, 30 year, 50 year, 75 year, 100 year, 200 year, 1000 year.  **Plate TR13.1-1-3-1 – Study Area**

1.2 Overview of catchment

Item	Comments
Brief description of catchment, or reference to section in accompanying report	The Bin Brook flows in a broadly west to east direction, starting approximately 750m east of Hardwick. Bin Brook flows beneath Gough Way and the footpath to the south of Herschel Road within the study area. The Bin Brook discharges into the River Cam approximately 3.4km downstream. The catchment of Bin Brook is predominately a rural catchment consisting of agricultural land and the urban areas of Hardwick, Coton and the western areas of Cambridge. The catchment slopes from approximately 68m AOD in the east to approximately 12m AOD in the west. There are two online lakes identied on OS mapping, one located to the west of Grantchester Road and one located to the south of Clarkson Road. These are labelled in Plate TR13.1-1-3-1 above. No reservoirs or artificial features have been identified from OS mapping. Soil mapping indicates that the majority of the catchment is underlain by lime-rich loamy and clayey soils with impeded drainage. Plate TR13.1-1-3-2 shows the four FEH catchments.

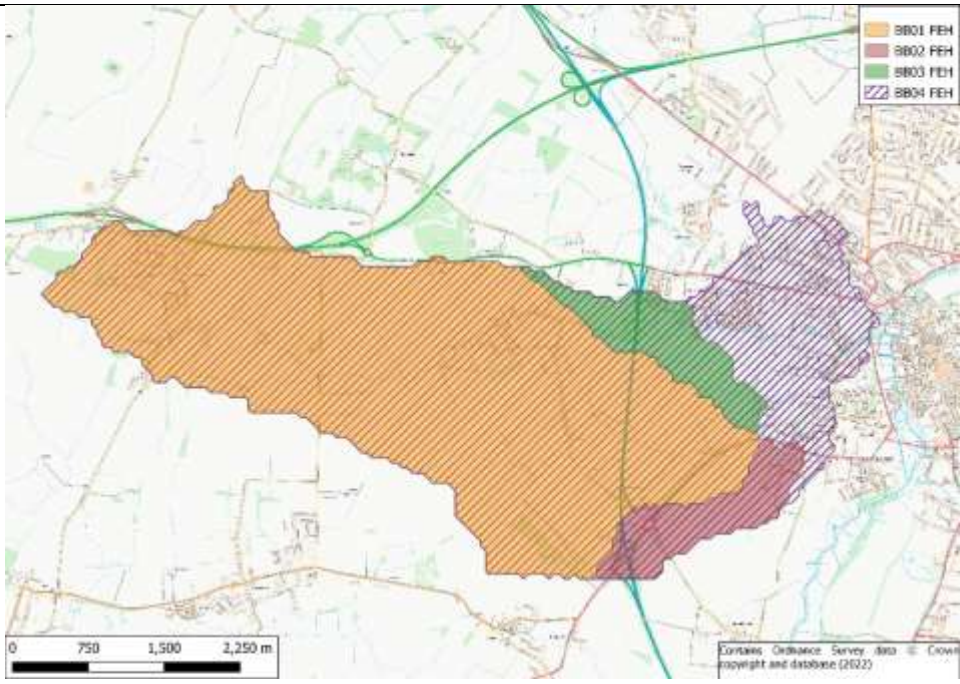


Plate TR13.1-1-3-2 – FEH Catchments

The catchments are relatively steep so are likely to have a rapid response to rainfall over a short duration. As it is a small overall catchment there will be a higher degree of uncertainty associated with the flow estimates due to the lack of gauged data that is similar to the study catchment.

1.3 Source of flood peak data

Was the HiFlows UK dataset used? If so, which version? If not, why not? Record any changes made	Yes – Version 10, August 2021

1.4 Gauging stations (flow or level)

An online search for potential gauging stations within the vicinity of the site was undertaken using the FEH Web Service looking at all NRFA sites. There are no gauging stations within the subject site catchment. The nearest gauge to the site is located on the River Cam and as such drains a catchment significantly different to the subject site. There is an Environment Agency gauging station located along the Bin Brook that was identified during a site visit, but it is a water level station and not for use in flood estimation.

Water-course	Station name	Gauging authority number	NRFA number (used in FEH)	Grid reference	Catch-ment area (km²)	Type (rated / ultrasonic / level…)	Start and end of flow record
N/A							

1.5 Data available at each flow gauging station

Station name	Start and end of data in HiFlows-UK	Update for this study?	Suitable for QMED?	Suitable for pooling?	Data quality check needed?	**Other comments on station and flow data quality** – e.g. information from HiFlows-UK, trends in flood peaks, outliers.

Station name	Start and end of data in HiFlows-UK	Update for this study?	Suitable for QMED?	Suitable for pooling?	Data quality check needed?	Other comments on station and flow data quality – e.g. information from HiFlows-UK, trends in flood peaks, outliers.
Give link/reference to any further data quality checks carried out						

1.6 Rating equations

Station name	Type of rating e.g. theoretical, empirical; degree of extrapolation	Rating review needed?	Reasons – e.g., availability of recent flow gaugings, amount of scatter in the rating.
Give link/reference to any rating reviews carried out			

1.7 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available ?	Source of data and licence reference if from EA	Date obtained	Details
Check flow gaugings (if planned to review ratings)		No			
Historic flood data – give link to historic review if carried out.		No			
Flow data for events		No			
Rainfall data for events		No			
Potential evaporation data		No			
Results from previous studies		No			
Other data or information (e.g. groundwater, tides)		No			

1.8 Initial choice of approach

Is FEH appropriate? (it may not be for very small, heavily urbanised or complex catchments) If not, describe other methods to be used.	FEH is considered to be appropriate; both the statistical and ReFH2.2 methods will be used as part of the study. There are no significant artificial influences.
Outline the conceptual model, addressing questions such as: • Where are the main sites of interest?	A catchment wide storm scenario is considered appropriate for the flow estimation. Flooding from the Bin Brook is likely to be controlled by the capacity and

• What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) • Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? • Is there a need to consider temporary debris dams that could collapse?	hydraulic characteristics of the watercourse and structures located on the watercourse. Peak flows, rather than volume, are likely to be the main factor considered. Flow estimates are required for the two tributaries of the Bin Brook upstream of the A603 and the tributary adjacent to Gough Way.
Any unusual catchment features to take into account? e.g. • highly permeable – avoid ReFH if BFIHOST>0.65, consider permeable catchment adjustment for statistical method if SPRHOST<20% • highly urbanised – avoid standard ReFH if URBEXT1990>0.125; consider FEH Statistical or other alternatives; consider method that can account for differing sewer and topographic catchments • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence (FARL<0.90) – consider flood routing • extensive floodplain storage – consider choice of method carefully	The BB02 catchment has a low FARL value of 0.9 due to the small size of the catchment, this may have an impact on the calculated flows. The lake is hydraulically connected to the Bin Brook on review of OS mapping. The M11 may also act as a barrier to overland flow paths but it is assumed that surface water can flow across the catchment without any impediment through culverts and other structures.
Initial choice of method(s) and reasons Will the catchment be split into subcatchments? If so, how?	Both the Statistical and ReFH2.2 methods were assessed in order to allow for a comparison of both methods.
Software to be used (with version numbers)	WINFAP 5 ReFH2.3 (version 3.1.7439)

2 Locations where flood estimates required

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space. To make a clear distinction between the different hydrological inputs for the hydraulic models, the tables below have been categorised by colour.

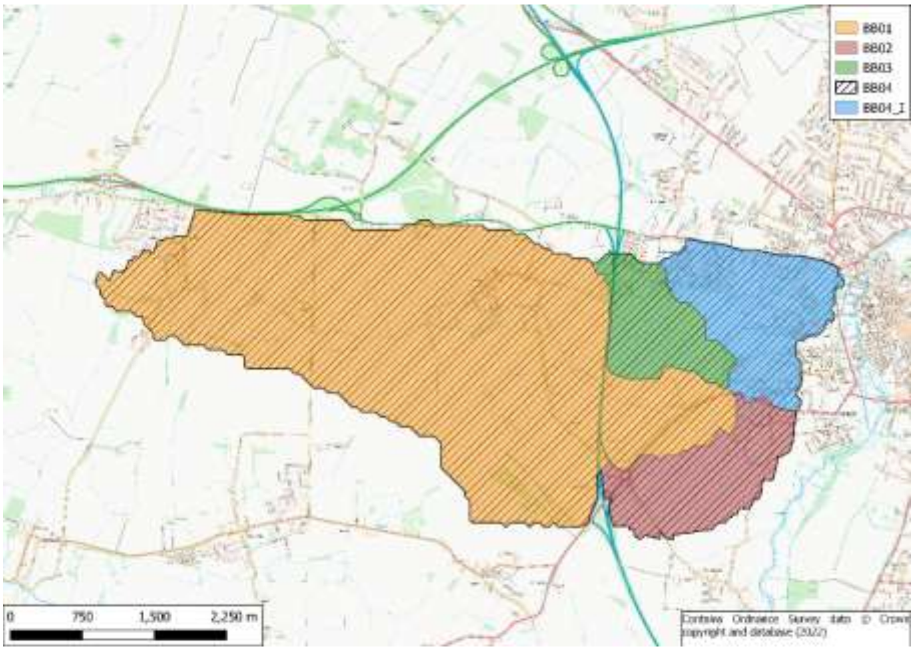
2.1 Summary of subject sites

Site code	Watercourse	Site	Easting	Northing	AREA on FEH Web Service (km^2)	Revised AREA if altered
BB01	Bin Brook	Upstream of A603 crossing for Bin Brook.	543200	257700	12.43	11.25
BB02	Bin Brook	Upstream of A603 crossing for tributary of Bin Brook.	543300	257650	1.05	1.61
BB03	Bin Brook	Tributary of Bin Brook adjacent to Gough Way.	543200	258100	1.10	1.16
BB04	Bin Brook	Downstream extent of hydraulic model.	544350	258800	17.32	15.94
BB04_I	Bin Brook	Incremental catchment for the downstream area of Bin Brook.	543570	258555	-	1.92
Reasons for choosing above locations		Locations of inflows for the hydraulic model.				

2.2 Important catchment descriptors at each subject site (incorporating any changes made)

Site code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST	URBEXT	FPEXT
BB01	1	0.24	0.351	4.60	24.5	556	49.54	0.042	0.09
BB02	0.90	0.26	0.317	1.56	9.9	549	55.08	0.027	0.29
BB03	1	0.26	0.290	1.63	12	552	57.94	0.009	0.22
BB04	0.99	0.25	0.353	5.26	20.7	555	50.75	0.071	0.15
BB04_I		0.25	0.353	1.43	12.75	555	49.87	0.311	-

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (refer to maps if needed)	The catchment boundaries were originally derived from FEH and checked against OS mapping and LiDAR data using a watershed analysis based on 2m LiDAR data. Plate TR13.1-1-3-2 below shows the amended catchments taken forward for the assessment.  **Plate TR13.1-1-3-3 – Amended Catchments**
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	The following checks were undertaken for each of the catchments: • BFIHOST and SPRHOST – Values adopted from the FEH catchments. FEH values were checked against soil mapping and appear to be reasonable. The incremental BB04_I catchment value was taken from BB04. • FARL – The FEH values were used, two ponds identified within catchments with BB02 and BB04. The incremental BB04_I catchment value was taken from BB02 as the proportion of the pond to the catchment area is similar. • URBEXT2000 – The FEH URBEXT values were checked against 10k OS mapping and appear to be reasonable. The values were updated to 2022 using the FEH UEF formula. The incremental BB04_I catchment value was calculated using area weighting and checked using an URBAN value of 0.5. • PROPWET / SAAR – FEH values adopted. The incremental BB04_I catchment values were taken from BB04. • DPSBAR – Manual check in GIS completed using LiDAR data where available. The FEH values were deemed appropriate for the catchments. The incremental BB04_I catchment value was calculated using area weighting and checked in GIS. • DPLBAR – The values were checked in GIS and the FEH used for the catchments. The incremental BB04_I catchment value was calculated using area weighting and checked in GIS.
Source of URBEXT	FEH URBEXT2000 (updated to 2022) was used for the FEH catchments. The BB04_I value was area weighted as is an incremental catchment.
Method for updating of URBEXT	Updated to 2022 using the standard FEH UEF formula for URBEXT2000.

3 Statistical method

3.1 Search for donor sites for QMED (if applicable)

Comment on potential donor sites Mention: • Number of potential donor sites available • Distances from subject site • Similarity in terms of AREA, BFIHOST, FARL and other catchment descriptors • Quality of flood peak data Include a map if necessary. Note that donor catchments should usually be rural.	The closest sites up to a distance of 50km (based on centroid distance from BB04) were identified using WINFAP FEH v5. The parameters were set to only include sites suitable for QMED and sites with an URBEXT 2000 <0.04 to reflect the relatively rural nature of the study catchment. An additional check for other donor sites including sites not suitable for QMED was also undertaken. Guidance for small catchments indicates that the single closet donor station should be used. The closest station (33021) has a ratio of 1.29 and was taken forward for donor adjustment as there was no details to suggest it was not suitable. The next nearest station (33052) has a ratio of 0.68 so was not taken forward as this was different to the other stations within the area.

Table 2 Potential Donor Sites

Station ID	Station Name	Area	BFIHOST 19	SPRHOST	FARL	URBEXT	PROPWET	SAAR (mm)	DPSBAR (m/km)	DPLBAR (km)
33021	Rhee @ Burnt Mill	308	0.792	24.05	0.994	0.021	0.24	559	24.8	18.49
33052	Swaffham Lode @ Swaffham Bulbeck	33	0.922	13.7	0.998	0.0	0.26	567	25.6	6.82
33027	Rhee @ Wimpole	128	0.693	31.54	1	0.0	0.24	558	22.1	10.92
33055	Granta @ Babraham	101	0.709	26.96	0.999	0.0	0.26	579	35.6	12.4
33051	Cam @ Chesterford	140	0.637	31.24	0.993	0.0	0.29	599	40.5	12.81
36012	Stour @ Kedington	76	0.38	43.95	0.99	0.0	0.26	599	30.1	11.19

3.2 Donor sites chosen and QMED adjustment factors

NRFA no.	Reasons for choosing or rejecting	Method (AM or POT)	Adjust-ment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
33021	Accepted - No reason to reject based on telemetry.	AM	N/A	7.72	5.70	1.36
33052	Rejected - The QMED ratio is 0.68 which is very different from other stations nearby.	AM	N/A	0.33	0.46	0.72
33027	Rejected - Difference in catchment descriptors including FARL and BFIHOST19.	AM	N/A	5.08	4.21	1.21
33055	Rejected - The station is drowned and bypassed at high flows.	AM	N/A	3.96	3.88	1.10

NRFA no.	Reasons for choosing or rejecting	Method (AM or POT)	Adjust-ment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
33051	Rejected - Much higher BFIHOST value in comparison to study site and distance value of 22.8 from study catchments.	AM	N/A	7.86	7.09	1.11
36012	Rejected - High downstream levels make estimate of flow peak uncertain.	AM	N/A	12.00	11.87	1.31
Which version of the urban adjustment was used for QMED at donor sites, and why? Note: The guidelines recommend great caution in urban adjustment of QMED on catchments that are also highly permeable (BFIHOST>0.8).				UAF applied in WinFAP5		

3.3 Overview of estimation of QMED at each subject site

<table>
<tr><th rowspan="3">Site code</th><th rowspan="3">Method</th><th rowspan="3">Initial estimate of QMED (m³/s)</th><th colspan="5">Data transfer</th><th rowspan="3">Final estimate of QMED (m³/s)</th></tr>
<tr><th rowspan="2">NRFA numbers for donor sites used (see 3.2)</th><th rowspan="2">Distance between centroids d_ij (km)</th><th rowspan="2">Moderated QMED adjustment factor, (A/B)^a</th><th colspan="2">If more than one donor</th></tr>
<tr><th>Weight</th><th>Weighted average adjustment factor</th></tr>
<tr><td>BB01</td><td>DT</td><td>1.53</td><td rowspan="5">33021</td><td rowspan="5">15.05</td><td rowspan="5">1.11</td><td rowspan="5">N/A</td><td rowspan="5">N/A</td><td>1.79</td></tr>
<tr><td>BB02</td><td>DT</td><td>0.21</td><td>0.24</td></tr>
<tr><td>BB03</td><td>DT</td><td>0.24</td><td>0.27</td></tr>
<tr><td>BB04</td><td>DT</td><td>1.97</td><td>2.38</td></tr>
<tr><td>BB04_I</td><td>DT</td><td>0.23</td><td>0.37</td></tr>
<tr><td colspan="5">Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?</td><td colspan="4">The QMED values are reasonably consistent with the increases in catchment area.</td></tr>
<tr><td colspan="5">Which version of the urban adjustment was used for QMED, and why?</td><td colspan="4">WinFAP5 UAF values</td></tr>
<tr><td colspan="9">Notes
Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer; CD – Catchment descriptors alone.
When QMED is estimated from POT data, it should also be adjusted for climatic variation. Details should be added.
When QMED is estimated from catchment descriptors, the revised 2008 equation from Science Report SC050050 Error! Bookmark not defined. should be used. If the original FEH equation has been used, say so and give the reason why.
The guidelines recommend great caution in urban adjustment of QMED on catchments that are also highly permeable (BFIHOST>0.8). The adjustment method used in WINFAP-FEH v3.0.003 is likely to overestimate adjustment factors for such catchments. In this case the only reliable flood estimates are likely to be derived from local flow data.
The data transfer procedure is from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in Table 3.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is (A/B)^a times the initial estimate from catchment descriptors.
If more than one donor has been used, use multiple rows for the site and give the weights used in the averaging. Record the weighted average adjustment factor in the penultimate column.</td></tr>
</table>

3.4 Derivation of pooling groups

The composition of each pooling group is provided in the Annex.

A single pooling group was derived in WINFAP for the downstream catchment (BB04). A single pooling group was considered appropriate to be applied to all of the study nodes considering their size and hydrological similarities. Only sites suitable for pooling were included and sites with an URBEXT < 0.04. The scope of the study allowed for a brief review of the pooling group. A number of sites at the top of the pooling group were reviewed in greater detail using the online NRFA data. The pooling group achieved the 500 years of data required with the catchments included in the pooling group being relatively hydrologically similar to the subject catchments.

No sites were removed from the original pooling group. The pooling group included permeable sites which were retained as they are hydrologically similar to the subject sites. A permeable adjustment was therefore undertaken as detailed below. It was this pooling group with the permeable adjustment that was carried forward.

Name of group	**Site code from whose descriptors group was derived**	**Subject site treated as gauged?** (enhanced single site analysis)	**Changes made to default pooling group, with reasons** Note also any sites that were investigated but retained in the group.	**Weighted average L-moments**, L-CV and L-skew, (before urban adjustment)
BB_PG	LB04	No	Noted above.	L-CV – 0.302 L-skew – 0.142
BB_PG_PA (following permeable adjustments)	LB04	No	As for BB_PG but 5 sites required a permeable adjustment within the pooling group (26016, 27073, 26014, 33054 and 39033) as these sites have a BFIHOST19 value greater than 0.8.	L-CV – 0.329 L-skew – 0.149
Notes Pooling groups were derived using the revised procedures from Science Report SC050050 (2008). The weighted average L-moments, before urban adjustment, can be found at the bottom of the Pooling-group details window in WINFAP-FEH.				

3.5 Derivation of flood growth curves at subject sites

Site code	**Method** (SS, P, ESS, J)	**If P, ESS or J, name of pooling group (3.4)**	**Distribution used and reason for choice**	**Note any urban adjustment or permeable adjustment**	**Parameters of distribution** (location, scale and shape) after adjustments	**Growth factor for 100-year return period**
BB04	P	BB_PG_PA	GL – best fit	-	Location – 1.000 Scale – 0.343 Shape – -0.150 Bound – -0.964	3.273
Notes Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters. Urban adjustments to growth curves should use the version 3 option in WINFAP-FEH: Kjeldsen (2010). Growth curves were derived using the revised procedures from Science Report SC050050 (2008).						

3.6 Flood estimates from the statistical method

Site code	**Flood peak (m^3/s) for the following return periods (in years)**									
	2	**5**	**10**	**20**	**30**	**50**	**75**	**100**	**200**	**1000**
BB01	1.79	2.74	3.39	4.06	4.48	5.04	5.51	5.86	6.76	9.24
BB02	0.24	0.36	0.45	0.54	0.59	0.66	0.73	0.77	0.89	1.22

Site code		Flood peak (m^3/s) for the following return periods (in years)								
	2	5	10	20	30	50	75	100	200	1000
BB03	0.27	0.42	0.52	0.62	0.69	0.77	0.84	0.90	1.03	1.41
BB04	2.38	3.64	4.51	5.41	5.96	6.70	7.33	7.79	8.99	12.30
BB04_I	0.37	0.56	0.69	0.83	0.92	1.03	1.13	1.20	1.38	1.89

4 Revitalised flood hydrograph (ReFH) method 2.2

4.1 Parameters for ReFH2.2 model

Note: If parameters are estimated from catchment descriptors, they are easily reproducible so it is not essential to enter them in the table.

Site code	**Method:** OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer (give details)	**Tp (hours)** Time to peak	**C_{max} (mm)** Maximum storage capacity	**BL (hours)** Baseflow lag	**BR (2 yr)** Baseflow recharge
BB01	CD	8.44	298.51	43.99	1.12
BB02	CD	5.44	268.70	31.50	0.86
BB03	CD	5.34	250.50	30.13	0.67
BB04	CD	9.18	297.49	44.61	1.14
BB04_I	CD	5.08	297.49	33.58	1.15
Brief description of any flood event analysis carried out (further details should be given below or in a project report)			N/A		

4.2 Design events for ReFH method

Site code	**Urban or rural**	**Season of design event (summer or winter)**	**Storm duration (hours)**	**Storm area for ARF** (if not catchment area)
BB01	Urban	Winter	15.00	-
BB02	Urban	Winter	9.00	-
BB03	Urban	Winter	9.00	-
BB04	Urban	Winter	15.00	-
BB04_I	Urban	Winter	9.00	-
Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?			Storm durations are not likely to be changed. Storm duration, SCF and ARF for BB04_I is based on the flow node BB03. The SCF and ARF for BB02 is based the flows node BB03.	

4.3 Flood estimates from the ReFH method

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	**5**	**10**	**20**	**30**	**50**	**75**	**100**	**200**	**1000**
BB01	2.26	3.06	3.64	4.28	4.71	5.38	6.04	6.57	8.02	11.53
BB02	0.48	0.67	0.80	0.95	1.05	1.20	1.34	1.47	1.81	2.67
BB03	0.39	0.53	0.64	0.76	0.84	0.97	1.09	1.19	1.46	2.14
BB04	3.04	4.12	4.91	5.78	6.37	7.26	8.14	8.86	10.80	15.54
BB04_I	0.55	0.76	0.92	1.09	1.21	1.38	1.56	1.70	2.09	3.06

5 FEH rainfall-runoff method – N/A

5.1 Parameters for FEH rainfall-runoff model

Methods:
FEA : Flood event analysis
LAG : Catchment lag
DT : Catchment descriptors with data transfer from donor catchment
CD : Catchment descriptors alone
BFI : SPR derived from baseflow index calculated from flow data

Site code	Rural (R) or urban (U)	Tp(0): method	Tp(0): value (hours)	SPR: method	SPR: value (%)	BF: method	BF: value (m^3/s)	If DT, numbers of donor sites used (see Section 5.2) and reasons

5.2 Donor sites for FEH rainfall-runoff parameters

No.	Watercourse	Station	Tp(0) from data (A)	Tp(0) from CDs (B)	Adjustment ratio for Tp(0) (A/B)	SPR from data (C)	SPR from CDs (D)	Adjust-ment ratio for SPR (C/D)
1								
2								

5.3 Inputs to and outputs from FEH rainfall-runoff model

Site code	Storm duration (hours)	Storm area for ARF (if not catchment area)	Flood peaks (m^3/s) or volumes (m^3) for the following return periods (in years)							
			2							

Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?	

6 Discussion and summary of results

6.1 Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method at example sites for two key return periods. Blank cells indicate that results for a particular site were not calculated using that method.

Site code	Ratio of peak flow to FEH Statistical peak					
	Return period 2 years			Return period 100 years		
	ReFH	Statistical	Ratio (ReFH / Statistical)	ReFH	Statistical	Ratio (ReFH / Statistical)
BB01	2.26	1.79	1.3	6.57	5.86	1.1
BB02	0.48	0.24	2.0	1.47	0.77	1.9
BB03	0.39	0.27	1.4	1.19	0.90	1.3
BB04	3.04	2.38	1.3	8.86	7.79	1.1
BB04_I	0.55	0.37	1.5	1.70	1.20	1.4

6.2 Final choice of method

Choice of method and reasons – include reference to type of study, nature of catchment and type of data available.

The ReFH method peak flow estimates are higher in comparison to the peak flow estimates produced by the Statistical method. There is not a high level of certainty in either method due to the lack of suitable donor sites.

Comparison of the Statistical and ReFH growth curves for BB04 as shown in Plate TR13.1-1-3-2 below indicates that Statistical method curve is steeper than the ReFH growth curve. The main difference between the two methodologies are the QMED peak flow estimates.

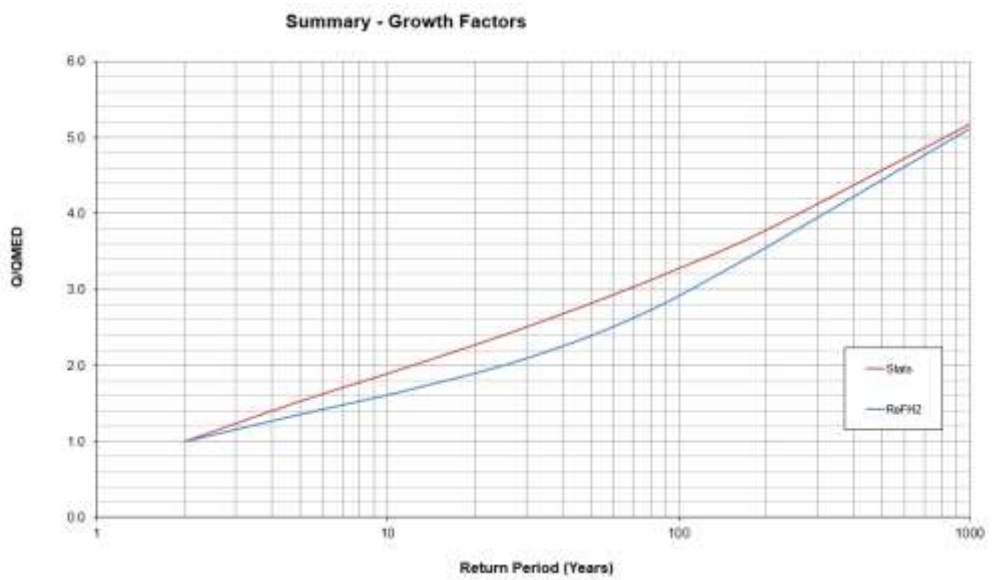


Plate TR13.1-1-3-4 – BB04 Growth Curves

Taking into consideration the differences in peak flow estimates produced between the Statistical method and ReFH method, the final peak flow estimates have been derived using the ReFH method as these are higher. This potentially provides conservative flow estimates but is considered appropriate for the assessment where a precautionary approach is advisable.

6.3 Assumptions, limitations and uncertainty

<table>
<tr><td>List the main assumptions made (specific to this study)</td><td>Standard FEH assumptions.</td></tr>
<tr><td>Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed</td><td>The estimated peak flows produced are uncertain due to lack of any gauged data needed to calibrate and verify the methods. There were no suitable donor sites identified.</td></tr>
<tr><td>Give what information you can on uncertainty in the results – e.g. confidence limits for the QMED estimates using FEH 3 12.5 or the factorial standard error from Science Report SC050050 (2008).</td><td>Detailed assessment outside of scope. Comparison of ReFH and Statistical method peak flow estimates provides some indication of the range of uncertainty. Environment Agency technical guidance[1] provides confidence intervals for design flows at ungauged rural sites. Table TR13.1.1-1-2-1 below shows the confidence intervals for the QMED peak flow estimates for the downstream catchment based on no donor sites.

Table TR13.1.1-1-2-1 Confidence Intervals
<table><tr><th rowspan="2">Site code</th><th colspan="2">68%</th></tr><tr><th>Lower</th><th>Upper</th></tr><tr><td>BB01</td><td>1.56</td><td>3.28</td></tr><tr><td>BB02</td><td>0.34</td><td>0.69</td></tr><tr><td>BB03</td><td>0.27</td><td>0.54</td></tr><tr><td>BB04</td><td>1.92</td><td>4.83</td></tr></table></td></tr>
<tr><td>Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.</td><td>N/A</td></tr>
<tr><td>Give any other comments on the study, for example suggestions for additional work.</td><td>Installation of a flow gauge (temporary or permanent) would help to verify and improve flow estimates for all of the study catchments.</td></tr>
</table>

6.4 Checks

<table>
<tr><td>Are the results consistent, for example at confluences?</td><td>Considering the different response times the peak flow estimates are considered reasonable.</td></tr>
<tr><td>What do the results imply regarding the return periods of floods during the period of record?</td><td>N/A</td></tr>
<tr><td>What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 to 4.0)</td><td>TR13.1.1-1-2-2 100year Growth Factors
<table><tr><th>Flow Node</th><th>Growth Factor</th></tr><tr><td>BB01</td><td>2.91</td></tr><tr><td>BB02</td><td>3.03</td></tr><tr><td>BB03</td><td>3.09</td></tr><tr><td>BB04</td><td>2.91</td></tr><tr><td>BB04_I</td><td>3.07</td></tr></table></td></tr>
<tr><td>If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?</td><td>1.75 – 1.82</td></tr>
</table>

[1] Using local data to reduce uncertainty in flood frequency estimation (2017) Environment Agency

What range of specific runoffs (l/s/ha) do the results equate to? Are there any inconsistencies?	TR13.1.1-1-2-3 shows the range of specific runoffs for the downstream flow node (BB04). **TR13.1.1-1-2-3 Specific Runoffs** **2 Year (m3/s/km)**: 1.91 **100 Year (m3/s/km)**: 5.56
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	N/A
Are the results compatible with the longer-term flood history?	N/A
Describe any other checks on the results	N/A

6.5 Final results

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	**5**	**10**	**20**	**30**	**50**	**75**	**100**	**200**	**1000**
BB01	2.26	3.06	3.64	4.28	4.71	5.38	6.04	6.57	8.02	11.53
BB02	0.48	0.67	0.80	0.95	1.05	1.20	1.34	1.47	1.81	2.67
BB03	0.39	0.53	0.64	0.76	0.84	0.97	1.09	1.19	1.46	2.14
BB04	3.04	4.12	4.91	5.78	6.37	7.26	8.14	8.86	10.80	15.54
BB04_I	0.55	0.76	0.92	1.09	1.21	1.38	1.56	1.70	2.09	3.06

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, name of ISIS model, or reference to table below)	Hydrographs\Bin Brook_Hydrographs_v0.1.xlsx

7 Annex - supporting information

7.1 Pooling group compositions

Original PG

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy	AREA	SAAR	FPEXT	FARL	URBEXT 2000
36010 (Bumpstead Brook @ Broad Green)	0.464	53	7.5	0.379	0.172	0.917	28	588	0.045	1.00	0.007
26016 (Gypsey Race @ Kirby Grindalythe)	0.889	23	0.101	0.312	0.258	0.780	16	757	0.030	1.00	0.000
27073 (Brompton Beck @ Snainton Ings)	0.924	40	0.816	0.215	0.019	0.971	8	721	0.237	1.00	0.008
36004 (Chad Brook @ Long Melford)	0.925	53	4.938	0.305	0.166	0.710	50	589	0.065	1.00	0.006
26014 (Water Forlornes @ Driffield)	0.937	22	0.431	0.299	0.119	1.394	32	721	0.016	1.00	0.007
30006 (Slea @ Leasingham Mill)	0.956	27	1.92	0.315	0.132	0.717	52	601	0.106	0.96	0.039
36003 (Box @ Polstead)	1.006	60	3.875	0.317	0.086	0.909	57	566	0.093	0.99	0.012
36007 (Belchamp Brook @ Bardfield Bridge)	1.024	55	4.63	0.378	0.111	1.355	58	560	0.079	1.00	0.004
33054 (Babingley @ Castle Rising)	1.07	44	1.132	0.205	0.068	1.220	49	686	0.118	0.94	0.005
39033 (Winterbourne Stream @ Bagnor)	1.105	58	0.401	0.342	0.382	2.442	45	717	0.033	1.00	0.001
37016 (Pant @ Copford Hall)	1.11	55	7.47	0.289	0.103	0.124	64	588	0.069	1.00	0.009
39089 (Gade @ Bury Mill)	1.117	47	0.612	0.239	0.085	0.460	45	724	0.040	0.98	0.033

Final PG

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy	AREA	SAAR	FPEXT	FARL	URBEXT 2000	Changes made to sites
36010 (Bumpstead Brook @ Broad Green)	0.464	53	7.5	0.379	0.172	0.917	27.582	588	0.045	0.999	0.007	
26016 (Gypsey Race @ Kirby Grindalythe)	0.889	23	0.101	0.283	0.314	0.78	15.85	757	0.03	1	0	Permeable adjustment
27073 (Brompton Beck @ Snainton Ings)	0.924	40	0.816	0.199	0.055	0.971	8.06	721	0.237	1	0.008	Permeable adjustment
36004 (Chad Brook @ Long Melford)	0.925	53	4.938	0.305	0.166	0.71	50.328	589	0.065	1	0.006	
26014 (Water Forlornes @ Driffield)	0.937	22	0.431	0.287	0.099	1.394	32.415	721	0.016	1	0.007	Permeable adjustment
30006 (Slea @ Leasingham Mill)	0.956	27	1.92	0.315	0.132	0.717	51.528	601	0.106	0.964	0.039	
36003 (Box @ Polstead)	1.006	60	3.875	0.317	0.086	0.909	56.72	566	0.093	0.993	0.012	
36007 (Belchamp Brook @ Bardfield Bridge)	1.024	55	4.63	0.378	0.111	1.355	58.16	560	0.079	0.996	0.004	
33054 (Babingley @ Castle Rising)	1.07	44	1.132	0.175	0.304	1.22	48.53	686	0.118	0.944	0.005	Permeable adjustment
39033 (Winterbourne Stream @ Bagnor)	1.105	58	0.401	0.419	0.086	2.442	45.312	717	0.033	1	0.001	Permeable adjustment
37016 (Pant @ Copford Hall)	1.11	55	7.47	0.289	0.103	0.124	63.8	588	0.069	0.997	0.009	
39089 (Gade @ Bury Mill)	1.117	47	0.612	0.239	0.085	0.46	44.735	724	0.04	0.979	0.033	

7.2 Additional supporting information

C2C CULVERT HYDROLOGY SIMPLE ASSESSMENT

Quality Control

DATE:	10/02/2023	**CONFIDENTIALITY:**	Public
VERSION:	2.0	**AUTHOR:**	L Mealey
CHECKED:	A Wilks Daly and S Haberfield	**APPROVED:**	T Jolley

Introduction

WSP has been commissioned to calculate the peak flows for the smaller watercourses other than the Bin Brook that flow through the proposed Public Transport Route (PTR) from Cambourne to Cambridge (C2C). The peak flows will be used to assess the impact of the scheme on the watercourses supporting the Flood Risk Assessment and used to design the smaller watercourse crossings. There are a number of new crossings as well as culvert extensions along the scheme. The delineation of the study catchments has taken into consideration the local topography, geology and natural flow paths. The ReFH2 methodology has been adopted for the assessment of the three catchments which are greater than 0.5km^2 as this is generally appropriate for very small catchments. Another six catchments which were less than 0.5km^2 used the peak flows from a previously calculated nearby catchment for a tributary of the Bin Brook and area-weighted to account for the different sizes of each of the catchments.

For the previously calculated peak flows within the Bin Brook catchment, both the Statistical methodology and ReFH2 methodology flows were calculated and compared, as is recommended in C786 Chapter 10.2[1]. The ReFH2 peak flows were higher and a conservative approach taking the ReFH2 peak flows forward for the assessment was appropriate. As a result, only undertaking a ReFH2 assessment of the three catchments is deemed to be an appropriate methodology based on the regional trends in the area.

Study Catchments

The nine study catchments are located starting from the west of Cambridge to the east of Cambourne and are located where a watercourse crossing is which requires a peak flow for the design.

Six out of the nine catchments are too small to be defined by FEH and as a result have been delineated using a watershed analysis through Global Mapper v20 based on available 2m LiDAR data. For the three larger catchments the FEH catchments were compared to the delineated catchments derived through watershed analysis from Global Mapper v20. The catchments based on the watershed analysis were taken forward for the assessment. Figure A shows the FEH catchments, and the amended delineated catchments based on the watershed analysis for the three catchments greater than 0.5km^2. Table TR13.1.1-1-3-1 shows the study catchment areas for each of the nine catchments. A brief review of OS mapping, satellite imagery and Soilscapes mapping has not identified any unusual catchment characteristics. Catchment 5 has not been included within Table TR13.1.1-1-3-1 below as it is the same catchment size as catchment 4 and it is currently unknown if there will be one extended culvert or two separate culverts at this location. If there will be two culverts it will be identical in size to the culvert for catchment 4.

The location and extent of all the delineated watershed catchments are shown in Plate TR13.1-1-2-1 (and Figure B in more detail). The catchments shown in blue are the catchments which have been amended from the FEH catchments, and the catchments shown in orange have used peak flows from a nearby catchment.

[1] CIRIA (2019). Culvert, screen and outfall manual – CIRIA C786.

Derivation of FEH Catchment Descriptors

Derivation of FEH Catchment Descriptors

Catchment descriptors for the eight catchments that are too small to be defined by FEH were based on a nearby catchment for a tributary of the Bin Brook named ‘BB03’. This catchment has previously been checked and approved as part of another project. It was determined to be representative of the eight smaller catchments due to the proximity of the catchment and the similarity in the urban extent. A check against the Soil Survey of England and Wales shows that the ‘BB03’ catchment and the eight small catchments derived by the watershed analysis are all within the same soil classification of 411-d. This is classified as ‘Typical Calcareous Pelosols’ of a Hanslope soil series. Furthermore, Soilscapes mapping also indicates that the underlying soils across the study catchment are consistent, all comprising of slightly impeded draining, lime-rich and clayey loamy soils.

The previously calculated peak flows for the ‘BB03’ catchment were then area-weighted for each of the eight catchments to account for the different sizes of the catchments in respect to the ‘BB03’ catchment.

The urban areas for the overall catchment have not been changed for the eight catchments and the ReFH2 default urbanisation parameters have been adopted. Plate TR13.1-1-2-2 shows the location of the chosen representative ‘BB03’ catchment, and Table TR13.1.1-1-3-2 below details the FEH descriptors for the ‘BB03’ catchment.

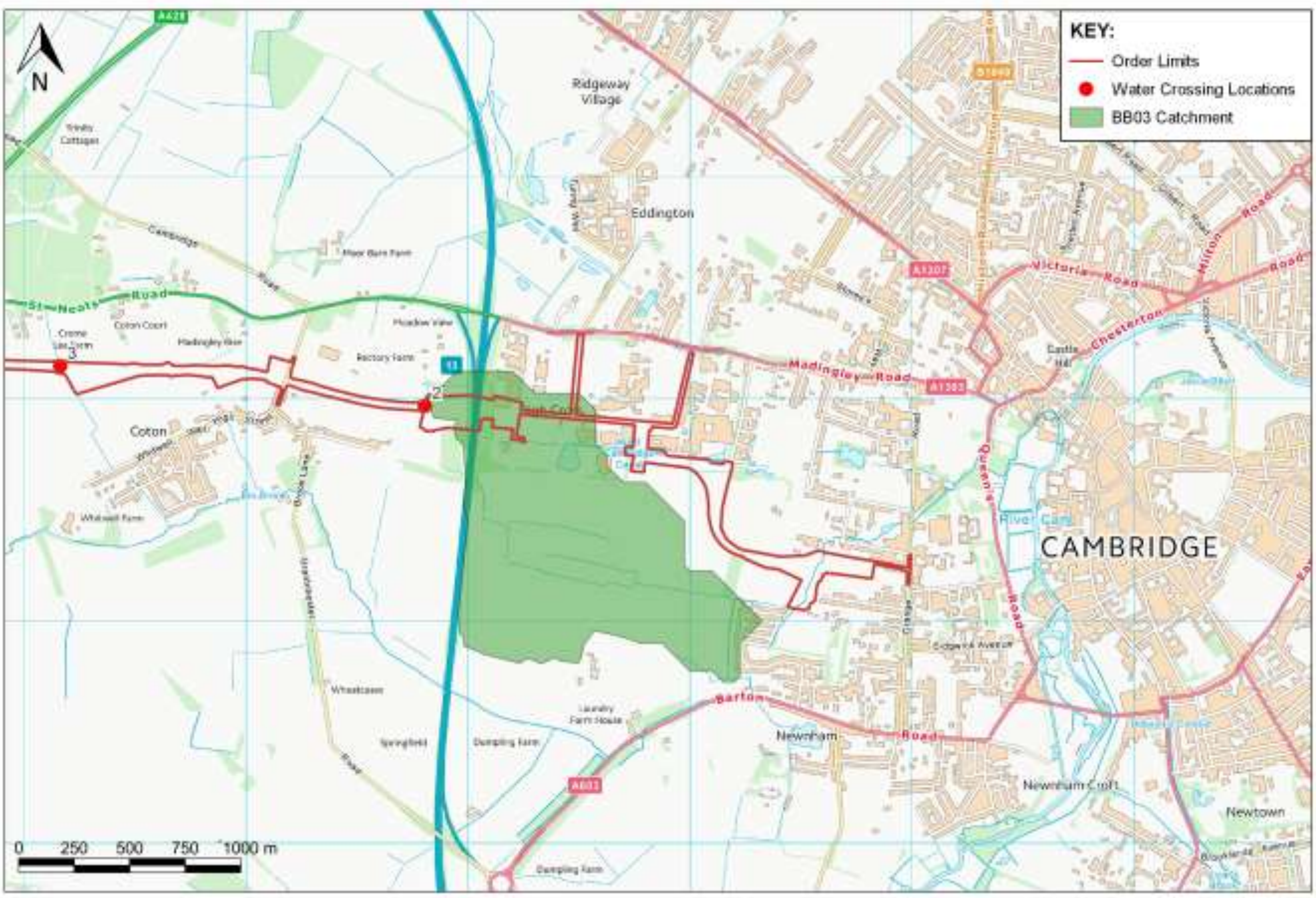


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Plate TR13.1-1-2-2 – Location of the ‘BB03’ catchment

Site Code	Season of design event	Storm Duration (hours)	ARF	SCF
FEH_Catchment_09	Winter	6.50	0.981	0.64

Summary of Results

Table TR13.1.1-1-3-5 provides a summary of the peak flows generated from the ReFH2 methodology for the study catchments. Eight of the peak flows have been calculated using the 'BB03' peak flows and area weighted (BB03_AW_01, BB03_AW_02, BB03_AW_03, BB03_AW_04, BB03_AW_05, BB03_AW_06, BB03_AW_10, BB03_AW_11). The other three catchments used FEH catchment descriptors, but the area was based on the watershed analysis (FEH_Catchment_07, FEH_Catchment_08, FEH_Catchment_09).

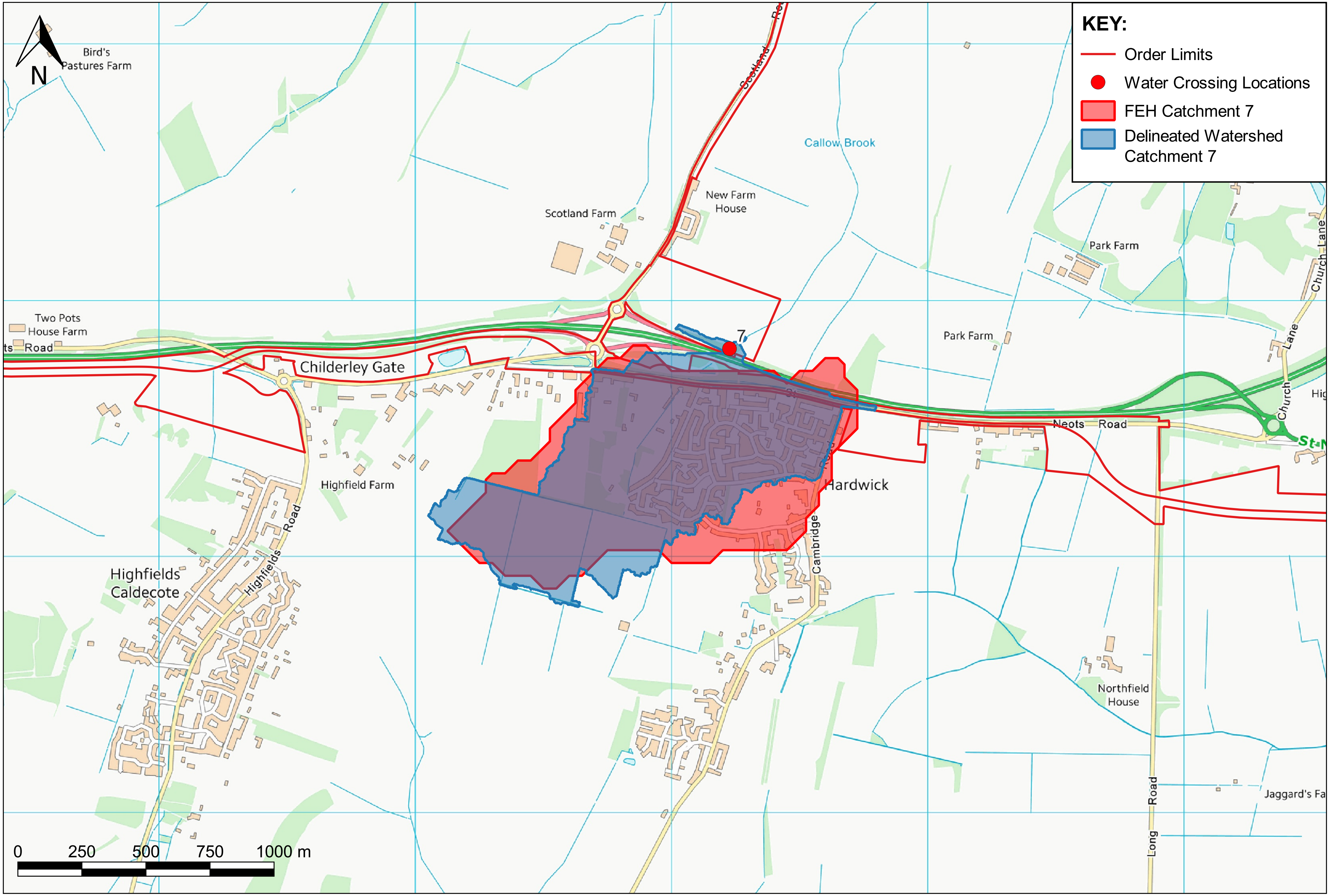
Table TR13.1.1-1-3-5 ReFH2 Results

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	5	10	20	30	50	75	100	200	1000
BB03_Amended	0.39	0.53	0.64	0.76	0.84	0.97	1.09	1.19	1.46	2.14
BB03_AW_02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.09
BB03_AW_03	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.06
BB03_AW_04a	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.04
BB03_AW_04b	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.04
BB03_AW_06	0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.11	0.16
FEH_Catchment_07	0.28	0.38	0.46	0.55	0.60	0.69	0.78	0.85	1.05	1.53
FEH_Catchment_08	0.18	0.25	0.31	0.36	0.40	0.46	0.52	0.56	0.69	1.01
FEH_Catchment_09	0.28	0.39	0.47	0.56	0.62	0.71	0.80	0.87	1.07	1.57
BB03_AW_11	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.04

Limitations

There are limitations associated with catchment definition and characteristics for very small catchments. There are limitations to applying FEH hydrology methods to small catchments because the methods have not been calibrated for catchments of this size and there is a lack of suitable donor sites and data available for the assessment. When estimating peak flows for culverts, CIRIA guidance C786[1] recommends that both the FEH Statistical and ReFH2 methods are undertaken. The hydrological assessment previously undertaken for the Bin Brook (BB03) included a comparison of the FEH Statistical and ReFH2 method flow estimates, with the flows from ReFH2 found to be higher and taken forward for the assessment.

For the eight sub catchments the peak flows have been estimated by means of area-weighting flows from BB03, it can be considered that a comparison between ReFH2 and FEH Statistical method flows has already been undertaken. For the three catchments where peak flows were estimated in ReFH2, this is considered a conservative approach as



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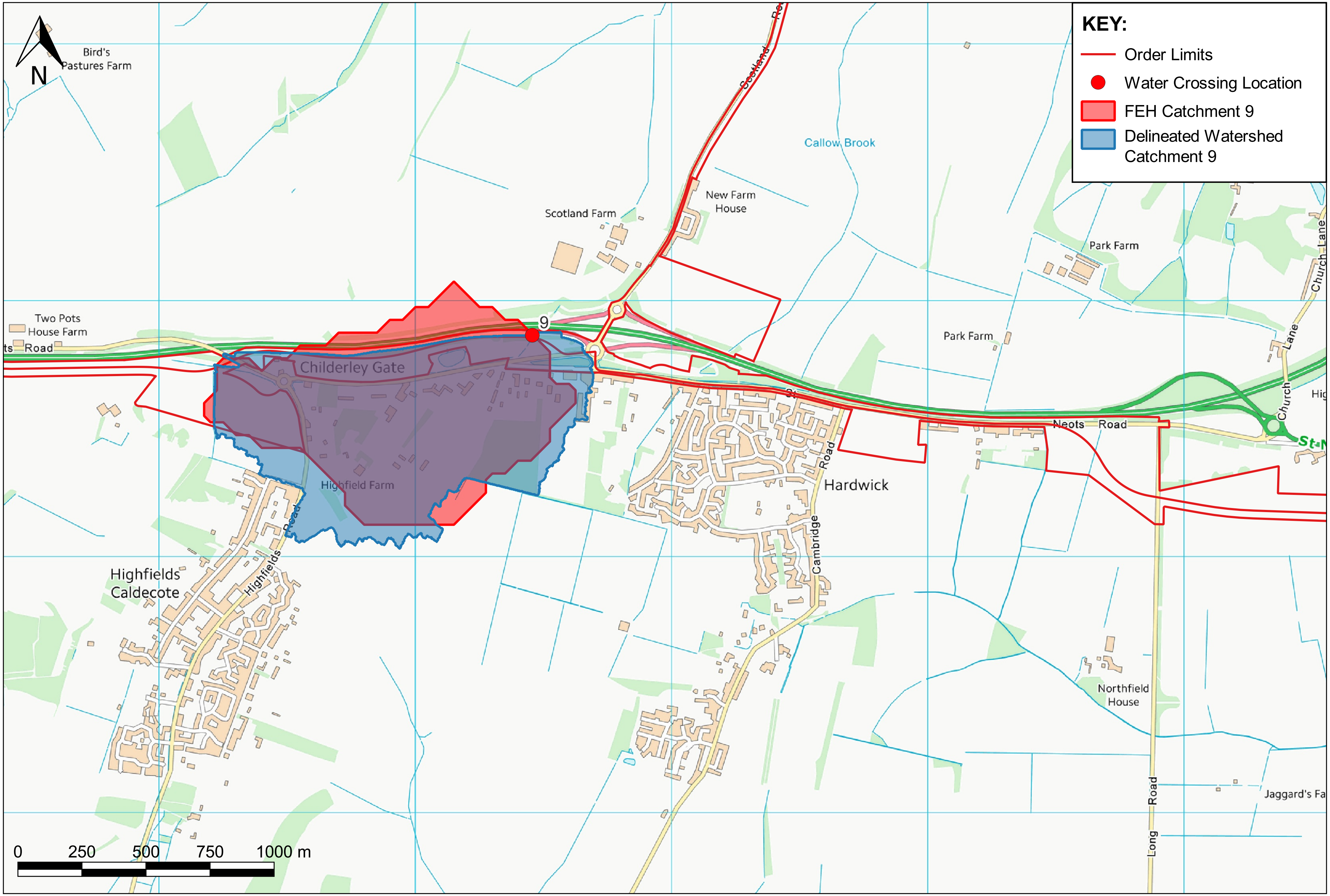

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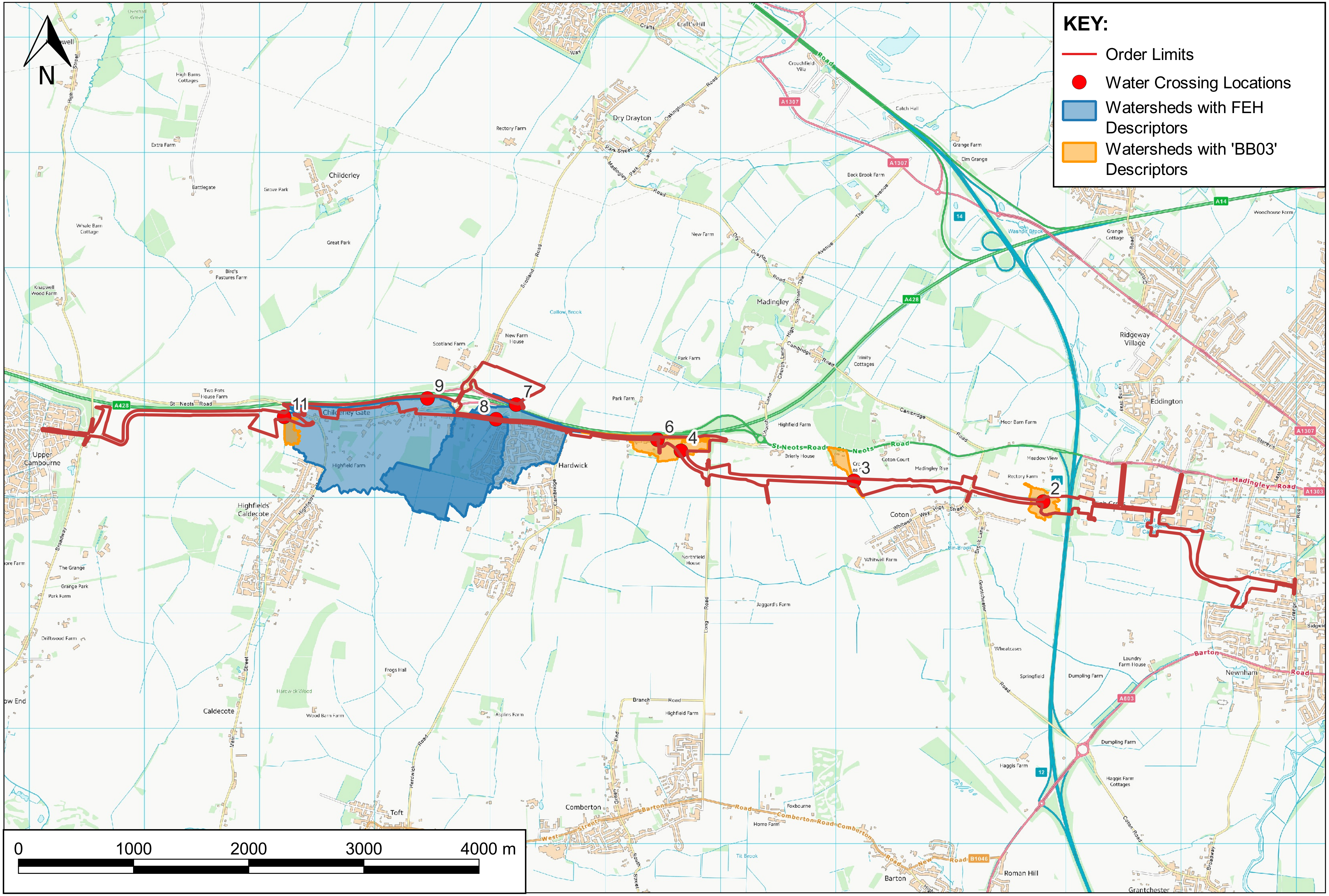

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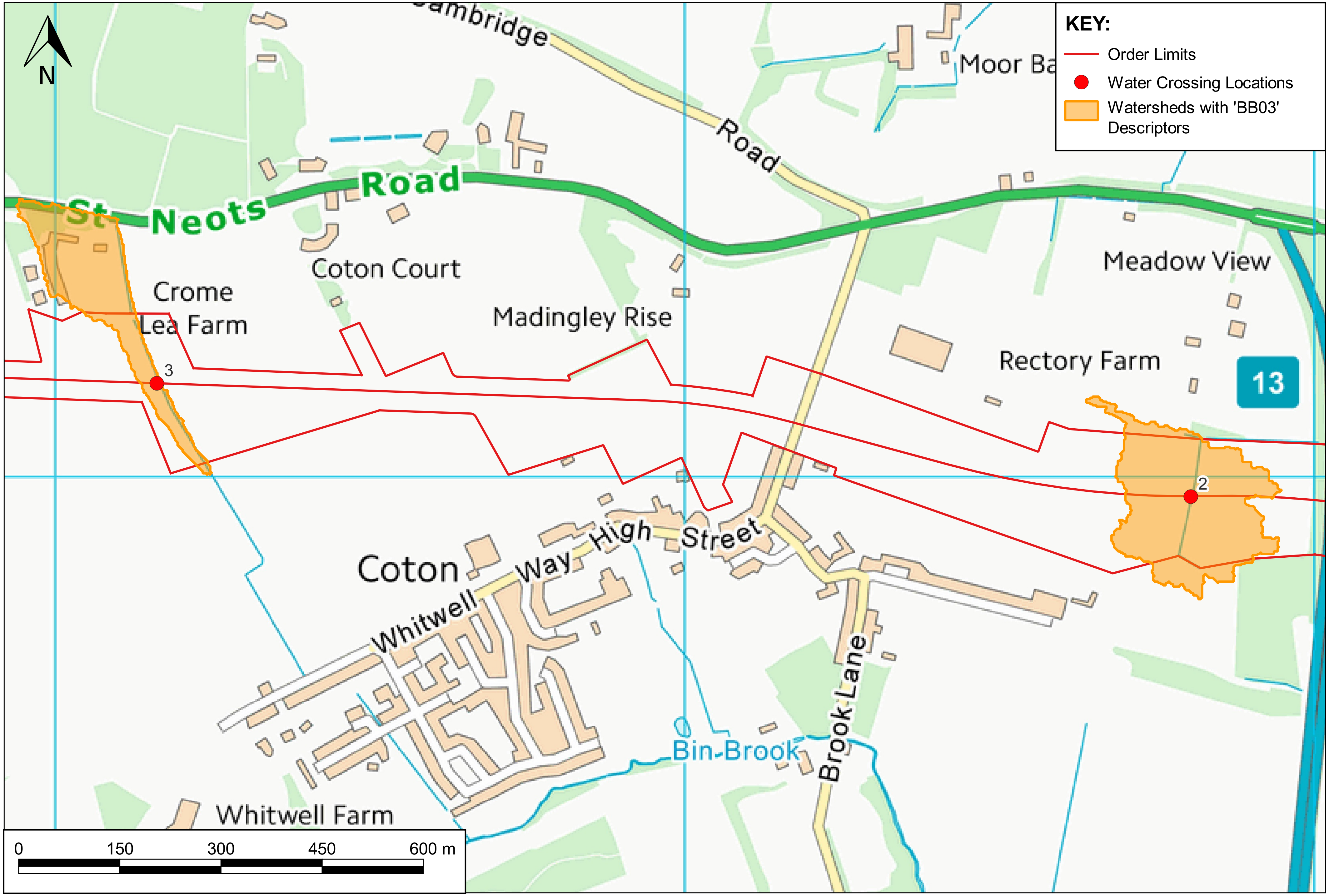

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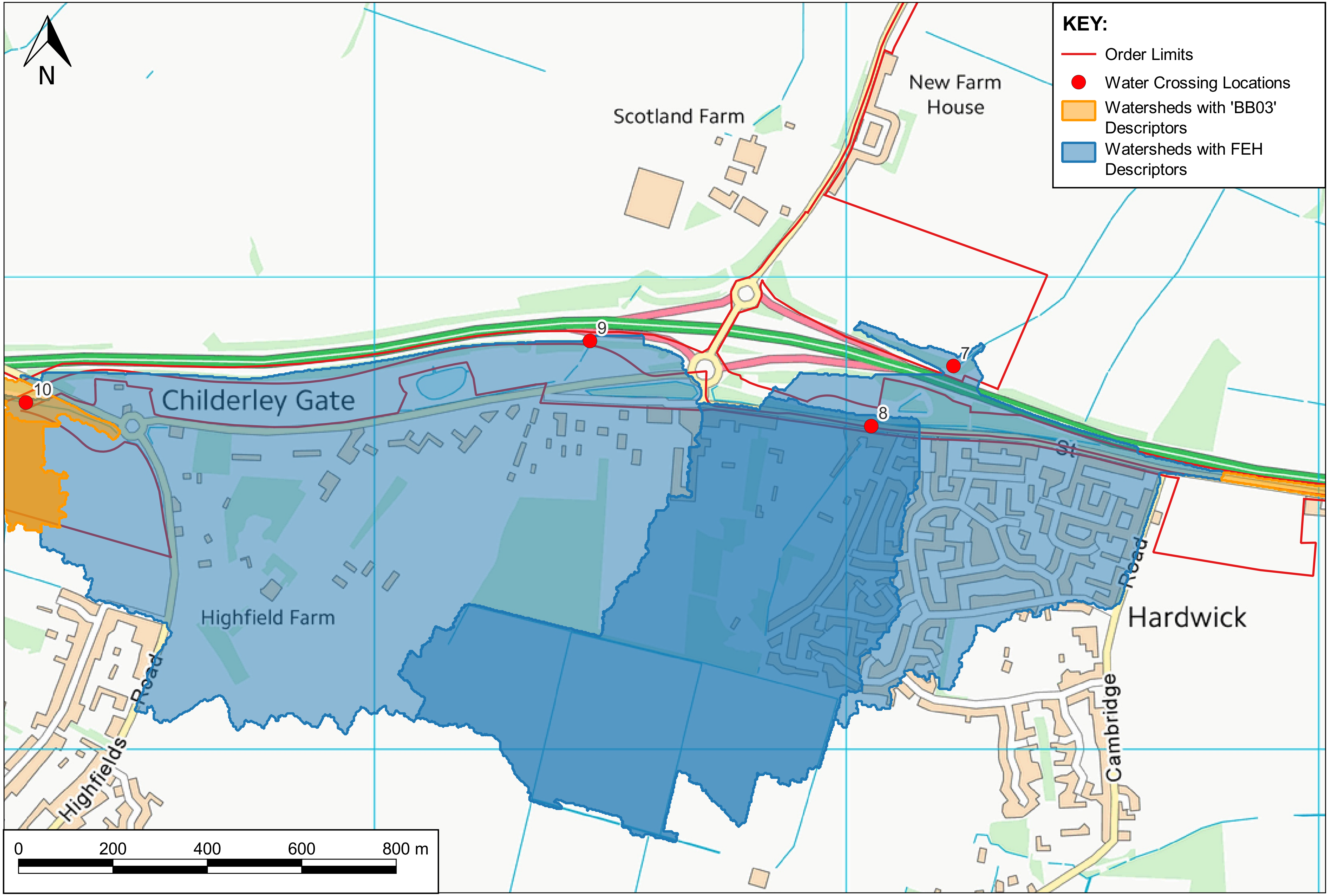

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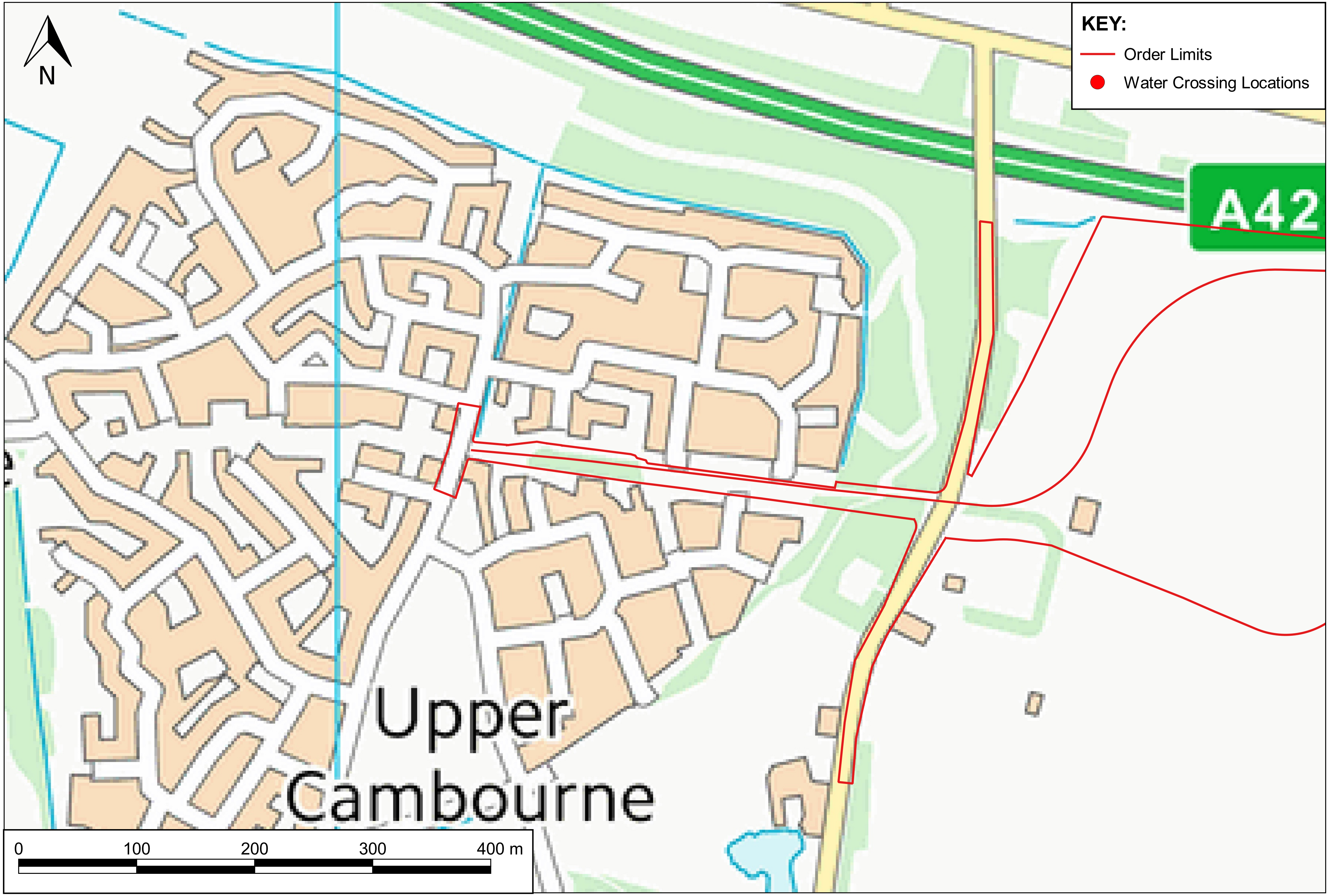

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Annex TR13.1.4

SURFACE WATER DRAINAGE STRATEGY

Public

Cambourne to Cambridge Better Public Transport Project (C2C)
Updated Drainage Strategy

Contents

1 **Introduction**
2 **Proposed Transport Route**
3 **Basis of Design**
4 **SuDS Strategy**
5 **Geology**
6 **Capture and Conveyance**
7 **Catchments**
8 **Existing Runoff Rates**
9 **Proposed Runoff Rates**
10 **Existing Runoff Volumes**
11 **Proposed Runoff Volumes**
12 **Required Volumes of Attenuation**
13 **Exceedance Events**
14 **Water Quality Treatment and Pollution Control**
15 **Biodiversity Benefits**
16 **Amenity Benefits**

Appendices

Ref	Title
Appendix A	Plans showing catchments
Appendix B	Plans showing basins, ponds, crates and outfalls
Appendix C	Greenfield runoff rate estimations
Appendix D	Surface water storage volume estimations
Appendix E	Technical Note 25/05/2023 by Stantec

Cambourne to Cambridge Better Public Transport Project (C2C)
Updated Drainage Strategy

1 Introduction

1.1 The Greater Cambridge Partnership (GCP) is proposing the construction of the infrastructure required to enable the operation of a Public Transport Route (PTR) service to operate between Cambourne and Cambridge. The scheme is to be known as the Cambourne to Cambridge Better Public Transport Project (C2C).

1.2 The Cambourne to Cambridge (C2C) Scheme will include a 13.6km long mainly dedicated busway connecting Cambourne in the west with Cambridge in the east. A service road and maintenance track, to be used as an active travel path, will run alongside the segregated sections of busway. The C2C Scheme will use hybrid vehicles (and in due course, electric vehicles), providing a service of around 10 buses per hour each way. The Scotland Farm travel hub (a park and ride facility) will be situated along the route, just north of the A428, approximately 5km west of Cambridge. Further details about the Scheme proposal are set out in Chapter 3 of the Environmental Statement (ES).

1.3 To summarise, the scheme aims to provide a dedicated public transport corridor for people traveling to Cambridge from towns and villages to its west while providing additional transport capacity for developments proposed and planned within Greater Cambridge to alleviate the impact of future growth along the corridor.

1.4 In March 2022, WSP produced a Water Drainage Strategy for the scheme. Stirling Maynard has been instructed by WSP to update the Drainage Strategy in line with design changes and scheme development.

1.5 In May 2023, Stantec produced a Technical Note dated 25th May 2023 to provide analyses of the drainage impact from the change of impermeable area derived from the extension of busway to link up the designated segregated bus route which is travelling from Cambourne to the centre of Cambridge.

1.6 Stirling Maynard has been instructed by WSP to update the Drainage Strategy in line with the Technical Note dated 25th May 2023. A copy of this Technical Note is provided in Appendix E.

1.7 Stirling Maynard has reviewed the results of hydraulic modelling undertaken at Bin Brook watercourse for the return period of 1:30 years with 35% Climate Change and the 1:100 years with 40% Climate Change. The impact of basin 07 and crates 13 drainage to Bin Brook watercourse is negligible.

2 Proposed Transport Route

2.1 The proposed works will comprise the following:

- A Public Transport Route (PTR) between Cambourne and Cambridge, the majority of which will be an off-road segregated route.
- An emergency access and maintenance track, running adjacent to or in the proximity of the PTR.
- A new Travel Hub site at Scotland Road, off the A428 / A1303.

2.2 The off-road segregated route of the PTR will comprise a 7.3m wide carriageway with full height kerbs and intermittent dropped kerbs laid flush.

2.3 The emergency access and maintenance track will comprise a 3.5 wide surface with flush edge restraint kerbs.

2.4 Further details about the Scheme proposal are set out in Chapter 3 of the ES.

3 Basis of Design

3.1 Guidance from the CIRIA SuDS (Sustainable Drainage Systems) Manual C753 and Cambridgeshire County Council Surface Water Planning Guidance (June 2021) has been followed. A drainage network utilising Sustainable Drainage Systems (SuDS) component is proposed, which will:

- Ensure that surface water drainage is managed as close to the source as possible and mimic natural drainage routes.
- Provide at source pollution control without the need for proprietary treatment systems where possible.
- Limit discharge rates to greenfield run-off rates to protect downstream watercourses and areas.
- To attenuate run-off up to the critical rainfall event and minimise flooding for the exceedance rainfall event.

4 SuDS Strategy

4.1 Cambridgeshire County Council require Sustainable Drainage Systems (SuDS) to be used, where practicable, to ensure that surface water drainage is managed as close to the source as possible and to mimic natural drainage routes.

Cambridgeshire County Council Surface Water Planning Guidance (June 2021) sets out the following drainage hierarchy:

- To ground in filter strips, swales, or infiltration basins.

- To a watercourse or pre-existing ponds.
- Connection to a surface water sewer, highway drain, or another drainage system.
- Connection into a combined sewer.

4.2 Discharge rates will be limited to Q_{BAR} (mean annual flow rate) or 2 l/s, whichever is the greater, where Q_{BAR} has been calculated using the IH 124 method.

5 Geology

5.1 The British Geology Survey Viewer shows Oadby Member (glacial till) overlaying Gault formation (mudstone).

5.2 Endeavour Drilling Ltd carried out a ground investigation in September 2022, which included seven cable percussive boreholes, four rotary boreholes and three window sample boreholes (with associated sampling and in-situ testing) and four falling head permeability tests.

5.3 A “Ground investigation (Factual)” report was produced in December 2022, which typically showed topsoil or made ground overlying slightly gravelly slightly sandy clay (Oadby Member) overlying Gault Formation.

5.4 The falling head permeability tests were carried out in accordance with BS 5930:1999, although no infiltration rates were calculated.

5.5 From the particle size distribution test certificates, it is likely that the soil would have a low infiltration rate.

5.6 From the infiltration test and particle size distribution testing, it is unlikely that the minimum infiltration rate of 1.0×10^{-6}m/s can be achieved and therefore infiltration drainage will not be practicable on the site.

6 Capture and Conveyance

6.1 In the rural sections of the route, surface water will be captured using dropped kerbs, laid flush with the carriageway surfacing, before passing across filter strips and then into swales or lined swales. SuDS components are the preferred means of providing at source pollution control in order to meet water quality treatment and pollution control requirements.

Surface water runoff will be conveyed within a network of swales before discharging to detention basins/ponds, which will then discharge to the local watercourses at flow rates restricted to Q_{BAR} or less, to help mitigate flooding.

6.2 In space constrained sections, such as west of Hardwick, immediately east and west of the M11 and near the Cambridge University Rugby Club, surface water will be captured using combined kerb and drainage systems (such as Beany Blocks).

Surface water runoff will be conveyed within the combined kerb and drainage systems before discharging to underground geocellular attenuation systems, which will then discharge through oil interceptors to the local watercourses at flow rates restricted to Q_{BAR} or less, to help mitigate flooding.

6.3 Road junctions and roundabouts will be drained via combined kerb and drainage systems or gullies, which will discharge through oil interceptors into the SuDS network or to an existing drainage network, where possible.

6.4 The proposed bridge over the M11 will be drained via combined kerb and drainage systems. These will discharge through oil interceptors to the proposed SuDS network, to the west of the M11, and to an existing water course on the West Cambridge site, to the west of the M11.

6.5 The swale network will be designed using “Flow+” drainage design software by Causeway. The following storm events will be considered, along with the associated surcharge and flooding requirements:

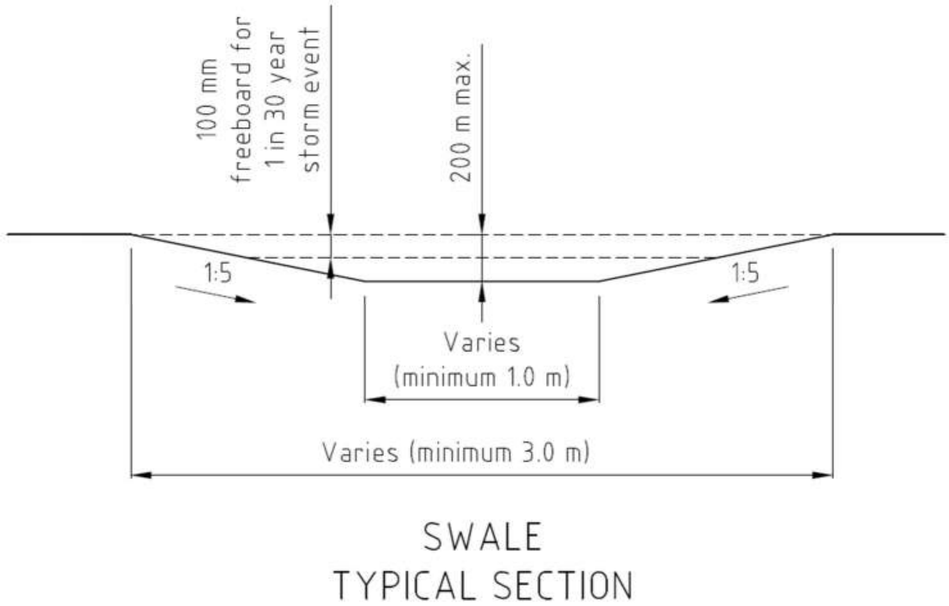
Storm event	Surcharge and flooding requirements	Guidance
1 in 1 year (100% AEP*)	No surcharge of the drainage system	
1 in 5 year (20% AEP)	No flooding of the drainage system	DMRB CG 501
1 in 30 year (3.3% AEP)	No flooding of the drainage system. For swales, this means 100 mm of freeboard should be achieved	
1 in 100 year (1% AEP) + 40% climate change	Some short-term flooding is managed such that it does not enter buildings or disrupt emergency access routes	

* Annual exceedance probability

6.6 For the 1 in 30 year (3.3% AEP) rainfall event there should be no flooding. Attenuation will be provided within swales, which will be designed to ensure a 100 mm freeboard is maintained. Check dams are to be installed to ensure attenuated storage volume is spread along the length of the swale. Where necessary, below ground attenuation will be utilised using granular material with high voids ratio or geocellular crates.

6.7 For the 1 in 100 year (1% AEP) rainfall event plus 40% climate change, some flooding is permitted, however, it should be managed such that it doesn’t enter buildings or disrupt emergency routes. Flooding is to be kept to a minimum with additional storage provided by both oversized detention basins/ponds.

6.8 Typically, swales will have a trapezoidal cross section with side slopes of 1 in 5, a maximum depth of 200 mm, a minimum width of 3.0 m, and a minimum base width of 1.0 m.



7 Catchments

7.1 Refer to plans in Appendix A

Table 1 – Catchment details		
Catchment details	**Attenuation system**	**Area (ha)**
CH 760 to 2420	Pond 01	3.207
CH 2420 to 3400	Basin 02	1.891
CH 3400 to 3750	Basin 02A	0.401
Park and ride (Scotland Road)	Basin 08	8.822
CH 5682 to 5965	Basin 09	0.975
CH 5965 to 6250	Basin 10	0.456
CH 6270 to 7062	Basin 11	1.531
CH 7062 to 9375	Basin 05	4.193
CH 9450 to 9600	Crates 12	0.172
CH 10150 to 10270	Crates 3	0.109

CH 10270 to 10350	Crates 4	0.069
CH 10400 to 10830	Pond 06	0.756
CH 10830 to 11400	Basin 07	0.719
CH 11400 to 11791	Crates 13	0.448

8 Existing Runoff Rates

8.1 Existing peak runoff rates (l/s/ha) have been calculated using the HR Wallingford Greenfield runoff rate estimation tool (IH124 method), for the following storm events:

- 1 in 1 year (100% AEP)
- 1 in 30 year (3.3% AEP)
- 1 in 100 year (1% AEP)

8.2 A summary of existing peak runoff rates is shown in **Table 1** below:

Table 1 – Existing greenfield runoff rates				
Attenuation system	**Catchment area (ha)**	**1 in 1 year (l/s/ha)**	**1 in 30 year (l/s/ha)**	**1 in 100 year (l/s/ha)**
Pond 01	3.207	1.82	5.14	7.47
Basin 02	1.891	1.83	5.15	7.48
Basin 02A	0.401	1.82	5.16	7.48
Basin 08	8.822	1.83	5.15	7.48
Basin 09	0.975	1.83	5.15	7.49
Basin 10	0.456	1.82	5.15	7.48
Basin 11	1.531	1.84	5.16	7.50
Basin 05	4.193	3.08	8.67	12.60
Crates 12	0.172	3.08	8.72	12.62
Crates 3	0.109	3.12	8.71	12.66
Crates 4	0.069	3.04	8.69	12.61
Pond 06	0.756	3.08	8.69	12.63
Basin 07	0.719	3.09	8.69	12.63
Crates 13	0.448	3.08	8.68	12.63

8.3 Copies of the greenfield runoff rate estimations can be found in Appendix C.

9 Proposed Runoff Rates

9.1 The runoff rates from the development will be restricted in line with the SuDS Non-Statutory Technical Standards.

9.2 Simple flow controls are proposed and, in accordance with Cambridgeshire County Council Surface Water Planning Guidance (June 2021), the peak runoff rate will be limited to Q_{BAR} (mean annual flow rate).

9.3 A summary of Q_{BAR} values and runoff rates to be adopted in the design is shown in **Table 2** below:

Table 2 – Q_{BAR} values and proposed runoff rates

Attenuation system	Catchment area (ha)	Q_{BAR} (l/s)	Proposed runoff rate (l/s)	Proposed runoff rate (l/s/ha)
Pond 01	3.207	6.73	5.0	1.6
Basin 02	1.891	3.98	3.9	2.1
Basin 02A	0.401	0.84	0.84	2.1
Basin 08	8.822	18.54	5.0	0.6
Basin 09	0.975	2.05	2.0	2.1
Basin 10	0.456	0.96	0.96	2.1
Basin 11	1.531	3.23	3.0	2.0
Basin 05	4.193	14.85	5.0	1.2
Crates 12	0.172	0.61	0.6	3.5
Crates 3	0.109	0.39	0.39	3.6
Crates 4	0.069	0.24	0.24	3.5
Pond 06	0.756	2.68	2.5	3.3
Basin 07	0.719	2.55	2.5	3.5
Crates 13	0.448	1.59	1.6	3.6

9.4 Runoff rates will need to be agreed with the Lead Local Flood Authority (LLFA) at the next design stage.

10 Existing Runoff Volumes

10.1 Existing peak runoff volumes (m^3/ha) have been calculated using FEH 13 rainfall data, for the following 6 hour rainfall events:

- 1 in 2 year (50% AEP)
- 1 in 30 year (3.3% AEP)
- 1 in 100 year (1% AEP)

10.2 A summary of existing runoff volumes is shown in **Table 3** below.

Table 3 – Existing runoff volumes

Attenuation system	Catchment area (ha)	1 in 2 year (m^3/ha)	1 in 30 year (m^3/ha)	1 in 100 year (m^3/ha)	1 in 100 year plus 40% (m^3/ha)
Pond 01	3.207	71	175	263	400
Basin 02	1.891	71	176	263	401
Basin 02A	0.401	72	177	264	401
Basin 08	8.822	71	176	263	400
Basin 09	0.975	72	175	262	397
Basin 10	0.456	72	175	261	397
Basin 11	1.531	71	176	261	397
Basin 05	4.193	88	216	316	473
Crates 12	0.172	87	215	314	471
Crates 3	0.109	88	216	316	473
Crates 4	0.069	88	216	316	473
Pond 06	0.756	89	216	315	474
Basin 07	0.719	89	216	316	473
Crates 13	0.448	89	217	315	473

11 Proposed Runoff Volumes

Table 4 – Proposed runoff volumes (prior to attenuation)

Attenuation system	Catchment area (ha)	1 in 100 year 6 hour rainfall depth (mm)	Runoff volume (m^3/ha)	1 in 100 year 6 hour rainfall depth plus 40% (mm)	Runoff volume (m^3/ha)
Pond 01	3.207	76.3	763	106.8	1068
Basin 02	1.891	76.3	763	106.8	1068
Basin 02A	0.401	76.3	763	106.8	1068
Basin 08	8.822	76.2	762	106.7	1067
Basin 09	0.975	75.8	758	106.1	1061

Basin 10	0.456	75.8	758	106.1	1061
Basin 11	1.531	75.8	758	106.1	1061
Basin 05	4.193	76.0	760	106.4	1064
Crates 12	0.172	75.9	762	106.3	1063
Crates 3	0.109	75.9	759	106.3	1063
Crates 4	0.069	75.9	759	106.3	1063
Pond 06	0.756	75.9	759	106.3	1063
Basin 07	0.719	75.9	759	106.3	1063
Crates 13	0.448	75.9	759	106.3	1063

11.1 The runoff volume from the development site to any surface water body or sewer in the 1 in 100 year (1% AEP), 6 hour rainfall event should not exceed the greenfield runoff volume for the same event.

11.2 Proposed runoff volumes have been calculated for each catchment to determine attenuation volumes, for the 1% AEP (1 in 100 year) plus climate change, 6 hour rainfall events. A summary of proposed runoff volumes is shown in **Table 4** below.

12 Required Volumes of Attenuation

12.1 Assessments of the volumes of attenuation storage have been carried out for each catchment. These are based on the 1 in 100 year (1% AEP) plus 40% climate change rainfall event and allowable discharge rates for the site.

12.2 A summary of required volumes of attenuation is shown in **Table 5** below.

Table 5 – Required volumes of attenuation

Attenuation system	Catchment area (ha)	Discharge rate (l/s)	1 in 100 year plus 40% (m^3)	1 in 100 year plus 40% (m^3/ha)
Pond 01	3.207	5.0	2358	735
Basin 02	1.891	3.9	1633	863
Basin 02A	0.401	0.84	377	940
Basin 08	8.822	5.0	9004	1020
Basin 09	0.975	2.0	829	850
Basin 10	0.456	0.96	410	899
Basin 11	1.531	3.0	1381	902
Basin 05	4.193	5.0	4072	971
Crates 12	0.172	0.6	175	1017
Crates 3	0.109	0.39	67	615
Crates 4	0.069	0.24	46	667
Pond 06	0.756	2.5	644	852
Basin 07	0.719	2.5	1008	1402
Crates 13	0.448	1.6	450	1004

12.3 A summary of volumes of attenuation provided is shown in **Table 6** below.

Table 6 – Volumes of attenuation provided

Attenuation system	Catchment area (ha)	Attenuation provided (m^3)
Pond 01	3.207	3643
Basin 02	1.891	1707
Basin 02A	0.401	422
Basin 08	8.822	9235
Basin 09	0.975	830
Basin 10	0.456	466
Basin 11	1.531	1388
Basin 05	4.193	4425
Crates 12	0.172	175
Crates 3	0.109	86
Crates 4	0.069	46
Pond 06	0.756	672
Basin 07	0.719	1008
Crates 13	0.448	450

12.4 The plans in Appendix B give details of the geometry of each basin and pond and also the locations of outfalls.

13 Exceedance Events

13.1 The design exceedance event is the 1 in 100 year (1% AEP) rainfall event plus 40% for climate change as per Cambridgeshire County Council Surface Water Drainage Guidance for Developers (June 2021) section 5.16.

13.2 It is proposed for the detention basins/ponds to be sized to meet the 1 in 100 year (1% AEP) rainfall event with a 300 mm freeboard. For the 1 in 100 year (1% AEP) rainfall event, plus 40% for climate change, runoff volumes will be contained within detention basins/ponds. Exceedance flows arising from the busway will be contained within the proposed busway corridor or will discharge to the swales.

14 Water Quality Treatment and Pollution Control

14.1 Surface water run-off arising from the carriageway requires treatment before discharging to watercourses. It is proposed to use SuDS components to provide close to source/primary treatment of run-off using the Simple Index Approach (SIA) described in the CIRIA SuDS Manual (C753). This method applies a hazard index to the surface being drained and a mitigation index to SuDS components such that:

Total SuDS mitigation index ≥ pollution hazard index

Where the mitigation index of an individual component is insufficient, two components (or more) in series will be required, where:

Total SuDS mitigation index = mitigation index$_1$ + 0.5 (mitigation index$_2$)

14.2 The busway is to be used exclusively by buses, with occasional use by service vehicles, and will not be designated as either a public low traffic road or a trunk road. Table 26.2 (Figure 1) shows that all roads, with the exception of low traffic roads and trunk roads, can be considered as having a medium pollution hazard index.

14.3 Figures 1 and 2 below are taken from the CIRIA SuDS Manual (C753).

Figure 1 – Pollution hazard indices for different land use classifications

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1]	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1]	High	0.8[2]	0.8[2]	0.9[2]

Notes

1 Motorways and trunk roads should follow the guidance and risk assessment process set out in Highways Agency (2009).

2 These should only be used if considered appropriate as part of a detailed risk assessment – required for all these land use types (Table 4.3). When dealing with high hazard sites, the environmental regulator should first be consulted for pre-permitting advice. This will help determine the most appropriate approach to the development of a design solution.

Figure 2 – Mitigation indices for individual SuDS components

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters

	Mitigation indices[1]		
Type of SuDS component	TSS	Metals	Hydrocarbons
Filter strip	0.4	0.4	0.5
Filter drain	0.4[2]	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond[4]	0.7[3]	0.7	0.5
Wetland	0.8[3]	0.8	0.8
Proprietary treatment systems[5,6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

14.4 It is proposed to install filter strips, swales, detention basins and ponds in series, which will provide 'sufficient' mitigation for all pollution hazard levels, when calculated in accordance with the CIRIA Simple Index Approach (SIA).

14.5 Generally, detention basins are dry, except during and immediately following the rainfall event. If vegetated, runoff will be treated as it is conveyed and filtered across the base of the basin.

14.6 Ponds are features with a permanent pool of water, which can be used to provide both attenuation and treatment of runoff, where outflows are controlled and water levels are allowed to increase following rainfall.

14.7 Where surface water runoff is discharged to an underground geocellular attenuation system, a bypass oil separator will be installed in the drainage network. A large catchpit will be installed immediately upstream of the oil separator in order to trap sediment.

15 Biodiversity Benefits

15.1 Landscaping is proposed on both sides of the carriageway where possible and will be incorporated within the verges, swales, and detention basins and ponds. These will provide green corridors adjacent to the route, reducing overall run-off and mitigating against the increase in impermeable area and the loss of trees in other areas along the route.

15.2 Planting is proposed to provide a diverse range of plants that are suited to the specific conditions of a SuDS swale (tolerant of varying water levels, slight pollution, etc). The planting mix within the swale will be determined at the next stage of design. Where above and below ground constraints allow and visibility splays are not impacted, trees will be incorporated along the top of the swale.

15.3 Where above and below ground constraints allow and visibility splays are not impacted, shrubs will be incorporated as part of the landscaping.

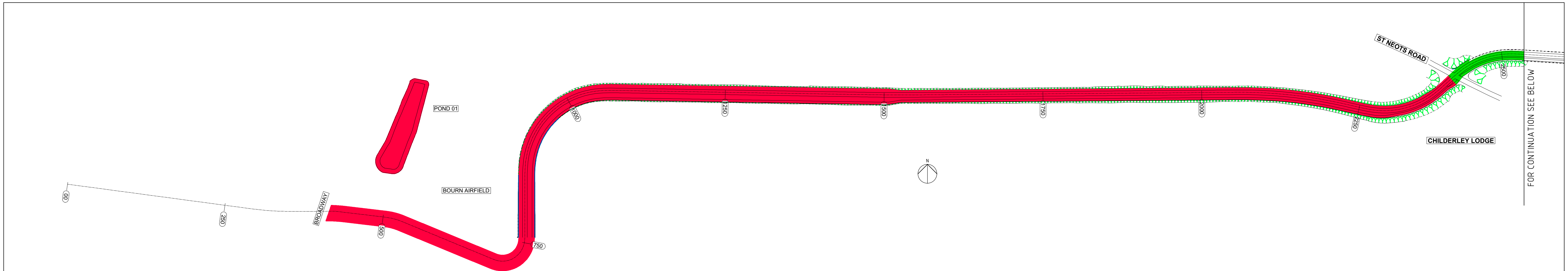
16 Amenity Benefits

16.1 The verges, swales, and detention basins will regularly be dry and are proposed to include planting that includes shrubs and trees where constraints allow. This will add to the wider green landscape and increase the number of trees and shrubs within the local area.

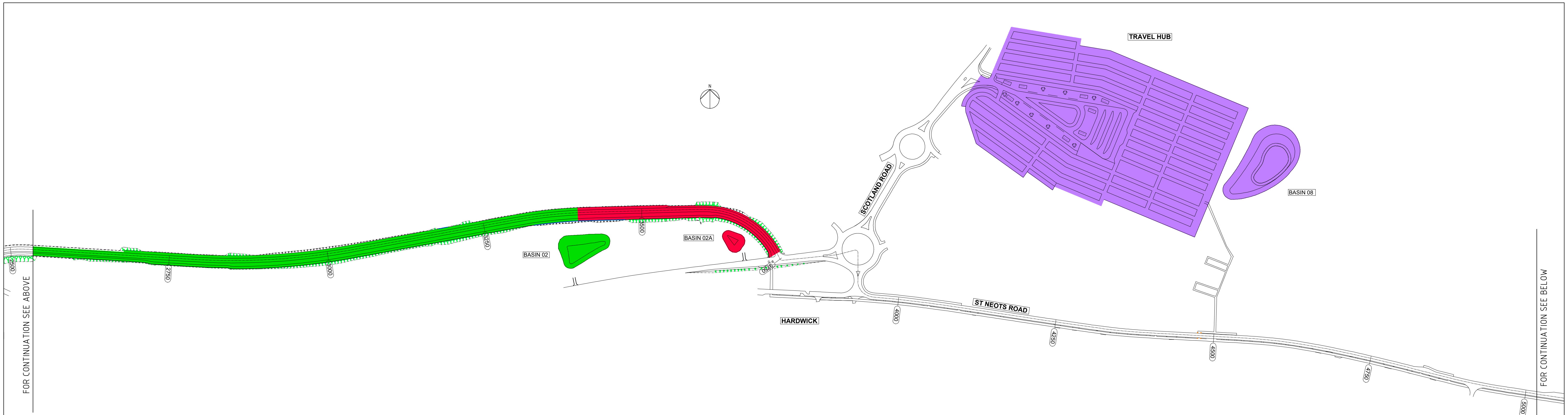
16.2 The ponds will support emergent and submerged vegetation along their shoreline and in shallow, marshy zones, which enhances treatment processes and biodiversity

16.3 The proposed planting and swale will complement the proposed shared pedestrian/cycleway that will run adjacent to the route, providing a pleasant environment encouraging active travel along the route for both leisure and commuting. The swale is proposed between the emergency access/maintenance track and busway, providing a buffer zone between bus and emergency/maintenance traffic and enhancing the experience of active travel users.

Appendix A: Plans showing catchments.

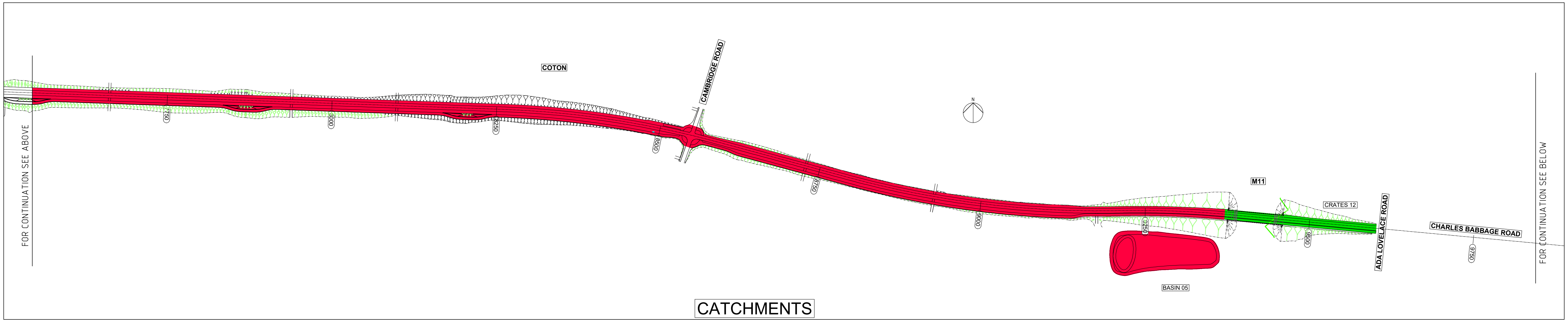


CATCHMENTS



CATCHMENTS

CATCHMENTS



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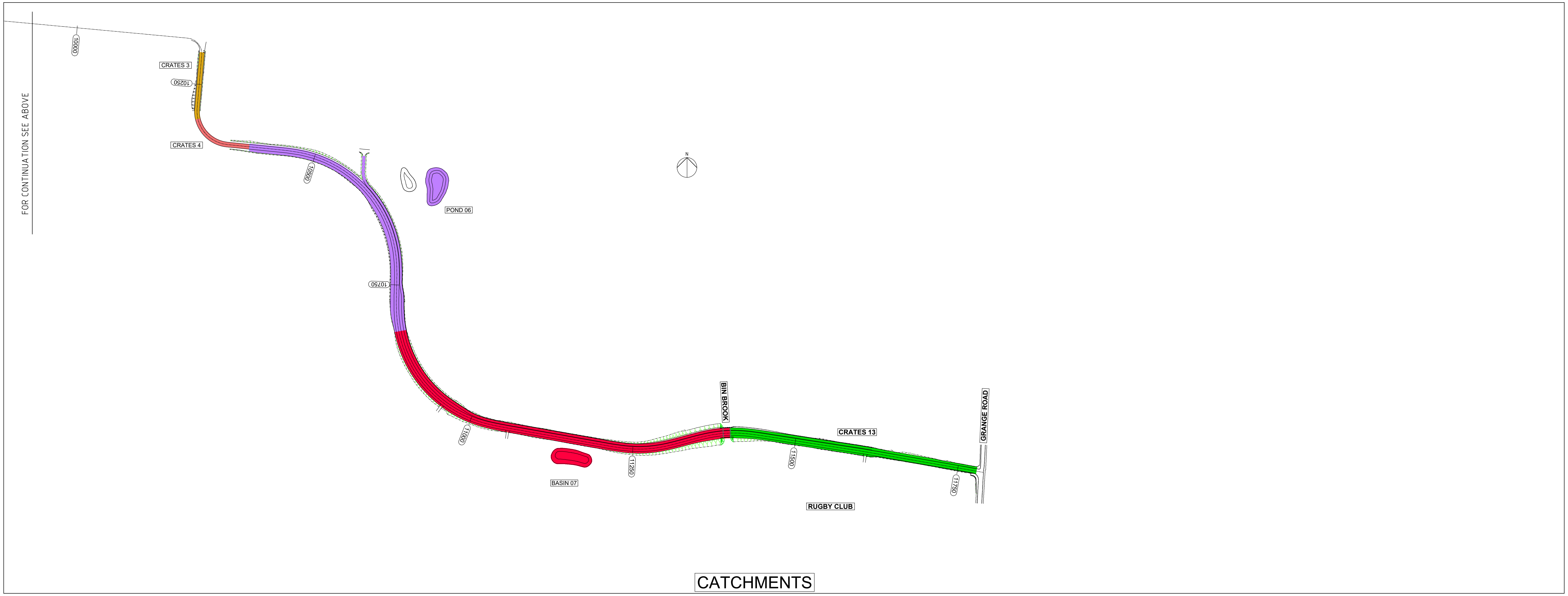


CATCHMENTS

Appendix B: Plans showing basins, ponds, crates and outfalls

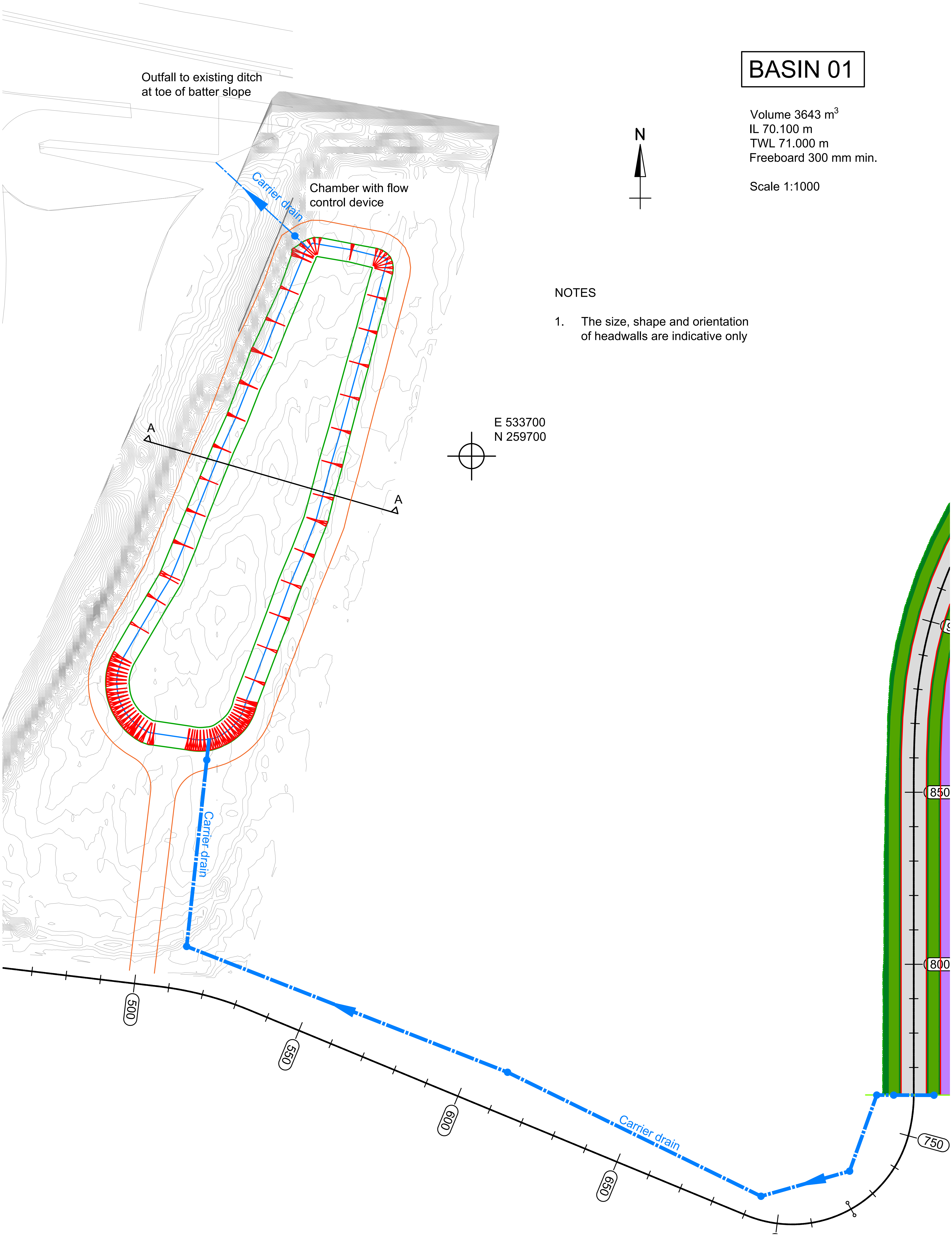
BASIN 01

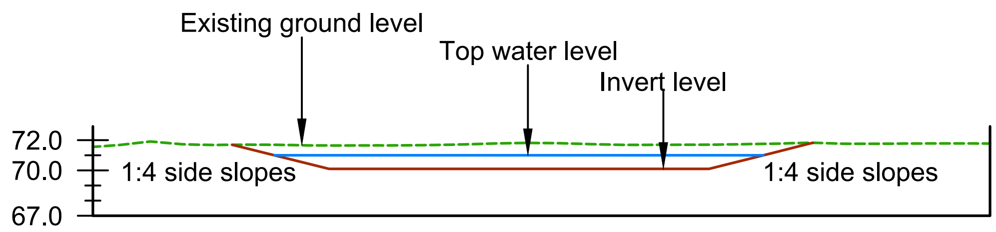
Volume 3643 m^3
IL 70.100 m
TWL 71.000 m
Freeboard 300 mm min.

Scale 1:1000

NOTES

1. The size, shape and orientation of headwalls are indicative only





SECTION A - A

Scale 1:500

NOTES

1. The size, shape and orientation of headwalls are indicative only

BASIN 02

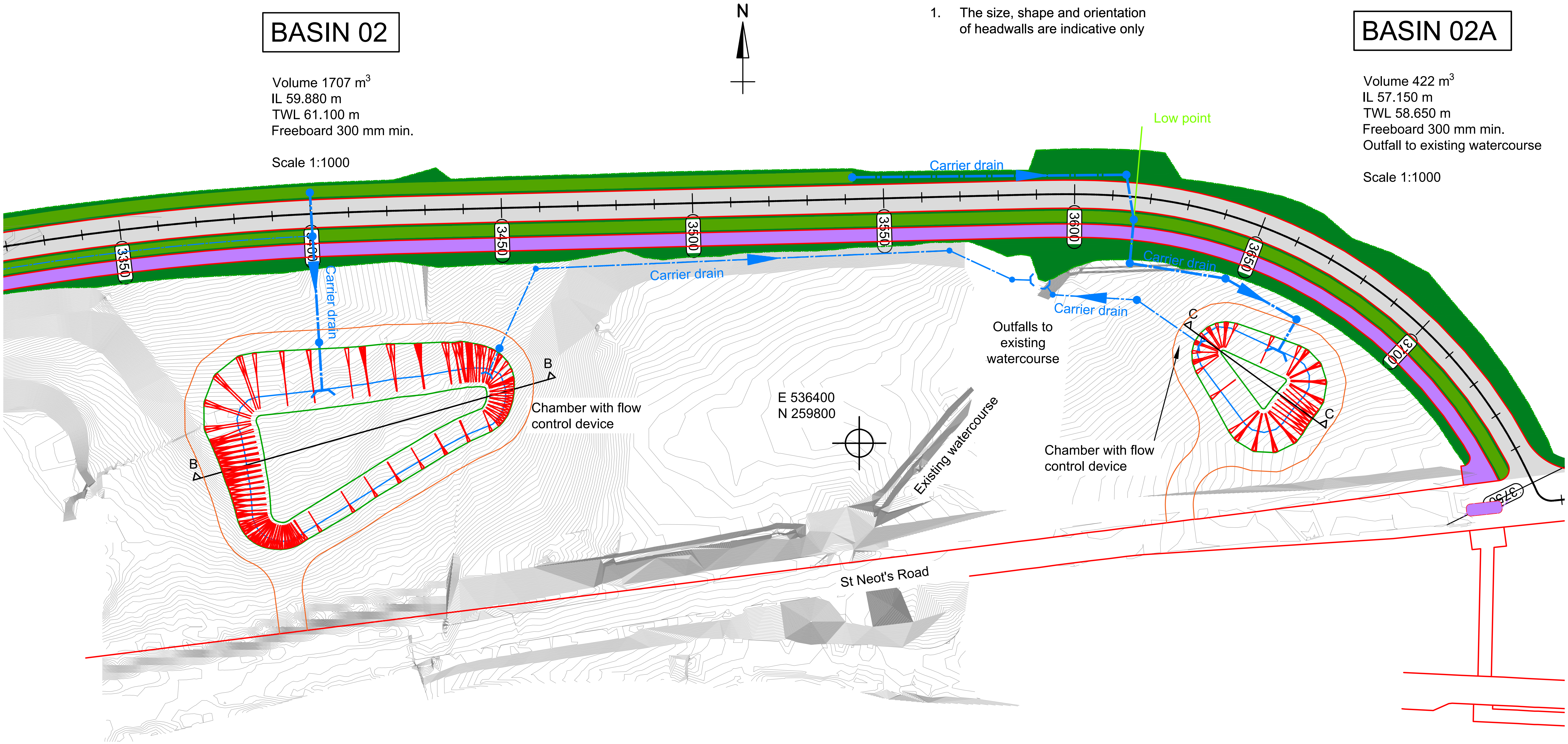
Volume 1707 m^3
IL 59.880 m
TWL 61.100 m
Freeboard 300 mm min.

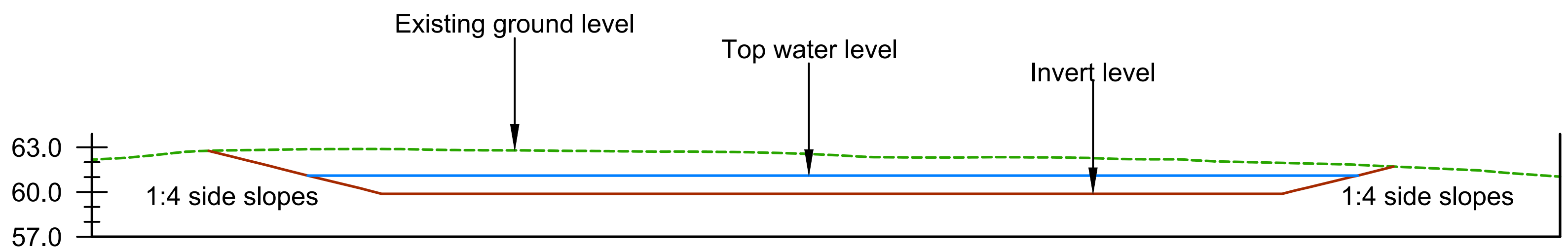
Scale 1:1000

BASIN 02A

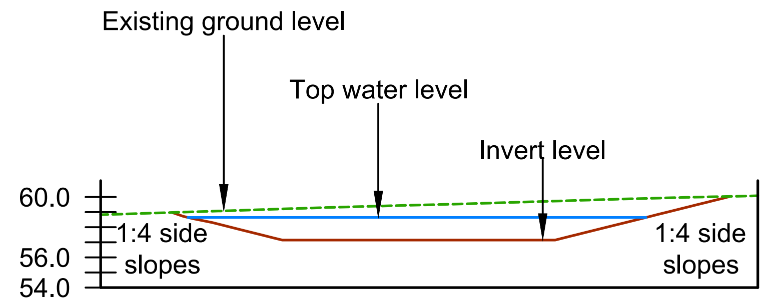
Volume 422 m^3
IL 57.150 m
TWL 58.650 m
Freeboard 300 mm min.
Outfall to existing watercourse

Scale 1:1000





SECTION B - B
Scale 1:500

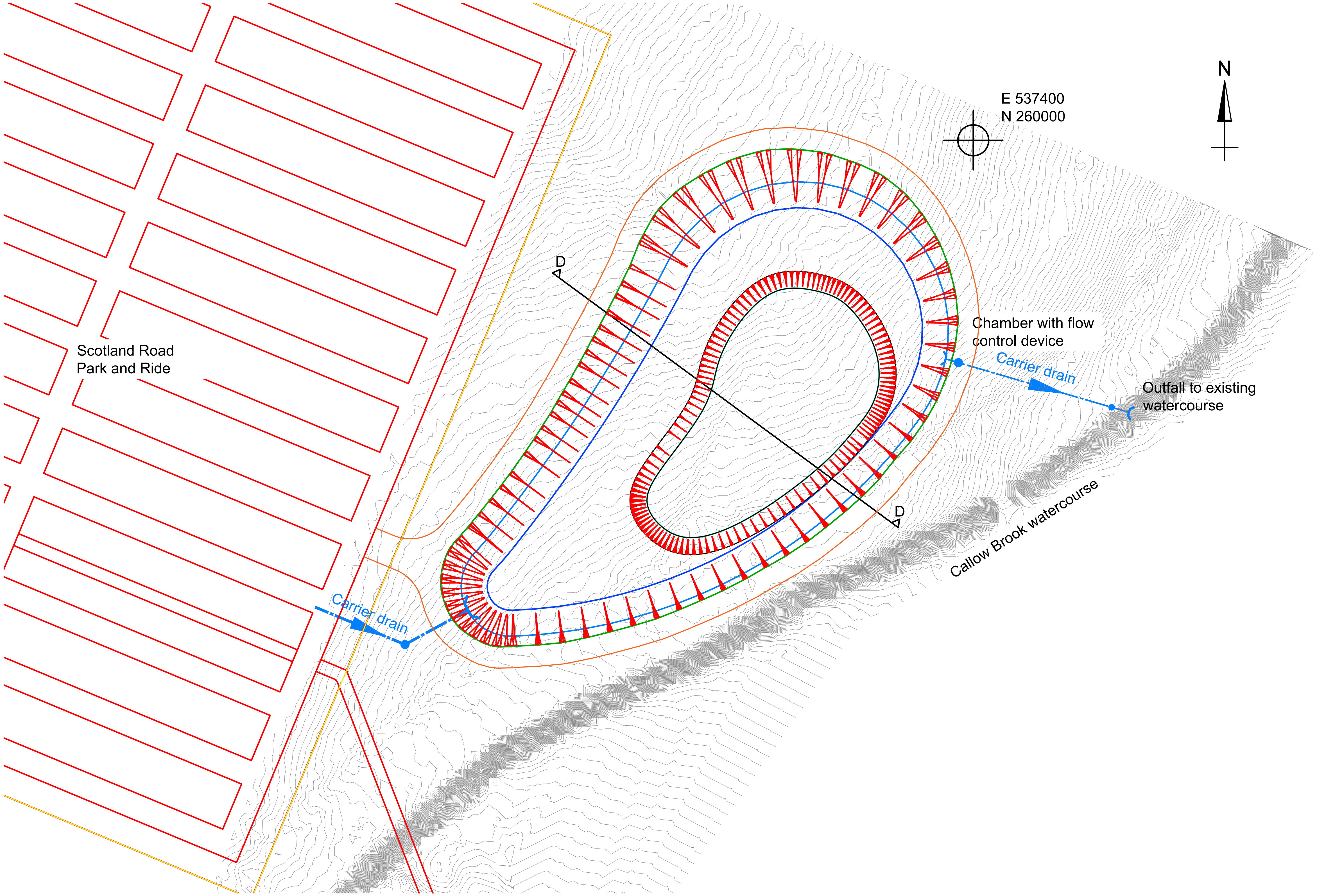


SECTION C - C
Scale 1:500

POND 08

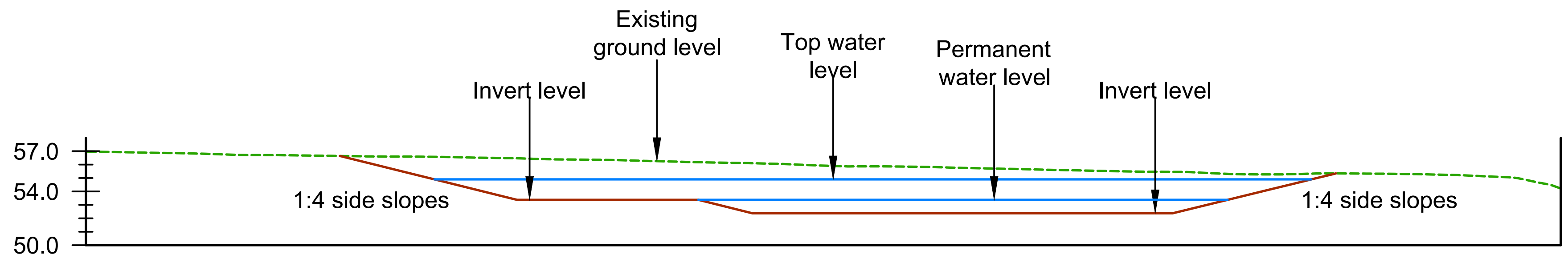
Volume 9235 m^3
IL 53.375 m
TWL 54.900 m
Freeboard 300 mm min.

Scale 1:1000



NOTES

1. The size, shape and orientation of headwalls are indicative only



SECTION D - D
Scale 1:500

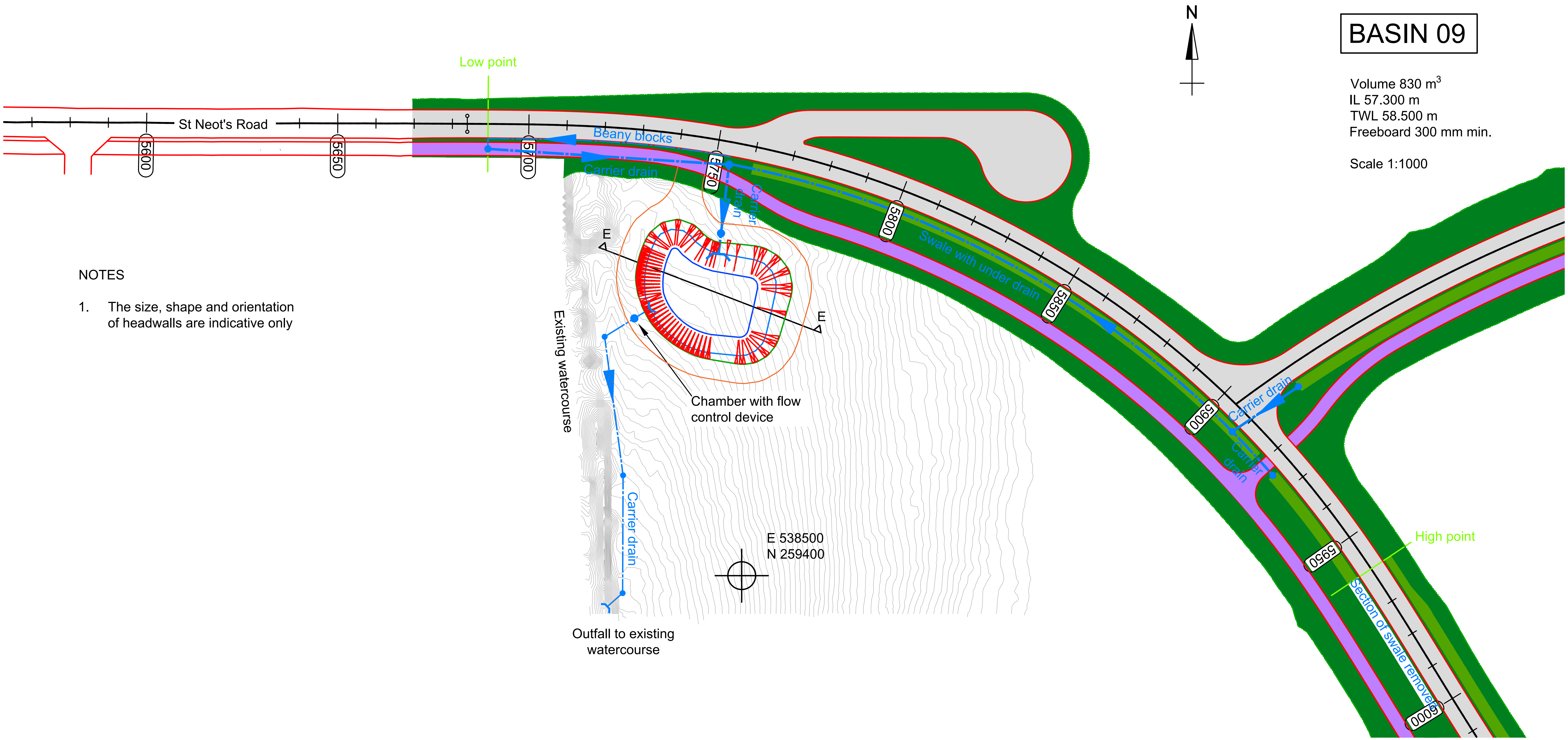
BASIN 09

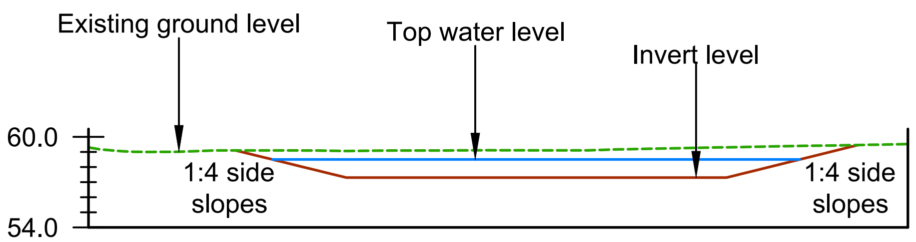
Volume 830 m^3
IL 57.300 m
TWL 58.500 m
Freeboard 300 mm min.

Scale 1:1000

NOTES

1. The size, shape and orientation of headwalls are indicative only





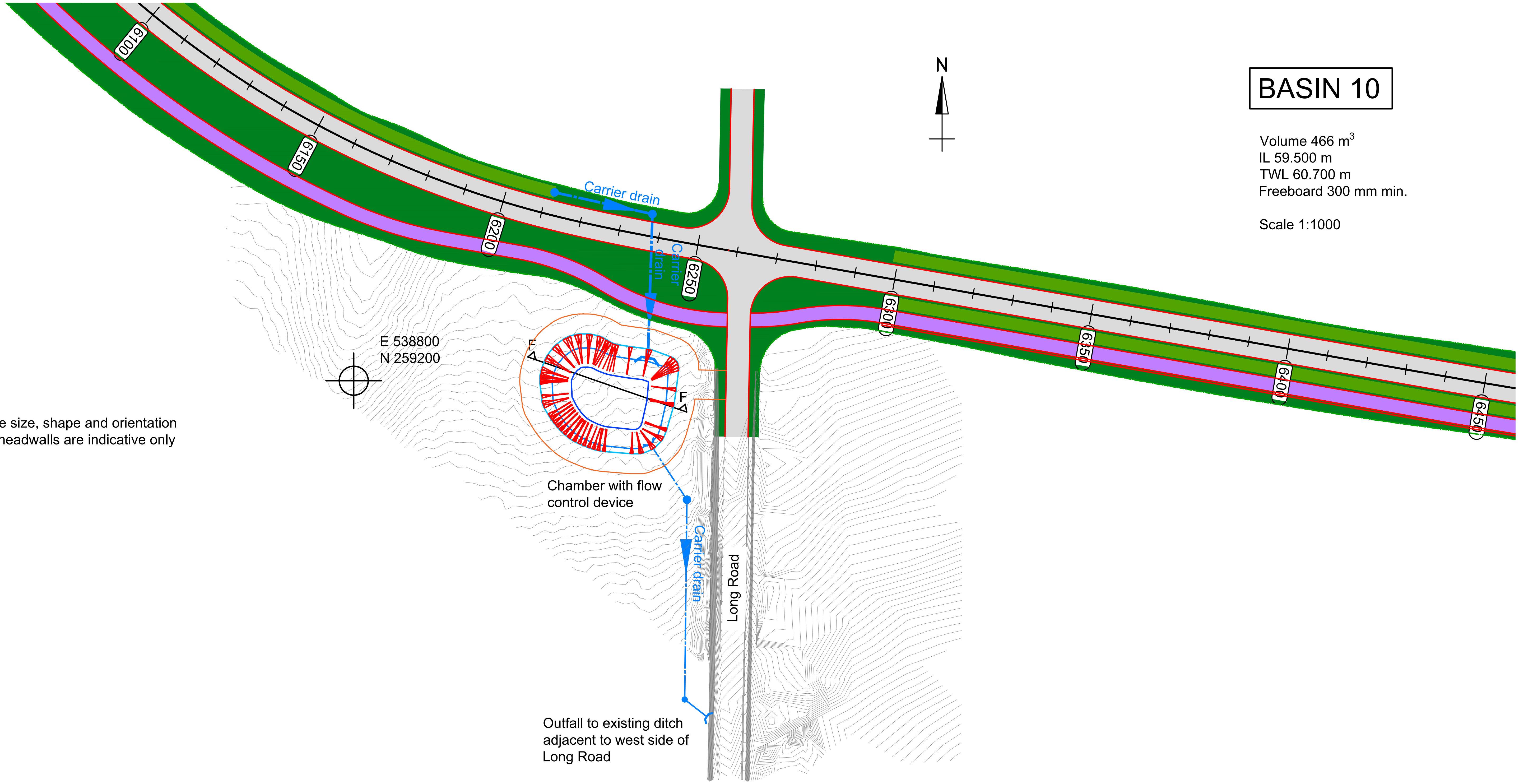
SECTION E - E

Scale 1:500

BASIN 10

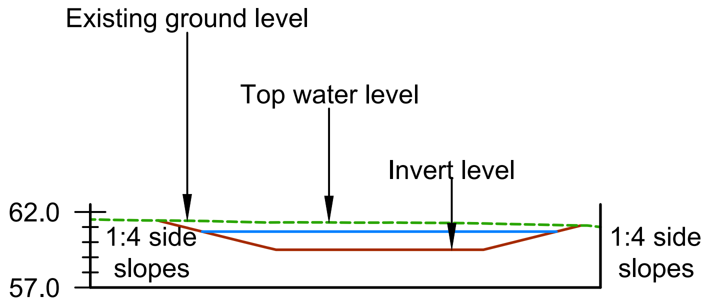
Volume 466 m^3
IL 59.500 m
TWL 60.700 m
Freeboard 300 mm min.

Scale 1:1000



NOTES

1. The size, shape and orientation of headwalls are indicative only



SECTION F - F
Scale 1:500

NOTES

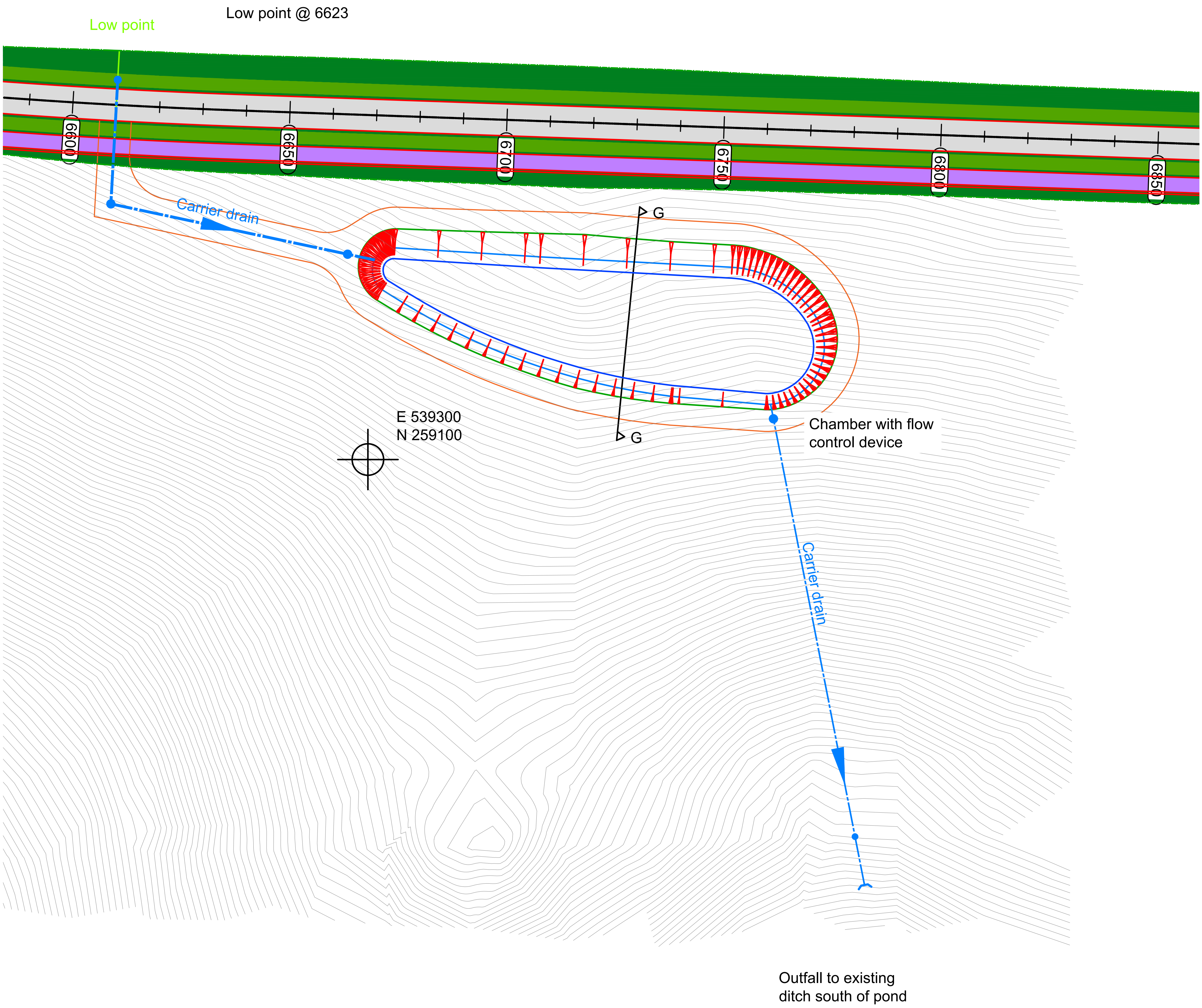
1. The size, shape and orientation of headwalls are indicative only

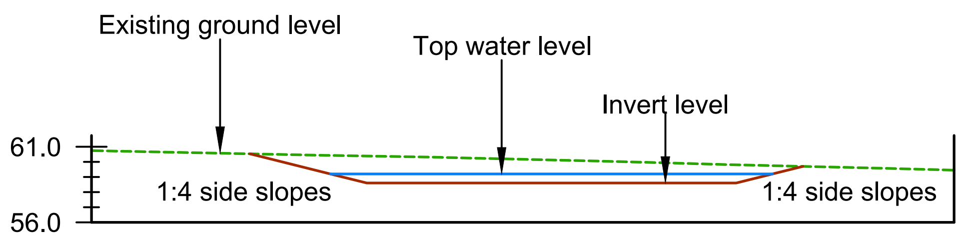
BASIN 11

Volume 1388 m^3
IL 58.575 m
TWL 59.200 m
Freeboard 300 mm min.

Scale 1:1000

N





SECTION G - G
Scale 1:500

NOTES

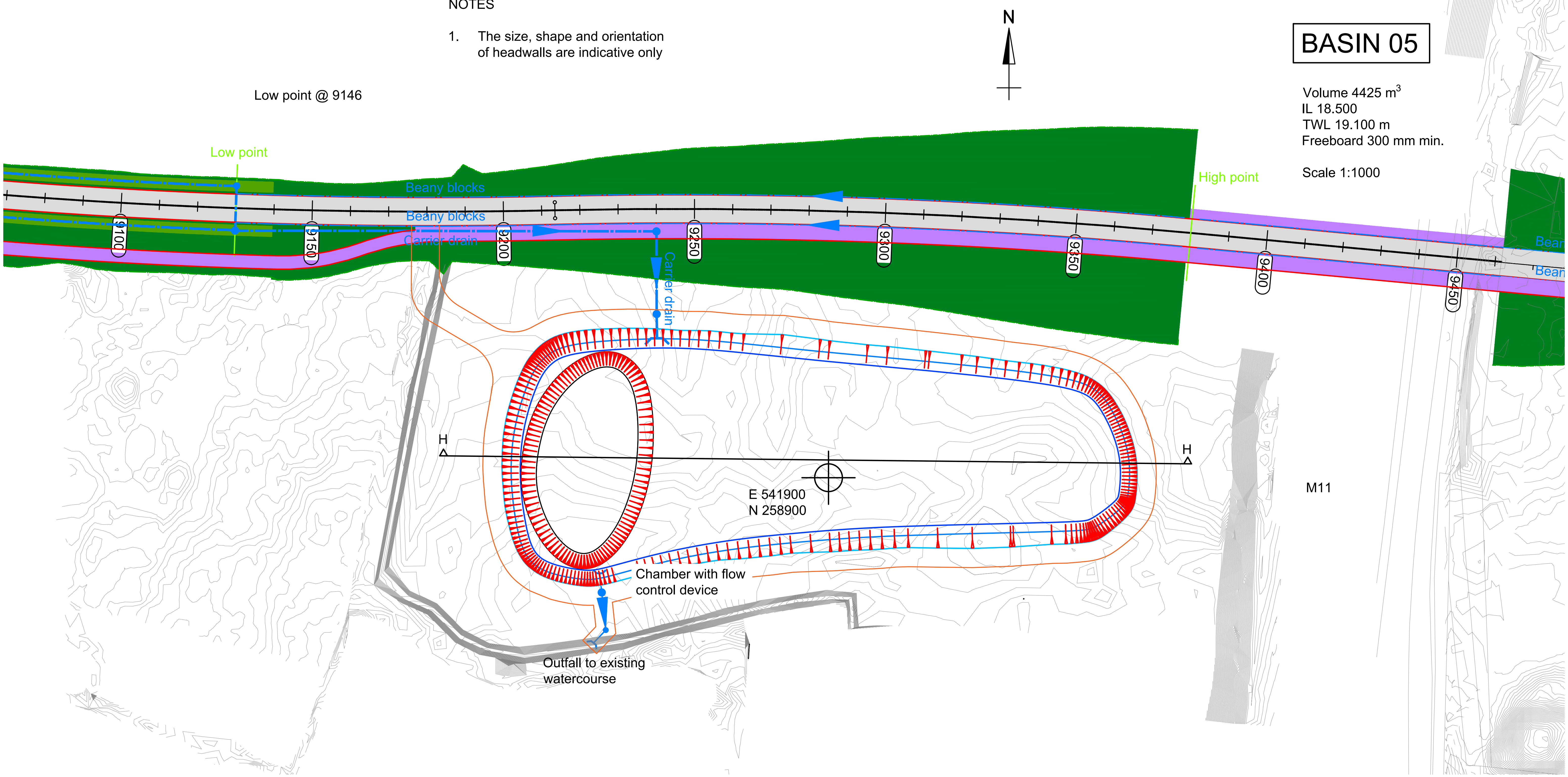
1. The size, shape and orientation of headwalls are indicative only

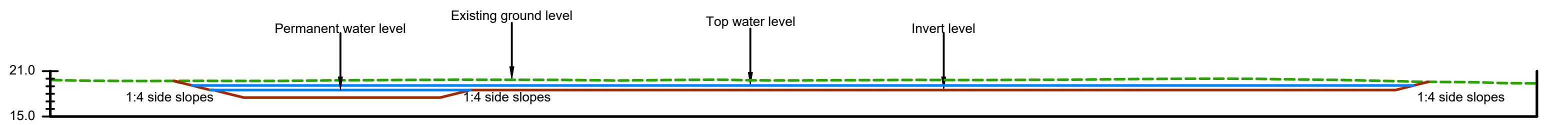
BASIN 05

Volume 4425 m^3
IL 18.500
TWL 19.100 m
Freeboard 300 mm min.

Scale 1:1000

Low point @ 9146



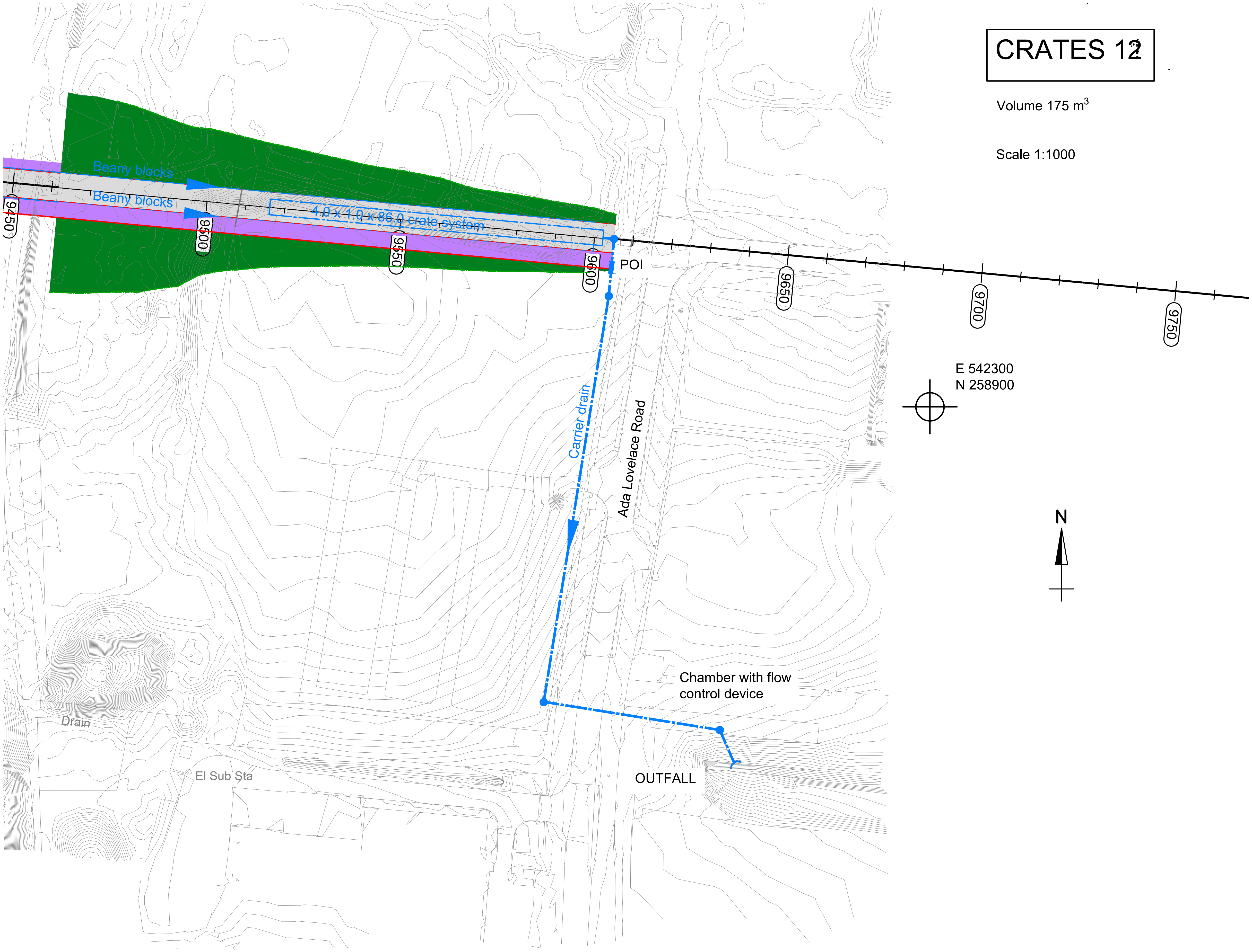


SECTION H - H
Scale 1:1000

CRATES 12

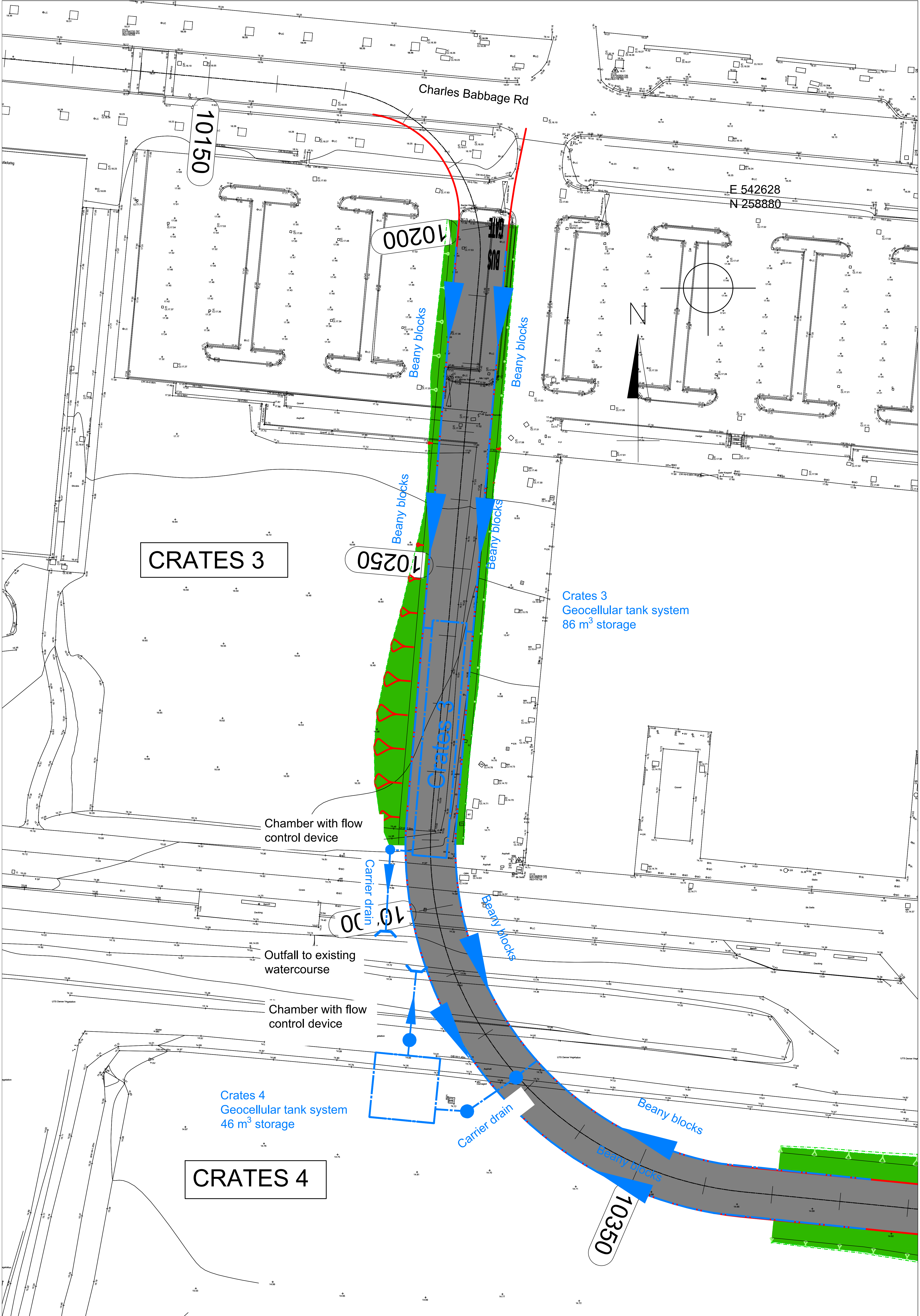
Volume 175 m^3

Scale 1:1000



E 542300
N 258900

N

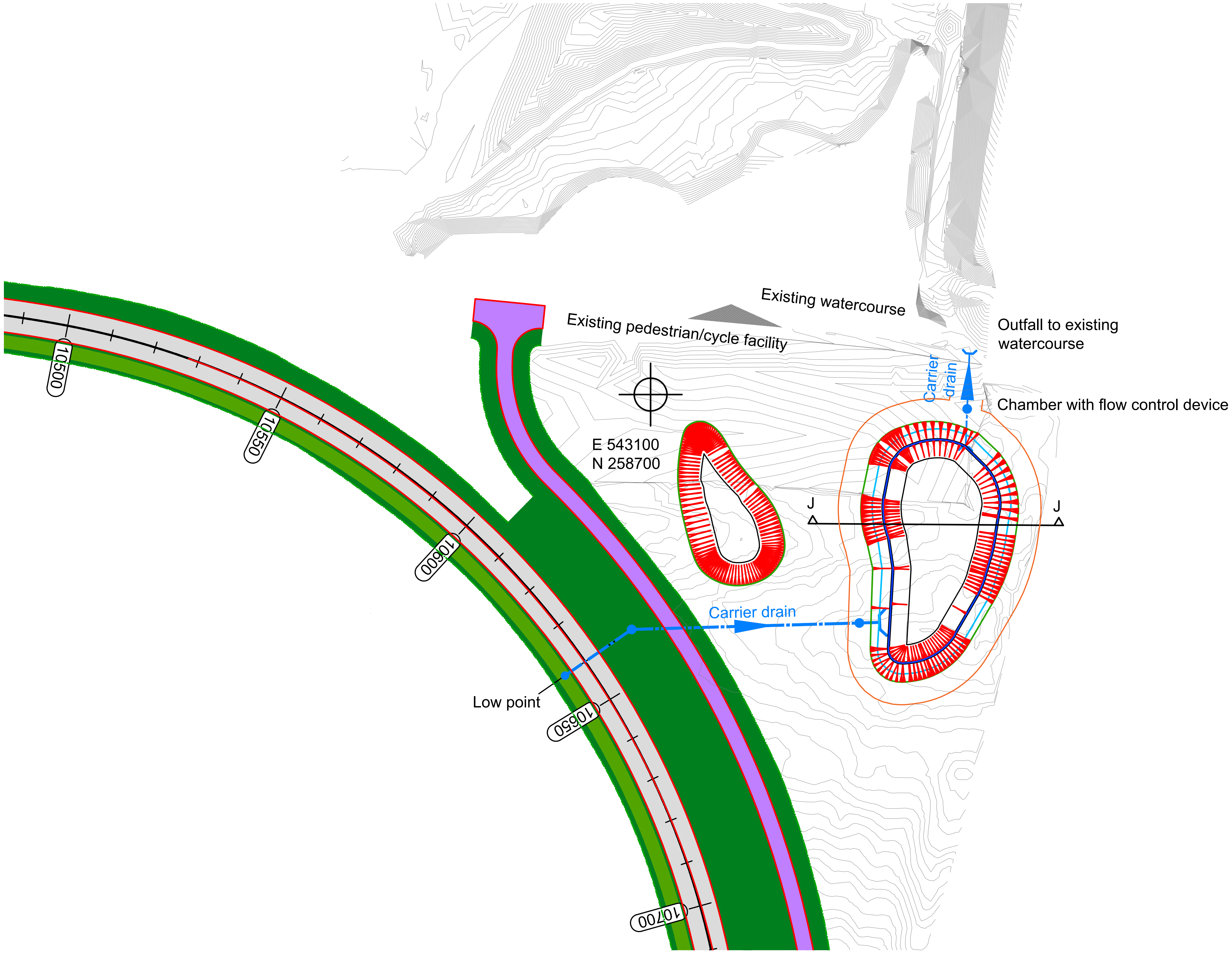


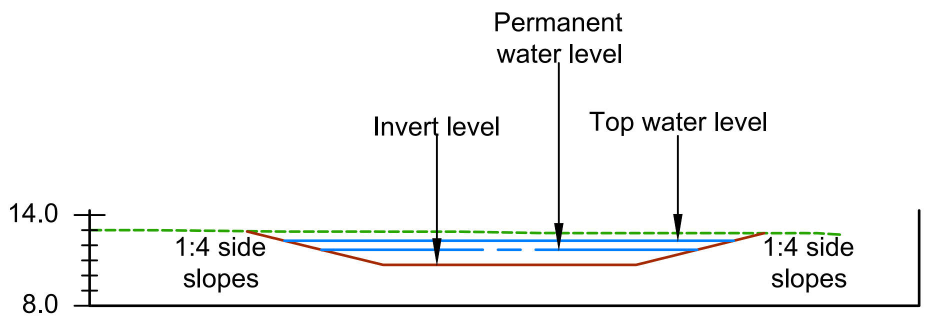
Charles Babbage Rd
10150
10200
E 542628
N 258880
N
Beany blocks
Beany blocks
Beany blocks
Beany blocks
CRATES 3
10250
Crates 3
Geocellular tank system
86 m^3 storage
Crates 3
Chamber with flow
control device
Carrier drain
Beany blocks
Outfall to existing
watercourse
Chamber with flow
control device
Crates 4
Geocellular tank system
46 m^3 storage
Carrier drain
Beany blocks
Beany blocks
CRATES 4
10350

POND 06

Volume 672 m^3
IL 11.700 m
TWL 12.300 m
Freeboard 300 mm min.

Scale 1:500





SECTION J - J
Scale 1:500

NOTES

1. The size, shape and orientation of headwalls are indicative only

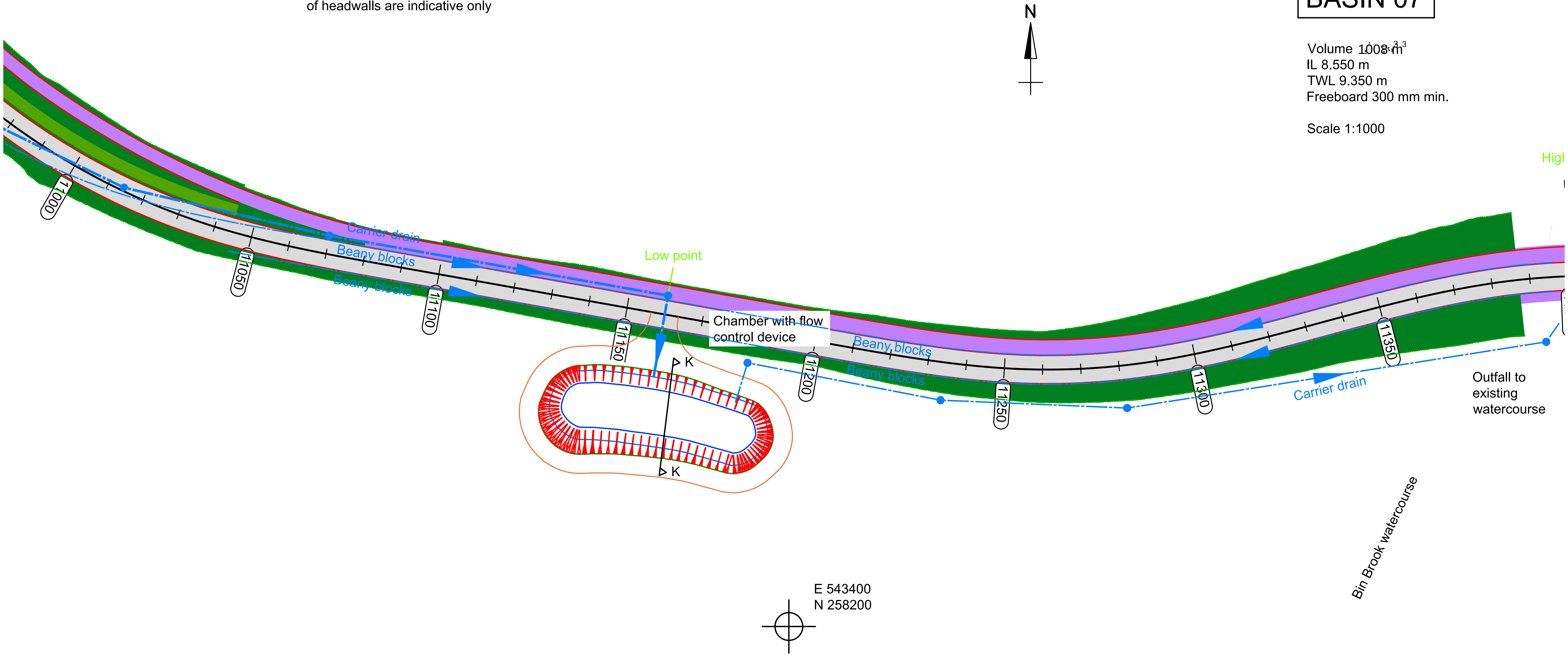
NOTES

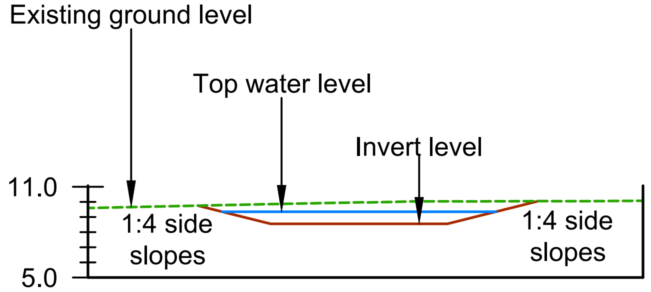
1. The size, shape and orientation of headwalls are indicative only

BASIN 07

Volume 1008 m^3
IL 8.550 m
TWL 9.350 m
Freeboard 300 mm min.

Scale 1:1000



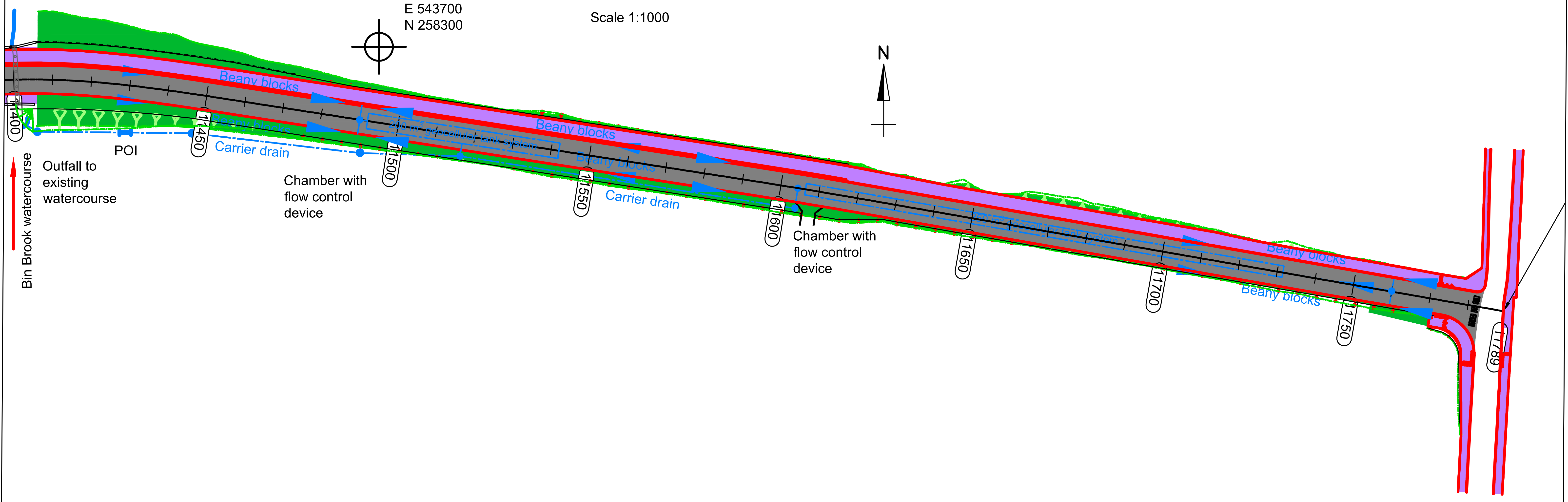


SECTION K - K
Scale 1:500

CRATES 13

Volume 450 m^3

Scale 1:1000



Appendix C: Greenfield runoff rate estimations

Print | Close Report

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 01
Site location:	Bourn airfield

Site Details

Latitude:	52.21917° N
Longitude:	0.0452° W
Reference:	445734366
Date:	Jul 27 2022 08:13

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 3.207

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics

	Default	Edited
SAAR (mm):	535	535
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	6.73	6.73
1 in 1 year (l/s):	5.85	5.85
1 in 30 years (l/s):	16.48	16.48
1 in 100 year (l/s):	23.95	23.95
1 in 200 years (l/s):	28.32	28.32

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement , which can both be found at www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 02
Site location:	West Hardwick

Site Details

Latitude:	52.21951° N
Longitude:	0.00641° W
Reference:	949505644
Date:	Jul 27 2022 08:25

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 1.891

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics	Default	Edited
SAAR (mm):	536	536
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	3.98	3.98
1 in 1 year (l/s):	3.46	3.46
1 in 30 years (l/s):	9.74	9.74
1 in 100 year (l/s):	14.15	14.15
1 in 200 years (l/s):	16.74	16.74

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 2A
Site location:	East of Hardwick

Site Details

Latitude:	52.21975° N
Longitude:	0.0027° W
Reference:	2573369797
Date:	Jul 27 2022 08:09

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 0.401

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics

	Default	Edited
SAAR (mm):	536	536
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	0.84	0.84
1 in 1 year (l/s):	0.73	0.73
1 in 30 years (l/s):	2.07	2.07
1 in 100 year (l/s):	3	3
1 in 200 years (l/s):	3.55	3.55

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 08
Site location:	Park and ride

Site Details

Latitude:	52.22160° N
Longitude:	0.00991° E
Reference:	184987488
Date:	Jul 27 2022 08:22

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 8.822

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics	Default	Edited
SAAR (mm):	536	536
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	18.54	18.54
1 in 1 year (l/s):	16.13	16.13
1 in 30 years (l/s):	45.44	45.44
1 in 100 year (l/s):	66.02	66.02
1 in 200 years (l/s):	78.07	78.07

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Working with water

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 09
Site location:	East of Hardwick

Site Details

Latitude:	52.21627° N
Longitude:	0.02563° E
Reference:	2891602678
Date:	Jul 27 2022 08:01

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 0.975

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics	Default	Edited
SAAR (mm):	536	536
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	2.05	2.05
1 in 1 year (l/s):	1.78	1.78
1 in 30 years (l/s):	5.02	5.02
1 in 100 year (l/s):	7.3	7.3
1 in 200 years (l/s):	8.63	8.63

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 10
Site location:	West of Long Road

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:	52.21379° N
Longitude:	0.03115° E
Reference:	3506664448
Date:	Jul 27 2022 08:05

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 0.456

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics

	Default	Edited
SAAR (mm):	536	536
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	0.96	0.96
1 in 1 year (l/s):	0.83	0.83
1 in 30 years (l/s):	2.35	2.35
1 in 100 year (l/s):	3.41	3.41
1 in 200 years (l/s):	4.04	4.04

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 11
Site location:	East of Long Road

Site Details

Latitude:	52.21361° N
Longitude:	0.03421° E
Reference:	1258341991
Date:	Jul 27 2022 08:06

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 1.531

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
HOST class:	N/A	N/A
SPR/SPRHOST:	0.37	0.37

Hydrological characteristics

	Default	Edited
SAAR (mm):	537	537
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	3.23	3.23
1 in 1 year (l/s):	2.81	2.81
1 in 30 years (l/s):	7.9	7.9
1 in 100 year (l/s):	11.48	11.48
1 in 200 years (l/s):	13.58	13.58

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 05
Site location:	West of M11

Site Details

Latitude:	52.20984° N
Longitude:	0.07398° E
Reference:	2833318641
Date:	Jul 27 2022 08:16

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 4.193

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm):	537	537
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	14.85	14.85
1 in 1 year (l/s):	12.92	12.92
1 in 30 years (l/s):	36.37	36.37
1 in 100 year (l/s):	52.85	52.85
1 in 200 years (l/s):	62.5	62.5

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Peter Swallow
Site name:	Crates 12
Site location:	Ada Lovelace Road

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:	52.21034° N
Longitude:	0.08010° E
Reference:	2894148419
Date:	Jan 25 2023 09:36

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 0.172

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics	Default	Edited
SAAR (mm):	538	538
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	0.61	0.61
1 in 1 year (l/s):	0.53	0.53
1 in 30 years (l/s):	1.5	1.5
1 in 100 year (l/s):	2.17	2.17
1 in 200 years (l/s):	2.57	2.57

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Joseph Darer
Site name:	Crates 3
Site location:	South of Charles Babbage Rd

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:	52.20945° N
Longitude:	0.08868° E
Reference:	2257764632
Date:	Jun 07 2023 16:09

Runoff estimation approach

IH124

Site characteristics

Total site area (ha):	0.109

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm):	538	538
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	0.39	0.39
1 in 1 year (l/s):	0.34	0.34
1 in 30 years (l/s):	0.95	0.95
1 in 100 year (l/s):	1.38	1.38
1 in 200 years (l/s):	1.63	1.63

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Joseph Darer
Site name:	Crates 4
Site location:	South of Charles Babbage Rd

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:	52.20944° N
Longitude:	0.08872° E
Reference:	3588171184
Date:	Jun 07 2023 16:31

Runoff estimation approach: IH124

Site characteristics

Total site area (ha):	0.069

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm):	538	538
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	0.24	0.24
1 in 1 year (l/s):	0.21	0.21
1 in 30 years (l/s):	0.6	0.6
1 in 100 year (l/s):	0.87	0.87
1 in 200 years (l/s):	1.03	1.03

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 06
Site location:	West of sports ground

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:	52.20761° N
Longitude:	0.09356° E
Reference:	4133522540
Date:	Jul 27 2022 08:19

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 0.756

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics	Default	Edited
SAAR (mm):	538	538
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	2.68	2.68
1 in 1 year (l/s):	2.33	2.33
1 in 30 years (l/s):	6.57	6.57
1 in 100 year (l/s):	9.55	9.55
1 in 200 years (l/s):	11.29	11.29

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Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	peter swallow
Site name:	Pond 07
Site location:	South of sports ground

Site Details

Latitude:	52.20405° N
Longitude:	0.09619° E
Reference:	4053865004
Date:	Jul 27 2022 08:20

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.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 0.719

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics	Default	Edited
SAAR (mm):	538	538
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	2.55	2.55
1 in 1 year (l/s):	2.22	2.22
1 in 30 years (l/s):	6.25	6.25
1 in 100 year (l/s):	9.08	9.08
1 in 200 years (l/s):	10.74	10.74

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HR Wallingford — Working with water

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Peter Swallow
Site name:	Crates 13
Site location:	C U Rugby Club

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:	52.20417° N
Longitude:	0.09998° E
Reference:	2501233079
Date:	Jan 25 2023 09:33

Runoff estimation approach: IH124

Site characteristics

Total site area (ha): 0.448

Methodology

Q_{BAR} estimation method: Calculate from SPR and SAAR

SPR estimation method: Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.47

Hydrological characteristics

	Default	Edited
SAAR (mm):	538	538
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

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):	1.59	1.59
1 in 1 year (l/s):	1.38	1.38
1 in 30 years (l/s):	3.89	3.89
1 in 100 year (l/s):	5.66	5.66
1 in 200 years (l/s):	6.69	6.69

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Appendix D: Surface water storage volume estimations

Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 01

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.21984° N
Longitude:	0.04588° W
Reference:	1715766873
Date:	Aug 18 2022 15:35

Site characteristics

Total site area (ha):	3.207
Significant public open space (ha):	0
Area positively drained (ha):	3.207
Impermeable area (ha):	3.207
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	3.21
Net impermable area for storage volume design (ha):	3.21
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
SPR:	0.37	0.37

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	86.24
FEH / FSR conversion factor:	1.12	1.12
SAAR (mm):	535	535
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	6.73	6.73
Q_{BAR} for net site area (l/s):	6.73	6.73

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	6.4	6.4
1 in 30 years (l/s):	6.7	6.7
1 in 100 year (l/s):	6.7	6.7

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	3385	3385
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	3385	3385

This report was produced using the storage estimation tool developed by HRWallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 02

Site Details

Latitude:	52.21967° N
Longitude:	0.00496° W
Reference:	576278446
Date:	Aug 18 2022 15:36

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	1.891
Significant public open space (ha):	0
Area positively drained (ha):	1.891
Impermeable area (ha):	1.891
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	1.89
Net impermable area for storage volume design (ha):	1.89
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
SPR:	0.37	0.37

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	87.78
FEH / FSR conversion factor:	1.14	1.14
SAAR (mm):	536	536
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	3.98	3.98
Q_{BAR} for net site area (l/s):	3.98	3.98

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	3.8	3.8
1 in 30 years (l/s):	4	4
1 in 100 year (l/s):	4	4

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	2038	2038
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	2038	2038

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 03A

Site Details

Latitude:	52.21965° N
Longitude:	0.00245° W
Reference:	3815930482
Date:	Aug 18 2022 15:37

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	0.401
Significant public open space (ha):	0
Area positively drained (ha):	0.401
Impermeable area (ha):	0.401
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.4
Net impermable area for storage volume design (ha):	0.4
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
SPR:	0.37	0.37

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	88.55
FEH / FSR conversion factor:	1.15	1.15
SAAR (mm):	536	536
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	0.84	0.84
Q_{BAR} for net site area (l/s):	0.84	0.84

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	2	2
1 in 100 year (l/s):	2	2

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	352	352
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	352	352

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 08

Site Details

Latitude:	52.22025° N
Longitude:	0.00833° E
Reference:	1866179073
Date:	Aug 18 2022 15:32

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	8.822
Significant public open space (ha):	0
Area positively drained (ha):	8.822
Impermeable area (ha):	8.822
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	8.82
Net impermable area for storage volume design (ha):	8.82
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
SPR:	0.37	0.37

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	88.55
FEH / FSR conversion factor:	1.15	1.15
SAAR (mm):	536	536
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	18.54	18.54
Q_{BAR} for net site area (l/s):	18.54	18.54

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	17.6	17.6
1 in 30 years (l/s):	18.5	18.5
1 in 100 year (l/s):	18.5	18.5

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	9607	9607
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	9607	9607

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 09

Site Details

Latitude:	52.21655° N
Longitude:	0.01464° E
Reference:	1516947594
Date:	Aug 18 2022 15:23

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	0.975
Significant public open space (ha):	0
Area positively drained (ha):	0.975
Impermeable area (ha):	0.975
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.98
Net impermable area for storage volume design (ha):	0.98
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
SPR:	0.37	0.37

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	86.24
FEH / FSR conversion factor:	1.16	1.12
SAAR (mm):	536	536
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	2.05	2.05
Q_{BAR} for net site area (l/s):	2.05	2.05

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	2	2
1 in 100 year (l/s):	2	2

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	1073	1029
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	1073	1029

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 10

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.21356° N
Longitude:	0.03195° E
Reference:	3691935815
Date:	Aug 18 2022 15:38

Site characteristics

Total site area (ha):	0.456
Significant public open space (ha):	0
Area positively drained (ha):	0.456
Impermeable area (ha):	0.456
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.46
Net impermable area for storage volume design (ha):	0.46
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	3	3
SPR:	0.37	0.37

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	90.86
FEH / FSR conversion factor:	1.18	1.18
SAAR (mm):	536	536
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	0.96	0.96
Q_{BAR} for net site area (l/s):	0.96	0.96

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	2	2
1 in 100 year (l/s):	2	2

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	428	428
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	428	428

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

HR Wallingford
Working with water

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 11

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.21280° N
Longitude:	0.03870° E
Reference:	3191388727
Date:	Aug 18 2022 15:39

Site characteristics

Total site area (ha):	1.531
Significant public open space (ha):	0
Area positively drained (ha):	1.531
Impermeable area (ha):	1.531
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	1.53
Net impermable area for storage volume design (ha):	1.53
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	90.86
FEH / FSR conversion factor:	1.18	1.18
SAAR (mm):	537	537
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	5.42	5.42
Q_{BAR} for net site area (l/s):	5.42	5.42

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	4.7	4.7
1 in 30 years (l/s):	5.4	5.4
1 in 100 year (l/s):	5.4	5.4

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	1517	1517
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	1517	1517

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 05

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.20996° N
Longitude:	0.07436° E
Reference:	3255084268
Date:	Aug 18 2022 15:29

Site characteristics

Total site area (ha):	4.193
Significant public open space (ha):	0
Area positively drained (ha):	4.193
Impermeable area (ha):	4.193
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	4.19
Net impermable area for storage volume design (ha):	4.19
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	91.63
FEH / FSR conversion factor:	1.19	1.19
SAAR (mm):	537	537
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	14.85	14.85
Q_{BAR} for net site area (l/s):	14.85	14.85

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	12.9	12.9
1 in 30 years (l/s):	14.8	14.8
1 in 100 year (l/s):	14.8	14.8

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	4197	4197
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	4197	4197

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Calculated by:	Joseph Darer
Site name:	C2C
Site location:	Crates 12

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.21033° N
Longitude:	0.08009° E
Reference:	3906112434
Date:	Jun 09 2023 16:34

Site characteristics

Total site area (ha):	0.172
Significant public open space (ha):	0
Area positively drained (ha):	0.172
Impermeable area (ha):	0.172
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.17
Net impermable area for storage volume design (ha):	0.17
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	91.63
FEH / FSR conversion factor:	1.19	1.19
SAAR (mm):	538	538
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	0.61	0.61
Q_{BAR} for net site area (l/s):	0.61	0.61

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	2	2
1 in 100 year (l/s):	2.2	2.2

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	114	114
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	114	114

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Joseph Darer
Site name:	C2C
Site location:	Crates 3

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design
of drainage systems. It is recommended that hydraulic modelling software is used to calculate
volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.20944° N
Longitude:	0.08871° E
Reference:	108993937
Date:	Jun 07 2023 15:32

Site characteristics

Total site area (ha):	.109
Significant public open space (ha):	0
Area positively drained (ha):	0.109
Impermeable area (ha):	.109
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.11
Net impermable area for storage volume design (ha):	0.11
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	92.4
FEH / FSR conversion factor:	1.2	1.2
SAAR (mm):	538	538
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	0.39	0.39
Q_{BAR} for net site area (l/s):	0.39	0.39

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	2	2
1 in 100 year (l/s):	2	2

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	64	64
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	64	64

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	Joseph Darer
Site name:	C2C
Site location:	Crates 3

Site Details

Latitude:	52.20942° N
Longitude:	0.08871° E
Reference:	4211272950
Date:	Jun 07 2023 16:33

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site characteristics

Total site area (ha):	0.069
Significant public open space (ha):	0
Area positively drained (ha):	0.069
Impermeable area (ha):	0.069
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.07
Net impermable area for storage volume design (ha):	0.07
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	92.4
FEH / FSR conversion factor:	1.2	1.2
SAAR (mm):	538	538
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	0.24	0.24
Q_{BAR} for net site area (l/s):	0.24	0.24

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	2	2
1 in 100 year (l/s):	2	2

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	32	32
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	32	32

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Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 06

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.20771° N
Longitude:	0.09336° E
Reference:	2088558061
Date:	Aug 18 2022 15:30

Site characteristics

Total site area (ha):	0.756
Significant public open space (ha):	0
Area positively drained (ha):	0.756
Impermeable area (ha):	0.756
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.76
Net impermable area for storage volume design (ha):	0.76
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	92.4
FEH / FSR conversion factor:	1.2	1.2
SAAR (mm):	538	538
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	2.68	2.68
Q_{BAR} for net site area (l/s):	2.68	2.68

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2.3	2.3
1 in 30 years (l/s):	2.7	2.7
1 in 100 year (l/s):	2.7	2.7

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	764	764
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	764	764

This report was produced using the storage estimation tool developed by HRWallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

Surface water storage requirements for sites

www.uksuds.com | Storage estimation tool

Calculated by:	peter swallow
Site name:	C2C
Site location:	Pond 07

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.20401° N
Longitude:	0.09650° E
Reference:	2275687588
Date:	Aug 18 2022 15:31

Site characteristics

Total site area (ha):	0.719
Significant public open space (ha):	0
Area positively drained (ha):	0.719
Impermeable area (ha):	0.719
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.72
Net impermable area for storage volume design (ha):	0.72
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Flow control to max of 2 l/s/ha or Qbar
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	91.63
FEH / FSR conversion factor:	1.19	1.19
SAAR (mm):	538	538
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	2.55	2.55
Q_{BAR} for net site area (l/s):	2.55	2.55

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2.2	2.2
1 in 30 years (l/s):	2.6	2.6
1 in 100 year (l/s):	2.6	2.6

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	719	719
Long term storage 1/100 years (m^3):	0	0
Total storage 1/100 years (m^3):	719	719

This report was produced using the storage estimation tool developed by HRWallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

Calculated by:	Joseph Darer
Site name:	C2C
Site location:	Crates 13

This is an estimation of the storage volume requirements that are needed 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). It is not to be used for detailed design of drainage systems. It is recommended that hydraulic modelling software is used to calculate volume requirements and design details before finalising the design of the drainage scheme.

Site Details

Latitude:	52.20414° N
Longitude:	0.09988° E
Reference:	3693845438
Date:	Jun 09 2023 16:38

Site characteristics

Total site area (ha):	0.448
Significant public open space (ha):	0
Area positively drained (ha):	0.448
Impermeable area (ha):	0.448
Percentage of drained area that is impermeable (%):	100
Impervious area drained via infiltration (ha):	0
Return period for infiltration system design (year):	10
Impervious area drained to rainwater harvesting (ha):	0
Return period for rainwater harvesting system (year):	10
Compliance factor for rainwater harvesting system (%):	66
Net site area for storage volume design (ha):	0.45
Net impermable area for storage volume design (ha):	0.45
Pervious area contribution to runoff (%):	30

* where rainwater harvesting or infiltration has been used for managing surface water runoff such that the effective impermeable area is less than 50% of the 'area positively drained', the 'net site area' and the estimates of Q_{BAR} and other flow rates will have been reduced accordingly.

Design criteria

Climate change allowance factor:	1.4
Urban creep allowance factor:	1.1
Volume control approach	Use long term storage
Interception rainfall depth (mm):	5
Minimum flow rate (l/s):	2

Methodology

esti	IH124
Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Soil characteristics

	Default	Edited
SOIL type:	4	4
SPR:	0.47	0.47

Hydrological characteristics

	Default	Edited
Rainfall 100 yrs 6 hrs:	--	63
Rainfall 100 yrs 12 hrs:	--	91.63
FEH / FSR conversion factor:	1.19	1.19
SAAR (mm):	538	538
M5-60 Rainfall Depth (mm):	20	20
'r' Ratio M5-60/M5-2 day:	0.4	0.4
Hydological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 10 year:	1.65	1.65
Growth curve factor 30 year:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Q_{BAR} for total site area (l/s):	1.59	1.59
Q_{BAR} for net site area (l/s):	1.59	1.59

Site discharge rates

	Default	Edited
1 in 1 year (l/s):	2	2
1 in 30 years (l/s):	3.9	3.9
1 in 100 year (l/s):	5.7	5.7

Estimated storage volumes

	Default	Edited
Attenuation storage 1/100 years (m^3):	319	319
Long term storage 1/100 years (m^3):	47	47
Total storage 1/100 years (m^3):	365	365

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Appendix E: Technical Note 25/5/2023 by Stantec

TECHNICAL NOTE

Job Name: West Cambridge

Job No: 332610161

Note No: DR/001

Date: 25/05/23

Prepared By: Rowan Taylor

Subject: **West Cambridge SW Drainage – GCP Busway Impact**

Introduction

This technical note analyses the drainage impact from the change of impermeable area derived from the extension of the busway to link up the designated segregated bus route which is travelling from Cambourne to the centre of Cambridge.

The total length of extended carriageway which is within the site boundary of the development is roughly 160m of proposed carriageway which is forming a bridge over the M11 with embankment either side. As well as roughly 115m of carriageway which is running adjacent to an existing service road. 590m of the bus route is expected to use the existing carriageway within the development and will have no impact to the existing drainage along this section.

The note has been prepared with reference to the following key documents;

- West Cambridge FRA [31500 - Flood Risk Assessment 20170630 REV B]
- P22069-SMCE-ZZ-XX-RP-D-0001 (Feb 2023)
- WEST CAMBS 2023 0418

Original Site Catchments and Drainage Strategy

In the previous FRA the impermeable areas were based on an assumption of land use as follows:

- 85% Impermeable for development Plots
- 35-50% impermeable for Public Open Space
- Discharge rate from attenuation features calculated based on a greenfield runoff rate of 2.592l/s/ha, which equates to the 1 in 1 year storm event with a further 10% reduction included.

Proposed Works

The proposed works cover 4 separate areas;

- Catchment 1 – M11 Overbridge landing (see Fig1)
- Catchment 2 – Charles Babbage Road
- Catchment 3 – Side Road (see Fig 2)
- Catchment 4 – South of site (see Fig 2)

For Catchments 1, 3 and 4, the developer has proposed to include geocellular crate storage to limit discharge from these areas to QBar, in line with Cambridgeshire County Council Surface Water Planning Guidance (2021).

The proposed discharge rate at QBar is higher than that allowed for in the original FRA (at 1 in 1 year less 10%). However, the proposals attenuate the full busway catchments, prior to discharge into the West Cambridge drainage network, which itself is an attenuated system.

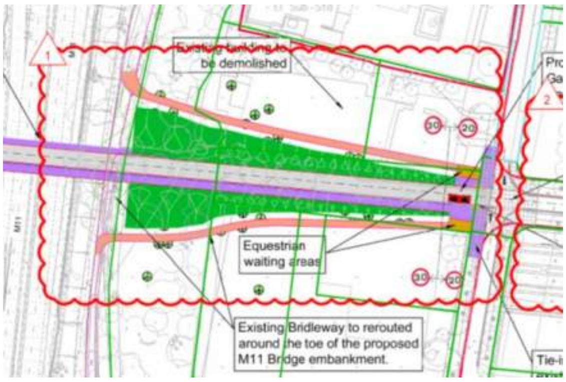

Figure 1 – Catchment 1

Figure 2 – Catchments 3 and 4

The impermeable areas contributing to the site runoff are summarised in Table 1 below;

	Original Impermeable Area	Original Discharge Rate	New Impermeable Area	Proposed attenuation	New Discharge Rate
Catchment 1	0.26	0.67 l/s	0.172	'Crates 12' 175m3 volume	0.6l/s
Catchment 2	N/A – No proposed change to catchment				
Catchment 3	0.109	0.28 l/s	Not Specified	86m3 volume	Not Specified
Catchment 4	N/A – outside Red Line	N/A – outside Red Line	Not Specified	46m3 volume	Not Specified

Conclusions

The information provided does not confirm the discharge rates allowed for Catchments 3 and 4, it is suggested that a request is made for this information for completeness.

Based on the rationale and calculations provided in the Busway Drainage Strategy Report, it is assumed that Catchments 3 and 4 have been designed to be attenuated to QBar in line with the rest of the Busway strategy.

On the basis of the above assumptions, the overall impact of the proposed works on the West Cambridge Drainage Strategy are anticipated to be negligible due to the relative scale of additional impermeable area added, and the proposed attenuation to be provided.

DOCUMENT ISSUE RECORD

Technical Note No	Rev	Date	Prepared	Checked	Approved
Job No/Brief/TN001	-	26/05/23	RT	WW	WW
Job No/Brief/TN001					

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