LAND AT AMBROSE WAY, IMPINGTON

POSITION STATEMENT REGARDING ONGOING HYDRAULIC MODELLING OF EXISTING ONSITE FLOOD RISK

Non-Technical Executive Summary

1.1. The Environment Agency has advised that the existing flood modelling and mapping in the vicinity of the site is "not accurate enough to determine site specific flood risk" and that "further study" is required.

1.2. Hydraulic modelling has therefore been undertaken to assess the present-day flood risk to the site. The modelling demonstrates that the flood risk to the site is significantly lower than shown on the Flood Map for Planning and that the extent of Flood Zone 3 (the high risk zone) is restricted to a small area in the south-eastern corner of the site.

1.3. A Flood Map Challenge has been submitted to the Environment Agency on the basis of this modelling.

1.4. Additional modelling of mitigation measures to protect the site from future flooding (including appropriate allowances for climate change) has also been undertaken. This modelling has shown the development to be deliverable with no downstream detriment.

Introduction and Baseline Conditions

1.5. A number of drainage ditches, field drains and manmade channels cross and bound the site. The drainage ditches form the Site's northern, eastern and southern boundaries and another drainage ditch crosses the southern area of the site. The drainage ditches have generally flat gradients but tend to flow towards the Site's southwestern corner in the direction of Ambrose Way.

1.6. The site is located at the head of two different catchments; one flowing southwest towards Ambrose Way and the other flowing to the north/north-east. Drainage patterns in the vicinity of the site are heavily modified due to the generally flat topography of the area.

1.7. South Cambridgeshire and Cambridge City's Level 1 Strategic Flood Risk Assessment (SFRA), dated September 2010, is a living document which aims to set out flood risk constraints for the study area. The SFRA for the area of the site does not include any detailed hydraulic modelling and the Environment Agency's (EA) Flood Zones have been used to inform the SFRA.

1.8. The EA's Flood Map for Planning shows parts of the site located within Flood Zones 1, 2 and 3. On first inspection the Flood Zones shown on the Flood Map for Planning do not appear realistic given the site's topography and the limited size of the upstream catchment.

1.9. Planning permission was granted for residential development on land located immediately to the south of the site in 2011 (application reference S/1847/10). This land is located entirely within Flood Zone 3. The planning application for this development was supported by a Flood Risk Assessment that demonstrated that the Flood Zones in this location were generated using upstream catchment information that was based on inaccurate ground level data.

1.10. Enquiries were made to the Environment Agency in 2017 to determine what current hydraulic information was available and if any updates to the Flood Zones were planned in this location.

1.11. The Environment Agency's response is reproduced in **Appendix 1**. With regards to the accuracy of the modelling data available the EA's response included the following:-

> *"The Flood Zones for this area pre-dates 2010. It is the most up to date mapping we have for this area."*
>
> *"The Flood Zones are generated using 2D JFlow modelling package. The Flood Zones are indicative of the natural undefended floodplain (i.e. without defences) as well as incorporating the combined extents from historic flooding."*
>
> *"…the JFlow modelling for this area is using relatively coarse modelling and digital terrain, it only looks at local general topography and indicates where water may go during a flood event if the terrain is unimpeded. It is not accurate enough to determine site specific flood risk at that location and only shows areas that may be at risk but require further study."*
>
> *"We currently have no plans to update the flood map in this area."*

1.12. A further request for updated hydraulic modelling data was made to the Environment Agency in 2019. The EA confirmed that no updated modelling was available. A copy of the EA's response is reproduced in **Appendix 2**. With regards to data available in this location the response from the Environment Agency's technical team included the following:

> *"Unfortunately, we do not hold detailed modelling for the Ordinary Watercourse in this area. The flood map here is the only information available. The flood zones are the result of broadscale JFLOW modelling and this is the best information we have available."*
>
> *However, please note that JFLOW modelling is indicative only and is not suitable for identifying whether an individual property will flood, for detailed decision making or for use in site specific Flood Risk or Strategic Flood Risk Assessments. Where this data is used for anything other than broad catchment or Shoreline Management Plan scale further evidence, verification and studies should be undertaken."*

1.13. On the basis of the Environment Agency's responses it is considered that the current Flood Map for Planning in this location is not suitable to inform land use planning decisions.

Initial Hydraulic Modelling

1.14. Initial modelling was undertaken to assess the flood risk to the site.

1.15. Due to the location of the site being relatively high up the river catchment along with the heavily modified drainage patterns within the catchment (evidenced by the large number of ditches, field drains and manmade channels) it is unlikely that a standard hydrological analysis will yield accurate hydrological estimation. FEH catchment descriptors were assessed for the site and found to provide a poor fit for the surrounding topography.

1.16. The initial modelling has therefore been undertaken using direct rainfall modelling onto a two-dimensional model domain. Rainfall data has been obtained from the FEH web service. Topographical data has been obtained from Lidar and site-specific topographical survey data. Soil parameters, including infiltration, have been obtained from the European database.

1.17. The initial outputs from this modelling generate significantly smaller Flood Zone 2 and 3 extents compared to the current Flood Map for Planning.

1.18. Initial model outputs for the 1 in 100 year (equivalent to Flood Zone 3) and 1 in 1000 year (equivalent to Flood Zone 2) return periods are shown on drawing number M384/7 in **Appendix 3.**

1.19. An enquiry was been made to the Environment Agency's Partnership and Strategic Overview team regarding the suitability of the above approach to modelling flooding from the ordinary watercourses in the vicinity of the site.

1.20. The Environment Agency's response indicates that, in principle, a direct rainfall modelling approach would be suitable to provide evidence to challenge the current flood map. A copy of the Environment Agency's email is reproduced in **Appendix 4**. The Environment Agency's response includes the following:-

> *"We agree to your direct rainfall modelling approach in principle, but we would need to review all your evidence before we can give a definitive answer on the flood map update."*
>
> *"We would then review the data and would need to be satisfied the evidence you have provided is better and more relevant then already exists before making any changes to the Flood Map for Planning."*

Flood Map Challenge

1.21. In order to challenge the existing Flood Zones outlined in the Flood Map for Planning a formal Evidence Based Review has been raised with the Environment Agency.

1.22. The flood extents contained in Appendix 3 have been updated based on fluvial modelling undertaken to date by Aegaea. The flood extents shown have been exported from the Aegaea "Histon Fluvial Model version 15" which have been updated to take into account intrusive site investigations examining the permeability of soils onsite.

1.23. The updated model outputs are supported by Aegea's Histon Technical Note, document reference AEG0055 contained in **Appendix 5**.

1.24. The technical note, flood model extents and modelling files were submitted to the Environment Agency as part of a formal Flood Map Challenge on 2nd June 2021.

Mitigation Modelling

1.25. The site is located at the head of the catchment. Therefore, the rainfall-runoff model that was submitted as part of the Flood Map Challenge was used to identify sub-catchments and the appropriate inflow locations for fluvial flows. The fluvial flows derived during the initial modelling were then scaled according to area and applied to the watercourse to simulate a set of baseline conditions.

1.26. In order to represent the proposed development, the land parcels were raised out of the floodplain. Additionally, three surface water drainage outfalls associated with the site were incorporated within the model. To mitigate the impacts of the development, an area of floodplain adjacent to the channel has been lowered by approximately 0.5m. The current mitigation strategy also includes amendments to the channel adjacent to the site, representing a two-stage approach on the right bank.

1.27. The model results have shown the development to be deliverable with no downstream detriment.

1.28. The locations of the dual use flood mitigation areas and SuDS features are shown on the Concept Masterplan (EDP's drawing number edp551_d023c) and the Land Budget Plan (EDP's drawing number edp5518_d024a), copies of which are reproduced in **Appendix 6**.

Conclusions

1.29. The Flood Map for Planning in the vicinity of the site is based on a pre-2010 JFlow model that uses coarse terrain data and modelling.

1.30. The Flood Map for Planning in this location is not suitable to be used to inform land use planning decision making.

1.31. The Environment Agency has agreed in principle that a direct rainfall modelling approach to generating more accurate Flood Zones in this location would be acceptable.

1.32. Modelling outputs show a reduction in the extent of Flood Zones 2 and 3 on the site.

1.33. The model was submitted to the Environment Agency as evidence to support a Flood Map Challenge in June 2021.

1.34. Further mitigation modelling has shown the development to be deliverable with no downstream detriment.

Appendix 1

Natalia Glowacka

From: Kilgallon, Rachel <Rachel.Kilgallon@environment-agency.gov.uk> on behalf of PSO-Brampton <PSO-Brampton@environment-agency.gov.uk>
Sent: 19 April 2017 11:27
To: nglowacka@pfaplc.com
Subject: REF: 42413 Land at Ambrose Way, Histon

Dear Natalia,

Many thanks for your enquiry on 27 March 2017 regarding flood risk information for the land at Ambrose Way, Histon, and grid reference TL4445963681.

As requested, I am providing further information regarding the flood map produced for this surrounding area.

- The Flood Zones for this area pre-dates 2010. It is the most up to date mapping we have for this area.

- The Flood Zones are generated using 2D JFlow modelling package. The Flood Zones are indicative of the natural undefended floodplain (i.e. without defences) as well as incorporating the combined extents from historic flooding.

- We hold no records of flooding in this area. However, we can only show flooding where we have adequate records. So, just because an area of land is shown outside the extents of recorded flooding, doesn't mean it has never flooded. Water causing flooding can come from different places, for example from rivers or the sea; surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system); overflowing or backing up of sewer or drainage systems which have been overwhelmed or from groundwater rising up from underground aquifers. This area is in an area at high risk of surface water flooding. For more information about how surface water flooding is managed in your local area please contact Cambridgeshire County Council.

- I have sourced the planning application that you have referred to – S/1847/10. It is my understanding that the modelling provided for that application was site specific. This would have been reviewed during the planning application and in conjunction with other site specific factors. As such, I am unable to comment fully on that application. However, as the JFlow modelling for this area is using relatively coarse modelling and digital terrain, it only looks at local general topography and indicates where water may go during a flood event if the terrain is unimpeded. It is not accurate enough to determine site specific flood risk at that location and only shows areas that may be at risk but require further study.

- We currently have no plans to update the flood map in this area. You may wish to complete an Evidence Review Request if you believe the current information for this area is not appropriate. We can only make changes based on appropriate evidence. For us to consider a change to Flood Zone 3 and 2 shown on the Flood Map for Planning (Rivers and Sea) you will need to provide us with a model, supporting data, and results. New evidence provided may not change a map but we may be able to provide more detailed information in a letter about the level of risk. We can only update the Flood Map for Planning (Rivers and Sea) if modelling is submitted for an evidence based review and not just under the planning process.

- A simple outline of what is required is provided below:
  - Estimate the flow (derive hydrology) using Flood Estimation Handbook methods
  - Gather Global Positioning System (GPS) derived ground survey (for all in channel sections and beach profiles) or GPS derived ground survey or LiDAR (Light Detection and Ranging) data for floodplain areas
  - Produce a hydraulic model to current best practice
  - Run the model to produce water level results and a mapped flood extent for specified annual probabilities.
  - Test the model against recorded events where data is available
  - Supply all supporting data, results, a modelling report and mapped outlines

- We are able to offer pre-application advice on Flood Risk Assessments about a proposed development, or change of use, for a specific plot of land. Developers needing more detailed technical advice, may be charged for planning advice.

If you have any queries or would like to discuss the content of this letter further please contact the Partnership and Strategic Overview Team at the Environment Agency on the details given at the bottom of this letter.

I hope that we have interpreted your request for information correctly.

Kind regards,

Rachel Kilgallon

FCRM Officer, Partnerships and Strategic Overview
East Anglia Area (Great Ouse catchment)
Environment Agency, Bromholme Lane, Brampton, Cambridgeshire, PE28 4NE.

Tel. No. (Ext.) 020847 49284. (Int.) 49284
Team Email: PSO-Brampton@environment-agency.gov.uk

Appendix 2

From:	Enquiries_EastAnglia
To:	Daniel Buciak
Subject:	EAn/2019/144925 Final response to your Product request for Land at Histon
Date:	25 October 2019 14:37:27
Attachments:	144925 letter.pdf East_Anglian_External Climate Change Allowances Guidance Oct2016.pdf 144925 Cott Lode 08_10_2019_EL.XLS FRA advisory note.pdf

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Dear Daniel,

Thank you for your request of the 3rd October 2019.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

I have attached a letter regarding Flood Product data you requested. Furthermore, please read below for the response from the technical team-

Unfortunately, we do not hold detailed modelling for the Ordinary Watercourse in this area. The flood map here is the only information available. The flood zones are the result of broadscale JFLOW modelling and this is the best information we have available.

For your information, JFLOW datasets are available for download under an open licence. Please find below a link to the 1% AEP and 0.1% AEP JFLOW outlines for the TL national grid square;

- *1% AEP - https://data.gov.uk/dataset/modelled-fluvial-flood-depth-data-created-2004-1-percent-annual-chance-for-grid-reference-tl*
- *0.1% AEP - https://data.gov.uk/dataset/modelled-fluvial-flood-depth-data-created-2004-0-1-percent-annual-chance-for-grid-reference-tl*

The section of relevance to this area is: TL46SW

However, please note that JFLOW modelling is indicative only and is not suitable for identifying whether an individual property will flood, for detailed decision making or for use in site specific Flood Risk or Strategic Flood Risk Assessments. Where this data is used for anything other than broad catchment or Shoreline Management Plan scale further evidence, verification and studies should be undertaken.

Historic Event Information
We have no historic flood event information for this area. It is possible that other flooding may have occurred that we do not have records for, and other organisations such as local authorities may have records.

Surface Water
The Risk of Flooding from Surface Water Flood Map (RoFSW) can be viewed and downloaded as a PDF file on GOV.UK by following this link: ***https://flood-warning-information.service.gov.uk/long-term-flood-risk/map***

The outputs from the RoFSW mapping are also available as open data to download as GIS layers from data.gov.uk.

This includes:

- *Risk of Flooding from Surface Water Suitability*
- *Risk of Flooding from Surface Water Depth (3.3, 1 and 0.1 percent annual chance)*
- *Risk of Flooding from Surface Water Speed (3.3, 1 and 0.1 percent annual chance)*
- *Risk of Flooding from Surface Water Hazard (3.3, 1 and 0.1 percent annual chance)*
- *Risk of Flooding from Surface Water Direction (2m) (3.3, 1 and 0.1 percent annual chance)*
- *Risk of Flooding from Surface Water Direction (25m) (3.3, 1 and 0.1 percent annual chance)*

The 1% chance depth can be found here. (See related datasets for additional scenarios)

We are unable to provide model input data and model files for the RoFSW mapping as we do not own the intellectual property rights to the datasets.

While the EA hosts this modelled data, it has been produced on behalf of Lead Local Flood Authorities (LLFA). Any queries regarding surface water flooding should be addressed to the LLFA (Cambridgeshire County Council).

*Lead Local Flood Authorities (LLFA) are responsible for managing local flood risk from ordinary watercourses, surface water flooding and groundwater flooding. They **may** be able to provide additional information relating to this area.*

Flood Map for Planning (Rivers and Sea)

*The Flood Map for Planning (Rivers and Sea) can be viewed and downloaded as a PDF file on GOV.UK by following this link: **https://flood-map-for-planning.service.gov.uk***

Long Term Flood Risk Information

*Long term flood risk mapping including: **Risk of Flooding from Rivers or the Sea**, **Flood Risk from Surface Water** and **Flood Risk from Reservoirs** can be viewed on GOV.UK: **https://flood-warning-information.service.gov.uk/long-term-flood-risk/map***

Please refer to the Open Government Licence available here: http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ which explains the permitted use of this information.

Please get in touch if you have any further queries or contact us within two months if you would like us to review the information we have sent.

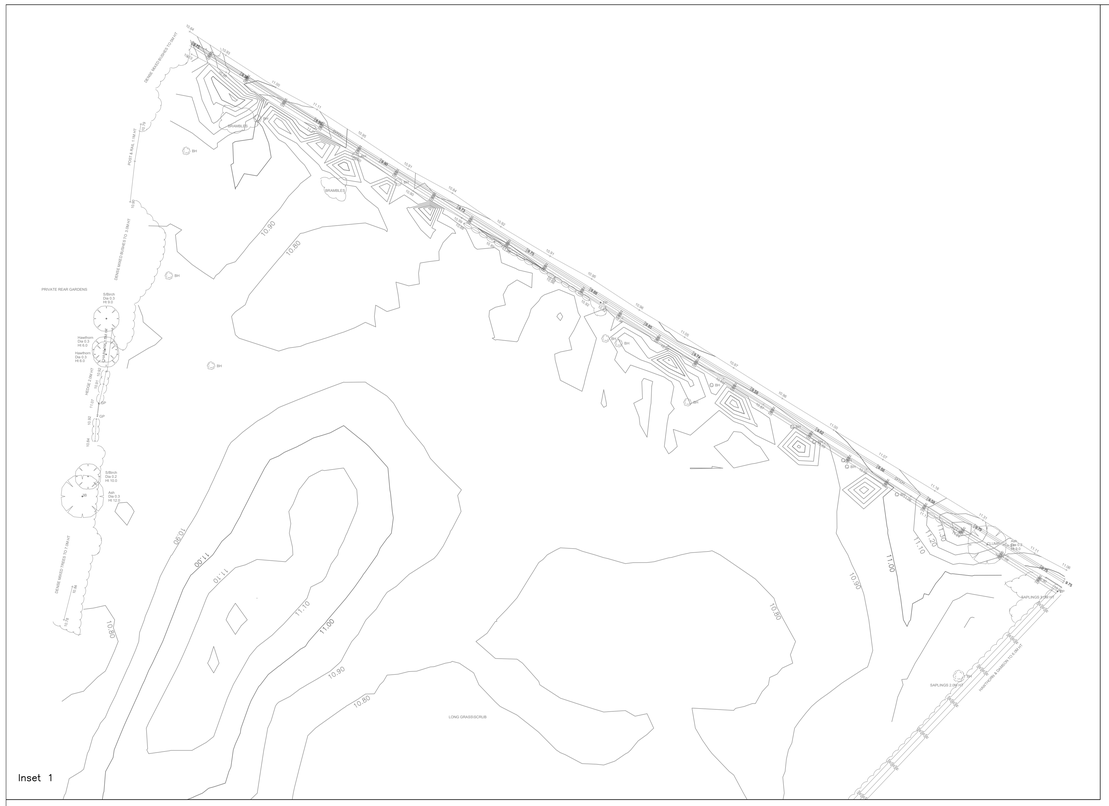
Please do contact me if I can be of further help.

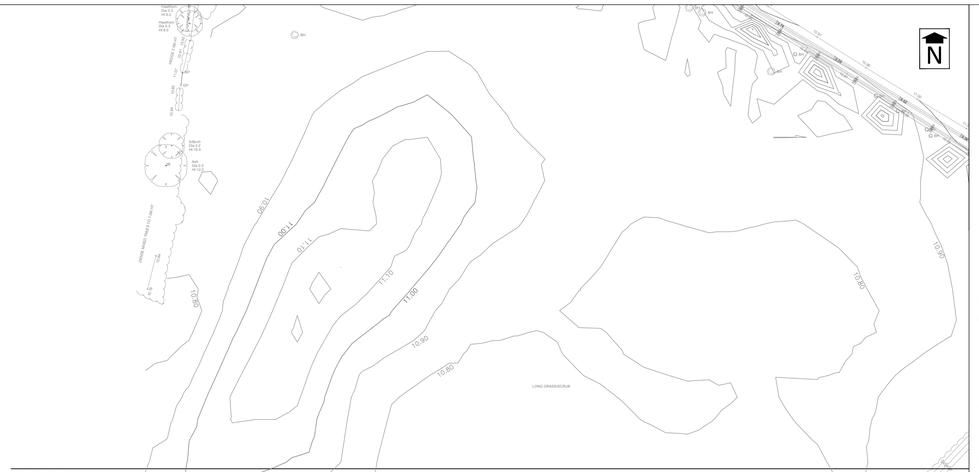
Kind regards

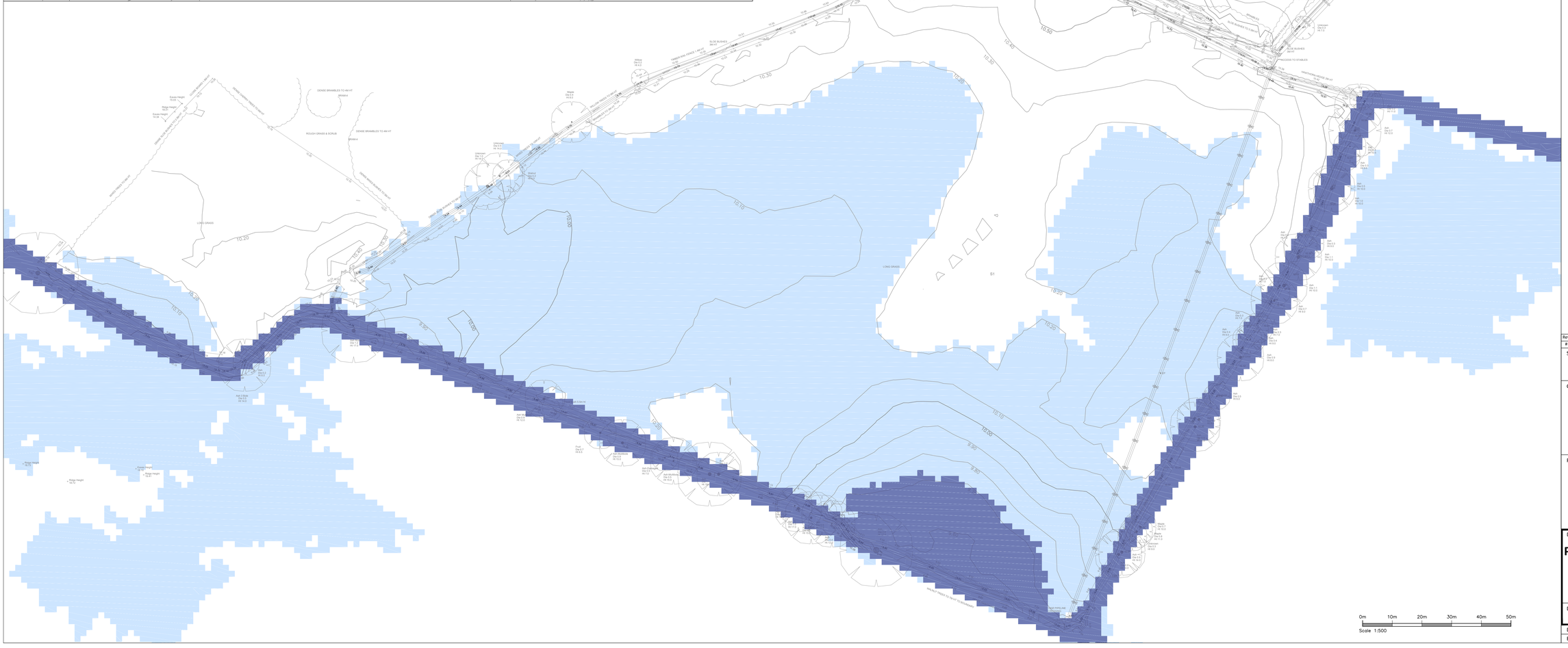
Lisa Ecclestone
Customers & Engagement Officer, Customers & Engagement Team, East Anglia Area
Environment Agency | Bromholme Lane, Brampton, Huntingdon, Cambridgeshire, PE28 4NE
Environment Agency | Iceni House, Cobham Road, Ipswich IP3 9JD

enquiries_eastanglia@environment-agency.gov.uk
External: 0203 02 55472

Appendix 3







PFA consulting

Stratton Park House, Wanborough Road
Swindon, SN3 4HG

Telephone
01793 828000

Website
www.pfaplc.com

NOTES

1. Based on Topographical Survey by Infomap Surveys & Mapping Ltd, dated October 2017, Drawing Number 1591.
2. Flooding extents shown are based on AEGAEA's Histon Fluvial Model version 15.
3. Drawing for information only with flood outlines shown used for preliminary information and are subject to change as flood modeling progresses during the flood map challenge process.
4. This drawing should be read in conjunction with AEGAEA's Histon Technical Note report, Document Reference AEG0055.

KEY

1 in 100 year Flood Extent. Equivalent to Flood Zone 3

1 in 1000 year Flood Extent. Equivalent to Flood Zone 2

Rev	Date	Description	Drawn	Check
#	14/04/21	First Issue.	DAB	MWS

Status

FOR INFORMATION

Client

MARTIN GRANT HOMES

Project

Land at Ambrose Way, Impington

Drawing Title

Preliminary Flood Outlines (Histon Fluvial Model Version 15)

Drawing No.

M384/07

Date: April 2021 | Scale: 1:500 @ A0

E-Mail: Dbuciak@pfaplc.com

Appendix 4

From:	Fryer, Andrew
To:	dbuciak@pfaplc.com
Subject:	Flood Map Challenge.
Date:	03 February 2020 16:00:54

Hi Daniel,

Thank you for your enquiry.

We agree to your direct rainfall modelling approach in principle, but we would need to review all your evidence before we can give a definitive answer on the flood map update.
The Flood map challenge process is an internal one and you would need to submit a request for an evidence based review. You would need to provide the environment agency with the model files and all outputs from the new model you have had made. As a minimum we will require a flood outline for the 1% and 0.1% AEP in GIS format (ESRI sahpefiles are preferable) as well as node point locations and extracted levels and flows which can be provided externally to customers. We would then review the data and would need to be satisfied the evidence you have provided is better and more relevant then already exists before making any changes to the Flood Map for Planning. You can either send the information to us by hard drive or we can send you a sharefile link and you could upload the data that way. We currently hold no plans to review/update the flood map in this area.

Kind Regards

Andrew Fryer.

Appendix 5

HISTON TECHNICAL NOTE

AEG0055

DESCRIPTION OF PROBLEM

SYNOPSIS OF WORK TO DATE

- On reviewing the flood outlines, topography and channel at the location of the catchment, it was identified that the fluvial flood outlines appeared to be incorrect. This is highlighted in Figure 1 below where there are extremely smooth, rounded flood outlines in areas where this would not be expected.
    - The flood outline is not aligned with the watercourse, probably due to the poor catchment delineation
    - The flood outlines do not appear to have been produced by flood modelling, but by original J-Flow outlines.
    - Shape of flood outlines do not look like they are “natural”.
- Given the catchment is at the head of the watercourse and in a very flat area, the flood risk at this site was considered to be a primarily rainfall driven problem, not suitable to a lumped hydrological input that is typical for a flood risk assessment. We therefore wished to create a direct rainfall model owing to:
    - Upper catchment
    - largely drainage ditches
    - very flat and difficult to get correct in FEH because the catchment is not well delineated.

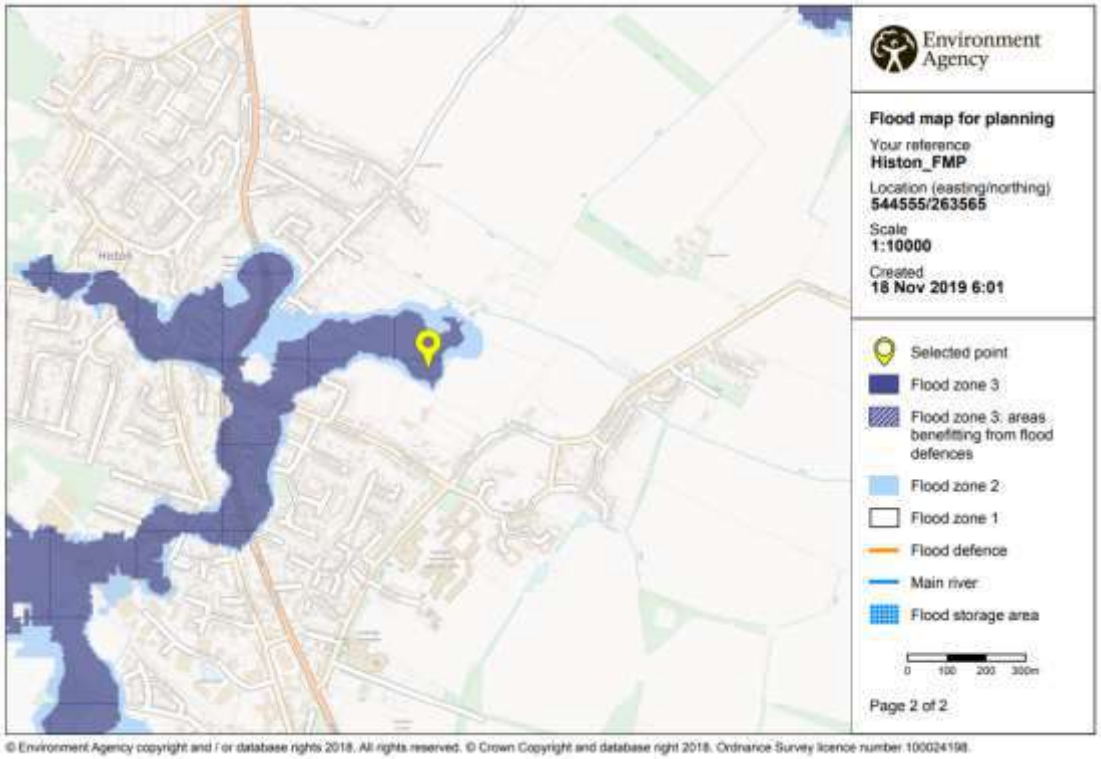


Figure 1 Fluvial Flood Map

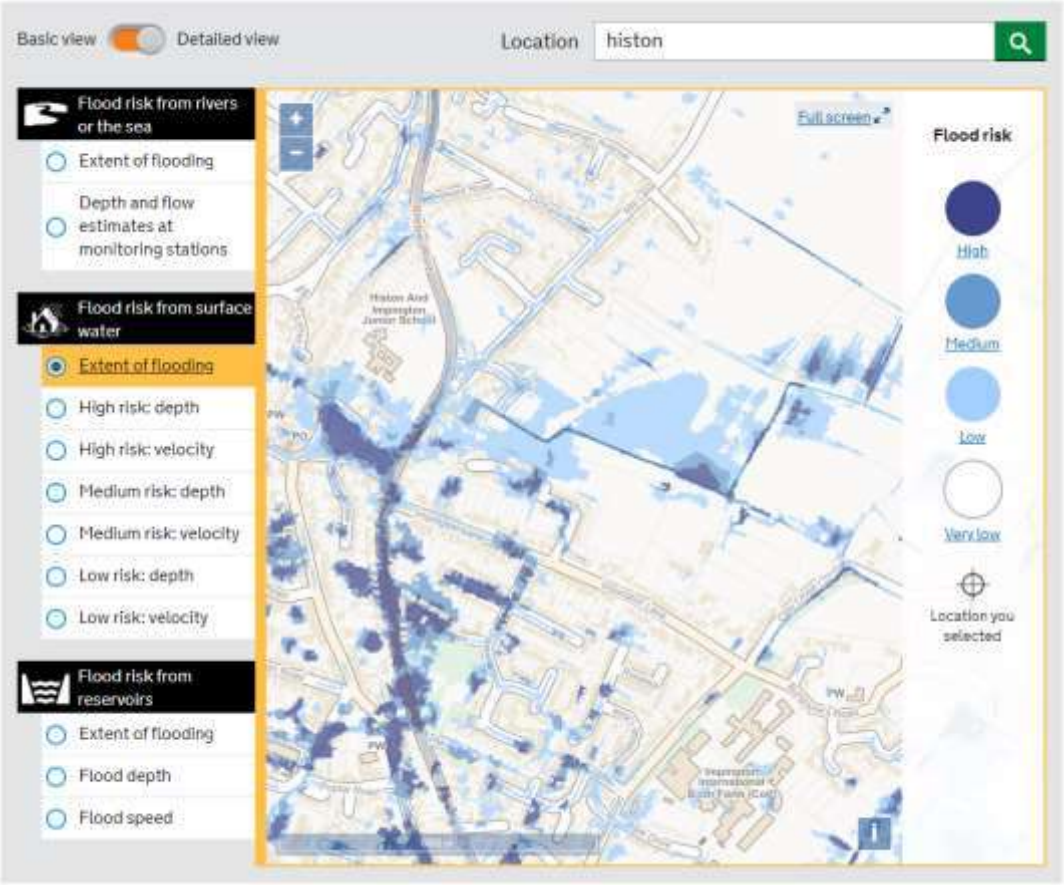


Figure 2 Risk of Flooding from Surface Water Map

- RoFSW maps show a bit more realism to observed topography and higher degree of accuracy in the upper catchment than the fluvial ones.
- However, we decided to model them since they are a simplistic representation of the issue and involve almost no structural inputs, or channel delineation and given that survey had been undertaken it seemed prudent.

We have therefore created a direct rainfall model of the site and surrounding area, to try and replicate the hydrological conditions using:

- Direct rainfall as extracted from FEH web
- Soils parameters from European database, including infiltration
- Channels and site survey data from surveyed information

FEH HYDROLOGY

- Even allowing for the fact that the catchment is hard to delineate from the topography, some flow analysis is still necessary. Using the FEH web tool, the following catchments were identified around the site.

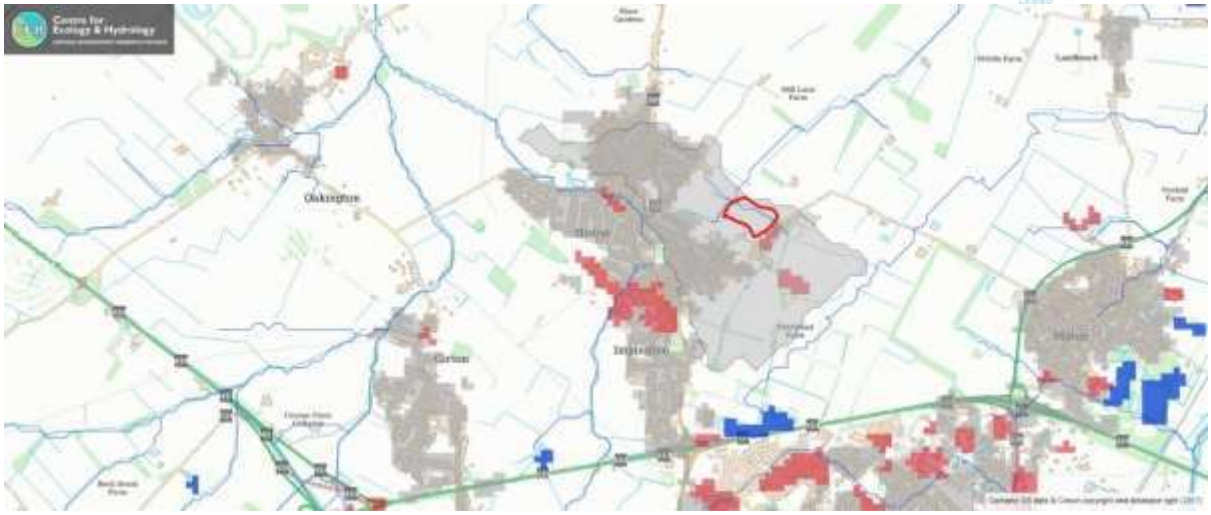


Figure 3 Site Location FEH

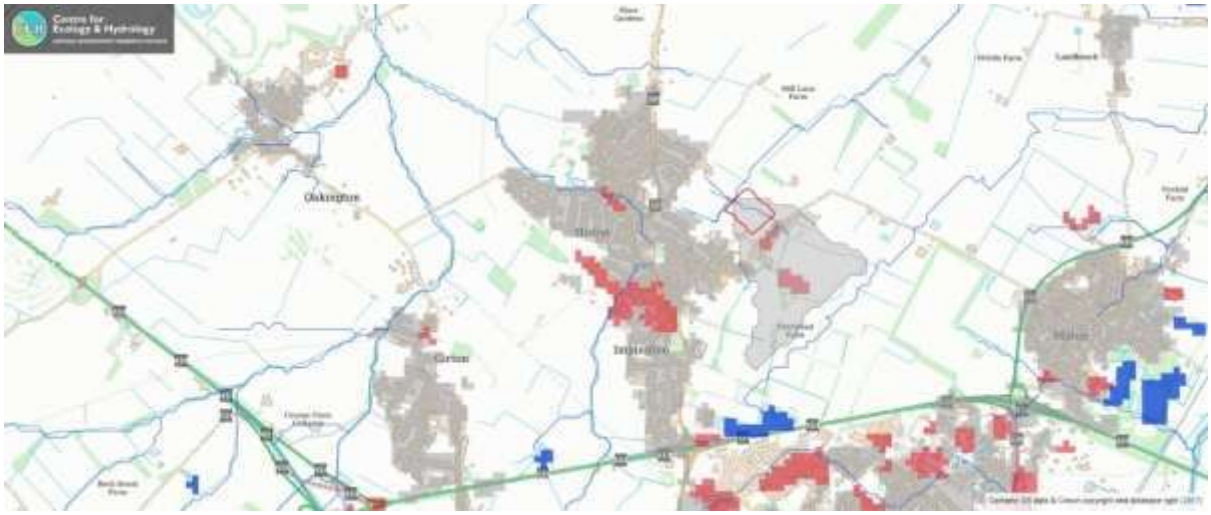


Figure 4 East Catchment

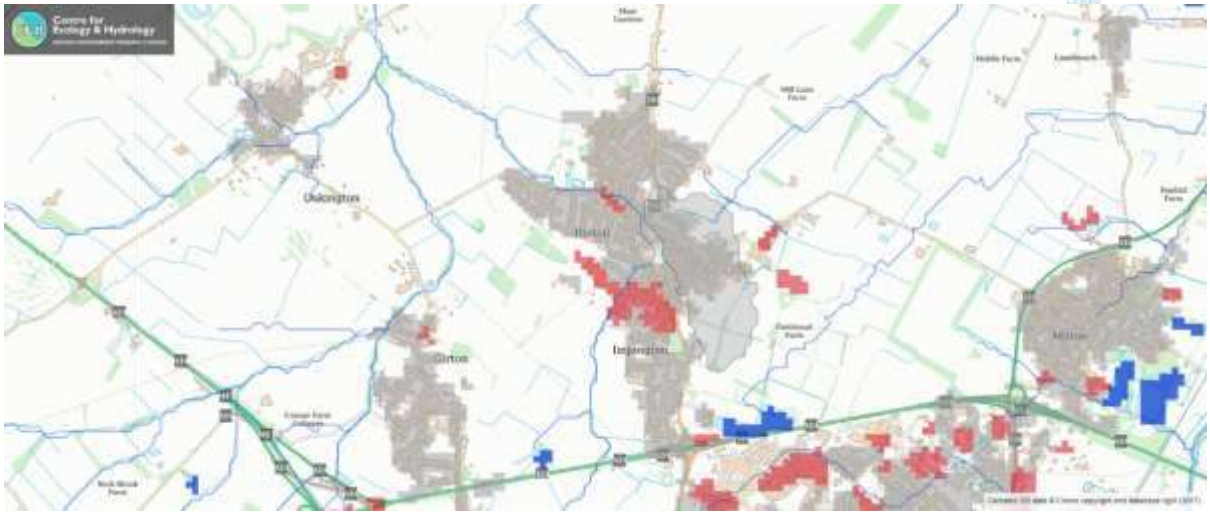


Figure 5 South Catchment

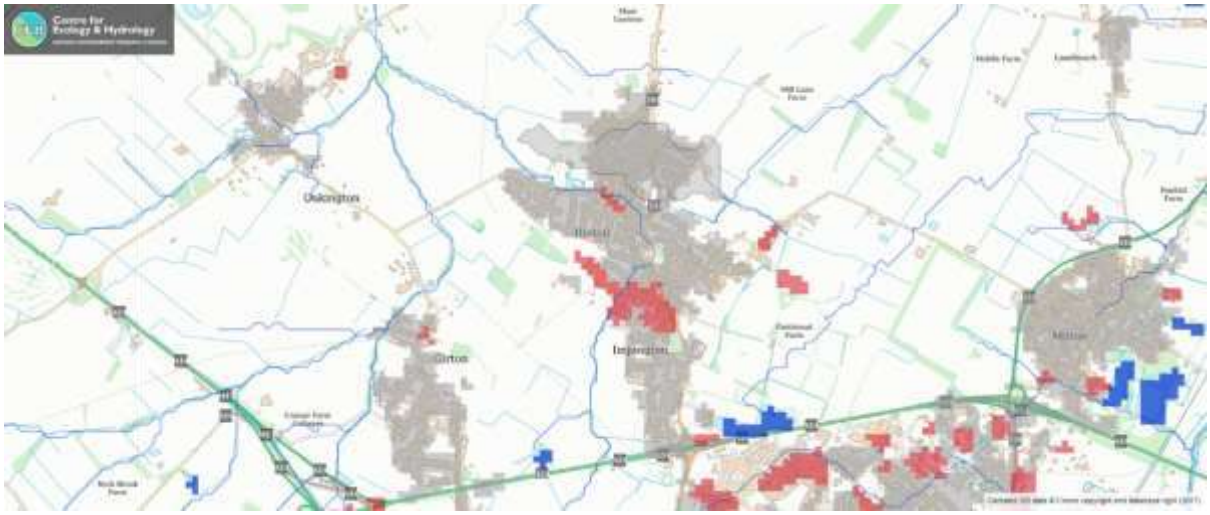


Figure 6 West Catchment

- The "East of Site" catchment below is the best fit for our site, it is about 0.54km^2, it encompasses the full catchment area and upstream of the site.
- The hydrological characteristics made it likely that the river flood mapping was really overestimating the flood outlines (see below), where:
    - Propwet is 0.26 suggesting dry soils. SPRHOST is 46% suggesting infiltration is potentially present. Middle to high BFIHOST of 0.49 suggesting a more permeable catchment
    - Soilscapes confirm it is a chalk catchment and might be susceptible to high ground water levels if the aquifer is high, however with low groundwater it should be freely draining.
    - Nonetheless full FEH and ReFH2 analysis was undertaken (see appendix A).
    - Hydrological analysis from FEH catchments suggested that we should be looking at a peak flow in the 100 year of between 0.6m^3/s and 1.35m^3/s depending on applicability of pooling and REFH2 estimation.

RAINFALL HYDROLOGY

- On the basis that the FEH outputs and the flood map outputs suggested that the normal approach might not be suitable, the rainfall characteristics were also exported from the FEH web interface in order to derive rainfall boundaries.
- It was found that a catchment critical storm duration of 4.5 hours was appropriate giving 73.54mm storm depth. This was generated into a rainfall hyetograph in TUFLOW.
- Other return periods, 5%, 1%, 1%cc20, 1%cc40 and 0.1% were also generated for the same storm duration.

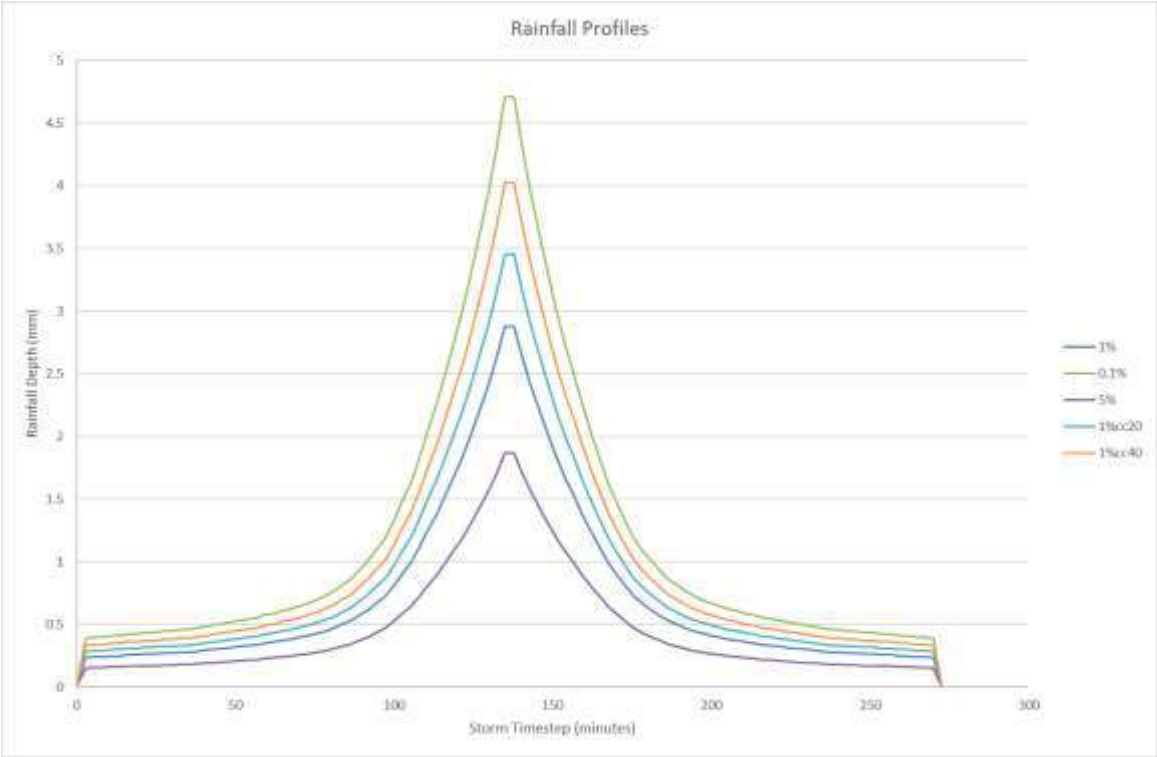


Figure 7 Rainfall Profiles for Pluvial Analysis

MODEL RESULT AND CALIBRATION

The rainfall model results were plotted and the resultant flow at the catchment terminus compared to that suggested by ReFH2 and the FEH analysis. Initially the modelling produced flows in excess of double the expected hydrological calculations. An analysis of soil types and infiltration was undertaken. The initial soil types were used as "defaults" without any changes. Therefore, the infiltration values were modified to increase infiltration and reduce terminus flows based on the infiltration tests available at boreholes across the site.

INFILTRATION ANALYSIS

Infitration testing was undertaken on site to help confirm he infiltration values, these have then been checked against the modelled parameters. The following represents the final infiltration rates in the modelling, compared to the infiltration rates observed on site. There is a good agreement between the two, giving confidence in the calibration.

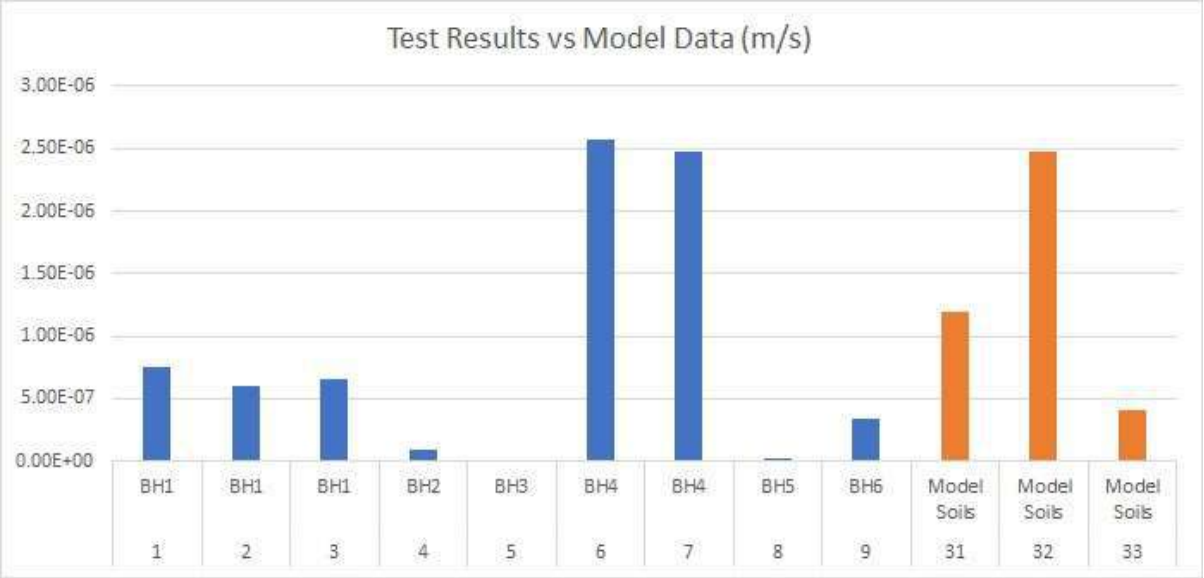


Figure 8 Borehole vs Modelled infiltration values

This confirms that the model representation of the soils is suitable for the analysis of flood extents.

UNCALIBRATED PLUVIAL OUTPUTS

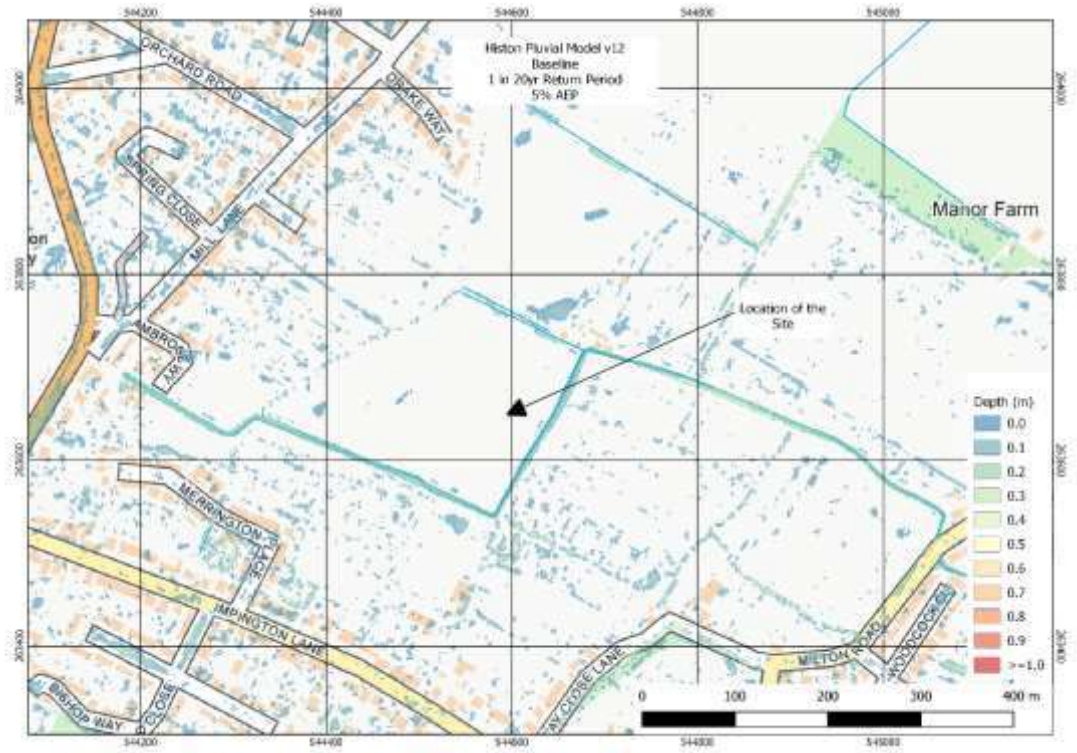


Figure 9 20 Year Rainfall

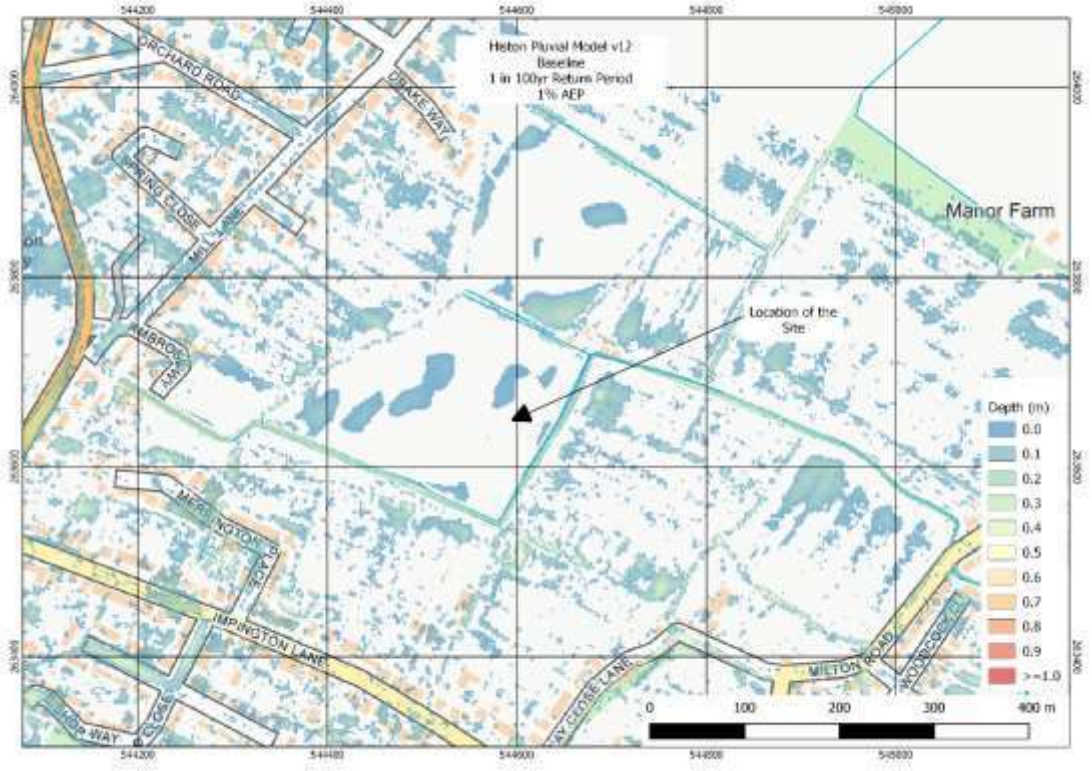


Figure 10 100 Year Rainfall

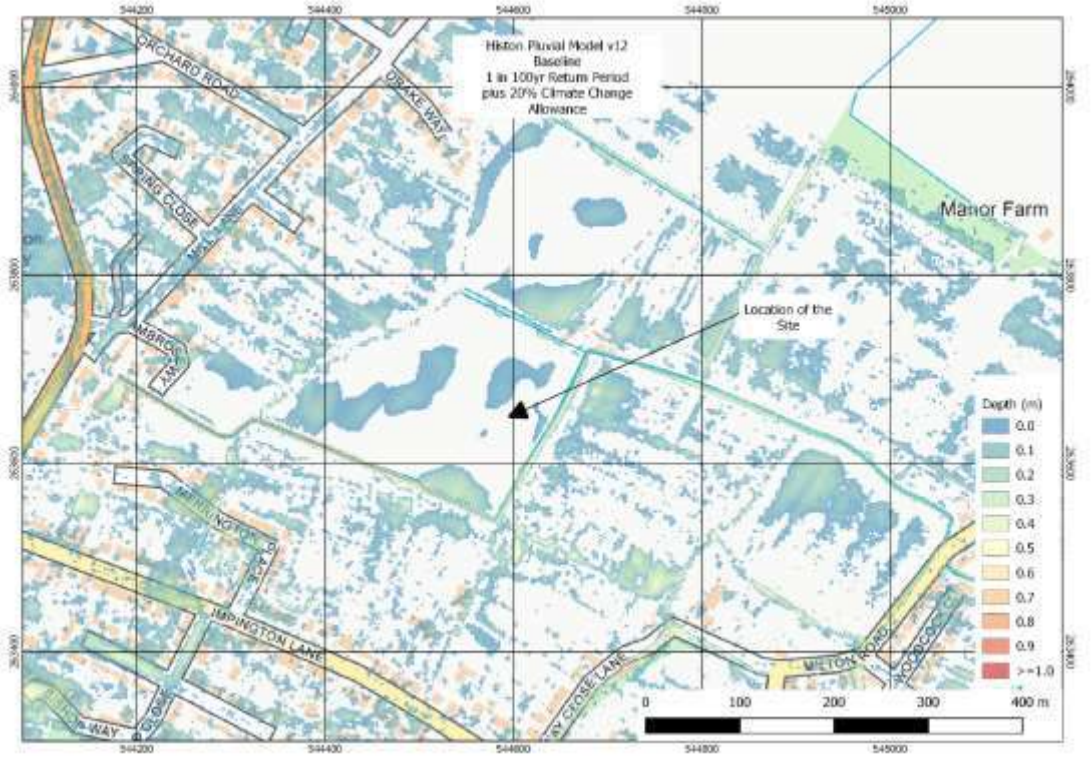


Figure 11 100 Year Climate Change Rainfall (20%)

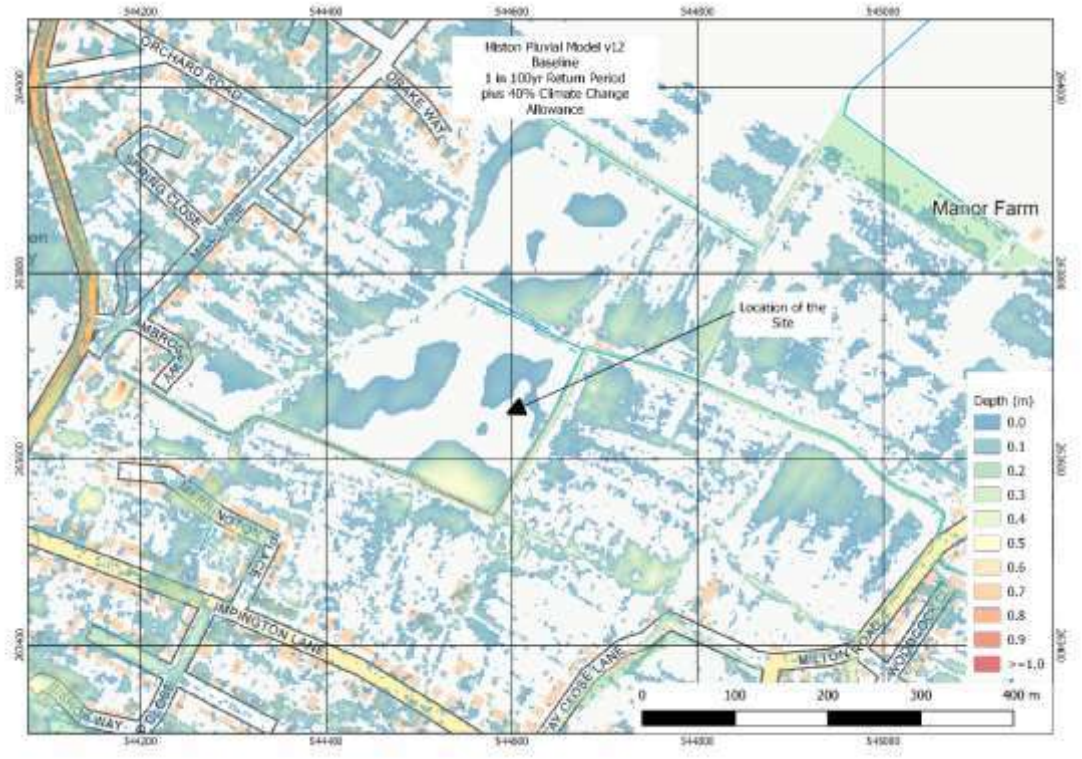


Figure 12 100 Year Climate Change Rainfall (40%)

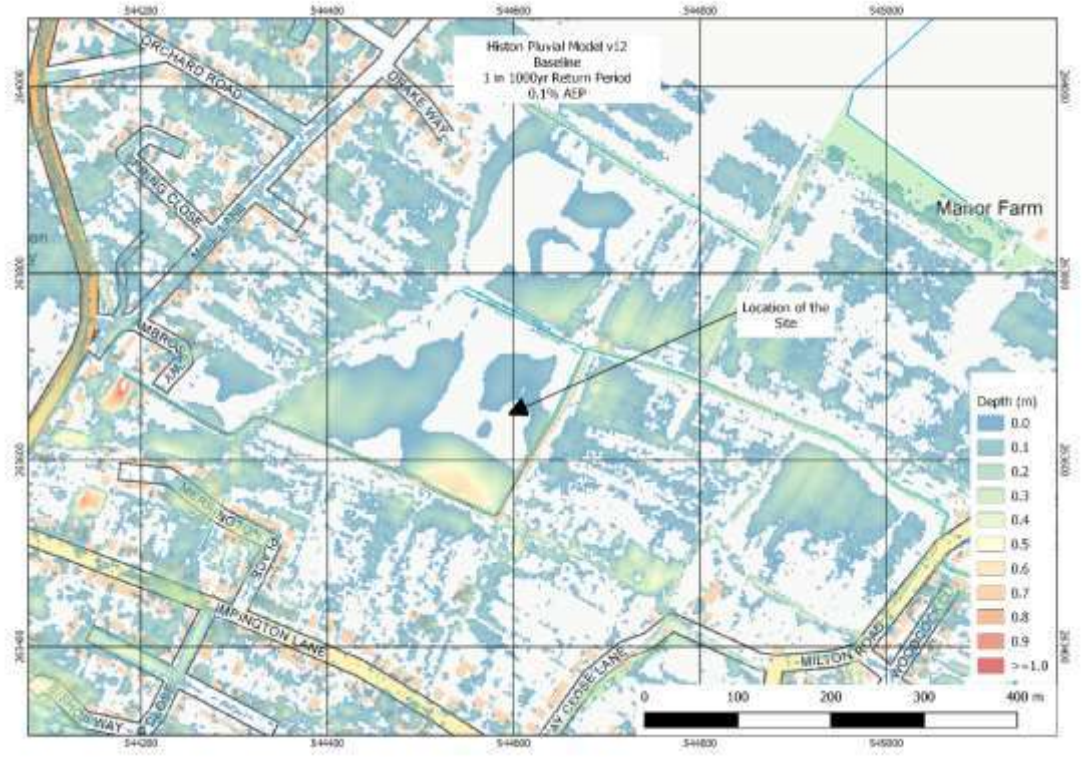


Figure 13 1000 Year Rainfall

CALIBRATED PLUVIAL OUTPUTS

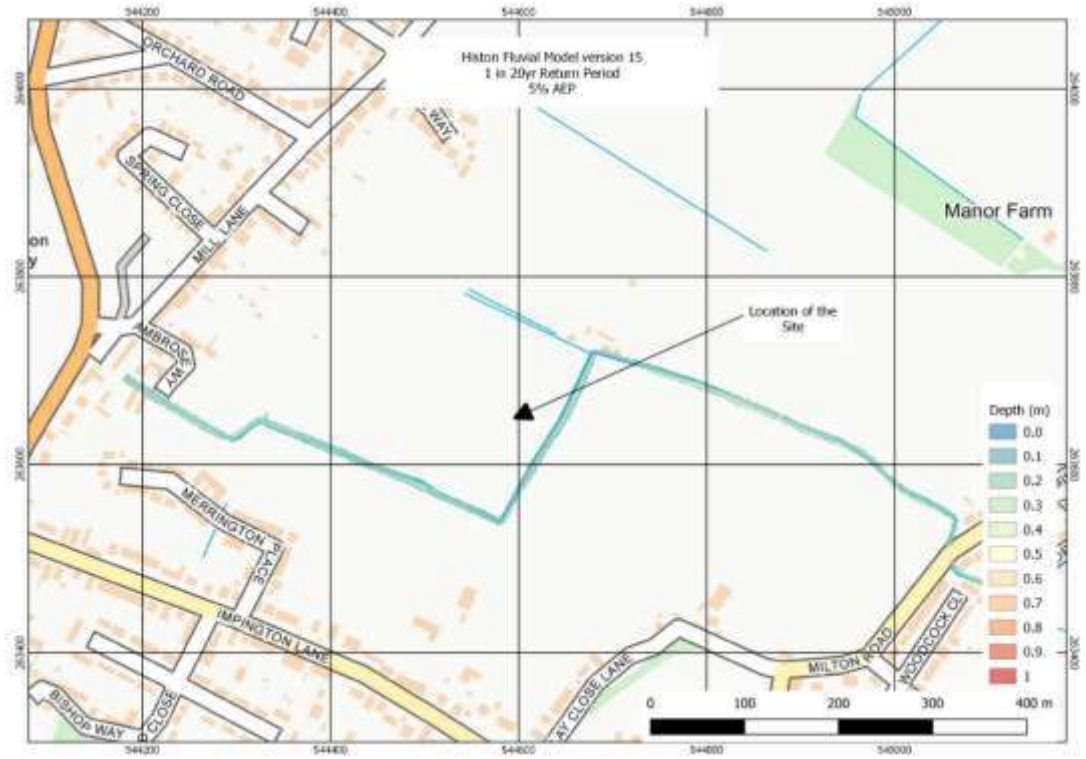


Figure 14 Pluvial 5% Return Calibrated

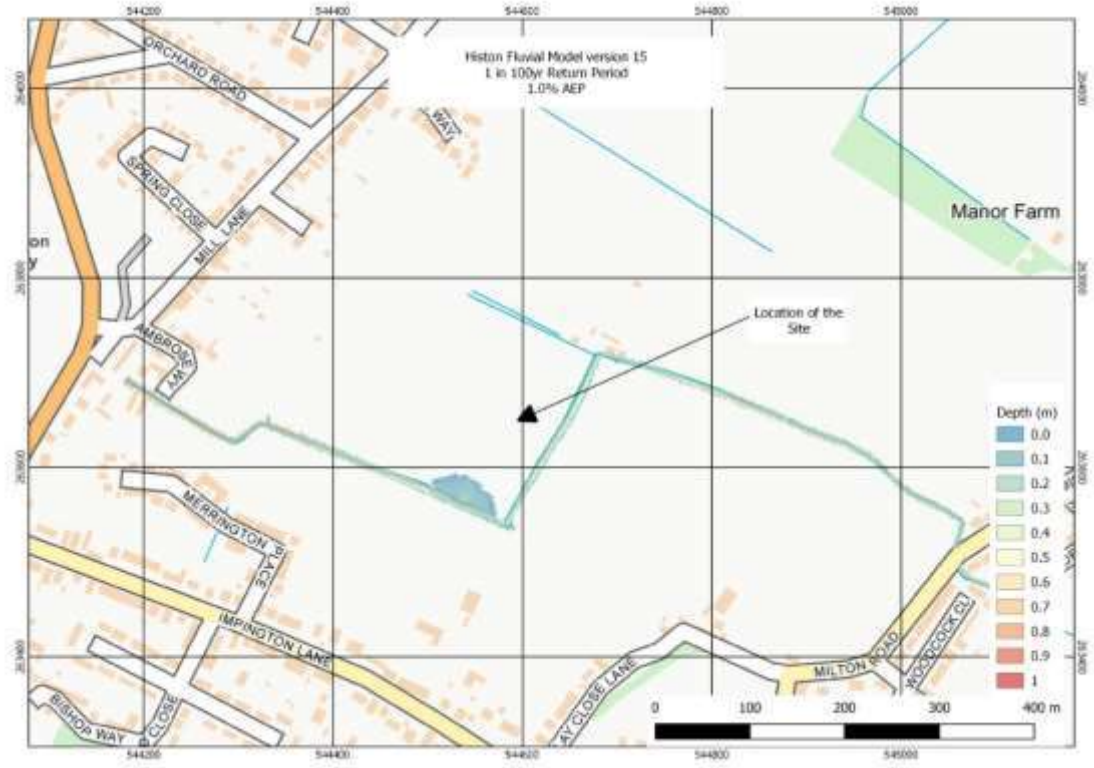


Figure 15 Pluvial 1% Return Calibrated

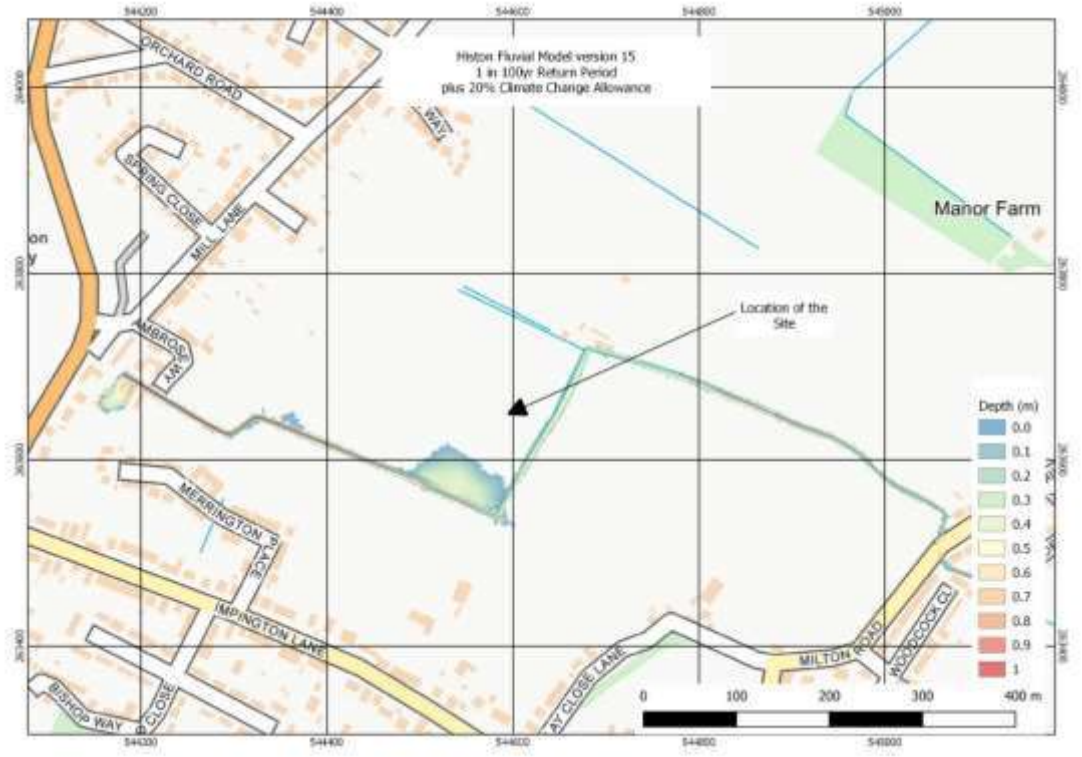


Figure 16 1%cc20 Return Calibrated

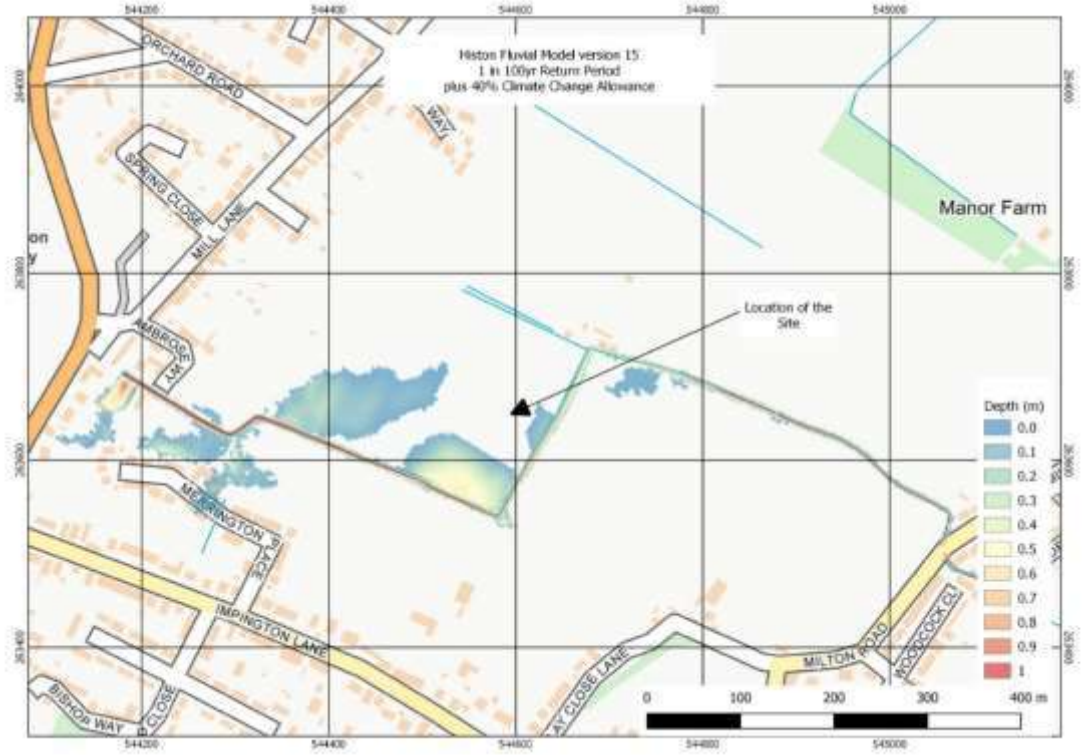


Figure 17 Pluvial 1%cc40 Return Calibrated

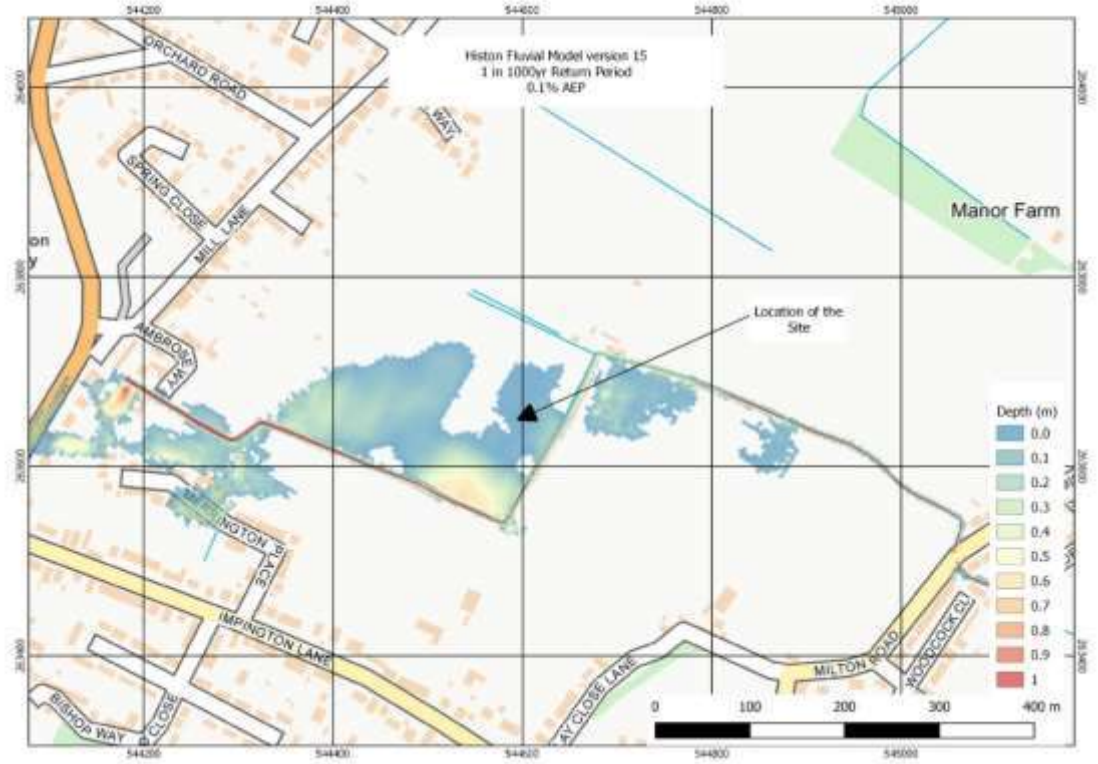


Figure 18 Pluvial 0.1% Return Calibrated

APPENDIX A

HISTON, CAMBRIDGESHIRE – HYDROLOGICAL REPORT

1. INTRODUCTION AND BACKGROUND

1.1. The study site is currently a greenfield use on the outskirts of Histon, Cambridgeshire. The downstream fluvial limit of the site is located at 544697, 263720.

1.2. The study area is exceptionally flat. A cursory examination of the FEH web service shows that the catchment delineation in that area is not clear. Selecting the downstream limit of the site selects a catchment of 2.03km^2 as per Figure 19

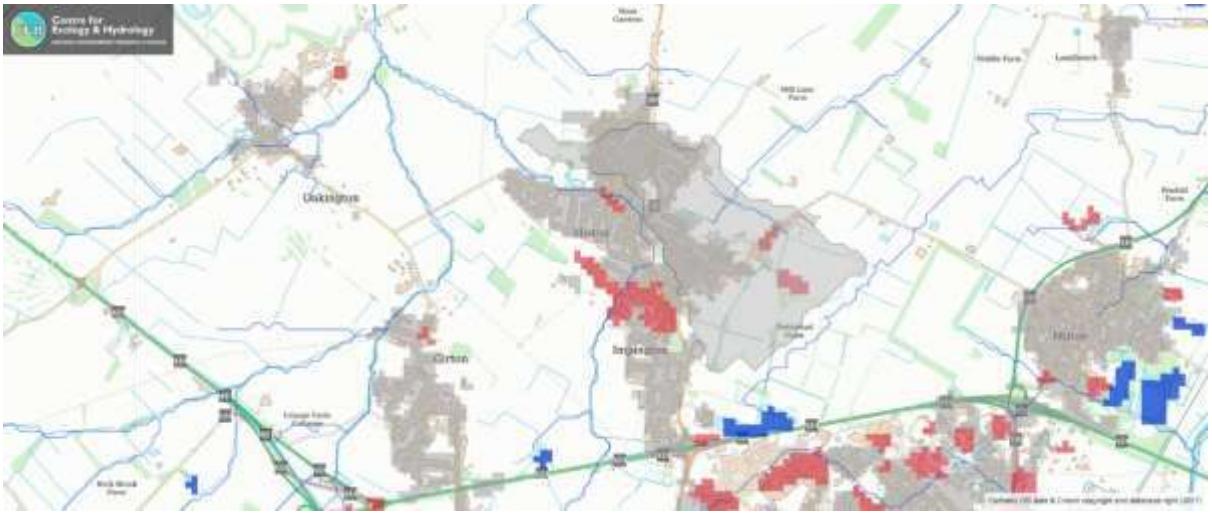


Figure 19 Location of Downstream catchment

1.3. There are alternate watercourses, such as that flowing North from Impington, however this appears to bypass the site and not be hydraulically linked to the site. However topographical survey suggests that there may be a culverted watercourse entering the site from the south, suggesting that the FEH mapping is incorrect. This watercourse has been surveyed as part of the modelling survey ANDNNANANDNANDNADNAD

1.4. Fluvial design flows are required for input into a hydraulic model in order to determine flood risk. Return periods required for design flows are:

- Fluvial peak flows for 5%, 1%, 1% plus climate change and 0.1% AEPs.

1.5. There is no existing hydraulic model for the area, therefore one is being created from surveyed watercourse and topographical data. The additional model data will be collected using local LiDAR with which catchment sizes will also be verified.

1.6. The catchment for study appears to be 2.03km^2 in size

1.7. There are no gauging stations on the watercourse – the closest being Jesus Lock and Bottisham, neither of which will be suitable for pooling or analasys. The closest usable gauge is Swafham Bulbeck, a 36km^2 catchment on the Swafham Lode.

2. CATCHMENT PARAMETERS AND OPTIONS

2.1. The catchment descriptors for the site exported from FEH Web show that the catchment is highly urbanised (URBEXT2000 of 0.31), the catchment is not attenuated (FARL of 1) and there is limited infiltration and catchment porosity (BFIHOST of 0.36 and SPRHOST of 41.77%). The catchment is also relatively dry (SAAR of 711).

2.2. Given the catchment area, it is likely that pooling group methodology will be inappropriate as there are a lack of suitable donor stations within the UK that may be suitable for transfer.

2.3. Given the urban nature of the catchment (as well as area), ReFH2 may offer a better solution for deriving hydrological conditions.

2.4. There are no suitable gauging stations or flow monitors with which to verify the analysis.

2.5. The proposed methodology is therefore:

- Undertake a ReFH2 analysis
- Undertake a pooled WINFAP analysis for the site.
- Contrast results with ReFH2 and ascertain whether methodology is suitable.
- Derive flow conditions using best method.

3. REFH2 ANALYSIS

3.1. ReFH2 catchment analysis for the whole catchment produced the following peak flows for each return period:

Table 1 ReFH2 Whole catchment predicted peak flows

Return period (yrs)	Urbanised peak flow (m^3/s)	As-rural peak flow (m^3/s)
1	0.57	0.49
2	0.66	0.56
5	0.93	0.80
10	1.12	0.97
20	1.33	1.14
30	1.45	1.26
50	1.63	1.41
75	1.78	1.54
100	1.89	1.64
200	2.20	1.92
1000	3.13	2.77

3.2. Given the urban nature of the watercourse, the urban component is the most viable descriptor of the catchment.

3.3. The critical storm duration from catchment descriptors is 4.5 hours, though the site specific critical duration may vary as a result of structures on the watercourse.

3.4. The ReFH2 method produces the following growth curve fittings which will be used later as a comparator to the WINFAP method:

Table 2 Growth Curve Fittings ReFH2

Return period (yrs)	Growth Curve Fittings
2	1.00
5	1.42
10	1.72
20	2.03
30	2.22
50	2.48
75	2.71
100	2.88
200	3.36
1000	4.77

4. WINFAP POOLING GROUP

4.1. The target site's key catchment descriptors are shown below. Using Area, SAAR, FPEXT and FARL, WINFAP 4 determines a pooling group that can represent the target site.

Table 3 Key Catchment Descriptors of the target site

AREA	**1.1425**
BFIHOST	0.36
FARL	1
FPEXT	0.0613
SAAR	711
SPRHOST	41.77
URBEXT2000	0.3107

4.2. The default WINFAP 4 pooling group is shown below. This is shown prior to amendments and validation:

Table 4

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	0.974	37	1.84	0.168	0.337	1.179
45816 (Haddeo @ Upton)	2.751	21	3.522	0.313	0.404	0.523
27051 (Crimple @ Burn Bridge)	2.82	42	4.539	0.221	0.149	0.598
28033 (Dove @ Hollinsclough)	3.03	35	4.666	0.259	0.417	0.539
27073 (Brompton Beck @ Snainton Ings)	3.366	33	0.82	0.192	0.052	1.146
91802 (Allt Leachdach @ Intake)	3.511	34	6.35	0.153	0.257	0.965
25019 (Leven @ Easby)	3.647	36	5.538	0.345	0.383	0.959
49006 (Camel @ Camelford)	3.673	8	11.65	0.125	-0.354	3.364
25011 (Langdon Beck @ Langdon)	3.687	28	15.878	0.238	0.318	1.146
26802 (Gypsey Race @ Kirby Grindalythe)	3.694	15	0.109	0.284	0.27	0.191
47022 (Tory Brook @ Newnham Park)	3.725	21	7.331	0.255	0.072	0.856
25003 (Trout Beck @ Moor House)	3.739	41	15.164	0.174	0.285	0.509
54022 (Severn @ Plynlimon Flume)	3.753	38	14.988	0.156	0.171	0.885
206006 (Annalong @ Recorder)	3.882	48	15.33	0.189	0.052	0.838
27010 (Hodge Beck @ Bransdale Weir)	4.009	41	9.42	0.224	0.293	0.121
44008 (South Winterbourne @ Winterbourne Steepleton)	4.102	35	0.448	0.414	0.336	2.181
Total		513				
Weighted means				0.23	0.234	

4.3. Of the stations chosen by default, the Camel @ Camelford has both a short record (8 years) and is strongly discordant with the target site. It will be removed from the pooling group for this reason.

4.4. Other sites show a high "distance" from the target site indicating that they are not a suitable hydrological donor for the target catchment. This is re-enforced below in Table 5 showing the catchment criteria of the pooling group.

Table 5

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
206006 (Annalong @ Recorder)	3.882	13.66	1720	0.024	0.98	0
25003 (Trout Beck @ Moor House)	3.739	11.46	1904	0.041	1	0
25011 (Langdon Beck @ Langdon)	3.687	12.79	1463	0.013	1	0.001
25019 (Leven @ Easby)	3.647	15.07	830	0.019	1	0.004
26802 (Gypsey Race @ Kirby Grindalythe)	3.694	15.85	757	0.03	1	0
27010 (Hodge Beck @ Bransdale Weir)	4.009	18.84	987	0.009	1	0.001
27051 (Crimple @ Burn Bridge)	2.82	8.15	855	0.013	1	0.006
27073 (Brompton Beck @ Snainton Ings)	3.366	8.06	721	0.237	1	0.008
28033 (Dove @ Hollinsclough)	3.03	7.93	1346	0.007	1	0

44008 (South Winterbourne @ Winterbourne Steepleton)	4.102	20.17	1012	0.015	1	0.004
45816 (Haddeo @ Upton)	2.751	6.81	1210	0.011	1	0.005
47022 (Tory Brook @ Newnham Park)	3.725	13.45	1403	0.023	0.942	0.014
49006 (Camel @ Camelford)	3.673	12.86	1418	0.012	1	0.004
54022 (Severn @ Plynlimon Flume)	3.753	8.69	2483	0.01	1	0
76011 (Coal Burn @ Coalburn)	0.974	1.63	1096	0.074	1	0
91802 (Allt Leachdach @ Intake)	3.511	6.52	2555	0.003	0.992	0

4.5. The variance within the pooling group is extreme among all catchment descriptors. SAAR ranges from an acceptable 721 to over triple that of the target site (2483 @ Plynlimon Flume). Only the Coal Burn @ Coalburn is proximal in terms of catchment area, others being in excel of 6 times larger than the target site.

4.6. Having removed the Camel @ Camelford on the basis of record length and discordancy, the pooling group yields the following key factors.

- Urban Adjustment Factor – 1.31
- Donor adjusted Qmed – 0.546 (0.448 unadjusted)
- Growth curve fittings (for comparison with ReFH2) and flood frequency flows

Table 6 WINFAP pooled growth curve fittings and flood flow peaks

Return Period (yrs)	GL	Flows (m^3/s)
2	1	0.45
5	1.388	0.62
10	1.686	0.76
20	2.019	0.90
30	2.238	0.96
50	2.544	1.00
75	2.814	1.14
100	3.023	1.26
200	3.59	1.35
1000	5.352	1.61

4.7. As stated above, the pooling group is not that desirable in terms of hydrological similarity with the target site, however there are not many stations within the pooling database representative of small, urbanised catchments.

5. PEAK FLOW COMPARISONS

5.1. Comparison of peak flows and growth curves from different methods is shown below for a range of return periods.

5.2. It is worth noting that Qmed (2 year return) is higher in ReFH2 than even in the donor adjusted QMed calculations from the pooled analysis.

5.3. The ReFH2 methodology specifically uses spatially varying rainfall data sets for the UK and also is suitable for the application to urban catchments.

5.4. The pooled analysis sites are overall not representative of the target site in their catchment descriptors.

5.5. The pooled analysis also produces a flood frequency curve lower than the ReFH2 method.

Table 7 Comparison of peak flows and growth curve fittings: Pooled and ReFH2

Return Period (yrs)	Pooled Flows (m^3/s)	Pooled Fitting	ReFH2 Flows (m^3/s)	ReFH2 Fittings
2	0.45	1	0.66	1.00
5	0.62	1.388	0.93	1.42
10	0.76	1.686	1.12	1.72
20	0.90	2.019	1.33	2.03
30	0.96	2.238	1.45	2.22
50	1.00	2.544	1.63	2.48
75	1.14	2.814	1.78	2.71
100	1.26	3.023	1.89	2.88
200	1.35	3.59	2.20	3.36
1000	2.40	5.352	3.13	4.77

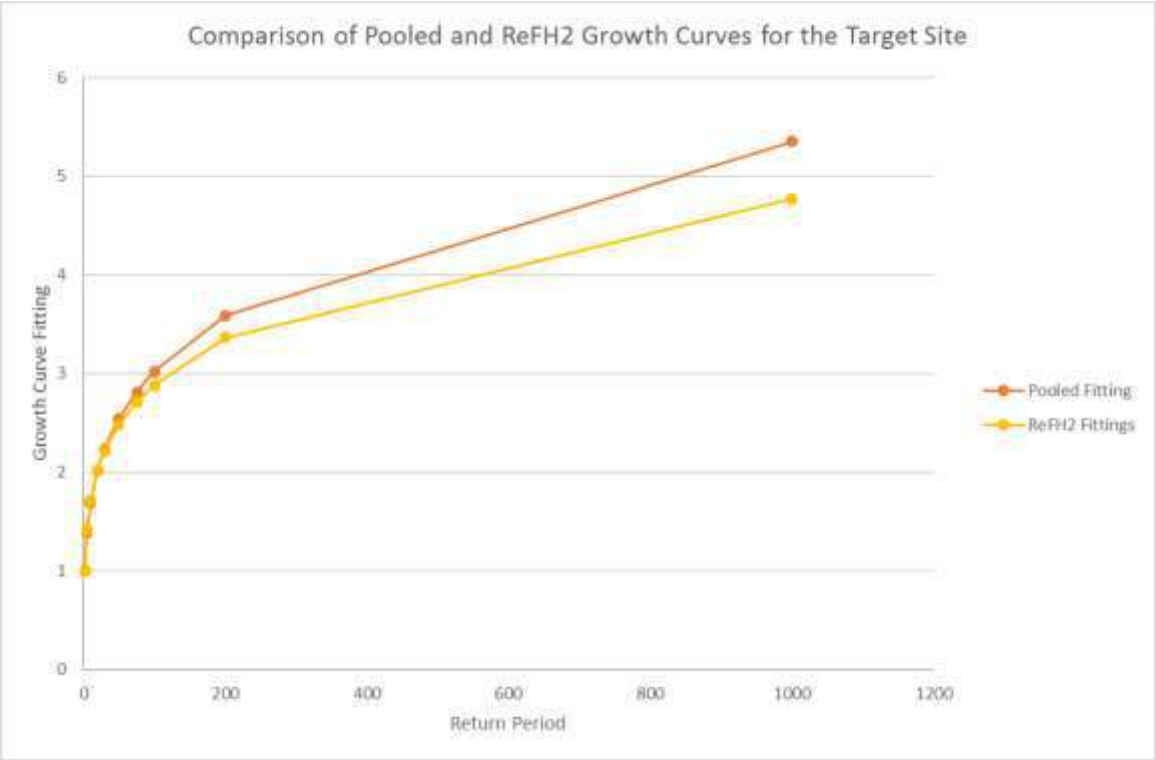


Figure 20 Comparison of Pooled and ReFH2 Growth Curves

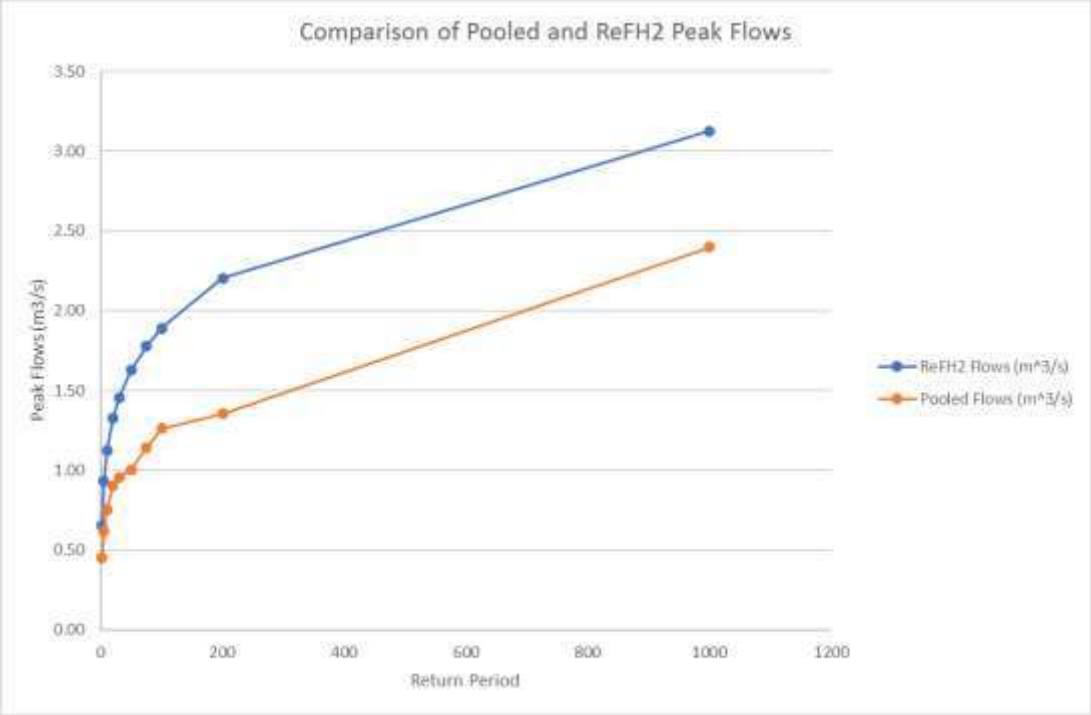


Figure 21 Comparison of ReFH2 and Pooled Peak flow analysis

5.6. Figure 21 shows that there is some discontinuity in the pooled analysis peak flows caused by the composition of the pooling group.

5.7. ReFH2 flows are consistently higher than those of the pooled analysis.

5.8. From a pragmatic and precautionary approach, it would be wise to adopt the ReFH2 flows for this catchment, specifically the 'as rural' flow set.

Appendix 6

the environmental dimension partnership

Registered office: 01285 740427 - www.edp-uk.co.uk - info@edp-uk.co.uk

date	19 NOVEMBER 2021
drawing number	edp5518_d023c
scale	1:2500
drawn by	CG
checked	PW
QA	-

client
Martin Grant Homes

project title
Ambrose Way, Impington

drawing title
Concept Masterplan

Site Boundary	8.71ha
Proposed Development @35dph = Up to circa 177 homes	5.07 ha
Infrastructure	0.30 ha
Open Space, comprising:	3.34 ha
Formal Open Space	(1.39 ha)
Formal Children's Play (LEAP)	(0.04 ha)
Surface Water Attenuation	(0.62ha)
Informal Open Space (Wild Areas)	(0.74 ha)
New Woodland	(0.41 ha)
Community Orchard	(0.13 ha)

Notes:
Policy SC/7: Outdoor Play Space, Informal Open Space and New Developments requires the following provision for 177 dwellings:

Outdoor Sport	0.68ha (assumed off-site)
Allotments and Orchards	0.17ha
Open Space	0.51ha
comprising:	
Formal Children's Play	(0.17ha)
Informal Children's Play	(0.17ha)
Informal Open Space	(0.17ha)

the environmental dimension partnership

Registered office: 01285 740427 - www.edp-uk.co.uk - info@edp-uk.co.uk

date	19 NOVEMBER 2021
drawing number	edp5518_d024a
scale	1:2500
drawn by	CG
checked	PW
QA	-

client
Martin Grant Homes

project title
Ambrose Way, Impington

drawing title
Land Budget