FLOODPLAN LIMITED

Project Title: 00361 7a Colgate Avenue

Product: Level 2 Flood Risk Assessment

Date: 25 May 2024

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Report Revision Log

Report Reference	Date Issued	Issued To	Notes
00361 7a Colgate Crescent	04/03/2024	Client	
00361 7a Colgate Crescent	25/05/2024	Client	

1. INTRODUCTION

1.1. PURPOSE OF THE REPORT

FloodPlan have been commissioned on behalf of A. James to produce a Flood Risk Assessment for 7a Colgate Crescent, M14 6FN. This assessment has been conducted with the understanding that the document will be used as part of a planning permission proposal by A. James.

1.2. LOCATION OF SUBJECT SITE

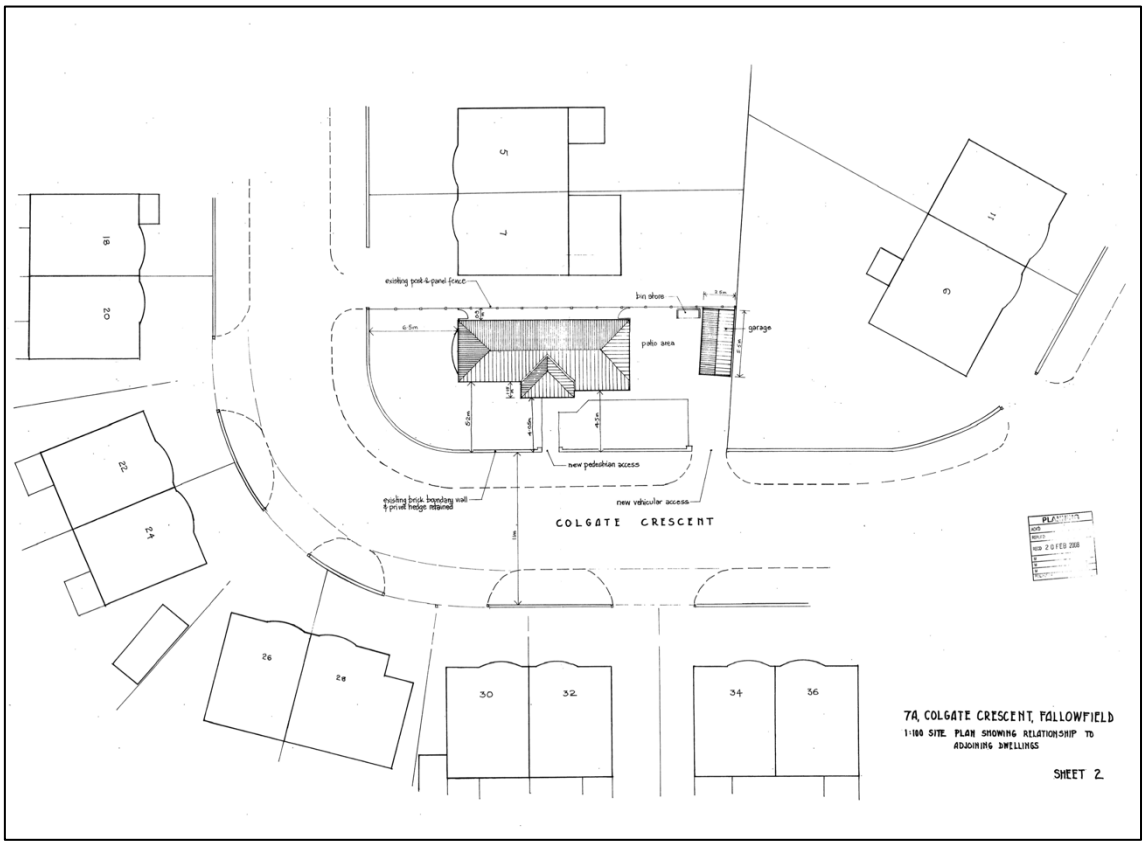


Figure 1: Site Location

1.3. SITE PROPOSALS

The development proposes the construction of a residential use dwelling.

2. ASSESSMENT OF NPPF

2.1. INTRODUCTION TO NPPF

The National Planning Policy Framework (NPPF) document provides guidance to local planning authorities to ensure the effective implementation of the planning policy. The policy seeks to direct development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. For these purposes:

- "areas at risk of flooding" means land within Flood Zones 2 and 3; or land within Flood Zone 1 which has critical drainage problems, and which has been notified to the local planning authority by the Environment Agency.
- "flood risk" means risk from all sources of flooding - including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers, and drainage systems, and from reservoirs, canals and lakes and other artificial sources.

Flood risk (from river and sea) are categorised inro one of the below:

2.2. FLOOD RISK CLASSIFICATIONS

Flood Zone	Probability of flooding
Zone 1	Low probability
Zone 2	Medium probability
Zone 3a	High probability
Zone 3b	Functional Floodplain

2.3. FLOOD RISK VULNERABILITY CLASSIFICATION

NPPF categorises land by vulnerability. A summary of categories can be seen below:

Vulnerability Class	Infrastructure
Essential Infrastructure	Power stations, water treatment works, wind turbines etc.

Highly vulnerable	Police stations, basement dwellings, caravans, mobile homes etc
More vulnerable	Hospitals, residential buildings, landfill sites, drinking establishments etc
Less Vulnerable	Emergency services stations, shops and building that offer professional services etc
Water compatible development	Pumping stations, docks, marinas etc

2.4. SUITABLE DEVELOPMENT MATRIX

The below table outlines the suitable development type for the flood zone classification assigned by the Environment Agency flood maps.

Flood risk vulnerability classification	Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Zone 1					
Zone 2			Exception Test Required		
Zone 3a	Exception Test Required			Exception Test Required	
Zone 3b Functional floodplain	Exception Test Required				

Figure 2: Suitable Development Matrix

Key: Blue Development is appropriate; Red Development should not be permitted; Green Development is appropriate with the passing of an Exception Test.

3. NPPF SITE ASSESSMENT

3.1. FLOOD ZONE CLASSIFICATION

As per Figure 3, the site is almost entirely within flood zone 2 and partially within flood zone 1.

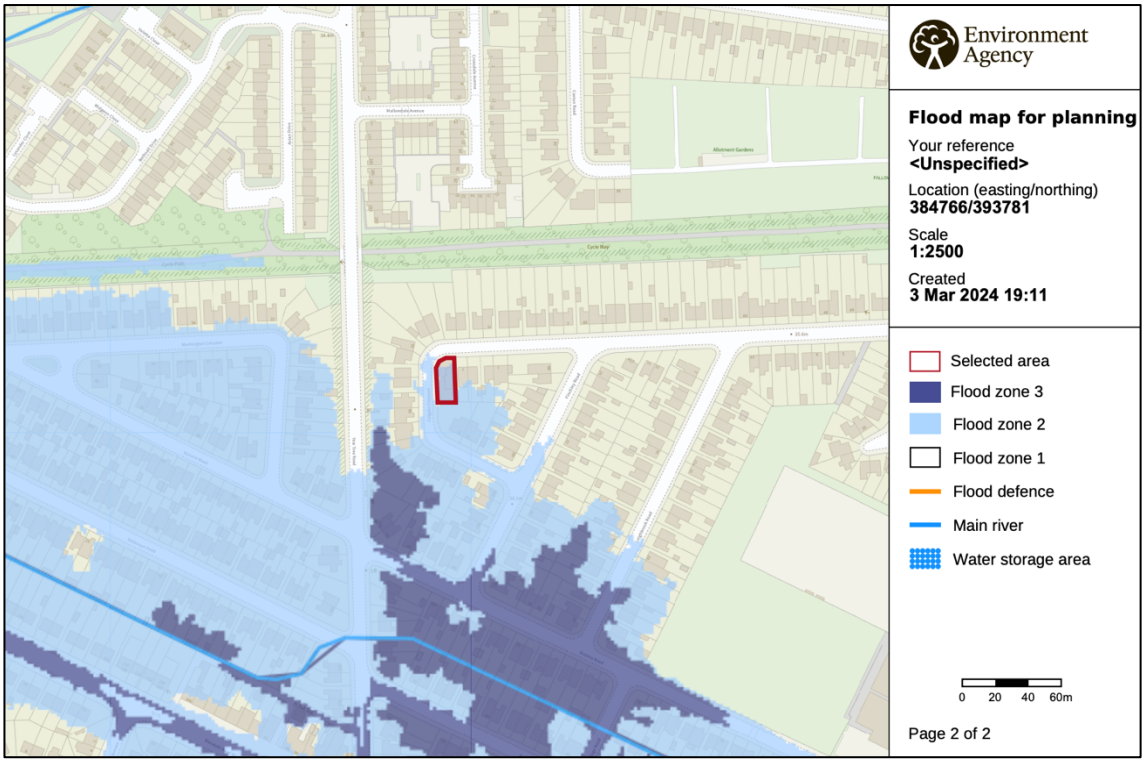


Figure 3: Flood Zone

3.2. LAND VULNERABILITY CLASSIFICATION

The existing land is used as an amenity area for the existing residential dwelling and is classified as 'less vulnerable' as per NPPF. The proposed use classification will also be used for residential purposes and therefore classified as 'more vulnerable' as per NPPF. The proposals increase the vulnerability classification of the site.

3.3. SITE SUITABILITY (NPPF)

'More vulnerable' development is suitable for flood zone 1 and 2 as per Figure 2.

4. SITE FLOOD RISK

4.1. THIRD PARTY FLOOD RISK DATA SUMMERY

A 'Groundsure' flood report has been acquired for advising this assessment. The full report can be found in Appendix B. The main findings are summarised below:

Type of Risk	Assessment of Risk
Overall Flood Risk	Moderate
Rivers and the Sea	Low
Surface Water	Negligible
Groundwater	High
Historic Flood	Not Identified
Flood Defences	No
FloodScoreTM – insurance rating	High

4.2. SURFACE WATER FLOODING

The Environment Agency surface water flood map Figure 4, shows the site to be at a low risk from surface water flooding.

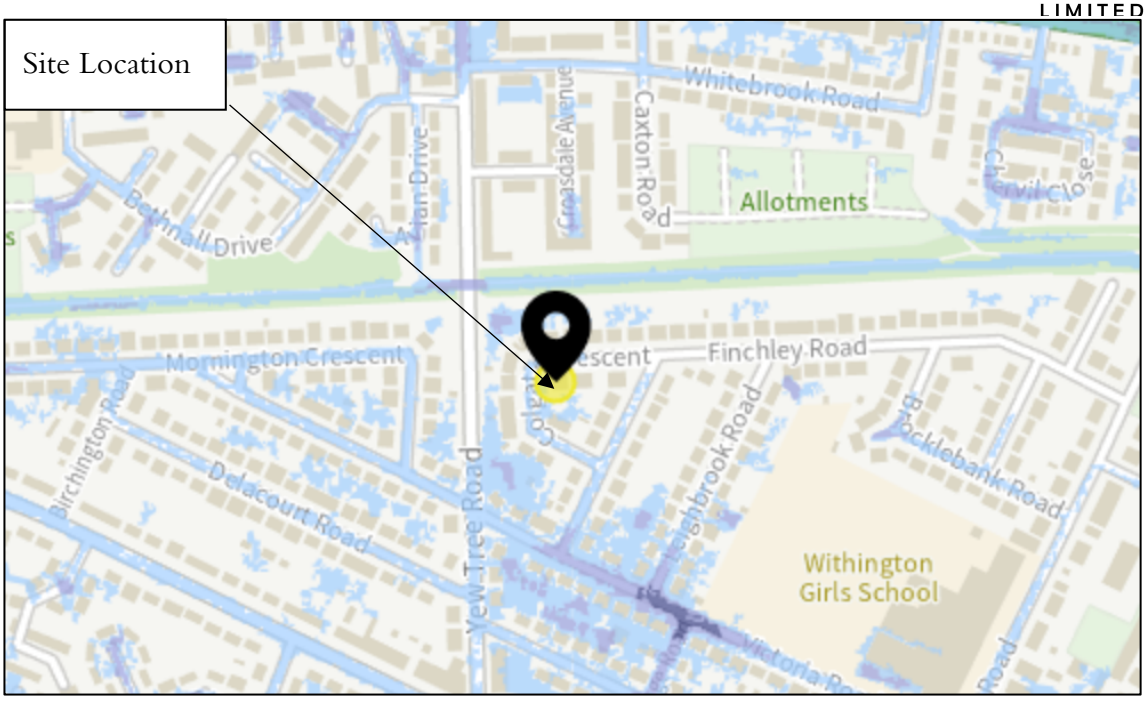


Figure 4: EA Surface Water Flood Map

Where the dark blue shaded area denotes high risk of surface water flooding; the light blue denotes low risk with white areas having very low risk of surface water flooding. The risk classification is comparable to the 'Groundsure' flood report.

4.3. Tidal and Fluvial flooding

The site is classified as having a low risk of flooding from tidal or river sources by the EA mapping.

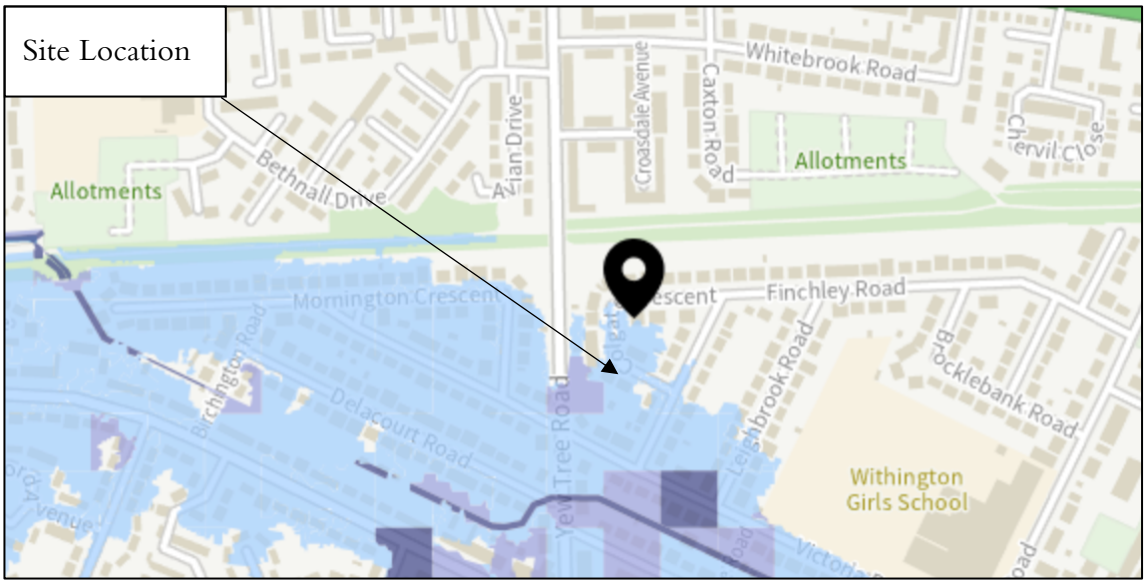


Figure 5: EA Tidal and Fluvial Flood Map

Where the dark blue shaded area denotes high risk of tidal and pluvial flooding; the light blue denotes low risk with the lightest blue areas having a very low risk of flooding.

4.4. FLOOD MODELLING DATA

LiDAR downloaded on the 25th of May 2024 shows the site to have a ground level of circa 34.2mOD-33.6mOD. Please note, levels vary across the site and an approximate location of the subject dwelling has been estimated. The applicant may wish to have levels verified by a topographic survey.

As part of this commission, FloodPlan contacted the Environment Agency to request flood modelling data and outputs for the site. The Environment Agency provided model outputs from the 'Cringle Brook' model.

The 1%AEP35%CC HMAX output shows the site to be affected, see below:

Figure 6: 100y35%CC HMAX flood extent

The 1%AEP35%CC HMAX shows the maximum flood level nearest to the site is 34.06mOD. The proposed FFL should be set to 34.36mOD to allow for a 300mm freeboard.

4.5. GROUNDWATER FLOODING

The 'Groundsure' flood report indicates that the site has a high risk of groundwater flooding.

4.6. RESERVOIR FLOODING

The risk of flooding is considered unlikely.

4.7. HISTORIC FLOODING

The 'Groundsure' flood report failed to identify any historic flood risk.

5. FURTHER SITE ASSESSMENT

5.1. SITE ACCESS AND EGRESS ROUTES

The site access is at risk from fluvial and pluvial flooding. Consideration should be given to adopting a flood evacuation plan.

5.2. FLOOD COMPENSATION

The proposals may displace floodwater during extreme flood events. Consideration should be given to providing compensatory flood storage.

5.3. FLOOD WARNING AREAS

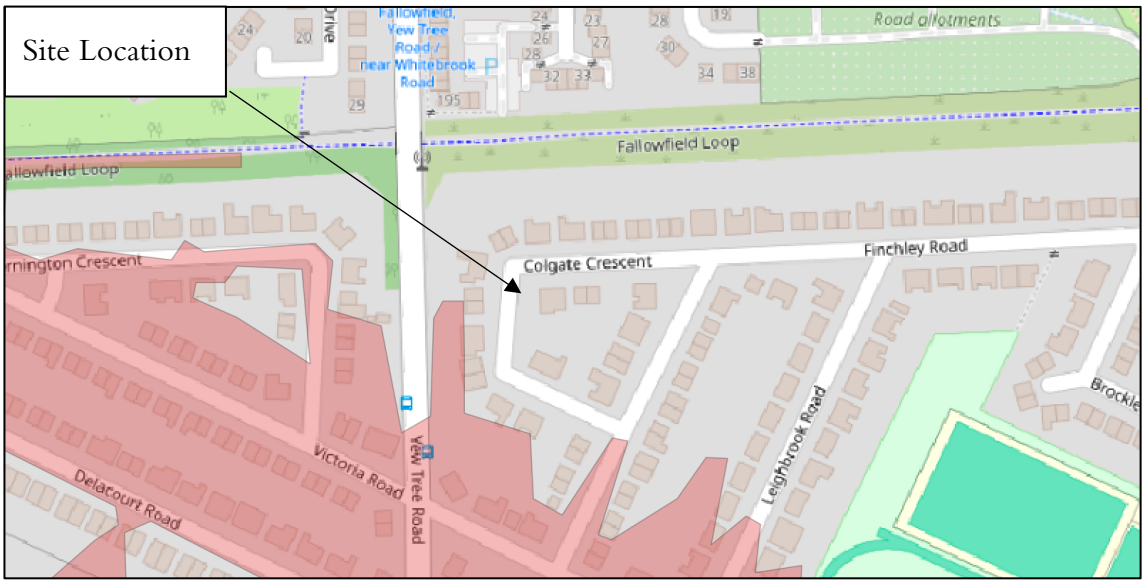


Figure 7: Flood Warning Areas

The site is outside of the EA flood warning areas.

5.4. AWARENESS OF FLOOD RISK

The developer should be aware that the site is not immune from flooding. It is recommended that all residents take the opportunity to develop emergency and non-emergency plans.

5.5. SEQUENTIAL TEST

Not Applicable

5.6. EXCEPTION TEST

Not Applicable

6. FINDINGS AND RECOMMENDATIONS

6.1. FINDINGS

The development proposes the construction of a residential use dwelling on land currently used as an amenity area. The site is within flood zone 2. The proposals may displace floodwater during extreme flood events.

6.2. RECOMMENDATIONS

This report recommends the following be considered to lower the risk and/or consequences that flooding may cause to the proposed development:

- Consideration should be given to adopting a flood evacuation plan.
- The proposals should consider proportionate flood resilience measures.
- Third parties should not be negatively impacted as part of the proposals.
- The proposals should be subject to a suitable SuDS drainage design, where appropriate.

List of Appendices

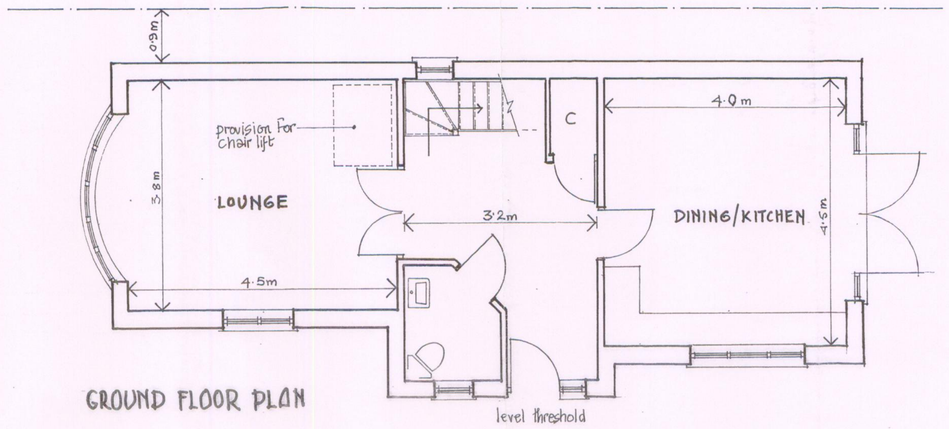
Appendix A: Development Plan

Appendix B: Groundsure Flood Report

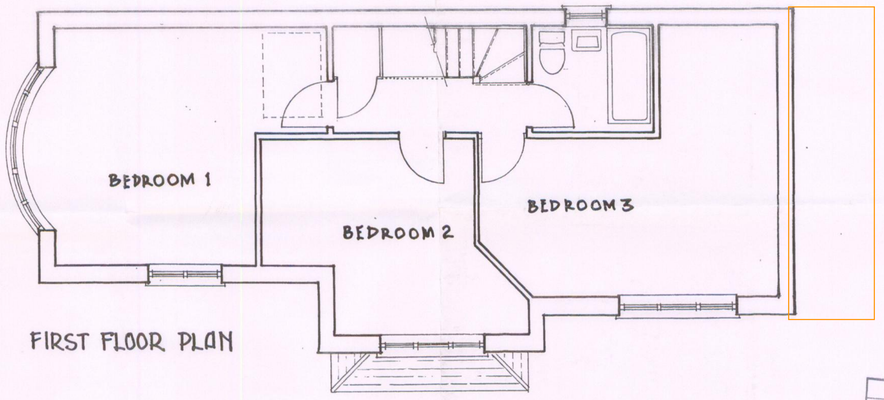
Appendix C: Flood Modelling Reports

Appendix A: Development Plan

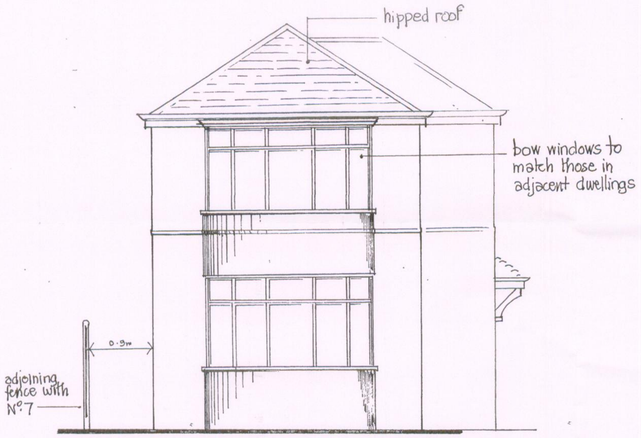
ENTRANCE (WEST) ELEVATION



GROUND FLOOR PLAN

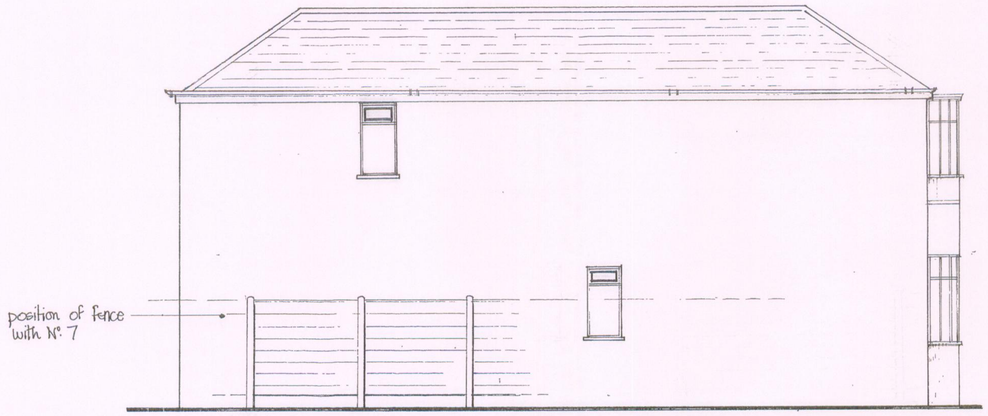


FIRST FLOOR PLAN

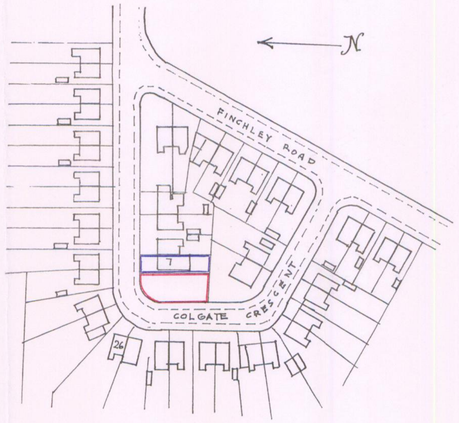


NORTH ELEVATION

SOUTH ELEVATION



EAST ELEVATION



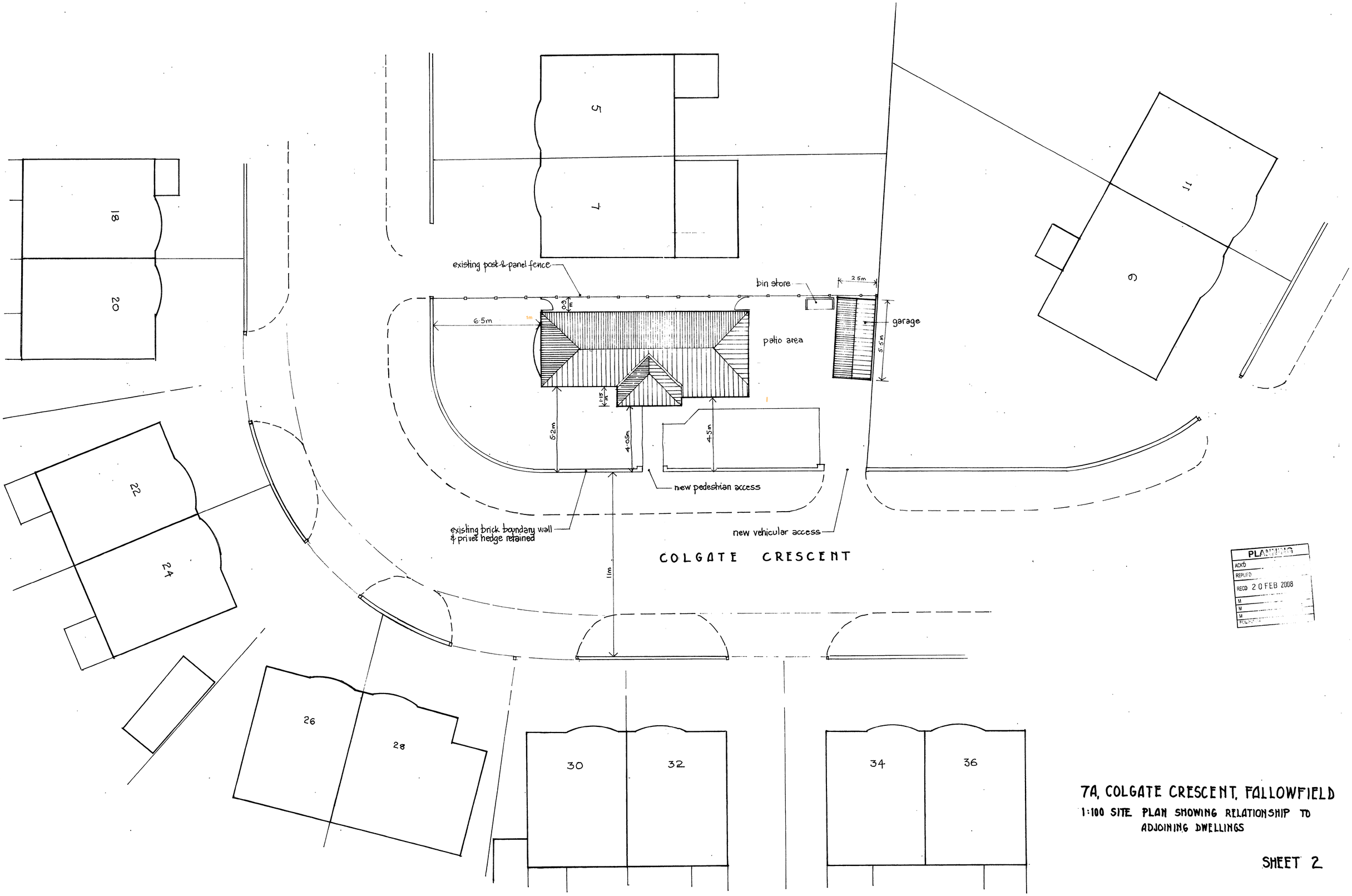
LOCATION PLAN 1:1250

PLANNING
RECD 20 FEB 2008

7A, COLGATE CRESCENT, FALLOWFIELD

PROPOSED DETACHED DWELLING: ELEVATIONS AND PLANS 1:50

SHEET 1



PLANNING
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REPLIED
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FILE NO

7A, COLGATE CRESCENT, FALLOWFIELD

1:100 SITE PLAN SHOWING RELATIONSHIP TO ADJOINING DWELLINGS

SHEET 2

Appendix B: Groundsure Flood Report

Groundsure
LOCATION INTELLIGENCE

Flood

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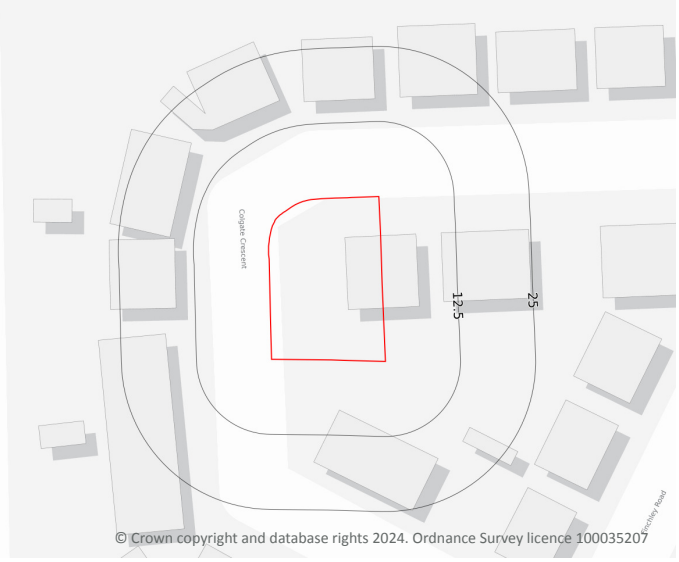
Overall Flood Risk

MODERATE

Groundsure Flood complies with relevant Law Society practice notes on flood risk in property transactions.

Site plan



Search Results

Rivers and the Sea
Low
page 3 >

Historic Flood
Not identified

Surface Water
Negligible

Flood Defences
No

Groundwater
High
page 4 >

FloodScore™ insurance rating
High
page 6 >

Full assessments for other environmental risks are available in additional Groundsure searches including the Groundsure Avista 7 in 1 report. Contact Groundsure or your search provider for further details.

Overview of findings and recommendations

To save you time when assessing the report, we only provide maps and data tables of features within the search radius that we have identified to be of note. These relate to environmental risks that may have liability implications, affect insurance premiums, property values and/or a lender's willingness to lend.

You can view the fully comprehensive library of information we have searched on **page 5 >**.

Flooding

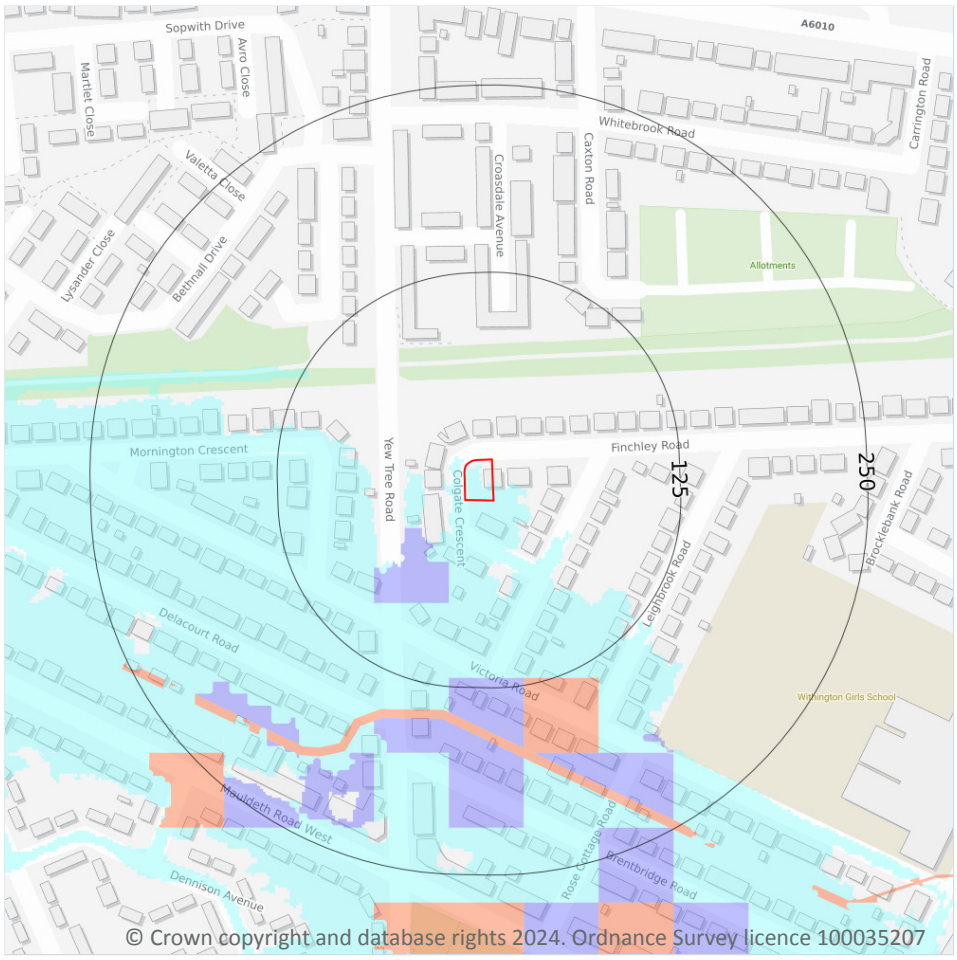
Flooding

An elevated level of flood risk has been identified at the property.

Next steps for consideration:

- check to see if the property is eligible for the Flood Re scheme, which enables many properties at risk of flooding to be insured at reasonable rates: http://www.floodre.co.uk/homeowner/about-us/ ↗
- investigate the insurance on offer for the property to ensure any implications on premiums are fully understood before completion
- a risk of groundwater flooding has been identified at the site. This will be more of an issue for properties with a basement or other section below ground. Further advice on groundwater flooding has been produced by the Environment Agency and the Local Government Association and can be found at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297421/flho0911bugi-e-e.pdf ↗
- the assessment in this report is based on the highest flood risk found within the site boundary. The maps within the flood risk section clearly highlight which parts have a higher probability of flood risk, allowing you to visualise whether flood risk affects the buildings or the associated land. If required, we can provide an assessment that provides separate flood risk ratings for the main building and for the land/gardens around it. This assessment is carried out manually by one of our in house experts and can only be ordered by contacting our customer support team at info@groundsure.com ↗
- if the property has recently been constructed, the flood risk assessment contained within this report will not take into account any measures put in place by the developer to deal with flooding. You should seek further information from the developer on flood risk mitigation for the site
- investigate the various forms of flood resistance and resilience measures that will help protect your property in the event of a flood

Flooding / Risk of flooding from rivers and the sea



Site Outline

Search buffers in metres (m)

River and coastal flooding:

- High
- Medium
- Low
- Very Low

- Historical Flood Events
- Areas Used for Flood Storage
- Areas Benefiting from Flood Defences
- Proposed Flood Defence Scheme
- Flood Defences

Risk of flooding from rivers and the sea

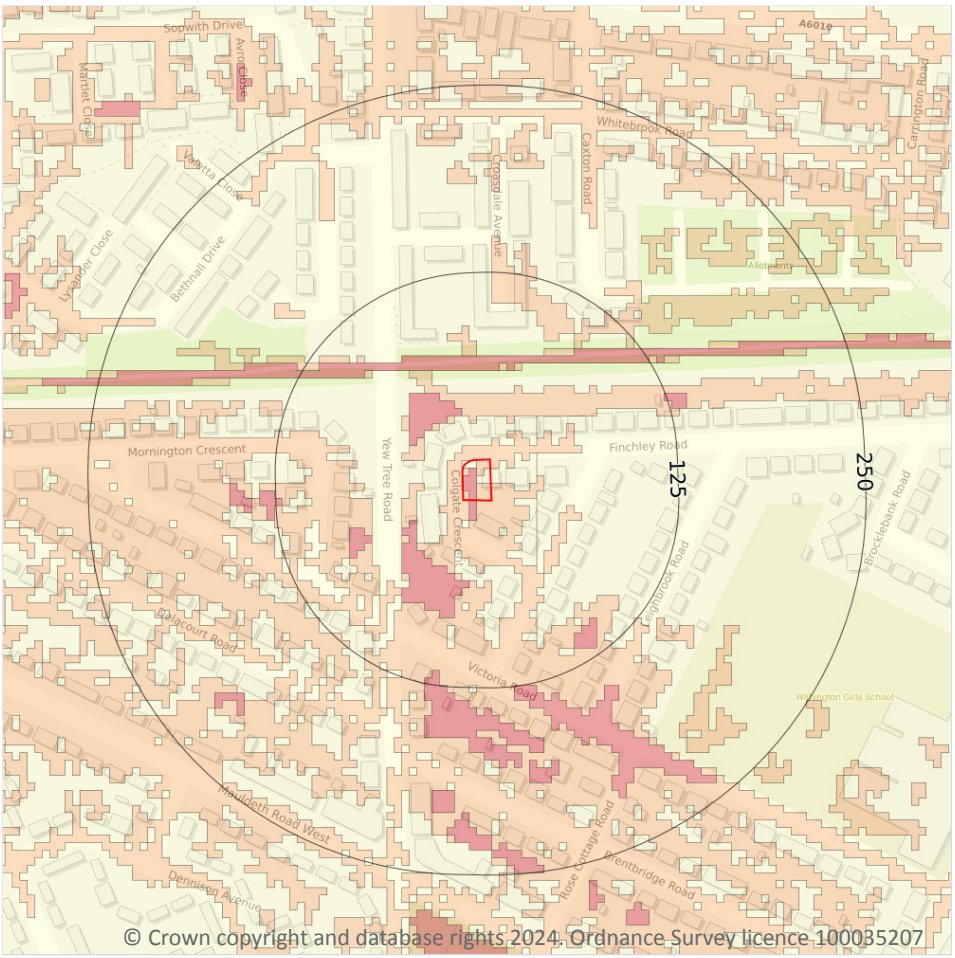
The property has a Low chance of flooding in any given year, according to Risk of Flooding from Rivers and Sea (RoFRaS)/Flood Risk Assessment Wales (FRAW) data. This could cause problems with insuring the property against flood risk. However, if built before 2009, it may be eligible for insurance assistance from the Flood Re scheme: www.floodre.co.uk/ ↗

RoFRaS/FRAW assesses flood risk from rivers and the sea in England and Wales, using local data and expertise. It shows the chance of flooding from rivers or the sea, taking account of flood defences and the condition those defences are in. The model uses local water level and flood defence data to model flood risk. See page page 6 > for explanation of the levels of flood risk.

Please see page 2 > for further advice.

This data is sourced from the Environment Agency and Natural Resources Wales.

Flooding / Groundwater flooding



Site Outline

Search buffers in metres (m)

- High
- Moderate - High
- Moderate
- Low
- Negligible

Ambiental data indicates that the property is in an area with a high risk of groundwater flooding. Should a 1 in 100-year groundwater flood occur, groundwater levels could rise above ground level to depth of over 25cm. Basement areas may become inundated.

Some of the responses contained in this report are based on data and information provided by the Natural Environment Research Council (NERC) or its component body British Geological Survey (BGS). Your use of any information contained in this report which is derived from or based upon such data and information is at your own risk. Neither NERC nor BGS gives any warranty, condition or representation as to the quality, accuracy or completeness of such information and all liability (including for negligence) arising from its use is excluded to the fullest extent permitted by law. Your use of the data/report/assessment constitutes your agreement to bring no claim against NERC or BGS in connection with it.

Datasets searched

This is a full list of the data searched in this report. If we have found results of note we will state "Identified". If no results of note are found, we will state "Not identified". Our intelligent filtering will hide "Not identified" sections to speed up your workflow.

Flooding	
Risk of flooding from rivers and the sea	**Identified**
Flood storage areas: part of floodplain	Not identified
Historical flood areas	Not identified
Areas benefiting from flood defences	Not identified
Flood defences	Not identified
Proposed flood defences	Not identified
Surface water flood risk	Not identified
Groundwater flooding	**Identified**

Flood information

The Flood Risk Assessment section is based on datasets covering a variety of different flooding types. No inspection of the property or of the surrounding area has been undertaken by Groundsure or the data providers. The modelling of flood hazards is extremely complex and in creating a national dataset certain assumptions have been made and all such datasets will have limitations. These datasets should be used to give an indication of relative flood risk rather than a definitive answer. Local actions and minor variations, such as blocked drains or streams etc. can greatly alter the effect of flooding. A low or negligible modelled flood risk does not guarantee that flooding will not occur. Nor will a high risk mean that flooding definitely will occur. Groundsure's overall flood risk assessment takes account of the cumulative risk of river and coastal data, historic flood events and areas benefiting from flood defences provided by the Environment Agency/Natural Resources Wales (in England and Wales) and surface water (pluvial) and groundwater flooding provided by Ambiental Risk Analytics. In Scotland the river and coastal flood models are also provided by Ambiental Risk Analytics.

Risk of flooding from rivers and the sea

This is an assessment of flood risk for England and Wales produced using local data and expertise, provided by the Environment Agency (RoFRaS model) and Natural Resources Wales (FRAW model). It shows the chance of flooding from rivers or the sea presented in categories taking account of flood defences and the condition those defences are in. The model uses local water level and flood defence data to model flood risk.

The categories associated with the Environment Agency and Natural Resources Wales models are as follows:

RoFRaS (rivers and sea) and FRAW (rivers):

Very Low - The chance of flooding from rivers or the sea is considered to be less than 1 in 1000 (0.1%) in any given year.

Low - The chance of flooding from rivers or the sea is considered to be less than 1 in 100 (1%) but greater than or equal to 1 in 1000 (0.1%) in any given year.

Medium - The chance of flooding from rivers or the sea is considered to be less than 1 in 30 (3.3%) but greater than 1 in 100 (1%) in any given year.

High - The chance of flooding from rivers or the sea is considered to be greater than or equal to 1 in 30 (3.3%) in any given year.

FRAW (sea):

Very Low - The chance of flooding from the sea is considered to be less than 1 in 1000 (0.1%) in any given year.

Low - The chance of flooding from the sea is considered to be less than 1 in 200 (0.5%) but greater than or equal to 1 in 1000 (0.1%) in any given year.

Medium - The chance of flooding from the sea is considered to be less than 1 in 30 (3.3%) but greater than 1 in 200 (0.5%) in any given year.

High - The chance of flooding from the sea is considered to be greater than or equal to 1 in 30 (3.3%) in any given year.

Historic flood events

Over 86,000 events are recorded within this database. This data is used to understand where flooding has occurred in the past and provides details as available. Absence of a historic flood event for an area does not mean that the area has never flooded, but only that Environment Agency/Natural Resources Wales do not currently have records of flooding within the area. Equally, a record of a flood footprint in previous years does not mean that an area will flood again, and this information does not take account of flood management schemes and improved flood defences.

Surface water flooding

Ambiental Risk Analytics surface water flood map identifies areas likely to flood following extreme rainfall events, i.e. land naturally vulnerable to surface water or “pluvial” flooding. This data set was produced by simulating 1 in 30 year, 1 in 100 year, 1 in 250 year and 1 in 1000 year rainfall events. The flood risks for these rainfall events are reported where the depth would be greater than the threshold for a standard property to modern building standards. Modern urban drainage systems are typically built to cope with rainfall events between 1 in 20 and 1 in 30 years, though older ones may even flood in a 1 in 5 year rainstorm event.

Proposed flood defences

The data includes all Environment Agency/Natural Resources Wales's projects over £100K that will change or sustain the standards of flood defence in England and Wales over the next 5 years. It also includes the equivalent schemes for all Local Authority and Internal Drainage Boards.

Flood storage areas

Flood Storage Areas may also act as flood defences. A flood storage area may also be referred to as a balancing reservoir, storage basin or balancing pond. Its purpose is to attenuate an incoming flood peak to a flow level that can be accepted by the downstream channel. It may also delay the timing of a flood peak so that its volume is discharged over a longer time interval. These areas are also referred to as Zone 3b or 'the functional floodplain' and has a 5% or greater chance of flooding in any given year, or is designed to flood in the event of an extreme (0.1%) flood or another probability which may be agreed between the Local Planning Authority and Environment Agency/Natural Resources Wales, including water conveyance routes. Development within Flood Storage Areas is severely restricted.

Groundwater flooding

Groundwater flooding is flooding caused by unusually high groundwater levels. It occurs as excess water emerging at the ground surface or within underground structures such as basements. Groundwater flooding tends to be more persistent than surface water flooding, in some cases lasting for weeks or months, and it can result in significant damage to property. This risk assessment is based on a 5m Digital Terrain Model (DTM) and 1 in 100 year and 1 in 250 year return periods.

Ambiental FloodScore™ insurance rating

The property has been rated as **High** risk. Please see **page 2 >** for further advice.

Ambiental's FloodScore™ risk rating gives an indicative assessment of the potential insurance risk classification from flooding, which can provide an indication of how likely it is that a property's policy will be ceded to Flood Re. The assessment is based on Ambiental's river, tidal and surface water flood data and other factors which some insurers may use in their assessment are not included.

Flood Re is a re-insurance scheme that makes flood cover more widely available and affordable as part of your residential property home insurance. Properties at higher risk of flooding may have the flood part of their policy ceded to Flood Re by their insurer. It is important to understand that Flood Re does not apply to all situations. Exclusions from Flood Re includes properties constructed after 1 January 2009; properties not within domestic Council Tax bands A to H (or equivalent); commercial properties, certain buy to let scenarios and buildings comprising four or more residential units. A full list of the exemptions can be found on the Flood Re website (https://www.floodre.co.uk/can-flood-re-help-me/eligibility-criteria/) ↗.

The Ambiental FloodScore™ insurance rating is classified into six different bandings:

Very High indicates a level of risk that may make it more likely that standard insurance premiums will be higher, or additional terms may apply to the provision of flood cover. There is a very high possibility that the cover for flooding at the property will be ceded into the Flood Re scheme, particularly if the property has flooded in the past.

High indicates a level of risk that may make it more likely that standard insurance premiums will be higher, or additional terms may apply to the provision of flood cover. There is a high possibility that the cover for flooding at the property will be ceded into the Flood Re scheme, particularly if the property has flooded in the past.

Moderate-High indicates a level of risk that may make it more likely that standard insurance premiums will be higher, or additional terms may apply to the provision of flood cover. There is a moderate possibility that the cover for flooding at the property will be ceded into the Flood Re scheme, particularly if the property has flooded in the past.

Moderate indicates a level of risk that may make it more likely that standard insurance premiums will be higher, or additional terms may apply to the provision of flood cover. There is a low possibility that the cover for flooding at the property will be ceded into the Flood Re scheme, unless the property has flooded in the past.

Low indicates a level of risk that is likely to mean standard cover and premiums are available for flood cover. There is a low possibility the cover for flooding at the property will be ceded into the Flood Re scheme, unless the property has flooded in the past.

Very Low indicates a level of flood risk that should not have any impact on the provision of flood cover for the property.

Conveyancing Information Executive and our terms & conditions

IMPORTANT CONSUMER PROTECTION INFORMATION

This search has been produced by Groundsure Ltd, Nile House, Nile Street, Brighton, BN1 1HW. Tel: 01273 257 755. Email: info@groundsure.com ↗. Groundsure adheres to the Conveyancing Information Executive Standards.

The Standards

- Conveyancing Information Executive Members shall act in a professional and honest manner at all times in line with the Conveyancing Information Executive Standards and carry out the delivery of the Search with integrity and due care and skill.
- Compliance with the Conveyancing Information Executive Standards will be a condition within the Conveyancing Information Executive Member's Terms and Conditions.
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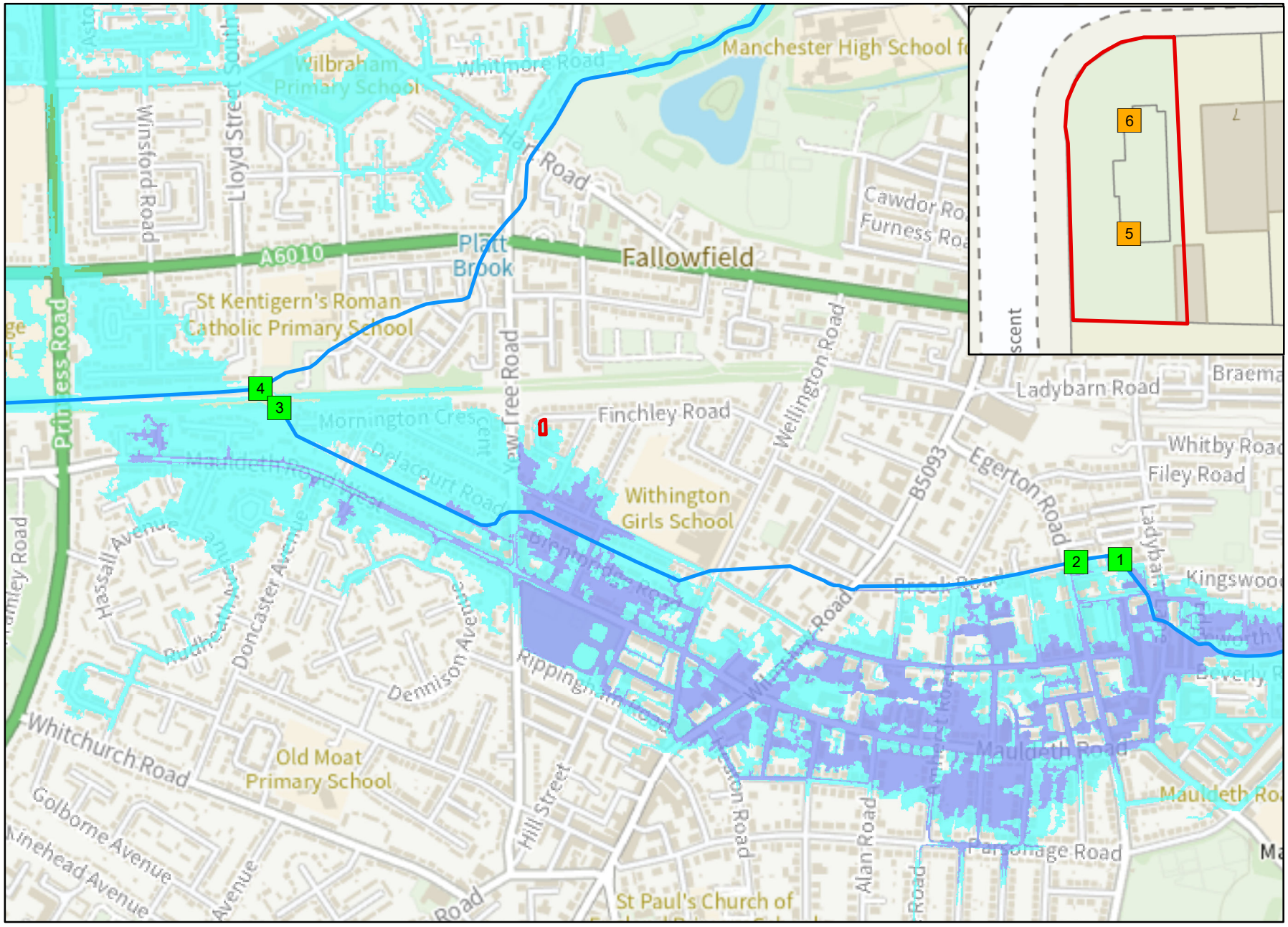
Appendix C: Flood Modelling Reports

Detailed Flood Map Centred on Colgate Crescent, Manchester, M14 6FN.
Created 08/05/2024 [GMMC357854SW]



Environment Agency

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Legend

- Site Location
- Model Measurements
- 2D Levels
- Main River
- Flood Zone 3
- Flood Zone 2

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					Undefended													Defended													
Map Reference	Model Node Reference	Easting	Northing	Data	50 % AEP (1 in 2 year)	20 % AEP (1 in 5 year)	10 % AEP (1 in 10 year)	5 % AEP (1 in 20 year)	4 % AEP (1 in 25 year)	2 % AEP (1 in 50 year)	1.33 % AEP (1 in 75 year)	1 % AEP (1 in 100 year)	1 % AEP (1 in 100 year) + 30% Increase in flow	1 % AEP (1 in 100 year) + 35% Increase in flow	1 % AEP (1 in 100 year) + 70% Increase in flow	0.5 % AEP (1 in 200 year)	0.1 % AEP (1 in 1000 year)	0.1 % AEP (1 in 1000 year) + 30% Increase in flow	50 % AEP (1 in 2 year)	20 % AEP (1 in 5 year)	10 % AEP (1 in 10 year)	5 % AEP (1 in 20 year)	4 % AEP (1 in 25 year)	2 % AEP (1 in 50 year)	1.33 % AEP (1 in 75 year)	1 % AEP (1 in 100 year)	1 % AEP (1 in 100 year) + 30% Increase in flow	1 % AEP (1 in 100 year) + 35% Increase in flow	1 % AEP (1 in 100 year) + 70% Increase in flow	0.5 % AEP (1 in 200 year)	0.1 % AEP (1 in 1000 year)	0.1 % AEP (1 in 1000 year) + 30% Increase in flow
1	ea013_0238_CRINO1_1633d	385828	393540	Modelled Water Level (m aodN)	37.88	38.09	38.52	38.54	38.54	38.55	38.55	38.56	38.57	38.57	38.61	38.56	38.64	38.68	37.88	38.09	38.52	38.54	38.54	38.55	38.55	38.56	38.57	38.57	38.61	38.56	38.64	38.68
				Modelled Flow (cumecs)	3.03	3.69	4.28	4.38	4.38	4.40	4.41	4.42	4.44	4.44	4.45	4.44	4.48	4.50	3.03	3.69	4.28	4.38	4.38	4.40	4.41	4.42	4.44	4.44	4.45	4.44	4.48	4.50
2	ea013_0238_CRINO1_1551u	385749	393534	Modelled Water Level (m aodN)	37.83	38.02	38.43	38.45	38.45	38.47	38.47	38.47	38.49	38.50	38.53	38.48	38.56	38.61	37.83	38.02	38.43	38.45	38.45	38.47	38.47	38.47	38.49	38.50	38.53	38.48	38.56	38.61
				Modelled Flow (cumecs)	3.03	3.69	4.27	4.37	4.38	4.40	4.41	4.42	4.44	4.44	4.44	4.43	4.47	4.49	3.03	3.69	4.27	4.37	4.38	4.40	4.41	4.42	4.44	4.44	4.44	4.43	4.47	4.49
3	ea013_0238_CRINO1_0050d	384281	393818	Modelled Water Level (m aodN)	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.89	31.91	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.89	31.91
				Modelled Flow (cumecs)	3.02	3.68	3.96	3.96	3.96	3.96	3.96	3.96	3.97	3.97	3.97	3.97	3.98	3.99	3.02	3.68	3.96	3.96	3.96	3.96	3.96	3.96	3.97	3.97	3.97	3.97	3.98	3.99
4	ea013_0238_CRINE1_0000	384246	393854	Modelled Water Level (m aodN)	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85	31.85
				Modelled Flow (cumecs)	3.02	3.68	3.96	3.96	3.96	3.96	3.96	3.96	3.97	3.97	3.97	3.97	4.24	4.75	3.02	3.68	3.96	3.96	3.96	3.96	3.96	3.96	3.97	3.97	3.97	3.97	4.24	4.75

Model data taken from Cringle Brook 2017

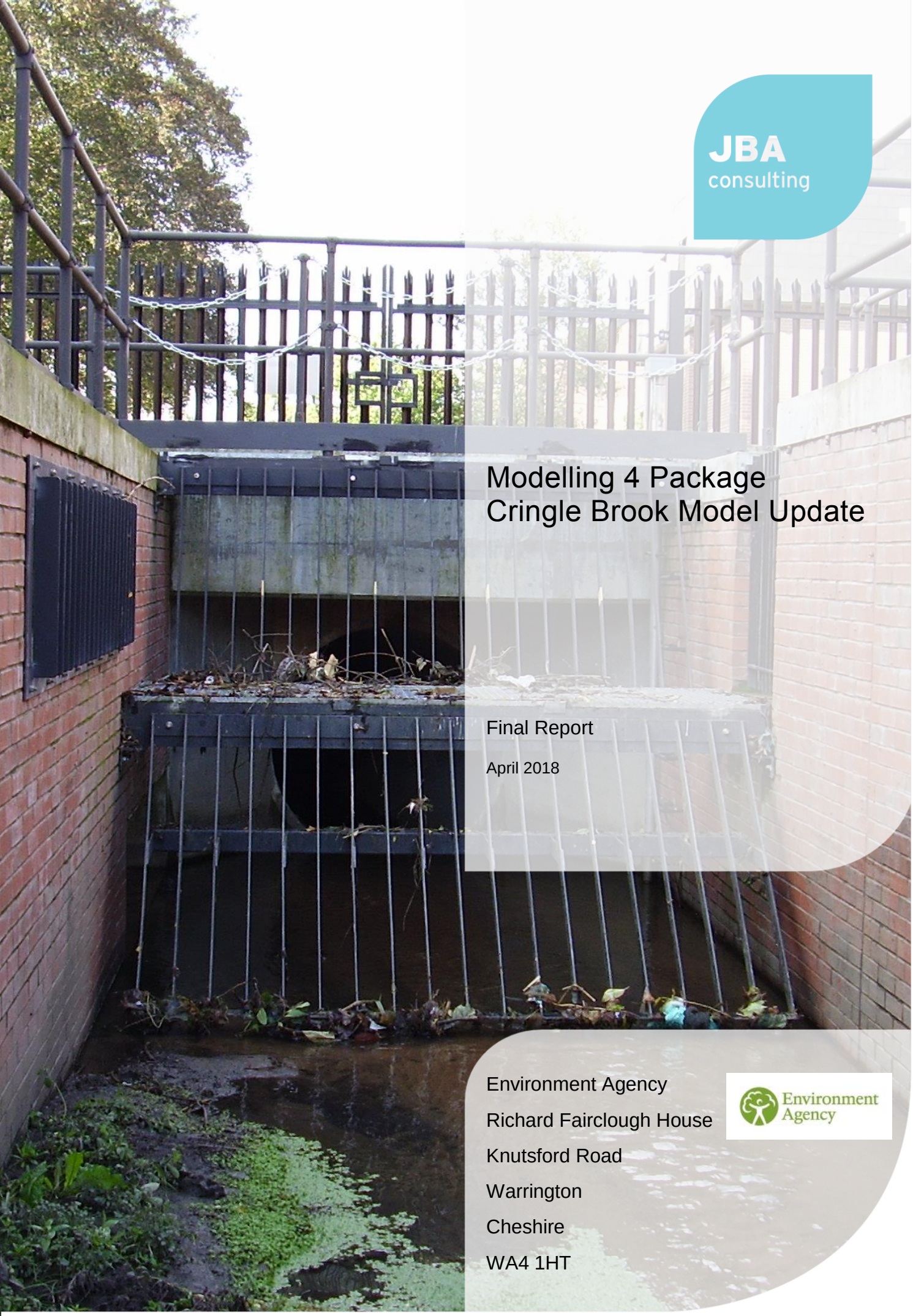
AEP - Annual Exceedence Probability

m aodN - metres above ordnance datum Newlyn

cumecs - cubic metres per second

Notes: *Climate Change Scenario - 30%, 35% and 70% increases in flow calculated for the 2080's (2070 - 2115). Please see https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances for more information regarding the new climate change guidance. The location of the site and the type (vulnerability) of development determine the climate change allowances to consider in any flood risk assessment.

					Undefended		Defended	
Map Reference	Model Node Reference	Easting	Northing	Data	0.1 % AEP (1 in 1000 year)	0.1 % AEP (1 in 1000 year) + 30% Increase in flow	0.1 % AEP (1 in 1000 year)	0.1 % AEP (1 in 1000 year) + 30% Increase in flow
5	2D Level	384766	393777	Modelled Water Level (m aodN)	34.16	34.22	34.16	34.23
6		384766	393788	Modelled Water Level (m aodN)	34.16	34.22	34.16	34.23



Modelling 4 Package
Cringle Brook Model Update

Final Report

April 2018

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft v1.0 (March 2018)		Sharon Holden (Environment Agency)
Final v1.0 (April 2018)	Reference provided to LIDAR tiles and survey reference numbers.	Sharon Holden (Environment Agency)

Contract

This report describes work commissioned by the Environment Agency as part of the Modelling 4 Package 2016/2017 awarded on the 10th November 2016. The Package Manager for the Environment Agency was Cath Sanders and the JBA Consulting Package Manager was Gary Deakin. The Environment Agency's representative for the project was Sharon Holden. Jenny Kirwan-Evans and Ellen Broad of JBA Consulting carried out this work.

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Executive Summary

JBA Consulting were commissioned by the Environment Agency in 2016 to produce a standalone 1D-2D model of the Cringle Brook watercourse from their existing 1D-2D model of the Chorlton Platt Gore. The main purpose of the study was to review and update the hydrology and hydraulic model for Cringle Brook, drawing on the existing model and the recent flow record at Egerton Road Culvert. The outputs from the study will be used to better understand the flood risk to properties within Fallowfield and inform an imminent appraisal study.

The Cringle Brook catchment includes the Manchester suburbs of Fallowfield, Heaton Chapel and Burnage and is heavily urbanised. The watercourse passes through a number of culverts, culminating in the 1.5-kilometre-long Egerton Road culvert near its downstream extent. Formal Environment Agency maintained flood defences are limited to two short stretches of flood walls in the reaches upstream of Egerton Road and Ladybarn Lane culverts that were installed as part of a Flood Alleviation Scheme in 2004, in response to past flooding. No out of bank flooding has occurred in the catchment since 2004. There is one level gauge and one flow gauge in the catchment, both located at the upstream of the Egerton Road culvert. The nearest rain gauges are located at Denton and Platt Fields.

Hydrology

A key requirement of the Cringle Brook study was the need for a new hydrological assessment to draw on the flow record now available within the catchment from the Egerton Debris Screen gauge, which was installed in June 2014. However, the flow gauge was considered unsuitable for use in the hydrological assessment due to data quality issues. Instead, a rating curve was derived for the nearby Egerton Road level gauge, which had been operational since 2001, using the updated model. An estimate of QMED was then generated by applying the LMED value taken from the gauged level series to the derived rating curve. The FEH Statistical method was then used to derive peak flows for more extreme events by generating a suitable pooled growth curve. The final model inflows were based on Urban ReFH hydrographs, using a 2-hour Summer storm, and set to the FEH Statistical peak flow estimates.

Hydraulic Modelling

An up-to-date, linked 1D-2D (FM-TUFLOW) model of Cringle Brook was created from the Environment Agency's existing Chorlton Platt Gore model following an initial model review. This linked a new-build 2D (TUFLOW) domain of 3.4 km^2 (with a cell size of 2m based on mostly 2016 LIDAR DTM) to the existing version of the 1D model that had been trimmed to Cringle Brook and undergone only a small number of minor modifications. The elevations of the flood defences were modelled on the basis of a small bank crest survey that was collected during the commission. The downstream boundary was extracted from the existing Chorlton Platt Gore model.

The revised Cringle Brook model was verified against the September 2016 event, which was the highest in the 16-year record at the Egerton Road level gauge. Unfortunately, the flow gauge could not be used for calibration as it was found to drop out during several of the high flow events in its short recording history (perhaps due to surcharging of the Egerton Road culvert) so rain gauge data was used to create plausible model inflows for this event. The verification exercise found that the September 2016 event was likely to have been in the order of a 10% AEP event and that the model was likely to produce conservative predictions of flood extent during events of this magnitude.

Model Scenarios

The following design events were run through both defended and undefended model scenarios to generate flood mapping deliverables:

- Present day - 50%, 20%, 10%, 5%, 4%, 3.3%, 2%, 1.3%, 1%, 0.5% and 0.1% AEP
- Future - 1% AEP + 30%, 1% AEP + 35%, 1% AEP + 70% and 0.1% AEP + 30%

Climate change was assessed using the latest UKCP09 guidance for catchments in NW England.

A blockage analysis was carried out at six key structures for three blockage proportions (25%, 50% & 75%) and two events (1% AEP and 1% AEP + 30%).

Outcomes

The following outcomes were identified from the hydraulic model results;

- The model predictions seem reasonable given the large uncertainties involved in modelling urban watercourses like Cringle Brook. If good quality high flow data can be recorded in future, then further calibration may better constrain model parameters reduce model uncertainties.
- A low flood threshold is predicted for property in the Cringle Brook catchment downstream of the (Mauldeth Road) railway line and flooding of the downstream part of the catchment is quite extensive, albeit shallow, because there is no mechanism for this floodwater to re-enter the watercourse due to extensive culverting. The main source of overtopping in the downstream catchment is modelled to be immediately upstream of the existing raised defences. Overtopping is also modelled across the unprotected right bank downstream of Kingswood Road Bridge.
- The flood risk to the catchment upstream of the (Mauldeth Road) railway line is modelled to be higher than the downstream catchment. Floodwater is modelled to escape from the upstream face of the Wellington Road Culvert at a low return period, but few properties are affected until an extreme event.
- The existing flood defences are modelled to have little impact at the 1% AEP level and it is proposed that there should be no formal Areas Benefitting from Defences defined from this study.
- Future (with climate change) 1% AEP events are modelled to flood large extents of both the upper and lower catchments; by both initiating the upstream flow route along Crossley Road and increasing the extent of overtopping upstream of Ladybarn Lane.
- The re-modelled 1% AEP and 0.1% AEP undefended flood outlines are broadly similar to the existing Environment Agency Flood Zones that are based on the 2012 model, except in the upper catchment where the newly modelled 0.1% AEP flood outline shows properties at risk from a flow route along Crossley Road from overtopping at the Wellington Road Culvert.
- Blockage is modelled to increase upstream river levels and increase the risk of surcharging at all six of the structures that were subject to a blockage analysis. However, since the Wellington Road, Ladybarn Lane and Egerton Road culverts are, anyway, by-passed at moderate return periods, the blockage of these structures is typically modelled to simply increase the volume of by-passing flow rather than invoking new flow routes. The blockage of Erwood Road, Kempton Road and Kingway are modelled to increase the risk of overtopping of these structures leading to flow routes that, under existing conditions, are only modelled at higher return periods.

Main Recommendation

Although, it was anticipated at the start of the study that the flow data from the newly operational Egerton Road Debris Screen gauge would provide increased confidence in the Cringle Brook hydraulic model predictions (by reducing uncertainties in design flow estimation and allowing better calibration of the model), the flow gauge would not appear to have performed well during recent high flow events. The reasons for this poor performance should be investigated to achieve these aims in future.

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Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
ABD	Area Benefiting from Defences
AEP	Annual Exceedance Probability
ASCII	American Standard Character set for Information Interchange
DTM	Digital Terrain Model
dVOL	Change in volume in the TUFLOW model since the previous time (m^3)
EA	Environment Agency
FAS	Flood Alleviation Scheme
FM	One dimensional modelling software
FEH	Flood Estimation Handbook
FWA	Flood Warning Area
FZ	Flood Zones
GIS	Geographical Information System
LIDAR	Light Detection and Ranging
MBE	Mass Balance Error
OS	Ordnance Survey
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SoP	Standard of Protection
TUFLOW	Two-dimensional Unsteady FLOW (hydraulic modelling software)
URBEXT	FEH index of fractional urban extent

1 Introduction

1.1 Background

JBA Consulting was commissioned by the Environment Agency in 2016 to create a standalone 1D-2D hydraulic model of Cringle Brook from an existing, larger scale, Environment Agency, ISIS-TUFLOW, model of Chorlton Platt Gore that was last updated in 2012. This work was undertaken under Lot 1 of the Water and Environmental Management (WEM) Framework. The main purpose of the study was to review and update the existing model representation of Cringle Brook using an updated hydrology that took into account the flow record that was available from the recently installed (2014) flow gauge located at the Egerton Road Culvert on Cringle Brook. The outputs from the study will be used to better understand the flood risk to properties within Fallowfield and inform an imminent appraisal study.

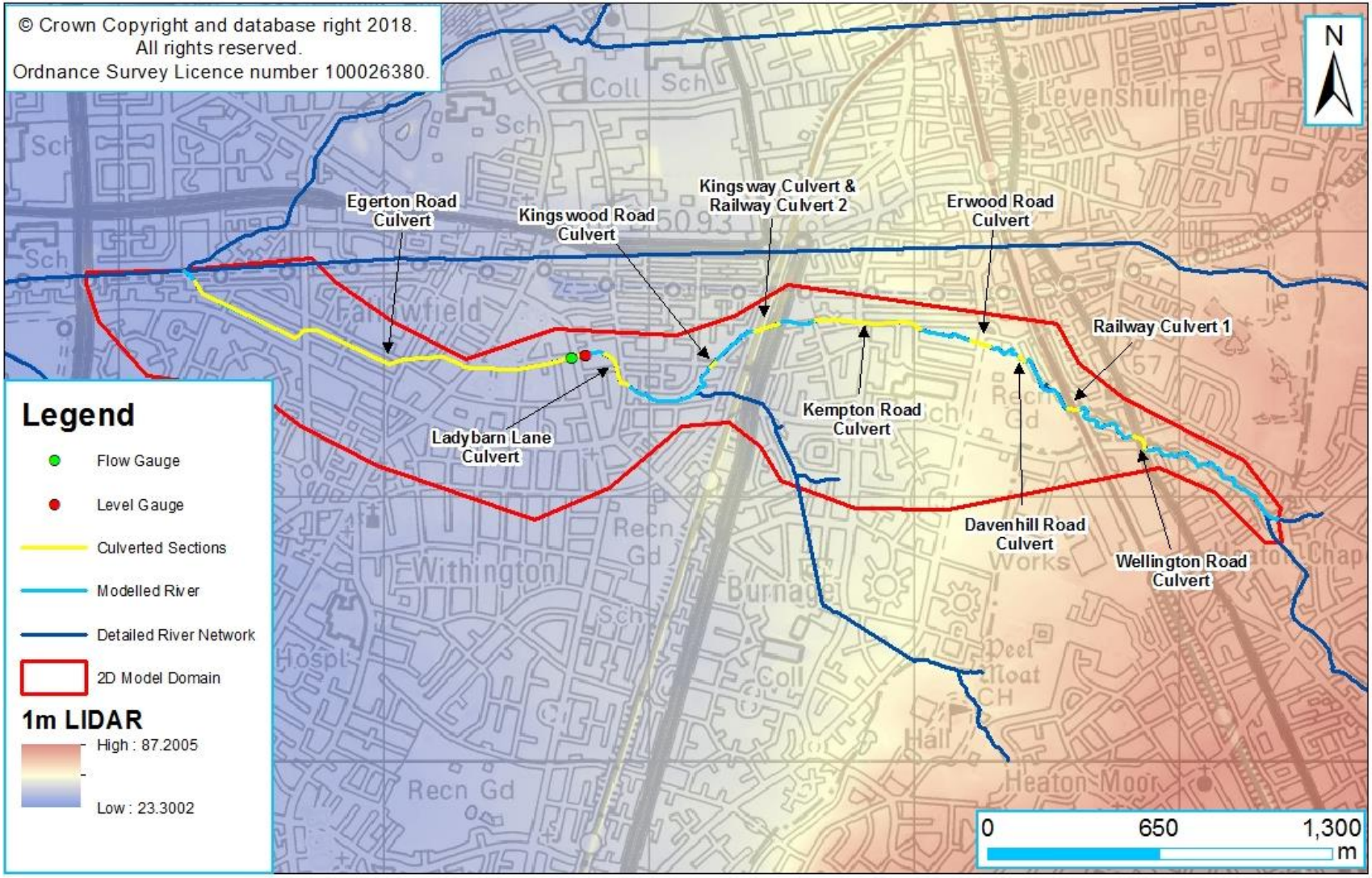
The current study is restricted to the fluvial flood risk from the Cringle Brook. The direct fluvial flood risk from other watercourses is not included, nor is the risk from other sources. The key flood pathways being considered are, therefore, restricted to direct overtopping from the modelled watercourse and/or the spread of floodwater through the floodplain. The potential impact of blockages at structures has also been studied.

1.2 Study Area

This study focusses on a 4.8km section of the Cringle Brook, from Heaton Chapel (at 388334, 392920) to the confluence with the Chorlton Platt Gore (at 384255, 393854) as shown in Figure 1-2. The catchment is very highly urbanised, with the watercourse flowing through the Manchester suburbs of Heaton Chapel and Fallowfield. Photographs showing the typical nature of the watercourse are shown in Figure 1-1.

Figure 1-1: Photographs of the Cringle Brook watercourse

Figure 1-2: Cringle Brook Study Extents



There are historical reports and evidence of past flooding within the catchment, although there are no records of fluvial flooding since a local Flood Alleviation Scheme (FAS) was implemented in the Ladybarn Lane and Egerton Road areas in 2004.

There is one flow and one level gauge within the catchment, both of which are located at the upstream end of the Egerton Road Culvert.

1.3 Assets

1.3.1 Hydraulic Structures

Culverts

There is a total of 11 culverts along the modelled extent of Cringle Brook, most of which are labelled in Figure 1-2. Culverts have the potential to significantly affect the flood hydraulics and limit downstream flows due to their limited size and/or the potential constriction of flow. This is particularly important for the Cringle Brook, as several of these culverts are quite long e.g. Egerton Road Culvert is approximately 1.5km in length. Further information on each culvert is provided in Appendix C but the full list of culverts in the Cringle Brook model from upstream to downstream is:

- Wellington Road Culvert (upstream face NGR 387872 393179)
- Railway Culvert 1 (387620 393331)
- Davenhill Road Culvert (387416 393508)
- Erwood Road Culvert (387293 393567)
- Kempton Road Culvert (387024 393629)
- Kingsway Culvert (386493 393656)
- Railway Culvert 2 (386437 393634)
- Kingswood Road Culvert (386249 393508)
- Ladybarn Lane Culvert (385921 393419)
- Egerton Road Culvert (385750 393536)
- Footpath Culvert (384265 393838)

Bridges

There is a total of three bridges along the modelled extent of Cringle Brook. Bridges have the potential to significantly affect the flood hydraulics and limit downstream flows due to their limited size and/or the potential constriction of flow. There is further information about the bridges in Appendix C.

Weirs

There is a series of 4 weirs in the section of walled channel immediately upstream of Ladybarn Lane Culvert. These were installed as part of the Flood Alleviation Scheme (FAS) in 2004. These have been modelled as spill units, with some further information in Appendix C.

1.3.2 Hydrometric Gauges

There are two Environment Agency gauges within the Cringle Brook catchment, as shown in Figure 1-2. These are both located at the upstream face of Egerton Road Culvert; one recording flow and the other recording level. The level gauge has been in place since 2001, but the flow gauge was only installed in 2014. A rating review of the level gauge has been carried out for this study (as described in detail in Appendix B) and data from these gauges was also used to inform the hydrology calculations and verify the model predictions.

Data was also available for three nearby rain gauges; Parrs Wood, Denton and Platt Fields. They were used, in conjunction with the flow and level gauges, to improve the model calibration as described in Section 6.

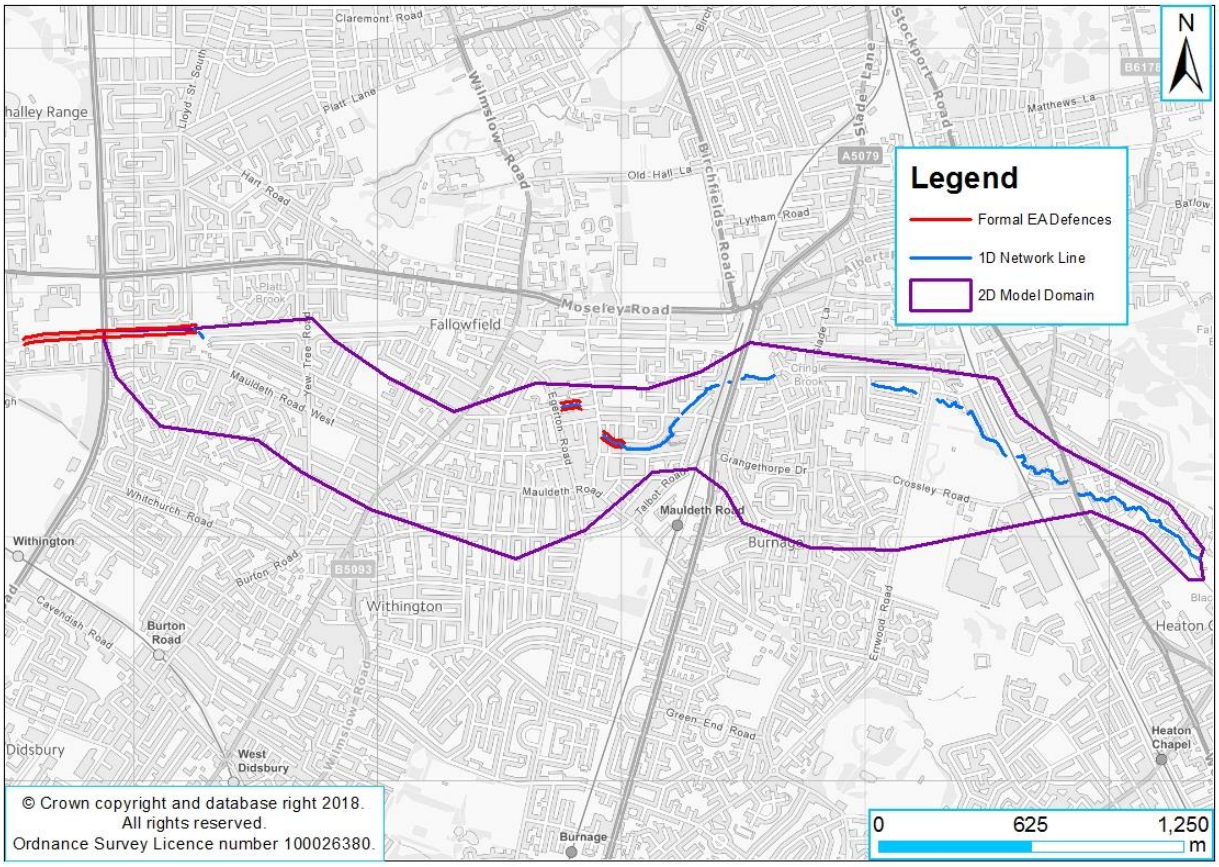
1.3.3 Flood Defences

The local Cringle Brook FAS was completed in 2004 and attempted to provide a 1% AEP standard of protection (SoP) to the Ladybarn Lane and Egerton road area, although no detailed local hydraulic model was available to inform the scheme. The FAS consisted of replacing degraded

culverts (Ladybarn Lane and Kingswood Road), constructing flood walls (formal Environment Agency defences) and adding several culverts (Erwood Road, Davenhill Road, Kempton Road and Kingsway). The scheme also involved adding debris screens to Egerton Road Culvert and near to Acorn Close in order to reduce the risk from culvert blockages.

The locations of formal Environment Agency defences within the Cringle Brook catchment are shown in Figure 1-3. These defences comprise of raised walls on both banks upstream of Egerton Road Culvert and Ladybarn Lane Culvert. There are also a number of informal walls alongside Cringle Brook, such as around McDonalds on the A6 (Stockport Road) that were not classed as formal defences prior to the study and the site visit found them in poor condition so these were not included in the defended (with defences) models. In addition, Figure 1-3 shows that there are also some formal raised flood defences along the Chorlton Platt Gore at the downstream end of the Cringle Brook.

Figure 1-3: Formal Environment Agency Defences within the Cringle Brook catchment



1.4 Flood History

The current Flood Zones show a significant area of Fallowfield to be at fluvial risk of flooding from the Cringle Brook. Upstream of Kingswood Road, the Flood Zones are smaller, and a minimal risk is shown in the vicinity of the Stockport Road and Davenhill Road Culverts.

September 2016 recorded the highest level in the 16-year record at the Egerton Road level gauge. Two properties were reported to have experienced flooding during this event, but this was discovered to have been due to surface water flooding and blocked drains that coincided with the fluvial peak. Fluvial flooding was reported in October 2001 near Ladybarn Lane, related to culvert blockage. However, this would have occurred prior to the installation of the local FAS, which include upgrading the capacity of this culvert. No fluvial flooding to property has been reported since the scheme was implemented.

1.5 Previous Studies

An original Cringle Brook hydraulic modelling study was undertaken by JBA Consulting as part of the 2006 Strategic Flood Risk Framework, which assesses the flood risk along Chorlton Platt Gore, Cringle Brook and Chorlton Brook (Cheadle). This produced an initial hydrology and the creation

of a 1D only (ISIS) model of the Chorlton Platt Gore that included Cringle Brook. Some basic 2D (JFLOW) modelling was also undertaken of some flow routes.

In 2010, Jacobs updated the Chorlton Platt Gore model to include a 2D (TUFLOW) domain to produce a linked 1D-2D (ISIS-TUFLOW) model. The hydrology remained unchanged from the previous study.

In 2012, Hyder Consulting were commissioned by the Environment Agency to make some minor updates to the Chorlton Platt Gore ISIS-TUFLOW model as part of an Upper Mersey Model Review and Update study. The most recent modelling report is from this study but, again, the hydrology of Cringle Brook remained unchanged.

In 2012, the Environment Agency also reviewed the hydrology for Cringle Brook as part of the South Manchester Strategy. This was undertaken because the existing river model appeared to show a poor correlation with historical flooding. Following this review and to aid future hydrology studies in the catchment, in 2014, the flow gauge was installed at Egerton Road Culvert and a rain gauge was also added in Platt Field Park.

1.6 Project Brief

The main aim of the Cringle Brook commission was to generate a new hydrology and an updated 1D-2D hydraulic model of Cringle Brook, which could be used to:

- Produce appropriate defended and undefended flood risk mapping deliverables;
- Provide an understanding of the risk of culvert blockage on these watercourses;
- Provide a robust evidence base to support any future Flood Alleviation Schemes (including an imminent PDU appraisal study).

1.7 Deliverables

The project findings are presented as follows:

- This Main Report with Technical Appendices, which detail the methods, assumptions, findings and recommendations;
- The updated 1D-2D hydraulic model;
- The mapped flood outlines;
- MapEdit compatible GIS layers.

1.8 About this report

This document forms the main report for the Cringle Brook Model study, which is part of the larger Environment Agency Modelling 4 package of works.

Chapter 2 describes the flood response in the Cringle Brook catchment. The hydrology and modelling approach and justification are outlined in Chapter 3 and the data that was available to the study in Chapter 4. Technical model (both hydrological and hydraulic) implementation is described in Chapter 5, which includes a summary of model proving, which is provided in greater detail for this study as part of Appendix C. Model calibration is discussed in Chapter 6 and model results are detailed in Chapter 7. The main assumptions made in developing the models and limitations of the final models and results are listed in Chapter 8. Conclusions and recommendations for further work are detailed in Chapter 9. Flood Warning will be provided in a separate addendum to this report.

2 Flood Response

This chapter briefly summarises the flood risk along the Cringle Brook, using the source-pathway-receptor model. A more detailed assessment of the flood response is provided in succeeding chapters.

2.1 Sources

Flooding could potentially occur in the Cringle Brook study area from a variety of sources; fluvial, surface water, ground water and/or surcharging of the sewer system[1]. However, this study only assesses the fluvial risk from the modelled watercourse. The source is, therefore, limited to high rainfall in the Cringle Brook catchment, although there may be some minor additional contributing factors (e.g. wet antecedent conditions that may leave rivers at a high level prior to a major fluvial event or high downstream levels on the Chorlton Platt Gore).

2.2 Pathways

Due to the significant urban coverage within the catchment, there is generally a very short lead time before a flood wave peaks on Cringle Brook and fluvial flooding will result when the channel capacity is exceeded. The most obvious risk is overtopping of the bank crest, potentially accentuated by structures, leading to potential inundation of receptors. There is also a risk to receptors from the blockage of structures leading to overtopping.

2.3 Receptors

The extent of the catchment is urban, including the Manchester suburbs of Fallowfield, Heaton chapel and Burnage. These urban areas have associated amenities, homes and businesses, many of which are at a potential risk of flooding. Previous modelling predicts that a large number of properties could be at risk in the downstream part of the catchment via flow routes that originate upstream of the 2004 FAS defences. Floodwater exiting the channel in these areas cannot easily return to the watercourse due to the limited length of open channel reaches, the presence of the walls and the gentle gradient of the lower catchment allowing floodwater to flow westwards through Fallowfield towards the Chorlton Platt Gore.

[1] The risk from surcharging of the sewer system has been accounted for to some extent within the hydrology, which uses Urban ReFH units, which account for the capacity of the sewer system (although this is a simplistic representation).

3 Model Approach and Justification

3.1 Approach Requirements

The main aim of the study was to generate new hydrology for the Cringle Brook and create a standalone 1D-2D hydraulic model of Cringle Brook from the Environment Agency's existing Chorlton Platt Gore model, which incorporated some of the recommendations of a model review that was carried out at an inception stage. The model will be used to facilitate improvements to the Environment Agency's Flood Map for Planning and deliver a baseline fluvial hydraulic model that can be used to inform future development proposals. The model outputs will also be used to produce data suitable for future use in the 'Risk of Flooding from Rivers and Sea' maps.

This chapter outlines the modelling rationale.

3.2 Hydrological Modelling

The project scope stated that a new hydrological assessment that draws on the flow record now available within the catchment was a key requirement of this study.

The FEH Statistical method was considered the most suitable method to derive peak flows using gauge data from within the catchment. However, the flow gauge was considered unsuitable for use in the hydrological assessment due to data quality issues. Instead, a rating curve was derived from the updated model to provide a relationship between level and flow at the Egerton Road gauging site. Therefore, the QMED peak flow estimate was generated by evaluating the LMED value from the river level record at Egerton Road gauge and applying the derived rating curve to this LMED value.

The hydrograph shapes were derived from Urban ReFH so include for the relative timings of inflows from both the rural and urban (sewer) components of the catchment. Further detail on the methodology and findings of the hydrological analysis can be found in Section 5.1 and Appendix B.

3.3 Hydraulic Modelling

The project scope required that this study would review and update the existing model representation of Cringle Brook, with a requirement to create a suitably high definition representation of the urban floodplain in 2D. On project start up, it became apparent that the most recent version of the Cringle Brook model already included a 2D (TUFLOW) domain. However, it was decided that a standalone model of Cringle Brook effectively required the development of a new higher definition 2D domain.

A formal model review was required at the inception of the study. This concluded that the main hydraulic model updates should be to trim the existing Chorlton Platt Gore model and increase the definition of the resulting Cringle Brook model. The approach to the model updates were documented as part of this review, which can be found in the Cringle Brook Technical Review Certificate provided as Appendix D. Further detail of the model development can be found in Section 5.2 and Appendix C.

4 Input Data

This chapter lists the data made available by the Environment Agency for use in the Cringle Brook study.

4.1 Existing Hydraulic Model

The Environment Agency supplied JBA with the most recent version of the Chorlton Platt Gore model and associated report, dated March 2012, which had been produced as part of the Upper Mersey Model Review Update by Hyder Consulting in 2012. This model was a linked 1D-2D (ISIS-TUFLOW) model covering the Chorlton Platt Gore and Chorlton Brook, in addition to Cringle Brook. Some of the key, supplied, baseline, model files that were used to undertake the model review are listed below.

Supplied 1D (ISIS) model components:

- CPG_JBA_DoMin_100_v9_HCL_2011_RA-v4.DAT
- IED files:
  - 10% - CPG_10_JBA.IED
  - 4% - CPG_25_JBA.IED
  - 1.3% - CPG_75_JBA.IED
  - 1% - CPG_100_JBA.IED
  - 0.1% - CPG_1000_JBA.IED and CPG_1000_JBA_HCL_2011.IED

Supplied 2D (TUFLOW) model components:

- Defended
  - 10% - CPG_DEF_Q10_JBA_HCL_2011-V4.tcf
  - 4% - CPG_DEF_Q25_JBA_HCL_2011-V4.tcf
  - 1.3% - CPG_DEF_Q75_JBA_HCL_2011-V4.tcf
  - 1% - CPG_DEF_Q100_JBA_HCL_2011-V4.tcf
  - 0.1% - CPG_DEF_Q1000_JBA_HCL_2011-V4.tcf
  - CPG_DoMin_QXXX_lower_HCL.tbc
  - CPG_DEF_QXXX_HCL.tgc
- Undefended
  - 4% - CPG_UNDEF_Q25_JBA_HCL_2011-V4.tcf
  - 1.3% - CPG_UNDEF_Q75_JBA_HCL_2011-V4.tcf
  - 1% - CPG_UNDEF_Q100_JBA_HCL_2011-V4.tcf
  - 0.1% - CPG_UNDEF_Q1000_JBA_HCL_2011-V4.tcf
  - CPG_DoMin_QXXX_lower_HCL.tbc
  - CPG_UNDEF_QXXX_HCL.tgc

4.2 Cartographic Data

4.2.1 Ordnance Survey Mapping

Ordnance Survey (OS) maps at 1:50,000 and 1: 250,000 scales, along with the 1: 10,000 scale Vector Map local, were supplied under license for use as map backgrounds.

OS Mastermap was also supplied and used to inform the spatially variant floodplain (2D) roughness map used by the model.

4.3 GIS Data

The following GIS layers were available to help inform the study and present the results;

- United Utilities Sewer Network GIS data (to assist with Urban Hydrology)
- Existing Flood Maps
- River Centrelines

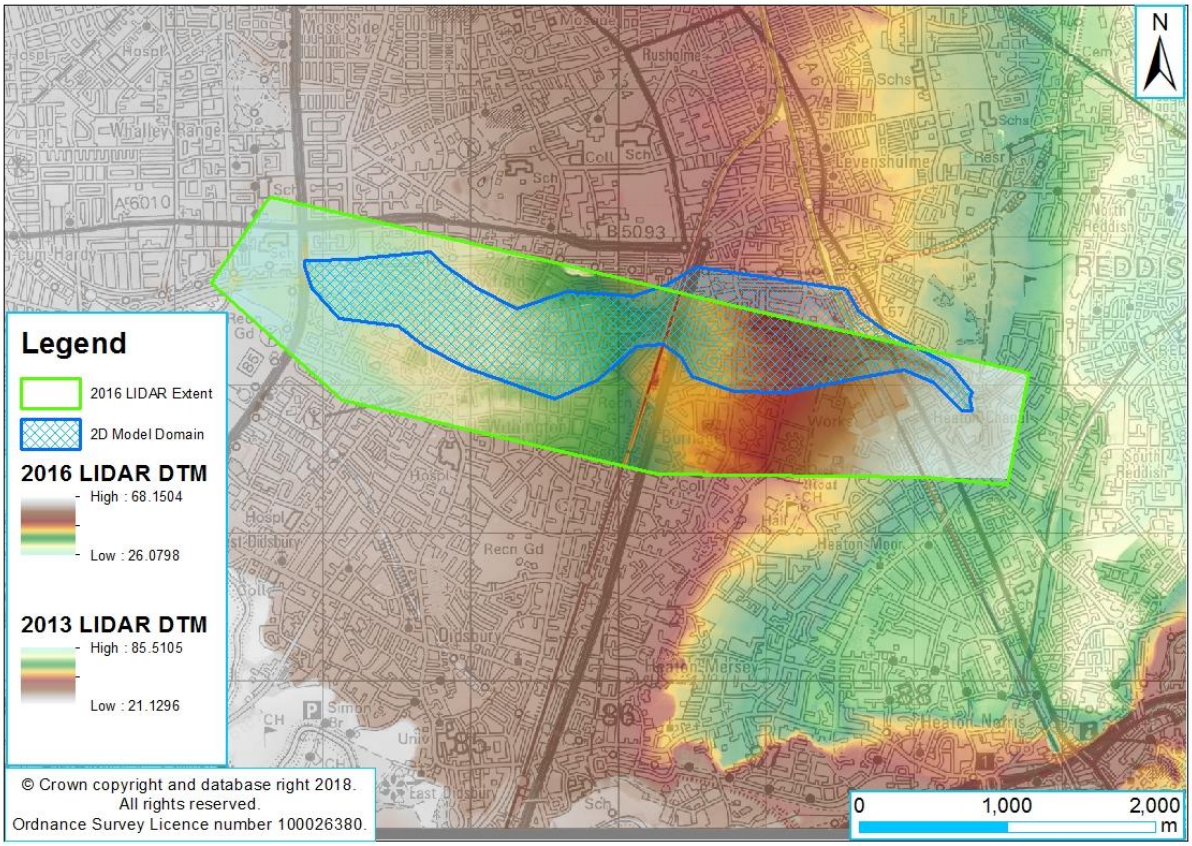
- Environment Agency Asset Database
- National Receptor Database

4.4 Topographic Data

4.4.1 LIDAR

The most up to date Environment Agency LIDAR DTM tiles for the study area were downloaded at 1m resolution from the Open Data data.gov.uk website for this study. This included LIDAR flown in March 2016 and February 2013. The 2016 LIDAR did not cover the entire study area, so was supplemented with 2013 LIDAR where necessary. The extent of the available LIDAR is shown in Figure 4-1. By contrast, the Chorlton Platt Gore (2012) hydraulic model had used LIDAR tiles dating from February 2002.

Figure 4-1: LIDAR coverage across the model extent



The 1m resolution LIDAR DTM tiles that were used in the model were downloaded from https://environment.data.gov.uk/ in August 2017 as the following tiles;

Flown in March 2016

- dtm_F0189976.asc_20160325_20160325_mm_units.asc
- dtm_F0189980.asc_20160325_20160325_mm_units.asc
- dtm_F0189971.asc_20160325_20160325_mm_units.asc
- dtm_F0189972.asc_20160325_20160325_mm_units.asc
- dtm_F0189967.asc_20160325_20160325_mm_units.asc
- dtm_F0189968.asc_20160325_20160325_mm_units.asc

Flown in December 2012 - February 2013

- dtm_F0158598_20121210_20130201_mm_units.asc
- dtm_F0158610_20121210_20130201_mm_units.asc
- dtm_F0158587_20121210_20130201_mm_units.asc

- dtm_F0158588_20121210_20130201_mm_units.asc
- dtm_F0158577_20121210_20130201_mm_units.asc
- dtm_F0158578_20121210_20130201_mm_units.asc

4.4.2 Topographic Survey

Previous Survey Data (2006)

All river section data within the existing Cringle Brook model was based on survey that had been collected by Maltby in October 2006. This survey was made available by the Environment Agency for this study. The Maltby survey covers the entire 1D model extent from Heaton Chapel to the confluence with Chorlton-Platt-Gore and contains 57 channel cross sections, 10 culverts, a series of small weirs, and several other smaller structures (e.g. footbridges, pipes).

The Maltby survey has been compared to the various LIDAR datasets and is much more consistent with the later (2013 and 2016) datasets than that from 2002. Therefore, the survey was used as supplied.

This survey data does not appear to have an Environment Agency reference number, although was given a reference number of 2016s1853 (relating to the original JBA Consulting project number). It was provided by the EA on a hard drive in the location "Survey Data\Cringle Brook\2007 Survey".

2017 Spot Level Survey

A local crest level survey of the walled defences upstream of Egerton Road and Ladybarn Lane was undertaken by JBA Consulting in October 2017 for this commission. This survey was used to define the crest level of the flood defences in the defended version of the model. The survey also picked up the base levels of the flood wall, which were used to define the bank crests in the undefended version of the model.

4.5 Hydrometric Data

Flow data at 15-minute intervals was provided for the Egerton Road Debris Screen gauge on Cringle Brook from June 2014 to June 2017. Level data was provided for the Egerton Road Culvert gauge from April 2001 to November 2011, also at 15-minute intervals. A small number spot gaugings were also provided by the Environment Agency for use in the rating review.

Rainfall data (at 15-minute intervals) was also provided for three gauges: Platt Fields Park (2014-present), Denton (1998-present) and Parr Wood (1990-2005) for use in the hydrology assessment and model calibration.

4.6 Calibration/Verification Data

No detailed flood information data, other than the hydrometric data listed above, was available for use in calibrating the model. There are some flood investigation reports available for the September 2016 event but, as flooding is now believed to have originated from surface water flooding, this was of little use to calibrating the fluvial model. A flood outline was also provided for the October 2001 event but, as this occurred before the FAS was installed, this event would not have been reproducible using the current model.

4.7 Culvert Inspection Reports

The Environment Agency supplied a set of eight culvert inspection reports dating from 1998, 2000 and 2005. Since these reports had previously been used to model the internal geometry of structures in the supplied Chorlton Platt Gore model, these were only used for reference.

4.8 Site Visit

A site walkover was attended by representatives from the Environment Agency and JBA Consulting on 2 March 2017.

A comprehensive record of photographs was taken during this site visit, some of which appear in this report.

5 Technical Method and Implementation

This chapter outlines the broad technical development of the hydrological and hydraulic models. Further detail on the hydrology and hydraulic model is provided in Appendix B and Appendix C, respectively.

5.1 Hydrological Modelling

5.1.1 Catchment Characteristics

The Cringle Brook is situated in South Manchester and flows through the suburbs of Heaton Chapel, Burnage and Fallowfield, before joining the Chorlton Platt Gore. At the upstream extent of the study reach, the catchment is 2.3km^2, increasing to 6.4km^2 at the downstream extent of the study reach, at the confluence with Chorlton Platt Gore.

The whole catchment is very heavily urbanised, with only small areas of parkland that are not paved. Many parts of the watercourse are culverted, particularly in the downstream reaches, which contain the 1.5km long Egerton Road Culvert. The watercourse is also relatively steep, which combined with the urban nature, leads to a very flashy response time to a rainfall event.

The Cringle Brook catchment comprises loamy and clayey soils, which is indicative of impeded drainage. The underlying geology is mainly sandstone and conglomerate, with some areas of mudstone, siltstone, coal, ironstone and ferricate, and superficial deposits of till. However, the main feature influencing the catchment runoff response is the high degree of urbanisation.

Further details of the catchment (and descriptors) are provided in the Flood Estimation Handbook (FEH) calculation record (Appendix B).

5.1.2 Methodology and Outcomes

The detail of the hydrological assessment is provided in Appendix B. Some important aspects of the hydrological analysis are;

- Peak flows were derived at four locations along the study reach. These were i) the upstream modelled extent of Cringle Brook, ii) the downstream modelled extent of Cringle Brook iii) the location of the flow and level gauges at the upstream of Egerton Road Culvert, and iv) at the downstream of one obvious tributary. The catchment boundaries for these four flow estimation points are shown in Figure 5-1.
- The Cringle Brook (1D-2D) hydraulic model updated for this study was used to generate a rating at the Egerton Road debris screen flow gauge. The modelled rating is shown in Figure 5-2. This rating was considered sufficiently reliable to produce an accurate estimate of QMED from the LMED value that was evident in the recorded (16 year) level gauge data but it should be noted that a reliable rating could only be achieved up to the level where surcharging and subsequent bypassing of the culvert occurred, which is close to a 10% AEP threshold. Further details on the rating can be found in Appendix B.
- The catchment descriptors for each of the flow estimation points were extracted from the FEH CD-ROM. However, after checking these against the OS Mapping and Detailed River Network (DRN), it became apparent that the CD-ROM incorrectly defines the Cringle Brook sub-catchments due to their heavily urbanised and modified nature. Therefore, catchment boundaries were altered based on an ArcHydro assessment using the available LIDAR data for all catchments. The ArcHydro assessment generated an updated set of catchment boundaries for all topographic sub-catchments and some additional manual adjustments of these were made to include drains that were evident in the DRN and other available watercourse information.
- To assign catchment descriptors to the manually edited Cringle Brook sub-catchments, the FEH catchments derived for the upstream and downstream extents of Cringle Brook were used as donors. These FEH donor catchments are shown in Figure 5-1, with the upstream FEH catchment used as a donor for CRIN_US, and the downstream FEH catchment used as a donor for CRIN_Gauge and TRIB_01 in addition to CRIN_DS for consistency. These catchment descriptors were updated for AREA, DPLBAR, FARL and URBEXT to reflect the final Cringle Brook sub-catchments.

Figure 5-1: Cringle Brook catchment boundaries and flow estimate locations

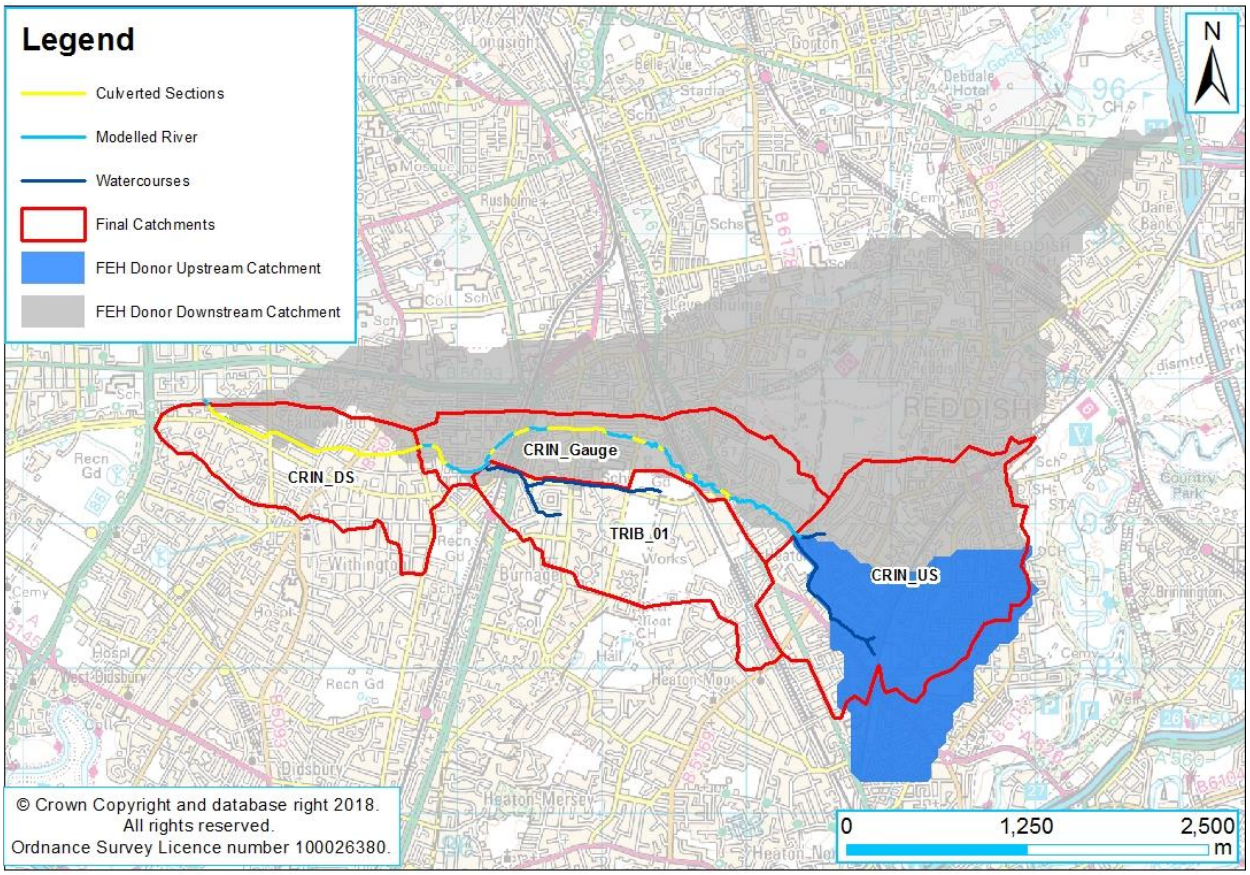
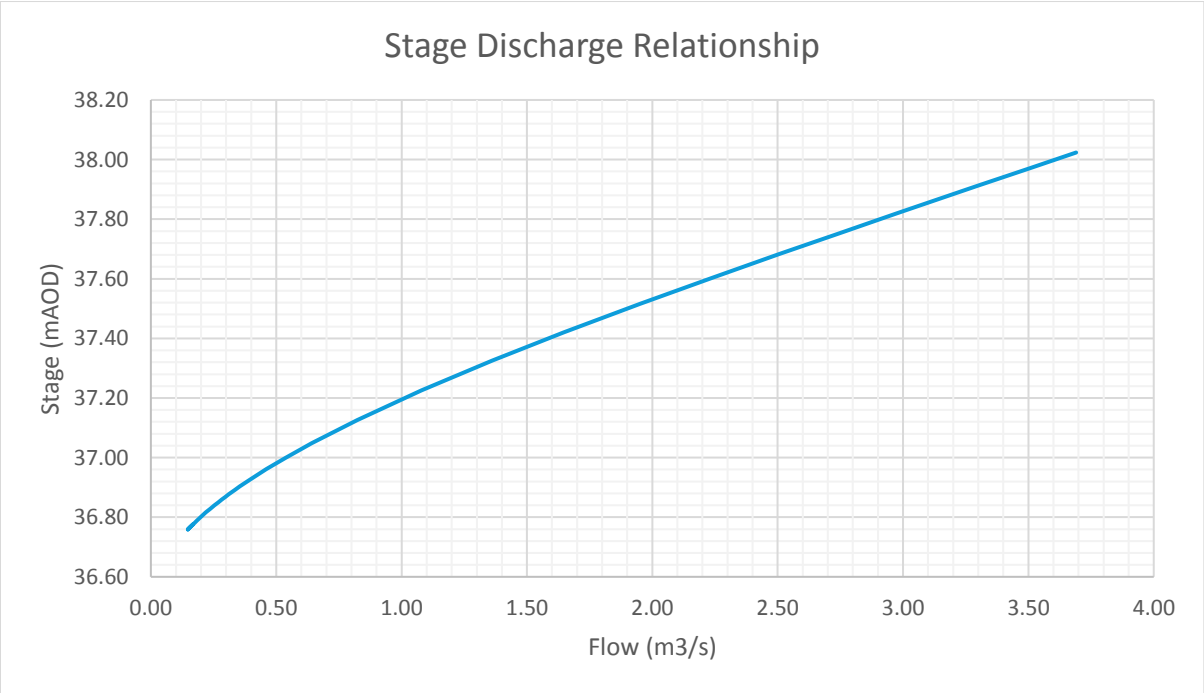


Figure 5-2: Stage Discharge Relationship at the Egerton Road Debris Screen Gauge



- Two different methods were used to generate peak flow estimates - the FEH Statistical method, which makes more use of the available gauge data, and the ReFH1 (Urban) method, which takes into account the urbanised nature of the catchment. For the FEH Statistical method, the level gauge data was used to calculate a value of LMED (i.e. the median level from the annual maximum series), which was then converted to a QMED (flow) using the model rating at the gauge. The adjustment factor for QMED at the gauge was also applied to the other sub-catchments to generate consistent QMED values.
- The comparison of peak flow estimates for the two different methods revealed that the FEH Statistical method produces higher estimates for QMED than the ReFH (Urban) method, but generally lower estimates for the 1% AEP event. This is attributed to the considerable catchment area that drains into the combined sewers so will not enter the main watercourse during low return period events but will, however, enter the watercourse for larger events when the sewer capacity is exceeded.
- The FEH Statistical method was preferred method in this study to generate peak flow estimates for the Cringle Brook catchments, since this method uses the observed data from the in-catchment level gauge to derive QMED. However, the hydrograph shapes have been derived from Urban ReFH, so these will better represent the timings of inflows from rural and urban components of the catchment. The ratio method (based on the ReFH1 ratio for the 0.1% AEP peak flow estimate compared to the 1% AEP peak flow estimate) was used to calculate peak flows for the extreme 0.1% AEP event. The final peak flow estimates are given in Table 5-1.

Table 5-1: Final calculated peak flow estimates for the Cringle Brook catchments

Site Code	Flood peak (m3/s) for the following return periods (in years)										
	2	**5**	**10**	**20**	**25**	**30**	**50**	**75**	**100**	**200**	**1000**
CRIN_US	1.6	2.0	2.3	2.7	2.8	2.9	3.3	3.6	3.9	4.6	10.4
CRIN_Gauge	3.0	3.9	4.5	5.3	5.5	5.8	6.5	7.1	7.6	8.9	20.2
CRIN_DS	3.7	4.7	5.5	6.4	6.8	7.0	7.9	8.7	9.3	10.9	25.7
TRIB_01	1.0	1.3	1.5	1.7	1.8	1.9	2.1	2.3	2.5	2.9	6.5

- The critical storm duration for Cringle Brook was assessed by running a set of four different storm durations through the updated model. These were 1.3 hours, 1.7 hours (the ReFH recommended duration), 2.1 hours and 2.9 hours. By analysing the resulting peak water levels, it was determined that the critical storm duration across the Cringle Brook catchment would be 2.1 hours.
- The catchments for Cringle Brook are very heavily urbanised, and as such, are likely to have a greater response to short duration, high peaked, flow events, rather than large volume flood events. Therefore, summer season hydrographs were used to derive appropriate model inflow hydrographs.
- Inflows from the un-modelled tributary and lateral catchment were also calculated and modelled using ReFH (Urban) derived hydrographs based on a design Summer rainfall event and a storm duration of 2.1 hours.

5.2 Hydraulic Modelling

This section summarises the updates that were made to the supplied Chorlton Platt Gore 1D-2D (ISIS-TUFLOW) model. A model schematic is provided as Figure 5-3 and further detail on the model is documented in Appendix C.

5.2.1 1D Domain

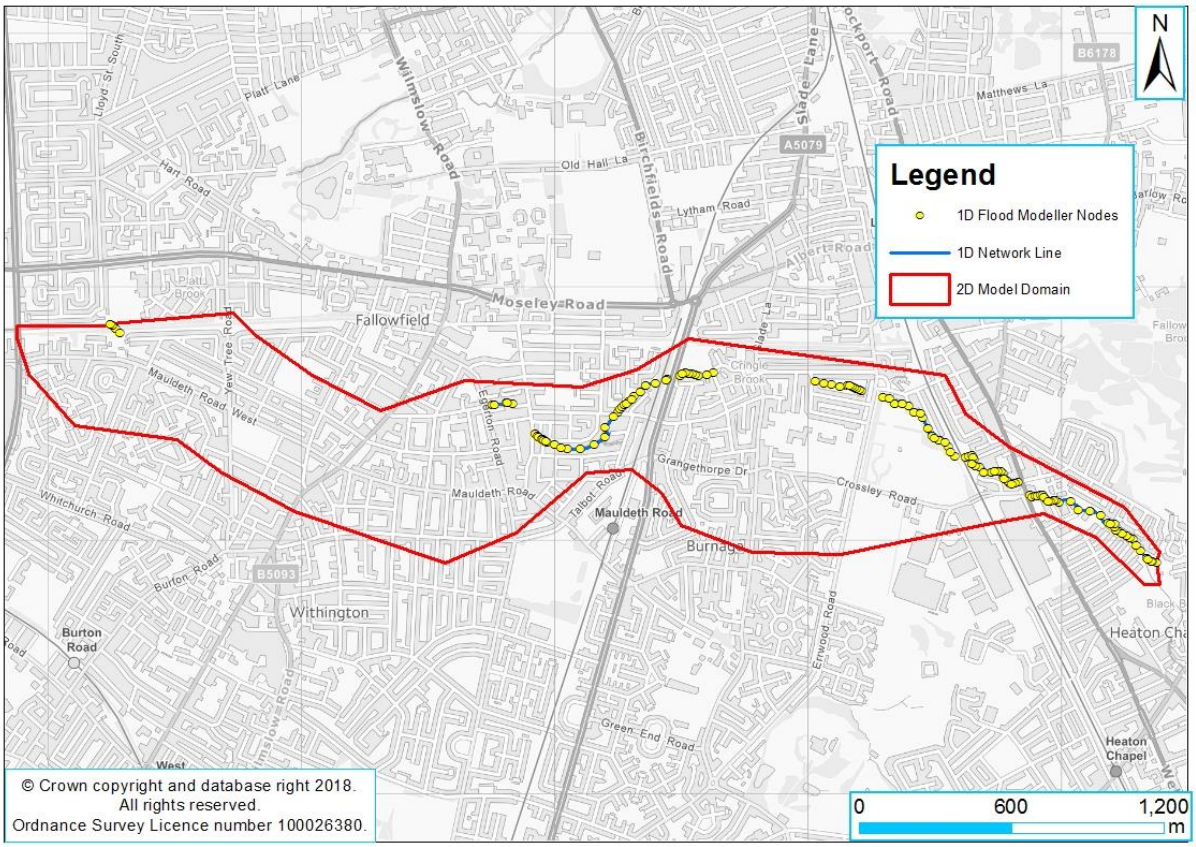
The project scope required that this study would review and update the existing model of Chorlton Platt Gore to produce a standalone model of Cringle Brook. The model review at the inception of the study concluded that the main changes that ought to be made to the 1D component of the model were to remove all watercourses other than Cringle Brook from the existing model and remove the unconventional use of flat cross-section extensions from the existing model. Some minor changes to 1D structures were also recommended. These changes are documented in more detail in the

Technical Review Certificate provided as Appendix D and the detailed modelling approach is documented in Appendix C.

In summary, the following 1D changes were made:

- The Chorlton Platt Gore 1D model was trimmed to just leave the Cringle Brook.
- Several of the river sections, which had 2m wide flat panels on both banks, were adjusted to remove these flat panels and, instead, the 2007 survey and/or most recent LIDAR (2016 or 2013) was used to obtain greater consistency between the active 1D and inactive 2D channel bank crests.
- Some small adjustments were made to roughness values in the vicinity of the gauging station at Egerton Road, and upstream of Ladybarn Lane Culvert. These were carried out to improve verification between model results and flood history observations as part of the model verification.
- Blockage units or orifice units that were present at the upstream face of several culverts were updated to culvert inlet units. A culvert outlet unit was also added to Erwood Road Culvert.
- Bridge unit cross sections were trimmed to the active 1D width of the upstream and downstream channel sections.
- A 1D overtopping SPILL was added to the Woodlands Road footbridge at the surveyed deck level.
- The series of weirs upstream of Ladybarn Lane Culvert were changed to SPILL units with a weir coefficient of 1.7. This increased their efficiency and improved the model verification relative to the existing configuration.
- Top slots were added to several culverts (Egerton Road, Ladybarn Lane, Kempton Road and Erwood Road) to improve stability during extreme events.

Figure 5-3: Cringle Brook Model Schematic



5.2.2 2D Domain

Although, the supplied Chorlton Platt Gore model already had an associated 2D (TUFLOW) domain, a new 2D domain was developed for this study to improve the model definition from the original model and allow a consistency of approach across the MP4 modelling package. This section highlights some of the main decisions that were involved in developing the 2D component of the hydraulic model;

- A 2m definition model grid was defined across an active area of 3.37m^2 that enclosed the most extreme flood outline obtained from the study without significantly ponding against the domain boundaries. A 2m cell size was able to provide a high urban definition at manageable run times aided by the relatively small size of the 2D domain.
- Floodplain ground elevations were primarily defined using filtered LIDAR (DTM). Several topographic modifications were made to this LIDAR based model grid, the most important being the elevation of the (1D-2D) bank crests. These are listed in Sections 2.3 and 6.4 of Appendix C.
- Floodplain roughness was defined based on OS MasterMap Land Use categories, as documented in Section 2.3 of Appendix C. This is consistent with other new build models that were created for the MP4 modelling package.
- Buildings were represented in the model via raised roughness values of 1.0 but with no topographic alterations (e.g. threshold levels). This is also consistent with other new build models that were created for the MP4 modelling package.

5.2.3 Model Scenarios

Defended Model

The walled defences alongside Cringle Brook were incorporated in the defended (with defences) version of the model by including the wall crest levels within a GIS z-line layer. These levels define the height of the bank crests on the basis of the wall crest survey that was undertaken by JBA Consulting in October 2017.

The model layer defining the defence crests on the Chorlton Platt Gore at the confluence with Cringle Brook was retained from the existing model.

Undefended Model

A different set of bank crest elevation points were defined in the undefended version of the model, which included the levels taken at the base of the walled defences (as surveyed in October 2017).

The model layer defining the defence crests on the Chorlton Platt Gore has been retained in the undefended version of the model. This is because it is not a Cringle Brook defence, and this configuration is likely to provide a worst-case scenario, as it prevents water enter the Chorlton Platt Gore, therefore keeping it in the Cringle Brook catchment.

Blockage Runs

In addition to modelling the present-day flood risk, the Environment Agency requested simulation of various structure blockage scenarios, to assess the implications of culvert or bridge blockage on local flood risk.

The impact of blockage was modelled at the following six structures;

- Wellington Road Culvert (the A6 near McDonalds)
- Erwood Road Culvert
- Kempton Road Culvert
- Kingsway Culvert (immediately upstream of the railway)
- Ladybarn Lane Culvert
- Egerton Road Culvert

Blockage runs were carried out for blockage proportions of 25%, 50% and 75% at each of these structures, and for both the 1% AEP (present day) and 1% AEP with climate change (+30%) events.

5.2.4 Hydraulic boundaries

Hydraulic boundaries are defined in both the 1D (FM) component and 2D (TUFLOW) components of the model. These include;

1D (FM) boundaries

- Three ReFH boundary units representing the inflow into the Cringle Brook at its upstream extent, a point inflow from the un-modelled tributary, and one diffuse lateral catchment inflow (modelled via a lateral inflow unit). It should be noted that a lateral inflow was not applied downstream of the Egerton Road gauge because the entire reach between the gauge and the Chorlton Platt Gore confluence is culverted, so any run-off generated within this downstream catchment area will be unable to enter the Cringle Brook. Therefore, flow estimates at the downstream of the model are based on the peak flows estimated for the gauge location (i.e. catchment CRIN_Gauge).
- A HTBDY (head-time) boundary is applied at the downstream extent of the model to represent the extracted 1% AEP level series on the Chorlton Platt Gore as extracted from the supplied model.

2D (TUFLOW) boundaries

- HX boundaries were defined along the river banks of open reaches to permit movement of water between the (1D) channel and (2D) floodplain.
- A HQ boundary was defined, as necessary, along the downstream edge of the active 2D domain to allow floodwater to exit the model via the floodplain into the Chorlton Platt Gore.

5.2.5 Climate Change

The Environment Agency released new guidelines, in February 2016, on how the predicted (UKCP09) effects of climate change should be applied to flood risk modelling. The Cringle Brook study area is situated in the NW England area and the climate change scenarios that were required to implement the new guidance in this study are shown in Table 5-2.

Table 5-2: Climate Change Scenarios

Study	AEP	Scenario	Flow increase
Cringle Brook	1%	2080s epoch – Central (50th)	30%
	1%	2080s epoch – Higher Central (70th)	35%
	1%	2080s epoch – Upper (90th)	70%
	0.1%	2080s epoch – Central (50th)	30%

5.3 Model Proving

5.3.1 Calibration

Full details of the model calibration are detailed in Section 6.

5.3.2 Sensitivity Testing

Sensitivity testing demonstrates the variation in model results that can arise from varying certain, key, model parameters and/or inputs within potentially realistic ranges. Sensitivity testing is described in detail in Appendix C (Section 5.2). All sensitivity tests were carried out on the 1% AEP defended model. In summary, sensitivity tests were carried out on the Cringle Brook model with respect to the following parameters;

- Manning's *n* roughness, ±20% change in roughness in 1D open channel and 2D domains.
- Model inflow - ±20% change in all 1% AEP model inflows.
- Downstream boundary - 10%, 1% and 0.1% AEP river levels on the Chorlton Platt Gore.

The following model sensitivities were recorded for the Cringle Brook model:

- Varying hydraulic roughness by ±20% causes variations in the 1% AEP peak river levels of up to 0.2 metres from the baseline case. The flood extents are relatively insensitive to changes in roughness, as a significant proportion of the watercourse is culverted.

- Varying model inflows by ±20% causes variations in the 1% AEP peak river levels of up to 0.6 metres from the baseline case, mainly upstream of Kingsway Culvert. The flood outlines vary by around ±36-59%, with the increase in flow having a larger effect than the decrease in flow.
- The modelled 1% AEP river levels and flood extent are relatively insensitive to the design event used on the Chorlton Platt Gore at the downstream boundary. The choice of downstream boundary was modelled to largely restrict variations in the 1% AEP peak head to within the Egerton Road culvert. The resulting flood extents are very similar for the 10% AEP and 1% AEP events, but the 0.1% AEP event causes an increase in flooding of 7.5% at the downstream extent of the model, solely originating from the downstream boundary.

5.4 Flood Mapping

In order to generate the Flood Mapping outputs required from the study, both defended ('with defences') and undefended ('without defences') versions of the model were developed. The files used in each version of the model are described in more detail in Appendix C.

The Cringle Brook model was configured to produce water level, depth, velocity and hazard grids at a 2-metre definition. These peak water level, depth, velocity and hazard grids have been supplied as project deliverables for each probability event that was run through the model and are supplied in Appendix A.

5.5 Model Performance

This section provides a summary of the general performance of the updated Cringle Brook (2018) hydraulic model:

- All models were run double precision with a one second 1D (FM) timestep and a 0.5 second 2D (TUFLOW) timestep.
- The model runs for the majority of the design events have been run for a hydrograph duration of 10 hours. There was still some slow spreading along the road network at this time but since this was slow and shallow and was considered unlikely to adversely impact on properties. The 1% AEP future events (accounting for climate change) and the 0.5% AEP event were run for longer hydrograph durations of 15 hours as there was still a faster, deeper spread of floodwater 10 hours into the model runs.
- Model runs typically took between 6 hours and 15 hours (dependent largely on the event, but also scenario and number of modelling cores that were being used at the same time).
- Several local and global stability measures were taken to prevent model instability from adversely influencing the model results and the final models are considered acceptably stable. These measures included:
    - i. The use of a global automated Priessmann slot in the 1D model.
    - ii. Local 2D roughness patches to improve local model stability with additional roughness patches for the most extreme design events.
    - iii. Top slots and/or bottom slots were applied in several of the culverts.

5.5.1 1D (FM) Stability

The Flood Modeller run-time convergence plots indicate that the Cringle Brook model is suitably stable. There are some short periods of non-convergence associated with the surcharging of Egerton Road culvert (which is 1.5km in length and changes shape), as shown in Figure 5-4 but the 1D time series results through this culvert have been checked and it is evident that these periods of instability do not affect the overall model results.

The 1D results plots merely reflect the flow within the confines of the channel and, during high flow events, 2D flow patterns should be considered. Some oscillation in the 1D-2D flux is evident in a small number of locations in the supplementary 2D flow results but this was not considered to be of a scale that could have adversely affected the model results.

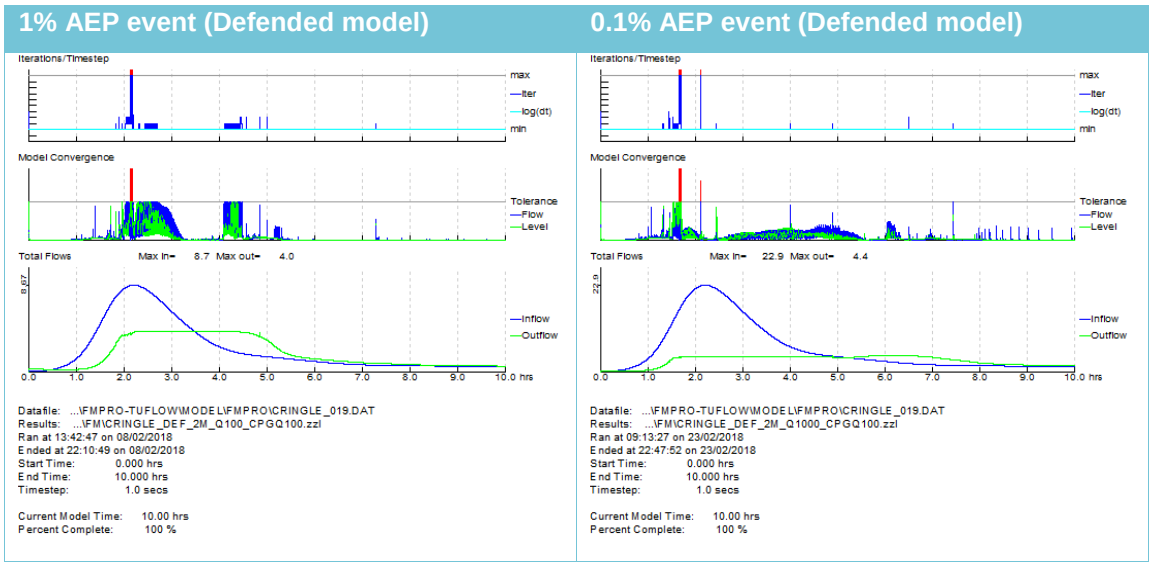
5.5.2 2D (TUFLOW) Stability

There are several TUFLOW stability checks that should be undertaken on models. These include:

- Checking the number and location of any negative depth warnings;

- Checking the 2D mass balance error (both cumulative as recorded in tabular form and spatially as viewable via MB1 and/or MB2 map outputs);
- Checking that there are no sharp or persistent oscillatory changes in the total volume of floodwater in the 2D domain between timesteps (dVol).

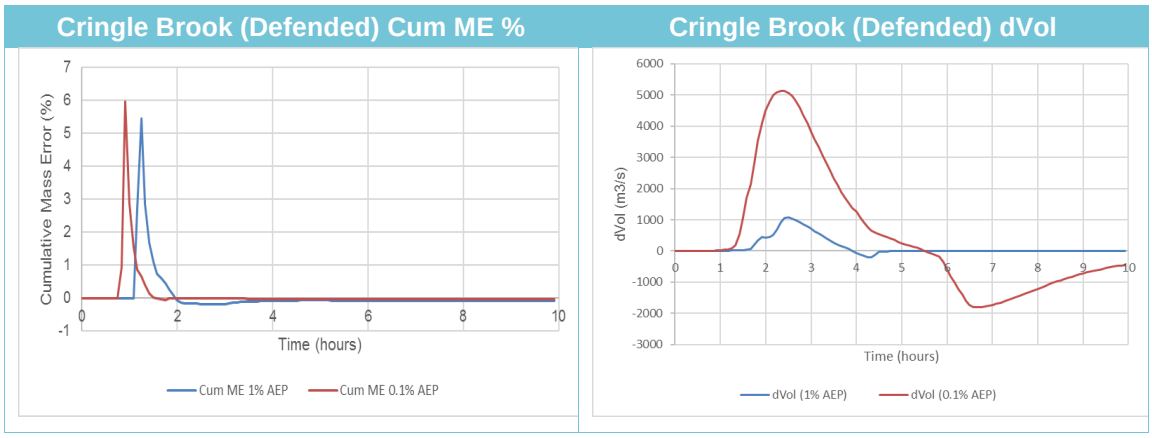
Figure 5-4: Flood Modeller Convergence Plots for the Cringle Brook Model



More detail on these checks on the Cringle Brook model can be found in Appendix C. In summary, across the model design runs:

- There are no 2D negative depths within the model domain.
- The final cumulative 2D mass balance errors are generally within the guideline tolerance of ±1%. Figure 5-5 shows the time varying cumulative mass balance error plots for the 1% and 0.1% AEP events and this shows that, apart from some issues on initial wetting that will have no impact on peak conditions, the MBE is smooth and within tolerance for the duration of the model runs.
- No local mass balance errors, as highlighted in the MB1 and MB2 maps, were found that could be considered to have had a significant adverse impact on the model results.
- The cumulative dVol plots (Figure 5-5) show no evidence of sudden changes or oscillatory behaviour in the dVol during the model runs. The overall shape is due to flood water entering the 2D domain (from 1D) during the rising limb of the flood event and, in the case of the 0.1% AEP event, some of this floodwater returning from the 2D domain (to 1D) as the inflow hydrographs recede. Some stability measures, including roughness patches and widening the 1D channel, helped reduce any initial oscillations in dVol.

Figure 5-5: TUFLOW 2D mass balance error (ME%) and dVol plots for 1% and 01% AEP events



6 Model Calibration

6.1 Introduction

The scope of the study specified the undertaking of a joint hydrologic and hydraulic modelling calibration of the Cringle Brook model limited to one event using the hydrometric datasets that were available for the study.

6.1.1 Available Data

The available datasets used in the model calibration were:

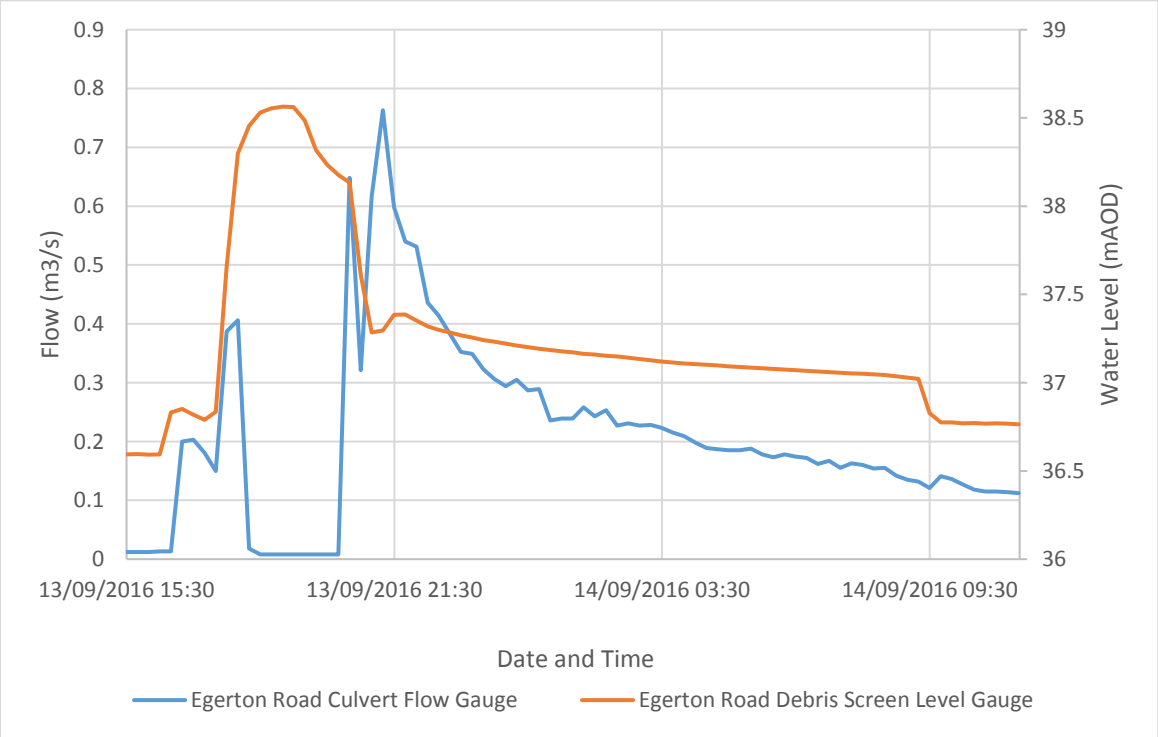
- 15-minute rainfall data at Denton TBR gauge
- 15-minute rainfall data at Platt Fields Park rain gauge
- 15-minute flow data at the Egerton Road Culvert flow gauge
- 15-minute level data at the Egerton Road Debris Screen level gauge
- A description of the specified event provided by the Environment Agency.

6.1.2 September 2016 Flood Event

The September 2016 flood event was chosen to calibrate the model, as this is the largest event on record at the Egerton Road Debris Screen level gauge. This event is also included in the rain gauge record at Platt Fields Park, which was only installed in 2014 so only has 3 years of rainfall data.

This event occurred after the installation of the flow gauge at Egerton Road Culvert flow gauge, so the observed flow should have been captured by this gauge. However, the flow gauge, unfortunately, was found to have dropped out during this event and did not record across the peak (Figure 6-1). Indeed, as documented further in Appendix B, the flow gauge has dropped out during several high flow events since it was installed in 2014 so, unfortunately, cannot be considered a reliable source of flow calibration data during high flow events and all events that were satisfactorily recorded appear to be below QMED so are not suitable for calibration of high flow events. Consequently, the Egerton Road Culvert flow gauge data was not considered useful enough to be used in the model calibration.

Figure 6-1: Measured flow and level series during the September 2016 event



Although the September 2016 event was the highest on record at the level gauge, the Environment Agency confirmed that it did not lead to any significant, observed out of bank flooding. Therefore, the calibration dataset for this event was limited to the rainfall data, the level gauge dataset at the Egerton Road Debris Screen and the observation of no significant flooding.

6.1.3 Model Set-up

The model inflows for the September 2016 calibration event were derived from the observed 15-minute rainfall series at Platt Fields Park and Denton TBR. The rainfall series for each of these model inflows was derived using Thiessen's polygon weightings of both rain gauges, which allowed the modelled event to account for any differences in the observed rainfall pattern across the catchment (i.e. between the two rainfall gauges). This resulted in a composite rainfall series for the upstream inflow to Cringle Brook, consisting of 82% from the Denton rainfall series and 18% from the Platt Fields rainfall. For the tributary and lateral inflow only, the rainfall observed at Platt Fields was used as this gauge was located more centrally to these sub-catchments.

This approach was considered to be the most appropriate way of deriving inflows to the model for the calibration event, but it should be stressed that there is significant uncertainty associated with the application of two local rainfall series to the whole of the Cringle Brook catchment (as there was significant spatial variability in rainfall between these two rainfall gauges).

The derived September 2016 inflows were run through the defended version of the model, which should best represent the state of the Cringle Brook watercourse at the time of the event. However, it should be noted that this model does not include any informal walls or defences along the channel banks and these may have contributed to a reduction or exacerbation of flood risk during the event.

The model was run for 20 hours, from 15:30 on 13th September 2016 to 11:30 on 14th September in order to capture the full event.

6.2 Calibration Results

Figure 6-2 shows a comparison of the observed and modelled hydrograph shapes at the Egerton Road Debris Screen level gauge. The modelled river level from the 10% AEP design event is also plotted because, in terms of flow at the gauge, this is the closest design event to that of the September 2016 event, as illustrated in Figure 6-3.

Figure 6-2: Modelled and recorded level series at Egerton Road gauge for September 2016 event

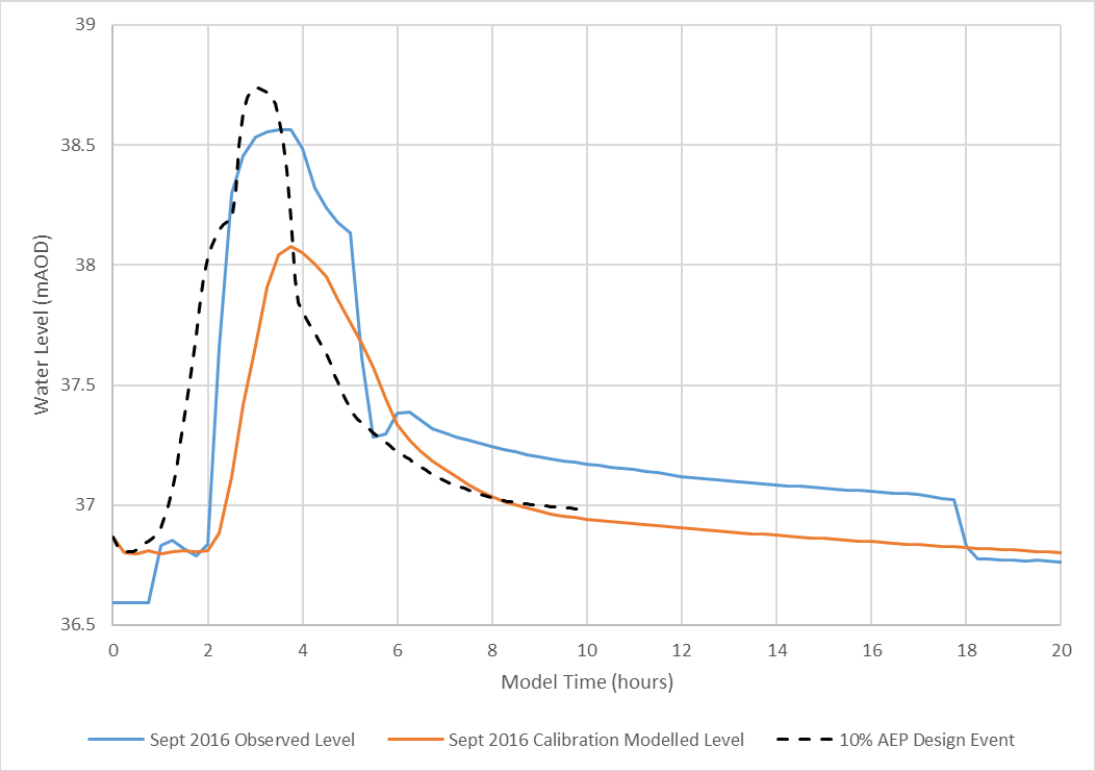
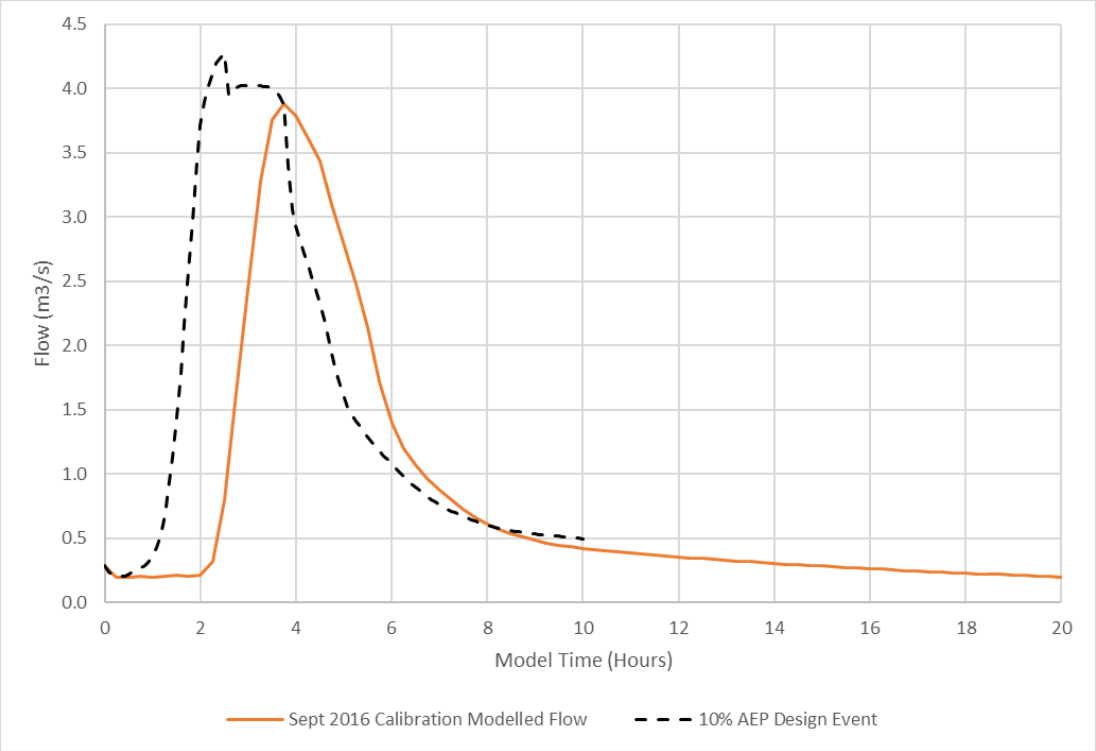


Figure 6-3: Modelled flow hydrograph for September 2016 event at Egerton Road gauge compared to 10% AEP design event



It is evident from Figure 6-2 that model is unable to accurately replicate the observed levels at the Egerton Road gauge for the September 2016 event. However, a perfect fit was not expected, due to the large number of uncertainties associated with this calibration event (i.e. the absence of direct flow data, the spatial variation in rainfall pattern between gauges, the highly urbanised nature of the study reach and the location of the level gauge just upstream of a major culvert).

From Figure 6-2 and Figure 6-3, it is also evident that the level at the gauge in an event of this magnitude is very sensitive to flow, noting that although there is only a small increase in peak flow between the September 2016 event and the 10% AEP event (Figure 6-3), there is modelled to be a proportionally larger increase in peak level (Figure 6-2). Part of this sensitivity is likely related to the surcharging of the Egerton Road culvert during events of this magnitude because the gauge is located just upstream of this structure and the observed level implies that surcharging of the Egerton Road culvert would have occurred during the September 2016 event. Therefore, any discrepancy in the September 2016 calibration would appear to have been aided by uncertainties in the calculated headloss when this structure begins to surcharge. Since it can be dangerous to force fit models to observed data when the observed flow is uncertain, the model parameters were not changed to better fit the observed data from the September 2016.

Some potentially important consequence of the model sensitivity documented in previous paragraphs are that;

- Although the September 2016 rainfall data combined to produce slightly lower peak flows than the 10% AEP design event, the two events result in significantly different outcomes. The calibration event under-predicts the observed levels at the gauge and does not lead to any out of bank flooding, whereas the 10% AEP design event predicts higher than observed levels at the gauge and does lead to out of bank flooding (e.g. see Figure 7-3). The model thresholds to flooding, as determined from the design event modelling, are discussed in Section 7.
- When the peak gauge level that was recorded during the September 2016 event, is reached during the design event model runs (e.g. during the 10% AEP design event as shown in Figure 6-2), the model predicts overtopping immediately upstream of the existing defence walls. Since overtopping was not observed in September 2016, this implies that the model is over-predicting the flood risk at this location. However, in view of the modelled sensitivity

at the gauge, it was considered prudent to err on the side of caution and produce a conservative assessment of the flood risk at this location.

- The sensitivity of the modelled river levels when the Egerton Road culvert becomes surcharged suggests that it may be awkward to base any local flood warning system on this gauge.

7 Flood Mapping Results

7.1 Introduction

This chapter provides an overview of the main model results, presenting and commenting on;

- Design flood levels and outlines;
- The threshold (onset) of any flooding to the main communities and infrastructure.

This chapter documents the main findings in relation to flood levels and outlines and the model deliverables (Appendix A) should be consulted to understand the minutiae of the results.

7.1.1 Design Events

As covered in Section 1, there are defences within the model, and both defended and undefended scenarios have been simulated. The following design events were run through both versions of the model;

- Present day - 50%, 20%, 10%, 4%, 5%, 3.3%, 2%, 1.3%, 1%, 0.5% and 0.1% AEP
- Future - 1% AEP + 30%, 1% AEP + 35%, 1% AEP + 70% and 0.1% AEP + 30%

Blockage runs were also undertaken as part of this commission and are detailed in Section 7.7.

7.1.2 Supplied Results

The following raw results are supplied within the hydraulic model for each design event and scenario combination:

- River levels, flows and velocities (in the FM results)
- Water Level, Depth, Velocity and Hazard grids (in the TUFLOW results)

The following processed results are supplied within Appendix A:

- Tables of peak river level, flow and velocity
- Flood outlines
- Water Level, Depth, Velocity and Hazard grids
- MapEdit compatible GIS layers

7.2 Peak River Levels

The modelled defended and undefended, peak, design river levels across the range of modelled events are provided in Appendix A. Figure 7-1 shows a long section profile of the modelled, defended, peak river levels along Cringle Brook. Figure 7-2 contains the same information for the undefended version of the model. The structures with the largest headlosses are labelled on these figures, which illustrate that the Wellington Road, Kempton Road and Kingsway culverts exert a significant control on peak upstream river levels and the subsequent pattern of flooding. The Egerton Road culvert is not shown from these diagrams to exert a significant influence on peak flood levels at the level of a 1% AEP event but, as was discussed in Section 6, surcharging of this culvert occurs at a lower (10% AEP) return period and upstream levels are thereafter limited by the magnitude of overtopping. The imposition of a 1% AEP downstream river level boundary along Chorlton Platt Gore also reduces the headloss that is depicted in Figure 7-1 and Figure 7-2.

7.3 Defended Flood Outlines

7.3.1 Present Day

The modelled, present day (i.e. without climate change), defended, flood outlines for each design run are provided as GIS deliverables in Appendix A. A select number of these defended modelled flood outlines from the Cringle Brook are shown on Figure 7-3. This illustrates that the fluvial flood risk in the Cringle Brook catchment, even in the presence of the flood defences, is modelled to be significant, as overtopping is initiated in the 10% AEP event immediately upstream of the defences near Ladybarn Lane culvert. This floodwater remains out of bank until it reaches as far downstream as Chorlton Platt Gore since there is nowhere for it to re-enter Cringle Brook downstream of this overtopping location (as the downstream part of Cringle Brook is largely culverted and the limited open channel reaches are lined by raised defences). Therefore, a large number of properties in

Fallowfield are modelled to be at potential risk from Cringle Brook; although much of the floodwater flowing through Fallowfield is modelled to be typically shallow. In addition to property in Fallowfield being at risk from overtopping immediately upstream of the existing defences, some properties in the vicinity of Edgeworth Drive are also modelled to be at risk at a low return period (10% AEP) from overtopping of the unprotected right bank downstream of Kingswood Road.

Figure 7-1: Defended Peak 1% and 0.1% AEP river level profiles along Cringle Brook

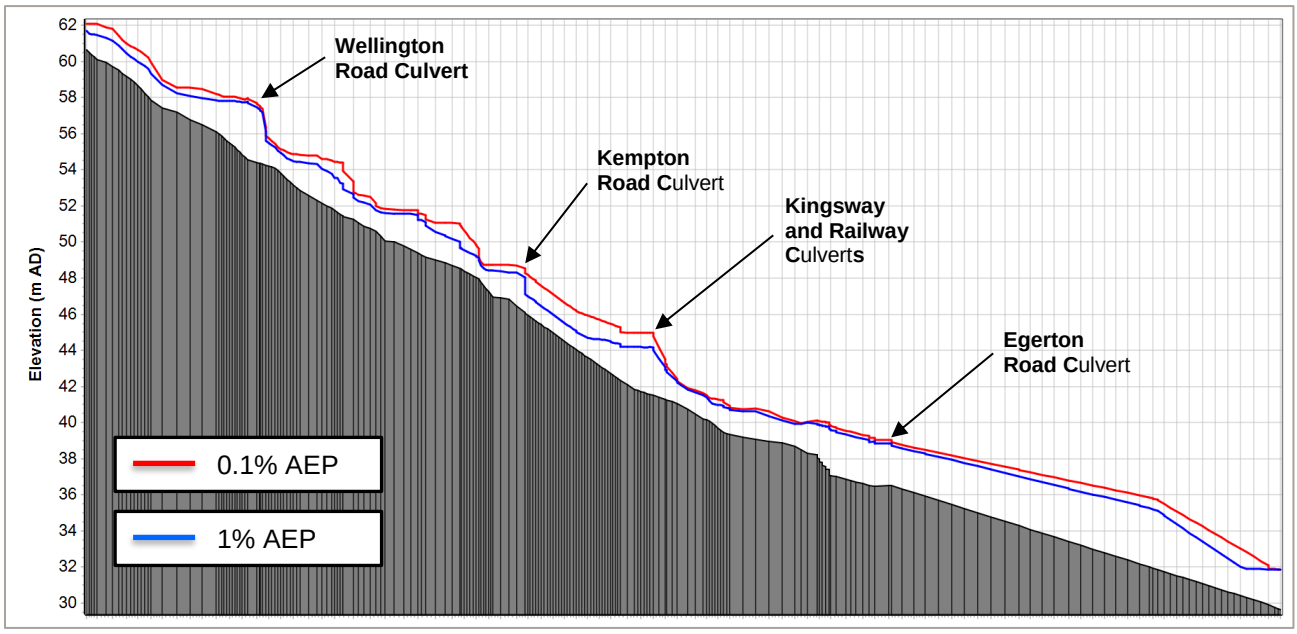
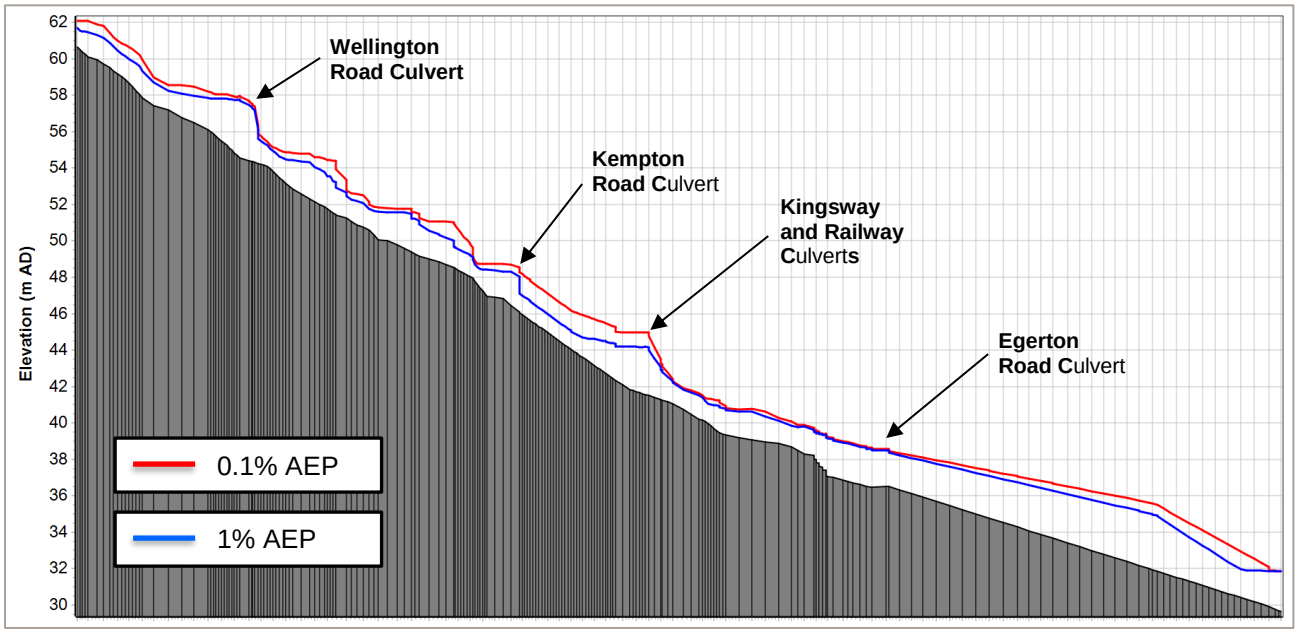


Figure 7-2: Undefended Peak 1% and 0.1% AEP river level profiles along Cringle Brook



Overtopping of Wellington Road culvert is also modelled for events above 10% AEP giving rise to flooding of the local (McDonalds and KFC) Food Park plus a flow route that crosses beneath the railway line. This latter flow route does not cause significant flooding until the 0.1% AEP event, during which it floods a large number of properties along Crossley Road until it ponds up against the railway line. It should be noted that there are walls upstream of Wellington Road, which would likely restrict the volume of overtopping in this area during an actual event. However, since these walls do not represent formal flood defences, they were not included in the defended flood modelling scenarios.

Figure 7-3: Modelled, present day, defended, flood outlines for Cringle Brook

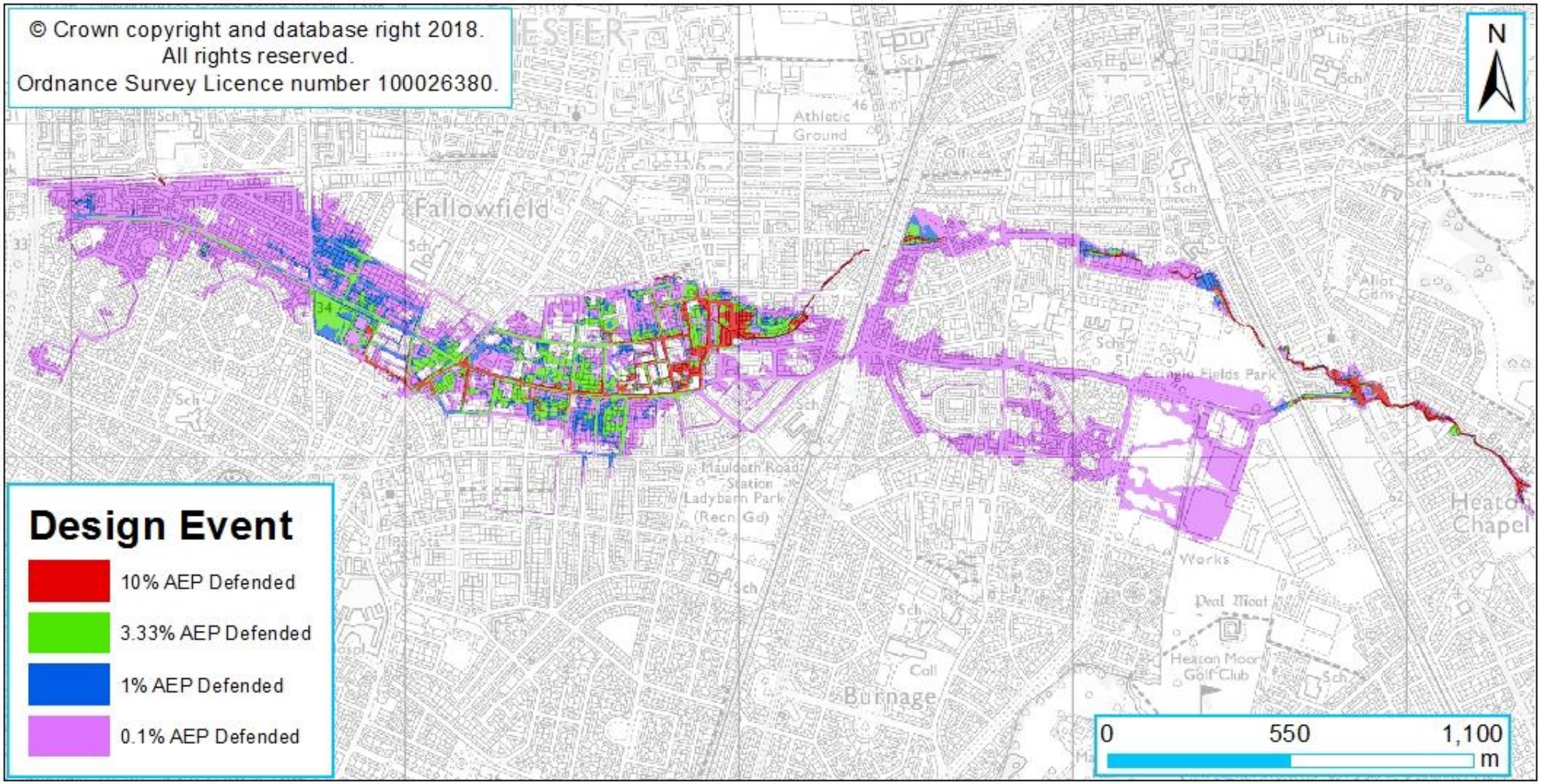
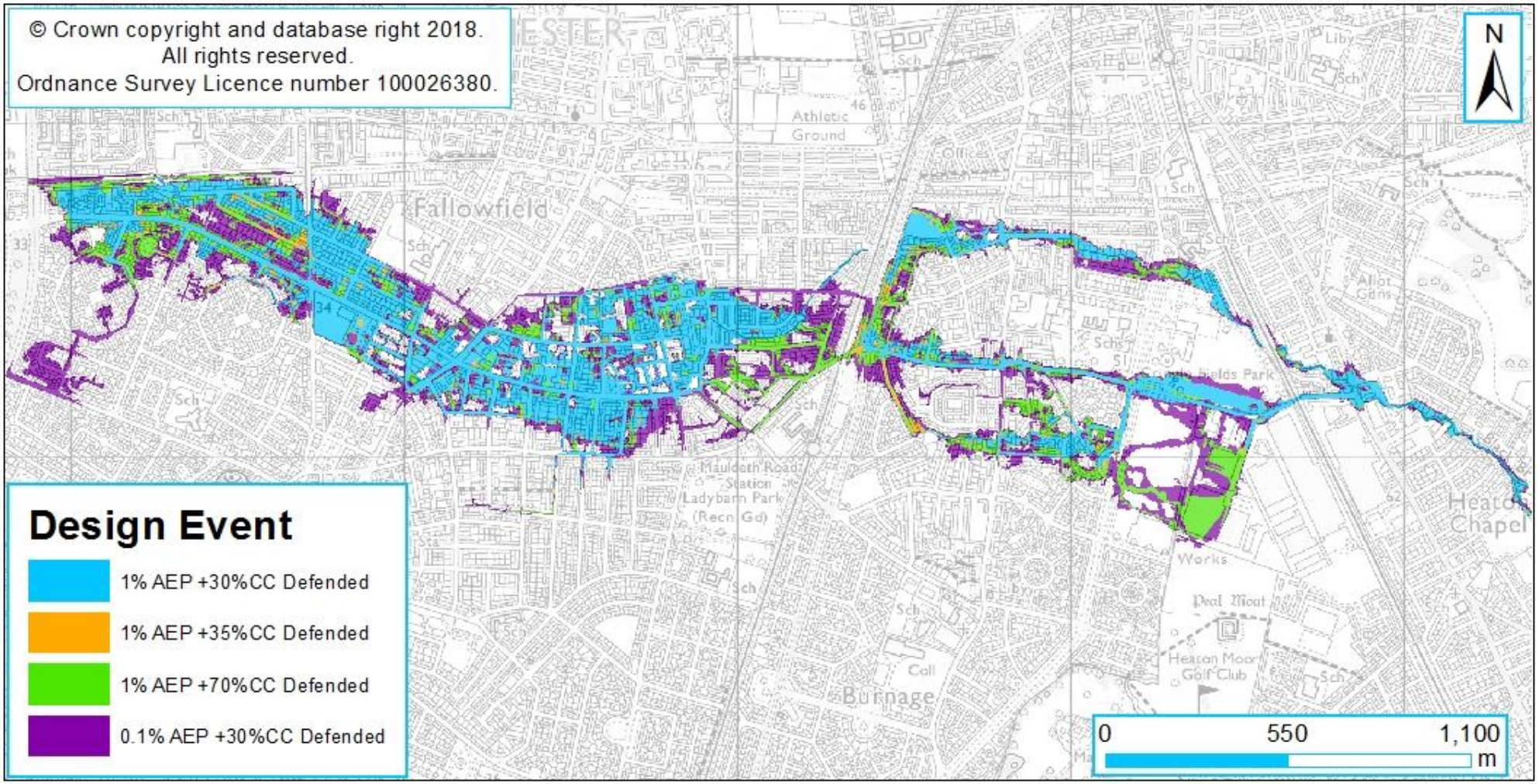


Figure 7-4: Modelled, future (with climate change), defended, flood outlines for Cringle Brook



7.3.2 Future

The modelled, future (i.e. with climate change), defended 1% and 0.1% AEP flood outlines are shown on Figure 7-4. This illustrates that the future 1% AEP fluvial flood risk from the Cringle Brook catchment is modelled to increase due to climate change. The risk to properties shown in the 1% AEP climate change enhanced events are between that of the present day (non-climate change enhanced) 0.5% and 0.1% AEP events. A flow route along Crossley Road is initiated during all modelled future 1% AEP events and a larger area of Fallowfield is predicted to be at risk due to climate change. Overtopping of Kempton Road culvert occurs in all modelled future events and overtopping of Erwood Road occurs in the 1% AEP plus 70% climate change and 0.1% AEP plus 30% climate change events.

Additional flooding results from the extreme 0.1% AEP event plus 30% climate change, with additional flooding in Fallowfield encroaching into the neighbouring Red Lion Brook catchment.

7.4 Undefended Flood Outlines

7.4.1 Present Day

The modelled, present day (i.e. without climate change), undefended, flood outlines for each design run are provided as GIS deliverables in Appendix A.

A select number of undefended modelled flood outlines from the Cringle Brook are shown on Figure 7-5. This illustrates that the undefended fluvial flood risk in the Cringle Brook catchment is modelled to be broadly similar to the defended fluvial flood risk due to the limited extent of the current raised defences. Whereas, in the defended scenario, the majority of water exits the channel immediately upstream of the defences near Ladybarn Lane, in the undefended scenario, water can exit the channel on the left bank immediately upstream of Ladybarn Lane culvert so there is modelled to be more flooding from the left bank and less flooding on the right bank in the undefended scenario. The differences between the two scenarios are less obvious for the extreme events.

Figure 7-6 and Figure 7-7 compare the modelled, present day, undefended, 1% and 0.1% AEP, flood outlines respectively, to the Environment Agency's Flood Zones 2 and 3 (prior to this study). This shows that the updated flood outlines are broadly similar to the existing flood zones in Fallowfield with some local differences in flow route and areas at risk. These local differences could have been aided by the update of the 2D domain to a higher definition DTM based on recently flown LIDAR in addition to subtle differences in the hydrology and 1D model configuration. The 0.1% AEP undefended flood extent is significantly different to Flood Zone 2 upstream of the (Mauldeth Road) railway line because of the modelled flow route that is now being modelled from the Wellington Road culvert (the A6). This flow route is shown to have been initiated in the current Flood Zone 2 but does not lead to the large extent of flooding associated with the 0.1% AEP event produced in the current commission.

7.4.2 Future

The modelled, future (i.e. with climate change), undefended flood outlines from the Cringle Brook model are shown on Figure 7-8. This illustrates that the future, fluvial, undefended flood risk across the Cringle Brook catchment is modelled to be very similar to the defended, future, fluvial, flood risk, as a large proportion of the catchment is flooded in these extreme events.

Figure 7-5: Modelled, present day, undefended, flood outlines for Cringle Brook

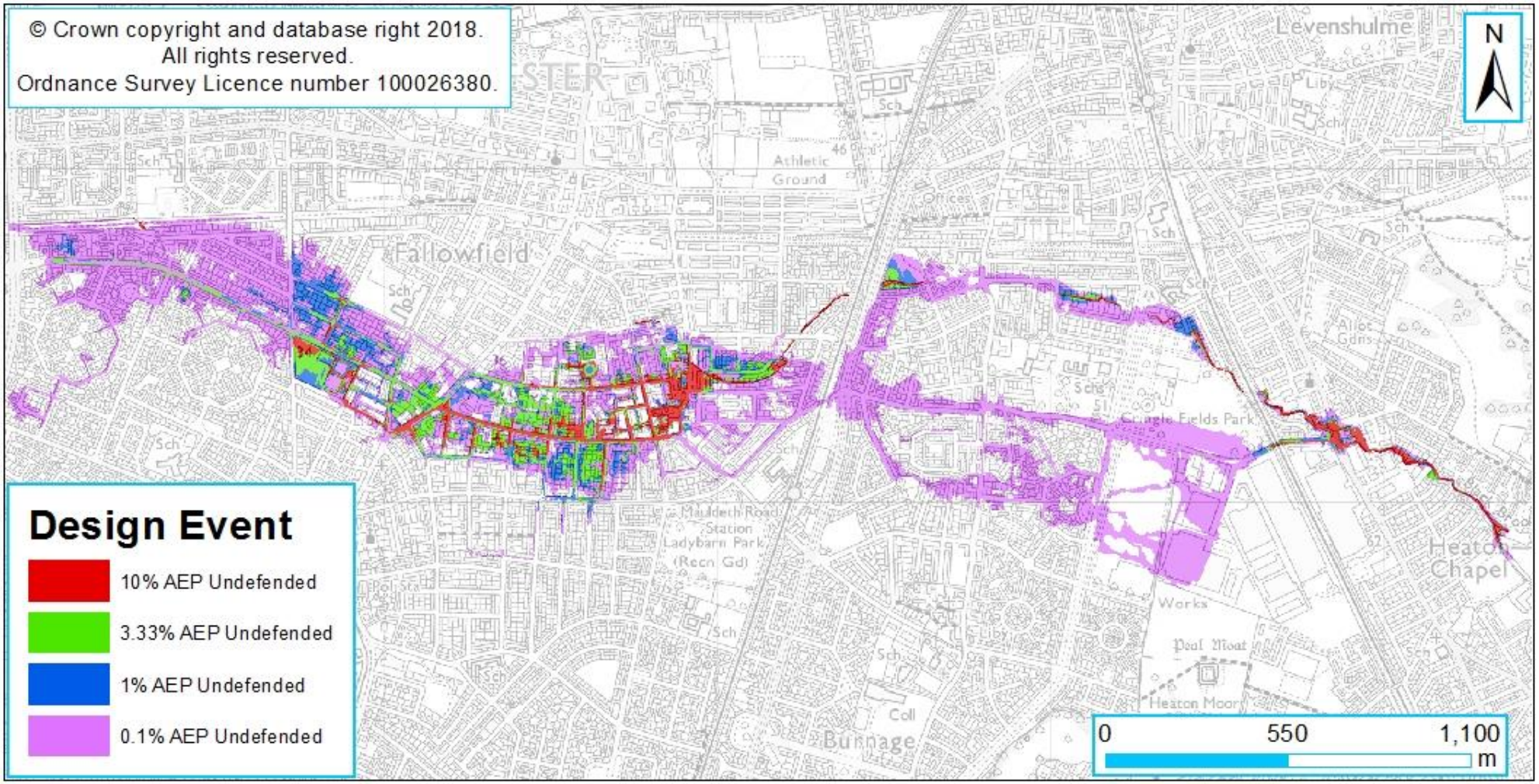


Figure 7-6: Modelled, present day, flood outline for 1% AEP event with current EA Flood Zone 3

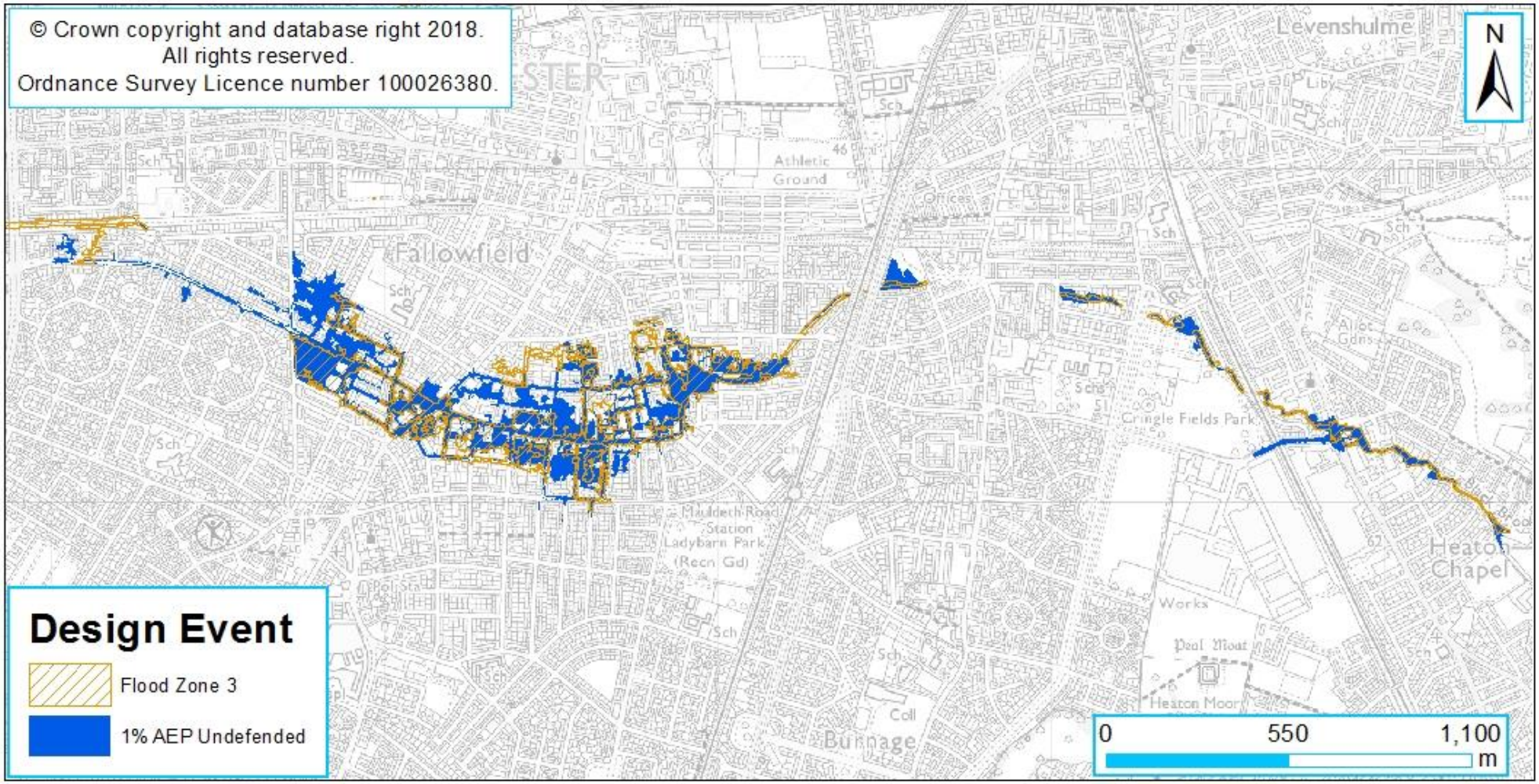


Figure 7-7: Modelled, present day, flood outline for 0.1% AEP event with current EA Flood Zone 2

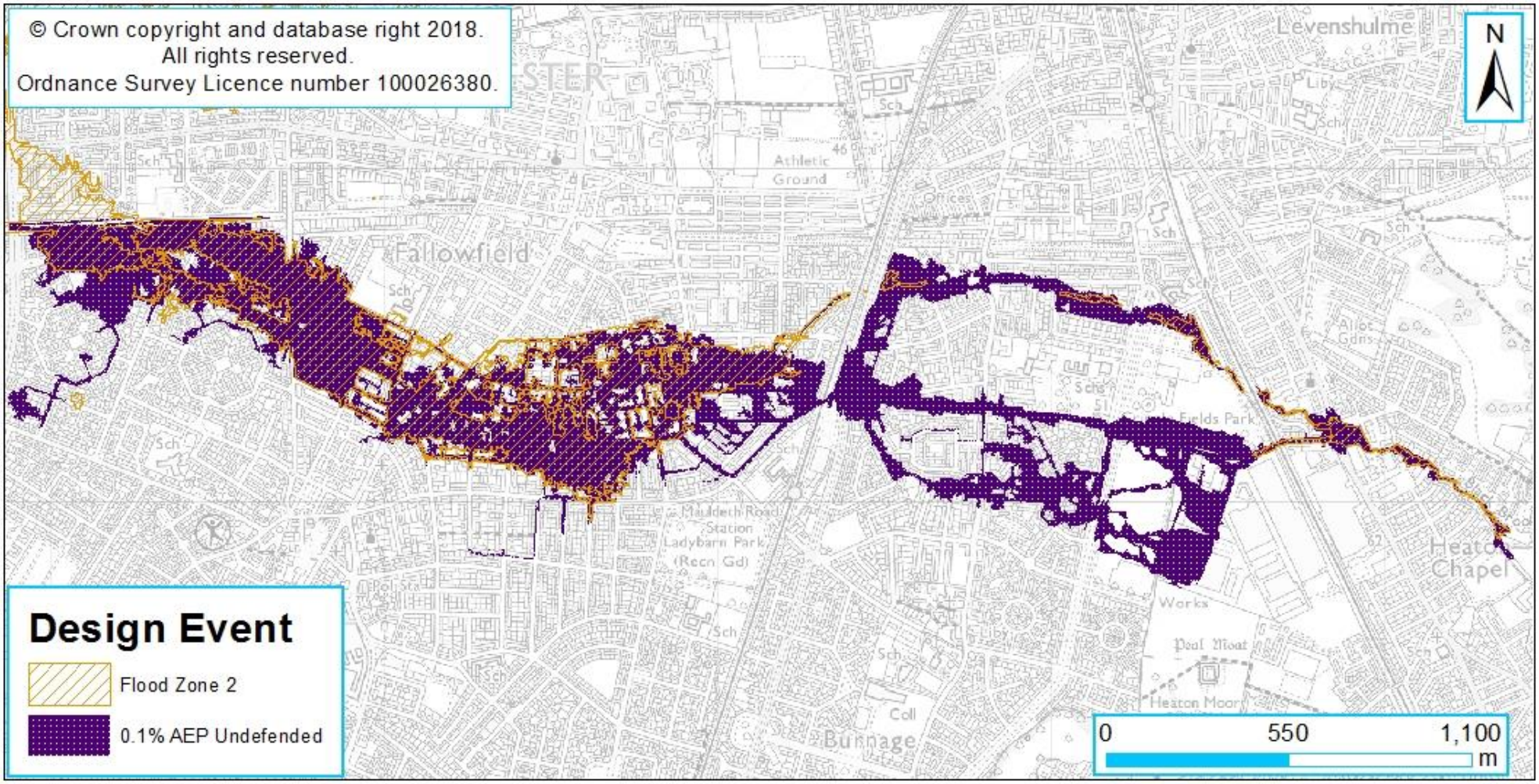
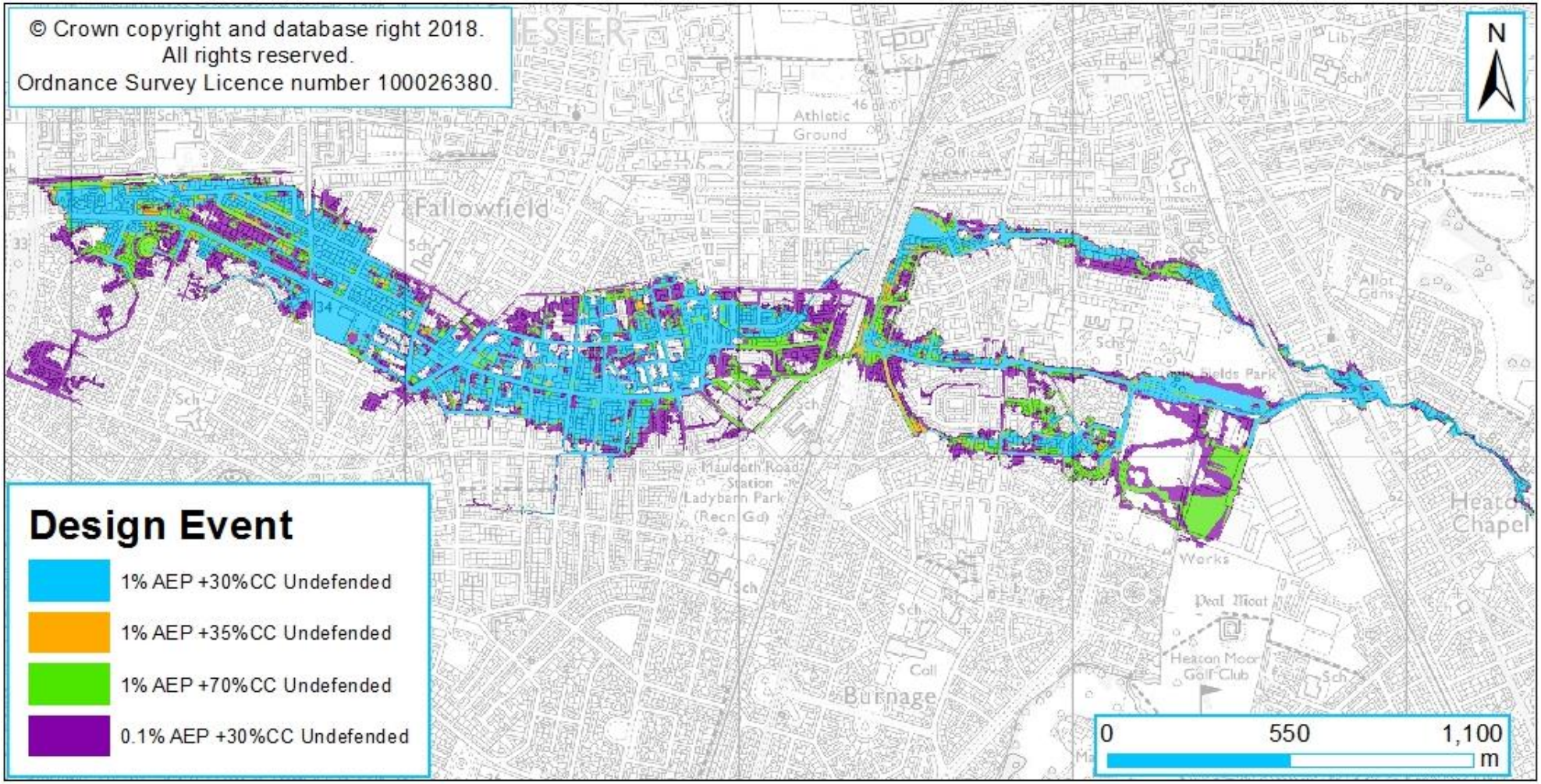


Figure 7-8: Modelled, future, undefended, flood outlines for Cringle Brook



7.5 Areas Benefitting from Defences (ABDs)

The Areas Benefitting from Defences (ABDs) are displayed as part of the fluvial flood maps for planning to show those areas that benefit directly from formal flood defences in a 1% AEP flood event. Along Cringle Brook, the low onset of flooding means that there are no large areas that can be demonstrated to benefit from the Cringle Brook defences at the 1% AEP level (see Figure 7-9). In addition, as shown in Figure 7-10, removing the defences cannot always be seen to provide a 'worst case' scenario along Cringle Brook (compared to the defended scenario) because the removal of the flood walls upstream of Ladybarn Lane has the effect of locally increasing the flooding to Fallowfield from the left bank but decreasing flooding from the right bank. Therefore, although Figure 7-9 shows some potential 'Areas Benefitting from Defences' based on the strict definition of an ABD, it is considered that none of these are significant enough to be represented on the Environment Agency's Flood Maps for planning.

Figure 7-9: 1% AEP defended and undefended flood outlines with potential ABDs

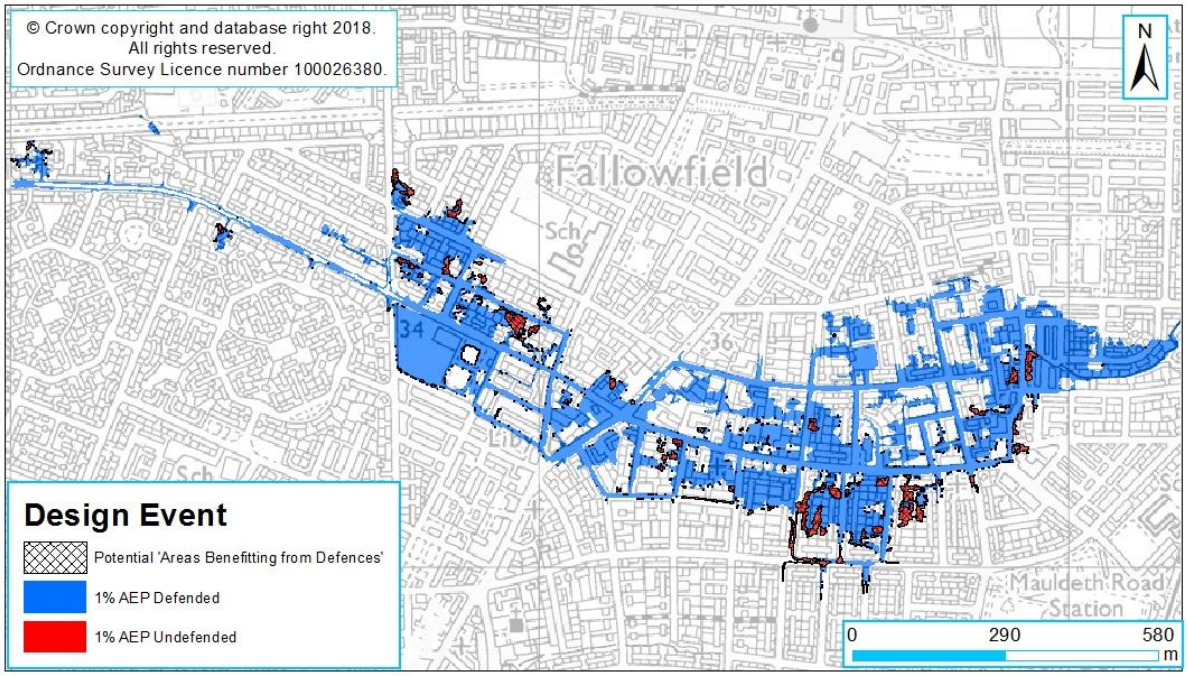
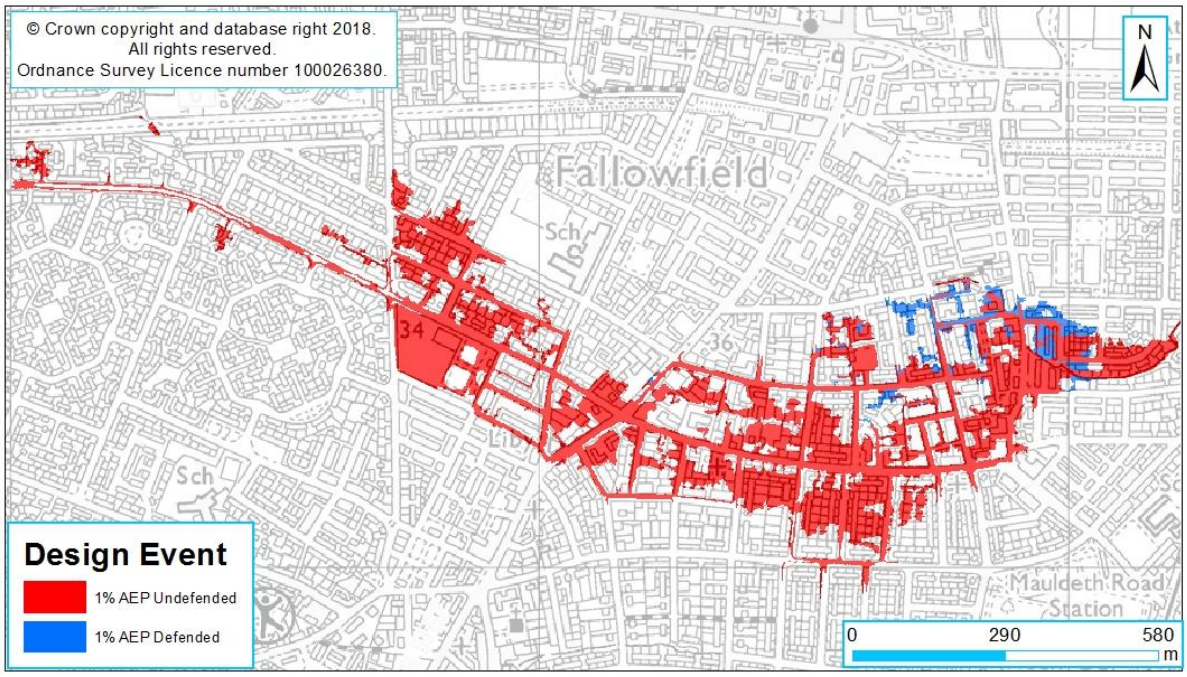


Figure 7-10: 1% AEP undefended outline not providing a 'worst case' scenario on Cringle Brook



7.6 Flood Hazard

Information about the flood depths, velocities and flood hazard for all scenarios and events can be found in Appendix A.2. The modelled, present day, defended flood depths for the 1% AEP event through Fallowfield are shown in Figure 7-11, highlighting that although the flood outlines are large, the flood depths are generally very shallow in the densely urbanised area (<0.2m). The flood velocities for this event are also generally low through Fallowfield (<0.2m/s), although there are some higher velocities predicted along the roads, as shown in Figure 7-12.

Therefore, although a large number of properties in Fallowfield are modelled to be at potential risk from Cringle Brook, the typically shallow flood depths and relatively low velocities that were modelled during the 1% AEP defended event result in a low general flood hazard. There is a similar low flood hazard for the 1% AEP undefended event, but the flood hazard is higher for more extreme events (such as 0.1% AEP).

Figure 7-11: Modelled, present day, defended flood depths for the 1% AEP event in Fallowfield

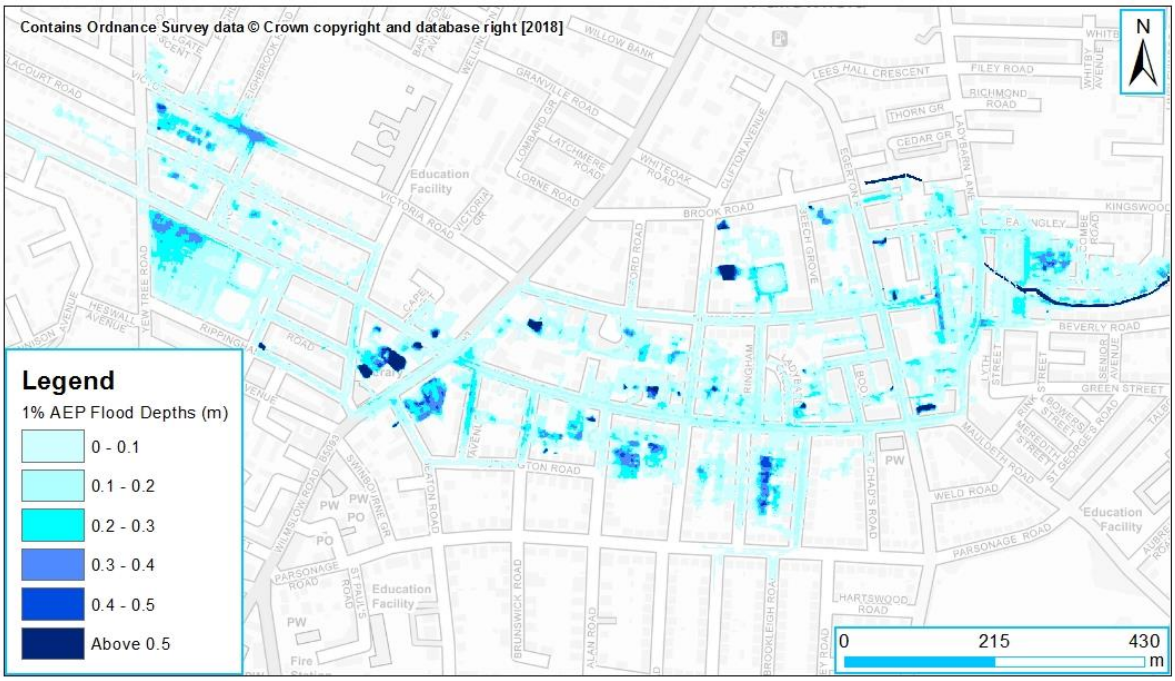
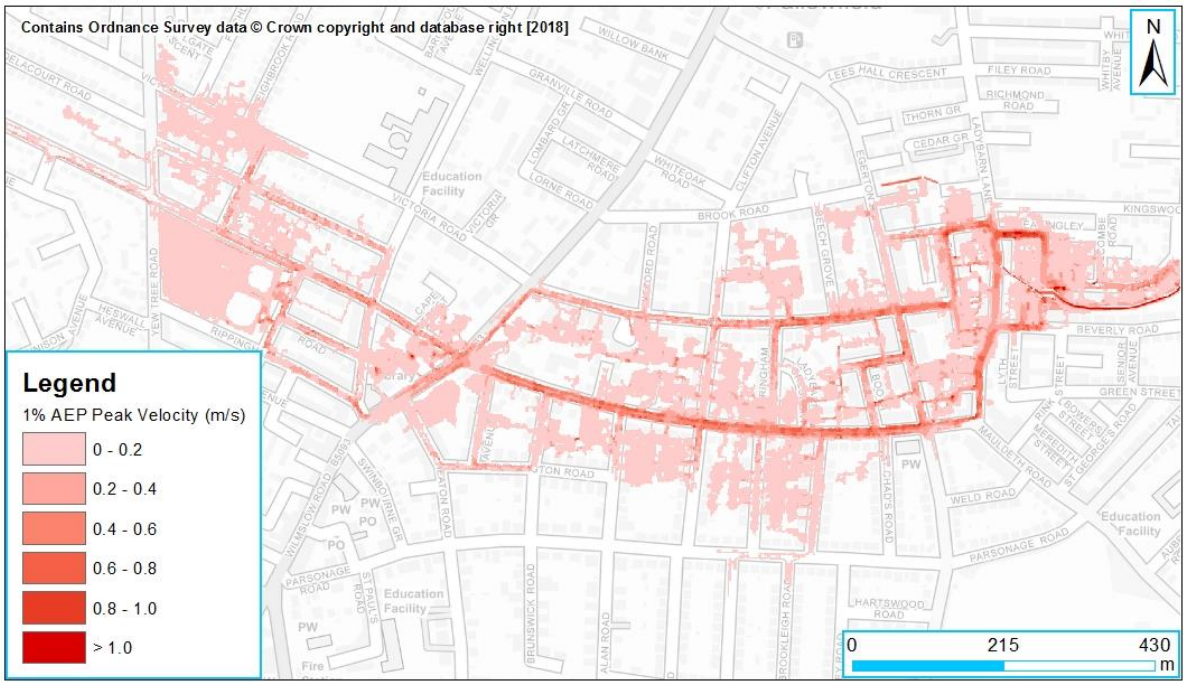


Figure 7-12: Modelled, present day, defended flood velocity for the 1% AEP event in Fallowfield



7.7 Blockage Assessment

In addition to the flood risk results documented above, this study has assessed the impact of blockages at six locations agreed with the Environment Agency;

- Wellington Road Culvert (the A6 near McDonalds)
- Erwood Road Culvert
- Kempton Road Culvert
- Kingsway Culvert (immediately upstream of the railway)
- Ladybarn Lane Culvert
- Egerton Road Culvert

These locations were identified as likely to have the greatest impact on flood risk if blocked. Three blockage proportions were modelled: low (25%), medium (50%), and high (75%). The impact of these varying degrees of blockage has been assessed for the 1% and 1% AEP plus 30% climate change events, using the defended version of the model.

All of the structures listed were modelled as culverts and blockages were simulated by inserting a blockage unit upstream of the culvert inlet and simulating the required blockage proportions through using different event (.ied) files.

Blockage at each location was assessed independently. The following sub-sections describe the impact of the assessment completed at each structure.

7.7.1 Wellington Road Culvert

Figure 7-13 illustrates the change in upstream water levels and flood outlines associated with blockage of Wellington Road Culvert for the 1% AEP defended event. Blocking the culvert by any of the percentages tested here provides minimal increase in water levels, and only the 75% blockage results in much of an increase in the duration of the culvert surcharging (increase of 45 minutes). Blocking the culvert results in almost no discernible increase in flood extent at the culvert and does not impact any properties, although depths increase on Crossley Road. There is a minimal reduction in flood extent in the lower reaches of the catchment (downstream of the railway line) for the 75% blocked scenario.

A similar pattern can be seen for blockage scenarios with the 1% AEP plus 30% climate change defended event (Figure 7-14), with culvert blockages providing minimal increases in water levels and duration of the culvert being surcharged. There are more obvious increases in flood extent for the 1% AEP plus 30% climate change blockage scenarios, with the 75% blockage initiating a flow route along Burnside Drive, although this mainly affects the road (rather than properties).

For the Wellington Road Culvert, all the modelled blockages during a present day 1% AEP event, and the lower percentage blockages during a future 1% AEP event plus 30% climate change have a minimal impact on the local flood risk. The 75% blockage during the climate change enhanced event initiates an additional flow route along Burnside Drive, which affects a few properties, but mainly has an impact on roads.

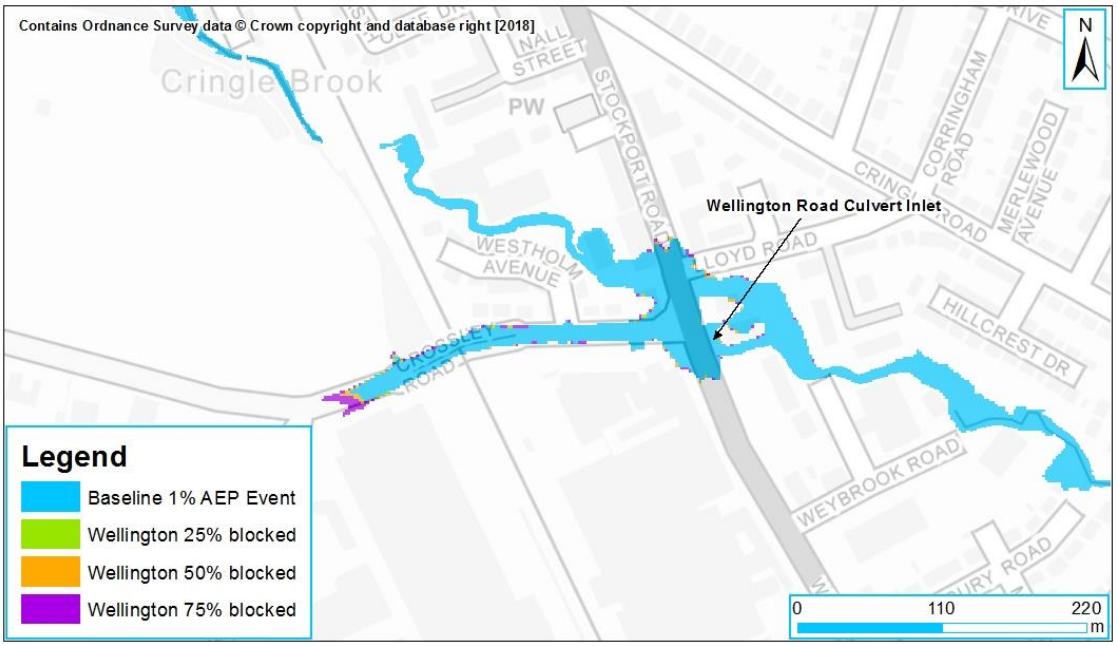
7.7.2 Erwood Road Culvert

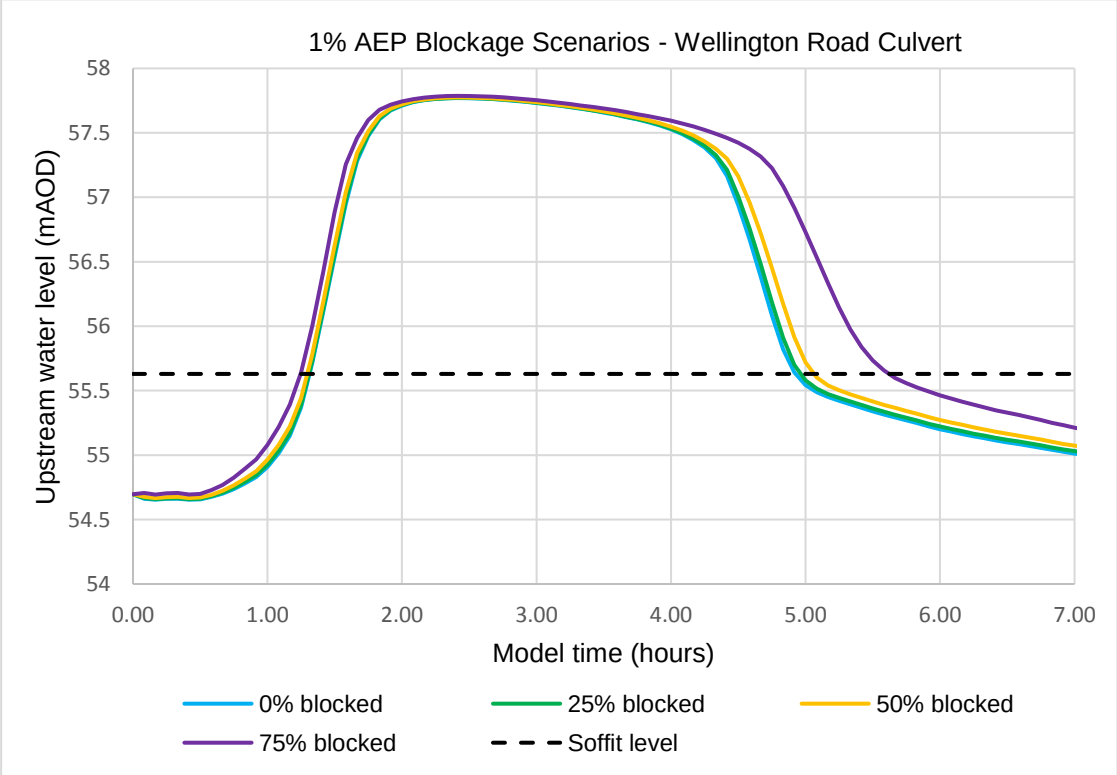
Figure 7-15 illustrates the change in upstream water levels and flood outlines associated with blockage of Erwood Road Culvert for the 1% AEP defended event. Blocking the culvert by 25%, 50% and 75% results in maximum 1% AEP river levels increasing by 0.09m, 0.37m, and 1.01m respectively. The culvert does not actually surcharge until the inlet is blocked between 25% and 50% but remains surcharged for almost 2.5 hours when blocked by 75%. Blocking the culvert has a small impact on flood extents for the 25% and 50% blocked scenarios, but a blockage of 75% results in overtopping of the culvert, and initiates a flow route along Ranford Road, affecting properties, and extending into Kempton Road and Milwain Road. There is also a minimal reduction in flood extent in the lower reaches of the catchment (downstream of the railway line) for the 75% blocked scenario.

In the defended 1% AEP event plus 30% climate change, culvert blockages of 25%, 50% and 75% raise upstream water levels by 0.16m, 0.5m and 0.85m respectively. The culvert surcharges during all modelled blockage proportions, with increasing duration for increased blockage. The impact on flood extent is similar to that in the 1% AEP event, with only the 75% blockage proportion causing overtopping of the culvert and flooding to Ranford Road, as seen in Figure 7-16.

Water levels upstream of Erwood Road are sensitive to blockage of the culvert, although this does not result in much change to the flood extent unless the blockage proportion is high. For both the present day 1% AEP event and future 1% AEP event, the 75% blockage causes overtopping the culvert, initiating a flow route along Ranford Road, which affects a number of properties.

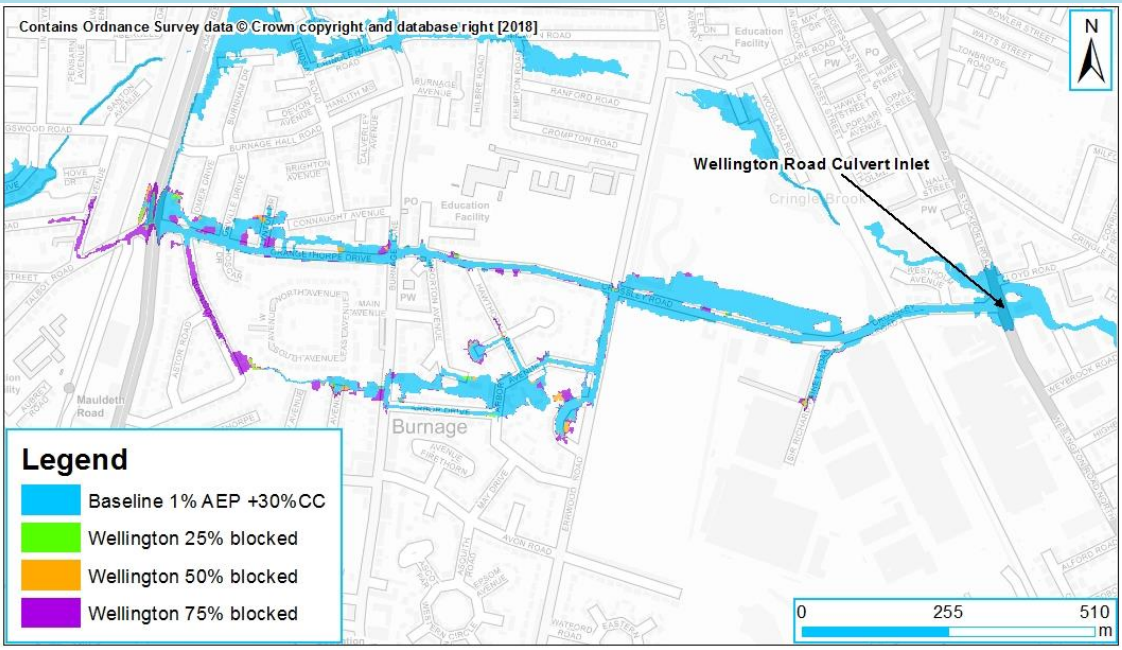
Figure 7-13: 1% AEP event blockage scenarios at Wellington Road Culvert

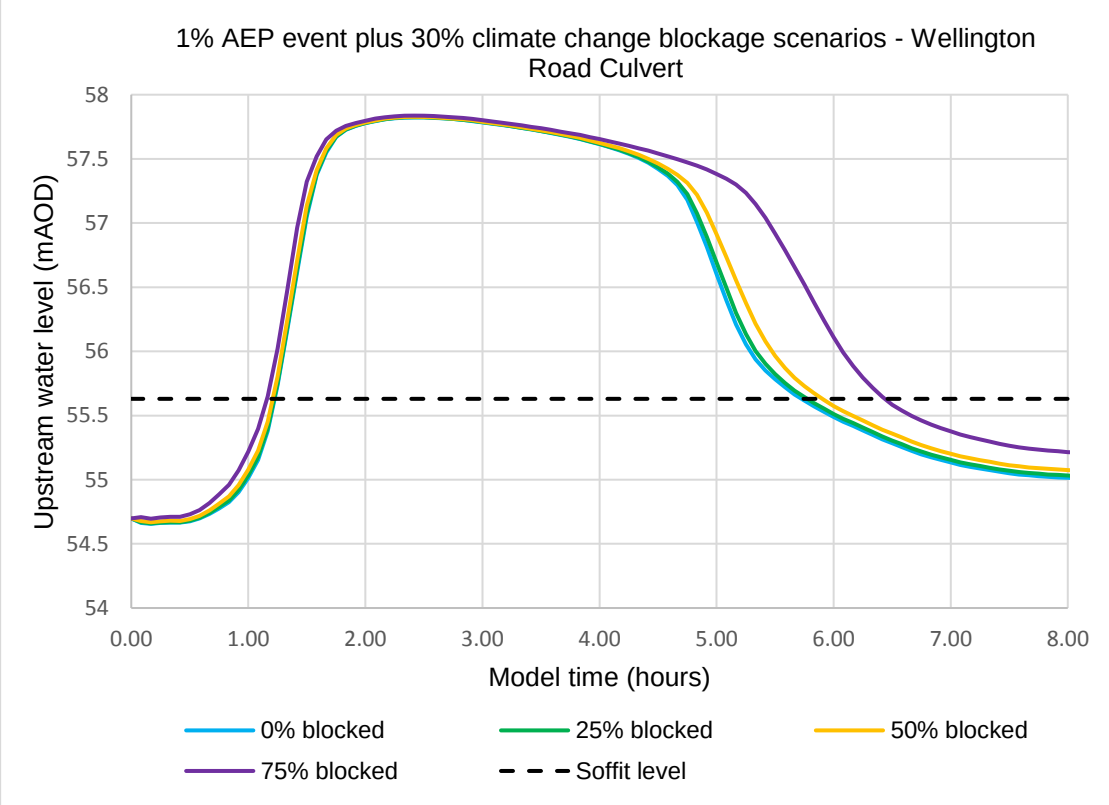




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	57.77	57.77	57.78	57.79
Surcharging duration (hours)	3.75	3.75	3.83	4.5

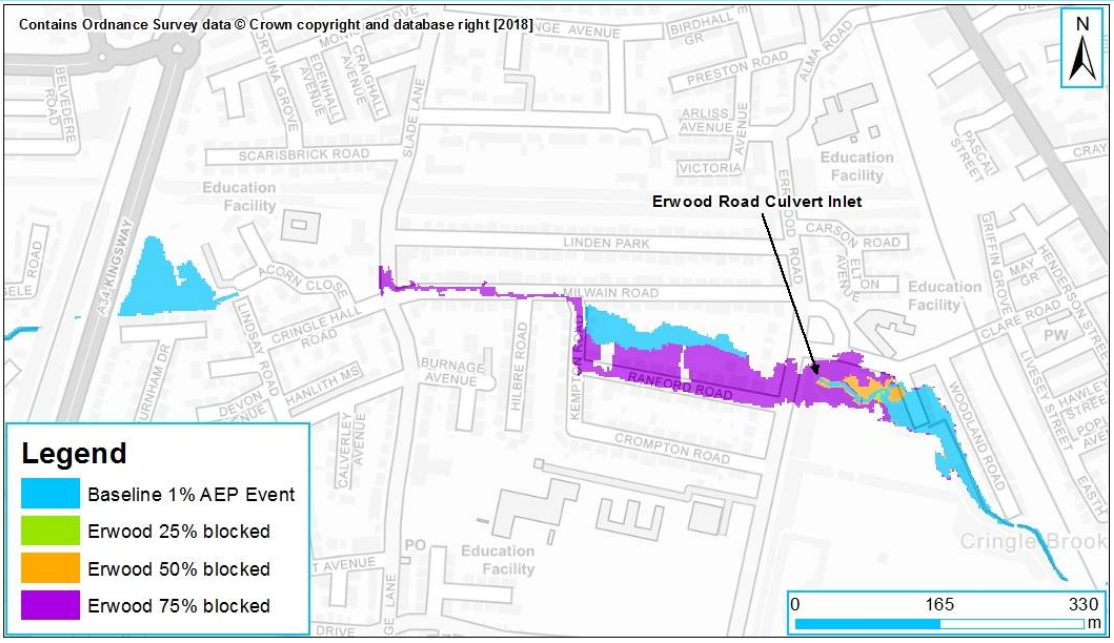
Figure 7-14: 1% AEP event plus 30% climate change blockage scenarios at Wellington Road Culvert

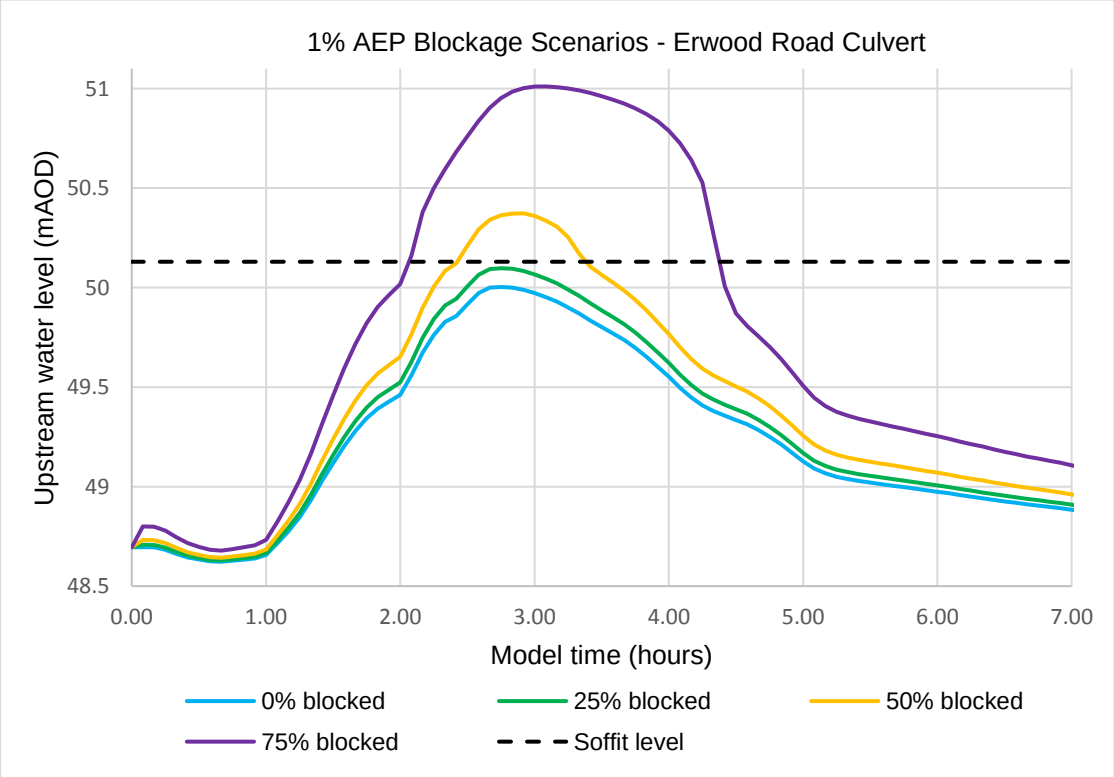




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	57.82	57.82	57.83	57.84
Surcharging duration (hours)	4.58	4.67	4.75	5.42

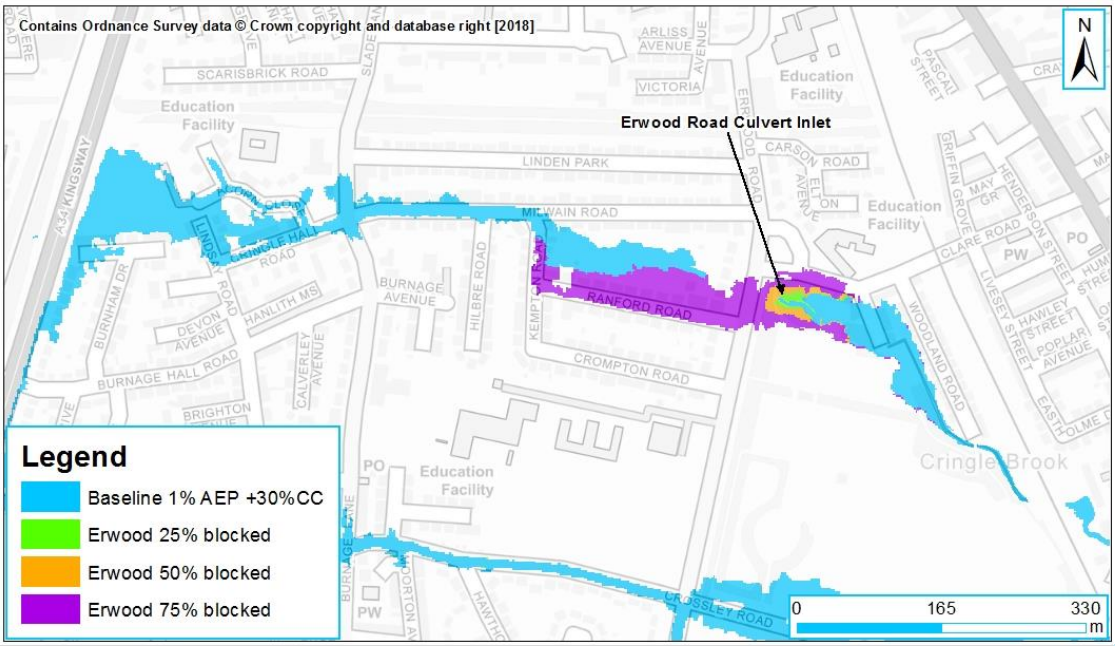
Figure 7-15: 1% AEP event blockage scenarios at Erwood Road Culvert

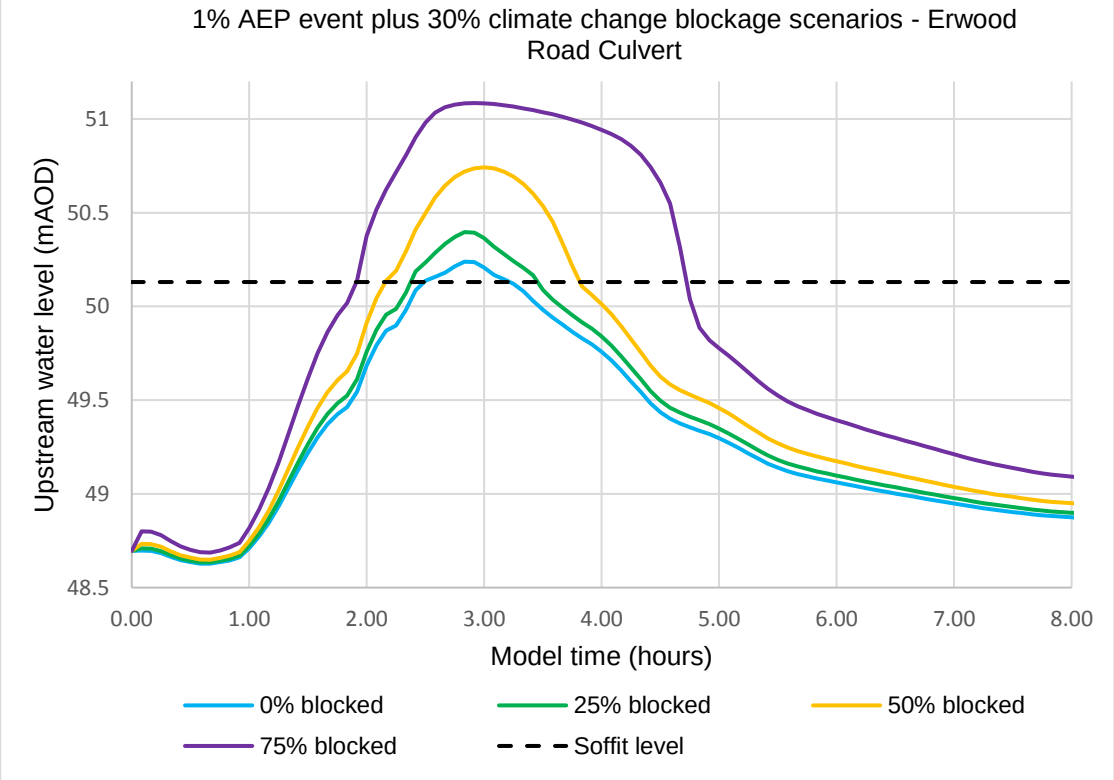




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	50	50.10	50.37	51.01
Surcharging duration (hours)	0	0	1	2.42

Figure 7-16: 1% AEP event plus 30% climate change blockage scenarios at Erwood Road Culvert





	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	50.24	50.40	50.74	51.08
Surcharging duration (hours)	0.75	1.17	1.67	2.83

7.7.3 Kempton Road Culvert

Figure 7-17 illustrates the change in upstream water levels and flood outlines associated with blockage of Kempton Road Culvert for the 1% AEP defended event. Blocking the culvert by 25%, 50% and 75% results in maximum 1% AEP river levels increasing by 0.18m, 0.39m, and 0.55m respectively. Increases in blockage proportion lead to increases in the duration of the culvert surcharging, with an increase of almost 2 hours between the baseline and the 75% blocked scenario. Even the lowest blockage proportion has a significant effect on the present day 1% AEP flood extent, as the culvert is overtopped, and a flow route is initiated along Milwain Road, extending into Cringle Hall Road and Acorn Close before re-entering Cringle Brook upstream of Kingsway. This only affects the roads in association with a 25% blockage but begins to affect properties in higher blockage scenarios. As with the previous culvert, some reduction in the flood extent in the lower reaches of the catchment (downstream of the railway line) is observed for the higher blockage scenarios.

In the defended 1% AEP event plus 30% climate change, culvert blockages of 25%, 50% and 75% raise upstream water levels by 0.12m, 0.27m and 0.43m respectively. The culvert surcharges during all modelled blockage proportions, with increasing duration for increased blockage. Figure 7-18 shows that increasing the blockage proportion increases the flood extent surrounding Kempton Road, although as the culvert overtops in the baseline 1% AEP event plus 30% climate change, this only affects a small number of additional properties in Acorn Close.

Water levels upstream of Kempton Road culvert, and the duration of the culvert surcharging are sensitive to blockage of the culvert. Flood extents are also moderately sensitive to blockage of the culvert, although this has much more of an effect for the present day 1% AEP event, for which any blockage proportion initiates overtopping of the culvert, and flooding to the surrounding roads. As overtopping already occurs in the baseline future 1% AEP event, the blockages cause less of an impact on the flood extent.

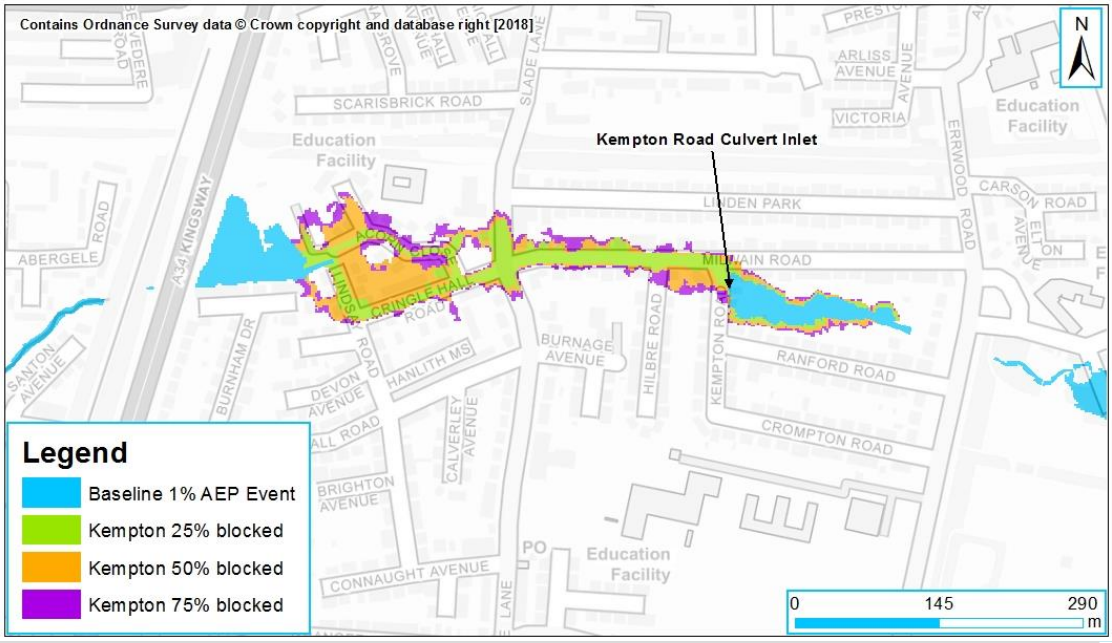
7.7.4 Kingsway Culvert

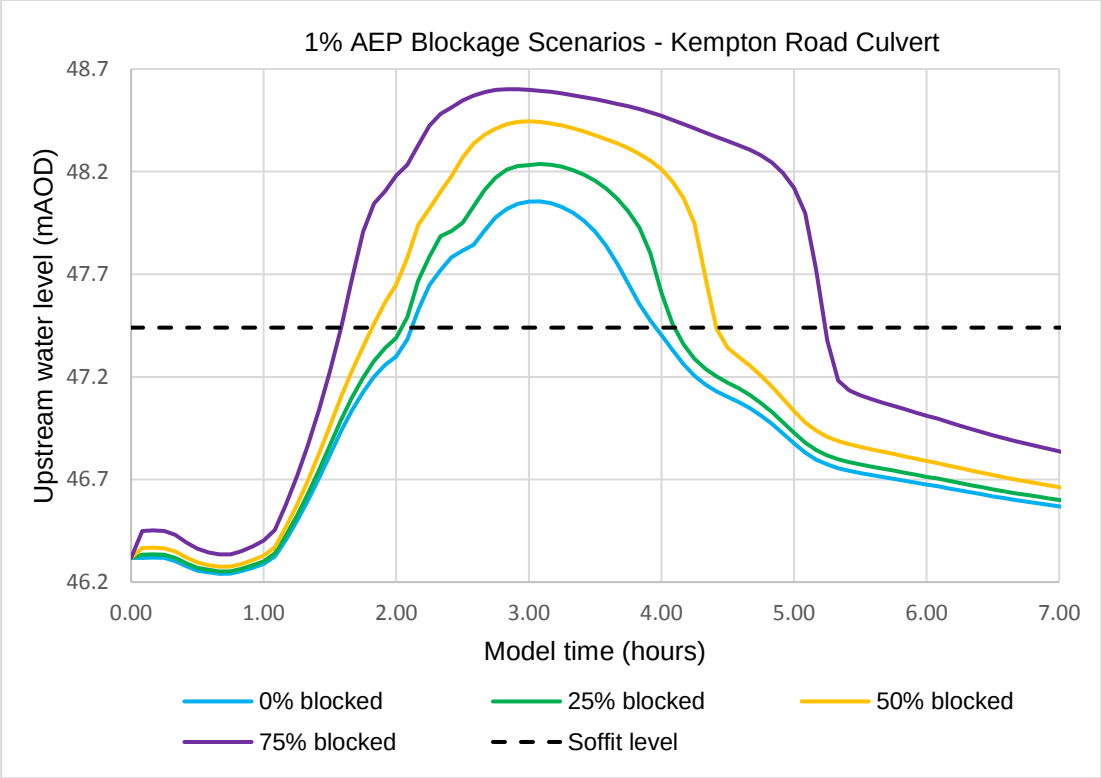
Figure 7-19 illustrates the change in upstream water levels and flood outlines associated with blockage of Kingsway Culvert for the 1% AEP defended event. Blocking the culvert by 25%, 50% and 75% results in maximum 1% AEP river levels increasing by 0.1m, 0.36m, and 0.68m respectively. Increases in blockage proportion lead to increases in the duration of the culvert surcharging, with an increase of almost 2 hours between the baseline and the 75% blocked scenario. Blocking the culvert has a minimal impact on 1% AEP flood extents for the 25% and 50% blockage proportions, but a blockage of 75% leads to overtopping of Kingsway at the crossroads with Grangethorpe Drive and Talbot Road and flow beneath the railway line. This affects properties along Kingsway, Burnham Drive and Beverly Road. However, blockage of this culvert results in a significant reduction to the flood extent and properties through Fallowfield, particularly for the higher blockage proportions, due to the greater retention of water upstream of the culvert.

In the defended 1% AEP event plus 30% climate change, culvert blockages of 25%, 50% and 75% raise upstream water levels by 0.08m, 0.21m and 0.4m respectively. The culvert surcharges during all modelled blockage proportions, with increasing duration for increased blockage. Figure 7-20 shows that blocking the culvert has a significant local impact on flood extent for the future 1% AEP event, with additional flooding predicted upstream of the railway line for all blockage proportions, and additional flow routes downstream of the railway line for the 50% and 75% blockage proportions, which affects roads and properties including along Beverly Road and Talbot Road. However, as with the present day 1% AEP event results, increasing blockage proportions is modleled to result in significant reductions to the flood extent through Fallowfield, particularly to Mornington Crescent.

Blockage of Kempton Road culvert has a significant impact on upstream water levels and flood extents, particularly for the present day 75% blockage and future 50% and 75 Blockages, where overtopping of the A34 (Kingsway) occurs at the crossroads of Grangethorpe Drive and Talbot Road. This can affect a number of properties in this area, although the increased blockage proportions significantly reduce flooding to Fallowfield downstream.

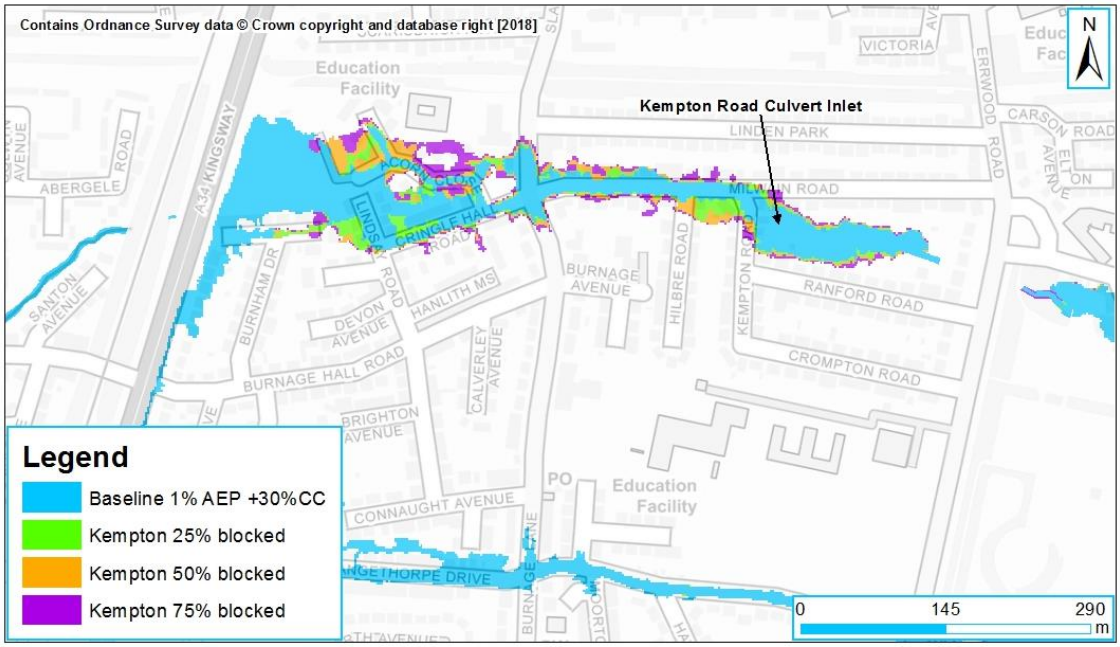
Figure 7-17: 1% AEP event blockage scenarios at Kempton Road Culvert

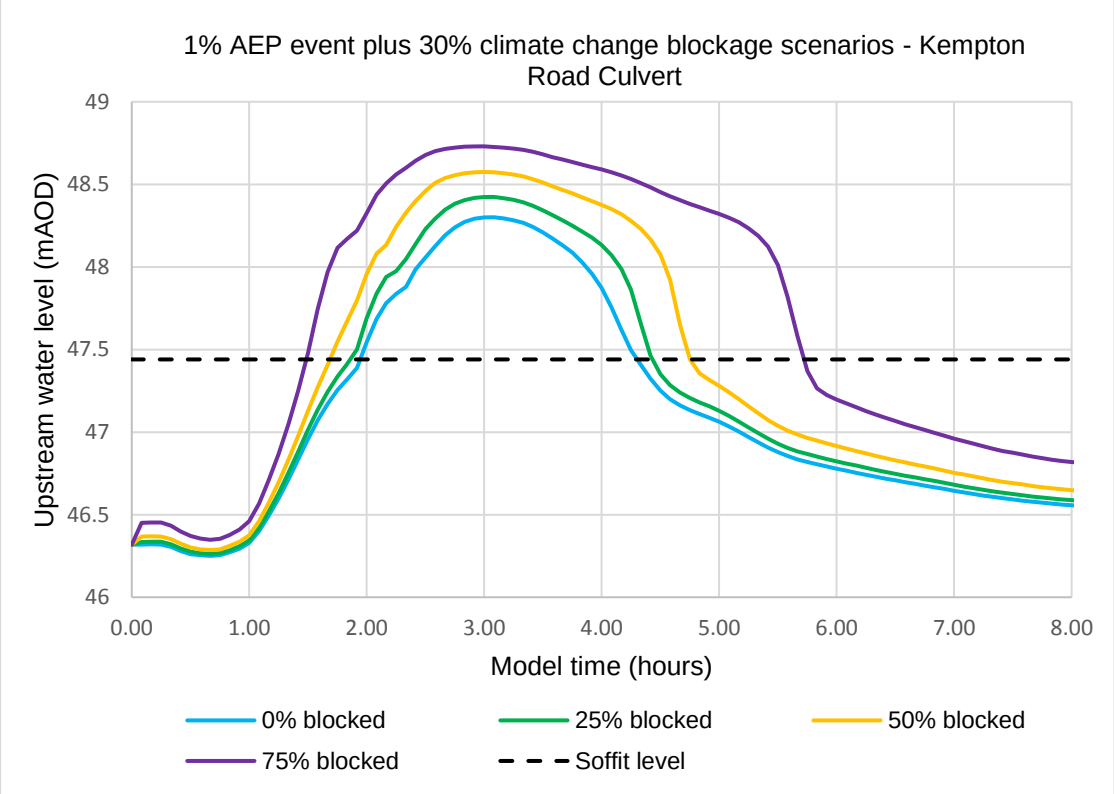




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	48.06	48.24	48.45	48.60
Surcharging duration (hours)	1.92	2.17	2.67	3.67

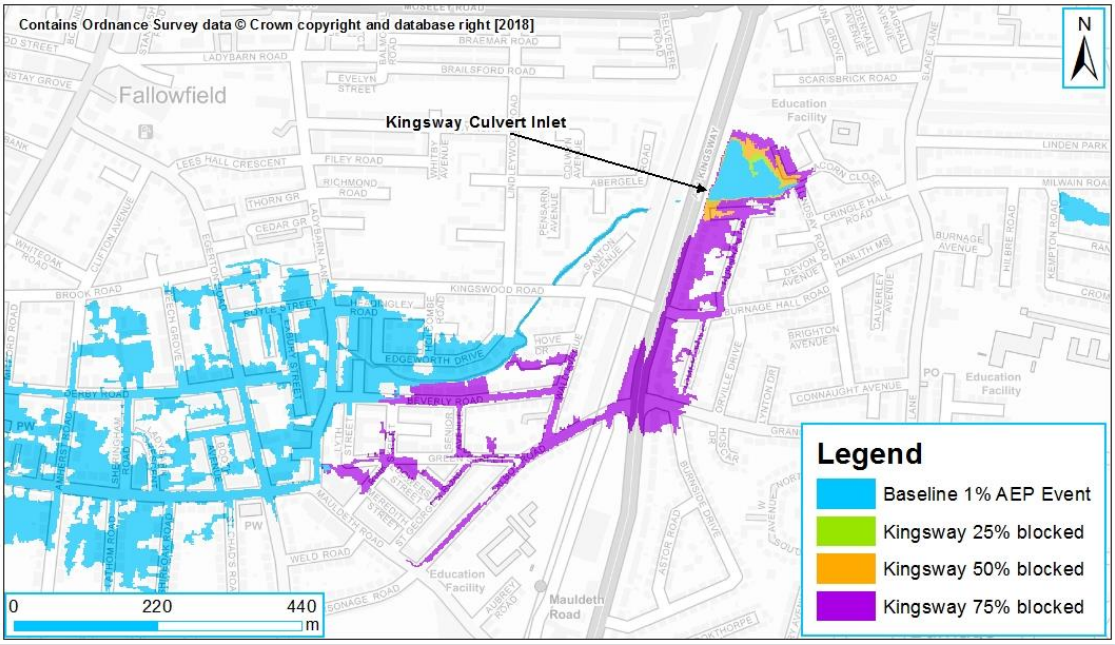
Figure 7-18: 1% AEP event plus 30% climate change blockage scenarios at Kempton Road Culvert

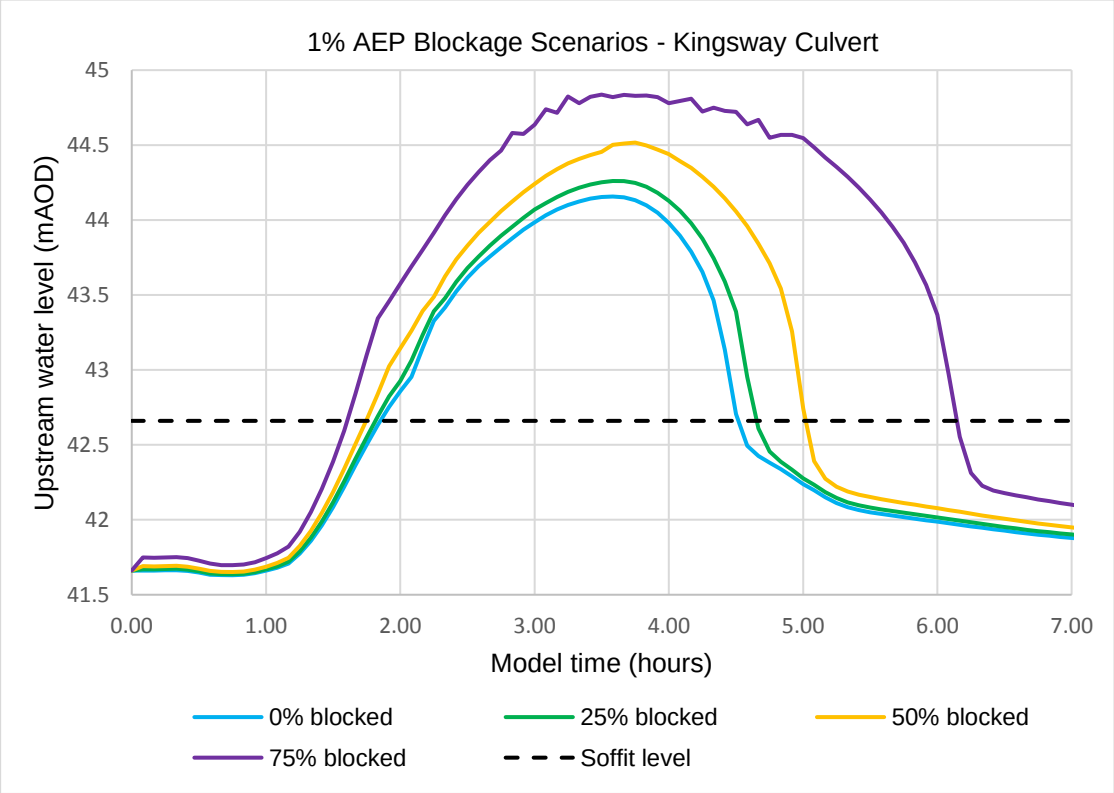




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	48.30	48.42	48.58	48.73
Surcharging duration (hours)	2.42	2.58	3.08	4.33

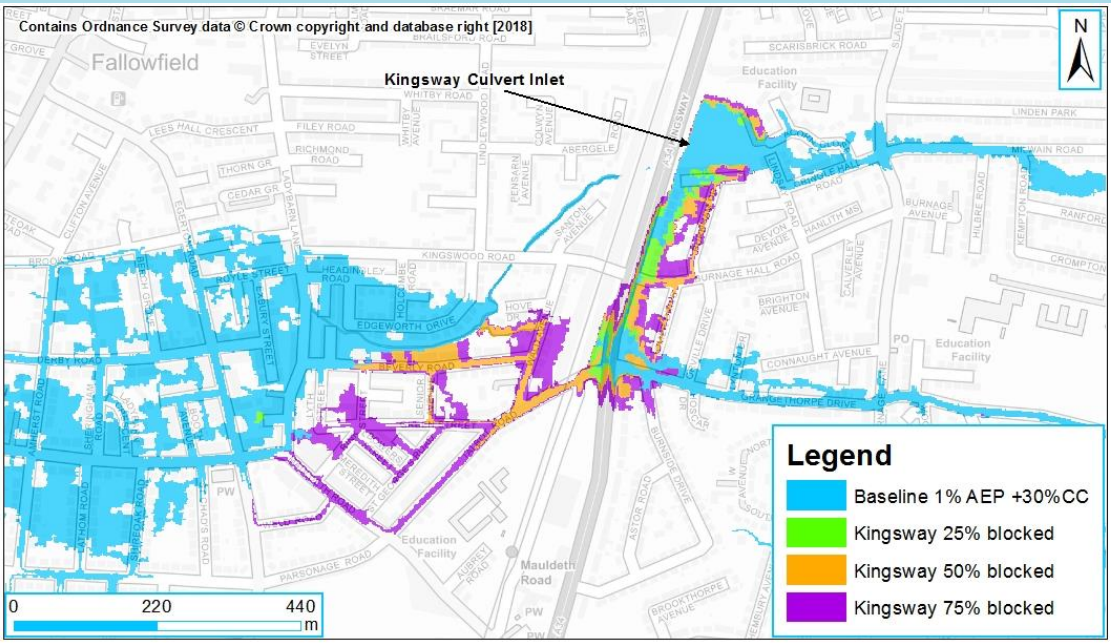
Figure 7-19: 1% AEP event blockage scenarios at Kingsway Culvert

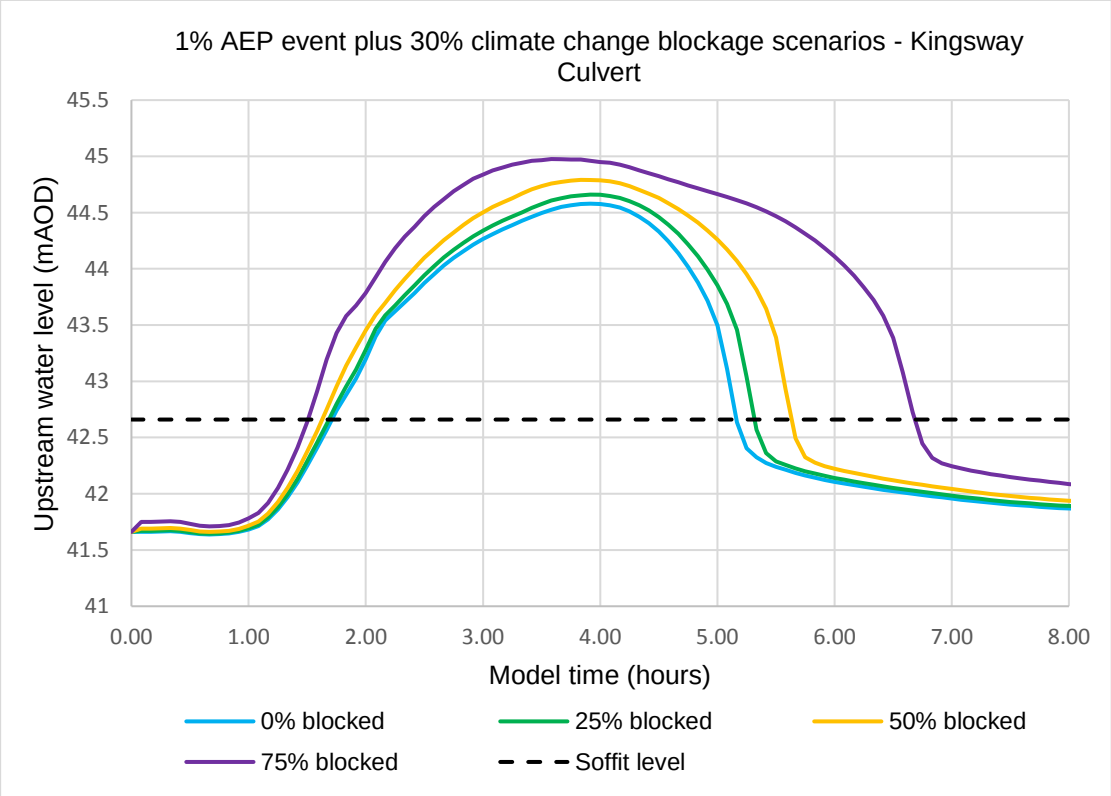




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	44.16	44.26	44.52	44.84
Surcharging duration (hours)	2.75	2.92	3.42	4.58

Figure 7-20: 1% AEP event plus 30% climate change blockage scenarios at Kingsway Culvert





	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	44.58	44.66	44.79	44.98
Surcharging duration (hours)	3.5	3.67	4.08	5.25

7.7.5 Ladybarn Lane Culvert

Figure 7-21 illustrates the change in upstream water levels and flood outlines associated with blockage of Ladybarn Lane Culvert for the 1% AEP defended event. Blocking the culvert by 25% and 50% does not alter peak water levels significantly, but a 75% blockage increases maximum water levels by 0.1m. Only the 75% blockage results in a noticeable increase in the duration of the culvert surcharging (increase of 25 minutes). Blocking the culvert only causes slight increases in flood extent for the 25% and 50% blockage proportions but causes a larger increase for the 75% blockage. This increase affects a number of properties in Fallowfield, particularly along Mornington Crescent, which does not flood in the baseline 1% AEP event.

A similar pattern can be seen for blockage scenarios with the 1% AEP plus 30% climate change defended event (Figure 7-22). Blocking the culvert by 25% and 50% has minimal impact on maximum water levels, duration of culvert surcharging and flood extent; however, the 75% blockage results in an increased flood extent, particularly at the downstream end of the catchment, causing flooding to Delacourt Road and Alford Avenue.

For Ladybarn Lane Culvert, the lower percentage blockages during both a present day 1% AEP event and future 1% AEP event plus 30% climate change are modelled to have a minimal impact on flooding. The 75% blockage causes an increase in flood extent to Fallowfield during both events, particularly in the downstream catchment, affecting properties around Mornington Crescent and Delacourt Road.

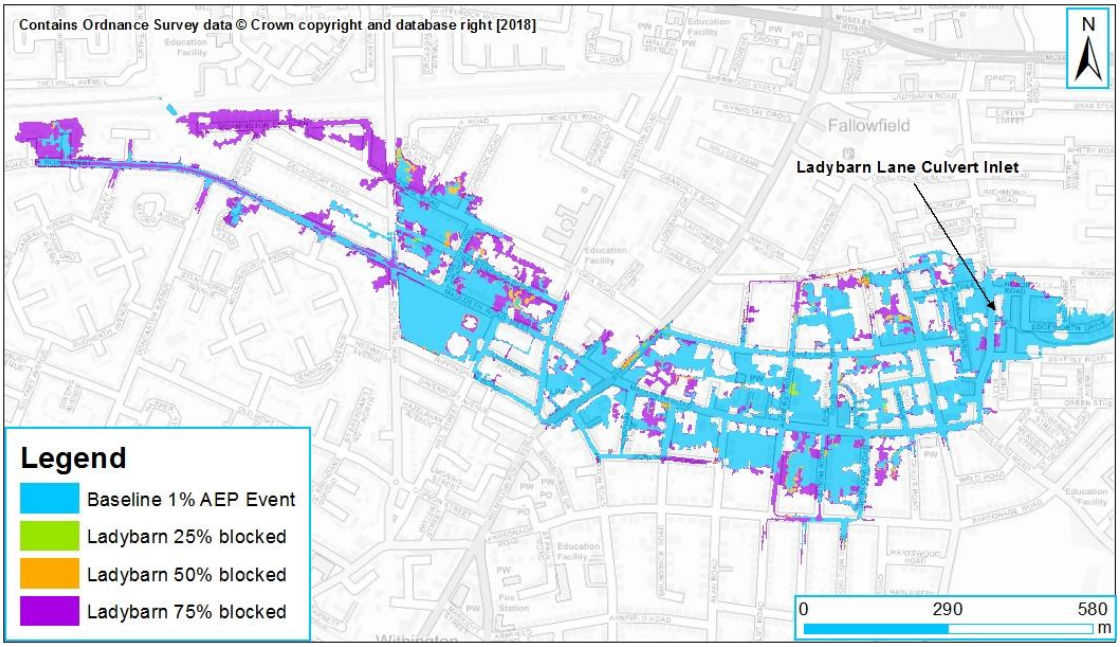
7.7.6 Egerton Road Culvert

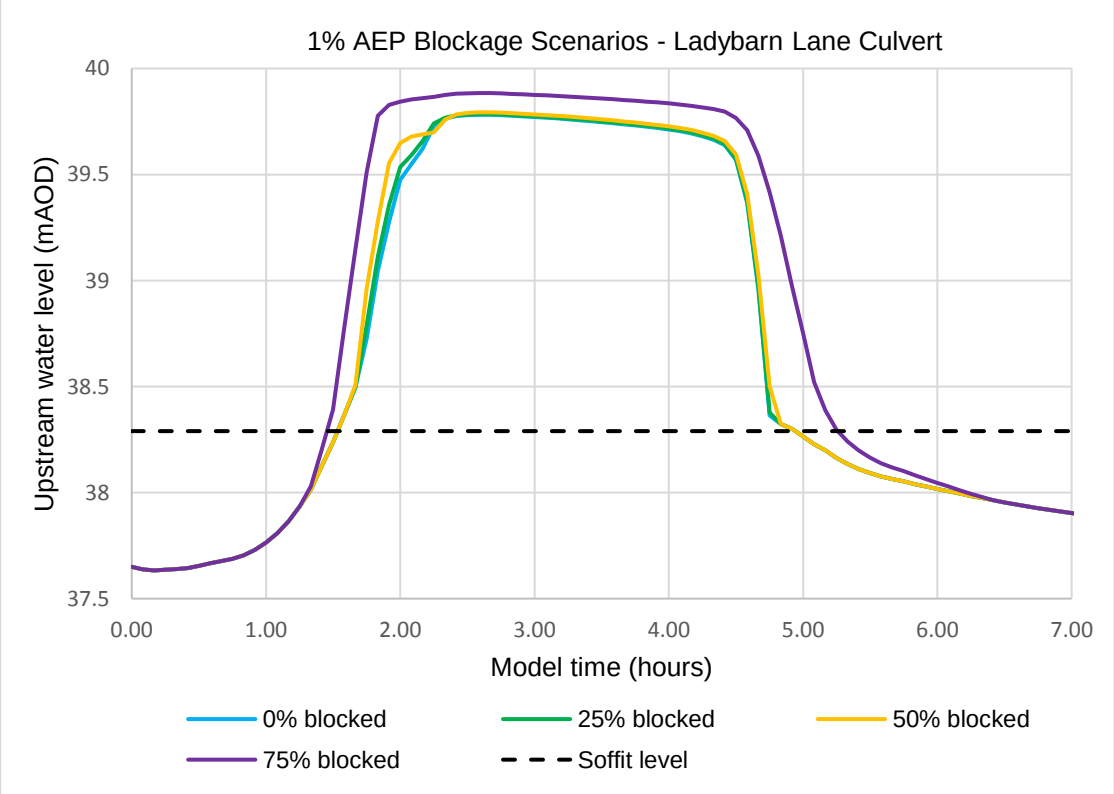
Figure 7-23 illustrates the change in upstream water levels and flood outlines associated with blockage of Egerton Road Culvert for the 1% AEP defended event. Blocking the culvert by 25%, 50% and 75% results in maximum 1% AEP river levels increasing by 0.02m, 0.07m, and 0.45m respectively. Increases in blockage proportion lead to some increases in the duration of the culvert surcharging, with the 75% blockage scenario causing the culvert to be surcharged for an hour longer compared to the baseline. The impact of culvert blockage at Egerton Road on flood extents is generally similar to that of blocking Ladybarn Lane, although the 75% blockage at Egerton Road is modelled to cause a larger increase in flood extent. This increase affects several properties in Fallowfield, particularly along Mornington Crescent, Victoria Road and Mauldeth Road West.

In the defended 1% AEP event plus 30% climate change, culvert blockages of 25%, 50% and 75% raise upstream water levels by 0.02m, 0.07m and 0.42m respectively. Blocking the culvert by 75% increases the duration it is surcharged by almost an hour. Figure 7-24 shows that all the modelled blockage proportions lead to an increase in flood extent, although these are more noticeable for the 75% blockage, which causes additional flooding to Delacourt Road and Alford Avenue.

Blockages at Egerton Road culvert have a similar impact on flooding to blockage at Ladybarn Lane culvert, although the increases in flood extent are slightly higher when blocking Egerton Road. All blockages result in additional flooding to Fallowfield, although these are most noticeable during the 75% blockage scenario for both the present day and future 1% AEP events, where properties around Mornington Crescent and Delacourt Road are affected.

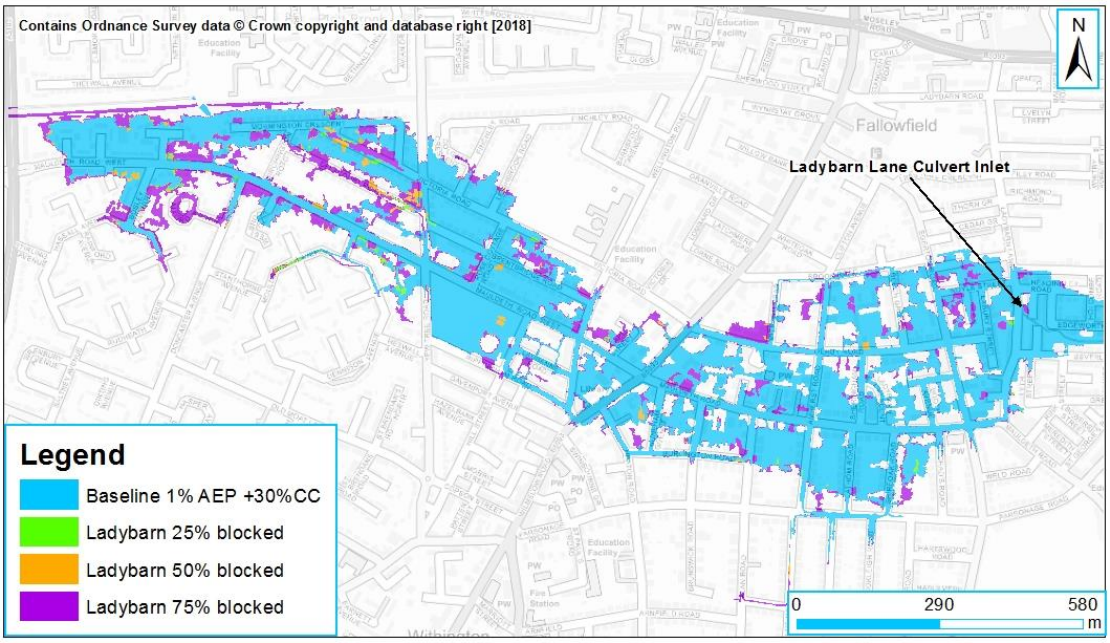
Figure 7-21: 1% AEP event blockage scenarios at Ladybarn Lane Culvert

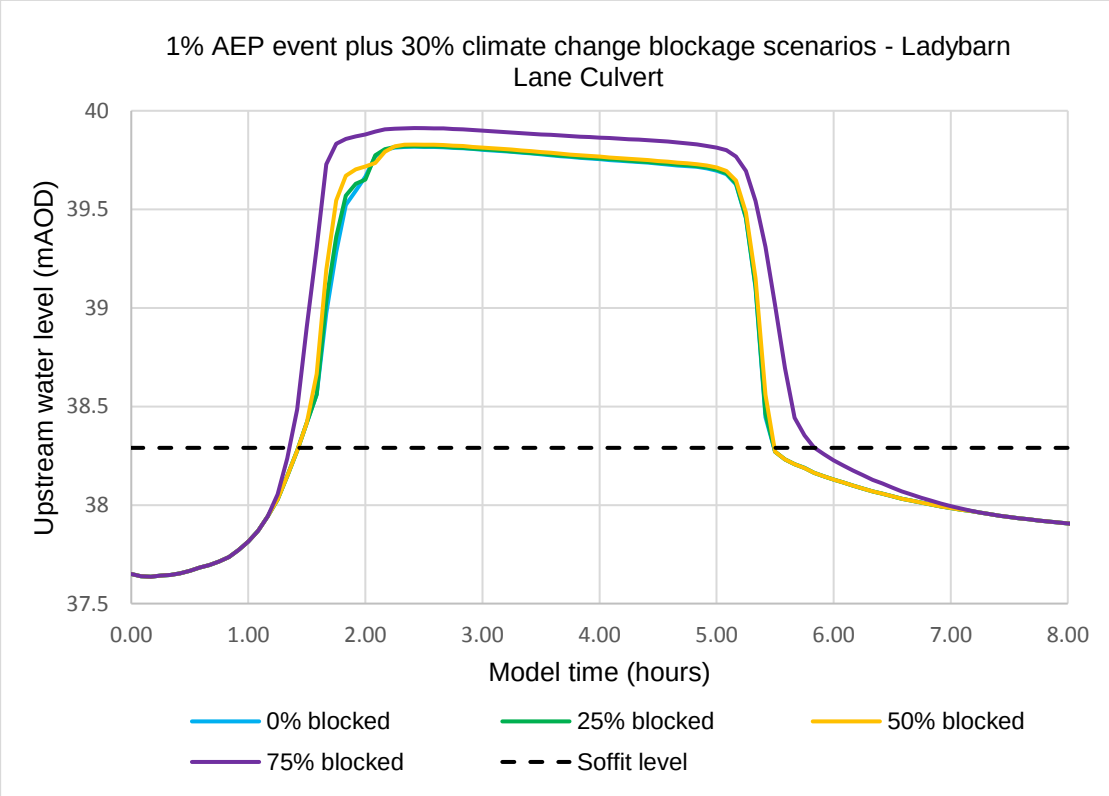




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	39.78	39.78	39.79	39.88
Surcharging duration (hours)	3.5	3.5	3.5	3.92

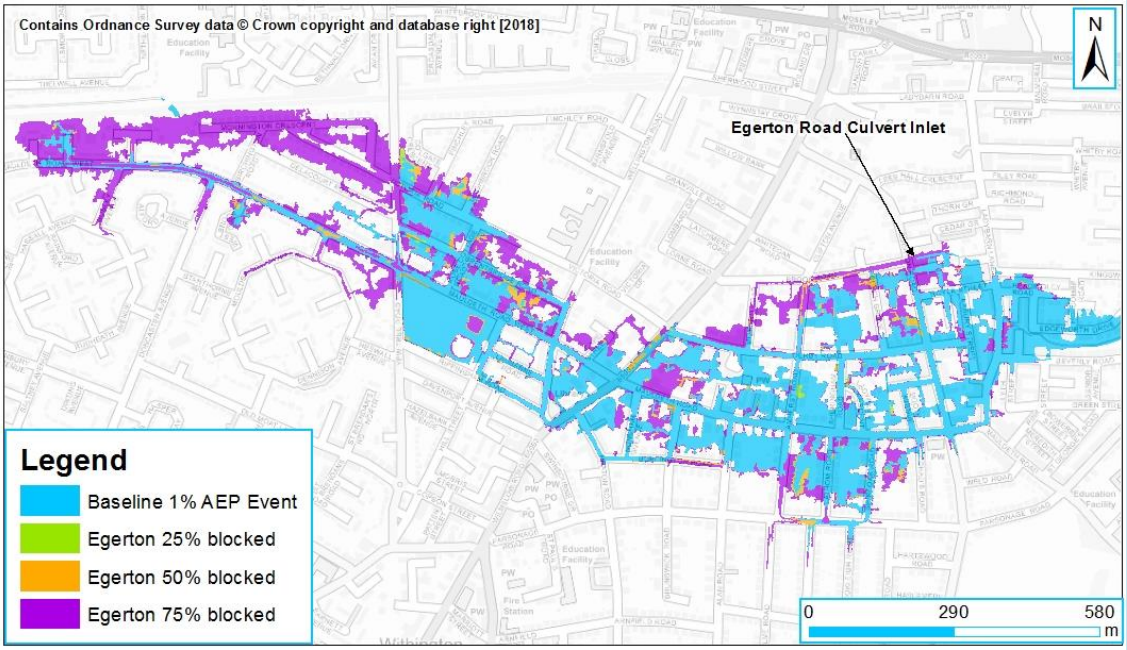
Figure 7-22: 1% AEP event plus 30% climate change blockage scenarios at Ladybarn Lane Culvert

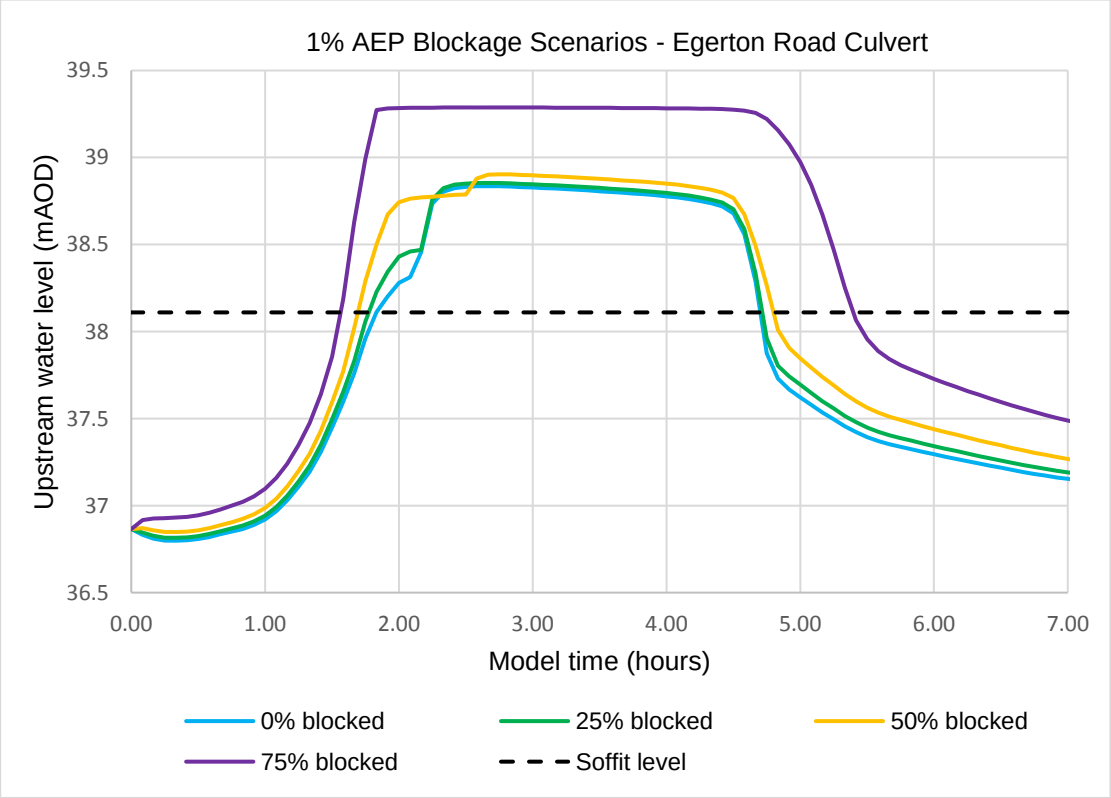




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	39.82	39.82	39.83	39.91
Surcharging duration (hours)	4.08	4.08	4.08	4.5

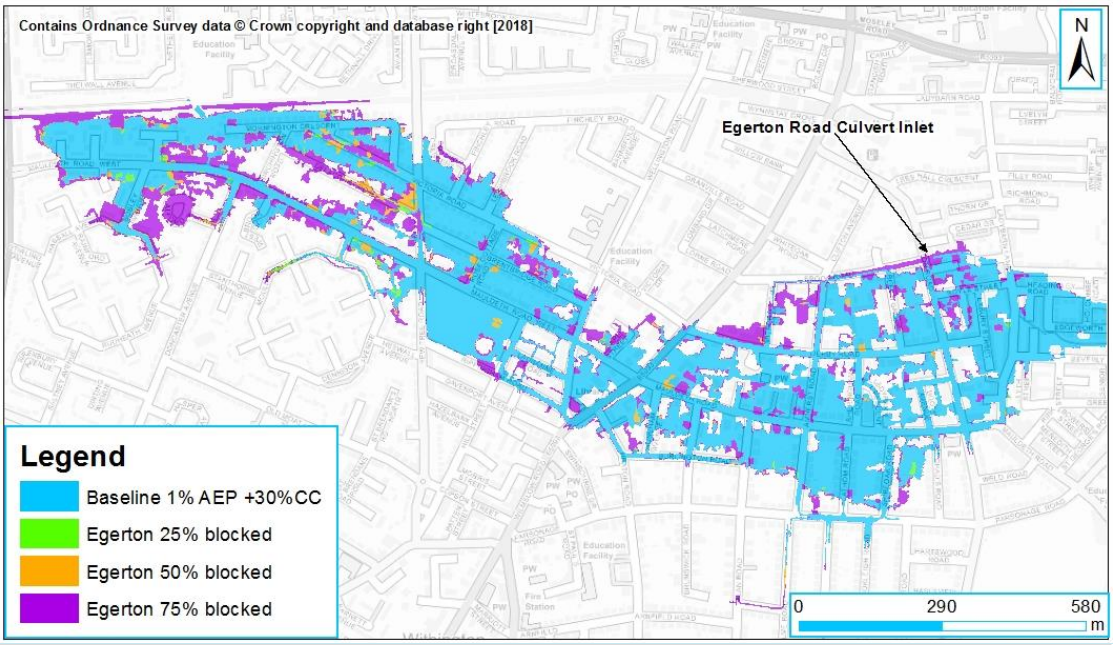
Figure 7-23: 1% AEP event blockage scenarios at Egerton Road Culvert

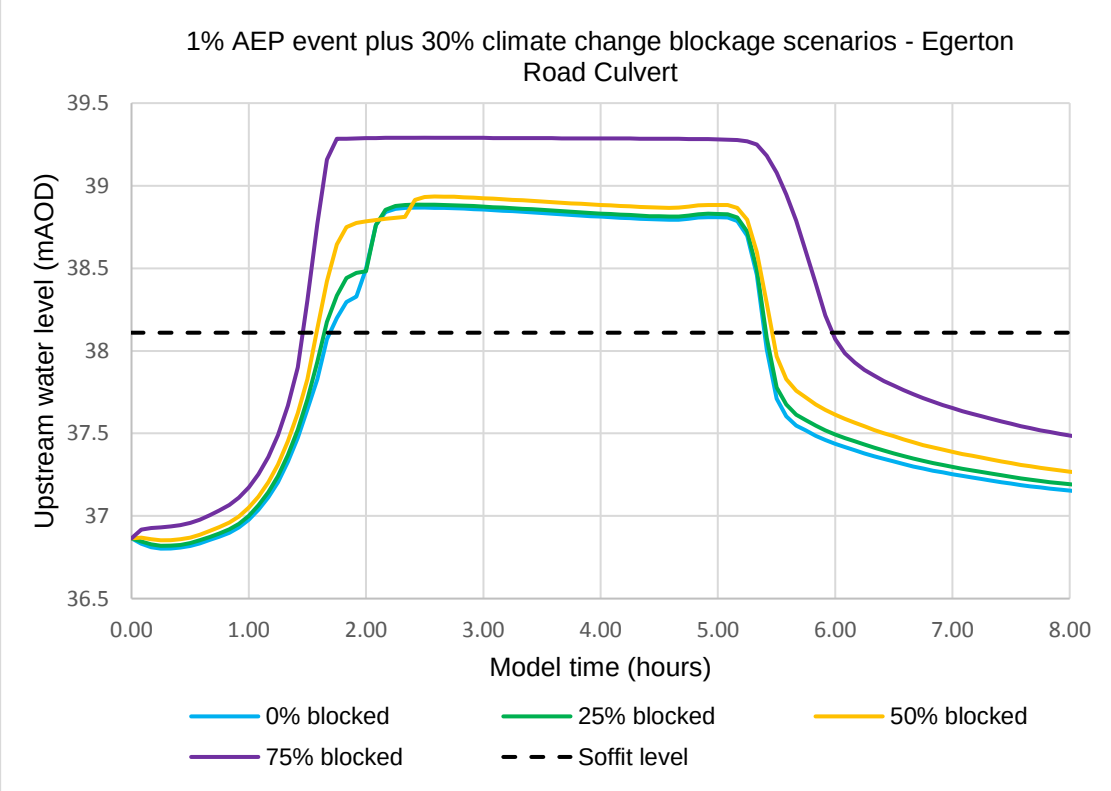




	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	38.84	38.85	38.90	39.29
Surcharging duration (hours)	2.92	3	3.17	3.92

Figure 7-24: 1% AEP event plus 30% climate change blockage scenarios at Egerton Road Culvert





	0% blocked	25% blocked	50% blocked	75% blocked
Peak water level upstream (m AOD)	38.87	38.89	38.93	39.29
Surcharging duration (hours)	3.75	3.83	4	4.58

8 Assumptions and Limitations

8.1 Introduction

Any hydrological and hydraulic modelling project is subject to various assumptions and limitations, given the nature of trying to represent a real-world scenario with the use of equations and computer software. A number of standard assumptions, such as the subjective approach of setting Manning's n roughness values, are inherent across all modelling projects.

8.2 Hydrological and Hydraulic Model Assumptions and Limitations

The following site-specific assumptions and limitations apply to the Cringle Brook study.

- Hydrological estimation is normally subject to considerable uncertainty. There are some flow and level measurements along the study watercourse, which should help to improve confidence in the flow estimates calculated. However, the gauges have their own limitations, and the flow gauge has not recorded any high flow events, which may be related to difficulties recording flow when the Egerton Road culvert is surcharged. Therefore, the flow gauge did not contribute as much as was initially expected to the hydrological analysis, which had to focus largely on the level gauge to provide an estimate for QMED.
- The FEH CD-ROM, DRN, OS Mapping, and Manchester Hidden Watercourses website had conflicting information regarding the watercourses and catchment areas draining into Cringle Brook. Therefore, although the catchment boundaries have been configured based on the best knowledge available, large uncertainties remain in the size and nature of the contributing sub-catchments.
- A significant proportion of the catchment is urbanised, so sewer catchment flows play a big part in the calculated hydrology. It has been assumed that the sewers draining into and out of the Cringle Brook catchment have been defined appropriately and set to an appropriate sewer capacity.
- A calibration/verification exercise has been undertaken against the largest recent flood event (September 2016) that has occurred since the Egerton Road flow and Platt Fields rain gauges were installed. However, although the model fit could potentially have been further improved, it was considered better to not force-fit the model to the observed levels due to a number of factors including the poor quality recorded flow series, the spatial variation in the observed rainfall series and the sensitivity of the model to the surcharging of Egerton Road culvert.
- The Cringle Brook model is an update to a previous model, and although it underwent a review at the start of the study and has been updated to reflect the recommendations of this review, it is possible that there are uncertainties inherent in the original model that have been transferred to the output of this study. These will largely relate to the 1D component of the model as the 2D model was effectively re-configured from scratch.
- The model runs for the majority of the design events have been stopped at 10 hours. There is still some slow spreading at this time, but it was assumed that this is slow and shallow and will not affect properties. The 1% AEP future events (accounting for climate change) and the 0.5% AEP event were run for longer (i.e. 15 hours) as there was a more obvious continuation in the spread of floodwater beyond 10 hours.
- The downstream boundary of the 1D model was chosen as the water level for the 1% AEP flood event on the Chorlton Platt Gore watercourse. This was taken directly from the existing Chorlton Platt Gore model (which includes representation of Cringle Brook). It has, therefore, been assumed that this boundary is appropriate for modelling design events, an assumption that was backed by sensitivity testing, which showed that the modelled flood outlines for Cringle Brook are relatively insensitive to the downstream boundary.
- The 2D model topography is largely based on filtered LIDAR (DTM) elevations, which can be influenced by dense vegetation and buildings. The LIDAR used for this study is at 1m resolution, but two different datasets had to be used (2016 and 2013) so there may be slight discrepancies at the intersection of these datasets. Survey data has been used where possible to define bank levels, as these are more accurate than LIDAR.
- In the absence of threshold data, it is assumed that all buildings are at ground level defined by the LIDAR DTM and exterior/interior walls inhibit water movement only by use of a high

Manning's n value. In reality, the impact of buildings will be more complex (e.g. floor levels will generally be smoother than LIDAR and exterior walls may hold back flow).

- The modelling undertaken represents only the fluvial flood risk from Cringle Brook and does not include for any direct surface water risk from the collection of rainfall, surcharging of the sewer system and urban runoff routes.
- The design levels and maps contained in the main part of Section 7 assumed that all structures remain free from blockage. The potential impact of blockage at key structures was detailed, separately, in Section 7.7.

9 Conclusions and Recommendations

9.1 Conclusions

The existing 1D-2D (ISIS-TUFLOW) hydraulic model of the Chorlton Platt Gore through Manchester has been updated to only include the Cringle Brook, itself. The following key changes were made to the existing model in order to define an up-to-date flood risk for mapping purposes:

- A new hydrological assessment was undertaken, drawing on the information available at the flow and level gauges at Egerton Road culvert.
- The 1D domain of the existing model was trimmed and updated following a review at start-up.
- A new 2D domain was created to define a higher definition (2m) floodplain based on recent (mostly 2016) LIDAR.
- A bank crest survey of the formal EA defences was undertaken as part of the commission and read into the 2D model to accurately define the bank crests.

The updated model was then used to create Flood Mapping deliverables, including peak river levels, modelled flood outlines and hazard grids. These outputs can be used to assess the design flood risk in Fallowfield and the benefits offered by formal defences within the catchment.

The following conclusions can be drawn from this project:

- The modelled fluvial flood risk is generally high for the Cringle Brook catchment, due to the constrained and culverted nature of the channel, and the significant urbanisation surrounding it.
- Flooding of property is modelled to occur at a low return period (10% AEP) due to overtopping of the banks immediately upstream of the existing defences (around Ladybarn Lane), where the bank crests are relatively low. The extent of flooding in Fallowfield is exacerbated by the fact that floodwater cannot return into the Cringle Brook further downstream as it is culverted for much of its downstream reach.
- Present day events in excess of 0.5% AEP and future (with climate change) 1% AEP events are modelled to flood parts of the upper catchment, alongside Crossley Road, from a flow route originating upstream of the Wellington Road culvert; although the volume of overtopping during an actual event could be limited by the presence of existing (non-defence) walls.
- The modelled risk generally ties in with the anecdotal flood history, which implies that no flooding has occurred since the Cringle Brook FAS was installed in 2004. The September 2016 event, which is the largest on record at the Egerton Road Debris Screen level gauge, is considered to be close to a 10% AEP event, based on a comparison of observed ad modelled levels at the gauge. However, the model has been demonstrated to be conservative during events of this magnitude as the model predicts overtopping further upstream when the observed September 2016 level at the gauge is matched.
- Blockage scenarios have been run for six culverts along Cringle Brook and the results show that blockages would generally result in an altered risk pattern from the unblocked (baseline) scenario.

9.2 Recommendations

The following recommendations are made considering the conclusions of the project:

- The Egerton Road flow gauge can be seen to have dropped out during several of the highest flow events that have occurred in its short (3-year history) in its record so does not seem to have been located in an ideal position to record high flow events. Therefore, it is recommended that the reasons for this gauge dropping out are investigated to determine whether it is possible to record good quality flow data at this location or whether it would be better relocated.
- The model is considered to produce a conservative prediction of the September 2016 event in the vicinity of Egerton Road and Ladybarn Lane culverts but the quality of the observed data (particularly flow) was not considered sufficient for the model to be calibrated to this dataset. However, if further calibration events yield more reliable data, then an improved model calibration should be attempted.

- The model predicts a 10% AEP property threshold in Fallowfield due to overtopping upstream of the existing defences. This would, therefore, appear to be a key area to examine in relation to future flood mitigation schemes.
- Consideration should be given as to whether the walls upstream of Wellington Road culvert should be maintained to act as flood defences.
- The model should be maintained in line with future development in the study area.

Appendices

A Deliverables

In addition to this report, the project has the following key deliverables which have been supplied in full in electronic format with final delivery.

A.1 Hydraulic Models

- All design event model files associated with the updated 1D-2D hydraulic models for Cringle Brook including results.

A.2 ASCII Grids

- ASCII grids for peak flood level, depth, velocity and hazard for all modelled design events.

A.3 GIS Polygons

- Flood outline polygons.

MapEdit deliverables

The following MapEdit data has been supplied:

- Modelled information locations (node points);
- Modelled Flood Group;
- Modelled Flood Outline;
- Modelled measurement;
- Areas Benefitting from Defences (including areas dis-benefitting from defences).

A.4 1D Node Point Tables

- Microsoft Excel spreadsheet containing peak level, flow and velocity at each 1D node for all design events.

B FEH Calculation Record

C Model User Report

D Cringle Brook Technical Review Certificate

E 2017 Spot Level Survey

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