

DfT Reference: TWA/24/APP/03
Document Ref: CD26-01-APP-W9-3
The Cambourne to Cambridge Order

Cambridgeshire County Council

Transport and Works Act 1992
Transport and Works (Inquiries Procedure) Rules 2004
Inquiry into:
THE CAMBOURNE TO CAMBRIDGE ORDER

APPENDICES TO PROOF OF EVIDENCE
of
Jack Southon
of WSP

On behalf of Cambridgeshire County Council

09th August 2025

Planning Inspectorate Reference: DPI/E0535/25/1

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1. ENVIRONMENT AGENCY CORRESPONDENCE 15 NOVEMBER 2023

Stephanie Haberfield
WSP

Our ref: AC/2022/131030/02-L01
Your ref: ENVPAC/1/EAN/00449

Sent via email:
[REDACTED]

Date: 15 November 2023

Dear Stephanie

CAMBOURNE TO CAMBRIDGE (BIN BROOK HYDRAULIC MODEL REVIEW)

Thank you for requesting the review of the Bin Brook Hydraulic Model. We have undertaken this work under the agreed cost recovery programme ref ENVPAC/1/EAN/00449.

We have reviewed the submitted model and unfortunately it is currently unsuitable for the intended use. There are a number of issues that will need to be addressed before we can consider the model fit for purpose, which are summarised below. Please see the attached hydraulic model review spreadsheet for full details of the issues identified.

- There are queries relating to the 1D model, 2D model and 1D2D linking that require addressing. The representation of the bank lines and structures needs reviewing. The 1,000-year 19% CC event glasswalls against the model boundary.
- Additional information/clarification is required to increase confidence in the model outputs and some elements of the models (especially clarification around the elevation values being used at structures) need revisiting. The provision of a model log with all modelling decisions would aid the review procedure along with a standard model user report.
- As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice. Furthermore, comments, such as the need to represent the post-development scenario, may require revisiting following the proposed updates, as they may result in change to the flood mechanisms.

We hope this information is of assistance. If you have any queries, please do not hesitate to contact us.

Yours sincerely

Environment Agency
Bromholme Lane, Bampton, Huntingdon, PE28 4NE.
[REDACTED]

Cont/d..

Alison Craggs
Sustainable Places Planning Advisor



2. WSP CORRESPONDENCE 14 DECEMBER 2023

From: Garratt, Lee <[REDACTED]>
Sent: Thursday, December 14, 2023 9:03 AM
To: Craggs, Alison <[REDACTED]>
Cc: Haberfield, Stephanie <[REDACTED]>; Smith, Andy <[REDACTED]>; Giesler, Nick <[REDACTED]>; Etheridge, Will <[REDACTED]>; Smith, Chloe (Guest) <[REDACTED]>; Higgins, Graham <[REDACTED]>
Subject: RE: Cambourne to Cambridge Scheme - Bin Brook Hydraulic Model

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Alison

Thank you for the review that was sent through. Can you please confirm that if all the orange and red items from the review are addressed, the Environment would retract the objection (assuming the proposal causes no detriment)? We assume there would not be further review with potential new requirements or observations which may delay things further?

Regards

Lee



Lee Garratt

Technical Director – Water Risk Management



WSP

The Mailbox

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Birmingham

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3. ENVIRONMENT AGENCY CORRESPONDENCE 20 DECEMBER 2023

From: Craggs, Alison <[REDACTED]>
Sent: Wednesday, December 20, 2023 4:31 PM
To: Garratt, Lee <[REDACTED]>
Cc: Haberfield, Stephanie <[REDACTED]>; Smith, Andy <[REDACTED]>; Giesler, Nick <[REDACTED]>; Etheridge, Will <[REDACTED]>; Smith, Chloe <[REDACTED]>; Higgins, Graham <[REDACTED]>
Subject: RE: Cambourne to Cambridge Scheme - Bin Brook Hydraulic Model

Hi Lee,

Thanks for your email.

Addressing the red and orange items should resolve our concerns regarding the model. However as we have not reviewed the FRA or any changes required due to our concerns with the model, we can't guarantee that other issues wouldn't arise.

Our pre-application advice is based on the information the applicant makes available at the time. It is based on the national planning policy, associated legislation and environmental data / information available at the time. If any of these elements change, then we may need to reconsider our position.

I hope this is helpful.

Kind regards,

Alison Craggs

Sustainable Places Advisor

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE

[REDACTED]

[REDACTED]



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4. ENVIRONMENT AGENCY CORRESPONDENCE 28 MARCH 2025

Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

From Craggs, Alison <[REDACTED]>

Date Fri 2025-03-28 14:53

To Southon, Jack (Guest) <[REDACTED]>

Cc Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt,
Lee <[REDACTED]>; Higgins, Graham <[REDACTED]>; Fuhrmann, George
<[REDACTED]>

 2 attachments (8 MB)

LIT 66039 - Flood Estimation Calculation Review Template_Cambourne_Arcadis_28032025.xlsx; LIT 17617 - Cambourne to Cambridge Hydraulic Model Review_Arcadis_18032025.xlsm;

Hi Jack,

We have received the completed model reviews for the Cambourne to Cambridge busway from our modelling team. Please see attached and below:

Hydrology Review

Overall, it is deemed the hydrology is not considered suitable for its intended use. A number of concerns are raised over the potential for outdated methods/ data used and the incorrect application of ReFH2. Two Red comments and eight Amber comments require addressing. A summary is given below with the full review providing further details.

Red Comments

1. Incorrect version of ReFH2 used (see item 1.1.2 and 2.5.5).
2. FEH13 may have been used as opposed to FEH22 (see item 7.3.1).

Amber Comments

1. Incorrect peak flow data used (see item 1.1.2 and 2.3.1).
2. The method to calculate URBEXT2000 is incorrect and needs to be updated to current year (see item 3.2.3).
3. An urban adjustment has not been applied to the growth factors (see item 4.3.1).
4. Catchments have been classified as urban as opposed to rural (see item 7.1.2).
5. Two different storm durations have been used (see item 7.3.2, item 7.3.3, item 7.3.4 and item 7.3.5).
6. The final estimates for ReFH2 are incorrect (see items 7.4.1 and item 7.4.2).
7. The final flow estimates may need amending, and the final choice of method may change (see item 9.2.1).
8. An inconsistent storm duration and no mention of how the flows are to be applied to the model to potentially account for this (see item 9.3.3.).

Hydraulic Modelling Review

The model is not currently suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.

Red Comments

- There is still some glass walling in 2d domain, please extend the code boundary accordingly.
- The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs.
- Have the model results been compared with Flood Zones maps as well? Please provide evidence of the comparison in the report and discuss why the differences with the previous modelling occur.
- Please update the zpoints as the zpoints on bankline and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.
- The report does not include full results and more details need to be added in terms of assumptions made to model the structures.

Amber Comments

- Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.
- Surveyed cross sections should be referenced in the model/.dat file and a structures table/log should be provided to enable the checks on structures dimensions.
- Please update the report to include how inflows have been applied in the model. A figure of the catchment boundary should be included in the report.
- Please include justification to omit those footbridges. If unavailability of survey is the prime reason, some assumptions can be applied to consider the losses. Also, provide structures log for the omitted structures.
- Please provide a structure log with reference to the surveyed cross section including naming convention. The structures log should also include the assumptions considered to model the structures. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the dimensions for BB01_1034cd culvert were defined, as the survey does not contain this information.
- Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m.
- Please revisit the approach to model the 1d channel under Robinsons College Building.
- Overflow Ditch Channel length and culvert dimension needs to be updated, and height contraction coefficient need to be defined for the culvert
- The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream.
- The slope has been updated, and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.
- Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?
- It is not clear which option is the final one for the proposed case scenario, please clarify that for example comp1 and comp2 results are not provided to review. XMDF files have not been provided, these would help the reviewing process.

If you have any queries, please do not hesitate to get in touch with us.

Kind regards,

Alison Craggs

Sustainable Places Advisor

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE





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Content details

Title	Flood Hydrology Review Template
Audience	Environment Agency
Type	Template
Reference	LIT 66039
Version	
Security marking	OFFICIAL

CONTROLLED CONTENT

FLOOD HYDROLOGY REVIEW

The latest version of the Flood Estimation guidelines is : LIT 11832 (available in Content Cloud)

Project :				
EA Area:				
Project undertaken by:				
	1st review	2nd review	3rd review	4th review
Report reference:	Flood Estimation Report: Bin Brook Cambourne to Cambridge Scheme			
Report version:	Version 2			
Report date:	06/02/2025			
Date of review:	28/03/2025			
Name of reviewer:	Arcadis Ltd.			

PURPOSE OF THE HYDROLOGICAL STUDY
and any particular concerns or aspects that need review

WSP were commissioned by the Greater Cambridge Partnership (GCP) to undertake hydraulic modelling of the Bin Brook to inform the design of a proposed bridge crossing over the watercourse along the proposed bus route connecting Cambridge to Cambourne and ultimately to undertake a Flood Risk Assessment for the Cambridge to Cambourne Scheme. The purpose of the hydrological study was to generate hydrographs and peak flow estimates to use within the hydraulic model.

SUMMARY - IS THE HYDROLOGY FIT FOR PURPOSE
and any particular aspects that require revision

Overall it is deemed the hydrology is not considered suitable for its intended use. A number of concerns are raised over the potential for outdated methods/ data used and the incorrect application of ReFH2. Two Red comments and eight Amber comments require addressing. A summary is given below with the full review providing further details.

Red Comments

- 1. Incorrect version of ReFH2 used (see item 1.1.2 and 2.5.5).
- 2. FEH13 may have been used as opposed to FEH22 (see item 7.3.1).

Amber Comments

- 1. Incorrect peak flow data used (see item 1.1.2 and 2.3.1).
- 2. The method to calculate URBEXT2000 is incorrect and needs to be updated to current year (see item 3.2.3).
- 3. An urban adjustment has not been applied to the growth factors (see item 4.3.1).
- 4. Catchments have been classified as urban as opposed to rural (see item 7.1.2).
- 5. Two different storm durations have been used (see item 7.3.2, item 7.3.3, item 7.3.4 and item 7.3.5).
- 6. The final estimates for ReFH2 are incorrect (see items 7.4.1 and item 7.4.2).
- 7. The final flow estimates may need amending and the final choice of method may change (see item 9.2.1).
- 8. An inconsistent storm duration and no mention of how the flows are to be applied to the model to potentially account for this (see item 9.3.3.).

RAG COMMENT CLASSIFICATION GRADING SYSTEM	
The following RAG system is used to classify comments and identify appropriate actions to be taken by the original authors of the report:	
N/A - not relevant to this study.	
OK – Good practice.	
Minimum expected response: No minimum. Maximum expected response: No maximum. Planning: No Objection.	
Green – Negligible impact on the results that is unlikely to change the outcome of the study. Consider for future studies. Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.	
Minimum expected response: Acknowledge the comment in the spreadsheet and update the limitation section of the report. Maximum expected response: Actions done to address the issue identified. Planning: No Objection.	
Amber – Potential impact on the results that may change the outcome of the study. Follow recommendation. Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.	
Minimum expected response: Comments justifying the approach taken and update the limitation section of the report. Maximum expected response: Actions done to address the issue identified. Planning: Consider objecting to the application based on comments highlighted in this category.	
Red – Has an impact on the results that may significantly change the outcome of the study. Must do. If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidence. If issues highlighted red are ignored, then submissions should always be sent back.	
Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if action is not addressed. Maximum expected response: Actions done to address the issue identified. Planning: Objection - Application to be objected if comments are highlighted in this category.	

WORKBOOK FOR REVIEWING FLOOD ESTIMATES

This workbook is a supporting document to the Environment Agency's Flood Estimation Guidelines. It can be used by analysts checking their own work (both internal staff and consultants working for us), supervisors carrying out internal reviews or staff reviewing consultants' calculations. Reviewers are assumed to be familiar with the Flood Estimation Guidelines and competent to judge what choices are appropriate. Flood hydrology report and calculation reviews are an essential component of the Quality Assurance (QA) process that provides confidence in flood estimates and that they are suitable for the intended purpose.

Evidence that the flood hydrology has undergone QA may be requested by external parties and hence all reviews should be written with an expectation that they will be read externally.

The structure of the checklist closely follows that of the Flood Estimation Report Template **LIT65087**.

Guidance notes are identical to those in the Flood Estimation Report Template Notes **LIT65088** which provides guidance notes to help completion of the Flood Estimation Report Template.

Evaluation should be appropriate to the level of detail and risk of the study. For example, lower risk studies needing a quick and approximate answer would not normally include a historic review or a lengthy calculation of ReFH model parameters from flow and rainfall data. Before reviewing studies carried out on behalf of the Environment Agency, check the brief and ask the project manager what has been agreed with them.

Should any issues be raised during the review process, the reviewer should detail the actions required in sufficient detail to allow the analyst to complete the changes as appropriate. Completion of this Flood Hydrology Review document does not automatically constitute calculation approval. Once the suggested changes have been completed, the reviewer may require that the report be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all the amendments have been completed satisfactorily, will the model be approved and the quality assured by the reviewer.

See example below for how the spreadsheet is structured. Each tab represents a separate chapter in the Flood Estimation Report Template. Other reporting templates can be used, but the same expectations of content and level of reporting detail apply.



1. Summary of assessment

1.1 Summary

[illegible]



1. Summary of assessment

1.1 Summary							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
1.1.1	Does the report include a summary at the start that covers: <ul style="list-style-type: none">●Catchment location●Purpose of study and complexity●Key catchment features●Flooding mechanisms●Gauging stations●Final choice of method●Key limitations and uncertainties	<ul style="list-style-type: none">●This section provides a summary of the key information contained within the detailed assessment in the following sections.●The aim is to enable quick and easy identification of the type of assessment undertaken. This should assist in identifying an appropriate reviewer and the ability to compare different studies more easily.●Keep the text to one or two sentences for each point.	Green	No summary sheet has been provided. It is considered that the key information is largely covered in the relevant sections of the body of the FEH calculation record.	Provide a summary sheet at the beginning of the document that details the key information contained within the assessment, to enable future users more efficient identification of the assessment methodologies and to allow for easier comparisons to different studies.		
1.1.2	<p>Stop and think! What has changed since the calculations were undertaken or previously reviewed? Consider if there have been any changes in methods, software and/or data that could significantly change the outcome of the study.</p> <p>Changes could include:</p> <ul style="list-style-type: none">●A recent large flood in the catchment being modelled.●New datasets, such as an updated NRFA dataset version. Although single year changes are expected to be small, the impacts of several years or more of changes could be more significant.●New methods, such as the FEH22 rainfall depth-duration-model, the updated ReFH2.3-FEH22 model, and the small catchments pooling method.●New software that includes bug fixes or changes to methods.	<p>These guidelines are not absolute and there may be some circumstances where a different approach is warranted. Decisions over methods and data should be justified with supporting evidence and proportionate to the project scope, impacts and risk. Please contact the National Flood Hydrology team for further support.</p> <p>In general, a 6 months' timeframe is considered reasonable for transitioning to using new methods and data (see National Flood Hydrology transition guidelines). However, sometimes a faster transition is needed if there are significant impacts on flood estimates. In other cases, new methods and data may have little impact on individual studies outcomes and older hydrological analysis may still be appropriate.</p> <p>Consultants can support this review action by providing sensitivity analysis or residual uncertainty analysis to take into account the potential impacts of using new methods or data. For example, a sensitivity test could use the latest data and methodologies to estimate lumped flow at one key location assessed in the study for the 1% AEP event for comparison with the original analysis:</p> <ul style="list-style-type: none">●If flows or volumes are increased by more than 20% , do not proceed further with this review. Mark this row as Red and request the calculations are updated using the latest data and methodologies.●If flows or volumes are increased by 10 – 20%, mark this row as Amber. Continue with the review and check that the potential impacts of this change are allowed for within the sensitivity analysis or residual uncertainty analysis.●If flows are volumes are increased by less than 10%, mark this row as Green. Note that best practice would be to use the latest methodologies and data, but these are unlikely to change the outcome of the study. Check that the potential impacts of the change are allowed for within the sensitivity analysis or residual uncertainty analysis.	Red	<p>The NRFA peak flow data set referenced to be used is Version 10. As per EA guidelines, the most up to date NRFA peak data set should be used, which is now 13.0.1.</p> <p>WINFAP5 is stated to have been used.</p> <p>Inconsistent referencing of ReFH is given throughout the report with ReFH2.2 mentioned predominately.</p> <p>The latest calibration of the ReFH2.3 model was released in 2023 to utilise the FEH22 design rainfall.</p>	Update the hydrology undertaken using FEH22 (in latest version ReFh2.3 version 4) and most up to date peak flows (Version 13).		



2. Method Statement

2.1 Requirements for flood estimates							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.1.1	Does the method statement include an overview of the project, its scope and hydrological complexity?	<ul style="list-style-type: none">•The content and level of detail provided in this section will depend on the scope of the study. The following should be included as a minimum:•Purpose of study•Peak flows or hydrographs?•Design events for which flow estimates are to be made (AEP %)•Climate change allowances with reference to relevant guidance•Potential number of locations for flow estimation•The purpose of the document•What is the complexity of the study – simple, routine, moderate, difficult, very difficult?•What does the client’s scope specify for inclusion in the study, e.g., review of existing studies, rating reviews / updates, simple / detailed flood history review, ReFH model parameter estimation, joint probability?•Include a reference to any modelling reports which this flood estimation calculation record supports.	Green	<p>The method statement provides the relevant project details. However, there is no note regarding the complexity of the study.</p> <p>There is no reference to the hydraulic modelling report which this study supports.</p> <p>No climate change allowance included and no reference made to the latest climate change allowances guidance.</p> <p>The hydraulic model report notes that the bridge will be designed to the 1 in 100 year plus climate change allowance of 19% for the catchment (correct percentage for the basin) but this is not referenced in the FEH calculation record itself. There is also reference made to the 1 in 1000 year plus 19% allowance for climate change event within the model report, which is not reflected in the calculation record.</p>	Update the report to include complexity of the study, a reference to the hydraulic modelling report and the climate change allowances to be used with references to the relevant guidance.		
2.1.2	(Additional space for other items checked)	N/A					
2.2 The catchment							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.2.1	Does the method statement include maps showing the catchment and key locations and hydrological features?	<ul style="list-style-type: none">•Include a map of the catchment in here, at a minimum showing the river network, catchment boundary and gauging stations, and appropriately labelled / referenced in a legend. Additional information which could be included is the model extent or locations of unusual / interesting features, for example. Think about the background mapping being used – scale and colour / greyscale – think about if the reader could easily identify locations from the background mapping.•Include more than one map if that would assist in presenting the information, consider including maps using satellite imagery as background if that would better show key catchment features, and consider including photographs if they would help understanding of features identified in the ‘Description’ section. For permeable catchments, consider including a hydrogeological map showing groundwater equipotential lines.•Remember to give all figures a number and title and refer to them in the text.•Consider changing the page orientation to landscape and the page size to A3 if necessary or including maps as a separate digital appendix	Green	<p>The mapping in Figure 1 and Figure 2 could more clearly define and label the river network. The locations of the Flood Estimation Points on Figure 2 in the mapping provided are not clearly definable.</p> <p>It would be useful to show the location of the lakes relevant to the catchment boundaries to corroborate the FARL values in Section 2.</p> <p>This will aid future readers to better understand the key catchment characteristics used in the derivation of the hydrological estimates.</p>	<p>Update Figure 1 and Figure 2 to include a clearer river network.</p> <p>Update Figure 2 to include the locations of the FEP, as opposed to just the catchments.</p> <p>Include the reservoirs on Figure 2.</p>		
2.2.2	Does the method statement describe the catchment and its hydrological features, including how runoff is generated during flood events and any unusual features that might affect the flood hydrology.	<ul style="list-style-type: none">•Think about how runoff will be generated and what features are going to affect runoff from the contributing catchment reaching the watercourse. Include:•Topography•Climate•Geology•Soils•Land use•Any unusual features (e.g., reservoirs, historic mining) that may affect the flood hydrology.•In some cases, it may be useful to include reference to things such as amount of modelled reach that is culverted but remember that this is not a hydraulic modelling report and detail on hydraulic features, such as weir and culvert sizes, is not required.	Green	<p>The method statement describes the key catchment and hydrological features and particular reference is made to the online lakes.</p> <p>There is no description of climate or rainfall received by the catchment. No assessment of historic mining in the catchment. Whilst it is acknowledged that incorporation of this in any future changes wouldn't affect the outcome of the study, it would help to provide a more conclusive picture of the catchment for readers.</p>	Add climate data for the catchment and investigate any historic mining in the catchment.		
2.2.3	(Additional space for other items checked)	N/A					
2.3 Hydrometric data							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.3.1	Are the sources of flood peak data listed? Is the latest version of the NRFA database used?	<ul style="list-style-type: none">•This should be updated to the latest version of the dataset at the time of the assessment.	Amber	The NRFA peak flow dataset is not the most up to date (Version 10 being used instead of the current Version 13).	Update the hydrology with the latest peak flow dataset (Version 13) or perform a sensitivity analysis on the implications of this.		
2.3.2	Are the type and record length of flow and level gauging stations listed, including stations outside the NRFA peak flows dataset and closed stations as well as current ones?	<ul style="list-style-type: none">•You only need to include gauges at or very near to the sites of flood estimates unless there is an exceptional reason to include other gauges.•If you have data extracted from WISKI the datafile may only provide the digital data period of record, and the actual operating period of the gauge may be longer. You should check this using the NRFA website.	Green	There is a EA level gauge located on the Bin Brook, in close proximity to the BB01 FEP. This and the data quality and potential uses need to be included within Table 1.4	Provide details of the Bin Brook level gauge in Table 1.4.		
2.3.3	Is the data available at each flow gauging station summarised, including data type, record length, data quality, and what further updates and checks are needed in this study?	<ul style="list-style-type: none">•This table can be deleted if the study catchment is ungauged.•A quality check of the data is not required if the gauge is in the NRFA, unless specifically called for in the project brief.•There is no need to repeat everything in the NRFA station description, for example, weir length, wingwall height. Just add the key factors which will affect the quality of flood flow measurement and hence confidence in the data. For more detailed studies consider looking for other sources of information, for example, gauging authority rating review reports, station files held at CEH Wallingford, or reports on earlier flood studies.•Any flood peak data not in the NRFA (e.g., extra stations, recent data or altered flows) should be provided in the appendix.•Provide details of how peaks-over-threshold (POT) data has been derived in the appendix.	Green	There is a level gauge located on the Bin Brook, in close proximity to the BB01 FEP, which could be used for Lag analysis.	Provide summary of data available at the Bin Brook gauging station and consider if it can be used for lag analysis. If so, update the ReFH2 flows accordingly.		

2.3.4	Is it appropriate to update the flood peak data (e.g. to include additional water years or a new rating) and if so has this been done?	●Tabulate any updated or revised flood peak series in the appendix and provide a summary here.	N/A	Not applicable.			
2.3.5	Have data quality checks been carried out, at minimum giving the NRFA peak flows classification? Is a more detailed review of data appropriate for this study and if so has it been done?	●Provide full details of data quality checks in the appendix and summarise findings here.	N/A	Not applicable.			
2.3.6	Are rating equations summarised and is a more detailed rating review needed?	●The Flood Estimation Guidelines provide suggestions on the information that should be collated and assessed for rating reviews (Section 2.1 'Rating reviews and improvements'). ●A site visit is an important component of any rating review.	N/A	Rating review out of scope.			
2.3.7	Have any changes to ratings been reported? (see additional tab 2a)	●Provide full details of rating updates in an additional report or the appendix.	N/A	Rating review out of scope.			
2.3.8	Has other relevant data been sought and presented in the report? Has data quality been reviewed? Have any flood alleviation schemes been carried out or other significant catchment changes which could affect the relevance of older data?	●Check flow gaugings / spot flow gaugings are only required if you are reviewing a rating ●Historical flood data: a chronology and interpretation of the flood history should be included in the appendix or in an additional report (add references). The detail included will depend on requirements in the project scope. If there is a flow gauge within the study reach (or close by), consider if the historical flood data could be used to extend the systematic gauge record (see FEH Local guidance for more information). ●Potential evaporation data may be required if the ReFH Calibration Utility is being used. ●Other data or information could include groundwater, tides, channel widths, low flow statistics, sewer network data, or any other data used in your analysis. Add extra rows to the table if needed.	N/A	None identified.			
2.3.9	Does the report conclude by clearly explaining what the data at each gauging station will be used for?	N/A	Green	Reference to Item 2.3.2 and Item 2.3.3. Conclusions should be made on the use of the data on the assessment.	Conclude on the use of the level gauge in assessment.		
2.3.10	(Additional space for other items checked)	N/A					

2.4 Hydrological understanding of the catchment							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.4.1	Are plots of flood peak data included and interpreted?	●This could be the AMAX series or the POT series. ●Visually examine the time series and identify if there are, for example, outliers, apparent truncation of the flood peaks, trends or fluctuations in the data, step changes in the data, or unusually small flows. You should include an interpretation of these and other features. ●If there is more than one gauge in the study area, correlation plots can help to identify patterns or inconsistencies in the hydrological behaviour. ●You could add informative plots, for example, showing the seasonality of floods or the correlation of peak flows at different gauges.	N/A	Not applicable.			
2.4.2	Are plots of flow data included and interpreted?	●This could include, for example, annual flow hydrographs or flood events. ●Plots should be followed by an interpretation of the plots, for example, discussion of catchment processes, response time, propagation of a flood, and contributions from tributaries. ●If there is more than one gauge in the study area it can be useful to plot the data for all gauges on the same graph as this can aid understanding of the relationship between flow at different locations. ●These plots can be useful for checking the quality of the data and it is often helpful to plot flow and rainfall together as this may identify problems.	N/A	None provided.			
2.4.3	Are plots of stage data included and interpreted?	●Many catchments do not have flow gauges, but stage / level data may be available. This data can provide valuable information on the catchment response in the absence of flow data, for example estimating Tp from lag analysis.	N/A	None provided.			
2.4.4	Has a conceptual model for the catchment flooding processes been described?	●See Section 3.3 of the Flood Estimation Guidelines. Include information on factors such as: ●Where are the main sites of interest? ●What is likely to cause flooding at those locations? (e.g., peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides...) ●Might those locations flood from runoff generated on part of the catchment only, e.g., downstream of a reservoir? ●Is there a need to consider temporary debris dams that could collapse?	OK	The conceptual model for flooding is provided.			
2.4.5	Have unusual catchment features been identified? What is their impact on choice of method and conceptual model? E.g.: ●Urbanisation: impacts on local flood generating processes and influence of the urban drainage network. ●Reservoirs: the potential need for reservoir routing calculations. ●Highly permeable catchments: hydrogeological setting and influence on flood generation. ●Pumped: alternative rainfall-runoff methods.	●See Section 7 of the Flood Estimation Guidelines. Include information on factors such as: ●highly permeable soils or geology ●heavily urbanised land use ●pumped watercourse ●major reservoir influence (FARL<0.90) ●flood storage areas, particularly those which are normally dry ●historical mining or operational mining activities	Green	Unusual catchment characteristics have been identified such as the impact of lakes (BB02 Has FARL of 0.9). However, BB04_1 has a particularly high URBEXT value (0.311) and this is not highlighted nor the impact on choice of method (i.e. summer storm profile for URBEXT >0.3 (0.311).	Note the impact that the URBEXT value has on choice of method and conceptual model in Section 1.8.		
2.4.6	(Additional space for other items checked)	N/A					

2.5 Initial choice of approach							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.5.1	Are FEH methods appropriate?	●FEH methods may not be appropriate, e.g., for extremely heavily urbanised or complex catchments). Explain your decision.	Green	FEH methods are considered broadly appropriate. However, see items 2.4.5 above and 2.5.2. below, where further rationale behind choice is required. Also, ReFH2.2 referenced in initial choice of method and later software referenced as ReFH2.3. ReFH2.3 should be used in line with best practice.	Update FEH method in line with latest best practice guidance.		

2.5.2	Is an initial choice of method(s) included with adequate reasons? Have unusual catchment features been considered and choices of methods justified?	<ul style="list-style-type: none">See Section 3 of the Flood Estimation Guidelines.Think about:the type of problemthe type of catchmentthe type of data availableWhich methods are appropriate? If more than one method is appropriate will all be applied, and the results compared before a final decision is made? Will non-stationary methods be applied? Will different storm durations need to be considered / tested?	Green	Initial choice of method provided. However, further explanation is required. EA Guidance notes that the statistical method is 'particularly preferable if there are lakes or other water bodies in the catchment and you are not planning to use flood routing to represent them. Their influence will be represented in a general way via the FARL descriptor, which is used in the statistical method but not in design event methods.' The guidance also notes that a rainfall runoff approach 'might be favoured for estimating the more extreme floods' required under the scope of the assessment (200 to 1000 years). No evidence of hybrid method for higher return periods was provided.	Revise reasoning of initial choice of method considering unusual catchment features, and update Table 1.8 to reflect this.		
2.5.3	How will hydrograph shapes be derived if needed?	<ul style="list-style-type: none">For example, ReFH1 or ReFH2 shapes, average hydrograph shape from gauged data.If using average hydrograph shapes, how will inflows from different tributaries be phased?	Green	No detail on derivation of hydrograph shape is provided. No gauged data available, so hydrograph shape is produced using ReFH2	Update Table 1.8 to state that hydrograph shape will be produced via ReFH2.		
2.5.4	Will the catchment be split into sub-catchments? If so, how?	<ul style="list-style-type: none">If the hydrological assessment is being undertaken to supply inflows to a hydraulic model, it is likely that a distributed approach will be taken, with the catchment split into sub-catchments and design flows routed from each sub-catchment.Think about what the split into sub-catchments will be based on, e.g., tributary confluences, changes in geology / urbanisation, key areas of interest, sewer outfalls.Will intervening area hydrographs be required and how will these be derived?If the catchment area changes significantly over the study reach, or tributaries are also being modelled, will different storm durations need to be considered / tested?	Green	No reference to split of the catchment has been made in Section 1.8 of the FEH Calculation Record. The catchment map (Figure 2) provided in Section 1.2 shows that the catchment comprises one upstream FEP representing the inflow to the top of the model extent, two tributary inflows and an intervening area to the downstream lumped catchment. No information on hydrograph derivation for intervening area is provided. No consideration of any necessary changes to storm duration made (tributaries have a shorter storm duration than upstream and lumped downstream catchments).	Update Table 1.8 to include that the catchment will be split into sub-catchments.		
2.5.5	What software will be used?	<ul style="list-style-type: none">See Section 1.2 of the Flood Estimation GuidelinesInclude version numbersInclude software used for non-stationary analysis, if undertaken.	Red	Software used is ReFH2.2.2, which is not the latest software.	Update the hydrology undertaken using FEH22 (in latest version ReFH2.3).		
2.5.6	(Additional space for other items checked)	N/A					



3. Locations where flood estimates are required

3.1 Summary of subject sites							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
3.1.1	Have locations where flood estimates are required been tabulated and shown on a map, clearly distinguishing between lumped catchments and sub-catchments (intervening areas) and explainint the purpose for which they have been created?	<ul style="list-style-type: none">●Include a map which shows the locations of the subject sites.●Use site codes in all subsequent tables for clarity and to save space.●Lumped catchments (L) are complete catchments draining to points at which design flows are required.●Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a distributed model. Details of these need to be included so that results can be fully reproduced and checked.	Green	Catchments are delineated for corresponding FEPs but the FEPs themselves are not labelled on maps as noted in section 2.2.1. It would be useful to add the model extents and the position of the bridge to the mapping for context.	Add FEPs, model extent and bridge location to Figure 3.		
3.1.2	Do you agree with the choice of flood estimation points? Do they cover the main locations of interest (e.g. confluences, areas of known flood risk, gauging stations, model boundaries) without including an excessive number of subcatchments or very similar catchments?	N/A	OK	Suitable choice of flood estimation points			
3.1.3	(Additional space for other items checked)	N/A					
3.2 Catchment descriptors							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
3.2.1	Are the final catchment descriptors tabulated for every subject site, indicating where changes have been made from default values?	<ul style="list-style-type: none">●Include any changes made. Use a different colour to identify catchment descriptors which have been changed from the default values.●Refer to Section 2.3 of the Flood Estimation Guidelines for suggestions on how to check and amend catchment descriptors. Any changes made must be recorded fully so that they can be checked and are reproducible.●Include sub-catchments and intervening areas required for a distributed approach.	Green	<p>The FARL for BB04_I is missing.</p> <p>A final catchment descriptor table was provided. It would aid future users to highlight what the changes were.</p> <p>The text notes that the BB04_I catchment value was taken from BB02, as the proportion of the pond to the catchment area is similar. The BFIHOST and SPRHOST values for BB04_I were taken from those derived for BB04 and checked.</p>	Update Section 2.2, to include the FARL and highlight which catchment descriptors were updated and provide the original values.		
3.2.2	Have FEH catchment boundaries been checked against high resolution LIDAR, sewer network, and OS data and refined where appropriate? If catchment area has been changed, have catchment descriptors been adjusted appropriately?	<ul style="list-style-type: none">●Add maps if needed to aid explanation of any changes.	Green	It would be useful to show the revision to the catchment boundaries on the same mapping to the existing FEH boundaries and with the relevant LIDAR data as background mapping to verify the changes appropriately.	Add catchment boundary delineation changes and existing FEH boundaries draining to Figure 3. Provide a figure of the LiDAR data.		
3.2.3	Does the calculation record state whether URBEXT1990 or URBEXT2000 has been used? Has the correct value been identified for the method(s) to be applied? Have the URBEXT values been updated to the current year or revised using the URBAN50k method if a discrepancy between the FEH urbanisation layer and current OS mapping has been identified?	<ul style="list-style-type: none">●Explain the source of URBEXT used in the analysis (e.g., URBEXT1990, URBEXT2000, manually derived using URBAN50k). URBEXT1990 should only be used in ReFH1.●If URBEXT values need to be substantially revised due to development or catchment boundary changes, see the URBAN50k method in Section 2.3 of the Flood Estimation Guidelines.●Default URBEXT1990 and URBEXT2000 values should always be updated to the current year. Explain what method has been used (e.g., CPRE formula, manual derivation) and where (e.g., edited catchment descriptor files, updated within WinFAP software, updated within ReFH2 software).	Amber	<p>In Table 2.2 and in most locations in the report, URBEXT is stated but no distinction between 2000 or 1990 is made. It is assumed that URBEXT2000 is used.</p> <p>The incremental BB04_I catchment value was calculated using area weighting and was checked using an URBAN value of 0.5. However, 10k OS mapping has been used instead of 50k mapping in line with EA guidelines.</p> <p>URBEXT was updated to 2022 but this is now out of date, and should be to 2025.</p>	Update or check URBAN calculations using 50k mapping. Confirm URBEXT2000 was used and update each value to current year.		
3.2.4	Has BFIHOST19 been used in preference to BFIHOST? Have values been checked against other soil or geological data? Has BFI been derived from local data?	<ul style="list-style-type: none">●BFIHOST19 should be used in the ReFH2 calculations, since the current release (ReFH2.3) was calibrated using BFIHOST19, and also in the FEH Statistical method, since this has been found to improve the results.●Soil association maps can be used to check BFIHOST values, especially if significant changes have been made to catchment boundaries. Any changes made must be recorded fully so that they can be checked and are reproducible.●If using other BFIHOST data, explain what has been used, why, and how it has been derived.	OK	BFIHOST19 was reported as used in the FEH Calculation record and checked against mapping.			
3.2.5	How have other catchment descriptors been checked and revised? How have catchment descriptors for sub-catchments been derived (particularly FARL, DPLBAR and URBEXT)?	<ul style="list-style-type: none">●Refer to Section 2.3 of the Flood Estimation Guidelines for suggestions on how to check and amend catchment descriptors.●Any changes made must be recorded fully so that they can be checked and are reproducible.●Include before and after tables if appropriate.	OK	Catchment descriptors form FEH were used and checked in Table 2.2			
3.2.6	(Additional space for other items checked)	N/A					



4. Stationarity statistical methods

4.1 Method overview							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
4.1.1	Is the reason for using this methods explained?	●Include a brief summary of the reasons, specific to this study, for applying the method.	OK	Whilst not reported in this Section, Section 2.5 outlines why the stat method was selected.			
4.1.2	What methods will be used to estimate QMED and growth curves? Has local data been used to its full potential?	●Include a brief summary of what methods will be used at which subject sites. ●More than one method may be tested at each site (e.g., comparing single site and pooled growth curves at a gauged site). ●Include all methods tested, even those ultimately rejected.	OK	Ungauged site. In line with EA guidelines, a pooled analysis based on a lumped downstream catchment was undertaken.			
4.1.3	(Additional space for other items checked)	N/A					

4.2 Estimating QMED							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
4.2.1	Has QMED been estimated at gauged sites appropriately? Have short records been adjusted for climatic variation?	●See Section 4.2 of the Flood Estimation Guidelines. ●When QMED is estimated from short records (less than 14 years), it should also be adjusted for climatic variation. Refer to FEH Volume 3, chapter 20. Provide full details of the adjustment in the appendix. ●If you estimate QMED from peaks-over-threshold (POT) or low flow duration curve statistics (LF), add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●More than one method may be used at each site. Use a different row for each method.	N/A	Ungauged site.			
4.2.2	Has QMED been estimated at ungauged sites appropriately?	●See Section 4.2 of the Flood Estimation Guidelines. ●Only fill in the cells needed. ●If you estimate QMED from bankfull channel width, add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●More than one method may be used at each site. Use a different row for each method.	Green	Small catchments procedure was undertaken. The donor method undertaken updates the URBEXT2000 value to 0.04. This is assumed to cover more gauges but the reasoning given is "URBEXT 2000 <0.04 to reflect the relatively rural nature of the study catchment." However, the distance from the donor to the FEP's has not been given.	Update Table 2 to include the distance from the donor sites to the FEPs.		
4.2.3	What method and parameters have been used for urban adjustment of subject and donor sites? Is this appropriate?	●List the method used for urban adjustment of subject and donor sites, if applicable (e.g., Kjeldsen (2010), WinFAP v4, WinFAP v5). ●List the parameters used for the urban adjustment. The standard values are listed below, and any amendments must be explained. ●Impervious fraction for built-up areas, IF: 0.3 ●Percentage runoff for impervious surfaces, PRimp: 70% ●Method for calculating fractional urban cover, URBAN: updated URBEXT 2000	OK	Urban adjustment applied in WINFAP.			
4.2.4	How were donor sites identified and selected? What urbanisation threshold was used? Has the use of urbanised donor sites been avoided unless appropriate for the catchment being assessed? Has the choice and number of donor sites been justified?	●Provide details regarding how potential donors were selected and the reasons why they were chosen / rejected. ●Include a map if helpful, which shows the location of the study catchment and donor stations under consideration. ●Section 4.2 of the Flood Estimation Guidelines provides guidance on selecting a donor(s) for data transfer. ●Consider using POT and low flow stations as donors, especially if used as gauged subject sites. ●If using WinFAP to search for donor sites: the default URBEXT2000 threshold value for donors in WinFAP v5 is 0.03. Explain if you have changed the threshold, for example to enable a more urbanised donor site to be used.	Green	The text states that the nearest gauge was used for donor estimation. However, the tabulated donor station information does not include distances from subject site. Choice of single donor closest to site is in line with guidance. However, there is no evidence that the closest site has been chosen as no distances are noted.	Provide distances for donor stations relative to subject site. Update if any closer but more urbanised gauges could have been considered.		

4.2.5	Was QMED estimated at donor sites appropriately? If donor sites are upstream or downstream of subject sites, have the adjusted QMED estimates been checked for consistency and averaged adjustment factors been used?	<ul style="list-style-type: none">•See Section 4.2 of the Flood Estimation Guidelines.•When QMED is estimated from short records (less than 14 years), it should also be adjusted for climatic variation. Refer to FEH Volume 3, chapter 20. Provide full details of the adjustment in the appendix.•If you estimate QMED from flow duration curve statistics (LF), add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced.•QMED from catchment descriptors is the 'as rural' value, i.e., with no urban adjustment factor applied. For urban donors, record whether and how the observed value of QMED has been "de-urbanised" for comparison with the as-rural estimate from catchment descriptors.•The adjustment ratio in the table below is the adjustment in full, with no distance factor applied.	OK	Small catchment procedure, in line with guidance, was used.			
4.2.6	(Additional space for other items checked)						

4.3 Estimating growth curves							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
4.3.1	Have growth curves been derived at subject sites using appropriate methods, distributions, adjustments and parameters? Where flood peak records are available, has single site and enhanced single site analysis been carried out? Has historical analysis been considered? Have urban and non-flood years adjustments been applied?	<ul style="list-style-type: none">•See the Flood Estimation Guidelines Section 4.2.•List all flood growth curves compared, including those ultimately rejected.•If using historical methods, provide full calculation details in the appendix.•An individual urban adjustment should be applied even if the same pooling group (including enhanced single-site analysis) has been applied to several sites, as each site is likely to have a different URBEXT2000 value and hence a different urban adjustment.•A non-flood years adjustment (previously known as the "permeable" adjustment) should be considered if there are non-flood years in the stations in the pooling group that may make a significant difference to the results. Adjustments to remove the influence of non-flood years are carried out using the method in FEH Volume 3, chapter 19. This is valid only for the GLO distribution.•More than one method may be used at each site. Use a different row for each method.•Edit the list of methods if any alternatives were used and highlight the changes made.	Amber	<p>GL chosen due to best fit and in line with guidance. No record of the best fit values provided though. Permeable adjustment has been carried out but no calculations have been provided to verify this adjustment.</p> <p>One pooling group (calculated at BB04) was used which is in line with EA guidelines. However, the consideration for the urbanisation of each of the catchments has not been given. This is because BB04_I has an URBEXT2000 value of 0.311. When applying growth curves from another FEP, an urban adjustment needs to be undertaken.</p>	<p>Provide evidence of best fit values for distribution. Add details on permeable adjustment.</p> <p>Recalculate the final peak flows at each catchment taking into account the urbanisation levels of each of the catchments.</p>		
4.3.2	Are flood frequency curve plots included?	<ul style="list-style-type: none">•Any relevant frequency plots, particularly showing any comparisons between single-site, enhanced single-site, and pooled growth curves (including flood peak data on the plot), should be shown here.	Green	No flood frequency curves provided.	Add flood frequency curves into the appendix.		
4.3.3	Have pooling groups been derived appropriately? Was the small catchment pooling procedure used, if appropriate? If there are several similar flow estimation points, have they used a single pooling group to aid simplicity and consistency?	<ul style="list-style-type: none">•Try to use as few groups as possible, this avoids step changes in flow estimates between flow estimation points for catchment-wide studies.•Section 4.2 of the Flood Estimation Guidelines provides further details on reviewing pooling groups.•Provide initial and final pooling group compositions in the appendix.•If you increase the URBEXT2000 threshold from the default value of 0.03, include a justification and compare the results with those from an all-rural pooling group.•L-moments are deurbanised by default in WinFAP v5.	Green	<p>Single pooling group applied based on catchment size and hydrological similarity. Used sites above>0.04.</p> <p>Permeable adjustment has been made owing to the permeability of the stations in the pooling group (no evidence has been provided).</p>	<p>Update the report to detail the permeable adjustment calculations undertaken.</p>		
4.3.4	Is the composition of the pooling group recorded? How has pooling group composition been reviewed and adjusted? Has the removal or retention of sites been adequately justified, especially discordant sites?	<ul style="list-style-type: none">•If no changes were made, just say "none", although it is helpful to provide details of stations which were investigated even if they were ultimately retained.•Provide original and final pooling group compositions in the appendix.•Weighted L-moments should be the pooling group L-CV and L-Skew, after any changes were made to composition, but before any urban or non-flood years adjustments.	Green	<p>Composition of the pooling group is not recorded. No adjustments were made but we cannot see a record of the pooling group stations to check if the stations are appropriate.</p> <p>Table 3.4 "Derivation of pooling groups" has a site code "LB04" this is assumed to be "BB04".</p>	<p>Add composition of pooling group into the appendix and record changes made.</p> <p>Update Table 3.4 to be "BB04".</p>		
4.3.5	(Additional space for other items checked)	N/A					
4.4 Final choice of QMED and growth curves							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2

4.4.1	Has the final choice of method for QMED and growth curves been explained and justified?	<ul style="list-style-type: none">Record your final choices of method for QMED and growth curves.Consider spatial consistency. Check values to ensure they are consistent with observations at upstream or downstream gauging stations. In some situations, using the data transfer method and switching between pooling groups can lead to unrealistic step changes. See Flood Estimation Guidelines Section 4.2.	Amber	<p>A permeable adjustment, in line with EA guidelines, one donor based on small catchment procedure is used.</p> <p>The final flood estimates show that BB02 has a smaller flow than BB03, whereas the area of BB02 is 40% larger than that of BB03. Confirmation on if the correct catchment parameters are applied is required or to aid future users of the hydrology a note on why there is potential spatial inconsistency should be added.</p>	Update the statistical method with the correct model parameters or add an explanation in Section 6 or Section 4 of the possible spatial inconsistency.		
4.4.2	Have the final flood estimates been tabulated?	<ul style="list-style-type: none">Add or remove columns as needed to change the return periods to those used in the study.	Amber	Whilst final flood estimates are tabulated in Section 3.6, they will need to be revised based on comments in item 4.3.1.	See item 4.3.1.		
4.4.3	(Additional space for other items checked)	N/A					



7. Revitalised flood hydrograph 2 (ReFH2) method

7.1 Method overview							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.1.1	What is the purpose of applying this method? Has the method been avoided for large catchments?	●Include a brief summary of the reasons, specific to this study, for applying the method.	Green	ReFH2 was used to produce estimates to be compared with the statistical method. No mention of the use of ReFH2 being used to derive hydrograph shape.	Update Section 4 to include the reason for using ReFH2.		
7.1.2	Are rural and urban sub-divisions used?	●This section can be deleted if the catchment is essentially rural. ●If the catchment is urban: ●Did you calculate paved areas using a method other than from URBEXT using the standard equations? ●Did you allow for transfer of water via sewers across the topographic catchment boundary? ●If yes to either of these questions provide details which give sufficient information to understand the process applied and any assumptions made. It may be useful to include a map of sub-catchments here, if not provided earlier in the report.	Amber	BB01, BB02, BB03 and BB04 are all rural catchments (slightly to moderately urbanised catchments" yet are treated as urban). As per EA guidelines, they should be treated as rural. It is acknowledged that the intervening area does have an URBEXT value of 0.311 and so should be treated as urban.	Rerun ReFH2 analysis using the rural catchments as rural.		
7.1.3	(Additional space for other items checked)	N/A					

7.2 Model parameters							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.2.1	What methods were used to estimate model parameters? Have model parameters been listed? If flow estimation points are at or near a gauging station, have model parameters been estimated from observed data?	●List parameters for all site codes, including intervening areas and sub-catchments. ●Include a brief summary of what methods will be used at which subject sites. See Section 4.3 of the Flood Estimation Guidelines. ●More than one method may be tested at each site. Include all methods tested, even those ultimately rejected. ●See the Flood Estimation Guidelines for recommended approaches for modelling urbanised catchments. You only need to provide the urban area, TP urban scaling factor, IF, IRF and DS parameters if modelling as urbanised. ●ReFH2 treats BR (baseflow recharge) as a state variable rather than a parameter, setting it automatically in order to conserve volume. The values of BR vary with return period and so are not reported here.	OK	Catchment descriptor method applied and noted in the record. Model parameters are listed. No observed data used to estimate model parameters.			
7.2.2	What analysis was undertaken to derive model parameters?	●For any methods other than catchment descriptors, provide a description here and include full calculation details in the appendix.	N/A	Catchment descriptors method applied.			
7.2.3	(Additional space for other items checked)	N/A					

7.3 Model inputs for design events							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.3.1	What rainfall DDF model has been used (e.g. FEH99, FEH13 or FEH22)? Have rainfall data and initial conditions been amended from default values?	●Model inputs include rainfall data and initial conditions. These are a complete package and should only be amended in some circumstances. See Section 4.3 of the Flood Estimation Guidelines.	Red	No reference to rainfall DDF model (assume FEH13 as FEH22 was released afterwards). No notation if any initial conditions were amended from default	Update using FEH22 rainfall in the latest ReFH2.3.		
7.3.2	Have different design events been used when considering lumped and sub-catchment sites? Does the report acknowledge that a single design storm will need to be applied to all inflow hydrographs in a distributed modelling approach?	●ReFH2 may be applied for both lumped catchments and sub-catchments in a study. Different design events will be needed when considering lumped and sub-catchment sites. Complete the relevant sections as appropriate for your study.	Amber	Two different design events are used (storm duration of 9hrs or 15hrs). A consistent storm duration is needed.	Rerun using a consistent storm duration.		
7.3.3	What design events are listed for lumped catchments? Are the choices suitable?	●Storm durations detailed here should be the values for the individual catchments. Lumped flows should be generated using the storm duration relevant to each lumped catchment. ●A summer storm should be used if the catchment is heavily urbanised (URBEXT2000 between 0.15 and 0.3) AND highly permeable (BFIHOST19>0.65). ●Cini and BFO values only need to be listed if amended from default values. ●This section can be deleted if ReFH2 is not being applied for lumped catchments.	Amber	The record reports on two different storm durations applicable across the FEPs (9 hours and 15 hours).The reasoning is not explained. The report does not acknowledge that a single design storm will need to be applied to all inflow hydrographs and no sensitivity analysis has been carried out. No note to define default storm duration.	Update the flows using a consistent storm duration based on the critical catchment.		

7.3.4	What design events are listed for subcatchments and intervening areas? Are the choices suitable?	<ul style="list-style-type: none">●This table can be deleted if ReFH2 is not being applied for sub-catchments.●This table is included to identify the storm which will be applied to all inflows to a distributed model (see Section 6.1 of the Flood Estimation Guidelines) and avoid the scenario of using a different storm for each inflow to the model.●If there are multiple flood risk areas throughout the model it may be necessary to allow for different storms in different parts of the model by carrying out multiple runs. Each model run should use the same storm applied to all inflows.●Use one row for each storm to be applied. If only one storm is to be applied, delete the additional rows.	Amber	Further information required, as multiple storm durations are being used and this is not in line with best practice (15 hours storm duration applied for upstream inflow and downstream lumped catchment and then smaller sub catchments representing tributary inflows in addition to intervening area have 9 hours storm durations). It is acknowledged by the reviewers that BB04_I is classified as urban and so a summer season storm should be applied. However, since BB04 is the critical catchment a winter season storm is acceptable.	Update the flows using a consistent storm duration based on the critical catchment.		
7.3.5	Has storm duration testing been undertaken using the hydraulic model?	<ul style="list-style-type: none">●If storm duration testing using the hydraulic model is being undertaken add details of the results, for example, which duration(s) has been selected and why, what the process will be in terms of presenting model results if more than one duration is selected.	Amber	No storm duration testing has been undertaken. The flows are produced to compare against the FEH Statistical values.	Update the flows using a consistent storm duration based on the critical catchment.		
7.3.6	(Additional space for other items checked)	N/A					

7.4 Final choice of ReFH2 flow estimates							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.4.1	Has the final choice of design inputs and model parameters been recorded? Are the choices suitable?	<ul style="list-style-type: none">●Record your final choices of method for model parameters and design inputs. You may have multiple choices of methods for lumped and distributed modelling.	Amber	As per items 7.1.2, 7.3.1 to 7.3.5, a consistent storm duration is required, alongside rural catchments should be rural as per EA guidelines.	Update in line with review comments.		
7.4.2	Are the final flood estimates from the ReFH2 method reported?	<ul style="list-style-type: none">●Add or remove columns as needed to change the return periods to those used in this study.●Results only need to be provided here for lumped catchments, for comparison to other methods. Results for distributed catchments can be provided digitally but must still be provided to allow for checking.●If you have modelled a catchment as urban, make sure you record the urbanised flows rather than the as-rural flows.	Amber	Final flood estimates are tabulated. However, owing to the issues concerning urban or rural classification and the inconsistent storm duration these would need updating.	Update accordingly.		
7.4.3	(Additional space for other items checked)	N/A					



9. Discussion and summary of results

9.1 Comparison of results from different methods							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.1.1	Are peak flows from different methods compared?	●Compare peak flows from preferred methods at key sites for selected return periods / AEP events.	OK	Peak flows are compared from the FEH Stat and ReFH2.3 methods.			
9.1.2	(Additional space for other items checked)	N/A					

9.2 Final choice of method							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.2.1	Is the choice of method justified by discussing the type of problem, the type of catchment and the type of data?	●Include reference to type of study, nature of catchment and type of data available. ●If different methods are chosen for different site codes or return periods, explain why.	Amber	Since ReFH and statistical flows will need to be recalculated the final choice of method may need to be reassessed. Hence, this item has been left as Amber. The justification is weighted heavily by the fact that the ReFH2 flows were higher than the flows derived from the FEH Statistical and therefore the approach is conservative. However, guidance states that higher estimates should not be the sole justification to chose a method. It is acknowledged that the conservative approach may be considered warranted owing to the higher flows being used in the model to define the design of the bridge.	If required update Section 6.2 to include a new final choice of method.		
9.2.2	Does the report explain how hydrograph shapes or volumes have been derived?	N/A	Green	No explanation of how hydrograph shape has been derived but is assumed to be from ReFH2.	Update Section 6 to include an explanation of how the hydrograph shapes are derived.		
9.2.3	How will the 0.1% AEP flows be estimated?	●You may choose a different method for the 0.1% AEP event (see Section 6.6 of the Flood Estimation Guidelines). Explain how growth factors and peak flows have been calculated, if using a hybrid method.	Green	Application of hybrid method has not been applied. EA guidelines note that "If you choose ReFH2 for the longer return periods, to avoid a discontinuity in the results, you could consider using ReFH2 to obtain the ratio of the 1000-year flow to the (say) 100-year flow. You can then multiply that ratio by the preferred estimate of the 100-year flow, which may be from the statistical method."	Update the final 0.1% flows with the hybrid method or provide reasoning for using ReFH2.		
9.2.4	How will the flows be applied to the hydraulic model?	●For example, will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	Green	No explanation provided within the FEH Calculation record.	Update the calculation record to include how the final flows will be applied to the model.		
9.2.5	(Additional space for other items checked)	N/A					

9.3 Final results							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.3.1	Have the final peak flow results been provided for all flow estimation points and design events?	●Include subcatchment and intervening catchment flows here or in digital files, to allow checking of the hydraulic model. ●If scaling factors have been used in a distributed model, provide full details of the original and final flows below or in the appendix.	OK	Final peak flow results have been provided for all flow estimation points and design events (no allowance for climate change as noted previously).			
9.3.2	Have any other information, data or results needed for the next stage of the study been provided?	N/A	N/A				
9.3.3	If appropriate, what design storms have been applied in the hydraulic model?	●Use this section if appropriate to record the ReFH1 or ReFH2 design storm parameters applied in the hydraulic model, if they are different to those recorded in the ReFH1 and ReFH2 sections of this report. ●You must apply a uniform storm duration and areal reduction factor across all subcatchments. Refer to the Flood Estimation Guidelines Section 6.1. This may result in a number of different design storms being modelled to give critical results at different locations in the catchment. List all details below.	Amber	Storm duration, SCF and ARF for BB04_I are based on the flow estimation point BB03. The SCF and ARF for BB02 are based on flow estimation point BB03. The storm duration for the upstream BB01 is 15 hours, compared to the other FEPs that have a storm duration of 8 hours. No further discussion is made in relation to the storm duration and how these are applied in the model.	Update the flows with a consistent storm duration.		
9.3.4	What climate change allowances have been applied and how?	●Refer to online guidance on climate change allowances for flood risk assessments and projects. ●Provide information on: ●What climate change allowances have been applied, e.g., rainfall and/or flow allowances, source of data, river basin, epoch, and percentiles. ●How the climate change allowances have been applied, e.g., applied to rainfall / flow hydrographs within the hydraulic modelling software using scaling factors. ●For non-stationary methods, refer to the practitioner guidance available on the FCERM R&D web page and provide full details and justification for the approach chosen.	Green	No climate change allowance has been recorded in the FEH Calculation record results. However, this is covered in the model report and so to aid future users of the hydrology should be included within Section 6.	Add climate change allowances into the report.		
9.3.5	(Additional space for other items checked)						

9.4 Checks on final results							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2

9.4.1	Are checks on results included?	<ul style="list-style-type: none">●See Section 3.5 of the Flood Estimation Guidelines.●These checks are important as a way of ensuring that everything has been considered and that the results are sensible.●All relevant sections should be completed for every study. Where sections are not relevant (where there are no flow gauges or previous studies, for example) a comment should be added to this effect rather than leaving a blank space.	Green	The relevant checks as outlined in the guidance have been undertaken. No reference to if the results are spatially consistent between upstream and downstream FEPs is made, which as per item 4.4.1 is required.	Update the report to include reference to spatial consistency inline with the actions from item 4.4.1.		
9.4.2	Have the 1% and 0.1% AEP growth factors been derived and sense-checked? If the 1% AEP growth factor is outside the typical range, has a justification been provided?	<ul style="list-style-type: none">●What is the range of 1% AEP (100-year) growth factors? Is this realistic?●What is the range of ratios for the 0.1% AEP (1000-year) over 1% AEP (100-year) flow?●What reasons are there for variations in ratios between sites?	OK	Range of 1% AEP growth factors is between 2.91 and 3.07, which is in line with acceptable range of 2.1 to 4.0 Range of ratios for 1000-year flow over 100-year flow is 1.75 to 1.82.			
9.4.3	Has the specific discharge (l/s/ha) been derived, and are variations between locations explained?	<ul style="list-style-type: none">●What specific discharge (flow in l/s/ha) do the results equate to? Can you explain variations in specific discharges between different locations across the study area?	Green	Specific runoffs have only been provided for the downstream lumped catchment and not the component catchments.	Add specific runoffs for component catchments.		
9.4.5	Have the design flows been checked for spatial consistency, e.g. at confluences and along reaches?	<ul style="list-style-type: none">●This will not be relevant for a study where there is only a single flow estimation point.●See Section 6.1 of the Flood Estimation Guidelines. FEH methods are intended for application at individual sites and may not give spatially consistent results if applied to multiple sites along a river system.●You should particularly check for consistency between upstream and downstream points and at confluences.	Green	No checks for spatial consistency referenced within the FEH Calculation Record.	As per item 9.4.1 add note on spatial consistency.		
9.4.6	Have return periods for notable historic floods been calculated?	<ul style="list-style-type: none">●What do the results imply regarding the return periods / frequency of major events in the gauged record? This can help justify the choice of flood growth curve.●If there is no flow data available, you can compare your design event hydraulic modelling results to observed level and flood extent data if available for major events.	N/A	No historic floods recorded.			
9.4.7	Are results compatible with the longer term flood history?	<ul style="list-style-type: none">●Consider whether the implied frequency of flooding from your design event hydraulic modelling results is compatible with what is known of the flood history of the study area.	Green	As per items 2.3.2 and item 2.3.3, a level gauge is present on the Bin Brook which could be used as a check flow in the modelling.	Use the level gauge as a check in the hydraulic modelling.		
9.4.8	Have results been compared with previous studies?	<ul style="list-style-type: none">●Explain any differences and conclude which results should be preferred.●This will not be relevant if there are no previous hydrological assessments.	N/A	Not within the scope of the study.			
9.4.9	Have the hydraulic model results been checked against lumped flow estimates?	<ul style="list-style-type: none">●Are flows generated by the hydraulic model consistent with those estimated from a lumped catchment FEH estimate at locations within the model reach?●Have any scaling factors been applied to reconcile model results to the preferred flow estimates?	OK	Whilst not in the report, the reviewers have checked the flows are correct in the model.			
9.4.10	(Additional space for other items checked)	N/A					

9.5 Assumptions, limitations and uncertainty

Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.5.1	Are assumptions, limitations and uncertainty reported?	<ul style="list-style-type: none">●Careful thought should be put into identifying the specific assumptions and limitations applicable to the design peak flow estimates (and design hydrographs).●Assessing and reporting on the uncertainty in the estimates is also very important.●These sections should be completed for every study and never left blank.	OK	Assumptions, uncertainty and project specific limitations associated with the hydrology have been reported.			
9.5.2	Are the assumptions acknowledged and specific to the study?	<ul style="list-style-type: none">●See Section 5.2 of the Flood Estimation Guidelines.●Assumptions should be specific to the study, have a large effect on the results, and can be tested. General assumptions do not need listing.	Green	Standard FEH assumptions' noted as being applied. However, assumptions specific to the study should be stated.	Add detailed assumptions that are specific to project.		
9.5.3	Are the limitations acknowledged and specific to the study?	<ul style="list-style-type: none">●See Section 5.3 of the Flood Estimation Guidelines.●This could include applying methods outside of the range of catchment characteristics or return periods for which they were developed.	Green	Lack of suitable gauged data and suitable donor is acknowledged. No discussion of limitations pertaining to the presence of the lakes within the catchment and the representative FARL values is provided.	Add limitations of assessment.		

9.5.4	Does the report comment on uncertainty in the design flows?	<ul style="list-style-type: none">●See Section 5.4 of the Flood Estimation Guidelines.●Uncertainties in the peak flow estimates should always be quantified if it is possible to do so for the method applied.●Note that the confidence limits given in the Flood Estimation Guidelines assume that the AMAX flows follow a generalised logistic distribution. If you have fitted a different distribution, these confidence limits will not be applicable.●Complete the table with flows from the uncertainty analysis. The default is the 95th percentile upper and lower bounds, but other estimates may need to be provided depending on the requirements of the study.	OK	Uncertainty bands are reported on.			
9.5.5	Is the suitability of the results for future studies considered?	<ul style="list-style-type: none">●With reference to the assumptions, limitations and uncertainties, comment on the suitability of these calculations for future studies, e.g., at nearby locations, or for different purposes such as detailed scheme design.	Green	The calculation record does not comment on the suitability of the results for future studies.	Update Section 6 to include comments about the suitability of the results for future studies.		
9.5.6	Are recommendations made for future work?	<ul style="list-style-type: none">●Make recommendations for how assumptions, limitations and uncertainties could be reduced in future work, for example flow monitoring, rating reviews, etc.	OK	Recommendations provided for installation of a flow gauge (temporary or permanent) which would help to verify and improve flow estimates for all of the study catchments.			
9.5.7	(Additional space for other items checked)	N/A					



10. Appendix

10.1 Digital files							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
10.1.1	Are input data, output data and profile files available to provide evidence of calculations?	●If you are submitting work commissioned by the Environment Agency or for review by the Environment Agency, you should be prepared to submit as digital files your input data, output data and project files (where these exist) from the software you have used in the flood estimation. Refer to Section 8.1 of the Flood Estimation Guidelines. ●Use this section to list the files you are submitting, if relevant.	OK	Reports provided only.			
10.1.2	Do the digital files use the same input data and parameters, and give the same results, as listed in the report?	N/A					
10.2 Other supporting information							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
10.2.1	Is other supporting information included as needed, complete and accurate?	●Include any additional information which best sits here rather than in the section text, for example, flood peak series, details of historical flood events, rating reviews, pooling groups, or details of flood event analysis. Include important information in the section text, for example, comparison of growth curves, or results of flood event analysis.					
10.2.2	(Add additional items checked here and below as needed, to review the supporting information included in the Appendix or separate reports.)						
10.2.3	(Additional space for other items checked)						
10.2.4	(Additional space for other items checked)						
10.2.5	(Additional space for other items checked)						
10.2.6	(Additional space for other items checked)						
10.2.7	(Additional space for other items checked)						

Content details

Title	Non-real time Hydraulic Model Review Template
Audience	Environment Agency, Defra
Type	Template
Reference	LIT 17617
Version	6.0
Security marking	OFFICIAL

CONTROLLED CONTENT

NON-REAL TIME HYDRAULIC MODEL REVIEW



Type of review

Fluvial/tidal 1D-2D model

Project	Cambourne to Cambridge	Job Number		Required coastal standard (if applicable)	
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Model Type	1D/2D	Software	FMP/TuFlow	2nd review	3rd review	4th review
Revision		Date	02/11/2023			
Area Client		Reviewer	Arcadis Consulting Ltd			

REVIEW SUMMARY/CONCLUSION

Is the model suitable for intended use?	The model is currently unsuitable for the intended use. There are queries relating to the 1D model, 2D model and 1D2D linking that require addressing. The representation of the bank lines and structures needs reviewing. The 1,000-year +19% CC event glasswalls against the model boundary.
Is the model suitable for intended use?	<p>2nd Review Summary - March 2025</p> <p>The model is not currently suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.</p> <p>Red Comments</p> <ul style="list-style-type: none">•There is still some glass walling in 2d domain, please extend the code boundary accordingly.•The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs.•Have the model results been compared with Flood Zones maps as well? Please provided evidence of the comparison in the report and discuss why the differences with the previous modelling occur.•Please update the zpoints as the zpoints on bankline and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.•The report does not include full results and more details need to be added in term of assumptions made to model the structures. <p>Amber Comments</p> <ul style="list-style-type: none">•Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.•Surveyed cross sections should be referenced in the model/.dat file and a structures table/log should be provided to enable the checks on structures dimensions.•Please update the report to include how inflows have been applied in the model. A figure of the catchment boundary should be included in the report.•Please include justification to omit those footbridges. If unavailability of survey is the prime reason, some assumptions can be applied to consider the losses. Also, provide structures log for the omitted structures.•Please provide a structure log with reference to the surveyed cross section including naming convention. The structures log should also include the assumptions considered to model the structures. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the dimensions for BB01_1034cd culvert were defined, as the survey does not contain this information.•Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m.•Please revisit the approach to model the 1d channel under Robinsons College Building.•Overflow Ditch Channel length and culvert dimension needs to be updated, and height contraction coefficient need to be defined for the culvert•The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream.•The slope has been updated, and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.•Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?•It is not clear which option is the final one for the proposed case scenario, please clarify that for example copm1 and comp2 results are not provided to review. XMDF files have not been provided, these would help the reviewing process.

MODEL REVIEW PROCESS

Hydraulic Model reviews are an essential component of the Hydraulic Modelling Quality Assurance (QA) process that provides confidence in a model's suitability for its intended purpose. Evidence that the model has undergone QA may be requested by external parties and hence all reviews should be written with an expectation that they could be read externally.

Should any issue(s) be raised during the review process, which require attention, the reviewer should detail the action(s) required in sufficient detail to allow the modeller to complete the changes as appropriate. Completion of this Model Review document does not automatically constitute model approval. Once the suggested changes have been completed, the reviewer may require that the model be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all the amendments have been completed satisfactorily, will the model be approved and the quality assured by the reviewer.

It is recommended that the reviewer makes good use of the fluvial design guide chapter 7 and the user manual/help guides for the appropriate modelling software.

Depending on the work being reviewed some questions or entire sections may not be relevant, in which case they can be deleted. On completion of the review the reviewer may choose to use the following colour coding system to alert the modeller to the priority of the actions required (if any).

Colour coding used:

OK – Good practice.
Minimum response: No minimum.
Maximum expected response: No maximum.
Planning: No Objection.

Green – Consider for future studies. Negligible impact on the results that is unlikely to change the outcome of the study.
Minimum response: Acknowledge the comment in the spreadsheet and update the limitation section of the report.
Maximum expected response: Actions done to address the issue identified.
Planning: No Objection.

Note: Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.

Amber – Follow recommendation. Potential impact on the results that may change the outcome of the study.
Minimum response: Comments justifying the approach taken and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Consider objecting to the application based on comments highlighted in this category.

Note: Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.

Red – Must do. Has an impact on the results that may have a significant impact on the outcome of the study.
Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Objection - Application to be objected if comments are highlighted in this category.
Note: If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidences. If issues highlighted red are ignored, then submissions should always be sent back.

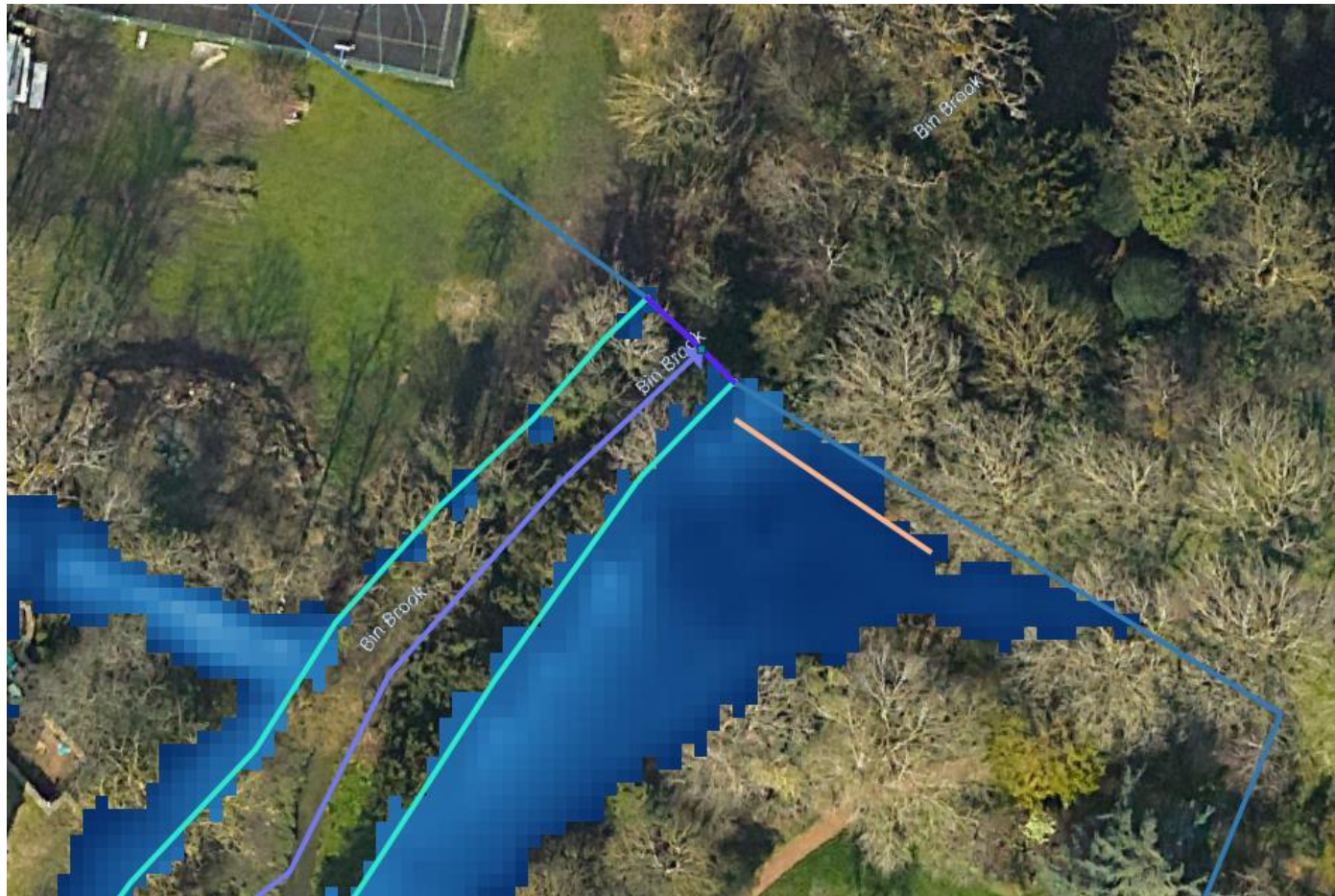


Figure 1: Downstream boundary not snapped to code layer

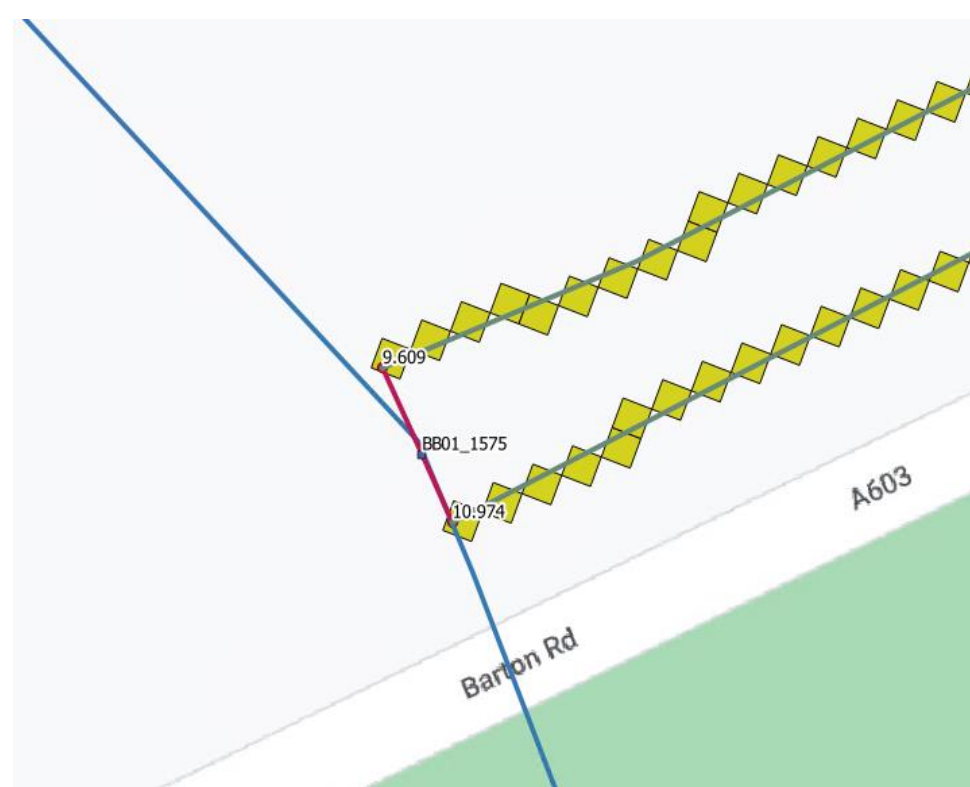


Figure 2: HX layer needs snapping to code layer

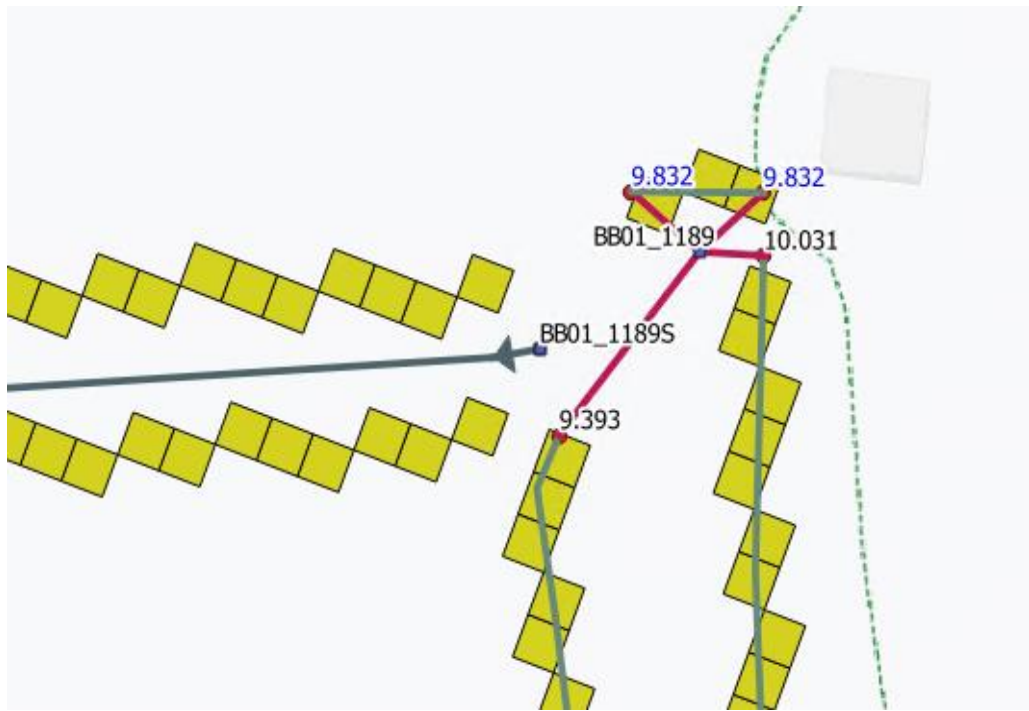


Figure 3: HX link gaps at watercourses and structures need closing



Figure 4: 1d_node / CN lines placed upstream of 1D cross section location, and ungeoreferenced cross sections



Figure 5: Glass walling at the upstream extent of the code layer

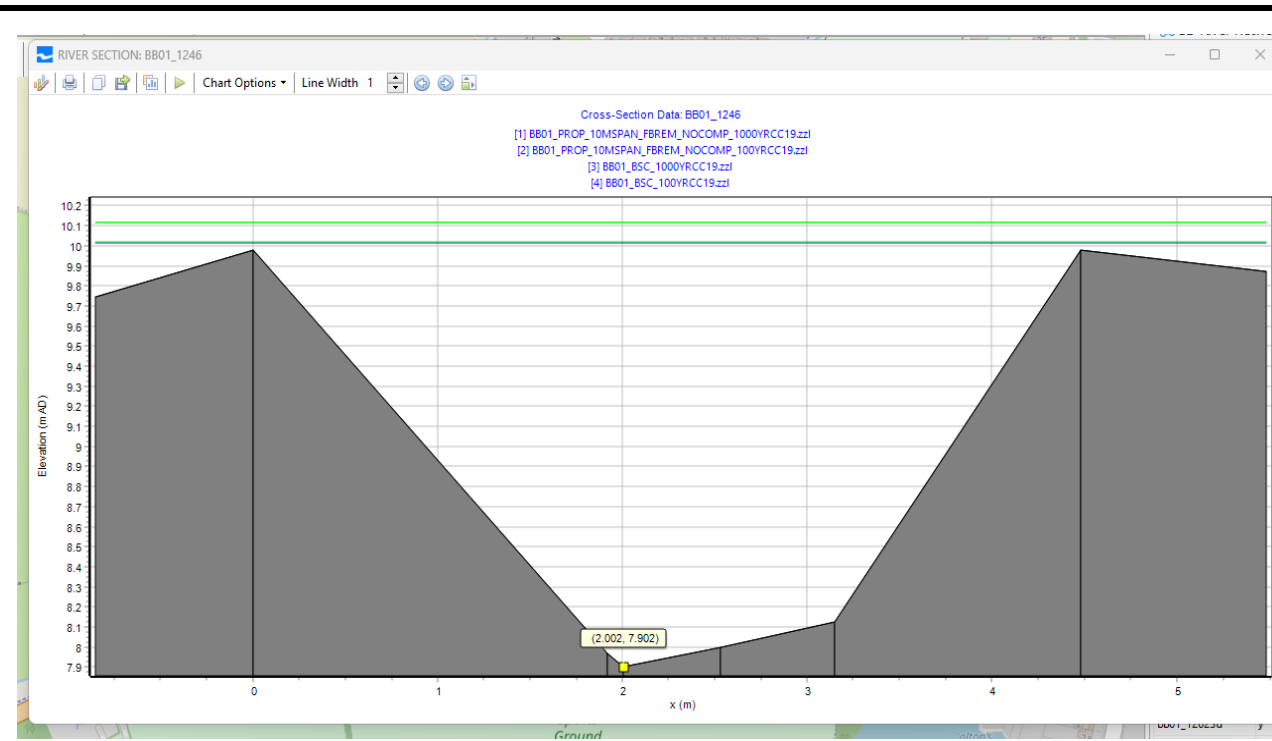


Figure 6: Cross section BB01_1246 which needs to be deactivated at bank top

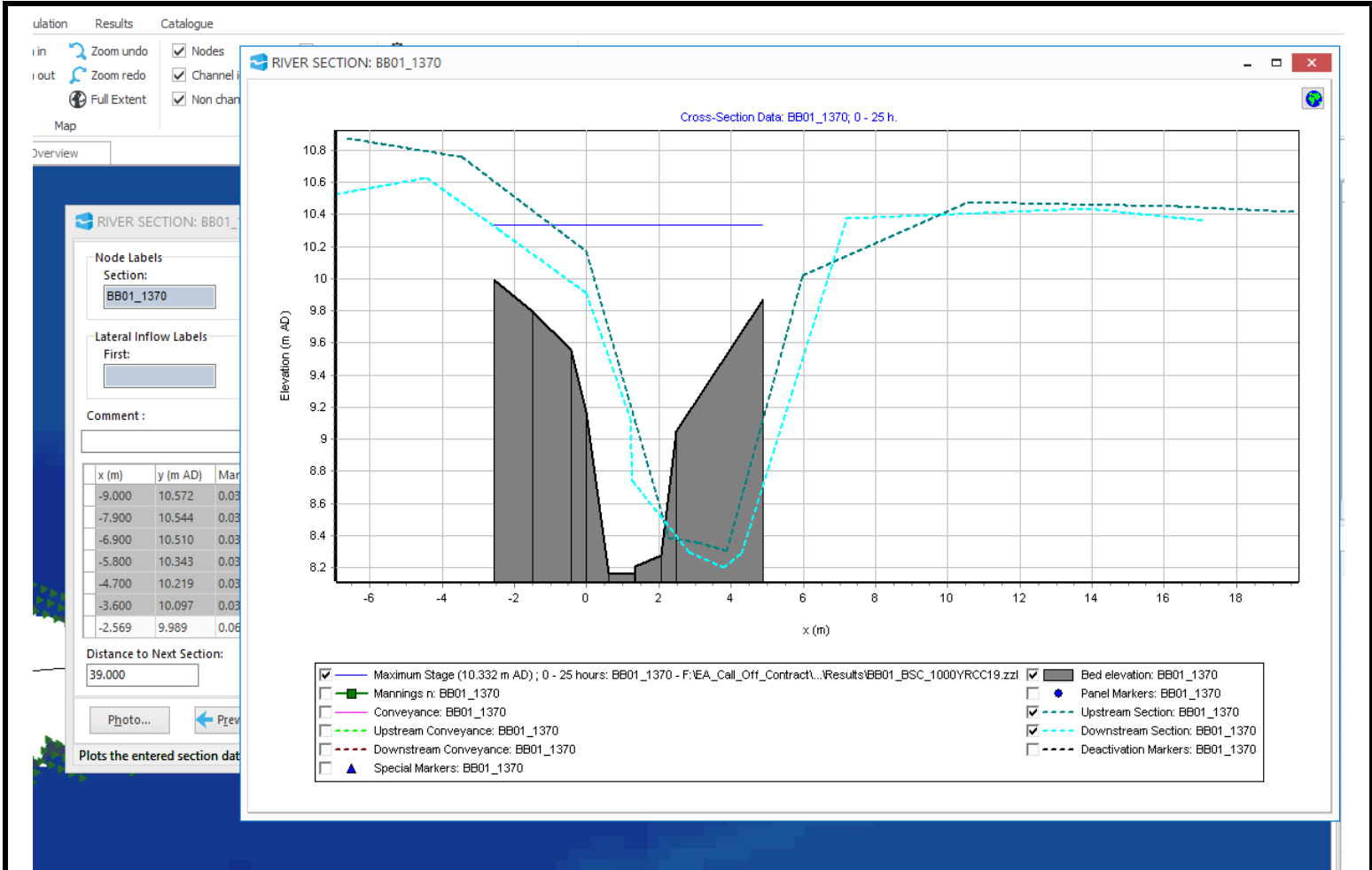


Figure 7: Glass walling in the 1D model. Upstream and downstream section with very different widths. 1d2d widths do not match. 2D width = 14m

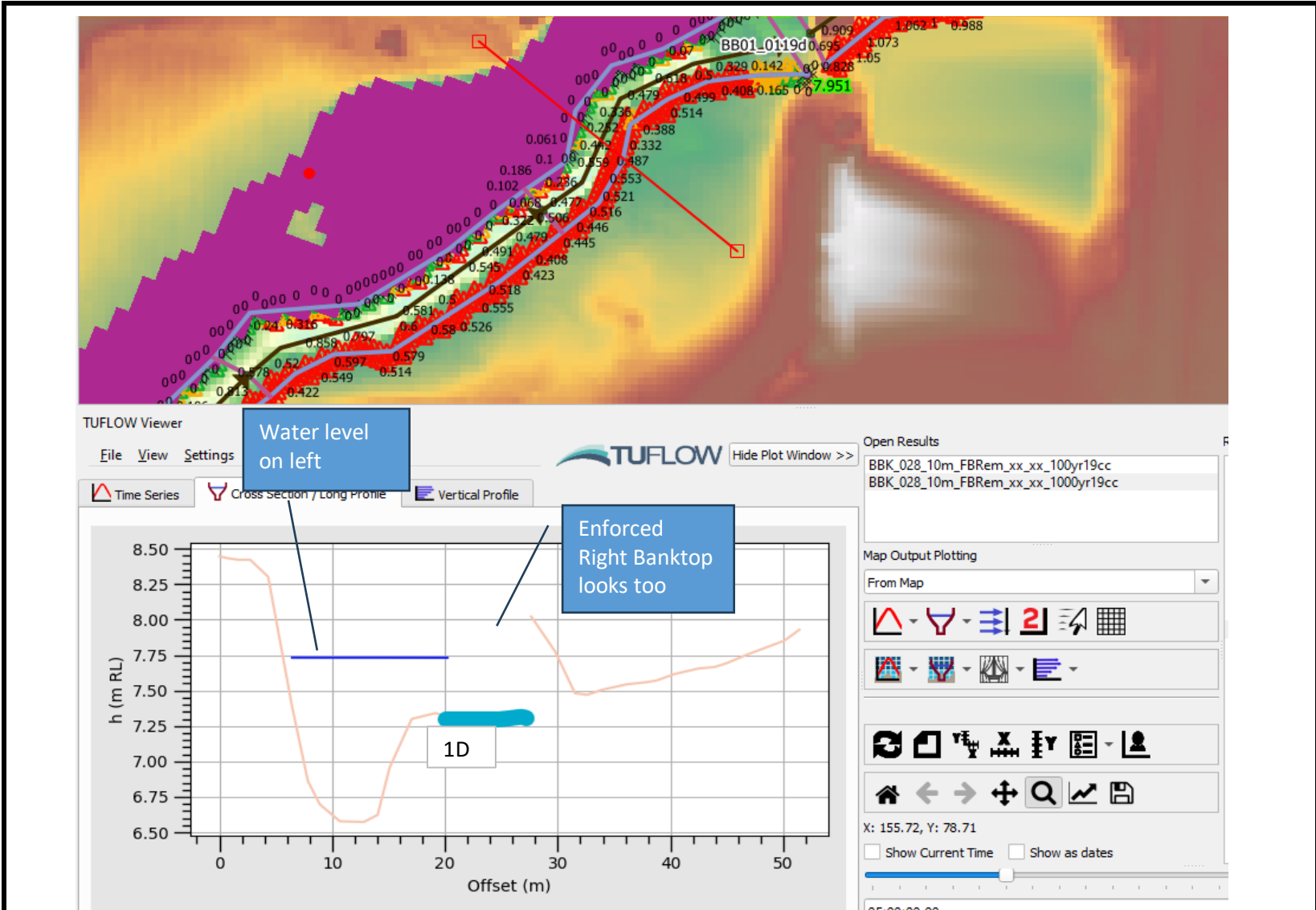


Figure 8: 1d_bank levels are interpolated and appear artificially high preventing water spilling to floodplain

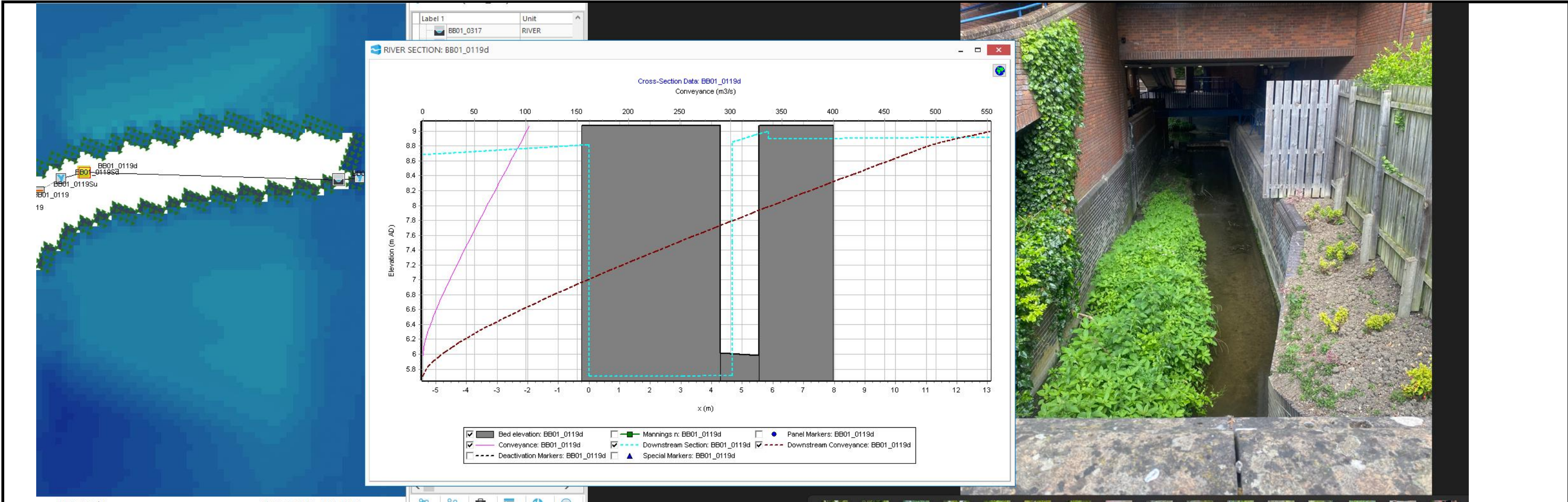


Figure 9: Section BB01_0119d is located downstream of the weir BB01_0119. The distance to next is 70m to the bridge. The channel cross section is 1.7m wide upstream and 4.7m downstream - this is modelling a tapering channel, the survey photo suggests the channel widens immediately downstream of the weir - the modelled channel reach appears to be too narrow as interpolates from one section to the next.

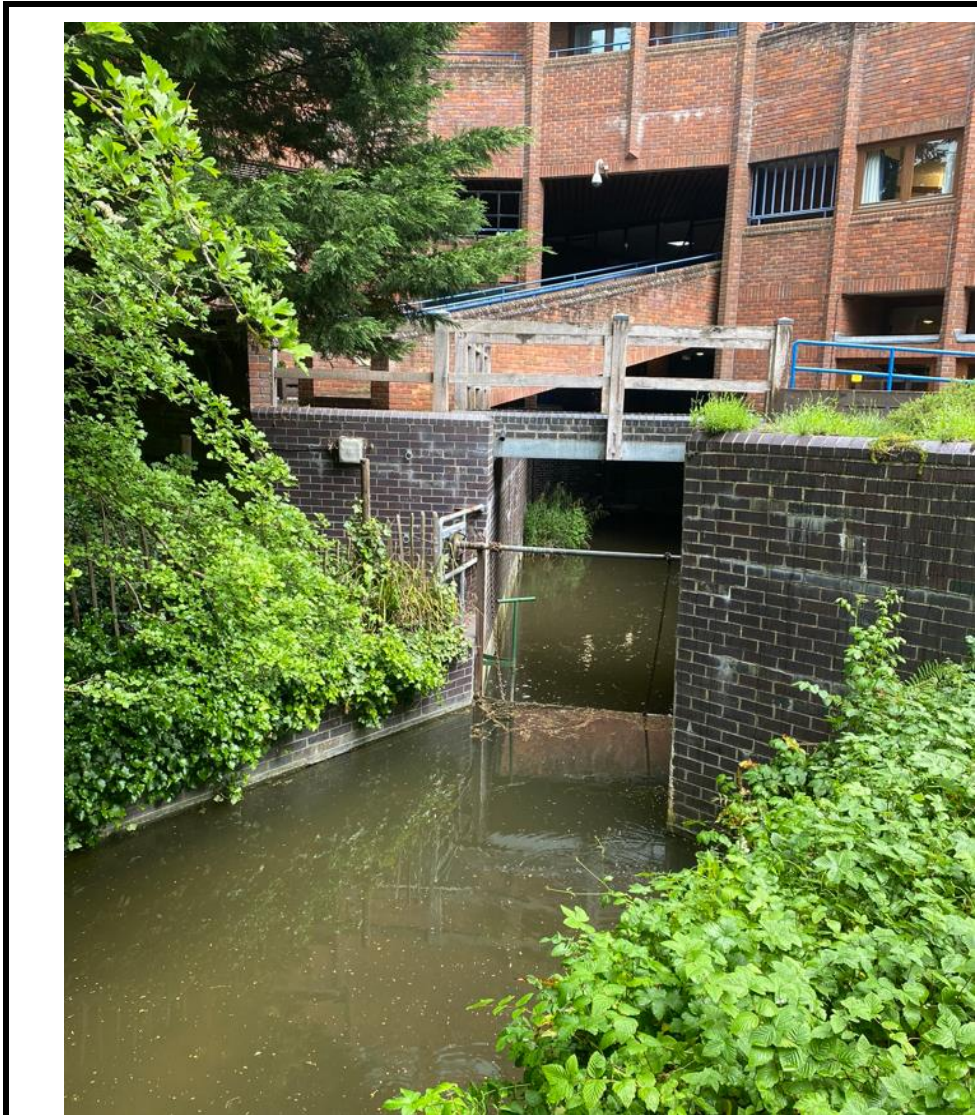


Figure 10: Weir looks to be sharp crested model with default broad crested coefficient

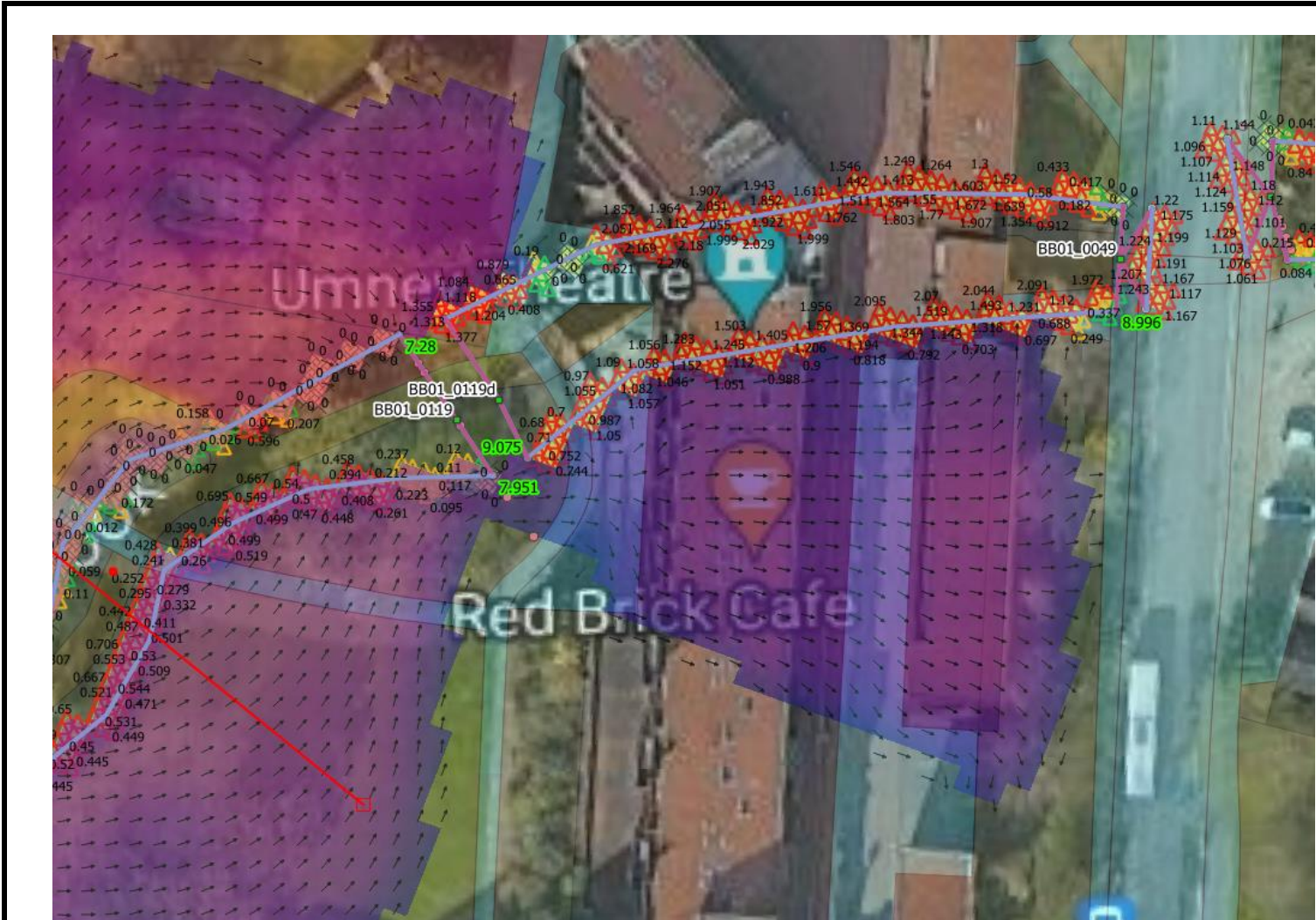


Figure 11: Split in the 2D link location for the weir looks slightly too far upstream. Flow appears to be by-passing the weir but the survey photos indicate ground levels behind may be higher. Modelling buildings a manning's 'n' is standard however in this instance further consideration needs to be given on the levels and flow mechanisms being modelled under / through the building. Are these correct, can water flow through the building and back into channel?

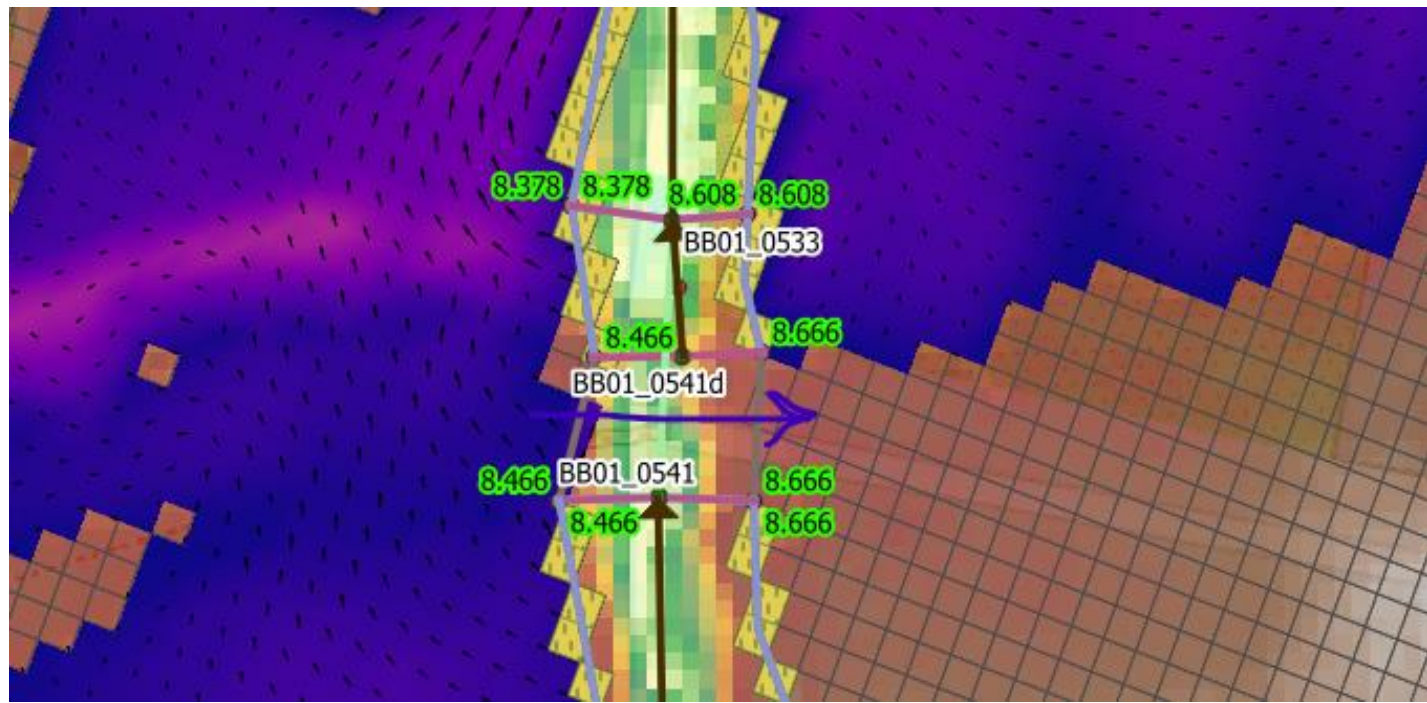


Figure 12: The flow not modelled in 2D possibly preventing flow over the bridge deck.

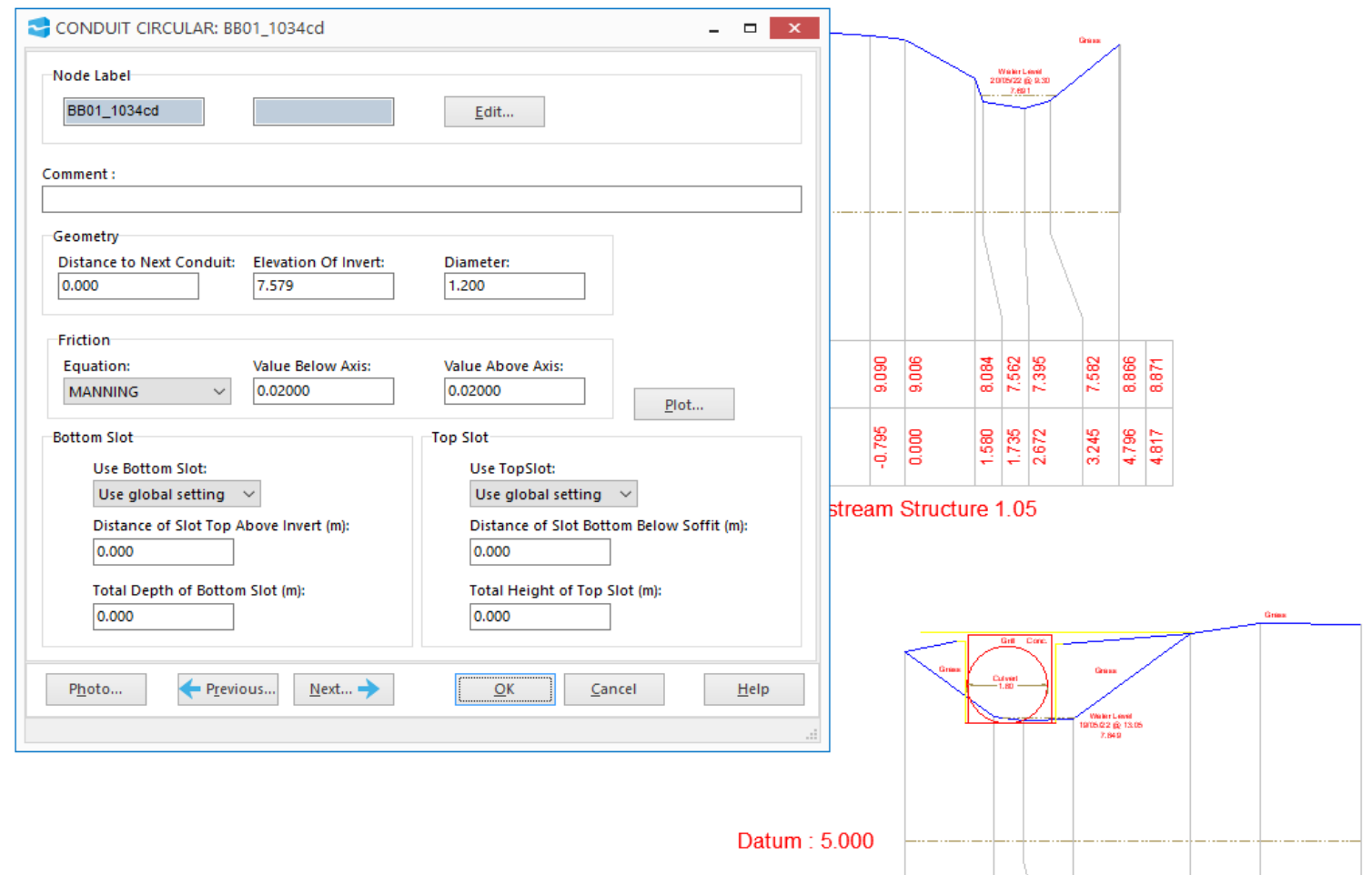


Figure 13: BB01_1189ci modelled as 1.8m diameter the culvert exit BB01_1134cd is modelled as 1.2m diameter. This decrease in culvert size does not appear to match the survey data

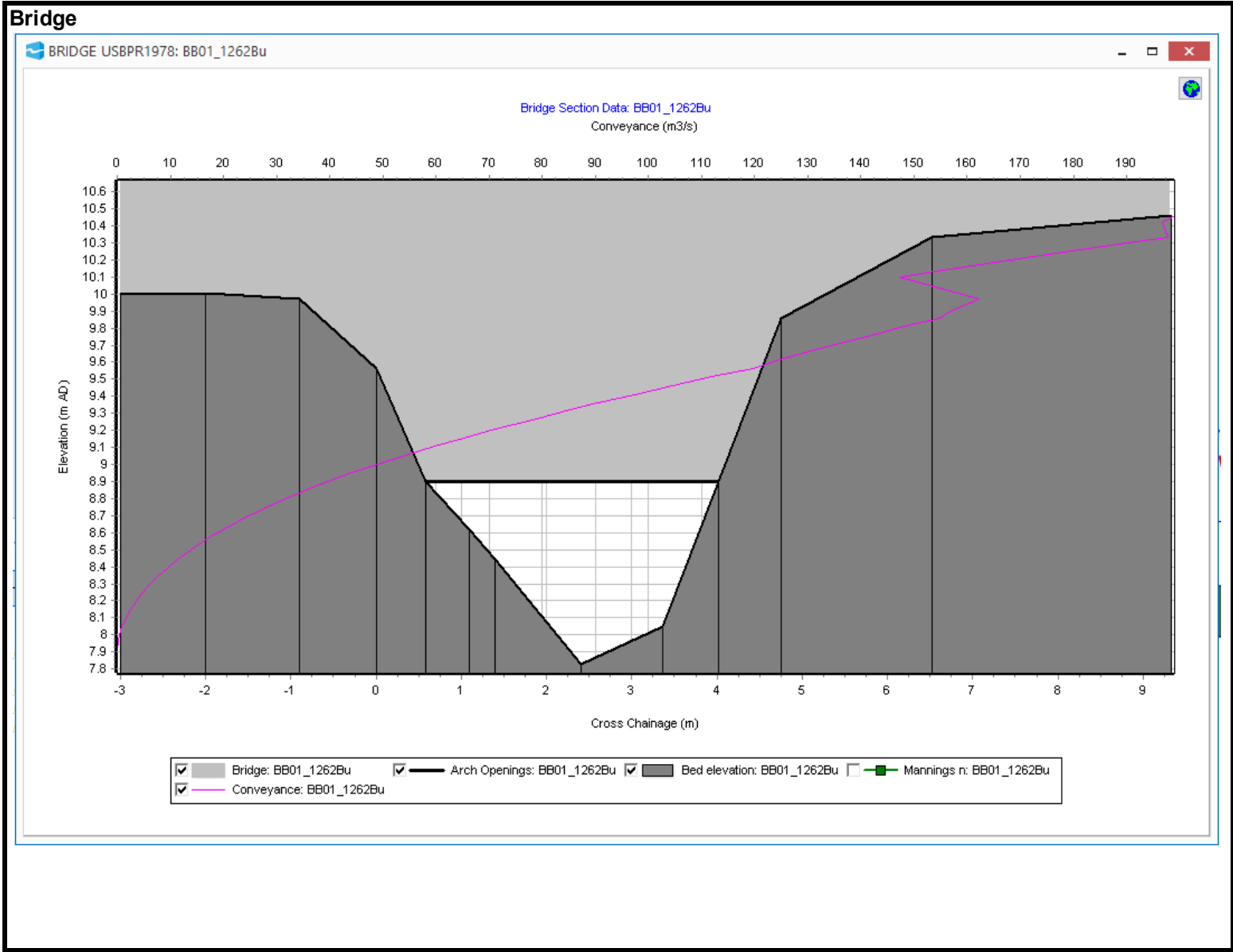
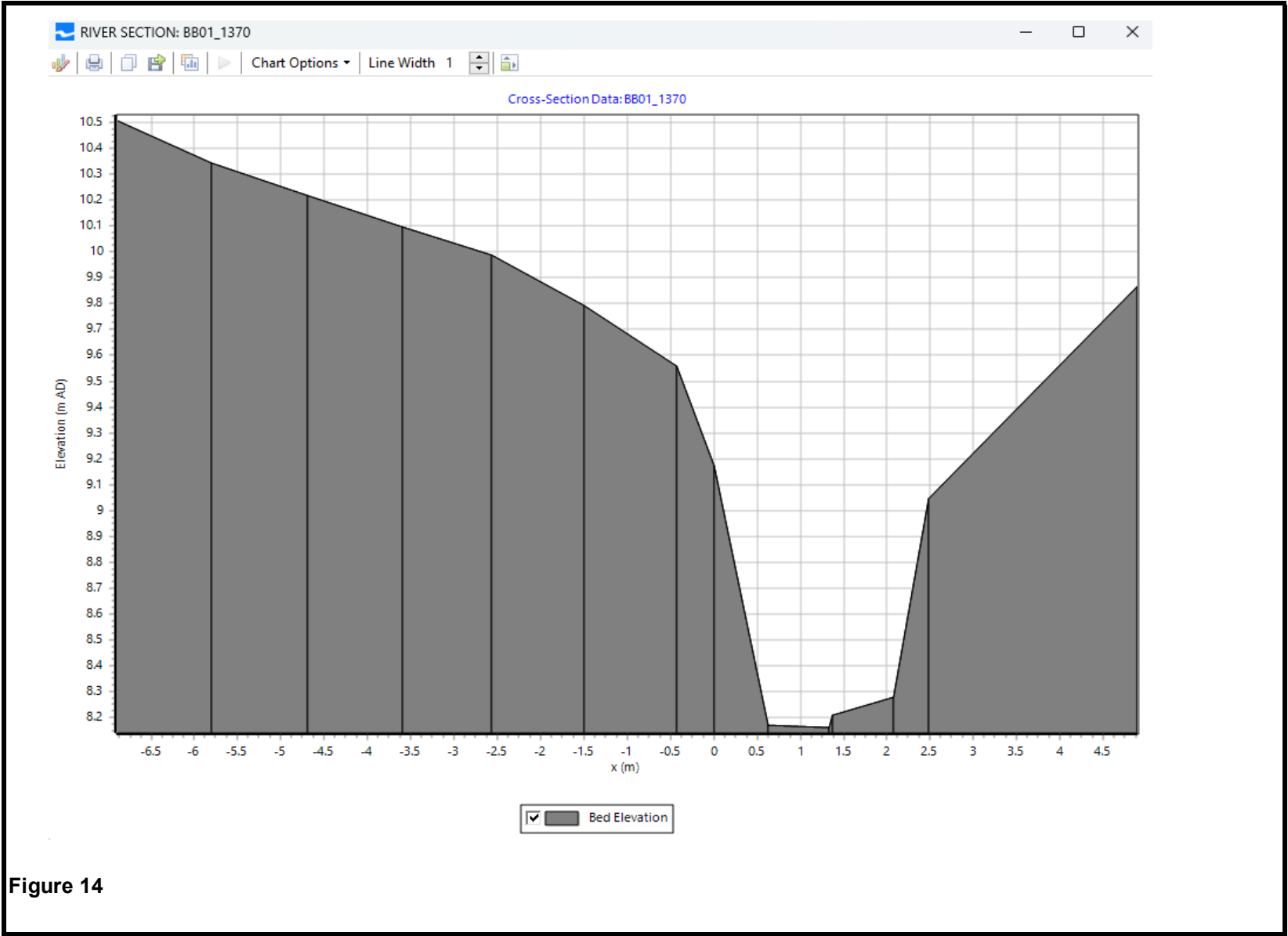


Figure 14

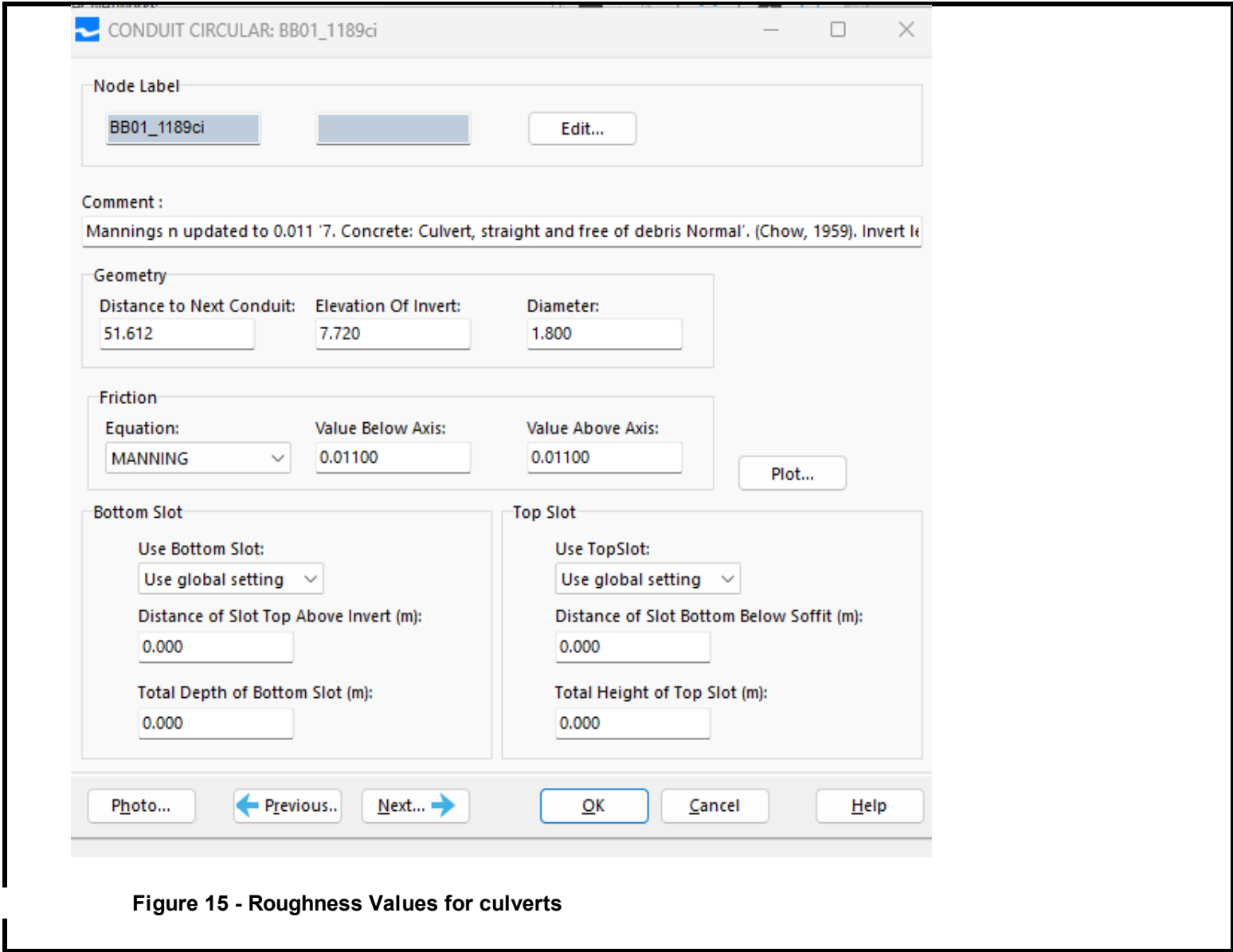


Figure 15 - Roughness Values for culverts

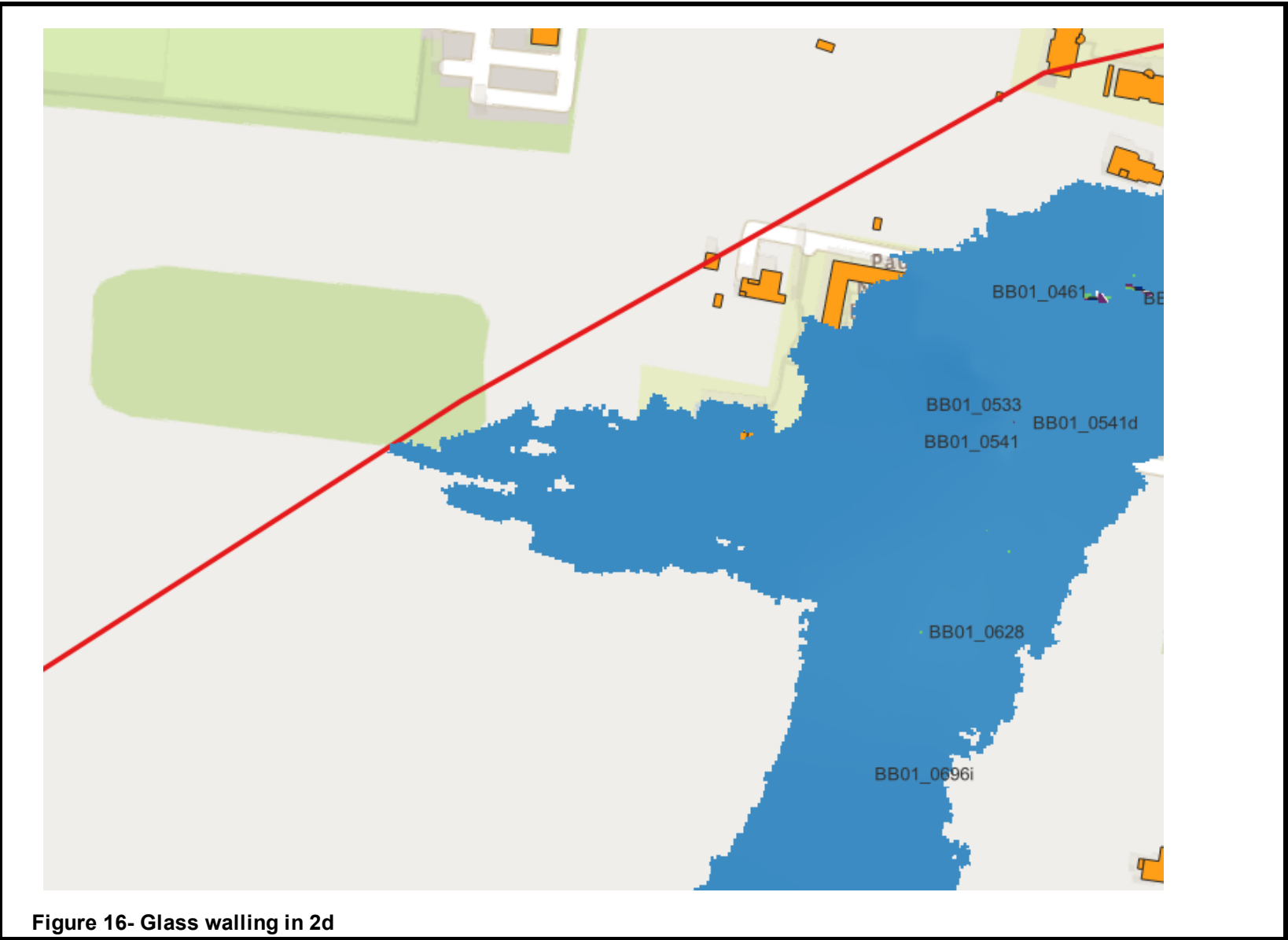
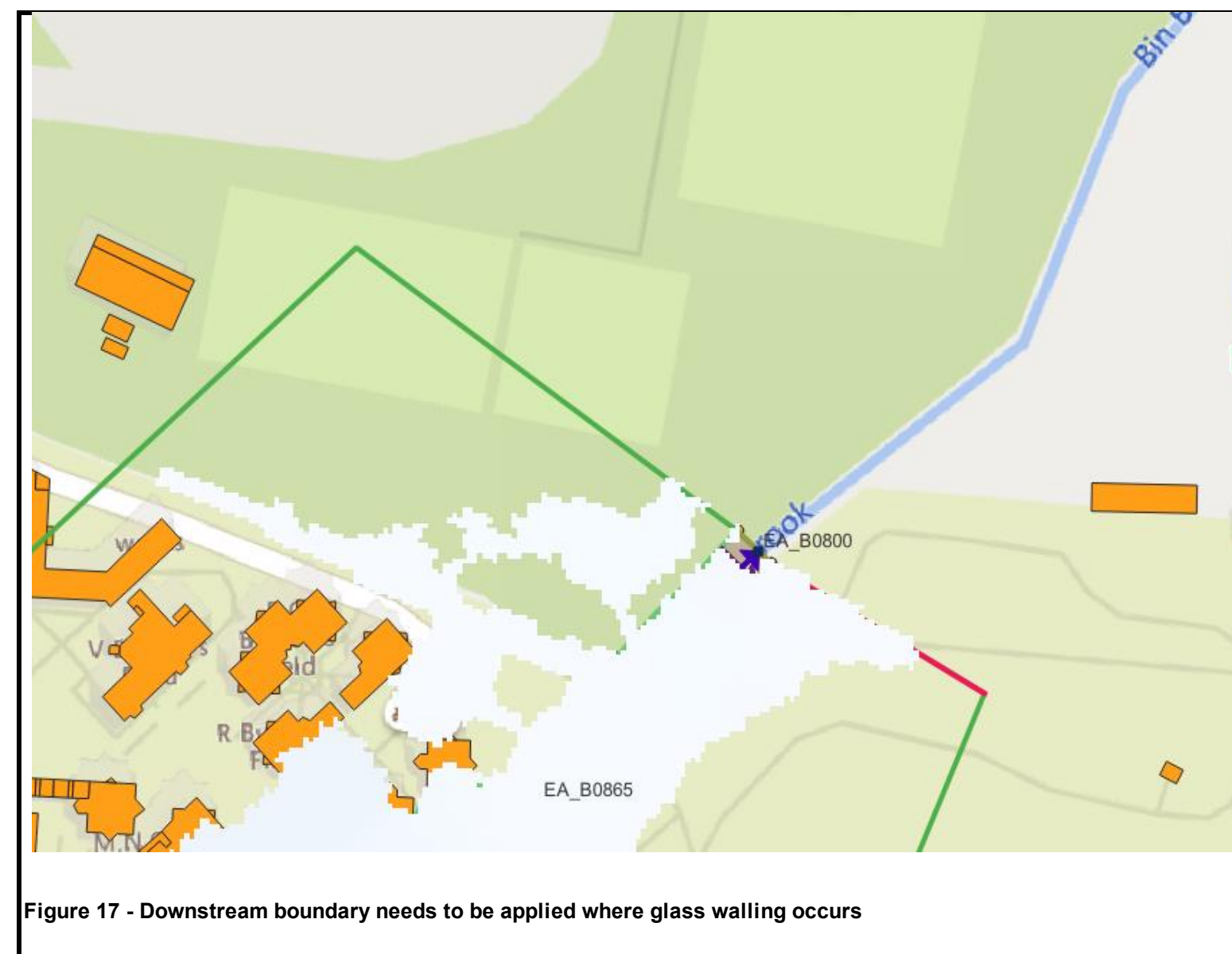
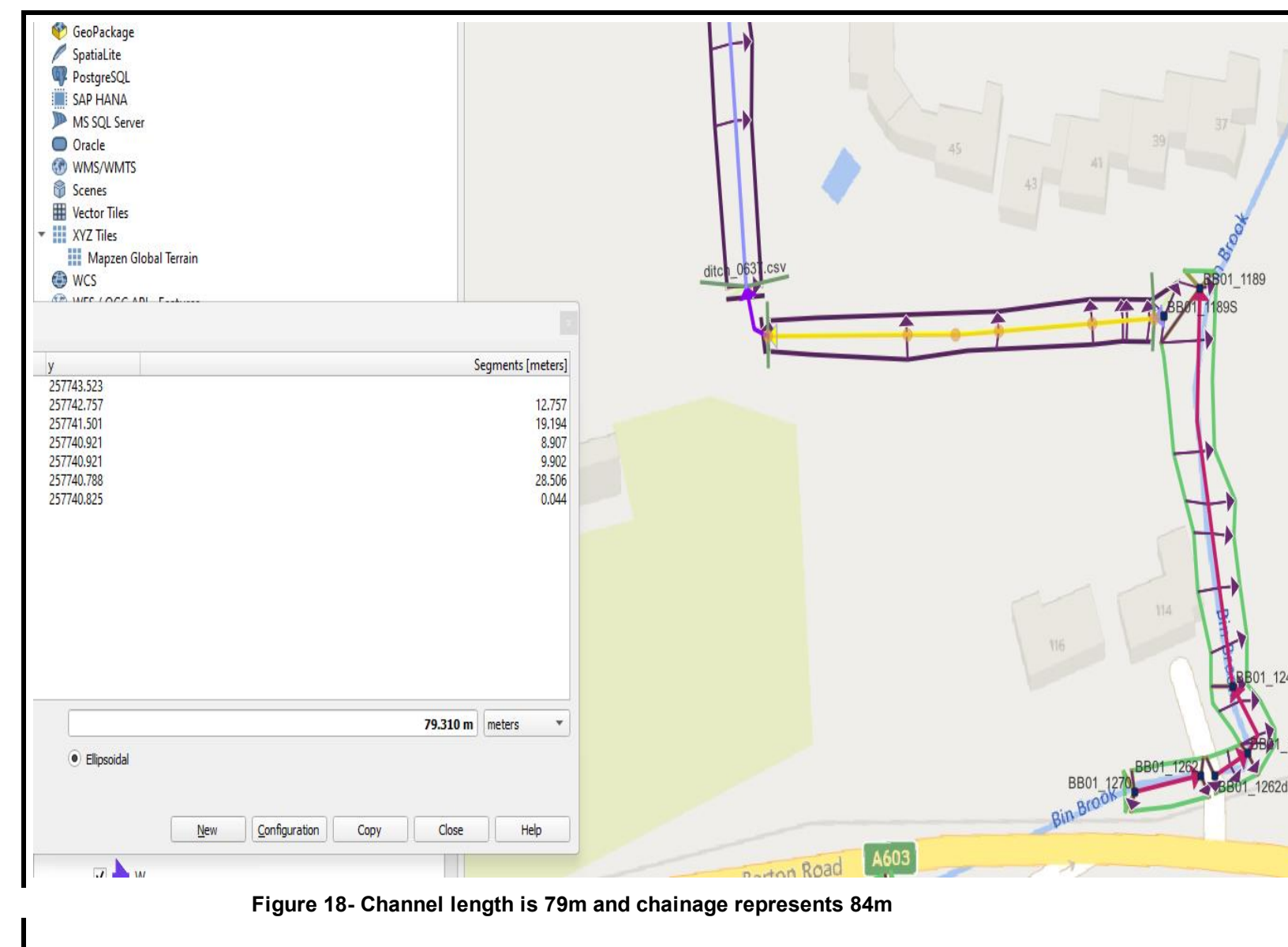
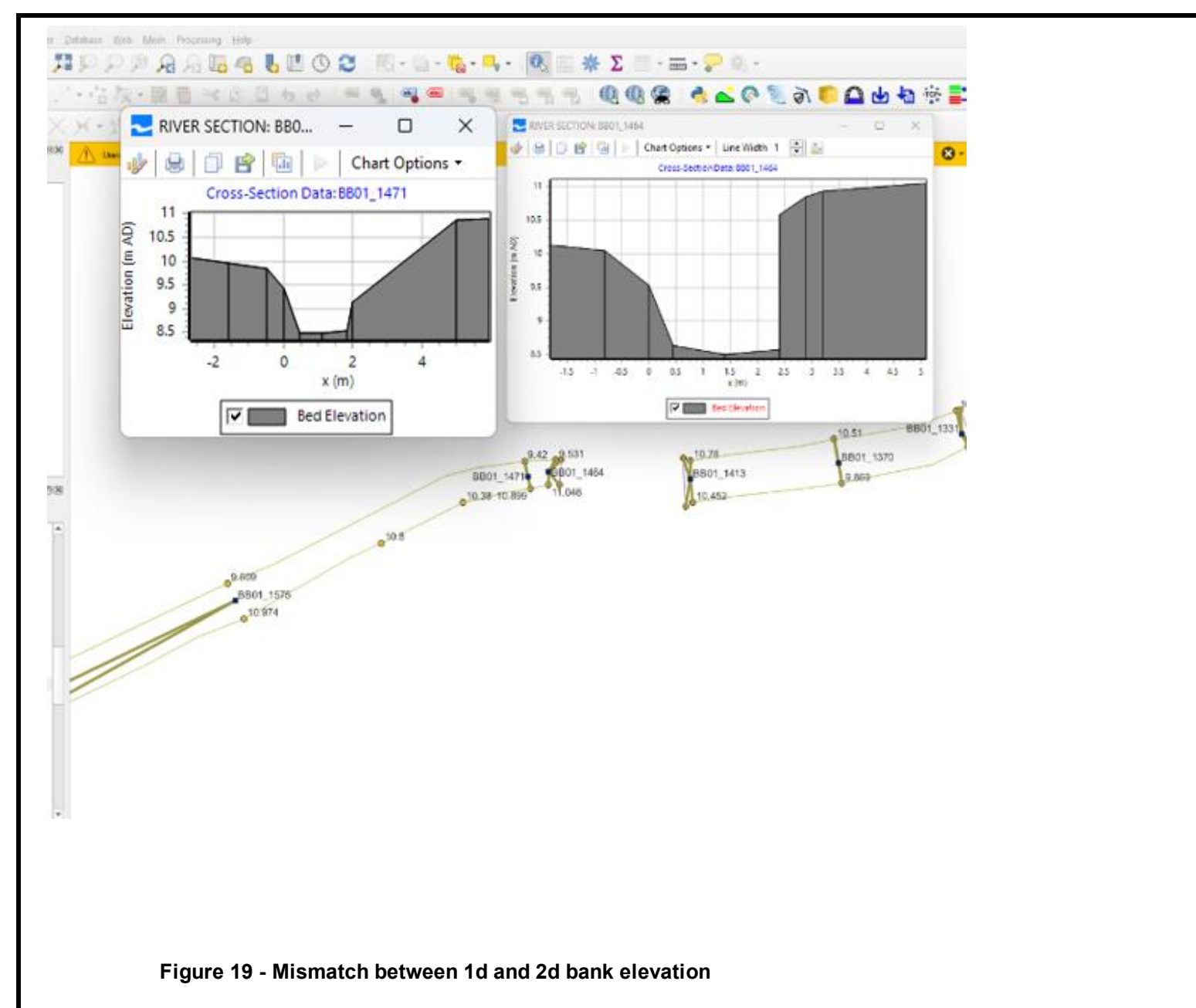
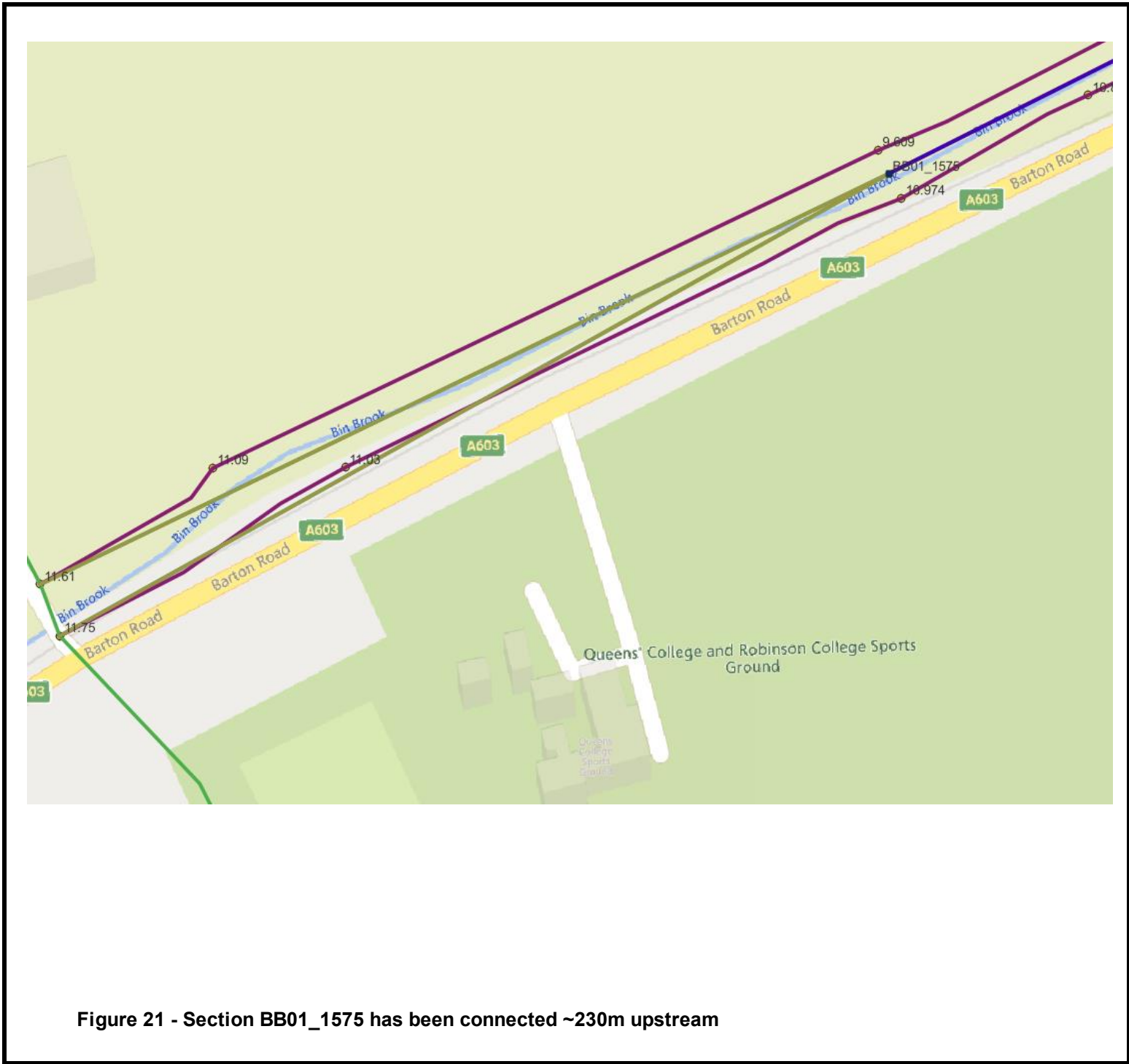
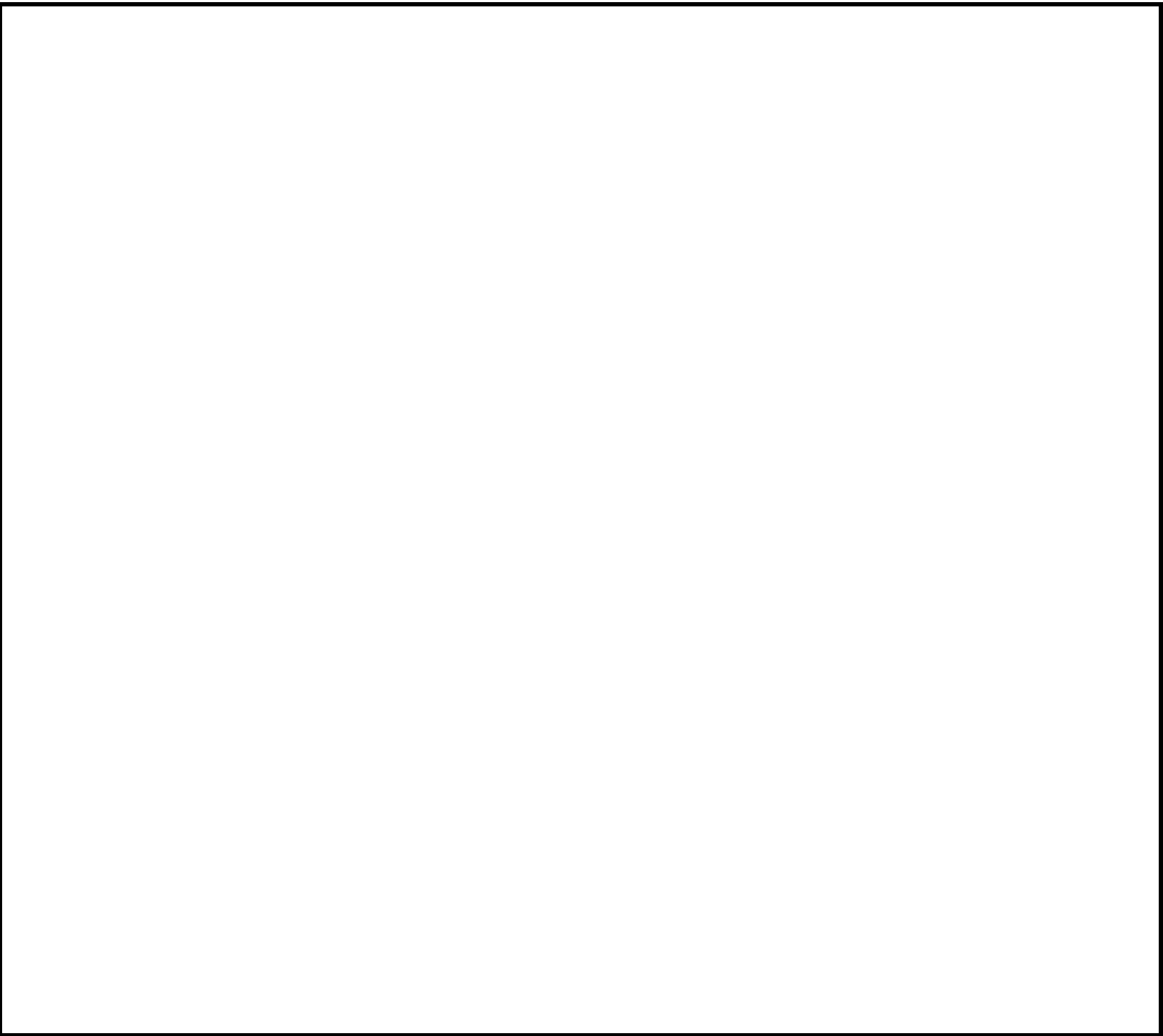
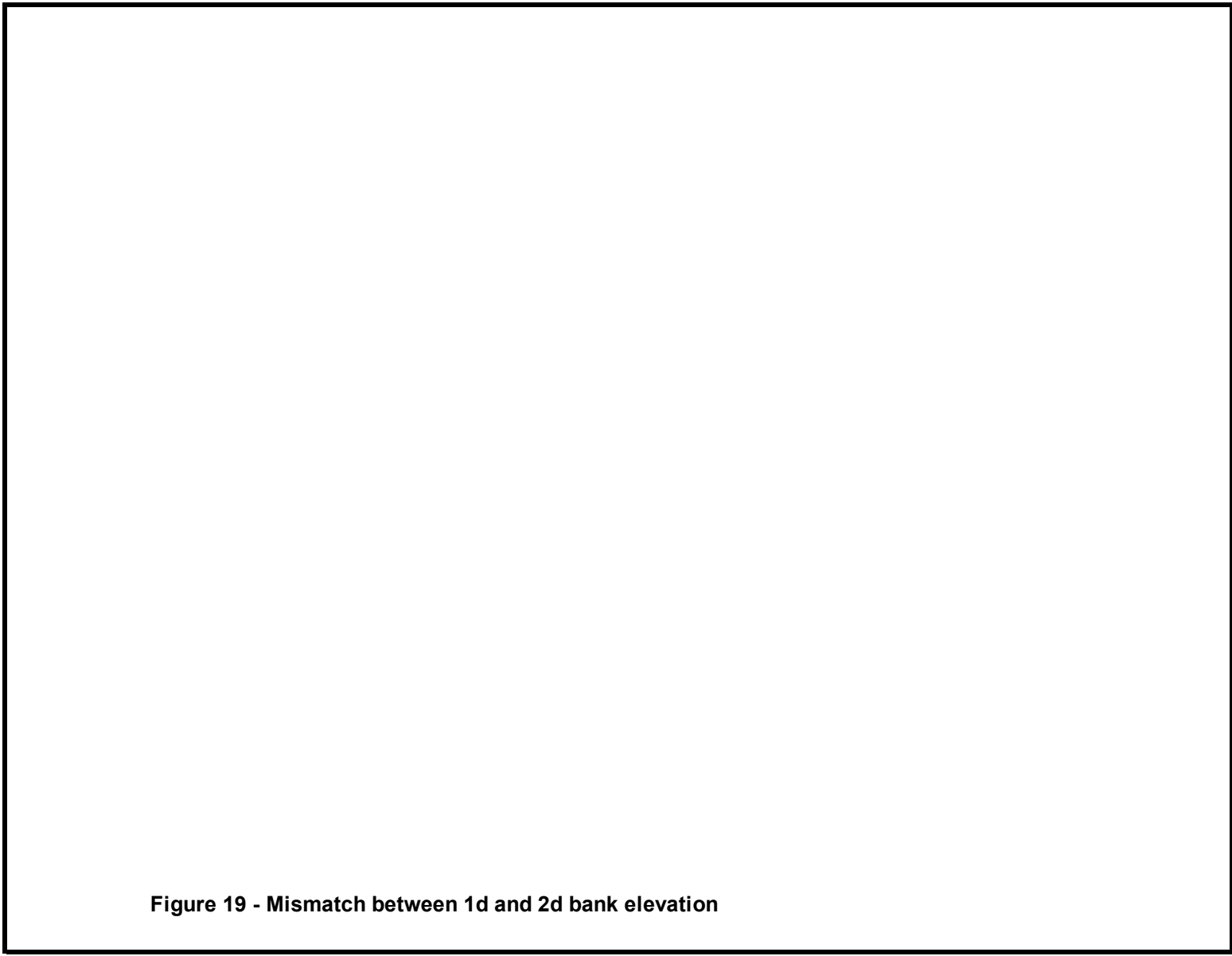
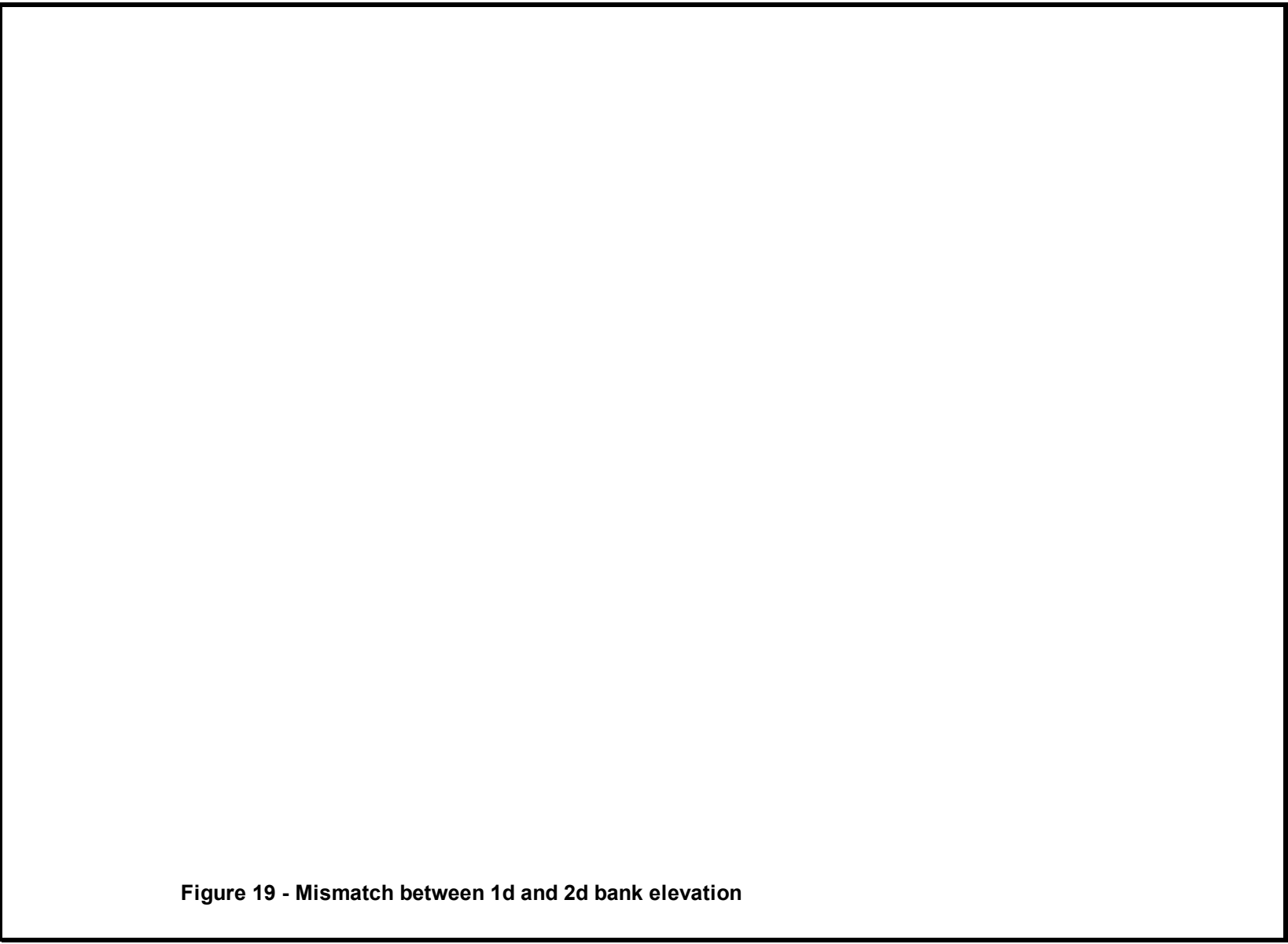


Figure 16- Glass walling in 2d





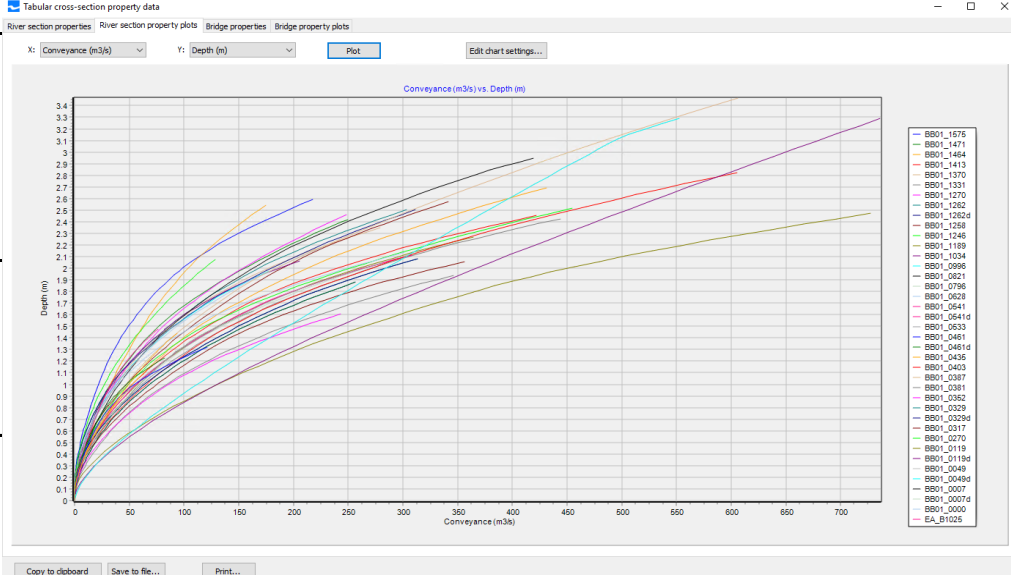
Description	Provided
Baseline scenario - 100-year +19% CC	✓
Baseline scenario - 1,000-year +19% CC	✓
Baseline scenario with a 20% decrease in DS boundary event scenario - 100-year +19% CC	✓
Baseline scenario with a 20% increase in DS boundary event scenario - 100-year +19% CC	✓
Baseline scenario with a 20% decrease in roughness sensitivity test - 100-year +19% CC	✓
Baseline scenario with a 20% increase in roughness sensitivity test - 100-year +19% CC	✓
Proposed scenario (10m bridge span) with the removal of downstream footbridge and Floodplain compensation area 1 - 100-year +19% CC	✗
Proposed scenario (10m bridge span) with the removal of downstream footbridge and Floodplain compensation area 2 - 100-year +19% CC	✗
Proposed scenario (10m bridge span) with the removal of downstream footbridge and no compensation - 100-year +19% CC	✓
Proposed scenario (10m bridge span) with the removal of downstream footbridge and no compensation - 1,000-year +19% CC	✓
Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% decrease in roughness scenario - 100-year +19% CC	✓
Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% increase in roughness scenario - 100-year +19% CC	✓
Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% decrease in DS boundary event scenario - 100-year +19% CC	✓
Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% increase in DS boundary event scenario - 100-year +19% CC	✓



PROJECT BACKGROUND AND APPROACH

PROJECT DESCRIPTION & REQUIREMENTS									
		Flood risk modelling has been undertaken to inform the design of the proposed bus route connecting Cambridge to Cambourne. The study uses an existing model of the Bin Brook and has been updated using topographic survey data and the designs of the bridge. Both a Baseline and a Proposed scenario are represented and have been reviewed.							
MODEL APPROACH & SUMMARY									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
1.1	What model approach has been adopted? Is it appropriate? (e.g. new 1D/2D build, existing model truncation, 1d only?).	OK	Existing EA 1D-2D FM TUFLOW model of the Bin Brook has been used and updated to assess the scheme. The model has been updated with topographic survey from the upstream extent of the survey down to Burrell's Walk (northeast of Grange Road), these are all sections called BB01_XXXX. This leaves only five original cross sections, called EA_BXXXX. Therefore, a full review of the model has been conducted.						
1.2	Software used, including versions?	Green	Model has been run with FM VER=5.1.0.8423 and TUFLOW 2020-10-AD-ISP-w64. This is not the latest version of the modelling software available, the latest is Flood Modeller 6.2 and TUFLOW 2023-03-AC.	Please use the latest software versions for future runs.	The updated software would provide no or minimal change to water levels. It is more important that both pre and post scenarios are run utilising the same version of software rather than the version.	Amber	Tuflow version 2023-03-AC-ISP-w64 and Flood Modeller VER=5.1.0.8423 have been used for latest runs. The Using Modelling for Flood Risk Assessments guidance (www.gov.uk/guidance/using-modelling-for-flood-risk-assessments) states that applicants should "build and run models in the latest versions of software, or provide robust justification and testing if this is not possible" and "it's your responsibility to check the suitability of an existing model for your development". Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.		
1.3	Model Version Reviewed	Red	The version of the model has only been defined in the TUFLOW section of the model (which uses v.011 for the .tbc and .tgc, and v.028 for the .ecf and .tcf). Nothing has been used for the 1D files which is not best practise. Note, the naming convention is not the same for all scenarios (e.g. the DS boundary sensitivity tests are defined as an event (-e1 100yr19ccDSde) where as the roughness tests are defined as a scenario with the event separately (-s4 R20de -e1 100yr19cc). This is confusing. In addition, the IEF file for the COMP1 and COMP2 writes results called 'BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19' in the 1D, which will overwrite. This needs to be fixed so all results can be produced for all events.	Fix the naming convention so it follows the same pattern, and define versions for the 1D files. Fix the results file paths for the COMP1 and COMP2 1D results so all model results can be outputted correctly.	Updated 1D files with version numbers where necessary. Updated naming for the sensitivity tests. The .ief for the COMP1 and COMP2 has been updated to write out separate results.	OK	The naming convention appears fine now, although the .ief COMP1 and COMP2 have not been provided and hence not reviewed.		
1.4	Are all model files provided?	OK	All model run files are provided.						
1.5	Does the model run?	OK	As part of this review, the model has been run using FM 6.2 and TUFLOW 2023-03-AC-ISP-w64 which are the latest versions. As in 1.3, the IEF file for the COMP1 and COMP2 results saved the 1D results with the wrong name. All other runs completed.						

EVENTS & SCENARIOS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
2.1	What events have been simulated (Q5, Q100, Q100CC, Q1000)? Are they sufficient to meet the project requirements?	Green	Two events modelled, the 100-year +19% CC and the 1,000-year +19% CC. Note the Model Report states the model was run for the 100-year +19% CC only in Section 2.3.4.	Update the Model Report to include reference to the 1,000-year + 19% CC event.	Updated.	OK	The report has been updated.		
2.2	Is a development being modelled? If so are appropriate scenarios modelled to assess the impact?	Green	Yes, both the Baseline and a Proposed scenario have been modelled, both are being modelled for the 100-year +19% CC and 1,000-year +19% CC events. For the Proposed scenario, the Model Report in Section 2.2.6 references three different bridge spans (10m, 16m and 21m), along with a removal of the downstream footbridge scenario, a retainment of the downstream footbridge scenario and floodplain compensation areas 1 & 2. Only the 10m span with the downstream footbridge being retained scenario has been provided and reviewed here.	The requirement to review the other scenarios (wider bridge spans and downstream footbridge retainment) should be revisited following model updates flagged in this review.	Only the 10m span opening is proposed and therefore only that model has been supplied. The outcome from the minor modifications shows that the 10m option is still to be taken forward.	OK	Thank you for clarifying.		
2.3	Flood Mapping scenarios?	OK	No						
2.4	Have climate change runs been undertaken?	OK	All runs have 19% climate change allowance applied, which is the Higher bound to 2080.						
2.5	Has a study for quantifying uncertainty been undertaken? If yes, what are the results?	OK	Both the Baseline and the Proposed model has been run for the Manning's ±20% and the downstream boundary ±20% for the 100-year +19% CC event. See Section 16 for comments on the results.						

1D MODEL BUILD										
1D NETWORK										
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments
3.1	Model overview: Node Summary 1d length	OK	Baseline model has 103 nodes and the Proposed model has 98 nodes. The difference in nodes is the removal of the bridge BB01_0541Bu and associated junctions, spill unit and downstream cross section in the Proposed model, which is in line with the results and control files provided. Both models are 1.798km in length. The FMP 1D model summary tool shows that the average spacing between nodes is around 50m. This spacing seems appropriate to capture changes in bed levels along the watercourse.							
3.2	Have appropriate distances between sections and/or nodes been used (dx)?	OK	FMP Summary tool shows the Baseline model has 6 nodes fail the erratic node spacing check, and 7 nodes fail in the Proposed scenario. This should not impact the model results.							
3.3	Are out of bank flows represented in 1d? If so, how has it been done and is it appropriate?	OK	Out of bank flows have been represented in 2D.							
3.4	Is the model geo-referenced?	Green	Model can be opened in both Flood Modeller and QGIS. Note, when displaying the locations of the cross sections as a line, a large number of the cross sections are only partially georeferenced. Ideally XY co-ordinates should be added to the cross sections so it is fully georeferenced.	Please georeference accordingly.	This has been retained.	Green	Cross-section are partially georeferenced but this does not impact on results. Ideally, the model should be fully georeferenced.			
3.5	Do the cross sections and bed profiles look reasonable?	Red	Cross sections and bed profiles of Bin Brook look largely sensible, with no unexplained steps or drops in the channel. A review of bank locations has been carried out, most are correct but not all. Section BB01_1246 should be deactivated at the top of banks (see Figure 6 in the 'Figures' tab). Section BB01_1370 looks significantly narrower than the upstream and downstream sections and is glass walling (Figure 7). No comments have been provided in the cross sections to indicate the source of the data - the topographic survey has been collected with cross sections being called 'Cross Section 1.XX' and the model having sections BB01_XXXX - comments added to reference which section in the model relates to which survey section would aid the review process. Looking at the surveyed cross sections and the model cross sections, it appears the model cross sections have been extended, but there is no reference to this in either the cross section comments or the Model Report.	Comments should be added through the model to clarify what data was used where. Section widths need to be reviewed and adjusted to make them consistent upstream downstream and with the 2D width. Clarify if sections have been extended and if so, the method used.	BB01_1246 deactivated at the top of banks. All banks have been reviewed and updated where appropriate. Channel length has been extended for BB01_1370. Sections which have been extended using LiDAR have had comments added to the FMP node in the baseline model network. These were extended prior to our current phase of work on the model so we can't provide any reason for why this was carried out, but most likely due to glasswalling if the model was previously run 1D only, or to keep more water in the 1D domain to aid model stability when running as a linked model.	Green	Section BB01_1246 has been deactivated appropriately and section BB01_1370 has been extended to match the 2d width and elevation (see Figure 14). Comment has been added to baseline model for extended section. However, naming convention of the surveyed sections should be included as a comment on the sections to aid the checking process.			
3.6	Chainage – compared to surveyed sections	Amber	Cannot be assessed due to the labelling of the cross sections compared to the labelling of the model sections.	Please provide naming convention and a cross sections and structures table, clarifying the source data for each model section.	This request does not provide assistance in checking model length v survey and therefore has not been undertaken. Model length can be simply measured from the map against model long section length.	Amber	"41094NOLS-Bin Brook Part 1 Main.CSV" and "41094NOLS-Bin Brook Part 1 Overflow.CSV" has included chainage and modelled sections naming conventions and chainage seems to match with surveyed sections. However, this should be referenced in the model/dat file and a structures table/log should be provided to enable the checks on structures dimensions.			
3.7	Does conveyance look appropriate?	Red	Conveyance plots mostly look appropriate. The section between BB01_0119d and BB01_0049 show the channel tapering along a 70m section of channel. Survey suggests this is a uniform channel and therefore channel conveyance will be underestimated here. Please check the reorientation of this section of channel is correct. In addition sections BB01_0119d and BB01_0049 appear to be U-shaped channels. The modelling manning's 'n' for the vertical walls does not appear to be applied correctly. A single hybrid manning's 'n' for the U-shaped channel would be more appropriate to estimate conveyance.	Check and correct the channel sections and conveyance.	We have updated elevations along this reach of the model and widened BB01_0119d as appropriate. Consistent Mannings values have been applied to the channel.	OK	The section has been updated along with manning values.			
3.8	If gauged flow is available, is there good flow reconciliation between the statistical estimates and the modelled, for given return periods?	N/A	Not available.							
3.9	Bank Markers. Are they used and if so, are they suitably located?	Red	Left and right bank markers have been applied at most cross sections, these are placed on the top of bank most are appropriate. Panel markers have also been used at changes in roughness and changes in geometry, these have mostly been applied appropriately. See comments 3.5 and 3.7 for issues associated with cross section with and panel marker application.	See comments in 3.5 and 3.7	Bank/panel markers have been updated at cross-sections where necessary. Channel section between BB01_0119d and BB01_0049 have been updated. Conveyance curves assessed to be suitable.	Green	Sections updated, please see action in 3.5.			
3.10	What approach to channel roughness has been used?	OK	The Model Report states in Section 2.2.2 and 2.2.3 that Manning's values based on Chow (1959) have been applied to the channel banks and bed.							
3.11	What manning's n value(s) have been used for the channel? If it is 1d only what values and how have they been applied in the flood plain?	OK	In general, the river sections have a roughness of 0.035 applied to the channel bed, with a value of 0.05 applied to the banks of the channel. A survey photo has been provided for each surveyed cross section. The values applied look to be appropriate.							

3.12	What method has been used to estimate roughness (USGS, Chow, etc. based on survey, photographs)? Are they appropriate	OK	Chow (1959) and photos taken by the surveyor. See comments above.						
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1D BOUNDARY CONDITIONS									
1D BOUNDARY CONDITIONS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
4.1	1d boundary model domain; is there glass walling anywhere in the modelled reaches?	OK	Out of bank flows are represented in the 2d. Representation is appropriate.						
4.2	How have the inflows boundaries been applied?	Amber	Three QT boundaries applied. BB01_1575 has been applied at the upstream of the model, with BB02 applied downstream of Barton Road (on the downstream face of the footbridge) and BB04_I applied at Clare Hall, just downstream of the area of interest. In the 100-year +19% CC event, BB01_1575 has a peak of 7.822m³/s, BB02 has a peak of 1.744m³/s and BB04_I has a peak of 2.022m³/s. Only the upstream QT boundary has been referenced in the reporting. No information has been provided on whether these boundaries are part of the original model received from the EA or if they are newly applied boundaries for the modelling.	Clarify whether these inflows have been updated as part of this study. Reference to all three inflows should be included in the reporting.	The three inflows have now been included in the report.	Amber	The report has been updated. However, why these inflow have been applied has not been defined in the report. Moreover, a figure of the catchment boundary should be included in the report.		
4.3	How is the downstream boundary(s) applied?	Amber	A single NC boundary has been applied at the downstream of the river, set to a slope value of 0.002 (1 in 500). The modelling report states this has been based upon the preceding river sections, but no information on which river sections. A check of the slope of the sections labelled EA_### shows a slope value of around 0.0008. No information has been provided on whether the slope value applied at the boundary is part of the original model received from the EA or if it is a newly calculated slope value for this modelling. There is also a HT boundary applied at the Bin Brook Diversion Channel, this does not appear to link to anything in the 2D domain or have any water levels applied to it.	Clarify whether the outflow has been updated as part of this study. Clarify the purpose of the HT boundary and include reference to it in the reporting. Justification of the slope value applied needs to be provided.	Outflow has been updated as part of this study. Purpose of the HT boundary is to represent the Bin Brook overflow diversion ditch. Updated the slope value at the downstream to 0.00082.	Green	The slope has been updated based on preceding EA section. However, the approach to model the overflow ditch has not been defined in the report - please add.		
4.4	If tidal - how has the boundary been derived?	N/A							
4.5	Have appropriate locations been chosen for the downstream model extents?	OK	The downstream boundary is 780m downstream of the site, and the spill unit BB01_0119Su is controlling water levels along the watercourse. There is therefore no impact at the site due to the downstream boundary and consequently the location is appropriate.						

1D STRUCTURES

1D STRUCTURES									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2		2nd Review Response (DATE)	RAG 3
5.1	Are all structures represented? If not have explanations for structures not modelled been given in the Log/report?	Amber	<p>A check of the topographic survey shows that all the surveyed sections have been included in the model, this includes five culverts, six bridges and a weir for the Baseline model (one of the bridges has been removed in the Proposed model). There appear to be two footbridges which have been omitted from both the survey and the model, at the downstream extent of the Bin Brook diversion channel (NGR 543488, 258057) and at Clare Hall (NGR 543601, 258334).</p> <p>No model log has been provided, and no model comments have been added at structure sections to identify which model section relates to which surveyed cross section, which would have aided the review procedure.</p> <p>Three bridges (BB01_1262Bu, BB01_0461Bu and BB01_0007Bu) have been included in the model as USBPR bridges to represent small footbridges over the channel - the equations were intended for large clear spanning bridges based off those in the USA. Generally, an arch bridge unit would be more appropriate for small bridges such as these. The bridge over Grange Road (BB01_0049Bu) has been included as an arch bridge.</p>	<p>Add comments in the model and provide the model log to add clarity over which surveyed cross section has been used for each model cross section.</p> <p>Justify the omitting of the two footbridges.</p> <p>Update or provide justification as to the use of USBPR bridge units instead of Arch Bridge units.</p>	<p>Survey was not taken for the footbridges therefore they have not been included in the model.</p> <p>The Arch Bridges have been to replace the USPBR bridges in the model and the model has been re-run.</p>	Amber	Please include justification to omit those footbridges if unavailability of survey is prime reason, some assumptions can be applied to consider the losses. Also, provide structures log for the omitted structures. Another bridge downstream of BB01_0170i is also not included in the model. Bridge structure have been defined as arch bridge units .		
5.2	Are invert levels correct compared to survey data?	Amber	<p>Review of each structure has been undertaken, issues are commented below:</p> <p>First culvert under A603 (BB01_1464ci) - the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed.</p> <p>Second culvert under A603 (BB01_1331ci) - As above, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The trash screen has not been represented.</p> <p>Footbridge (BB01_1262Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance (Figure 12). See comment above on the use of USBPR units.</p> <p>Culvert under houses (BB01_1189ci) - As above, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed, The surveyed drawing labels the downstream invert as 7.582m which is above the modelled invert yet this is not how it is shown in the drawing. The upstream trash screen has not been represented or commented on in the report. There is no survey photo of culvert exit, does this culvert actually reduce in size from 1.8m to 1.2m diameter, the long section plot of the survey does not show the culvert decreasing in size?</p> <p>Footbridge (BB01_0541Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. See comment above on the use of USBPR units.</p> <p>Footbridge (BB01_0461Bu) - same comments as previous footbridge, the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. Junctions are not needed. See comment above on the use of USBPR units.</p> <p>Culvert at Needham Research Institute (BB01_0403Ci) - confirmation of where the soffit elevations have been taken from is needed.</p> <p>Second culvert at Needham Research Institute (BB01_0381Ci) - again, confirmation of where the soffit elevations have been taken from is needed.</p> <p>Footbridge (BB01_0329Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance.</p> <p>Weir (BB01_0119Su) - the junctions are not needed, the spill unit representing the weir can be directly linked to the river units. Confirmation of where the elevation of the weir crest has been derived from is needed. The unit is modelled using a default spill coefficient but looks to be more like a sharp crested weir (Figure 10.)</p> <p>Bridge at Grange Road (BB01_0049Bu) - cannot determine which cross section has been used to define this, confirmation is needed. Junctions are not needed.</p> <p>Footbridge (BB01_0007Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. See comment above on the use of USBPR units.</p> <p>Spill at Diversion Channel (BB01_1189LS) - confirmation of what this is representing is needed.</p> <p>A blanket value of 0.02 has been applied at all culverts, but the culverts are constructed from different materials (corrugated metal vs. concrete), justification of the blanket value needs to be provided.</p>	<p>Confirmation of where invert / soffit levels have been derived from needs to be provided at all structure sections.</p> <p>Missing length at BB01_1331ci and BB01_1189ci needs justifying.</p> <p>Justify not representing trash screens.</p> <p>Embankment markers should be added at all bridges to improve conveyance.</p> <p>Justify the use of the USBPR bridge units instead of Arch Bridge units.</p> <p>justification of the blanket value of 0.02 set at all culverts despite the different materials used in the construction needs to be provided.</p>	<p>The invert/soffit levels have been derived from structure surveys. The levels have been derived through utilising annotated invert/soffit levels if provided, utilising lowest/most appropriate bed levels on the cross section, measured in CAD between invert and a know elevation point or the long section drawing. All levels have come from the survey information.</p> <p>Trash screens have been included for two bridges.</p> <p>Embankment markers have been added to bridges to improve conveyance.</p> <p>Arch Bridges have been utilised to replace the USPBR bridges.</p> <p>Updated Mannings value for culverts have been utilised in the model, no longer just a blanket 0.02 value for all.</p> <p>The spill at the diversion channel is to help define the elevation at which water spills between the channels.</p>	Amber	<p>The dimensions have been measured using survey data for most of the structure and they seem appropriate. A structure log with reference of the surveyed cross section including naming convention should be provided. The structure log should also include the assumptions considered to model the structures. The bridge units have been updated as arch bridge units, embankment markers have been applied appropriately and trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the culvert dimensions for BB01_1034cd culvert were defines, as the survey does not contain this information. Please see Figure 13 for the trash screens and the downstream face of the culvert. BB01_0119Su weir coefficient has been updated to 1.6 which is appropriate.</p> <p>BB01_1189LS spill elevation seem appropriate and checked against survey.</p> <p>The roughness values have been updated according to culvert material defined in the comments (see Figure 15).</p>		
5.3	Do bridges surcharge? If so has orifice flow been enabled?	OK	All bridges have orifice flow enabled, with all parameters for the upper and lower transition distances set to 0.1m, with the orifice discharge coefficient set to 1. This seems to be appropriate.						
5.4	Are there spills around the structure or over the top represented appropriately?	Amber	<p>There is a mismatch with how overtopping methods have been represented, some of the bridges use 1D spill units to represent the overtopping methodology and some use HX lines in the 2D domain. This should be justified. All culverts use HX lines to represent the overtopping methods, Figure 12.</p> <p>No elevations are provided in the survey for the bridge decks where spill units are used, confirmation of how the elevations have been derived is needed.</p>	<p>Confirmation of where levels which have been to derive the spill levels needs to be provided.</p> <p>Justify the mismatch in representation of overtopping (1D spills vs. 2D HX lines).</p>	<p>Bridge spill units have been updated to be representative of the same overtopping methodology. Generally, for structures of less length than 2-3 cells length, decks are represented in 1D, those with longer decs (in direction of flow) are modelled in 2D.</p> <p>Elevations of bridge decks are based on surveyed levels and adjacent LiDAR levels.</p>	Amber	Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m. Also provide structures log for all the assumptions made on the elevations/dimensions.		
5.5	If there are any movable structures have they been modelled correctly?	N/A	None in the model.						

5.6	Structure coefficients - Have they been changed from default values?	Amber	<div>Spill representing the weir at Robinson College is set to default (1.2) broad crested weir the weir appears to be sharp crested and therefore different to the default.</div> <div>The inlet unit for the first culvert under A603 (BB01_1464ci) is set up for a circular corrugated metal pipe which is projecting, the pipe is not projecting. The Ki value has been updated from default of 0.9 to 0.5.</div>	<div>Update the spill weir coefficient to a more appropriate value at Robinson College BB01_0119.</div> <div>Justification for the values applied for the inlet unit at BB01_1464ci (culvert is not projecting, Ki value updated) is needed.</div>	<div>Increased weir coefficient from 1.2 to 1.6.</div> <div>Reviewed culvert inlet loss using the culvert wizard in Flood Modeller Pro. Values have been updated using parameters: Circular > Corrugated Metal > Headwall. Based on site photos of BB01_1464ci structure.</div>	OK	The weir coefficient has been updated and Ki value of 5 has been applied.		
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1D RUN PARAMETERS

1D RUN PARAMETERS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
6.1	What time step has been used for the 1D model? Is it appropriate?	OK	1D timestep (0.5s) is half the 2D timestep (1.0s). This is appropriate.						
6.2	What initial conditions have been used? Steady state, hotstart file?	OK	IIC file has been used for the Baseline model, and a separate IIC file used for the Proposed model. Spot check of the sections does not show any issues with the initial conditions.						
6.3	Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified?	Green	Dflood has been increased from the default of 3 to 5. This has not been justified.	Justify the increase in dflood.	Changed back to default	OK	Dflood restored to default value.		

2D MODEL BUILD									
DIGITAL TERRIAN MODEL									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
7.1	Number of domains?	OK	One 2D domain.						
7.2	Area of 2d domain/s	Red	55 hectares. There is glass walling occurring in the 1,000-year +19% CC results near Clare Hall Gym and Pool in both the Baseline and Proposed modelling.	The code layer needs to be extended to prevent glass walling.	Code layer extended upstream.	Red	There is still some glass walling - please see Figure 16.		
7.3	What dataset has been used to define the DTM elevations? LiDAR, Photogrammetric DTM?	Green	1m LiDAR has been used to define the floodplain. The Model Report states in Section 1.3.5 this was downloaded from the EA webpage in May 2022, no date of when the LiDAR was flown is referenced.	Include reference to year data was flown in the Model Report.		Green	No action or acknowledgement, remains green.		
7.4	What grid resolution has been used? Is it suitable to accurately represent flow paths, e.g. between buildings?	OK	A 2m grid resolution has been used, this seems appropriate for the modelling outcomes.						
7.5	Has the DTM been rotated to optimise flow route representation?	N/A	Modelling report does not state that DTM has been rotated.						
7.6	Is there any obstruction to flow?	Amber	The A603 at the upstream extent of the model forms an obstruction to flow, nothing else of note. Bin Brook flows under the Robinson College building, BB01_0049. It is possible that this building could impede the overland flows to a greater extent than currently modelled, Figure 11. The filtered lidar creates flood storage in this location that may not be correct.	Review the representation of the Robinsons College building to confirm flows can pass through the building as currently modelled.	Updated so that flow constrictor shapefiles have been set up for the Robinson Building. Flow constricted by 90% with Mannings value of 0.05 applied. The central Robinson College area applies a minimum elevation of 8.2mAOD. Something similar has also been applied for Needham Research Institute and all other buildings within the model domain.	Amber	2d_FCSH has been applied with 90 % blockage. However, the representation of the 1d channel is still not updated as the flow is unlikely to come out of bank where the building is located. Please revisit the approach to model the 1d channel under Robinsons College Building. The representation used for Needham Research Institute looks more appropriate, i.e. use of culvert with no spills.		
7.7	Has additional site specific topographic survey data been used?	OK	Survey data has been used to define channel sections, nothing applied in the 2D domain.						
7.8	How have buildings been represented within the DTM?	Amber	Buildings have then been applied using the materials file taken from OS MasterMap using a high roughness value of 0.5, which in the most part seems appropriate however see 7.6 for comments on the Robinson College building.		See comment above.	Amber	See action above.		
7.9	Are defences/embankments/bank crests accurately represented?	Red	The banks are represented using zlines and zpoints, for both Bin Brook and the ditch which appear to be taken from survey. There are also zlines and zpoints representing the levels of the spills. See 2D_Structures 10.3 for comments on these structures. No other defences or embankments are formally represented. The bankline representation ZSH check shows significant bank raising which appears to be artificially bunding the watercourse Figure 8. Further justification for the bank raising is required.	Check and confirm the bank raising applied at the 1D2D link location is appropriate. Also see comments in 10.3.	Banklines have been updated to better represent height where there was a large discrepancy between Lidar and bank levels from the model. Checked using zln zpt check layer and reviewing the dZ value.	Red	Please see action in 10.3.		
7.10	If post-development scenarios are required have the proposed ground levels and building been represented appropriately?	Amber	One post development model has been provided as part of this review, the 10m span bridge with the downstream footbridge removed. This has been set to an elevation of 10.5m as per the Model Report. However no consideration has been given to a change in roughness.	Confirm if a change of roughness as part of the proposed model is needed.	No needed to increase roughness, even in the highest flood event, the embankment is not at risk of flooding up to the 10.5mAOD.	Green	Thank you noted. This will need to be revisited after the hydrology is signed off, in case the maximum stage changes. Ideally the roughness changes need to be captured or mentioned in the model limitations in the report if higher events, i.e. the 0.1% AEP needs to be modelled for future uses of the model.		

2D ROUGHNESS									
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG	2nd Review Comments	2nd Review Response (DATE)	RAG
8	What manning's n values have been used to define floodplain roughness? Have they been applied correctly?	OK	OS Master Map is used to define roughness. The background roughness across the 2D domain has been set to 0.06, this is listed in the tmf as 'General Green Areas/Natural Roadside'. All areas within the active model domain have a defined roughness.						
8.1	What methods have been used to estimate roughness?	OK	See above						
8.2	Is the representation of different roughness areas sufficiently accurate and detailed?	OK	A review of the 2d_mat layer shows that the different roughness areas are sufficiently detailed and capture the different land use types as are all defined by the OS MasterMap shapefile.						



2D BOUNDARIES

2D BOUNDARY CONDITIONS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
9.1	Have any boundaries been used in the 2D domain? If so detail.	Red	One inflow QT boundary has been applied in the drain, there is no indication if this has been updated as part of this modelling study. Check files show the boundary is being read in correctly, and applying the correct inflow. There is also a HQ downstream boundary with a slope value of 0.03432 set, the Model Report states this is based on the Lidar. The boundary is not snapped to the code layer.	Indicate whether either of these boundaries have been updated as part of the study and justify slope value. Snap the downstream boundary to the code layer.	The hydrological boundaries have been updated as part of this modelling study. The downstream boundary has been updated to snap to the code layer.	Red	The downstream boundary has been snapped to the 2d_code layer. The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs, see Figure 17.		
9.2	Is the model boundary suitably large? i.e. the flood extent should not reach the boundary.	Red	There is glass walling at the downstream extent of the model as the downstream boundary is not snapped to the 2d_code layer, and also does not extend far enough east, see Figure 1 in the 'Figures' tab. There is also glass walling in all three events at the upstream boundary, see Figure 5 in 'Figures' tab. No other glass walling.	Extend the downstream boundary eastwards to cover the full extent of the flooding. Justify the presence of glass walling at the upstream extent of the model.	The downstream boundary has been updated to snap to the code layer. Extended upstream extent of the model to prevent glass walling.	Red	There is still some glass walling - please see Figure 16.		
9.3	Has rainfall been applied directly to the 2d model domain?	N/A							
9.4	Coastal - How has the wave overtopping been applied?	N/A							



2D STRUCTURES									
2D STRUCTURES									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
10.1	Have any structures been included in the 2D domain? If so how have they been represented?	OK	The Bin Brook Diversion channel has been included in the 2D domain using network lines and 1d_tab file for the cross sections. The diversion channel is linked to the 1D model using a X1DQ link, which links the flow to and from the FM model to the ESTRY section.						
10.2	Are invert levels correct compared to survey data?	Amber	Spot checks show the channel sections match the survey levels for the cross sections. At the culvert, the length and the width do not match the survey, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The Manning's value has been set to 0.013, this is different to the generic 0.02 applied to the culverts in the 1D domain, and different to the Manning's value applied to the rest of the diversion channel (0.017). The height contraction coefficient has also not been set.	Review the culvert in the Diversion channel against the topographic survey, and justify / correct values applied.	The culvert matches what has been surveyed. See 5.2	Amber	Roughness values seem appropriate. Channel length and culvert dimension needs to be updated and height contraction coefficient need to be defined, see Figure 18.		
10.3	How have defences been represented? Zline? If there are flood zone scenarios have the defences been excluded adequately?	Amber	Three features have been included in the 2D domain, the first being zlines and zpoints along the banks of Bin Brook representing the bank levels, the second zlines and zpoints along the banks of the drain, and the third zlines and zpoints representing the spill levels over structures. At all three features, the zline is snapped to the 2d_bc_hxi bank line and zpoints placed along it, this could be represented as just bank lines and points (all included in the 2d_bc_hxi). All lines have been applied as THICK, this is working as needed. The points applied in the 2D domain for the banks of Bin Brook do not match with the 1D cross sections, there should be a match. There is no indication where the values for the Bin Brook diversion channel or the spills along the main Bin Brook channel have been taken from, this needs to be clarified.	1D cross sections should match the 2D bank points, the cross sections should be updated to match. Confirmation of the method used to determine levels for the spill bank points and the Bin Brook Diversion channel is needed.	1D and 2D bank points match. These have been spot checked throughout. Bin Brook diversion channel ditch levels have been taken from watercourse survey document 'Bin Brook Overflow'	Amber	The zpoints and 1d-cross sections do not match see Figure 19. Please review all the cross sections.		
10.4	Have appropriate loss coefficients and roughness values been used?	N/A	None applied.						



2D RUN PARAMETERS

INITIAL CONDITONS & OTHER RUN PARAMETERS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
11.1	What time step has been used for the 2D model? Is it appropriate?	OK	Cell size is 2m, the 2D timestep has been set as 1 second and the 1D timestep to 0.5 seconds. The timestep is appropriate.						
11.2	Have initial water levels been applied? Are they correct?	OK	None applied in the 2D domain.						
11.3	Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default?	OK	No additional parameters have been applied						



1D/2D MODEL LINKS

MODEL LINKS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
12.1	How have the 1D/2D models been coupled, is it appropriate?	Red	The 1D and 2D domains have been linked using HX and CN lines. Connections have mostly been digitised appropriately. The upstream of the model should be snapped to the code boundary (see Figure 2 in the 'Figure' tab). The HX lines at the structures throughout the model and the link to the ditch need to be reviewed, many should be closed so a single HX line is applied (see Figure 3 in the 'Figures' tab as an example).	Please amend throughout the model.	Gaps in the 1D and 2D domains have been closed.	OK	The code boundary is snapped with the upstream boundary. The gaps have been closed		
12.2	Is the digitisation of the links acceptable?	Red	Bank points have been added at the river cross sections from the 1D domain, but not at interpolate nodes. Some bank level points need revisiting. The 1D top of banks do not always agree with the TUFLOW zpoints used. This might over/under estimate out of bank flooding. Bank points also should be added at the interpolate units using the LiDAR data, and at changes in bank elevations.	Please justify or amend accordingly.	Update zpts along the banks to give better representation of the banks for areas where there were long sections with no bank survey points in-between.	Red	Bank points for interpolates need to be updated as these are not applied for interpolates and in between - see Figure 20. Also, see action in 10.3.		
12.3	Is the 2d representation of the river channel comparable in width with the 1d model cross sections?	Amber	In some locations, there is a good match between the width of the channel in the 2d domain and the 1D model cross sections, however in others, there is not. Looking at the locations of the 1D cross sections and the 1d_nodes / CN lines in the TUFLOW domain, there are also locations where cross sections have been moved upstream or downstream in the 2D domain, see Figure 4 in the 'Figures' tab. Note a large number of the cross sections are not fully georeferenced in the 1D domain.	Please justify or amend accordingly.	The 2d links and CN lines are now in a more appropriate location.	Amber	The width of the 1d and 2d cross-sections are matching now. The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream - see Figure 21.		
12.4	Representation of 1D output in 2D domain	Green	There are no water level lines applied down the channel, therefore no results are displayed in the channel. This does not impact model results, but does create display issues.	Water level lines should be applied so results are being displayed fully. This should be updated in line with best practice, particularly as results are being used in figures.	WLLs have been created and the TufLOW model results now display these properly.	OK	WLL have been applied.		
12.5	Have any default link parameters been changed (i.e. to improve stability)?	N/A	No changes to default link parameters						



MODEL OUTPUTS & CALIBRATION

CALIBRATION/VERIFICATION									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
15.1	Have calibration runs been completed? Is data for calibration available? Gauge data, extents, anecdotal etc.	N/A	No calibration has been carried out. Hydraulic Modelling Report states there are no gauges to calibrate against or any historical flood data available.						
15.2	Are the simulated hydrograph peaks reasonably similar to the recorded peaks?	N/A							
15.3	Is the shape of the simulated hydrograph and therefore the volume suitably similar?	N/A							
15.4	Are simulated floodplain extents similar to recorded extents? Are flow routes similar?	N/A							
15.5	Has suitable effort been made to attempt and improve calibration. Have attempted changes been documented with a quantification of impact?	N/A							
15.6	If no historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large difference, does it seem sensible?	Red	Nothing has been provided to compare to. As this model is based on a previous model as a minimum in the absence of any other validation data the model results should be compared to previous model results as a sense check.	Please justify or amend accordingly.	Previous results are much less extensive as they are without 19%CC. The upstream end of the 2017 model results show a different distribution of flooding, with nothing coming out of the right bank as it does in the updated model, otherwise the pattern of flooding is generally the same (other than width of flooding due to increased volume).	Red	Have the model results been compared with Flood Zones maps as well? Please provided evidence of the comparison in the report and discuss why the differences occur.		

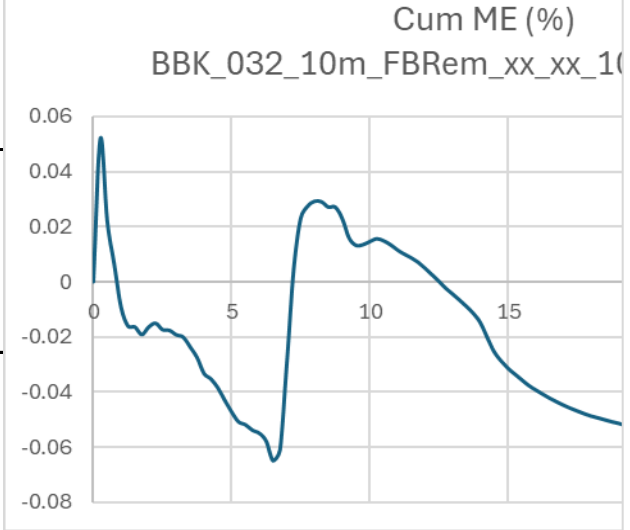
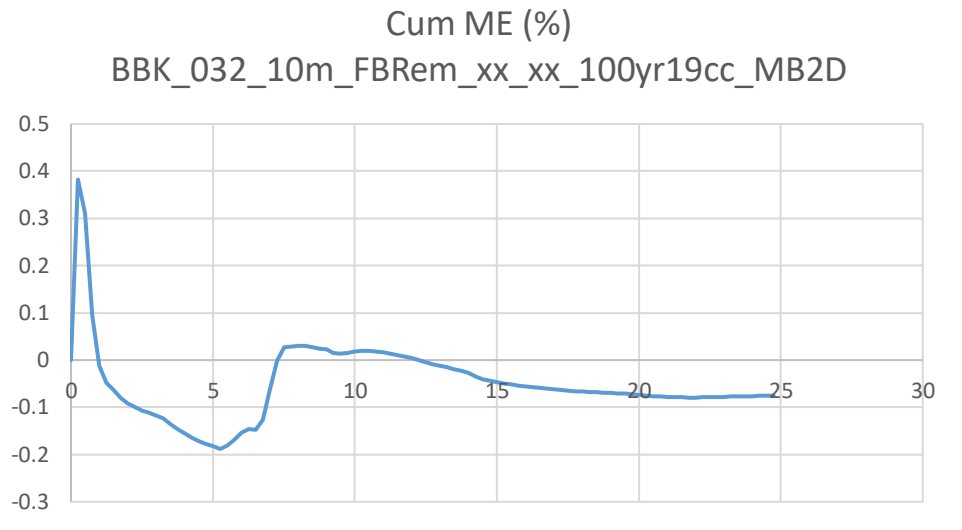


MODEL SENSITIVITY

SENSITIVITY TESTING & UNCERTAINTY									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
16.1	Have appropriate model parameters been chosen for sensitivity testing? Typical tests include: ☐ Sensitivity to roughness ± 20% (Manning's "n" both in 1D and 2D) ☐ Sensitivity to flows ± 20% (From central estimate) ☐ Sensitivity to downstream boundary ☐ Key structure blockage(s)	Amber	A number of sensitivity tests have been carried out including Manning's ±20 and the downstream boundary ±20% for both the Baseline and Proposed modelling. However this has only been applied in the 1D domain, not the 2D domain. A slope value of 0.0025 has been applied in to the downstream boundary +20%, however a 20% increase is actually 0.0024. Again, in the downstream boundary -20%, the value applied is 0.00166667 but the calculated value should be 0.0016. A check of the Manning's sensitivity .DAT files for the baseline shows the change in roughness has been applied to the river sections correctly, but not to the culvert sections. The change in roughness has been applied to the culverts in the proposed Manning's sensitivity tests.	Justify not sensitivity testing the 2D domain. Justify the slope values applied. Justify the approach to changing / not changing the roughness values applied to the culverts in the Manning's sensitivity tests.	The slope value for the downstream boundary has been updated to 0.00082. The 20% decrease and increase change for the downstream boundary has therefore been updated to 0.000656 and 0.000984 respectively. The change in roughness has not be applied to the culverts in the model due to instability issues that occurred when these were changed. Therefore as much of the model was changed as possible without impeding the model to crash and return any results.	Amber	The slope has been updated and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.		
16.2	Do the results of the tests show the models to be particularly sensitive to certain parameters?	OK	The model results show the site is not sensitive to any changes made to Manning's or the downstream boundary.			Green	Please specify which culverts/structure are sensitive and to which parameters.		
16.3	Have confidence limits for model results (+/- mm) been presented? How were they derived and does this seem sensible?	Amber	Confidence limits have not been presented	Please provide	There is no defined modelling tolerance within either FMP or Tuflow. We have used the best available data for boundary slopes, hydrology, cross sections, and LiDAR. All assumptions are listed. Confidence limits are requested for Environment Agency procured studies which this is not.	Amber	Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?		



MODEL STABILITY

1D MODEL STABILITY											
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)
13.1	Errors/Comments/Warnings?	Amber	There are a number of warning related to different values for Manning's n encountered in same panel. There are also a large number of messages related to poor model convergence at BB01_1189LS, this is the spill unit into the diversion channel.	Add panel markers at changes in roughness in the 1D model to remove warning messages.	Panel markers have been added to the model to improve this	OK	The issue has been resolved.				
13.2	Convergence	Amber	The mass balance error in the Baseline 100-year +19% CC is 21.77%. In the proposed 10m span with no footbridge downstream model, the 100-year +19% CC mass balance error is -9.48% and in the 1,000-year +19% CC is -41.78%. This indicates the model has some stability issues.	The changes recommended through this review should be completed and a review of the 1D model stability carried out again.	Updated results provided which have addressed these issues. MB and 2DMB plots shown for ME% to the left showing they are within tolerance	OK	The ME is within the tolerance of +/-1%.				
13.3	Does a basic check of animations and graphed outputs give an indication of good model stability?	Amber	The animations and the graphs show some issues on the rising limb of both the Baseline and Proposed results, with fluctuations in the water levels noticed. This also indicates the model has stability issues.	The changes recommended through this review should be completed and a review of the 1D model stability carried out again.	Updated results provided which address these issues	OK	No major issue observed.				

2D MODEL STABILITY											
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)
14.1	Is mass balance within tolerable limits?	OK	All Baseline and Proposed models show a spike up in the mass balance error as the model wets up. However the error is within the ±1% bounds which indicates a healthy model after 5.5 hours of model simulation.								
14.2	Are CE and dV values relatively stable and remain so once the run has got going.	OK	Spot checks of the ttf files show the CE and dV values are stable throughout the simulation.					<pre>Simulation FINISHED TUFLOW 1D Negative Depths: 0 Classic 2D Negative Depths: 0 WARNINGS prior to simulation: 238 [0 not in _messages layer] WARNINGS during simulation: 0 [0 not in _messages layer] CHECKs prior to simulation: 4 [0 not in _messages layer] CHECKs during simulation: 0 [0 not in _messages layer]</pre>			
14.3	Errors/Comments/Warnings?	Amber	There is a message which should be fixed, the CHECK 2099 - Ignored repeat application of boundary to 2D cell. The WARNING 1100 - Structure ditch_0649C crest/invert (8.079) is below bed (8.143) of primary upstream channel ditch_0733 also needs to be reviewed to check the schematisation is correct.	Review the locations of the CHECK 2099 messages and fix cells. Review the WARNING 1100 against the survey and fix or justify.	2099 error fixed by moving the spill HX line into an adjacent cell. The 1100 warning has been investigated but the ditch is modelled as per survey. The warnings merely highlighting there could be an error and it should be checked, having checked the data and schematisation is correct therefore these warnings remain (but with a justifiable reasoning)	OK	The invert is correct as per survey.				
14.4	Negative Depths	Amber	There are a large number of negative depths between 4 and 5 hours at ditch_0091, the downstream of the diversion channel. This indicates a stability issue at this location. No other negative depths.	Review ditch_0091 and surrounding sections or justify the negative depth messages.	The model no longer contains negative depths	OK	No negative depth observed with the updated model.				
14.5	Does a basic check of animations and graphed outputs give an indication of good model stability?	Green	The 2D results animations show good stability, nothing of concern noted, Note there are display issues with the animations due to the lack of water level lines which mean the channel is not displayed. There are no PO lines in the model this aim checking 2D results and calculation of the mass conservation through the model.	Add WLLs to display results in the channel.	WLLs have been added so that the watercourse is shown flooding	OK	WLL have been included.				
14.6	2d extents and outputs	Green	The model does not output grids (as ascii files), this would aid in the review process.	Output grids for depth, velocity and water levels.	Raw outputs are provided. There is no need to provide a full suite of outputs grids as they are not needed for the FRA which this model supports. Raw data has been provided so the reviewer can extract additional items if they wish.	OK	Grids have been provided.				



AUDIT TRAIL

AUDIT TRAIL									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
17.1	Was a model run log provided?	Amber	No	Model log to be provided to see model history and decision making process	Model log created and provided	OK	Model log has been provided.		
17.2	Was a suitable file naming, structure & management system used?	OK	Yes, standard FMP and TUFLOW folder structure.						
17.3	Were check files provided?	OK	Provided for the Baseline 100-year +CC event and the Proposed a 10m bridge span with the downstream footbridge removal 100-year +CC scenarios only.						
17.4	Were comments provided within the model?	Green	No comments within the model to identify what has been updated / remained as is.	Add comments to the model to identify where updates have take place to aid the review process.	The updates are discussed in the associated reporting				
17.5	Was there good version control? Is the model history detailed where applicable?	Amber	Not detailed, so cannot comment. There is no version number for the model.	Model log to be provided to see model history and decision making process	Model log has been provided	OK	Model log with version updates has been provided.		
17.6	Were Errors / comments / warnings made available?	OK	Yes, the model results files for FM and log files for TUFLOW have been provided so checks of the messages could be completed.						
17.7	Was a technical overview of the model and its background provided	OK	Yes - technical overview and background info have been provided in the modelling report.						
17.8	Were notes on how the model operates under different flow conditions provided?	OK	Section 3 of the modelling report details the impacts of the baseline flooding and the inclusion of the bridge .						
17.9	Was an explicit statement of any concerns about the accuracy of the model or its ability to represent reality provided?	Red	There is no summary in the report of the modelling assumptions and limitations, this should be included.	Add an Assumptions and Limitations section to the Hydraulic Modelling Report.	This has been included in the reporting	OK	Assumptions and specifications have been included in section 4.2.		
18	Is there anything else missing or are there suggestions for additional information or clarification?	Amber	Twelve different scenarios have been run, but the reporting does not comment on many of them.	Add information on the results of all scenarios modelled to the report.	It is not common practice to report on options that are not taken forward, the reporting is to provide information of what is being proposed not an appraisal of options and outcomes therefore this is not supplied (it is not of any value). 100 and 1000 (both CC) year results for baseline and scheme are provided along with 100+CC sensitivity tests only	Amber	It is not clear which option is the final one for the proposed case scenario, please clarify that for example copm1 and comp2 results are not provided to review.XMDF files have not been provide, these would help in checking process		

Audit_Trail

18.1	Comment on the quality of the reports:	Red	The supplied memo is insufficient and lacks information about the location of the updates to the model etc.. A model report should include: an overview of model build including a model schematic, hydraulic roughness (including photographs) and representation of any defence networks or use of non-standard elements discussion of structures (including photographs and details of how they have been modelled) comment on model stability and measure taken to improve stability justification of any remaining errors and warning messages produced etc..	A model report detailing all relevant information should accompany the model.	The report has been updated to provide the sailient information required to support the update to the hydraulic model. The baseline hydraulic model was supplied by the Environment Agency.	Red	The report do not include full results and more details need to be added in term of assumptions made to model the structures.		
18.2	is a freeboard analysis necessary? If yes have you review the report? What are is the agreed freeboard?	N/A	Not applicable to this study						



Additional information

Additional information						
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2
100.1						
100.2						
100.3						
100.4						
100.5						
100.6						
100.7						
100.8						
100.9						
101						

[Return to 1D model build](#)[Return to 2D model build](#)

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.03	0.033
b. same as above, but more stones and weeds	0.03	0.035	0.04
c. clean, winding, some pools and shoals	0.033	0.04	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.05
e. same as above, lower stages, more ineffective slopes and sections	0.04	0.048	0.055
f. same as "d" with more stones	0.045	0.05	0.06
Chainage – compared to surveyed sections	0.05	0.07	0.08
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.1	0.15
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.03	0.04	0.05
b. bottom: cobbles with large boulders	0.04	0.05	0.07
3. Floodplains			
a. Pasture, no brush			
1. short grass	0.025	0.03	0.035
2. high grass	0.03	0.035	0.05
b. Cultivated areas			
1. no crop	0.02	0.03	0.04
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.03	0.04	0.05
c. Brush			
1. scattered brush, heavy weeds	0.035	0.05	0.07
2. light brush and trees, in winter	0.035	0.05	0.06
3. light brush and trees, in summer	0.04	0.06	0.08
4. medium to dense brush, in winter	0.045	0.07	0.11
5. medium to dense brush, in summer	0.07	0.1	0.16
d. Trees			
1. dense willows, summer, straight	0.11	0.15	0.2
2. cleared land with tree stumps, no sprouts	0.03	0.04	0.05
3. same as above, but with heavy growth of sprouts	0.05	0.06	0.08
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.08	0.1	0.12
5. same as 4. with flood stage reaching branches	0.1	0.12	0.16
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.02
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.03
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.03

2. grass, some weeds	0.025	0.03	0.033
3. dense weeds or aquatic plants in deep channels	0.03	0.035	0.04
4. earth bottom and rubble sides	0.028	0.03	0.035
5. stony bottom and weedy banks	0.025	0.035	0.04
6. cobble bottom and clean sides	0.03	0.04	0.05
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.05	0.06
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.04
2. jagged and irregular	0.035	0.04	0.05
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.05	0.08	0.12
2. clean bottom, brush on sides	0.04	0.05	0.08
3. same as above, highest stage of flow	0.045	0.07	0.11
4. dense brush, high stage	0.08	0.1	0.14
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.01	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.01	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplanned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.01	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.02
4. unfinished	0.014	0.017	0.02
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.02	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.02
2. random stone in mortar	0.017	0.02	0.024
3. cement rubble masonry, plastered	0.016	0.02	0.024
4. cement rubble masonry	0.02	0.025	0.03
5. dry rubble or riprap	0.02	0.03	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.02	0.025
2. random stone mortar	0.02	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.03
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017

i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.03		0.5

Manning's n for Closed Conduits
Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.01	0.013
2. Steel:			
Lockbar and welded	0.01	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.01	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.03
6. Cement:			
Neat Surface	0.01	0.011	0.013
Mortar	0.011	0.013	0.015
7. Concrete:			
Culvert, straight and free of debris	0.01	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.02
8. Wood:			
Stave	0.01	0.012	0.014
Laminated, treated	0.015	0.017	0.02
9. Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
10. Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.02
Rubble masonry, cemented	0.018	0.025	0.03

Manning's n for Corrugated Metal
Pipe (AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	n
1. Annular 2.67 x 1/2 inch (all diameters)	0.024
2. Helical 1.50 x 1/4 inch	
8" diameter	0.012
10" diameter	0.014
3. Helical 2.67 x 1/2 inch	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.02
60" diameter	0.021
4. Annular 3x1 inch (all diameters)	0.027
5. Helical 3x1 inch	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
6. Corrugations 6x2 inches	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.03
180" diameter	0.028

5. WSP CORRESPONDENCE 07 APRIL 2025

Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

From Southon, Jack <[REDACTED]>

Date Mon 2025-04-07 06:52

To Craggs, Alison <[REDACTED]>

Cc Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK - Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee <[REDACTED]>; Higgins, Graham <[REDACTED]>; Fuhrmann, George <[REDACTED]>

 2 attachments (12 MB)

LIT 66039 - Flood Estimation Calculation Review Template_Cambourne_Arcadis_28032025_WSP.xlsx; LIT 17617 - Cambourne to Cambridge Hydraulic Model Review_Arcadis_18032025_WSP.xlsm;

Hi Alison,

Please find attached our completed responses for the two review documents.

We have provided commentary against all the feedback provided.

We have sort to provide justification where we think appropriate for most of the comments

We did find one set of comments in the hydrology review actionable, so we have committed to undertaking a sensitivity test on storm duration and providing the results to you. We expect to be able to issue a short technical note (to be appended to the FEH Calculation record) by 15/04.

I would be grateful if you could get us back in the list for review to seek to close out the final comments. If at all possible, it would be good to set a call for w/c 14/04 to confirm the current thinking to our written responses pending the sensitivity test to close out.

I am away this coming week (07/04-11/04) so please copy Stephanie Haberfield in on any questions or requests.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)

[REDACTED]



Confidential

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FLOOD HYDROLOGY REVIEW



The latest version of the Flood Estimation guidelines is : LIT 11832 (available in Content Cloud)

Project :	
EA Area:	
Project undertaken by:	

	1st review	2nd review	3rd review	4th review
Report reference:	Flood Estimation Report: Bin Brook Cambourne to Cambridge Scheme			
Report version:	Version 2			
Report date:	06/02/2025			
Date of review:	28/03/2025			
Name of reviewer:	Arcadis Ltd.			

PURPOSE OF THE HYDROLOGICAL STUDY and any particular concerns or aspects that need review
WSP were commissioned by the Greater Cambridge Partnership (GCP) to undertake hydraulic modelling of the Bin Brook to inform the design of a proposed bridge crossing over the watercourse along the proposed bus route connecting Cambridge to Cambourne and ultimately to undertake a Flood Risk Assessment for the Cambridge to Cambourne Scheme. The purpose of the hydrological study was to generate hydrographs and peak flow estimates to use within the hydraulic model.

SUMMARY - IS THE HYDROLOGY FIT FOR PURPOSE and any particular aspects that require revision
Overall it is deemed the hydrology is not considered suitable for its intended use. A number of concerns are raised over the potential for outdated methods/ data used and the incorrect application of ReFH2. Two Red comments and eight Amber comments require addressing. A summary is given below with the full review providing further details. Red Comments 1. Incorrect version of ReFH2 used (see item 1.1.2 and 2.5.5). 2. FEH13 may have been used as opposed to FEH22 (see item 7.3.1). Amber Comments 1. Incorrect peak flow data used (see item 1.1.2 and 2.3.1). 2. The method to calculate URBEXT2000 is incorrect and needs to be updated to current year (see item 3.2.3). 3. An urban adjustment has not been applied to the growth factors (see item 4.3.1). 4. Catchments have been classified as urban as opposed to rural (see item 7.1.2). 5. Two different storm durations have been used (see item 7.3.2, item 7.3.3, item 7.3.4 and item 7.3.5). 6. The final estimates for ReFH2 are incorrect (see items 7.4.1 and item 7.4.2). 7. The final flow estimates may need amending and the final choice of method may change (see item 9.2.1). 8. An inconsistent storm duration and no mention of how the flows are to be applied to the model to potentially account for this (see item 9.3.3.).

RAG COMMENT CLASSIFICATION GRADING SYSTEM

The following RAG system is used to classify comments and identify appropriate actions to be taken by the original authors of the report:

N/A - not relevant to this study.

OK – Good practice.

Minimum expected response: No minimum.
Maximum expected response: No maximum.
Planning: No Objection.

Green – Negligible impact on the results that is unlikely to change the outcome of the study. Consider for future studies.
Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.

Minimum expected response: Acknowledge the comment in the spreadsheet and update the limitation section of the report.
Maximum expected response: Actions done to address the issue identified.
Planning: No Objection.

Amber – Potential impact on the results that may change the outcome of the study. Follow recommendation.
Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.

Minimum expected response: Comments justifying the approach taken and update the limitation section of the report.
Maximum expected response: Actions done to address the issue identified.
Planning: Consider objecting to the application based on comments highlighted in this category.

Red – Has an impact on the results that may significantly change the outcome of the study. Must do.
If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidence. If issues highlighted red are ignored, then submissions should always be sent back.

Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if action is not addressed.
Maximum expected response: Actions done to address the issue identified.
Planning: Objection - Application to be objected if comments are highlighted in this category.



1. Summary of assessment

1.1 Summary							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
1.1.1	Does the report include a summary at the start that covers: ●Catchment location ●Purpose of study and complexity ●Key catchment features ●Flooding mechanisms ●Gauging stations ●Final choice of method ●Key limitations and uncertainties	●This section provides a summary of the key information contained within the detailed assessment in the following sections. ●The aim is to enable quick and easy identification of the type of assessment undertaken. This should assist in identifying an appropriate reviewer and the ability to compare different studies more easily. ●Keep the text to one or two sentences for each point.	Green	No summary sheet has been provided. It is considered that the key information is largely covered in the relevant sections of the body of the FEH calculation record.	Provide a summary sheet at the beginning of the document that details the key information contained within the assessment, to enable future users more efficient identification of the assessment methodologies and to allow for easier comparisons to different studies.	The use of the FEH calculation record format is specifically designed to allow for easy comparison between different studies. As acknowledged the key information is set out in the FEH calculation record. An additional 'summary sheet' would seem superfluous. If this is considered best practice then we would recommend it is incorporated into the next update to the FEH Calculation record template produced by the Environment Agency. No future action proposed	
1.1.2	<p>Stop and think! What has changed since the calculations were undertaken or previously reviewed? Consider if there have been any changes in methods, software and/or data that could significantly change the outcome of the study.</p> <p>Changes could include:</p> <ul style="list-style-type: none">●A recent large flood in the catchment being modelled.●New datasets, such as an updated NRFA dataset version. Although single year changes are expected to be small, the impacts of several years or more of changes could be more significant.●New methods, such as the FEH22 rainfall depth-duration-model, the updated ReFH2.3-FEH22 model, and the small catchments pooling method.●New software that includes bug fixes or changes to methods.	<p>These guidelines are not absolute and there may be some circumstances where a different approach is warranted. Decisions over methods and data should be justified with supporting evidence and proportionate to the project scope, impacts and risk. Please contact the National Flood Hydrology team for further support.</p> <p>In general, a 6 months' timeframe is considered reasonable for transitioning to using new methods and data (see National Flood Hydrology transition guidelines). However, sometimes a faster transition is needed if there are significant impacts on flood estimates. In other cases, new methods and data may have little impact on individual studies outcomes and older hydrological analysis may still be appropriate.</p> <p>Consultants can support this review action by providing sensitivity analysis or residual uncertainty analysis to take into account the potential impacts of using new methods or data. For example, a sensitivity test could use the latest data and methodologies to estimate lumped flow at one key location assessed in the study for the 1% AEP event for comparison with the original analysis:</p> <ul style="list-style-type: none">●If flows or volumes are increased by more than 20% , do not proceed further with this review. Mark this row as Red and request the calculations are updated using the latest data and methodologies.●If flows or volumes are increased by 10 – 20%, mark this row as Amber. Continue with the review and check that the potential impacts of this change are allowed for within the sensitivity analysis or residual uncertainty analysis.●If flows are volumes are increased by less than 10%, mark this row as Green. Note that best practice would be to use the latest methodologies and data, but these are unlikely to change the outcome of the study. Check that the potential impacts of the change are allowed for within the sensitivity analysis or residual uncertainty analysis.	Red	<p>The NRFA peak flow data set referenced to be used is Version 10. As per EA guidelines, the most up to date NRFA peak data set should be used, which is now 13.0.1.</p> <p>WINFAP5 is stated to have been used.</p> <p>Inconsistent referencing of ReFH is given throughout the report with ReFH2.2 mentioned predominately.</p> <p>The latest calibration of the ReFH2.3 model was released in 2023 to utilise the FEH22 design rainfall.</p>	<p>Update the hydrology undertaken using FEH22 (in latest version ReFh2.3 version 4) and most up to date peak flows (Version 13).</p>	<p>The Hydrology study was prepared and undertaken in 2022 and made use of NRFA peak flow data set v10 which was the most recent version at the time of the study. It should be noted that the hydrology study concludes by recommending the flow estimates from ReFH2 in preference to the Statistical method as the ReFH2 method peak flow estimates are higher in comparison to the peak flow estimates produced by the Statistical method. ReFH2 does not use the NRFA peak flow data set so even updating this to use NRFA peak flow data set v13 (which is the current version as of the time of writing), would not impact on the flow estimates used in the model.</p> <p>The use of 'ReFH' to specifically reference Revitalised Flood Hydrograph rainfall-runoff method version 2 or ReFH2 is now common parlance in hydrology studies and is generally an acceptable alternative to 'ReFH2', some 10 years after ReFH2 was released with ReFH(1) being largely defunct and no longer in common use. This is consistent with how the Environment Agency's template FEH calculation record's use of abbreviations. There is one incorrect reference to ReFH2.3 (version 3.1.7439); this should read ReFH2.2 (version 3.2.7650.24314). This will be corrected in any future revisions and a clarification attached to the FRA to confirm this.</p> <p>As noted above the study was prepared in 2022 prior to the release of ReFH2.3 and therefore used the most up to date methods and data available at the time of preparation. As set out in the FEH calculation record and FRA the study is to show the relative impact on baseline flood risk conditions as a result of the introduction of development works, principally a new bridge and road embankment. Therefore the focus is on relative change. Provided consistent hydrology was applied to the baseline and proposed models it is not considered that the use of ReFH2.3 (and FEH22) compared to ReFH2.2 (and FEH19) has the potential to 'significantly change the outcome of the study'.</p> <p>We would stipulate that this should be a green comment as it has 'negligible impact on the results that is unlikely to change the outcome of the study' but should be 'consider[ed] for future studies'.</p>	
1.1.3	(Additional space for other items checked)	N/A					



2. Method Statement

2.1 Requirements for flood estimates							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.1.1	Does the method statement include an overview of the project, its scope and hydrological complexity?	<ul style="list-style-type: none">•The content and level of detail provided in this section will depend on the scope of the study. The following should be included as a minimum:•Purpose of study•Peak flows or hydrographs?•Design events for which flow estimates are to be made (AEP %)•Climate change allowances with reference to relevant guidance•Potential number of locations for flow estimation•The purpose of the document•What is the complexity of the study – simple, routine, moderate, difficult, very difficult?•What does the client’s scope specify for inclusion in the study, e.g., review of existing studies, rating reviews / updates, simple / detailed flood history review, ReFH model parameter estimation, joint probability?•Include a reference to any modelling reports which this flood estimation calculation record supports.	Green	<p>The method statement provides the relevant project details. However, there is no note regarding the complexity of the study.</p> <p>There is no reference to the hydraulic modelling report which this study supports.</p> <p>No climate change allowance included and no reference made to the latest climate change allowances guidance.</p> <p>The hydraulic model report notes that the bridge will be designed to the 1 in 100 year plus climate change allowance of 19% for the catchment (correct percentage for the basin) but this is not referenced in the FEH calculation record itself. There is also reference made to the 1 in 1000 year plus 19% allowance for climate change event within the model report, which is not reflected in the calculation record.</p>	Update the report to include complexity of the study, a reference to the hydraulic modelling report and the climate change allowances to be used with references to the relevant guidance.	Both the FEH Calculation record and the Hydraulic modelling report form appendices to the Flood Risk Assessment. Climate change allowances and the relevant guidance are clearly set out therein and as such when read together as intended there is no ambiguity in this regard. No action proposed.	
2.1.2	(Additional space for other items checked)	N/A					

2.2 The catchment							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.2.1	Does the method statement include maps showing the catchment and key locations and hydrological features?	<ul style="list-style-type: none">•Include a map of the catchment in here, at a minimum showing the river network, catchment boundary and gauging stations, and appropriately labelled / referenced in a legend. Additional information which could be included is the model extent or locations of unusual / interesting features, for example. Think about the background mapping being used – scale and colour / greyscale – think about if the reader could easily identify locations from the background mapping.•Include more than one map if that would assist in presenting the information, consider including maps using satellite imagery as background if that would better show key catchment features, and consider including photographs if they would help understanding of features identified in the 'Description' section. For permeable catchments, consider including a hydrogeological map showing groundwater equipotential lines.•Remember to give all figures a number and title and refer to them in the text.•Consider changing the page orientation to landscape and the page size to A3 if necessary or including maps as a separate digital appendix	Green	<p>The mapping in Figure 1 and Figure 2 could more clearly define and label the river network. The locations of the Flood Estimation Points on Figure 2 in the mapping provided are not clearly definable.</p> <p>It would be useful to show the location of the lakes relevant to the catchment boundaries to corroborate the FARL values in Section 2.</p> <p>This will aid future readers to better understand the key catchment characteristics used in the derivation of the hydrological estimates.</p>	<p>Update Figure 1 and Figure 2 to include a clearer river network.</p> <p>Update Figure 2 to include the locations of the FEP, as opposed to just the catchments.</p> <p>Include the reservoirs on Figure 2.</p>	Figure 1 has lakes and watercourse labelled. The River network is shown on the OS mapping used as the basemap. Figure 2 includes catchments, FEP locations could be added for future studies but this information (easting and northing) for each FEP is clearly set out in section 2.1. No action proposed	
2.2.2	Does the method statement describe the catchment and its hydrological features, including how runoff is generated during flood events and any unusual features that might affect the flood hydrology.	<ul style="list-style-type: none">•Think about how runoff will be generated and what features are going to affect runoff from the contributing catchment reaching the watercourse. Include:•Topography•Climate•Geology•Soils•Land use•Any unusual features (e.g., reservoirs, historic mining) that may affect the flood hydrology.•In some cases, it may be useful to include reference to things such as amount of modelled reach that is culverted but remember that this is not a hydraulic modelling report and detail on hydraulic features, such as weir and culvert sizes, is not required.	Green	<p>The method statement describes the key catchment and hydrological features and particular reference is made to the online lakes.</p> <p>There is no description of climate or rainfall received by the catchment. No assessment of historic mining in the catchment. Whilst it is acknowledged that incorporation of this in any future changes wouldn't affect the outcome of the study, it would help to provide a more conclusive picture of the catchment for readers.</p>	Add climate data for the catchment and investigate any historic mining in the catchment.	As per response to 2.1.1 climate change discussed in main FRA to which the FEH calculation record forms an appendix. Mining noted for future studies.	
2.2.3	(Additional space for other items checked)	N/A					

2.3 Hydrometric data							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.3.1	Are the sources of flood peak data listed? Is the latest version of the NRFA database used?	<ul style="list-style-type: none">•This should be updated to the latest version of the dataset at the time of the assessment.	Amber	The NRFA peak flow dataset is not the most up to date (Version 10 being used instead of the current Version 13).	Update the hydrology with the latest peak flow dataset (Version 13) or perform a sensitivity analysis on the implications of this.	Please see response to 1.1.2	
2.3.2	Are the type and record length of flow and level gauging stations listed, including stations outside the NRFA peak flows dataset and closed stations as well as current ones?	<ul style="list-style-type: none">•You only need to include gauges at or very near to the sites of flood estimates unless there is an exceptional reason to include other gauges.•If you have data extracted from WISKI the datafile may only provide the digital data period of record, and the actual operating period of the gauge may be longer. You should check this using the NRFA website.	Green	There is a EA level gauge located on the Bin Brook, in close proximity to the BB01 FEP. This and the data quality and potential uses need to be included within Table 1.4	Provide details of the Bin Brook level gauge in Table 1.4.	Noted in the event of a future update.	
2.3.3	Is the data available at each flow gauging station summarised, including data type, record length, data quality, and what further updates and checks are needed in this study?	<ul style="list-style-type: none">•This table can be deleted if the study catchment is ungauged.•A quality check of the data is not required if the gauge is in the NRFA, unless specifically called for in the project brief.•There is no need to repeat everything in the NRFA station description, for example, weir length, wingwall height. Just add the key factors which will affect the quality of flood flow measurement and hence confidence in the data. For more detailed studies consider looking for other sources of information, for example, gauging authority rating review reports, station files held at CEH Wallingford, or reports on earlier flood studies.•Any flood peak data not in the NRFA (e.g., extra stations, recent data or altered flows) should be provided in the appendix.•Provide details of how peaks-over-threshold (POT) data has been derived in the appendix.	Green	There is a level gauge located on the Bin Brook, in close proximity to the BB01 FEP, which could be used for Lag analysis.	Provide summary of data available at the Bin Brook gauging station and consider if it can be used for lag analysis. If so, update the ReFH2 flows accordingly.	please see response to 2.3.2	

2.3.4	Is it appropriate to update the flood peak data (e.g. to include additional water years or a new rating) and if so has this been done?	●Tabulate any updated or revised flood peak series in the appendix and provide a summary here.	N/A	Not applicable.			
2.3.5	Have data quality checks been carried out, at minimum giving the NRFA peak flows classification? Is a more detailed review of data appropriate for this study and if so has it been done?	●Provide full details of data quality checks in the appendix and summarise findings here.	N/A	Not applicable.			
2.3.6	Are rating equations summarised and is a more detailed rating review needed?	●The Flood Estimation Guidelines provide suggestions on the information that should be collated and assessed for rating reviews (Section 2.1 'Rating reviews and improvements'). ●A site visit is an important component of any rating review.	N/A	Rating review out of scope.			
2.3.7	Have any changes to ratings been reported? (see additional tab 2a)	●Provide full details of rating updates in an additional report or the appendix.	N/A	Rating review out of scope.			
2.3.8	Has other relevant data been sought and presented in the report? Has data quality been reviewed? Have any flood alleviation schemes been carried out or other significant catchment changes which could affect the relevance of older data?	●Check flow gaugings / spot flow gaugings are only required if you are reviewing a rating ●Historical flood data: a chronology and interpretation of the flood history should be included in the appendix or in an additional report (add references). The detail included will depend on requirements in the project scope. If there is a flow gauge within the study reach (or close by), consider if the historical flood data could be used to extend the systematic gauge record (see FEH Local guidance for more information). ●Potential evaporation data may be required if the ReFH Calibration Utility is being used. ●Other data or information could include groundwater, tides, channel widths, low flow statistics, sewer network data, or any other data used in your analysis. Add extra rows to the table if needed.	N/A	None identified.			
2.3.9	Does the report conclude by clearly explaining what the data at each gauging station will be used for?	N/A	Green	Reference to Item 2.3.2 and Item 2.3.3. Conclusions should be made on the use of the data on the assessment.	Conclude on the use of the level gauge in assessment.	please see response to 2.3.2	
2.3.10	(Additional space for other items checked)	N/A					

2.4 Hydrological understanding of the catchment							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.4.1	Are plots of flood peak data included and interpreted?	●This could be the AMAX series or the POT series. ●Visually examine the time series and identify if there are, for example, outliers, apparent truncation of the flood peaks, trends or fluctuations in the data, step changes in the data, or unusually small flows. You should include an interpretation of these and other features. ●If there is more than one gauge in the study area, correlation plots can help to identify patterns or inconsistencies in the hydrological behaviour. ●You could add informative plots, for example, showing the seasonality of floods or the correlation of peak flows at different gauges.	N/A	Not applicable.			
2.4.2	Are plots of flow data included and interpreted?	●This could include, for example, annual flow hydrographs or flood events. ●Plots should be followed by an interpretation of the plots, for example, discussion of catchment processes, response time, propagation of a flood, and contributions from tributaries. ●If there is more than one gauge in the study area it can be useful to plot the data for all gauges on the same graph as this can aid understanding of the relationship between flow at different locations. ●These plots can be useful for checking the quality of the data and it is often helpful to plot flow and rainfall together as this may identify problems.	N/A	None provided.			
2.4.3	Are plots of stage data included and interpreted?	●Many catchments do not have flow gauges, but stage / level data may be available. This data can provide valuable information on the catchment response in the absence of flow data, for example estimating Tp from lag analysis.	N/A	None provided.			
2.4.4	Has a conceptual model for the catchment flooding processes been described?	●See Section 3.3 of the Flood Estimation Guidelines. Include information on factors such as: ●Where are the main sites of interest? ●What is likely to cause flooding at those locations? (e.g., peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides...) ●Might those locations flood from runoff generated on part of the catchment only, e.g., downstream of a reservoir? ●Is there a need to consider temporary debris dams that could collapse?	OK	The conceptual model for flooding is provided.			
2.4.5	Have unusual catchment features been identified? What is their impact on choice of method and conceptual model? E.g.: ●Urbanisation: impacts on local flood generating processes and influence of the urban drainage network. ●Reservoirs: the potential need for reservoir routing calculations. ●Highly permeable catchments: hydrogeological setting and influence on flood generation. ●Pumped: alternative rainfall-runoff methods.	●See Section 7 of the Flood Estimation Guidelines. Include information on factors such as: ●highly permeable soils or geology ●heavily urbanised land use ●pumped watercourse ●major reservoir influence (FARL<0.90) ●flood storage areas, particularly those which are normally dry ●historical mining or operational mining activities	Green	Unusual catchment characteristics have been identified such as the impact of lakes (BB02 Has FARL of 0.9). However, BB04_1 has a particularly high URBEXT value (0.311) and this is not highlighted nor the impact on choice of method (i.e. summer storm profile for URBEXT >0.3 (0.311).	Note the impact that the URBEXT value has on choice of method and conceptual model in Section 1.8.	Noted in the event of a future update.	
2.4.6	(Additional space for other items checked)	N/A					

2.5 Initial choice of approach							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
2.5.1	Are FEH methods appropriate?	●FEH methods may not be appropriate, e.g., for extremely heavily urbanised or complex catchments). Explain your decision.	Green	FEH methods are considered broadly appropriate. However, see items 2.4.5 above and 2.5.2. below, where further rationale behind choice is required. Also, ReFH2.2 referenced in initial choice of method and later software referenced as ReFH2.3. ReFH2.3 should be used in line with best practice.	Update FEH method in line with latest best practice guidance.	See response to 1.1.2	

2.5.2	Is an initial choice of method(s) included with adequate reasons? Have unusual catchment features been considered and choices of methods justified?	<ul style="list-style-type: none">●See Section 3 of the Flood Estimation Guidelines.●Think about:<ul style="list-style-type: none">●the type of problem●the type of catchment●the type of data available●Which methods are appropriate? If more than one method is appropriate will all be applied, and the results compared before a final decision is made? Will non-stationary methods be applied? Will different storm durations need to be considered / tested?	Green	Initial choice of method provided. However, further explanation is required. EA Guidance notes that the statistical method is 'particularly preferable if there are lakes or other water bodies in the catchment and you are not planning to use flood routing to represent them. Their influence will be represented in a general way via the FARL descriptor, which is used in the statistical method but not in design event methods.' The guidance also notes that a rainfall runoff approach 'might be favoured for estimating the more extreme floods' required under the scope of the assessment (200 to 1000 years). No evidence of hybrid method for higher return periods was provided.	Revise reasoning of initial choice of method considering unusual catchment features, and update Table 1.8 to reflect this.	Noted for future studies. It is observed that the higher FARL value is only observed on FEP BB02 which is a minor tributary (1.05km2 catchment compared to 17.32km2 for the downstream extent). FARL for the area of interest in this study is expected to be ~0.99. For the avoidance of doubt in this case both FEH statistical method and ReFH2 method were taken forwards to prepare estimates for the FEPs. The final choice of method was based on ReFH2 being more conservative (higher) flow estimates. Therefore the initial choice of method has no bearing on the outcome of the study. It would also seem disingenuous to retrospectively update the initial choice of method when this should in our view document the thinking at the time of the assessment. Where ReFH2 already provides the higher estimates and is adopted for being conservative it would not seem appropriate to adopt a hybrid approach.	
2.5.3	How will hydrograph shapes be derived if needed?	<ul style="list-style-type: none">●For example, ReFH1 or ReFH2 shapes, average hydrograph shape from gauged data.●If using average hydrograph shapes, how will inflows from different tributaries be phased?	Green	No detail on derivation of hydrograph shape is provided. No gauged data available, so hydrograph shape is produced using ReFH2	Update Table 1.8 to state that hydrograph shape will be produced via ReFH2.	Noted in the event of a future update.	
2.5.4	Will the catchment be split into sub-catchments? If so, how?	<ul style="list-style-type: none">●If the hydrological assessment is being undertaken to supply inflows to a hydraulic model, it is likely that a distributed approach will be taken, with the catchment split into sub-catchments and design flows routed from each sub-catchment.●Think about what the split into sub-catchments will be based on, e.g., tributary confluences, changes in geology / urbanisation, key areas of interest, sewer outfalls.●Will intervening area hydrographs be required and how will these be derived?●If the catchment area changes significantly over the study reach, or tributaries are also being modelled, will different storm durations need to be considered / tested?	Green	No reference to split of the catchment has been made in Section 1.8 of the FEH Calculation Record. The catchment map (Figure 2) provided in Section 1.2 shows that the catchment comprises one upstream FEP representing the inflow to the top of the model extent, two tributary inflows and an intervening area to the downstream lumped catchment. No information on hydrograph derivation for intervening area is provided. No consideration of any necessary changes to storm duration made (tributaries have a shorter storm duration than upstream and lumped downstream catchments).	Update Table 1.8 to include that the catchment will be split into sub-catchments.	Noted in the event of a future update.	
2.5.5	What software will be used?	<ul style="list-style-type: none">●See Section 1.2 of the Flood Estimation Guidelines●Include version numbers●Include software used for non-stationary analysis, if undertaken.	Red	Software used is ReFH2.2.2, which is not the latest software.	Update the hydrology undertaken using FEH22 (in latest version ReFH2.3).	Please see response to 1.1.2	
2.5.6	(Additional space for other items checked)	N/A					



3. Locations where flood estimates are required

3.1 Summary of subject sites							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
3.1.1	Have locations where flood estimates are required been tabulated and shown on a map, clearly distinguishing between lumped catchments and sub-catchments (intervening areas) and explainint the purpose for which they have been created?	<ul style="list-style-type: none">●Include a map which shows the locations of the subject sites.●Use site codes in all subsequent tables for clarity and to save space.●Lumped catchments (L) are complete catchments draining to points at which design flows are required.●Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a distributed model. Details of these need to be included so that results can be fully reproduced and checked.	Green	Catchments are delineated for corresponding FEPs but the FEPs themselves are not labelled on maps as noted in section 2.2.1. It would be useful to add the model extents and the position of the bridge to the mapping for context.	Add FEPs, model extent and bridge location to Figure 3.	See response to 2.2.1	
3.1.2	Do you agree with the choice of flood estimation points? Do they cover the main locations of interest (e.g. confluences, areas of known flood risk, gauging stations, model boundaries) without including an excessive number of subcatchments or very similar catchments?	N/A	OK	Suitable choice of flood estimation points			
3.1.3	(Additional space for other items checked)	N/A					
3.2 Catchment descriptors							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
3.2.1	Are the final catchment descriptors tabulated for every subject site, indicating where changes have been made from default values?	<ul style="list-style-type: none">●Include any changes made. Use a different colour to identify catchment descriptors which have been changed from the default values.●Refer to Section 2.3 of the Flood Estimation Guidelines for suggestions on how to check and amend catchment descriptors. Any changes made must be recorded fully so that they can be checked and are reproducible.●Include sub-catchments and intervening areas required for a distributed approach.	Green	<p>The FARL for BB04_I is missing.</p> <p>A final catchment descriptor table was provided. It would aid future users to highlight what the changes were.</p> <p>The text notes that the BB04_I catchment value was taken from BB02, as the proportion of the pond to the catchment area is similar. The BFIHOST and SPRHOST values for BB04_I were taken from those derived for BB04 and checked.</p>	Update Section 2.2, to include the FARL and highlight which catchment descriptors were updated and provide the original values.	Noted in the event of a future update.	
3.2.2	Have FEH catchment boundaries been checked against high resolution LIDAR, sewer network, and OS data and refined where appropriate? If catchment area has been changed, have catchment descriptors been adjusted appropriately?	<ul style="list-style-type: none">●Add maps if needed to aid explanation of any changes.	Green	It would be useful to show the revision to the catchment boundaries on the same mapping to the existing FEH boundaries and with the relevant LIDAR data as background mapping to verify the changes appropriately.	Add catchment boundary delineation changes and existing FEH boundaries draining to Figure 3. Provide a figure of the LiDAR data.	Noted in the event of a future update.	
3.2.3	Does the calculation record state whether URBEXT1990 or URBEXT2000 has been used? Has the correct value been identified for the method(s) to be applied? Have the URBEXT values been updated to the current year or revised using the URBAN50k method if a discrepancy between the FEH urbanisation layer and current OS mapping has been identified?	<ul style="list-style-type: none">●Explain the source of URBEXT used in the analysis (e.g., URBEXT1990, URBEXT2000, manually derived using URBAN50k). URBEXT1990 should only be used in ReFH1.●If URBEXT values need to be substantially revised due to development or catchment boundary changes, see the URBAN50k method in Section 2.3 of the Flood Estimation Guidelines.●Default URBEXT1990 and URBEXT2000 values should always be updated to the current year. Explain what method has been used (e.g., CPRE formula, manual derivation) and where (e.g., edited catchment descriptor files, updated within WinFAP software, updated within ReFH2 software).	Amber	<p>In Table 2.2 and in most locations in the report, URBEXT is stated but no distinction between 2000 or 1990 is made. It is assumed that URBEXT2000 is used.</p> <p>The incremental BB04_I catchment value was calculated using area weighting and was checked using an URBAN value of 0.5. However, 10k OS mapping has been used instead of 50k mapping in line with EA guidelines.</p> <p>URBEXT was updated to 2022 but this is now out of date, and should be to 2025.</p>	Update or check URBAN calculations using 50k mapping. Confirm URBEXT2000 was used and update each value to current year.	As noted in 1.1.2 the study was prepared in 2022 and as such is reflective of the latest data available at the time. No significant urbanisation between 2022 and 2025 identified from review of aerial photography.	
3.2.4	Has BFIHOST19 been used in preference to BFIHOST? Have values been checked against other soil or geological data? Has BFI been derived from local data?	<ul style="list-style-type: none">●BFIHOST19 should be used in the ReFH2 calculations, since the current release (ReFH2.3) was calibrated using BFIHOST19, and also in the FEH Statistical method, since this has been found to improve the results.●Soil association maps can be used to check BFIHOST values, especially if significant changes have been made to catchment boundaries. Any changes made must be recorded fully so that they can be checked and are reproducible.●If using other BFIHOST data, explain what has been used, why, and how it has been derived.	OK	BFIHOST19 was reported as used in the FEH Calculation record and checked against mapping.			
3.2.5	How have other catchment descriptors been checked and revised? How have catchment descriptors for sub-catchments been derived (particularly FARL, DPLBAR and URBEXT)?	<ul style="list-style-type: none">●Refer to Section 2.3 of the Flood Estimation Guidelines for suggestions on how to check and amend catchment descriptors.●Any changes made must be recorded fully so that they can be checked and are reproducible.●Include before and after tables if appropriate.	OK	Catchment descriptors form FEH were used and checked in Table 2.2			
3.2.6	(Additional space for other items checked)	N/A					



4. Stationarity statistical methods

4.1 Method overview							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
4.1.1	Is the reason for using this methods explained?	●Include a brief summary of the reasons, specific to this study, for applying the method.	OK	Whilst not reported in this Section, Section 2.5 outlines why the stat method was selected.			
4.1.2	What methods will be used to estimate QMED and growth curves? Has local data been used to its full potential?	●Include a brief summary of what methods will be used at which subject sites. ●More than one method may be tested at each site (e.g., comparing single site and pooled growth curves at a gauged site). ●Include all methods tested, even those ultimately rejected.	OK	Ungauged site. In line with EA guidelines, a pooled analysis based on a lumped downstream catchment was undertaken.			
4.1.3	(Additional space for other items checked)	N/A					

4.2 Estimating QMED							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
4.2.1	Has QMED been estimated at gauged sites appropriately? Have short records been adjusted for climatic variation?	●See Section 4.2 of the Flood Estimation Guidelines. ●When QMED is estimated from short records (less than 14 years), it should also be adjusted for climatic variation. Refer to FEH Volume 3, chapter 20. Provide full details of the adjustment in the appendix. ●If you estimate QMED from peaks-over-threshold (POT) or low flow duration curve statistics (LF), add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●More than one method may be used at each site. Use a different row for each method.	N/A	Ungauged site.			
4.2.2	Has QMED been estimated at ungauged sites appropriately?	●See Section 4.2 of the Flood Estimation Guidelines. ●Only fill in the cells needed. ●If you estimate QMED from bankfull channel width, add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●More than one method may be used at each site. Use a different row for each method.	Green	Small catchments procedure was undertaken. The donor method undertaken updates the URBEXT2000 value to 0.04. This is assumed to cover more gauges but the reasoning given is "URBEXT 2000 <0.04 to reflect the relatively rural nature of the study catchment." However, the distance from the donor to the FEP's has not been given.	Update Table 2 to include the distance from the donor sites to the FEPs.	Noted in the event of a future update.	
4.2.3	What method and parameters have been used for urban adjustment of subject and donor sites? Is this appropriate?	●List the method used for urban adjustment of subject and donor sites, if applicable (e.g., Kjeldsen (2010), WinFAP v4, WinFAP v5). ●List the parameters used for the urban adjustment. The standard values are listed below, and any amendments must be explained. ●Impervious fraction for built-up areas, IF: 0.3 ●Percentage runoff for impervious surfaces, PRimp: 70% ●Method for calculating fractional urban cover, URBAN: updated URBEXT 2000	OK	Urban adjustment applied in WINFAP.			
4.2.4	How were donor sites identified and selected? What urbanisation threshold was used? Has the use of urbanised donor sites been avoided unless appropriate for the catchment being assessed? Has the choice and number of donor sites been justified?	●Provide details regarding how potential donors were selected and the reasons why they were chosen / rejected. ●Include a map if helpful, which shows the location of the study catchment and donor stations under consideration. ●Section 4.2 of the Flood Estimation Guidelines provides guidance on selecting a donor(s) for data transfer. ●Consider using POT and low flow stations as donors, especially if used as gauged subject sites. ●If using WinFAP to search for donor sites: the default URBEXT2000 threshold value for donors in WinFAP v5 is 0.03. Explain if you have changed the threshold, for example to enable a more urbanised donor site to be used.	Green	The text states that the nearest gauge was used for donor estimation. However, the tabulated donor station information does not include distances from subject site. Choice of single donor closest to site is in line with guidance. However, there is no evidence that the closest site has been chosen as no distances are noted.	Provide distances for donor stations relative to subject site. Update if any closer but more urbanised gauges could have been considered.	see 4.2.2	

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4.2.5	Was QMED estimated at donor sites appropriately? If donor sites are upstream or downstream of subject sites, have the adjusted QMED estimates been checked for consistency and averaged adjustment factors been used?	<ul style="list-style-type: none">•See Section 4.2 of the Flood Estimation Guidelines.•When QMED is estimated from short records (less than 14 years), it should also be adjusted for climatic variation. Refer to FEH Volume 3, chapter 20. Provide full details of the adjustment in the appendix.•If you estimate QMED from flow duration curve statistics (LF), add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced.•QMED from catchment descriptors is the 'as rural' value, i.e., with no urban adjustment factor applied. For urban donors, record whether and how the observed value of QMED has been "de-urbanised" for comparison with the as-rural estimate from catchment descriptors.•The adjustment ratio in the table below is the adjustment in full, with no distance factor applied.	OK	Small catchment procedure, in line with guidance, was used.			
4.2.6	(Additional space for other items checked)						

4.3 Estimating growth curves							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
4.3.1	Have growth curves been derived at subject sites using appropriate methods, distributions, adjustments and parameters? Where flood peak records are available, has single site and enhanced single site analysis been carried out? Has historical analysis been considered? Have urban and non-flood years adjustments been applied?	<ul style="list-style-type: none">•See the Flood Estimation Guidelines Section 4.2.•List all flood growth curves compared, including those ultimately rejected.•If using historical methods, provide full calculation details in the appendix.•An individual urban adjustment should be applied even if the same pooling group (including enhanced single-site analysis) has been applied to several sites, as each site is likely to have a different URBEXT2000 value and hence a different urban adjustment.•A non-flood years adjustment (previously known as the "permeable" adjustment) should be considered if there are non-flood years in the stations in the pooling group that may make a significant difference to the results. Adjustments to remove the influence of non-flood years are carried out using the method in FEH Volume 3, chapter 19. This is valid only for the GLO distribution.•More than one method may be used at each site. Use a different row for each method.•Edit the list of methods if any alternatives were used and highlight the changes made.	Amber	<p>GL chosen due to best fit and in line with guidance. No record of the best fit values provided though. Permeable adjustment has been carried out but no calculations have been provided to verify this adjustment.</p> <p>One pooling group (calculated at BB04) was used which is in line with EA guidelines. However, the consideration for the urbanisation of each of the catchments has not been given. This is because BB04_I has an URBEXT2000 value of 0.311. When applying growth curves from another FEP, an urban adjustment needs to be undertaken.</p>	<p>Provide evidence of best fit values for distribution. Add details on permeable adjustment.</p> <p>Recalculate the final peak flows at each catchment taking into account the urbanisation levels of each of the catchments.</p>	<p>For this study FEH Stats method was not taken forward for use in design runs. Comparison of BB04 results for ReFH2 and FEH stats in section 6.2 show ReFH2 to be the more conservative method. Consequently update to the other FEPs as suggested would not impact on the outcome of the study and is therefore noted for future updates but no action proposed.</p>	
4.3.2	Are flood frequency curve plots included?	<ul style="list-style-type: none">•Any relevant frequency plots, particularly showing any comparisons between single-site, enhanced single-site, and pooled growth curves (including flood peak data on the plot), should be shown here.	Green	No flood frequency curves provided.	Add flood frequency curves into the appendix.	Noted in the event of a future update.	
4.3.3	Have pooling groups been derived appropriately? Was the small catchment pooling procedure used, if appropriate? If there are several similar flow estimation points, have they used a single pooling group to aid simplicity and consistency?	<ul style="list-style-type: none">•Try to use as few groups as possible, this avoids step changes in flow estimates between flow estimation points for catchment-wide studies.•Section 4.2 of the Flood Estimation Guidelines provides further details on reviewing pooling groups.•Provide initial and final pooling group compositions in the appendix.•If you increase the URBEXT2000 threshold from the default value of 0.03, include a justification and compare the results with those from an all-rural pooling group.•L-moments are deurbanised by default in WinFAP v5.	Green	<p>Single pooling group applied based on catchment size and hydrological similarity. Used sites above>0.04.</p> <p>Permeable adjustment has been made owing to the permeability of the stations in the pooling group (no evidence has been provided).</p>	Update the report to detail the permeable adjustment calculations undertaken.	Noted in the event of a future update.	
4.3.4	Is the composition of the pooling group recorded? How has pooling group composition been reviewed and adjusted? Has the removal or retention of sites been adequately justified, especially discordant sites?	<ul style="list-style-type: none">•If no changes were made, just say "none", although it is helpful to provide details of stations which were investigated even if they were ultimately retained.•Provide original and final pooling group compositions in the appendix.•Weighted L-moments should be the pooling group L-CV and L-Skew, after any changes were made to composition, but before any urban or non-flood years adjustments.	Green	<p>Composition of the pooling group is not recorded. No adjustments were made but we cannot see a record of the pooling group stations to check if the stations are appropriate.</p> <p>Table 3.4 "Derivation of pooling groups" has a site code "LB04" this is assumed to be "BB04".</p>	<p>Add composition of pooling group into the appendix and record changes made.</p> <p>Update Table 3.4 to be "BB04".</p>	Noted in the event of a future update.	
4.3.5	(Additional space for other items checked)	N/A					
4.4 Final choice of QMED and growth curves							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2

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4.4.1	Has the final choice of method for QMED and growth curves been explained and justified?	<ul style="list-style-type: none">•Record your final choices of method for QMED and growth curves.•Consider spatial consistency. Check values to ensure they are consistent with observations at upstream or downstream gauging stations. In some situations, using the data transfer method and switching between pooling groups can lead to unrealistic step changes. See Flood Estimation Guidelines Section 4.2.	Amber	<p>A permeable adjustment, in line with EA guidelines, one donor based on small catchment procedure is used.</p> <p>The final flood estimates show that BB02 has a smaller flow than BB03, whereas the area of BB02 is 40% larger than that of BB03. Confirmation on if the correct catchment parameters are applied is required or to aid future users of the hydrology a note on why there is potential spatial inconsistency should be added.</p>	Update the statistical method with the correct model parameters or add an explanation in Section 6 or Section 4 of the possible spatial inconsistency.	see 4.3.1 would not impact on the outcome of the study and is therefore noted for future updates but no action proposed.	
4.4.2	Have the final flood estimates been tabulated?	<ul style="list-style-type: none">•Add or remove columns as needed to change the return periods to those used in the study.	Amber	Whilst final flood estimates are tabulated in Section 3.6, they will need to be revised based on comments in item 4.3.1.	See item 4.3.1.	see 4.3.1 would not impact on the outcome of the study and is therefore noted for future updates but no action proposed.	
4.4.3	(Additional space for other items checked)	N/A					



7. Revitalised flood hydrograph 2 (ReFH2) method

7.1 Method overview							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.1.1	What is the purpose of applying this method? Has the method been avoided for large catchments?	•Include a brief summary of the reasons, specific to this study, for applying the method.	Green	ReFH2 was used to produce estimates to be compared with the statistical method. No mention of the use of ReFH2 being used to derive hydrograph shape.	Update Section 4 to include the reason for using ReFH2.	Noted in the event of a future update.	
7.1.2	Are rural and urban sub-divisions used?	•This section can be deleted if the catchment is essentially rural. •If the catchment is urban: •Did you calculate paved areas using a method other than from URBEXT using the standard equations? •Did you allow for transfer of water via sewers across the topographic catchment boundary? •If yes to either of these questions provide details which give sufficient information to understand the process applied and any assumptions made. It may be useful to include a map of sub-catchments here, if not provided earlier in the report.	Amber	BB01, BB02, BB03 and BB04 are all rural catchments (slightly to moderately urbanised catchments" yet are treated as urban). As per EA guidelines, they should be treated as rural. It is acknowledged that the intervening area does have an URBEXT value of 0.311 and so should be treated as urban.	Rerun ReFH2 analysis using the rural catchments as rural.		
7.1.3	(Additional space for other items checked)	N/A					
7.2 Model parameters							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.2.1	What methods were used to estimate model parameters? Have model parameters been listed? If flow estimation points are at or near a gauging station, have model parameters been estimated from observed data?	•List parameters for all site codes, including intervening areas and sub-catchments. •Include a brief summary of what methods will be used at which subject sites. See Section 4.3 of the Flood Estimation Guidelines. •More than one method may be tested at each site. Include all methods tested, even those ultimately rejected. •See the Flood Estimation Guidelines for recommended approaches for modelling urbanised catchments. You only need to provide the urban area, TP urban scaling factor, IF, IRF and DS parameters if modelling as urbanised. •ReFH2 treats BR (baseflow recharge) as a state variable rather than a parameter, setting it automatically in order to conserve volume. The values of BR vary with return period and so are not reported here.	OK	Catchment descriptor method applied and noted in the record. Model parameters are listed. No observed data used to estimate model parameters.			
7.2.2	What analysis was undertaken to derive model parameters?	•For any methods other than catchment descriptors, provide a description here and include full calculation details in the appendix.	N/A	Catchment descriptors method applied.			
7.2.3	(Additional space for other items checked)	N/A					
7.3 Model inputs for design events							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.3.1	What rainfall DDF model has been used (e.g. FEH99, FEH13 or FEH22)? Have rainfall data and initial conditions been amended from default values?	•Model inputs include rainfall data and initial conditions. These are a complete package and should only be amended in some circumstances. See Section 4.3 of the Flood Estimation Guidelines.	Red	No reference to rainfall DDF model (assume FEH13 as FEH22 was released afterwards). No notation if any initial conditions were amended from default	Update using FEH22 rainfall in the latest ReFH2.3.	As per 1.1.2 the study was undertaken in 2022 and FEH22 was not available at the time therefore study used FEH13 rainfall and ReFH 2.2 which was the latest available at the time of the study.	
7.3.2	Have different design events been used when considering lumped and sub-catchment sites? Does the report acknowledge that a single design storm will need to be applied to all inflow hydrographs in a distributed modelling approach?	•ReFH2 may be applied for both lumped catchments and sub-catchments in a study. Different design events will be needed when considering lumped and sub-catchment sites. Complete the relevant sections as appropriate for your study.	Amber	Two different design events are used (storm duration of 9hrs or 15hrs). A consistent storm duration is needed.	Rerun using a consistent storm duration.	Acceptable to inform choice of method but design runs should be of consistent storm duration. Design estimates for consistent 9 and 15 hour storm duration to be prepare for all FEPs and sensitivity tested in the model. Final design hydrographs to be appended to FEH Calculation record	
7.3.3	What design events are listed for lumped catchments? Are the choices suitable?	•Storm durations detailed here should be the values for the individual catchments. Lumped flows should be generated using the storm duration relevant to each lumped catchment. •A summer storm should be used if the catchment is heavily urbanised (URBEXT2000 between 0.15 and 0.3) AND highly permeable (BFIHOS19>0.65). •Cini and BFO values only need to be listed if amended from default values. •This section can be deleted if ReFH2 is not being applied for lumped catchments.	Amber	The record reports on two different storm durations applicable across the FEPs (9 hours and 15 hours).The reasoning is not explained. The report does not acknowledge that a single design storm will need to be applied to all inflow hydrographs and no sensitivity analysis has been carried out. No note to define default storm duration.	Update the flows using a consistent storm duration based on the critical catchment.	see 7.3.2	
7.3.4	What design events are listed for subcatchment and intervening areas? Are the choices suitable?	•This table can be deleted if ReFH2 is not being applied for sub-catchments. •This table is included to identify the storm which will be applied to all inflows to a distributed model (see Section 6.1 of the Flood Estimation Guidelines) and avoid the scenario of using a different storm for each inflow to the model. •If there are multiple flood risk areas throughout the model it may be necessary to allow for different storms in different parts of the model by carrying out multiple runs. Each model run should use the same storm applied to all inflows. •Use one row for each storm to be applied. If only one storm is to be applied, delete the additional rows.	Amber	Further information required, as multiple storm durations are being used and this is not in line with best practice (15 hours storm duration applied for upstream inflow and downstream lumped catchment and then smaller sub catchments representing tributary inflows in addition to intervening area have 9 hours storm durations). It is acknowledged by the reviewers that BB04 _ is classified as urban and so a summer season storm should be applied. However, since BB04 is the critical catchment a winter season storm is acceptable.	Update the flows using a consistent storm duration based on the critical catchment.	see 7.3.2	
7.3.5	Has storm duration testing been undertaken using the hydraulic model?	•If storm duration testing using the hydraulic model is being undertaken add details of the results, for example, which duration(s) has been selected and why, what the process will be in terms of presenting model results if more than one duration is selected.	Amber	No storm duration testing has been undertaken. The flows are produced to compare against the FEH Statistical values.	Update the flows using a consistent storm duration based on the critical catchment.	see 7.3.2	
7.3.6	(Additional space for other items checked)	N/A					
7.4 Final choice of ReFH2 flow estimates							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
7.4.1	Has the final choice of design inputs and model parameters been recorded? Are the choices suitable?	•Record your final choices of method for model parameters and design inputs. You may have multiple choices of methods for lumped and distributed modelling.	Amber	As per items 7.1.2, 7.3.1 to 7.3.5, a consistent storm duration is required, alongside rural catchments should be rural as per EA guidelines.	Update in line with review comments.	see 7.3.2	
7.4.2	Are the final flood estimates from the ReFH2 method reported?	•Add or remove columns as needed to change the return periods to those used in this study. •Results only need to be provided here for lumped catchments, for comparison to other methods. Results for distributed catchments can be provided digitally but must still be provided to allow for checking. •If you have modelled a catchment as urban, make sure you record the urbanised flows rather than the as-rural flows.	Amber	Final flood estimates are tabulated. However, owing to the issues concerning urban or rural classification and the inconsistent storm duration these would need updating.	Update accordingly.	see 7.3.2	
7.4.3	(Additional space for other items checked)	N/A					



9. Discussion and summary of results

9.1 Comparison of results from different methods							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.1.1	Are peak flows from different methods compared?	●Compare peak flows from preferred methods at key sites for selected return periods / AEP events.	OK	Peak flows are compared from the FEH Stat and ReFH2.3 methods.			
9.1.2	(Additional space for other items checked)	N/A					
9.2 Final choice of method							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.2.1	Is the choice of method justified by discussing the type of problem, the type of catchment and the type of data?	●Include reference to type of study, nature of catchment and type of data available. ●If different methods are chosen for different site codes or return periods, explain why.	Amber	Since ReFH and statistical flows will need to be recalculated the final choice of method may need to be reassessed. Hence, this item has been left as Amber. The justification is weighted heavily by the fact that the ReFH2 flows were higher than the flows derived from the FEH Statistical and therefore the approach is conservative. However, guidance states that higher estimates should not be the sole justification to chose a method. It is acknowledged that the conservative approach may be considered warranted owing to the higher flows being used in the model to define the design of the bridge.	If required update Section 6.2 to include a new final choice of method.	Choice of method is based primarily on comparison of flow estimation at BB04. This review raises quires regarding other FEPs that are largely immaterial to the choice of method. The choice of a conservative method to inform bridge design and undertake comparative impact assessment is considered sufficient justification.	
9.2.2	Does the report explain how hydrograph shapes or volumes have been derived?	N/A	Green	No explanation of how hydrograph shape has been derived but is assumed to be from ReFH2.	Update Section 6 to include an explanation of how the hydrograph shapes are derived.	As per 7.3.2 - Design estimates for consistent 9 and 15 hour storm duration to be prepare for all FEPs and sensitivity tested in the model. Final design hydrographs to be appended to FEH Calculation record noting hydrograph shape is from ReFH2	
9.2.3	How will the 0.1% AEP flows be estimated?	●You may choose a different method for the 0.1% AEP event (see Section 6.6 of the Flood Estimation Guidelines). Explain how growth factors and peak flows have been calculated, if using a hybrid method.	Green	Application of hybrid method has not been applied. EA guidelines note that "If you choose ReFH2 for the longer return periods, to avoid a discontinuity in the results, you could consider using ReFH2 to obtain the ratio of the 1000-year flow to the (say) 100-year flow. You can then multiply that ratio by the preferred estimate of the 100-year flow, which may be from the statistical method."	Update the final 0.1% flows with the hybrid method or provide reasoning for using ReFH2.	Use of ReFH2 as conservative as noted above in 9.2.1	
9.2.4	How will the flows be applied to the hydraulic model?	●For example, will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	Green	No explanation provided within the FEH Calculation record.	Update the calculation record to include how the final flows will be applied to the model.	See 9.2.2 above	
9.2.5	(Additional space for other items checked)	N/A					

9.3 Final results							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.3.1	Have the final peak flow results been provided for all flow estimation points and design events?	●Include subcatchment and intervening catchment flows here or in digital files, to allow checking of the hydraulic model. ●If scaling factors have been used in a distributed model, provide full details of the original and final flows below or in the appendix.	OK	Final peak flow results have been provided for all flow estimation points and design events (no allowance for climate change as noted previously).			
9.3.2	Have any other information, data or results needed for the next stage of the study been provided?	N/A	N/A				
9.3.3	If appropriate, what design storms have been applied in the hydraulic model?	●Use this section if appropriate to record the ReFH1 or ReFH2 design storm parameters applied in the hydraulic model, if they are different to those recorded in the ReFH1 and ReFH2 sections of this report. ●You must apply a uniform storm duration and areal reduction factor across all subcatchments. Refer to the Flood Estimation Guidelines Section 6.1. This may result in a number of different design storms being modelled to give critical results at different locations in the catchment. List all details below.	Amber	Storm duration, SCF and ARF for BB04_I are based on the flow estimation point BB03. The SCF and ARF for BB02 are based on flow estimation point BB03. The storm duration for the upstream BB01 is 15 hours, compared to the other FEPs that have a storm duration of 8 hours. No further discussion is made in relation to the storm duration and how these are applied in the model.	Update the flows with a consistent storm duration.	See 9.2.2 above	
9.3.4	What climate change allowances have been applied and how?	●Refer to online guidance on climate change allowances for flood risk assessments and projects. ●Provide information on: ●What climate change allowances have been applied, e.g., rainfall and/or flow allowances, source of data, river basin, epoch, and percentiles. ●How the climate change allowances have been applied, e.g., applied to rainfall / flow hydrographs within the hydraulic modelling software using scaling factors. ●For non-stationary methods, refer to the practitioner guidance available on the FCERM R&D web page and provide full details and justification for the approach chosen.	Green	No climate change allowance has been recorded in the FEH Calculation record results. However, this is covered in the model report and so to aid future users of the hydrology should be included within Section 6.	Add climate change allowances into the report.	See 2.1.1	
9.3.5	(Additional space for other items checked)						

9.4 Checks on final results

Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.4.1	Are checks on results included?	●See Section 3.5 of the Flood Estimation Guidelines. ●These checks are important as a way of ensuring that everything has been considered and that the results are sensible. ●All relevant sections should be completed for every study. Where sections are not relevant (where there are no flow gauges or previous studies, for example) a comment should be added to this effect rather than leaving a blank space.	Green	The relevant checks as outlined in the guidance have been undertaken. No reference to if the results are spatially consistent between upstream and downstream FEPs is made, which as per item 4.4.1 is required.	Update the report to include reference to spatial consistency inline with the actions from item 4.4.1.	Noted in the event of a future update.	
9.4.2	Have the 1% and 0.1% AEP growth factors been derived and sense-checked? If the 1% AEP growth factor is outside the typical range, has a justification been provided?	●What is the range of 1% AEP (100-year) growth factors? Is this realistic? ●What is the range of ratios for the 0.1% AEP (1000-year) over 1% AEP (100-year) flow? ●What reasons are there for variations in ratios between sites?	OK	Range of 1% AEP growth factors is between 2.91 and 3.07, which is in line with acceptable range of 2.1 to 4.0 Range of ratios for 1000-year flow over 100-year flow is 1.75 to 1.82.			
9.4.3	Has the specific discharge (l/s/ha) been derived, and are variations between locations explained?	●What specific discharge (flow in l/s/ha) do the results equate to? Can you explain variations in specific discharges between different locations across the study area?	Green	Specific runoffs have only been provided for the downstream lumped catchment and not the component catchments.	Add specific runoffs for component catchments.	Noted in the event of a future update.	
9.4.5	Have the design flows been checked for spatial consistency, e.g. at confluences and along reaches?	●This will not be relevant for a study where there is only a single flow estimation point. ●See Section 6.1 of the Flood Estimation Guidelines. FEH methods are intended for application at individual sites and may not give spatially consistent results if applied to multiple sites along a river system. ●You should particularly check for consistency between upstream and downstream points and at confluences.	Green	No checks for spatial consistency referenced within the FEH Calculation Record.	As per item 9.4.1 add note on spatial consistency.	see 9.4.1	
9.4.6	Have return periods for notable historic floods been calculated?	●What do the results imply regarding the return periods / frequency of major events in the gauged record? This can help justify the choice of flood growth curve. ●If there is no flow data available, you can compare your design event hydraulic modelling results to observed level and flood extent data if available for major events.	N/A	No historic floods recorded.			
9.4.7	Are results compatible with the longer term flood history?	●Consider whether the implied frequency of flooding from your design event hydraulic modelling results is compatible with what is known of the flood history of the study area.	Green	As per items 2.3.2 and item 2.3.3, a level gauge is present on the Bin Brook which could be used as a check flow in the modelling.	Use the level gauge as a check in the hydraulic modelling.	As there is no upstream observed flow and only one level gauge it would require the inclusion of observed rainfall into ReFH2 which has its own set of uncertainties about a priori conditions that would limit the effectiveness of this exercise	
9.4.8	Have results been compared with previous studies?	●Explain any differences and conclude which results should be preferred. ●This will not be relevant if there are no previous hydrological assessments.	N/A	Not within the scope of the study.			
9.4.9	Have the hydraulic model results been checked against lumped flow estimates?	●Are flows generated by the hydraulic model consistent with those estimated from a lumped catchment FEH estimate at locations within the model reach? ●Have any scaling factors been applied to reconcile model results to the preferred flow estimates?	OK	Whilst not in the report, the reviewers have checked the flows are correct in the model.			
9.4.10	(Additional space for other items checked)	N/A					
9.5 Assumptions, limitations and uncertainty							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
9.5.1	Are assumptions, limitations and uncertainty reported?	●Careful thought should be put into identifying the specific assumptions and limitations applicable to the design peak flow estimates (and design hydrographs). ●Assessing and reporting on the uncertainty in the estimates is also very important. ●These sections should be completed for every study and never left blank.	OK	Assumptions, uncertainty and project specific limitations associated with the hydrology have been reported.			
9.5.2	Are the assumptions acknowledged and specific to the study?	●See Section 5.2 of the Flood Estimation Guidelines. ●Assumptions should be specific to the study, have a large effect on the results, and can be tested. General assumptions do not need listing.	Green	Standard FEH assumptions' noted as being applied. However, assumptions specific to the study should be stated.	Add detailed assumptions that are specific to project.	Noted in the event of a future update.	
9.5.3	Are the limitations acknowledged and specific to the study?	●See Section 5.3 of the Flood Estimation Guidelines. ●This could include applying methods outside of the range of catchment characteristics or return periods for which they were developed.	Green	Lack of suitable gauged data and suitable donor is acknowledged. No discussion of limitations pertaining to the presence of the lakes within the catchment and the representative FARL values is provided.	Add limitations of assessment.	Noted in the event of a future update.	

9.5.4	Does the report comment on uncertainty in the design flows?	<ul style="list-style-type: none">●See Section 5.4 of the Flood Estimation Guidelines.●Uncertainties in the peak flow estimates should always be quantified if it is possible to do so for the method applied.●Note that the confidence limits given in the Flood Estimation Guidelines assume that the AMAX flows follow a generalised logistic distribution. If you have fitted a different distribution, these confidence limits will not be applicable.●Complete the table with flows from the uncertainty analysis. The default is the 95th percentile upper and lower bounds, but other estimates may need to be provided depending on the requirements of the study.	OK	Uncertainty bands are reported on.			
9.5.5	Is the suitability of the results for future studies considered?	<ul style="list-style-type: none">●With reference to the assumptions, limitations and uncertainties, comment on the suitability of these calculations for future studies, e.g., at nearby locations, or for different purposes such as detailed scheme design.	Green	The calculation record does not comment on the suitability of the results for future studies.	Update Section 6 to include comments about the suitability of the results for future studies.	Noted in the event of a future update.	
9.5.6	Are recommendations made for future work?	<ul style="list-style-type: none">●Make recommendations for how assumptions, limitations and uncertainties could be reduced in future work, for example flow monitoring, rating reviews, etc.	OK	Recommendations provided for installation of a flow gauge (temporary or permanent) which would help to verify and improve flow estimates for all of the study catchments.			
9.5.7	(Additional space for other items checked)	N/A					



10. Appendix

10.1 Digital files							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
10.1.1	Are input data, output data and profile files available to provide evidence of calculations?	●If you are submitting work commissioned by the Environment Agency or for review by the Environment Agency, you should be prepared to submit as digital files your input data, output data and project files (where these exist) from the software you have used in the flood estimation. Refer to Section 8.1 of the Flood Estimation Guidelines. ●Use this section to list the files you are submitting, if relevant.	OK	Reports provided only.			
10.1.2	Do the digital files use the same input data and parameters, and give the same results, as listed in the report?	N/A					
10.2 Other supporting information							
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2
10.2.1	Is other supporting information included as needed, complete and accurate?	●Include any additional information which best sits here rather than in the section text, for example, flood peak series, details of historical flood events, rating reviews, pooling groups, or details of flood event analysis. Include important information in the section text, for example, comparison of growth curves, or results of flood event analysis.					
10.2.2	(Add additional items checked here and below as needed, to review the supporting information included in the Appendix or separate reports.)						
10.2.3	(Additional space for other items checked)						
10.2.4	(Additional space for other items checked)						
10.2.5	(Additional space for other items checked)						
10.2.6	(Additional space for other items checked)						
10.2.7	(Additional space for other items checked)						

NON-REAL TIME HYDRAULIC MODEL REVIEW



Type of review Fluvial/tidal 1D-2D model

Project	Cambourne to Cambridge	Job Number		Required coastal standard (if applicable)	
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Model Type	1D/2D	Software	FMP/TuFlow	2nd review	3rd review	4th review
Revision		Date	02/11/2023	Mar-25		
Area Client		Reviewer	Arcadis Consulting Ltd	Arcadis Consulting Ltd		

REVIEW SUMMARY/CONCLUSION

Is the model suitable for intended use?	The model is currently unsuitable for the intended use. There are queries relating to the 1D model, 2D model and 1D2D linking that require addressing. The representation of the bank lines and structures needs reviewing. The 1,000-year +19% CC event glasswalls against the model boundary.
Is the model suitable for intended use?	<p>2nd Review Summary - March 2025</p> <p>The model is not currently suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.</p> <p>Red Comments</p> <ul style="list-style-type: none">•There is still some glass walling in 2d domain, please extend the code boundary accordingly.•The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs.•Have the model results been compared with Flood Zones maps as well? Please provided evidence of the comparison in the report and discuss why the differences with the previous modelling occur.•Please update the zpoints as the zpoints on bankline and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.•The report does not include full results and more details need to be added in term of assumptions made to model the structures. <p>Amber Comments</p> <ul style="list-style-type: none">•Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.•Surveyed cross sections should be referenced in the model/.dat file and a structures table/log should be provided to enable the checks on structures dimensions.•Please update the report to include how inflows have been applied in the model. A figure of the catchment boundary should be included in the report.•Please include justification to omit those footbridges. If unavailability of survey is the prime reason, some assumptions can be applied to consider the losses. Also, provide structures log for the omitted structures.•Please provide a structure log with reference to the surveyed cross section including naming convention. The structures log should also include the assumptions considered to model the structures. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the dimensions for BB01_1034cd culvert were defined, as the survey does not contain this information.•Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m.•Please revisit the approach to model the 1d channel under Robinsons College Building.•Overflow Ditch Channel length and culvert dimension needs to be updated, and height contraction coefficient need to be defined for the culvert•The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream.•The slope has been updated, and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.•Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?•It is not clear which option is the final one for the proposed case scenario, please clarify that for example copm1 and comp2 results are not provided to review. XMDF files have not been provided, these would help the reviewing process.

MODEL REVIEW PROCESS

Hydraulic Model reviews are an essential component of the Hydraulic Modelling Quality Assurance (QA) process that provides confidence in a model's suitability for its intended purpose. Evidence that the model has undergone QA may be requested by external parties and hence all reviews should be written with an expectation that they could be read externally.

Should any issue(s) be raised during the review process, which require attention, the reviewer should detail the action(s) required in sufficient detail to allow the modeller to complete the changes as appropriate. Completion of this Model Review document does not automatically constitute model approval. Once the suggested changes have been completed, the reviewer may require that the model be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all the amendments have been completed satisfactorily, will the model be approved and the quality assured by the reviewer.

It is recommended that the reviewer makes good use of the fluvial design guide chapter 7 and the user manual/help guides for the appropriate modelling software.

Depending on the work being reviewed some questions or entire sections may not be relevant, in which case they can be deleted. On completion of the review the reviewer may choose to use the following colour coding system to alert the modeller to the priority of the actions required (if any).

Colour coding used:

OK – Good practice.
Minimum response: No minimum.
Maximum expected response: No maximum.
Planning: No Objection.

Green – Consider for future studies. Negligible impact on the results that is unlikely to change the outcome of the study.
Minimum response: Acknowledge the comment in the spreadsheet and update the limitation section of the report.
Maximum expected response: Actions done to address the issue identified.
Planning: No Objection.

Note: Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.

Amber – Follow recommendation. Potential impact on the results that may change the outcome of the study.
Minimum response: Comments justifying the approach taken and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Consider objecting to the application based on comments highlighted in this category.

Note: Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.

Red – Must do. Has an impact on the results that may have a significant impact on the outcome of the study.
Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if not sorted.
Maximum expected response: Actions done to address the issue identified.
Planning: Objection - Application to be objected if comments are highlighted in this category.

Note: If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidences. If issues highlighted red are ignored, then submissions should always be sent back

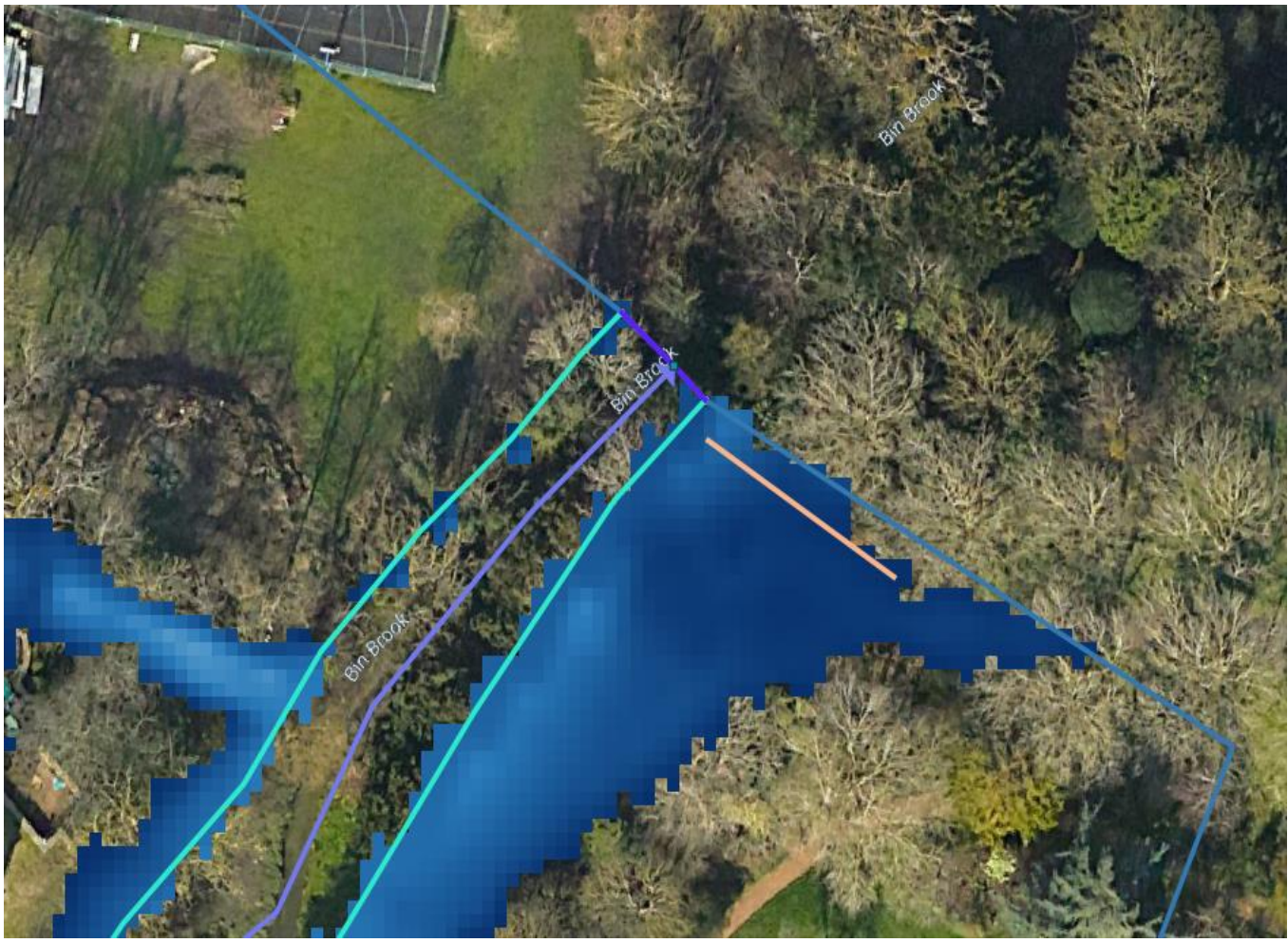


Figure 1: Downstream boundary not snapped to code layer

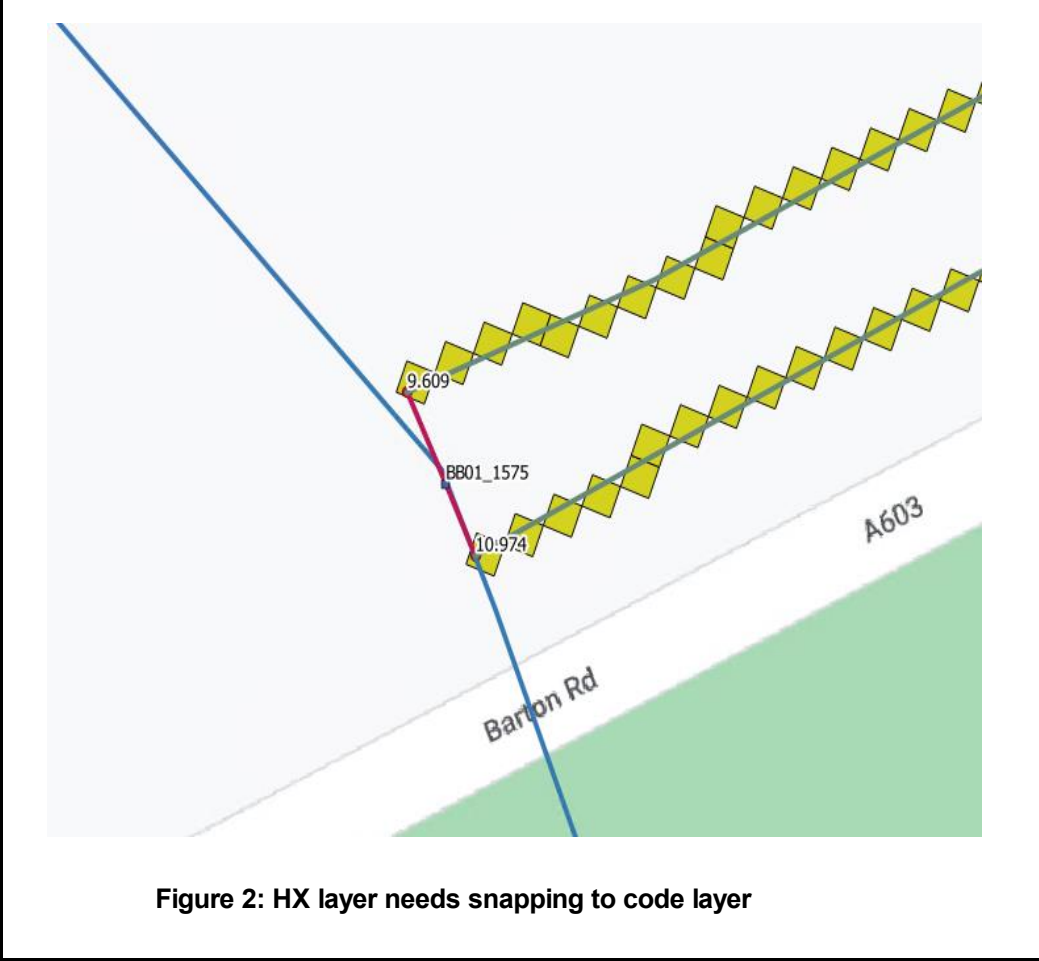


Figure 2: HX layer needs snapping to code layer

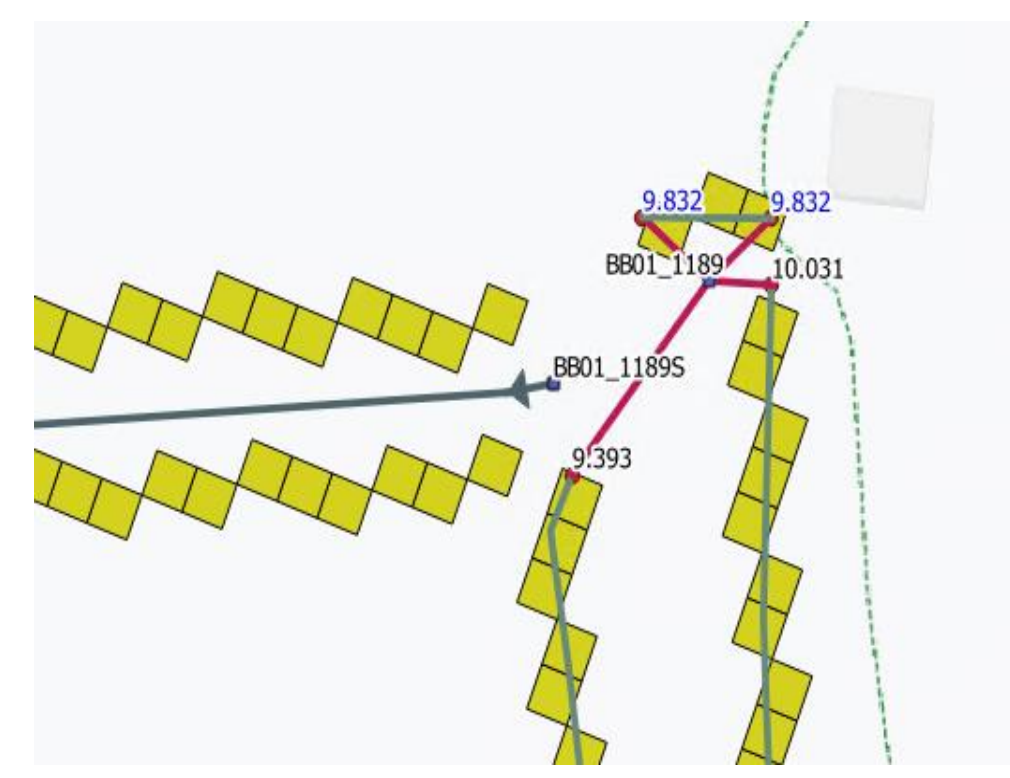


Figure 3: HX link gaps at watercourses and structures need closing



Figure 4: 1d_node / CN lines placed upstream of 1D cross section location, and ungeoreferenced cross sections



Figure 5: Glass walling at the upstream extent of the code layer

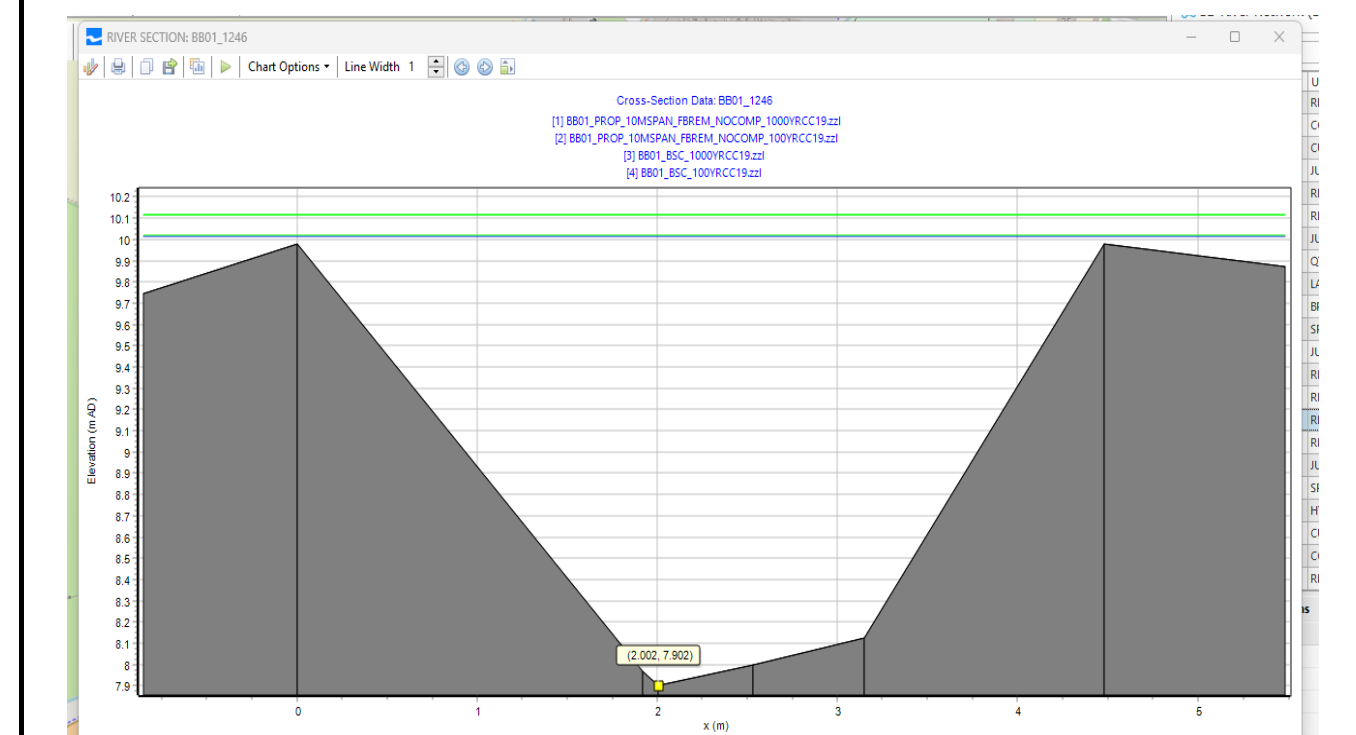


Figure 6: Cross section BB01_1246 which needs to be deactivated at bank top

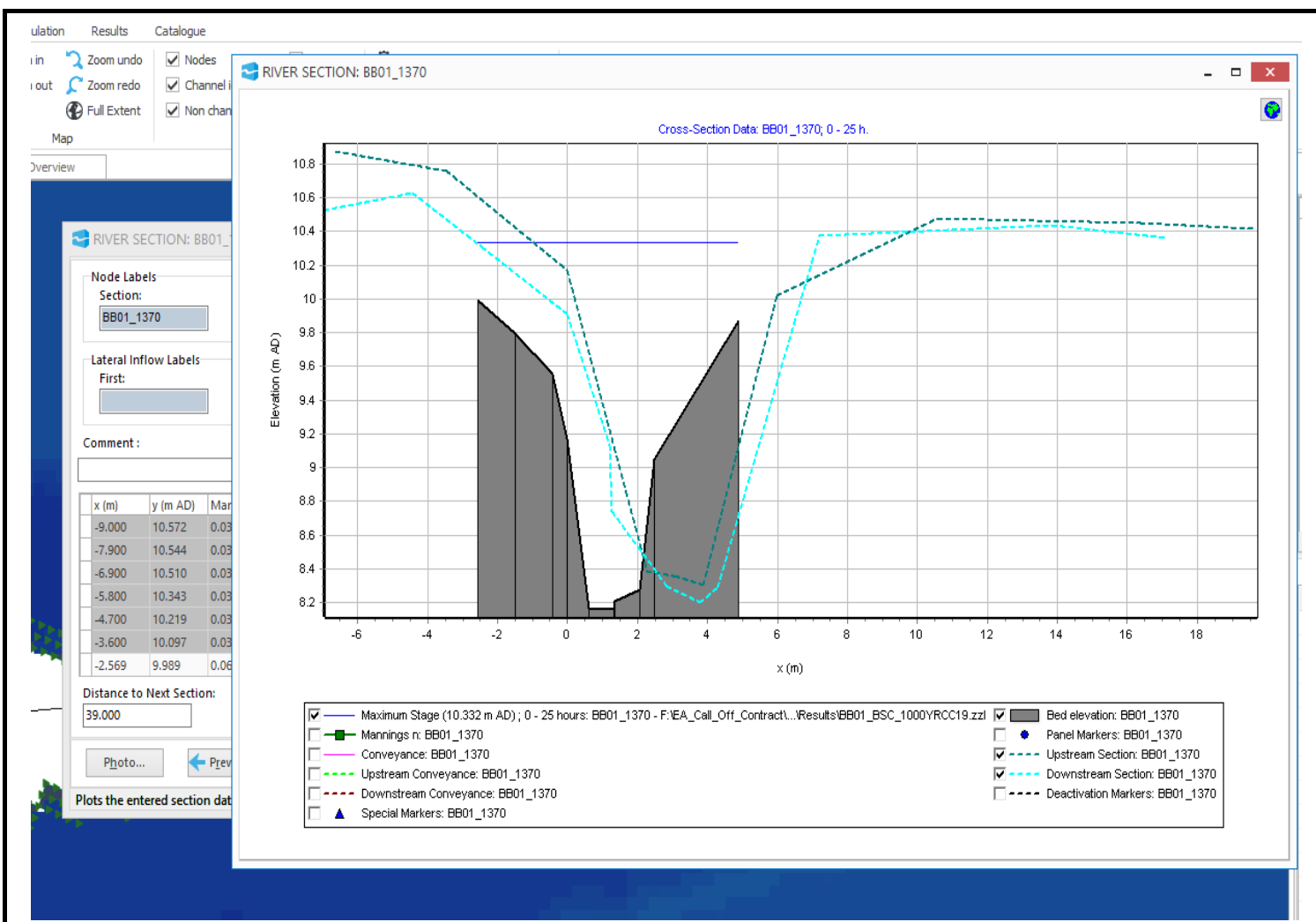


Figure 7: Glass walling in the 1D model. Upstream and downstream section with very different widths. 1d2d widths do not match. 2D width = 14m

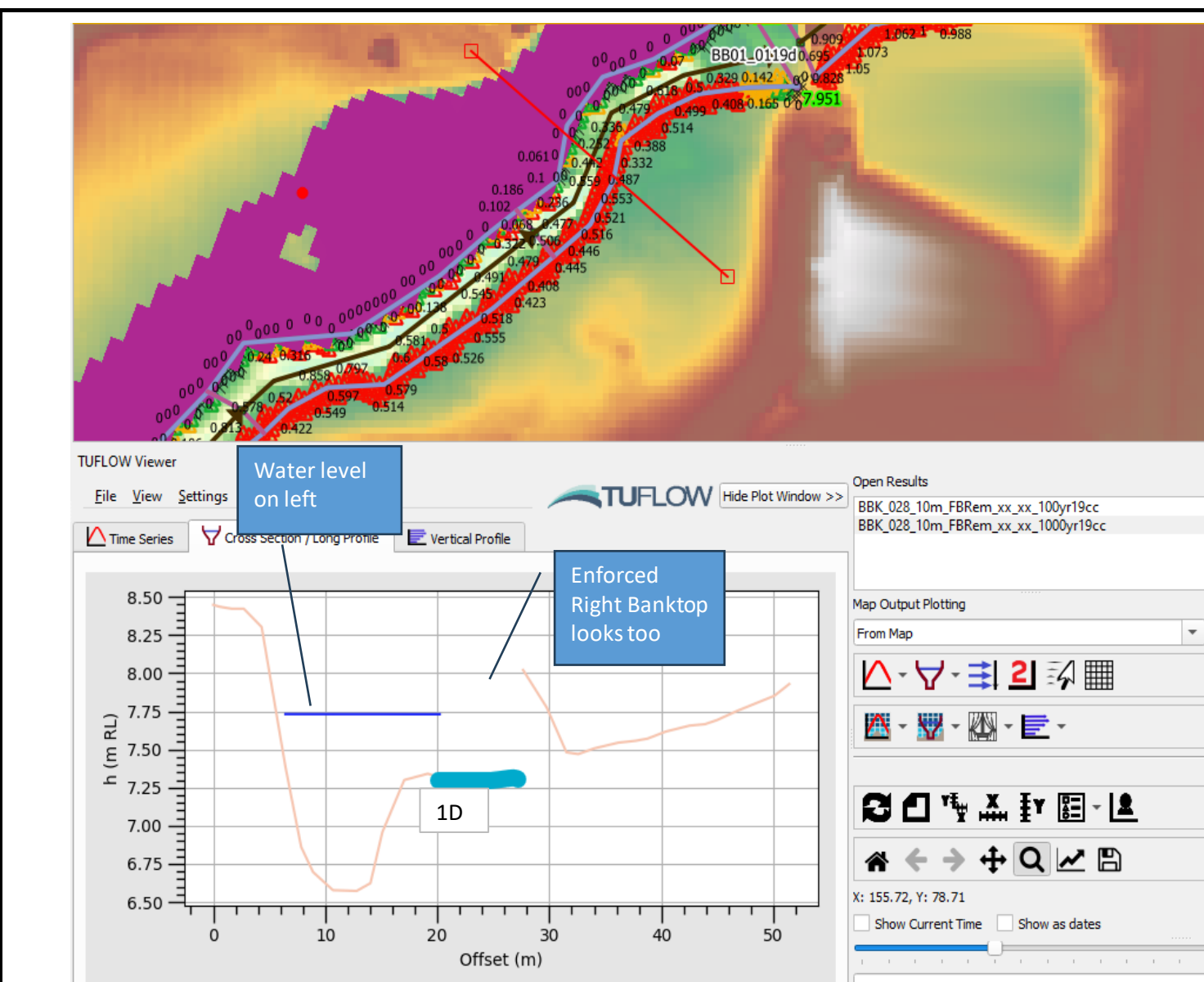


Figure 8: 1d_bank levels are interpolated and appear artificially high preventing water spilling to floodplain

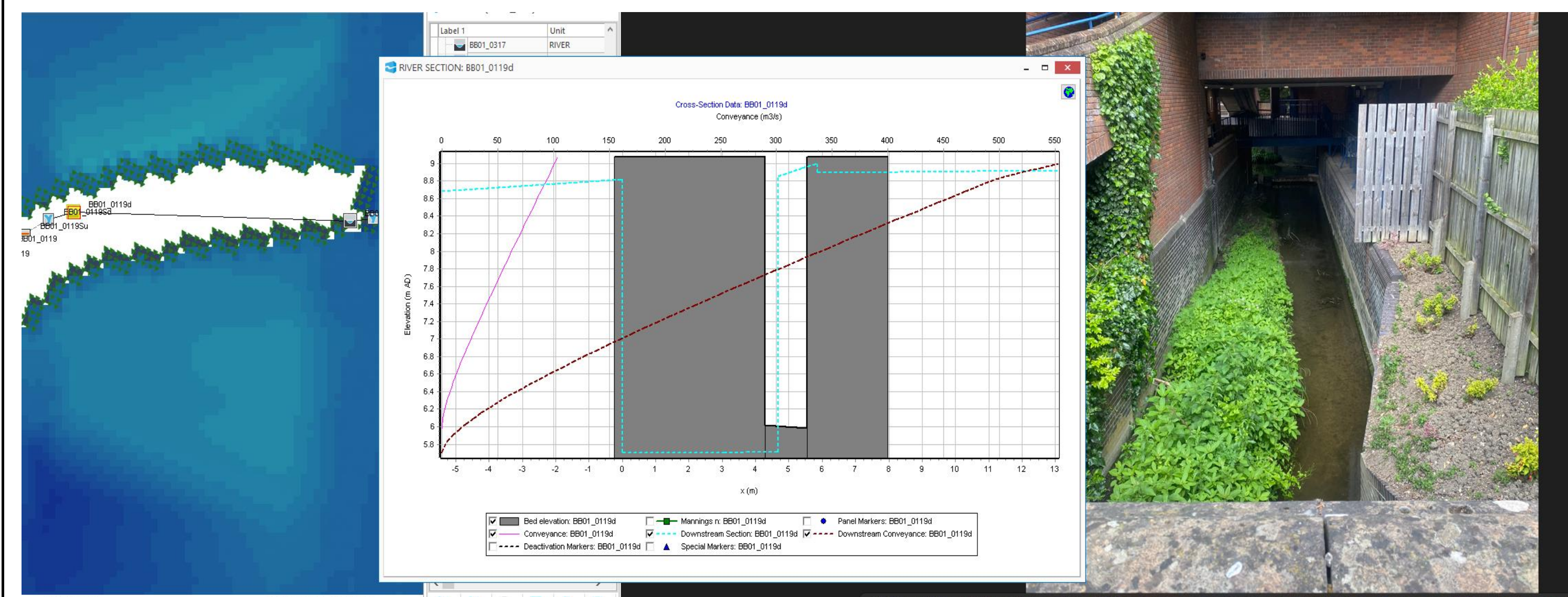


Figure 9: Section BB01_0119d is located downstream of the weir BB01_0119. The distance to next is 70m to the bridge. The channel cross section is 1.7m wide upstream and 4.7m downstream - this is modelling a tapering channel, the survey photo suggests the channel widens immediately downstream of the weir - the modelled channel reach appears to be too narrow as interpolates from one section to the next.

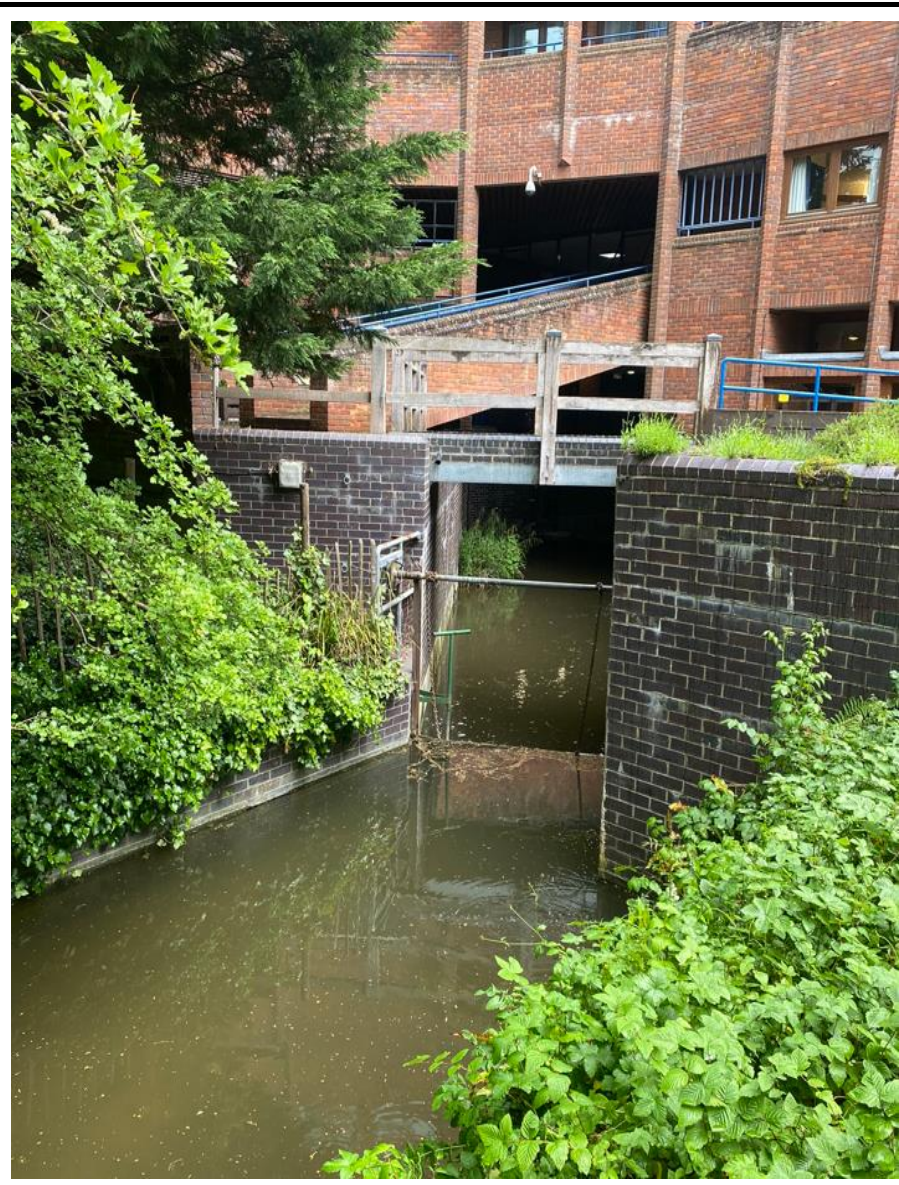


Figure 10: Weir looks to be sharp crested model with default broad crested coefficient

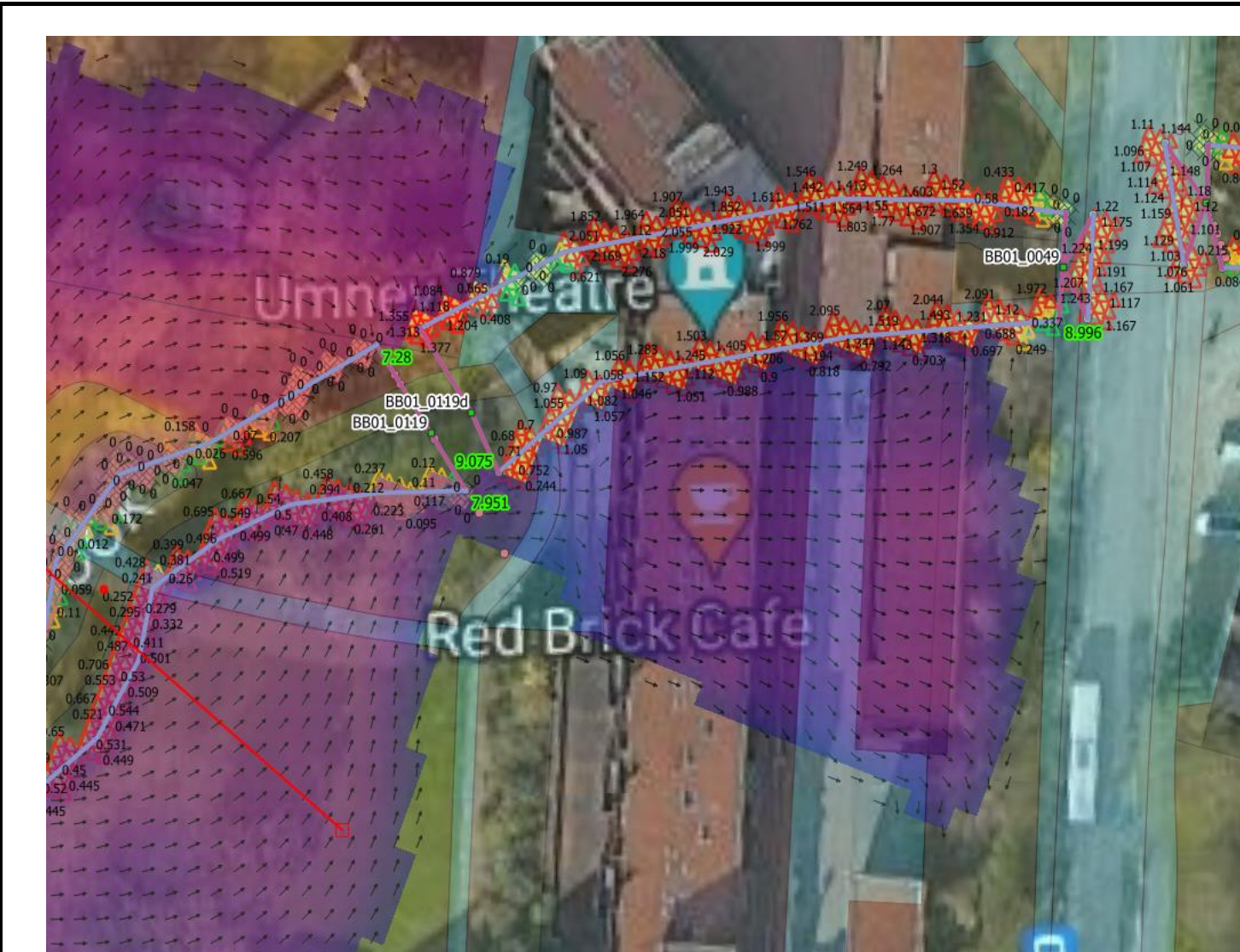


Figure 11: Split in the 2D link location for the weir looks slightly too far upstream. Flow appears to be by-passing the weir but the survey photos indicate ground levels behind may be higher. Modelling a manning's 'n' is standard however in this instance further consideration needs to be given on the levels and flow mechanisms being modelled under / through the building. Are these correct, can water flow through the building and back into channel?



Figure 12: The flow not modelled in 2D possibly preventing flow over the bridge deck.

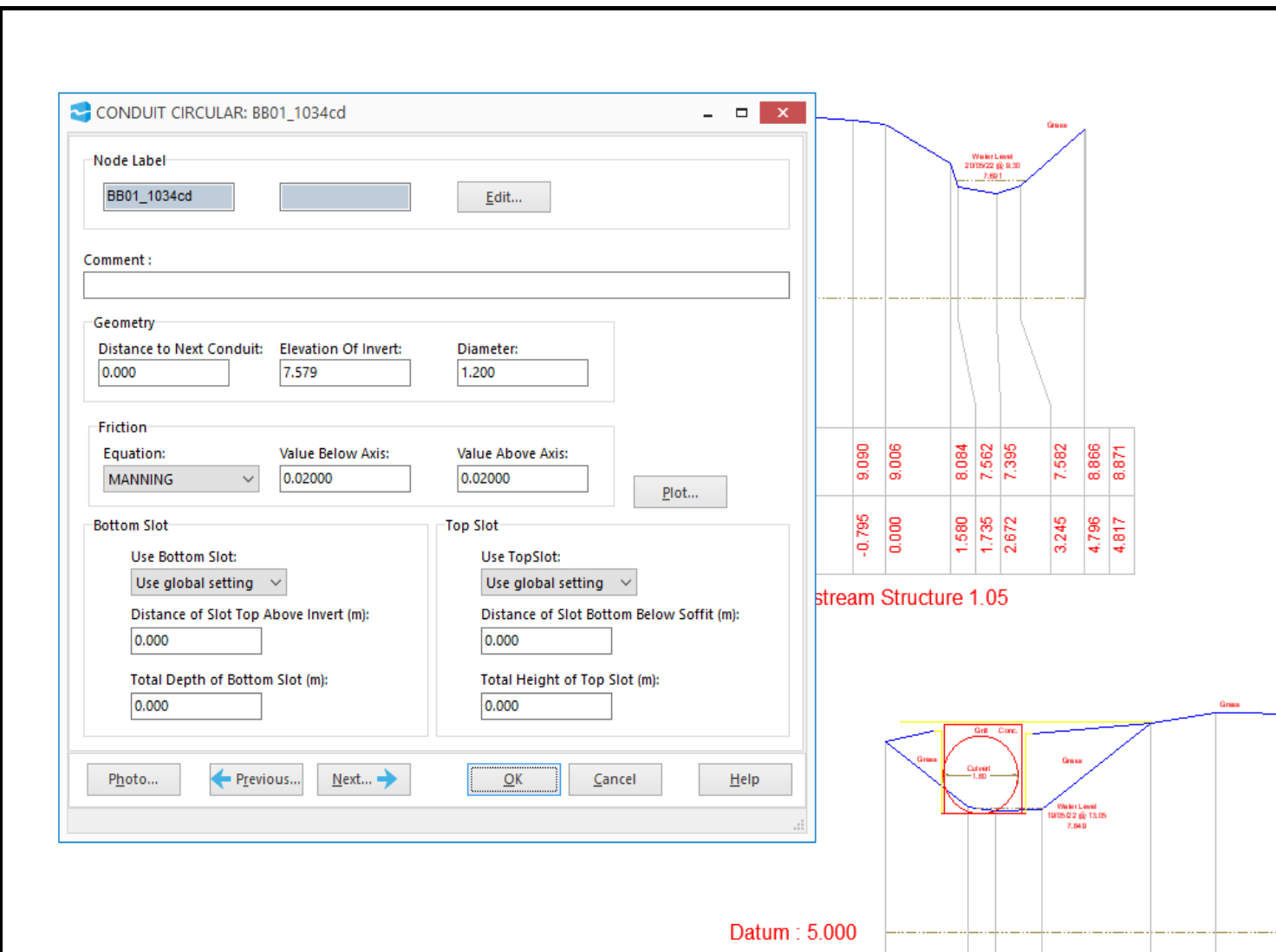
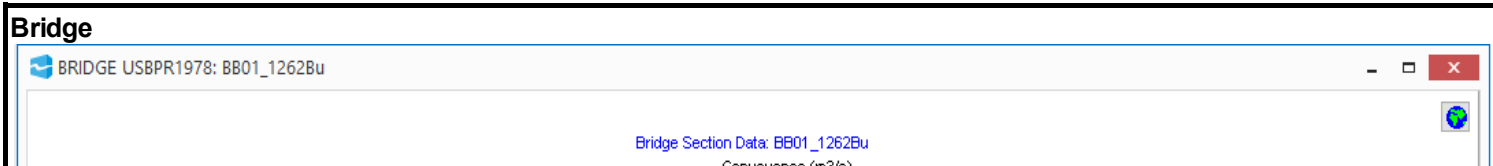
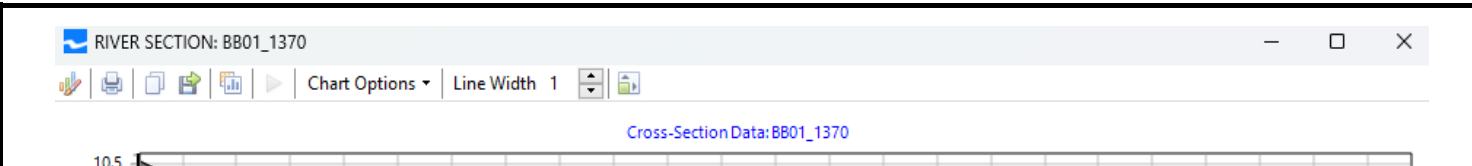


Figure 13: BB01_1189ci modelled as 1.8m diameter the culvert exit BB01_1134cd is modelled as 1.2m diameter. This decrease in culvert size does not appear to match the survey data



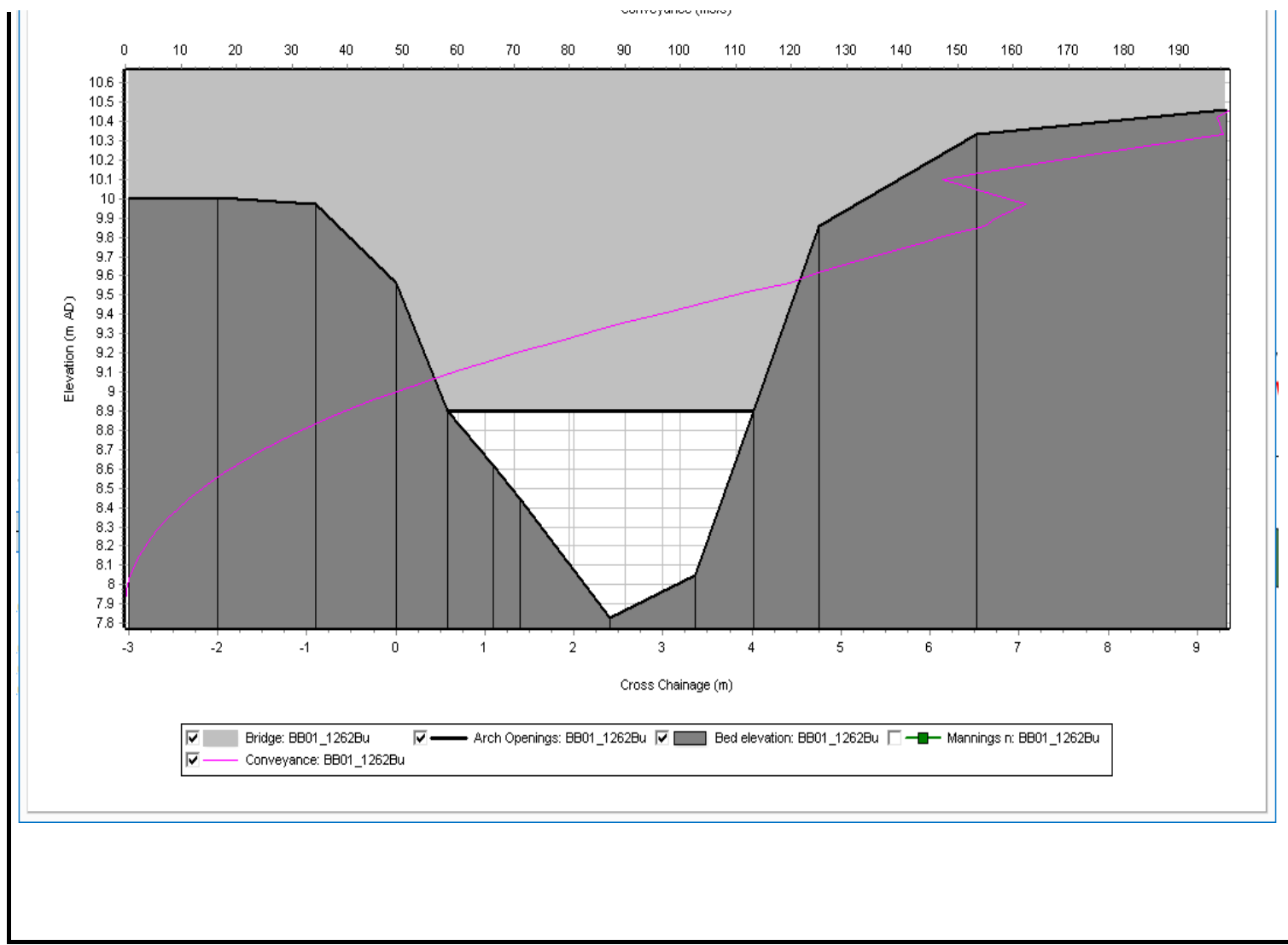
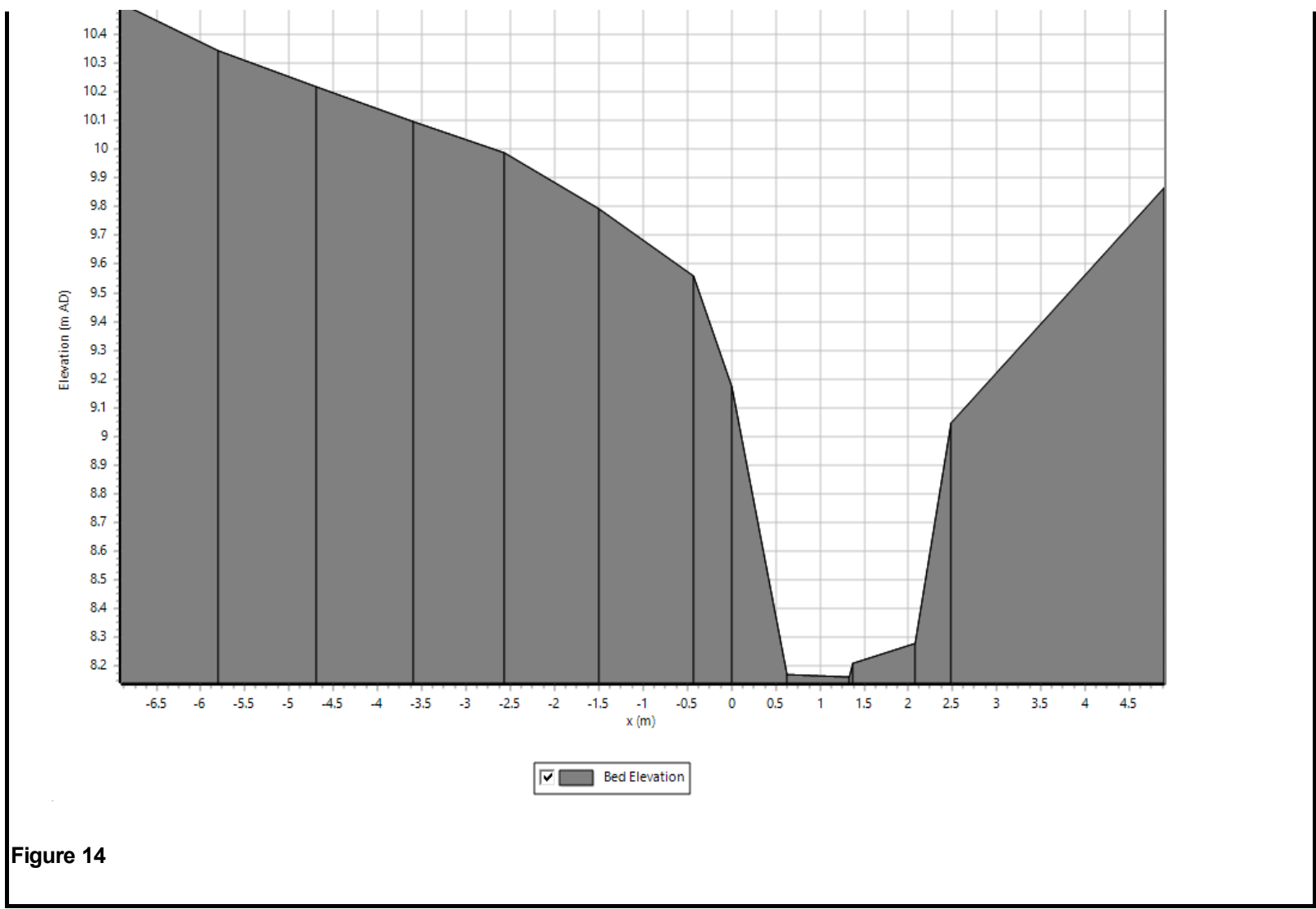


Figure 14

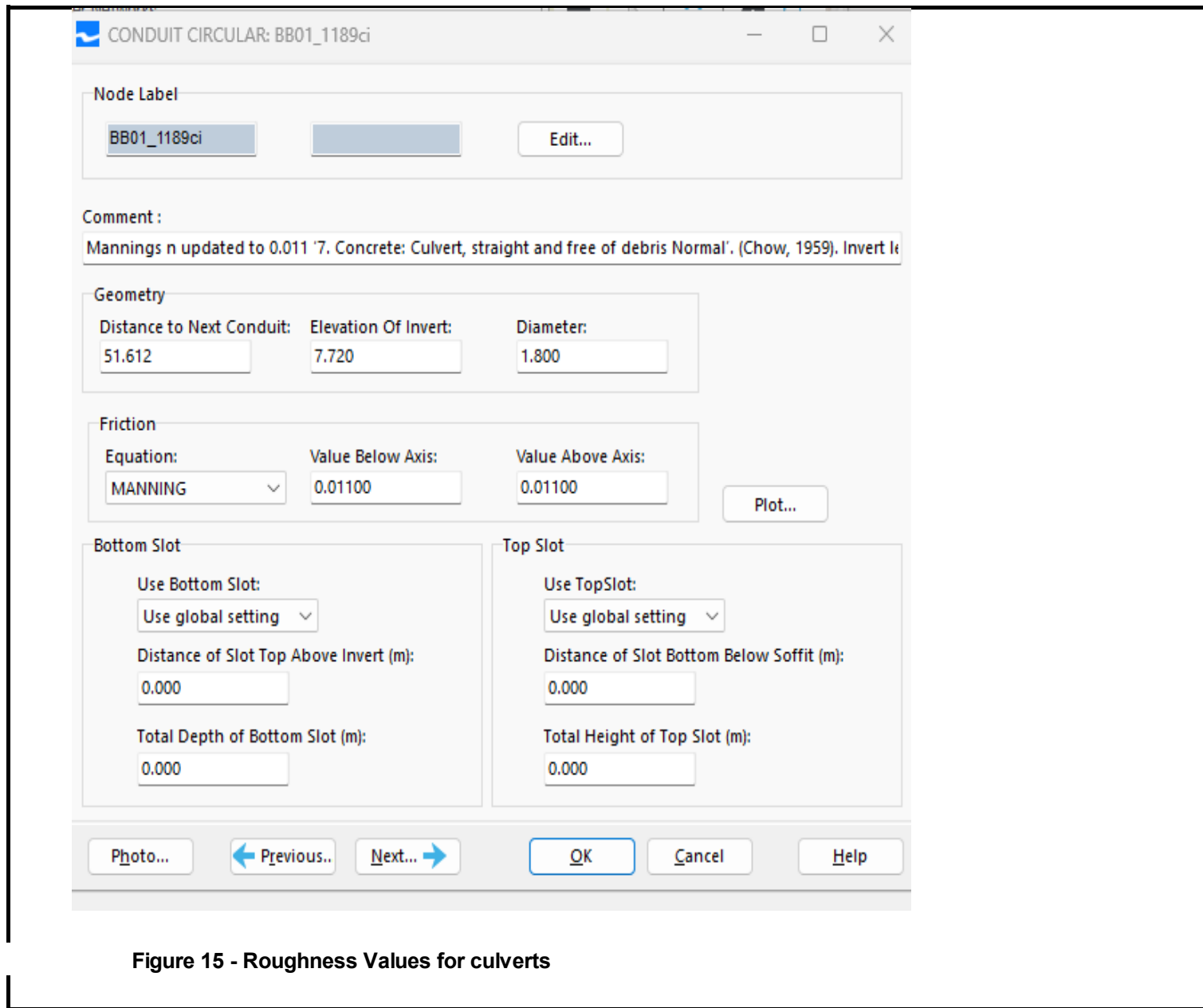


Figure 15 - Roughness Values for culverts

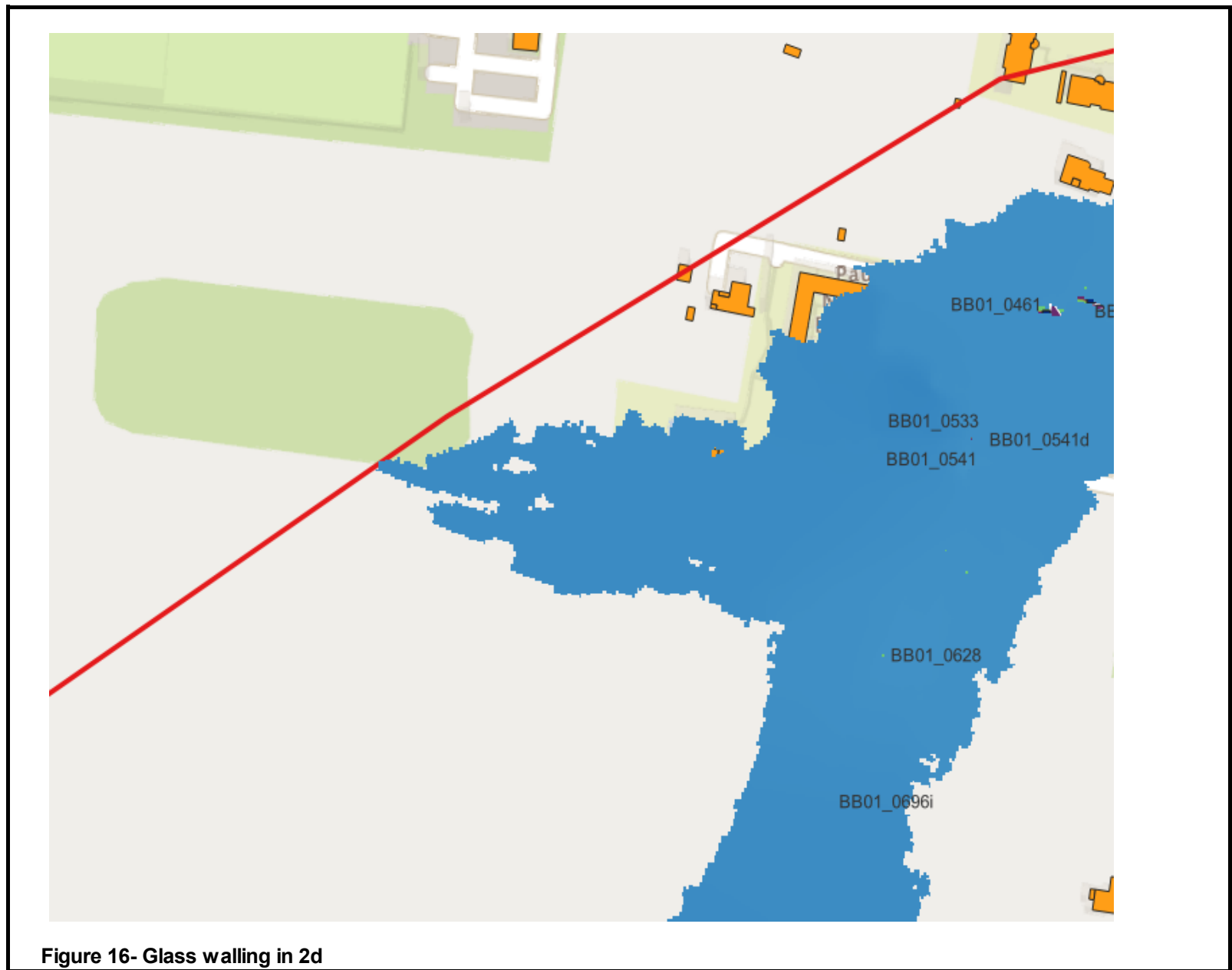


Figure 16- Glass walling in 2d



Figure 17 - Downstream boundary needs to be applied where glass walling occurs

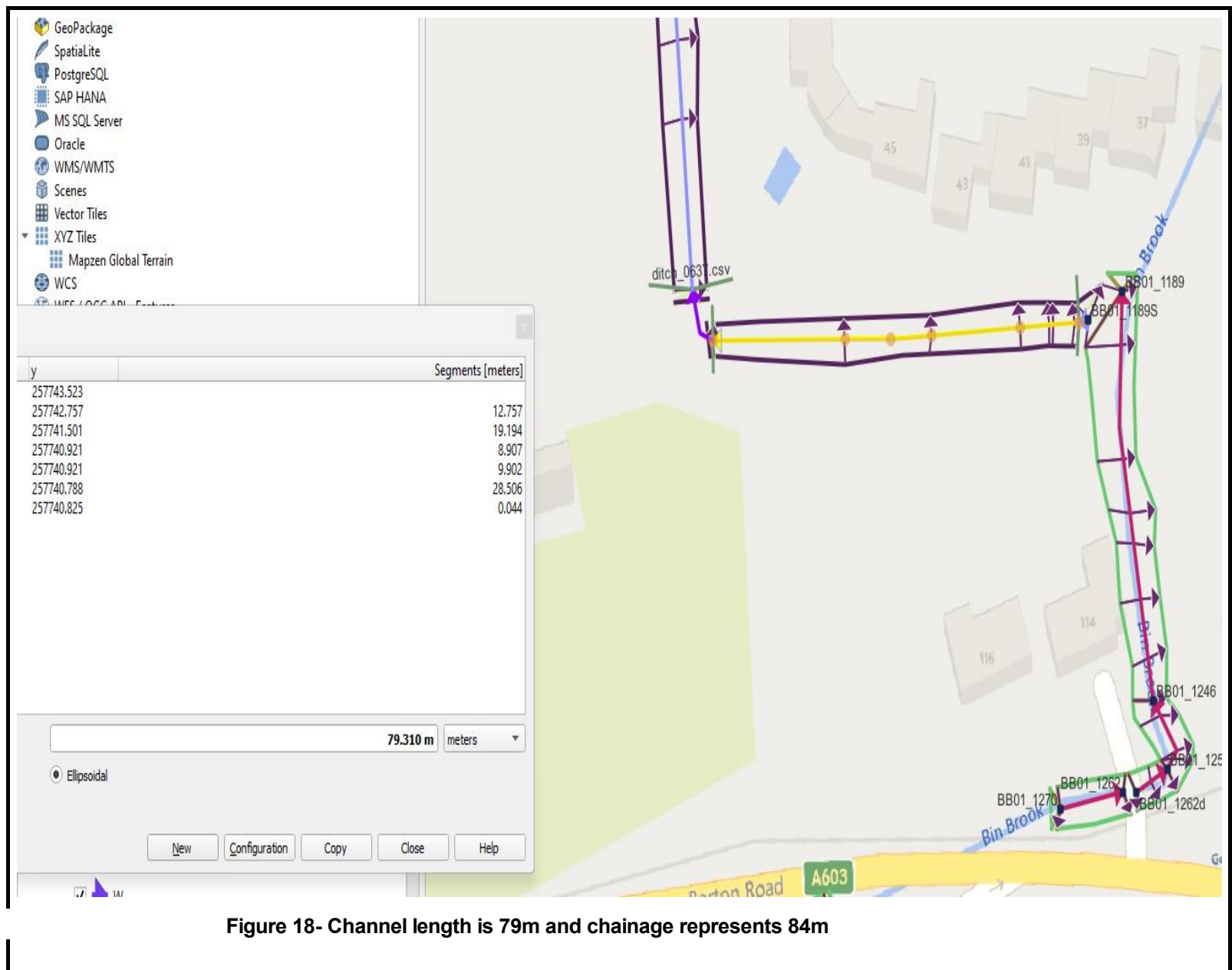


Figure 18- Channel length is 79m and chainage represents 84m

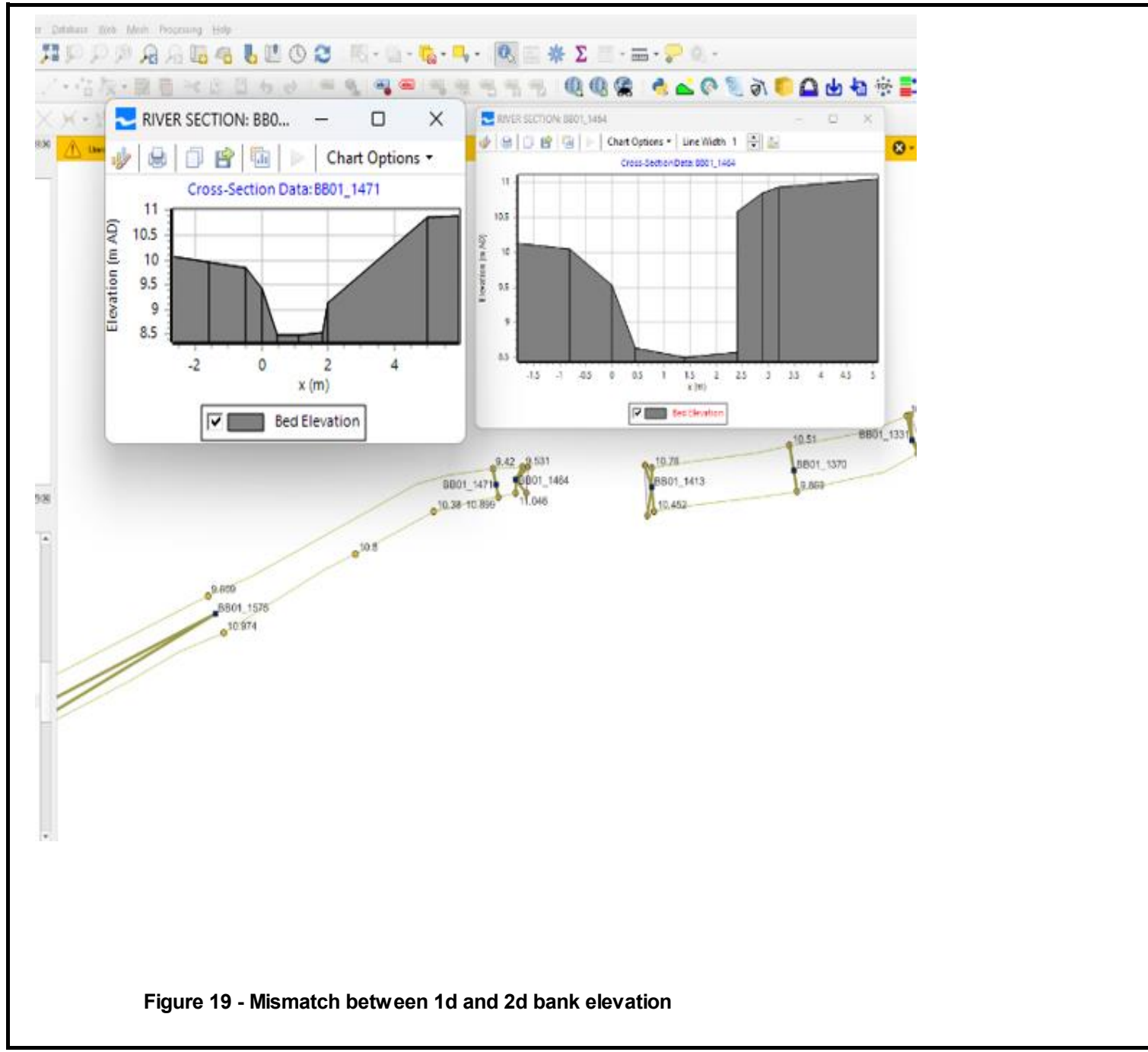


Figure 19 - Mismatch between 1d and 2d bank elevation

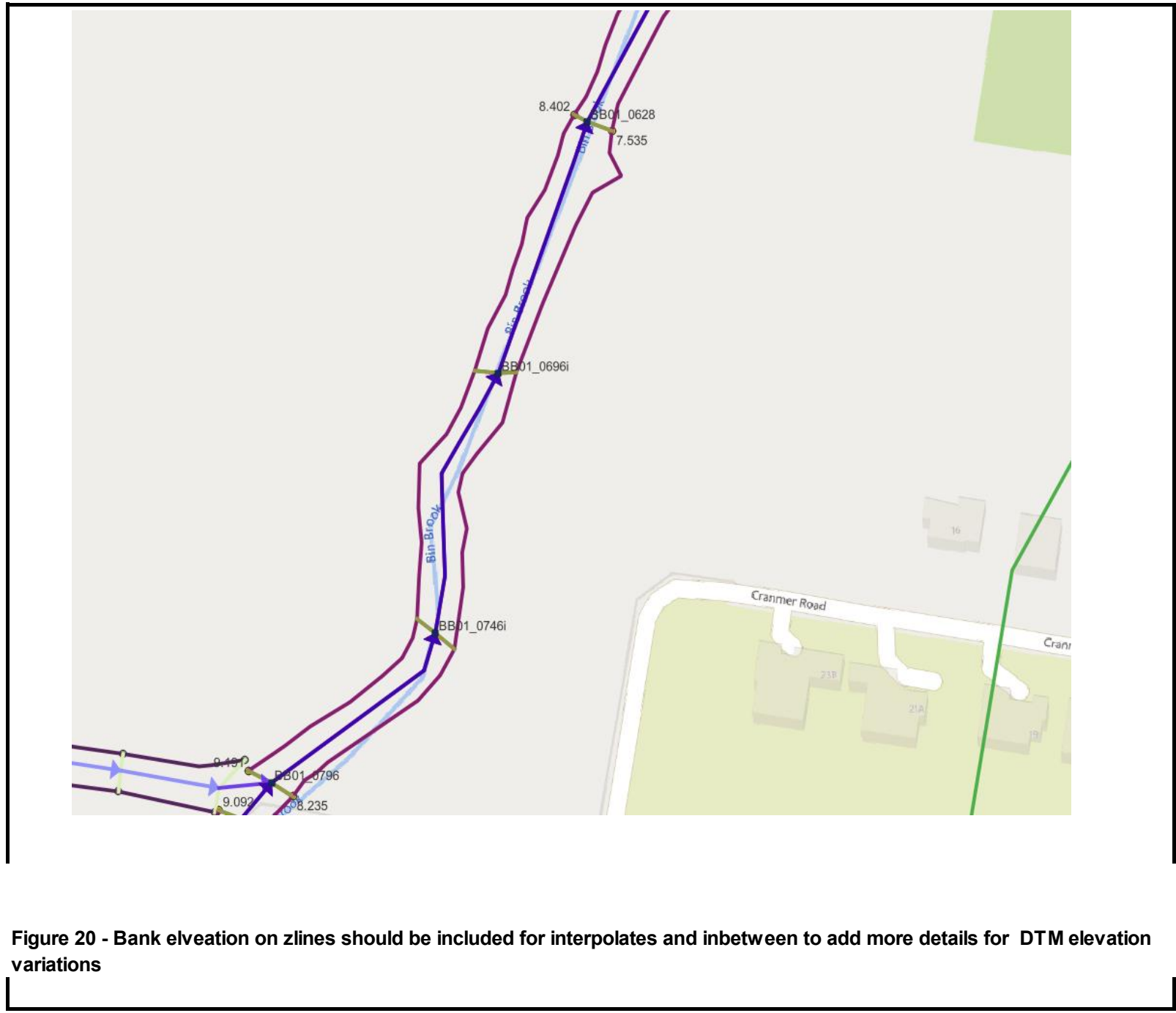


Figure 20 - Bank elevation on zlines should be included for interpolates and inbetween to add more details for DTM elevation variations



Figure 21 - Section BB01_1575 has been connected ~230m upstream

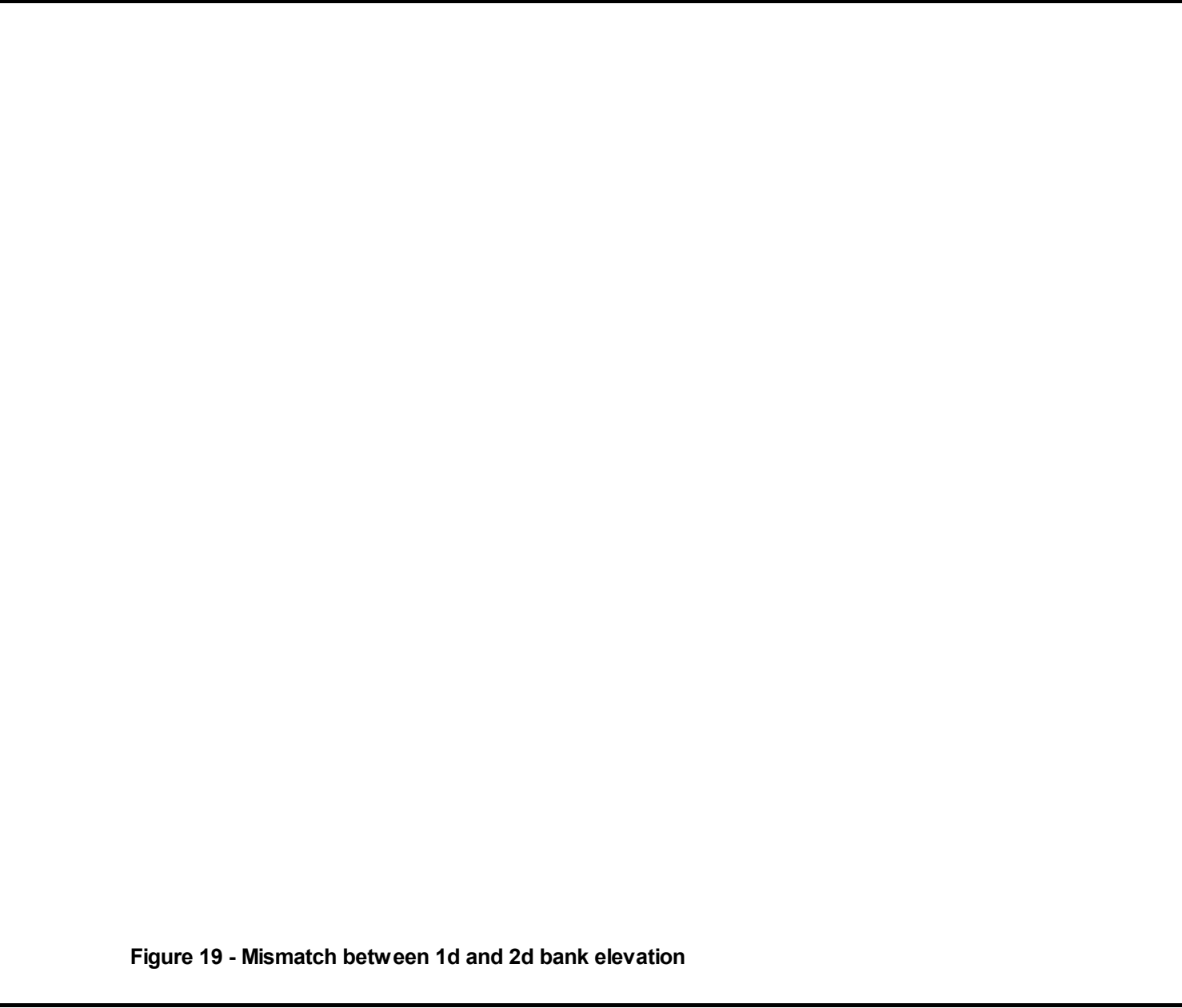


Figure 19 - Mismatch between 1d and 2d bank elevation

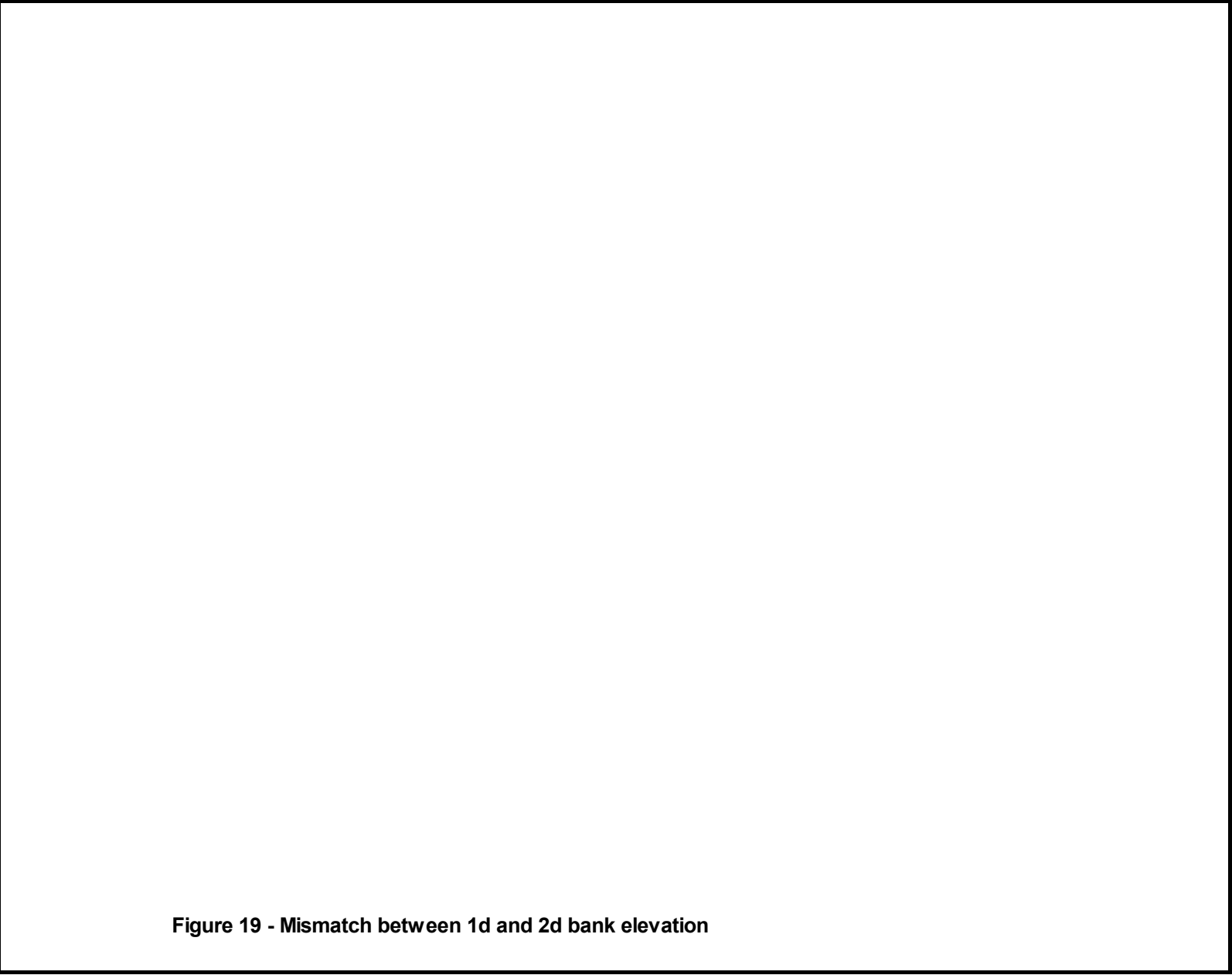


Figure 19 - Mismatch between 1d and 2d bank elevation

Runs

Name	Description	Provided
BB01_BSC_100yrCC19	Baseline scenario - 100-year +19% CC	✓
BB01_BSC_1000yrCC19	Baseline scenario - 1,000-year +19% CC	✓
BB01_BSC_100yrCC19DSde	Baseline scenario with a 20% decrease in DS boundary event scenario - 100-year +19% CC	✓
BB01_BSC_100yrCC19DSin	Baseline scenario with a 20% increase in DS boundary event scenario - 100-year +19% CC	✓
BB01_BSC_R20de_100yrCC19	Baseline scenario with a 20% decrease in roughness sensitivity test - 100-year +19% CC	✓
BB01_BSC_R20in_100yrCC19	Baseline scenario with a 20% increase in roughness sensitivity test - 100-year +19% CC	✓

BB01_Prop_10mSpan_FBRem_Comp1_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and Floodplain compensation area 1 - 100-year +19% CC	✖
BB01_Prop_10mSpan_FBRem_Comp2_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and Floodplain compensation area 2 - 100-year +19% CC	✖
BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and no compensation - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_NoComp_1000yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and no compensation - 1,000-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_R20de_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% decrease in roughness scenario - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_R20in_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% increase in roughness scenario - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_xx_100yrCC19DSde	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% decrease in DS boundary event scenario - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_xx_100yrCC19DSin	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% increase in DS boundary event scenario - 100-year +19% CC	✓



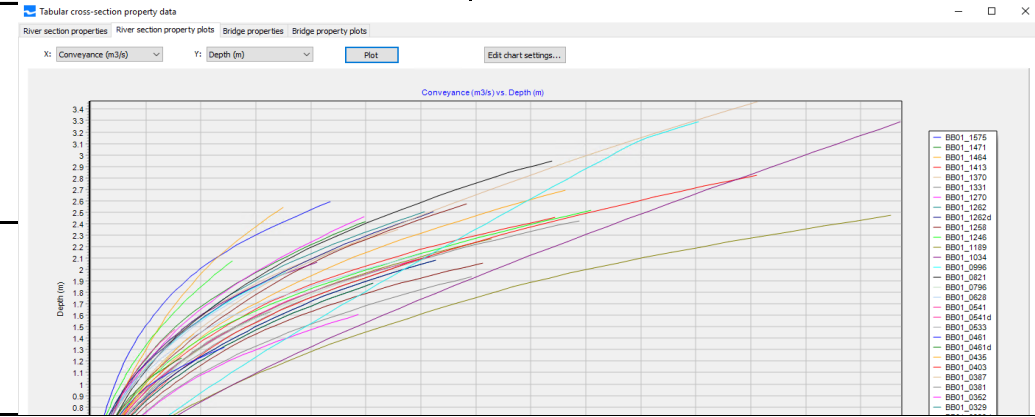
PROJECT BACKGROUND AND APPROACH

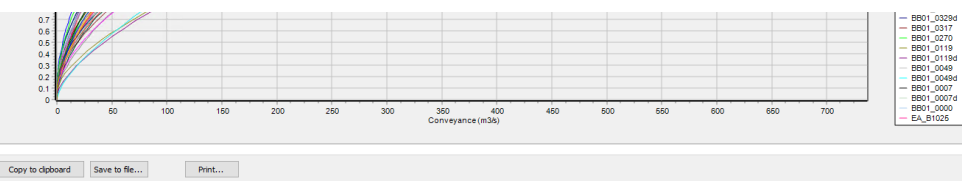
PROJECT DESCRIPTION & REQUIREMENTS									
		Flood risk modelling has been undertaken to inform the design of the proposed bus route connecting Cambridge to Cambourne. The study uses an existing model of the Bin Brook and has been updated using topographic survey data and the designs of the bridge. Both a Baseline and a Proposed scenario are represented and have been reviewed.							
MODEL APPROACH & SUMMARY									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
1.1	What model approach has been adopted? Is it appropriate? (e.g. new 1D/2D build, existing model truncation, 1d only?).	OK	Existing EA 1D-2D FM TUFLOW model of the Bin Brook has been used and updated to assess the scheme. The model has been updated with topographic survey from the upstream extent of the survey down to Burrell's Walk (northeast of Grange Road), these are all sections called BB01_XXXX. This leaves only five original cross sections, called EA_BXXXX. Therefore, a full review of the model has been conducted.						
1.2	Software used, including versions?	Green	Model has been run with FM VER=5.1.0.8423 and TUFLOW 2020-10-AD-ISP-w64. This is not the latest version of the modelling software available, the latest is Flood Modeller 6.2 and TUFLOW 2023-03-AC.	Please use the latest software versions for future runs.	The updated software would provide no or minimal change to water levels. It is more important that both pre and post scenarios are run utilising the same version of software rather than the version.	Amber	Tuflow version 2023-03-AC-ISP-w64 and Flood Modeller VER=5.1.0.8423 have been used for latest runs. The Using Modelling for Flood Risk Assessments guidance (www.gov.uk/guidance/using-modelling-for-flood-risk-assessments) states that applicants should "build and run models in the latest versions of software, or provide robust justification and testing if this is not possible" and "it's your responsibility to check the suitability of an existing model for your development". Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.	Model was run with supported versions of the relevant software at the time of the assessment. The 1% AEP event to be re-run using Tuflow 2025 and Flood Modeller 7 to provide confirmation of no change in results. There are no significant matters listed in the release notes for either software that would impact on results from this study.	
1.3	Model Version Reviewed	Red	The version of the model has only been defined in the TUFLOW section of the model (which uses v.011 for the .tbc and .tgc, and v.028 for the .ecf and .tcf). Nothing has been used for the 1D files which is not best practise. Note, the naming convention is not the same for all scenarios (e.g. the DS boundary sensitivity tests are defined as an event (-e1 100yr19ccDSde) where as the roughness tests are defined as a scenario with the event separately (-s4 R20de -e1 100yr19cc). This is confusing. In addition, the IEF file for the COMP1 and COMP2 writes results called 'BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19' in the 1D, which will overwrite. This needs to be fixed so all results can be produced for all events.	Fix the naming convention so it follows the same pattern, and define versions for the 1D files. Fix the results file paths for the COMP1 and COMP2 1D results so all model results can be outputted correctly.	Updated 1D files with version numbers where necessary. Updated naming for the sensitivity tests. The .ief for the COMP1 and COMP2 has been updated to write out separate results.	OK	The naming convention appears fine now, although the .ief COMP1 and COMP2 have not been provided and hence not reviewed.		
1.4	Are all model files provided?	OK	All model run files are provided.						
1.5	Does the model run?	OK	As part of this review, the model has been run using FM 6.2 and TUFLOW 2023-03-AC-ISP-w64 which are the latest versions. As in 1.3, the IEF file for the COMP1 and COMP2 results saved the 1D results with the wrong name. All other runs completed.						

EVENTS & SCENARIOS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
2.1	What events have been simulated (Q5, Q100, Q100CC, Q1000)? Are they sufficient to meet the project requirements?	Green	Two events modelled, the 100-year +19% CC and the 1,000-year +19% CC. Note the Model Report states the model was run for the 100-year +19% CC only in Section 2.3.4.	Update the Model Report to include reference to the 1,000-year + 19% CC event.	Updated.	OK	The report has been updated.		
2.2	Is a development being modelled? If so are appropriate scenarios modelled to assess the impact?	Green	Yes, both the Baseline and a Proposed scenario have been modelled, both are being modelled for the 100-year +19% CC and 1,000-year +19% CC events. For the Proposed scenario, the Model Report in Section 2.2.6 references three different bridge spans (10m, 16m and 21m), along with a removal of the downstream footbridge scenario, a retainment of the downstream footbridge scenario and floodplain compensation areas 1 & 2. Only the 10m span with the downstream footbridge being retained scenario has been provided and reviewed here.	The requirement to review the other scenarios (wider bridge spans and downstream footbridge retainment) should be revisited following model updates flagged in this review.	Only the 10m span opening is proposed and therefore only that model has been supplied. The outcome from the minor modifications shows that the 10m option is still to be taken forward.	OK	Thank you for clarifying.		
2.3	Flood Mapping scenarios?	OK	No						
2.4	Have climate change runs been undertaken?	OK	All runs have 19% climate change allowance applied, which is the Higher bound to 2080.						
2.5	Has a study for quantifying uncertainty been undertaken? If yes, what are the results?	OK	Both the Baseline and the Proposed model has been run for the Manning's ±20% and the downstream boundary ±20% for the 100-year +19% CC event. See Section 16 for comments on the results.						



[Chow roughness values](#)

1D MODEL BUILD									
1D NETWORK									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
3.1	Model overview: Node Summary 1d length	OK	Baseline model has 103 nodes and the Proposed model has 98 nodes. The difference in nodes is the removal of the bridge BB01_0541Bu and associated junctions, spill unit and downstream cross section in the Proposed model, which is in line with the results and control files provided. Both models are 1.798km in length. The FMP 1D model summary tool shows that the average spacing between nodes is around 50m. This spacing seems appropriate to capture changes in bed levels along the watercourse.						
3.2	Have appropriate distances between sections and/or nodes been used (dx)?	OK	FMP Summary tool shows the Baseline model has 6 nodes fail the erratic node spacing check, and 7 nodes fail in the Proposed scenario. This should not impact the model results.						
3.3	Are out of bank flows represented in 1d? If so, how has it been done and is it appropriate?	OK	Out of bank flows have been represented in 2D.						
3.4	Is the model geo-referenced?	Green	Model can be opened in both Flood Modeller and QGIS. Note, when displaying the locations of the cross sections as a line, a large number of the cross sections are only partially georeferenced. Ideally XY co-ordinates should be added to the cross sections so it is fully georeferenced.	Please georeference accordingly.	This has been retained.	Green	Cross-section are partially georeferenced but this does not impact on results. Ideally, the model should be fully georeferenced.	Noted for future	
3.5	Do the cross sections and bed profiles look reasonable?	Red	Cross sections and bed profiles of Bin Brook look largely sensible, with no unexplained steps or drops in the channel. A review of bank locations has been carried out, most are correct but not all. Section BB01_1246 should be deactivated at the top of banks (see Figure 6 in the 'Figures' tab). Section BB01_1370 looks significantly narrower than the upstream and downstream sections and is glass walling (Figure 7). No comments have been provided in the cross sections to indicate the source of the data - the topographic survey has been collected with cross sections being called 'Cross Section 1.XX' and the model having sections BB01_XXXX - comments added to reference which section in the model relates to which survey section would aid the review process. Looking at the surveyed cross sections and the model cross sections, it appears the model cross sections have been extended, but there is no reference to this in either the cross section comments or the Model Report.	Comments should be added through the model to clarify what data was used where. Section widths need to be reviewed and adjusted to make them consistent upstream downstream and with the 2D width. Clarify if sections have been extended and if so, the method used.	BB01_1246 deactivated at the top of banks. All banks have been reviewed and updated where appropriate. Channel length has been extended for BB01_1370. Sections which have been extended using LiDAR have had comments added to the FMP node in the baseline model network. These were extended prior to our current phase of work on the model so we can't provide any reason for why this was carried out, but most likely due to glasswalling if the model was previously run 1D only, or to keep more water in the 1D domain to aid model stability when running as a linked model.	Green	Section BB01_1246 has been deactivated appropriately and section BB01_1370 has been extended to match the 2d width and elevation (see Figure 14). Comment has been added to baseline model for extended section. However, naming convention of the surveyed sections should be included as a comment on the sections to aid the checking process.	Noted for future	
3.6	Chainage – compared to surveyed sections	Amber	Cannot be assessed due to the labelling of the cross sections compared to the labelling of the model sections.	Please provide naming convention and a cross sections and structures table, clarifying the source data for each model section.	This request does not provide assistance in checking model length v survey and therefore has not been undertaken. Model length can be simply measured from the map against model long section length.	Amber	"41094NOLS-Bin Brook Part 1 Main.CSV" and "41094NOLS-Bin Brook Part 1 Overflow.CSV" has included chainage and modelled sections naming conventions and chainage seems to match with surveyed sections. However, this should be referenced in the model/dat file and a structures table/log should be provided to enable the checks on structures dimensions.	We do not agree that this comment has 'potential impact on the results that may change the outcome of the study'. We recognise that this may aid the reviewer in their work however it does not have the potential to impact on the results. The resources provided are sufficient to undertake the checks outlined. We will consider for future studies.	
3.7	Does conveyance look appropriate?	Red	Conveyance plots mostly look appropriate. The section between BB01_0119d and BB01_0049 show the channel tapering along a 70m section of channel. Survey suggests this is a uniform channel and therefore channel conveyance will be underestimated here. Please check the reorientation of this section of channel is correct. In addition sections BB01_0119d and BB01_0049 appear to be U-shaped channels. The modelling manning's 'n' for the vertical walls does not appear to be applied correctly. A single hybrid manning's 'n' for the U-shaped channel would be more appropriate to estimate conveyance.	Check and correct the channel sections and conveyance.	We have updated elevations along this reach of the model and widened BB01_0119d as appropriate. Consistent Mannings values have been applied to the channel.	OK	The section has been updated along with manning values.		
3.8	If gauged flow is available, is there good flow reconciliation between the statistical estimates and the modelled, for given return periods?	N/A	Not available.						
3.9	Bank Markers. Are they used and if so, are they suitably located?	Red	Left and right bank markers have been applied at most cross sections, these are placed on the top of bank most are appropriate. Panel markers have also been used at changes in roughness and changes in geometry, these have mostly been applied appropriately. See comments 3.5 and 3.7 for issues associated with cross section with and panel marker application.	See comments in 3.5 and 3.7	Bank/panel markers have been updated at cross-sections where necessary. Channel section between BB01_0119d and BB01_0049 have been updated. Conveyance curves assessed to be suitable.	Green	Sections updated, please see action in 3.5.	Comments in 3.5 relate to cross section naming conventions and have no bearing on bank markers. This reference seems misplaced. No actions proposed	
3.10	What approach to channel roughness has been used?	OK	The Model Report states in Section 2.2.2 and 2.2.3 that Manning's values based on Chow (1959) have been applied to the channel banks and bed.						
3.11	What manning's n value(s) have been used for the channel? If it is 1d only what values and how have they been applied in the flood plain?	OK	In general, the river sections have a roughness of 0.035 applied to the channel bed, with a value of 0.05 applied to the banks of the channel. A survey photo has been provided for each surveyed cross section. The values applied look to be appropriate.						

3.12	What method has been used to estimate roughness (USGS, Chow, etc. based on survey, photographs)? Are they appropriate	OK	Chow (1959) and photos taken by the surveyor. See comments above.							
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1D BOUNDARY CONDITIONS									
1D BOUNDARY CONDITIONS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
4.1	1d boundary model domain; is there glass walling anywhere in the modelled reaches?	OK	Out of bank flows are represented in the 2d. Representation is appropriate.						
4.2	How have the inflows boundaries been applied?	Amber	Three QT boundaries applied. BB01_1575 has been applied at the upstream of the model, with BB02 applied downstream of Barton Road (on the downstream face of the footbridge) and BB04_I applied at Clare Hall, just downstream of the area of interest. In the 100-year +19% CC event, BB01_1575 has a peak of 7.822m³/s, BB02 has a peak of 1.744m³/s and BB04_I has a peak of 2.022m³/s. Only the upstream QT boundary has been referenced in the reporting. No information has been provided on whether these boundaries are part of the original model received from the EA or if they are newly applied boundaries for the modelling.	Clarify whether these inflows have been updated as part of this study. Reference to all three inflows should be included in the reporting.	The three inflows have now been included in the report.	Amber	The report has been updated. However, why these inflow have been applied has not been defined in the report. Moreover, a figure of the catchment boundary should be included in the report.	The modelling report forms an appendix to the FRA along with the FEH calculation record. Collectively they provide a comprehensive discussion of the flow estimation and application to the model. As the purpose of the study is to assess the relative change between a baseline and developed scenario we would propose that the provided consistent boundaries are applied to both the baseline and proposed models then this comment dose not have the "potential impact on the results that may change the outcome of the study" and as such should be a green.	
4.3	How is the downstream boundary(s) applied?	Amber	A single NC boundary has been applied at the downstream of the river, set to a slope value of 0.002 (1 in 500). The modelling report states this has been based upon the preceding river sections, but no information on which river sections. A check of the slope of the sections labelled EA_### shows a slope value of around 0.0008. No information has been provided on whether the slope value applied at the boundary is part of the original model received from the EA or if it is a newly calculated slope value for this modelling. There is also a HT boundary applied at the Bin Brook Diversion Channel, this does not appear to link to anything in the 2D domain or have any water levels applied to it.	Clarify whether the outflow has been updated as part of this study. Clarify the purpose of the HT boundary and include reference to it in the reporting. Justification of the slope value applied needs to be provided.	Outflow has been updated as part of this study. Purpose of the HT boundary is to represent the Bin Brook overflow diversion ditch. Updated the slope value at the downstream to 0.00082.	Green	The slope has been updated based on preceding EA section. However, the approach to model the overflow ditch has not been defined in the report - please add.	The linking of a 1D 2D model via an HT boundary is a well established principal that can be clearly seen from the model files and confirmed to have worked via the model results files. It is not considered a necessity to describe every standard 1D-2D link in the model.	
4.4	If tidal - how has the boundary been derived?	N/A							
4.5	Have appropriate locations been chosen for the downstream model extents?	OK	The downstream boundary is 780m downstream of the site, and the spill unit BB01_0119Su is controlling water levels along the watercourse. There is therefore no impact at the site due to the downstream boundary and consequently the location is appropriate.						



1D STRUCTURES

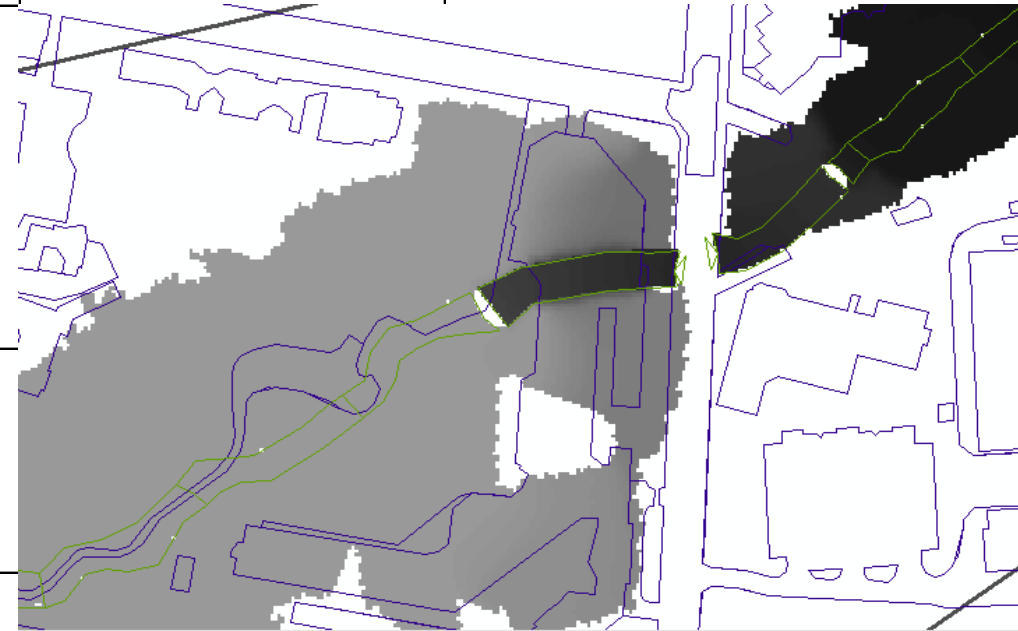
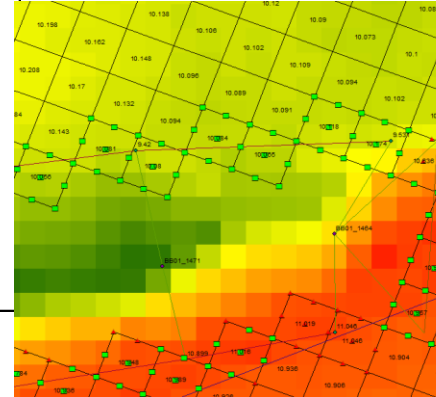
1D STRUCTURES											
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	
5.1	Are all structures represented? If not have explanations for structures not modelled been given in the Log/report?	Amber	<p>A check of the topographic survey shows that all the surveyed sections have been included in the model, this includes five culverts, six bridges and a weir for the Baseline model (one of the bridges has been removed in the Proposed model). There appear to be two footbridges which have been omitted from both the survey and the model, at the downstream extent of the Bin Brook diversion channel (NGR 543488, 258057) and at Clare Hall (NGR 543601, 258334).</p> <p>No model log has been provided, and no model comments have been added at structure sections to identify which model section relates to which surveyed cross section, which would have aided the review procedure.</p> <p>Three bridges (BB01_1262Bu, BB01_0461Bu and BB01_0007Bu) have been included in the model as USBPR bridges to represent small footbridges over the channel - the equations were intended for large clear spanning bridges based off those in the USA. Generally, an arch bridge unit would be more appropriate for small bridges such as these. The bridge over Grange Road (BB01_0049Bu) has been included as an arch bridge.</p>	<p>Add comments in the model and provide the model log to add clarity over which surveyed cross section has been used for each model cross section.</p> <p>Justify the omitting of the two footbridges.</p> <p>Update or provide justification as to the use of USBPR bridge units instead of Arch Bridge units.</p>	<p>Survey was not taken for the footbridges therefore they have not been included in the model.</p> <p>The Arch Bridges have been to replace the USPBR bridges in the model and the model has been re-run.</p>	Amber	<p>Please include justification to omit those footbridges if unavailability of survey is prime reason, some assumptions can be applied to consider the losses.</p> <p>Also, provide structures log for the omitted structures. Another bridge downstream of BB01_0170i is also not included in the model. Bridge structure have been defined as arch bridge units .</p>	<p>It is acknowledged that three structures are not included in the model (consistent for baseline and proposed) these are : 1 downstream extent of the Bin Brook diversion channel (NGR 543488, 258057) 2 Clare Hall (NGR 543601, 258334 3 BB01_0170(Robinsons college) (NGR 534883,258403).</p> <p>Structure one is a clear span foot bridge with a thin deck (pictured) with a slatted wooden parapet that is not continuous beyond the bride deck. In the event of the bridge being surcharged it would be locally bypassed by out flanking flood flows and therefore was not considered to have a material impact on the flood modelling results. Structure of this nature that bypass early are often a source of model instability and therefore it is common place to exclude them where the impact on modelled flood levels is likely to be minimal and local to the structure.</p> <p>Structure two was observed in the Environment Agency baseline model to have a spill lower than the soffit of the orifice unit it is representing. It is observed to be an ornamental foot bridge with a soffit higher than the banks either side that would be subject to local bypass in the event of a flood. Based on review of the existing model this structure was excluded for the same reason as structure one above.</p> <p>Structure three is a circular foot path in the grounds of Robinson College over the widened Bin Brook which forms an online pond in this location. This structure is similarly excluded from the existing Environment Agency model. Water levels in this location are controlled by a downstream sluice (represented in the model as a spill unit). The foot bride is not considered to be hydraulically significant. It is a approximately 350m downstream of the areas of development.</p>	  		
5.2	Are invert levels correct compared to survey data?	Amber	<p>Review of each structure has been undertaken, issues are commented below: First culvert under A603 (BB01_1464ci) - the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. Second culvert under A603 (BB01_1331ci) - As above, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The trash screen has not been represented. Footbridge (BB01_1262Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance (Figure 12). See comment above on the use of USBPR units. Culvert under houses (BB01_1189ci) - As above, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The surveyed drawing labels the downstream invert as 7.582m which is above the modelled invert yet this is not how it is shown in the drawing. The upstream trash screen has not been represented or commented on in the report. There is no survey photo of culvert exit, does this culvert actually reduce in size from 1.8m to 1.2m diameter, the long section plot of the survey does not show the culvert decreasing in size? Footbridge (BB01_0541Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. See comment above on the use of USBPR units. Footbridge (BB01_0461Bu) - same comments as previous footbridge, the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. Junctions are not needed. See comment above on the use of USBPR units. Culvert at Needham Research Institute (BB01_0403Ci) - confirmation of where the soffit elevations have been taken from is needed. Second culvert at Needham Research Institute (BB01_0381Ci) - again, confirmation of where the soffit elevations have been taken from is needed. Footbridge (BB01_0329Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. Weir (BB01_0119Su) - the junctions are not needed, the spill unit representing the weir can be directly linked to the river units. Confirmation of where the elevation of the weir crest has been derived from is needed. The unit is modelled using a default spill coefficient but looks to be more like a sharp crested weir (Figure 10.) Bridge at Grange Road (BB01_0049Bu) - cannot determine which cross section has been used to define this, confirmation is needed. Junctions are not needed. Footbridge (BB01_0007Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. See comment above on the use of USBPR units.</p> <p>Spill at Diversion Channel (BB01_1189LS) - confirmation of what this is representing is needed.</p> <p>A blanket value of 0.02 has been applied at all culverts, but the culverts are constructed from different materials (corrugated metal vs.</p>	<p>Confirmation of where invert / soffit levels have been derived from needs to be provided at all structure sections.</p> <p>Missing length at BB01_1331ci and BB01_1189ci needs justifying.</p> <p>Justify not representing trash screens.</p> <p>Embankment markers should be added at all bridges to improve conveyance.</p> <p>Justify the use of the USBPR bridge units instead of Arch Bridge units.</p> <p>Justification of the blanket value of 0.02 set at all culverts despite the different materials used in the construction needs to be provided.</p>	<p>The invert/soffit levels have been derived from structure surveys. The levels have been derived through utilising annotated invert/soffit levels if provided, utilising lowest/most appropriate bed levels on the cross section, measured in CAD between invert and a know elevation point or the long section drawing. All levels have come from the survey information.</p> <p>Trash screens have been included for two bridges.</p> <p>Embankment markers have been added to bridges to improve conveyance.</p> <p>Arch Bridges have been utilised to replace the USBPR bridges.</p> <p>Updated Mannings value for culverts have been utilised in the model, no longer just a blanket 0.02 value for all.</p> <p>The spill at the diversion channel is to help define the elevation at which water spills between the channels.</p>	Amber	<p>The dimensions have been measured using survey data for most of the structure and they seem appropriate. A structure log with reference of the surveyed cross section including naming convention should be provided. The structure log should also include the assumptions considered to model the structures. The bridge units have been updated as arch bridge units, embankment markers have been applied appropriately and trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the culvert dimensions for BB01_1034cd culvert were defines, as the survey does not contain this information. Please see Figure 13 for the trash screens and the downstream face of the culvert.</p> <p>BB01_0119Su weir coefficient has been updated to 1.6 which is appropriate.</p> <p>BB01_1189LS spill elevation seem appropriate and checked against survey.</p> <p>The roughness values have been updated according to culvert material defined in the comments (see Figure 15).</p> <p>We do not agree that this comment has 'potential impact on the results that may change the outcome of the study'. We recognise that this may aid the reviewer in their work however it does not have the potential to impact on the results. The resources provided are sufficient to undertake the checks outlined. We will consider for future studies.</p>				
5.3	Do bridges surcharge? If so has orifice flow been enabled?	OK	All bridges have orifice flow enabled, with all parameters for the upper and lower transition distances set to 0.1m, with the orifice discharge coefficient set to 1. This seems to be appropriate.								
5.4	Are there spills around the structure or over the top represented appropriately?	Amber	<p>There is a mismatch with how overtopping methods have been represented, some of the bridges use 1D spill units to represent the overtopping methodology and some use HX lines in the 2D domain. This should be justified. All culverts use HX lines to represent the overtopping methods, Figure 12.</p> <p>No elevations are provided in the survey for the bridge decks where spill units are used, confirmation of how the elevations have been derived is needed.</p>	<p>Confirmation of where levels which have been to derive the spill levels needs to be provided.</p> <p>Justify the mismatch in representation of overtopping (1D spills vs. 2D HX lines).</p>	<p>Bridge spill units have been updated to be representative of the same overtopping methodology. Generally, for structures of less length than 2-3 cells length, decks are represented in 1D, those with longer decs (in direction of flow) are modelled in 2D.</p> <p>Elevations of bridge decks are based on surveyed levels and adjacent LiDAR levels.</p>	Amber	<p>Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m. Also provide structures log for all the assumptions made on the elevations/dimensions.</p>	All spills either represented in 1D or 2D. Where in the 2D the distance between upstream and downstream active area may have been expanded to separate HX lines.			
5.5	If there are any movable structures have they been modelled correctly?	N/A	None in the model.								
5.6	Structure coefficients - Have they been changed from default values?	Amber	<p>Spill representing the weir at Robinson College is set to default (1.2) broad crested weir the weir appears to be sharp crested and therefore different to the default.</p> <p>The inlet unit for the first culvert under A603 (BB01_1464ci) is set up for a circular corrugated metal pipe which is projecting, the pipe is not projecting. The Ki value has been updated from default of 0.9 to 0.5.</p>	<p>Update the spill weir coefficient to a more appropriate value at Robinson College BB01_0119.</p> <p>Justification for the values applied for the inlet unit at BB01_1464ci (culvert is not projecting, Ki value updated) is needed.</p>	<p>Increased weir coefficient from 1.2 to 1.6.</p> <p>Reviewed culvert inlet loss using the culvert wizard in Flood Modeller Pro. Values have been updated using parameters: Circular > Corrugated Metal > Headwall. Based on site photos of BB01_1464ci structure.</p>	OK	The weir coefficient has been updated and Ki value of 5 has been applied.				



1D RUN PARAMETERS

1D RUN PARAMETERS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
6.1	What time step has been used for the 1D model? Is it appropriate?	OK	1D timestep (0.5s) is half the 2D timestep (1.0s). This is appropriate.						
6.2	What initial conditions have been used? Steady state, hotstart file?	OK	IIC file has been used for the Baseline model, and a separate IIC file used for the Proposed model. Spot check of the sections does not show any issues with the initial conditions.						
6.3	Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified?	Green	Dflood has been increased from the default of 3 to 5. This has not been justified.	Justify the increase in dflood.	Changed back to default	OK	Dflood restored to default value.		

2D MODEL BUILD

DIGITAL TERRIAN MODEL														
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4	4th Review Comments	4th Review Response (DATE)
7.1	Number of domains?	OK	One 2D domain.											
7.2	Area of 2d domain/s	Red	55 hectares. There is glass walling occurring in the 1,000-year +19% CC results near Clare Hall Gym and Pool in both the Baseline and Proposed modelling.	The code layer needs to be extended to prevent glass walling.	Code layer extended upstream.	Red	There is still some glass walling - please see Figure 16.	Figure 16 shows two cells where the modelled flood extent in the 0.1% + CC AEP event reaches the boundary of the model domain. The maximum modelled water level in this area in the baseline scenario is 9.62mAOD and in the proposed scenario is 9.53mAOD. The ground level in these cells is 9.61mAOD and 9.45mAOD. This means that for the two cells there is 0.01m and 0.17m of glass walling in the worst case. From review of Lidar the ground levels continue to rise beyond the model boundary. The image to the right shows the active model boundary as a grey line, the baseline 0.1% + CC AEP event depth grid in black and the LIDAR for the area categorised as below 9.53mAOD (Blue), between 9.53 and 9.62mAOD (Yellow,) and above 9.62mAOD (Red). As can be seen there is potential to extend into an area of approximately 34m2 beyond the active domain. Due to the small plan area (~34m2) and very small depth (0.01-0.17m) including this area within the model domain is likely to have an extremely limited impact on model results (estimated to be on the scale of 0.001m or less). As this is a feature of both the baseline and proposed models this will not have an impact on the outcome of the study and as such should not be a red comment. It is reasonable to flag as a green comment for action alongside any other planned future model updates where the 0.01% + CC AEP event results are required.						
7.3	What dataset has been used to define the DTM elevations? LiDAR, Photogrammetric DTM?	Green	1m LiDAR has been used to define the floodplain. The Model Report states in Section 1.3.5 this was downloaded from the EA webpage in May 2022, no date of when the LiDAR was flown is referenced.	Include reference to year data was flown in the Model Report.		Green	No action or acknowledgement, remains green.	Noted for future						
7.4	What grid resolution has been used? Is it suitable to accurately represent flow paths, e.g. between buildings?	OK	A 2m grid resolution has been used, this seems appropriate for the modelling outcomes.											
7.5	Has the DTM been rotated to optimise flow route representation?	N/A	Modelling report does not state that DTM has been rotated.											
7.6	Is there any obstruction to flow?	Amber	The A603 at the upstream extent of the model forms an obstruction to flow, nothing else of note. Bin Brook flows under the Robinson College building, BB01_0049. It is possible that this building could impede the overland flows to a greater extent than currently modelled, Figure 11. The filtered lidar creates flood storage in this location that may not be correct.	Review the representation of the Robinsons College building to confirm flows can pass through the building as currently modelled.	Updated so that flow constrictor shapefiles have been set up for the Robinson Building. Flow constricted by 90% with Mannings value of 0.05 applied. The central Robinson College area applies a minimum elevation of 8.2mAOD. Something similar has also been applied for Needham Research Institute and all other buildings within the model domain.	Amber	2d_FCSH has been applied with 90 % blockage. However, the representation of the 1d channel is still not updated as the flow is unlikely to come out of bank where the building is located. Please revisit the approach to model the 1d channel under Robinsons College Building. The representation used for Needham Research Institute looks more appropriate, i.e. use of culvert with no spills.	Review of Water surface elevation grid results show the impact on the Robinson College sluice on in channel water levels. Water levels in the culvert under the college building are below the minimum elevation applied to the building foot print. Any flooding of the building is from flow that comes out of back up stream of the sluice. As such the flow is not coming out where the building is located. results form the 0.1% + CC AEP event shown to the right.						
7.7	Has additional site specific topographic survey data been used?	OK	Survey data has been used to define channel sections, nothing applied in the 2D domain.											
7.8	How have buildings been represented within the DTM?	Amber	Buildings have then been applied using the materials file taken from OS MasterMap using a high roughness value of 0.5, which in the most part seems appropriate however see 7.6 for comments on the Robinson College building.		See comment above.	Amber	See action above.	See 7.6						
7.9	Are defences/embankments/bank crests accurately represented?	Red	The banks are represented using zlines and zpoints, for both Bin Brook and the ditch which appear to be taken from survey. There are also zlines and zpoints representing the levels of the spills. See 2D_Structures 10.3 for comments on these structures. No other defences or embankments are formally represented. The bankline representation ZSH check shows significant bank raising which appears to be artificially bunding the watercourse Figure 8. Further justification for the bank raising is required.	Check and confirm the bank raising applied at the 102D link location is appropriate. Also see comments in 10.3.	Banklines have been updated to better represent height where there was a large discrepancy between Lidar and bank levels from the model. Checked using zln zpt check layer and reviewing the dZ value.	Red	Please see action in 10.3.	Unclear why there is a red comment here referring to 10.3 (an amber comment). As stated previously Z lines based on survey to supersede LIDAR (the same approach as was adopted by the EA model when updating the 2010 model which used lidar based HX lines). Minor inconsistency for BB01_1471 and BB01_1464 where left bank panel marker has been read in to Z line rather than left deactivation marker value. As the Max command is used this Z line has no						
7.10	If post-development scenarios are required have the proposed ground levels and building been represented appropriately?	Amber	One post development model has been provided as part of this review, the 10m span bridge with the downstream footbridge removed. This has been set to an elevation of 10.5m as per the Model Report. However no consideration has been given to a change in roughness.	Confirm if a change of roughness as part of the proposed model is needed.	No needed to increase roughness, even in the highest flood event, the embankment is not at risk of flooding up to the 10.5mAOD.	Green	Thank you noted. This will need to be revisited after the hydrology is signed off, in case the maximum stage changes. Ideally the roughness changes need to be captured or mentioned in the model limitations in the report if higher events, i.e. the 0.1% AEP needs to be modelled for future uses of the model.	Noted for future						

2D ROUGHNESS														
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG	2nd Review Comments	2nd Review Response (DATE)	RAG	3rd Review Comments	3rd Review Response (DATE)	RAG	4th Review Comments	4th Review Response (DATE)
8	What manning's n values have been used to define floodplain roughness? Have they been applied correctly?	OK	OS Master Map is used to define roughness. The background roughness across the 2D domain has been set to 0.06, this is listed in the trmf as 'General Green Areas/Natural Roadside'. All areas within the active model domain have a defined roughness.											
8.1	What methods have been used to estimate roughness?	OK	See above											

8.2	Is the representation of different roughness areas sufficiently accurate and detailed?	OK	A review of the 2d_mat layer shows that the different roughness areas are sufficiently detailed and capture the different land use types as are all defined by the OS MasterMap shapefile.									
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2D BOUNDARIES

2D BOUNDARY CONDITIONS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
9.1	Have any boundaries been used in the 2D domain? If so detail.	Red	One inflow QT boundary has been applied in the drain, there is no indication if this has been updated as part of this modelling study. Check files show the boundary is being read in correctly, and applying the correct inflow. There is also a HQ downstream boundary with a slope value of 0.03432 set, the Model Report states this is based on the Lidar. The boundary is not snapped to the code layer.	Indicate whether either of these boundaries have been updated as part of the study and justify slope value. Snap the downstream boundary to the code layer.	The hydrological boundaries have been updated as part of this modelling study. The downstream boundary has been updated to snap to the code layer.	Red	The downstream boundary has been snapped to the 2d_code layer. The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs, see Figure 17.	See 7.2	
9.2	Is the model boundary suitably large? i.e. the flood extent should not reach the boundary.	Red	There is glass walling at the downstream extent of the model as the downstream boundary is not snapped to the 2d_code layer, and also does not extend far enough east, see Figure 1 in the 'Figures' tab. There is also glass walling in all three events at the upstream boundary, see Figure 5 in 'Figures' tab. No other glass walling.	Extend the downstream boundary eastwards to cover the full extent of the flooding. Justify the presence of glass walling at the upstream extent of the model.	The downstream boundary has been updated to snap to the code layer. Extended upstream extent of the model to prevent glass walling.	Red	There is still some glass walling - please see Figure 16.	See 7.2	
9.3	Has rainfall been applied directly to the 2d model domain?	N/A							
9.4	Coastal - How has the wave overtopping been applied?	N/A							



2D STRUCTURES									
2D STRUCTURES									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
10.1	Have any structures been included in the 2D domain? If so how have they been represented?	OK	The Bin Brook Diversion channel has been included in the 2D domain using network lines and 1d_tab file for the cross sections. The diversion channel is linked to the 1D model using a X1DQ link, which links the flow to and from the FM model to the ESTRY section.						
10.2	Are invert levels correct compared to survey data?	Amber	Spot checks show the channel sections match the survey levels for the cross sections. At the culvert, the length and the width do not match the survey, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The Manning's value has been set to 0.013, this is different to the generic 0.02 applied to the culverts in the 1D domain, and different to the Manning's value applied to the rest of the diversion channel (0.017). The height contraction coefficient has also not been set.	Review the culvert in the Diversion channel against the topographic survey, and justify / correct values applied.	The culvert matches what has been surveyed. See 5.2	Amber	Roughness values seem appropriate. Channel length and culvert dimension needs to be updated and height contraction coefficient need to be defined, see Figure 18.	Channel length is correct when measured from centre of channel, not from schematised spill location. Default heigh contraction assumed. Unlikely to be orifice flow due to high downstream water level. Noted for futre work.	
10.3	How have defences been represented? Zline? If there are flood zone scenarios have the defences been excluded adequately?	Amber	Three features have been included in the 2D domain, the first being zlines and zpoints along the banks of Bin Brook representing the bank levels, the second zlines and zpoints along the banks of the drain, and the third zlines and zpoints representing the spill levels over structures. At all three features, the zline is snapped to the 2d_bc_hxi bank line and zpoints placed along it, this could be represented as just bank lines and points (all included in the 2d_bc_hxi). All lines have been applied as THICK, this is working as needed. The points applied in the 2D domain for the banks of Bin Brook do not match with the 1D cross sections, there should be a match. There is no indication where the values for the Bin Brook diversion channel or the spills along the main Bin Brook channel have been taken from, this needs to be clarified.	1D cross sections should match the 2D bank points, the cross sections should be updated to match. Confirmation of the method used to determine levels for the spill bank points and the Bin Brook Diversion channel is needed.	1D and 2D bank points match. These have been spot checked throughout. Bin Brook diversion channel ditch levels have been taken from watercourse survey document 'Bin Brook Overflow'	Amber	The zpoints and 1d-cross sections do not match see Figure 19. Please review all the cross sections.	see 7.9	
10.4	Have appropriate loss coefficients and roughness values been used?	N/A	None applied.						



N PARAMETERS

CONDITIONS & OTHER						
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2
11.1	What time step has been used for the 2D model? Is it appropriate?	OK	Cell size is 2m, the 2D timestep has been set as 1 second and the 1D timestep to 0.5 seconds. The timestep is appropriate.			
11.2	Have initial water levels been applied? Are they correct?	OK	None applied in the 2D domain.			
11.3	Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default?	OK	No additional parameters have been applied			



MODEL LINKS

MODEL LINKS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
12.1	How have the 1D/2D models been coupled, is it appropriate?	Red	The 1D and 2D domains have been linked using HX and CN lines. Connections have mostly been digitised appropriately. The upstream of the model should be snapped to the code boundary (see Figure 2 in the 'Figure' tab). The HX lines at the structures throughout the model and the link to the ditch need to be reviewed, many should be closed so a single HX line is applied (see Figure 3 in the 'Figures' tab as an example).	Please amend throughout the model.	Gaps in the 1D and 2D domains have been closed.	OK	The code boundary is snapped with the upstream boundary. The gaps have been closed		
12.2	Is the digitisation of the links acceptable?	Red	Bank points have been added at the river cross sections from the 1D domain, but not at interpolate nodes. Some bank level points need revisiting. The 1D top of banks do not always agree with the TUFLOW zpoints used. This might over/under estimate out of bank flooding. Bank points also should be added at the interpolate units using the LiDAR data, and at changes in bank elevations.	Please justify or amend accordingly.	Update zpts along the banks to give better representation of the banks for areas where there were long sections with no bank survey points in-between.	Red	Bank points for interpolates need to be updated as these are not applied for interpolates and in between - see Figure 20. Also, see action in 10.3.	See 7.9 - as stated previously Zpts for banks are based on survey - no survey is avail for interpolates therefore zpts for banks are also interpolated at these locations.	
12.3	Is the 2d representation of the river channel comparable in width with the 1d model cross sections?	Amber	In some locations, there is a good match between the width of the channel in the 2d domain and the 1D model cross sections, however in others, there is not. Looking at the locations of the 1D cross sections and the 1d_nodes / CN lines in the TUFLOW domain, there are also locations where cross sections have been moved upstream or downstream in the 2D domain, see Figure 4 in the 'Figures' tab. Note a large number of the cross sections are not fully georeferenced in the 1D domain.	Please justify or amend accordingly.	The 2d links and CN lines are now in a more appropriate location.	Amber	The width of the 1d and 2d cross-sections are matching now. The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream - see Figure 21.	HX line at Upstream extent has been extended to allow lumped inflow at top of model to adequately spread out to avoid glass walling at the upstream extent of the model. Consistent in both baseline and development model - no impact on outcome of study	
12.4	Representation of 1D output in 2D domain	Green	There are no water level lines applied down the channel, therefore no results are displayed in the channel. This does not impact model results, but does create display issues.	Water level lines should be applied so results are being displayed fully. This should be updated in line with best practice, particularly as results are being used in figures.	WLLs have been created and the TufLOW model results now display these properly.	OK	WLL have been applied.		
12.5	Have any default link parameters been changed (i.e. to improve stability)?	N/A	No changes to default link parameters						



PUTS & CALIBRATION

ACTION/VERIFICATION									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
15.1	Have calibration runs been completed? Is data for calibration available? Gauge data, extents, anecdotal etc.	N/A	No calibration has been carried out. Hydraulic Modelling Report states there are no gauges to calibrate against or any historical flood data available.						
15.2	Are the simulated hydrograph peaks reasonably similar to the recorded peaks?	N/A							
15.3	Is the shape of the simulated hydrograph and therefore the volume suitably similar?	N/A							
15.4	Are simulated floodplain extents similar to recorded extents? Are flow routes similar?	N/A							
15.5	Has suitable effort been made to attempt and improve calibration. Have attempted changes been documented with a quantification of impact?	N/A							
15.6	If no historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large difference, does it seem sensible?	Red	Nothing has been provided to compare to. As this model is based on a previous model as a minimum in the absence of any other validation data the model results should be compared to previous model results as a sense check.	Please justify or amend accordingly.	Previous results are much less extensive as they are without 19%CC. The upstream end of the 2017 model results show a different distribution of flooding, with nothing coming out of the right bank as it does in the updated model, otherwise the pattern of flooding is generally the same (other than width of flooding due to increased volume).	Red	Have the model results been compared with Flood Zones maps as well? Please provided evidence of the comparison in the report and discuss why the differences occur.	commentary on local flood modelling compared to other sources of data in FRA. Model runs include climate change. Flood zones do not. Therefore limited insight to be gained from comparing them in this instance. No impact on conclusion of study	



EL SENSITIVITY

TESTING & UNCERTAINTY									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
16.1	Have appropriate model parameters been chosen for sensitivity testing? Typical tests include: ☐ Sensitivity to roughness $\pm 20\%$ (Manning's "n" both in 1D and 2D) ☐ Sensitivity to flows $\pm 20\%$ (From central estimate) ☐ Sensitivity to downstream boundary ☐ Key structure blockage(s)	Amber	A number of sensitivity tests have been carried out including Manning's ± 20 and the downstream boundary $\pm 20\%$ for both the Baseline and Proposed modelling. However this has only been applied in the 1D domain, not the 2D domain. A slope value of 0.0025 has been applied in to the downstream boundary +20%, however a 20% increase is actually 0.0024. Again, in the downstream boundary -20%, the value applied is 0.00166667 but the calculated value should be 0.0016. A check of the Manning's sensitivity .DAT files for the baseline shows the change in roughness has been applied to the river sections correctly, but not to the culvert sections. The change in roughness has been applied to the culverts in the proposed Manning's sensitivity tests.	Justify not sensitivity testing the 2D domain. Justify the slope values applied. Justify the approach to changing / not changing the roughness values applied to the culverts in the Manning's sensitivity tests.	The slope value for the downstream boundary has been updated to 0.00082. The 20% decrease and increase change for the downstream boundary has therefore been updated to 0.000656 and 0.000984 respectively. The change in roughness has not be applied to the culverts in the model due to instability issues that occurred when these were changed. Therefore as much of the model was changed as possible without impeding the model to crash and return any results.	Amber	The slope has been updated and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.	See 16.2	
16.2	Do the results of the tests show the models to be particularly sensitive to certain parameters?	OK	The model results show the site is not sensitive to any changes made to Manning's or the downstream boundary.			Green	Please specify which culverts/structure are sensitive and to which parameters.	Model stability sensitive at culvert locations. Not able to identify specific culverts where flood results were sensitive to parameter change due to the instability.	
16.3	Have confidence limits for model results (+/- mm) been presented? How were they derived and does this seem sensible?	Amber	Confidence limits have not been presented	Please provide	There is no defined modelling tolerance within either FMP or TufLOW. We have used the best available data for boundary slopes, hydrology, cross sections, and LiDAR. All assumptions are listed. Confidence limits are requested for Environment Agency procured studies which this is not.	Amber	Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?	It is not considered appropriate to combined sensitivity testing with the assessment of impact of a development option therefore it is recommended that sensitivity testing discussion be limited to baseline only going forward.	



ODEL STABILITY

ODEL STABILITY												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
13.1	Errors/Comments/Warnings?	Amber	There are a number of warning related to different values for Manning's n encountered in same panel. There are also a large number of messages related to poor model convergence at BB01_1189LS, this is the spill unit into the diversion channel.	Add panel markers at changes in roughness in the 1D model to remove warning messages.	Panel markers have been added to the model to improve this	OK	The issue has been resolved.	<div>Cum ME (%) BBK_032_10m_FBRem_xx_xx_100yr19cc_MB2D</div>				
13.2	Convergence	Amber	The mass balance error in the Baseline 100-year +19% CC is 21.77%. In the proposed 10m span with no footbridge downstream model, the 100-year +19% CC mass balance error is -9.48% and in the 1,000-year +19% CC is -41.78%. This indicates the model has some stability issues.	The changes recommended through this review should be completed and a review of the 1D model stability carried out again.	Updated results provided which have addressed these issues. MB and 2DMB plots shown for ME% to the left showing they are within tolerance	OK	The ME is within the tolerance of +/-1%.	<div>Cum ME (%) BBK_032_10m_FBRem_xx_xx_100yr19cc_MB2D</div>				
13.3	Does a basic check of animations and graphed outputs give an indication of good model stability?	Amber	The animations and the graphs show some issues on the rising limb of both the Baseline and Proposed results, with fluctuations in the water levels noticed. This also indicates the model has stability issues.	The changes recommended through this review should be completed and a review of the 1D model stability carried out again.	Updated results provided which address these issues	OK	No major issue observed.					

ODEL STABILITY												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
14.1	Is mass balance within tolerable limits?	OK	All Baseline and Proposed models show a spike up in the mass balance error as the model wets up. However the error is within the ±1% bounds which indicates a healthy model after 5.5 hours of model simulation.					Simulation FINISHED TUFLOW 1D Negative Depths: 0 Classic 2D Negative Depths: 0				
14.2	Are CE and dV values relatively stable and remain so once the run has got going.	OK	Spot checks of the tif files show the CE and dV values are stable throughout the simulation.					WARNINGS prior to simulation: 238 [0 not in _messages layer] WARNINGS during simulation: 0 [0 not in _messages layer] CHECKs prior to simulation: 4 [0 not in _messages layer] CHECKs during simulation: 0 [0 not in _messages layer]				
14.3	Errors/Comments/Warnings?	Amber	There is a message which should be fixed, the CHECK 2099 - Ignored repeat application of boundary to 2D cell. The WARNING 1100 - Structure ditch_0649C crest/invert (8.079) is below bed (8.143) of primary upstream channel ditch_0733 also needs to be reviewed to check the schematisation is correct.	Review the locations of the CHECK 2099 messages and fix cells. Review the WARNING 1100 against the survey and fix or justify.	2099 error fixed by moving the spill HX line into an adjacent cell. The 1100 warning has been investigated but the ditch is modelled as per survey. The warnings merely highlighting there could be an error and it should be checked, having checked the data and schematisation is correct therefore these warnings remain (but with a justifiable reasoning)	OK	The invert is correct as per survey.					
14.4	Negative Depths	Amber	There are a large number of negative depths between 4 and 5 hours at ditch_0091, the downstream of the diversion channel. This indicates a stability issue at this location. No other negative depths.	Review ditch_0091 and surrounding sections or justify the negative depth messages.	The model no longer contains negative depths	OK	No negative depth observed with the updated model.					
14.5	Does a basic check of animations and graphed outputs give an indication of good model stability?	Green	The 2D results animations show good stability, nothing of concern noted, Note there are display issues with the animations due to the lack of water level lines which mean the channel is not displayed. There are no PO lines in the model this aim checking 2D results and calculation of the mass conservation through the model.	Add WLLs to display results in the channel.	Wlls have been added so that the watercourse is shown flooding	OK	WLL have been included.					
14.6	2d extents and outputs	Green	The model does not output grids (as ascii files), this would aid in the review process.	Output grids for depth, velocity and water levels.	Raw outputs are provided. There is no need to provide a full suite of outputs grids as they are not needed for the FRA which this model supports. Raw data has been provided so the reviewer can extract additional items if they wish.	OK	Grids have been provided.					



UDIT TRAIL									
AUDIT TRAIL									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3
17.1	Was a model run log provided?	Amber	No	Model log to be provided to see model history and decision making process	Model log created and provided	OK	Model log has been provided.		
17.2	Was a suitable file naming, structure & management system used?	OK	Yes, standard FMP and TUFLOW folder structure.						
17.3	Were check files provided?	OK	Provided for the Baseline 100-year +CC event and the Proposed a 10m bridge span with the downstream footbridge removal 100-year +CC scenarios only.						
17.4	Were comments provided within the model?	Green	No comments within the model to identify what has been updated / remained as is.	Add comments to the model to identify where updates have take place to aid the review process.	The updates are discussed in the associated reporting				
17.5	Was there good version control? Is the model history detailed where applicable?	Amber	Not detailed, so cannot comment. There is no version number for the model.	Model log to be provided to see model history and decision making process	Model log has been provided	OK	Model log with version updates has been provided.		
17.6	Were Errors / comments / warnings made available?	OK	Yes, the model results files for FM and log files for TUFLOW have been provided so checks of the messages could be completed.						
17.7	Was a technical overview of the model and its background provided	OK	Yes - technical overview and background info have been provided in the modelling report.						
17.8	Were notes on how the model operates under different flow conditions provided?	OK	Section 3 of the modelling report details the impacts of the baseline flooding and the inclusion of the bridge .						
17.9	Was an explicit statement of any concerns about the accuracy of the model or its ability to represent reality provided?	Red	There is no summary in the report of the modelling assumptions and limitations, this should be included.	Add an Assumptions and Limitations section to the Hydraulic Modelling Report.	This has been included in the reporting	OK	Assumptions and specifications have been included in section 4.2.		
18	Is there anything else missing or are there suggestions for additional information or clarification?	Amber	Twelve different scenarios have been run, but the reporting does not comment on many of them.	Add information on the results of all scenarios modelled to the report.	It is not common practice to report on options that are not taken forward, the reporting is to provide information of what is being proposed not an appraisal of options and outcomes therefore this is not supplied (it is not of any value). 100 and 1000 (both CC) year results for baseline and scheme are provided along with 100+CC sensitivity tests only	Amber	It is not clear which option is the final one for the proposed case scenario, please clarify that for example copm1 and comp2 results are not provided to review.XMDF files have not been provide, these would help in checking process	Comp 1 and Comp2 are redundant. Option model clearly set out in report and FRA.	
18.1	Comment on the quality of the reports:	Red	The supplied memo is insufficient and lacks information about the location of the updates to the model etc.. A model report should include: an overview of model build including a model schematic, hydraulic roughness (including photographs) and representation of any defence networks or use of non-standard elements discussion of structures (including photographs and details of how they have been modelled) comment on model stability and measure taken to improve stability justification of any remaining errors and warning messages produced etc..	A model report detailing all relevant information should accompany the model.	The report has been updated to provide the sailient information required to support the update to the hydraulic model. The baseline hydraulic model was supplied by the Environment Agency.	Red	The report do not include full results and more details need to be added in term of assumptions made to model the structures.	Full results will be provided directly to interested parties negating the need to present tabularised tables of water levels. Long section plots to be produced following agreement on final model version.	
18.2	is a freeboard analysis necessary? If yes have you review the report? What are is the agreed freeboard?	N/A	Not applicable to this study						

[Return to 1D model build](#)

[Return to 2D model build](#)

Manning's n for Channels (Chow, 1959).

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.03	0.033
b. same as above, but more stones and weeds	0.03	0.035	0.04
c. clean, winding, some pools and shoals	0.033	0.04	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.05
e. same as above, lower stages, more ineffective slopes and sections	0.04	0.048	0.055
f. same as "d" with more stones	0.045	0.05	0.06
Chainage – compared to surveyed sections	0.05	0.07	0.08
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.1	0.15
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.03	0.04	0.05
b. bottom: cobbles with large boulders	0.04	0.05	0.07
3. Floodplains			
a. Pasture, no brush			
1. short grass	0.025	0.03	0.035
2. high grass	0.03	0.035	0.05
b. Cultivated areas			
1. no crop	0.02	0.03	0.04
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.03	0.04	0.05
c. Brush			
1. scattered brush, heavy weeds	0.035	0.05	0.07
2. light brush and trees, in winter	0.035	0.05	0.06
3. light brush and trees, in summer	0.04	0.06	0.08
4. medium to dense brush, in winter	0.045	0.07	0.11
5. medium to dense brush, in summer	0.07	0.1	0.16
d. Trees			
1. dense willows, summer, straight	0.11	0.15	0.2
2. cleared land with tree stumps, no sprouts	0.03	0.04	0.05
3. same as above, but with heavy growth of sprouts	0.05	0.06	0.08
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.08	0.1	0.12
5. same as 4. with flood stage reaching branches	0.1	0.12	0.16
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			

1. clean, recently completed	0.016	0.018	0.02
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.03
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.03
2. grass, some weeds	0.025	0.03	0.033
3. dense weeds or aquatic plants in deep channels	0.03	0.035	0.04
4. earth bottom and rubble sides	0.028	0.03	0.035
5. stony bottom and weedy banks	0.025	0.035	0.04
6. cobble bottom and clean sides	0.03	0.04	0.05
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.05	0.06
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.04
2. jagged and irregular	0.035	0.04	0.05
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.05	0.08	0.12
2. clean bottom, brush on sides	0.04	0.05	0.08
3. same as above, highest stage of flow	0.045	0.07	0.11
4. dense brush, high stage	0.08	0.1	0.14
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.01	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.01	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplanned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.01	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015
2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.02
4. unfinished	0.014	0.017	0.02
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.02	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.02
2. random stone in mortar	0.017	0.02	0.024
3. cement rubble masonry, plastered	0.016	0.02	0.024
4. cement rubble masonry	0.02	0.025	0.03

5. dry rubble or riprap	0.02	0.03	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.02	0.025
2. random stone mortar	0.02	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.03
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.03		0.5

Manning's n for Closed Conduits
Flowing Partly Full (Chow, 1959).

Type of Conduit and Description	Minimum	Normal	Maximum
1. Brass, smooth:	0.009	0.01	0.013
2. Steel:			
Lockbar and welded	0.01	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
3. Cast Iron:			
Coated	0.01	0.013	0.014
Uncoated	0.011	0.014	0.016
4. Wrought Iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
5. Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Stormdrain	0.021	0.024	0.03
6. Cement:			
Neat Surface	0.01	0.011	0.013
Mortar	0.011	0.013	0.015
7. Concrete:			
Culvert, straight and free of debris	0.01	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.02
8. Wood:			

Stave	0.01	0.012	0.014
Laminated, treated	0.015	0.017	0.02
9. Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified Subdrain with open joint	0.014	0.016	0.018
10. Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections	0.012	0.013	0.016
Paved invert, sewer, smooth bottom	0.016	0.019	0.02
Rubble masonry, cemented	0.018	0.025	0.03

Manning's n for Corrugated Metal Pipe
(AISI, 1980).

Type of Pipe, Diameter and Corrugation Dimension	n
1. Annular 2.67 x 1/2 inch (all diameters)	0.024
2. Helical 1.50 x 1/4 inch	
8" diameter	0.012
10" diameter	0.014
3. Helical 2.67 x 1/2 inch	
12" diameter	0.011
18" diameter	0.014
24" diameter	0.016
36" diameter	0.019
48" diameter	0.02
60" diameter	0.021
4. Annular 3x1 inch (all diameters)	0.027
5. Helical 3x1 inch	
48" diameter	0.023
54" diameter	0.023
60" diameter	0.024
66" diameter	0.025
72" diameter	0.026
78" diameter and larger	0.027
6. Corrugations 6x2 inches	
60" diameter	0.033
72" diameter	0.032
120" diameter	0.03
180" diameter	0.028

6. WSP CORRESPONDENCE 02 MAY 2025

Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

From Southon, Jack <[REDACTED]>

Date Fri 2025-05-02 13:25

To Craggs, Alison <[REDACTED]>

Cc Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt,
Lee <[REDACTED]>; Higgins, Graham <[REDACTED]>; Fuhrmann, George
<[REDACTED]>

 1 attachment (180 KB)

CtoC_FloodModellingandHydrology_2025 TN_V0.3.pdf;

Hi Alison,

I'm pleased to enclose a copy of the technical note setting out the results of the sensitivity testing we proposed in our review feedback comments, as well as our availability for w/c 12/05 for a call to discuss the same.

Monday 12/05

9am-10am

2.30pm-5.30pm

Tuesday 13/05

10am-4.30pm

Wednesday 14/05

9am-10am

3.30pm-5.30pm

Thursday 15/05

10.30am to 3pm

Friday 16/05

1pm to 5.30pm

Please can you let me know a good time to arrange the proposed follow-up call.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)

[REDACTED]



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UK Limited, a limited company registered in England & Wales with registered number 01383511. Registered office: WSP House, 70 Chancery Lane, London, WC2A 1AF.

From: Craggs, Alison <[REDACTED]>
Sent: Wednesday, April 9, 2025 14:09
To: Southon, Jack <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
<[REDACTED]>; Higgins, Graham <[REDACTED]>; Fuhrmann, George
<[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Jack,

Thanks for sending this through.

The modelling team would prefer to review all work together i.e. conduct a review once they have received the technical note on the sensitivity test.

We are happy to arrange a meeting, however I think this would be most beneficial once the modelling team have been able to review your submissions. Therefore I suggest a meeting on 23rd, 24th or 25th. Please let me know your availability and I will look at booking something in.

Kind regards,

Alison Craggs

Sustainable Places Advisor

East Anglia Area (West)

Environment Agency, Bromholme Lane, Bampton, Huntingdon, Cambs. PE28 4NE



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TECHNICAL NOTE

DATE:	25 April 2025	CONFIDENTIALITY:	Public
SUBJECT:	Hydrology 2025 Addendum		
PROJECT:	Cambridge to Cambourne TWOA	AUTHOR:	S Haberfield
CHECKED:	J Chambers	APPROVED:	J Southon

Introduction

This Technical Note (TN) has been prepared as an addendum to the Flood Estimation Handbook (FEH) Calculation Record prepared in 2022 and previous Flood modelling report in response to the Environment Agency’s review of the hydrology calculated to support the Cambridge to Cambourne (CtoC) Transport and Works Act (TWOA) application. Additional hydrology has been prepared to understand the impact on the peak flows generated when considering the following points:

- A consistent storm duration across all of the study catchments.
- Current (April 2025) flood datasets and software (ReFH2.3).

Additional hydraulic model runs have been undertaken to understand the impact on flood mapping and impact assessment when considering the following points:

- Current (April 2025) hydraulic modelling software (Flood Modeller 7.2 and TUFLOW 2025.0.2)

The CtoC Scheme includes a replacement bridge crossing across the Bin Brook which has been assessed using a hydraulic model to understand local flooding mechanisms and the impact of the scheme. The assessment was prepared in 2022 and used the most recently available National River Flow Archive Peak Flows dataset available at the time of publication (version 10 published August 2021 which includes data up to the end of September 2020) along with the most recent release of the ReFH2 software at the time of publication (ReFH2.2). Subsequent to the preparation of this work and the submission of the TWOA application updated Peak Flows datasets have been released (with the most recent at the time of writing being version 13 published August 2024, which includes additional water year for all active peak flow stations in the UK up to the end of September 2023) and ReFH2.3 has been released along with additional catchment descriptors including FEH22 rainfall which were not available at the time of the assessment.

Similarly the hydraulic modelling previously prepared used Flood Modeller version 5.1 and TUFLOW version 2023-03. Subsequent to the preparation of this work and the submission of the TWOA application updated version of these software are available with Flood Modeller version 7.2 and TUFLOW version 2025.0.2 being the most recently available adopted versions at the time of writing (April 2025). It should be noted that Flood Modeller version 7.3 was released on the 16th of April 2025 and TUFLOW version 2025.0.3 was released 11th April 2025 with TUFLOW version 2025.1.0 expected to be released imminently in May 2025. However, we are still undertaking internal sensitivity and security testing on these software releases and they are therefore not yet adopted or available for use in this assessment.

This Note is intended to demonstrate the work undertaken to test if the conclusions drawn from the impact assessment of the proposed scheme used to inform the Flood Risk Assessment (FRA) are sensitive to the updated data and software versions currently available compared to those used at the time of the assessment.

TECHNICAL NOTE

DATE:	25 April 2025	CONFIDENTIALITY:	Public
SUBJECT:	Hydrology 2025 Addendum		
PROJECT:	Cambridge to Cambourne TWA	AUTHOR:	S Haberfield
CHECKED:	J Chambers	APPROVED:	J Southon

Hydrology Updates

All of the original catchment descriptors previously used in the 2022 hydrology calculations have been checked and deemed to still be appropriate to take forward as part of the additional hydrology calculations.

A check and comparison between using the current FEH22 and the original FEH13 rainfall models for the downstream catchment (BB04) which covers the entire model extent has been undertaken using all of the original catchment descriptors and model parameters. **Table 1** below shows the peak flows calculated using ReFH2.3 for both rainfall models. As shown in **Table 1** there is a slight increase in peak flows when comparing the FEH13 and FEH22 rainfall models for all return periods apart from the 1 in 200yr return period. The peak flow increases by approximately 0.23 m³/s in the 1 in 2yr return period which is a 7.5% increase. The peak flow increases by approximately 0.25 m³/s in the 1 in 100yr return period which is a 3% increase.

Table 1 – Comparison of peak flows between FEH13 and FEH22 rainfall models

FEH Rainfall Model	Flood peak (m ³ /s) for the following return periods (in years)									
	2	5	10	20	30	50	75	100	200	1000
FEH13	3.04	4.13	4.91	5.78	6.37	7.27	8.15	8.87	10.82	15.56
FEH22	3.27	4.68	5.63	6.58	7.16	7.93	8.59	9.11	10.61	16.36

Table 2 and **Table 3** below show the peak flows for all of the study catchments for a 9hr storm duration and a 15hr storm duration respectively and also compare the differences between the FEH13 and FEH22 rainfall models. **Table 2** and **Table 3** show that there is a slight increase in peak flows when comparing the FEH13 and FEH22 rainfall models for all return periods apart from the 1 in 200yr return period. The comparison between a 9hr and a 15hr storm duration show relatively similar peak flows with the results from the 9hr storm duration marginally higher than the 15hr storm duration results.

TECHNICAL NOTE

DATE:	25 April 2025	CONFIDENTIALITY:	Public
SUBJECT:	Hydrology 2025 Addendum		
PROJECT:	Cambridge to Cambourne TOWA	AUTHOR:	S Haberfield
CHECKED:	J Chambers	APPROVED:	J Southon

Table 2 – Peak flows from the ReFH Method using a 9hr storm duration

Site Code	Flood peak (m ³ /s) for the following return periods (in years)									
	2	5	10	20	30	50	75	100	200	1000
FEH13										
BB01	2.23	3.04	3.63	4.28	4.73	5.41	6.08	6.63	8.12	11.81
BB02	0.48	0.66	0.79	0.94	1.03	1.18	1.33	1.45	1.78	2.63
BB03	0.38	0.53	0.64	0.75	0.83	0.96	1.08	1.17	1.44	2.11
BB04	2.99	4.07	4.87	5.73	6.33	7.23	8.12	8.85	10.83	15.74
BB04_I	0.53	0.73	0.89	1.06	1.17	1.35	1.52	1.66	2.05	3.00
FEH22										
BB01	2.41	3.48	4.21	4.94	5.38	5.96	6.46	6.84	7.91	11.96
BB02	0.51	0.75	0.91	1.08	1.18	1.31	1.42	1.50	1.75	2.69
BB03	0.41	0.60	0.73	0.86	0.94	1.05	1.13	1.20	1.39	2.13
BB04	3.21	4.63	5.61	6.57	7.16	7.92	8.59	9.09	10.51	15.90
BB04_I	0.52	0.78	0.96	1.13	1.24	1.38	1.50	1.59	1.85	2.84

Table 3 – Peak flows from the ReFH Method using a 15hr storm duration

Site Code	Flood peak (m ³ /s) for the following return periods (in years)									
	2	5	10	20	30	50	75	100	200	1000
FEH13										
BB01	2.26	3.06	3.64	4.28	4.72	5.38	6.04	6.58	8.02	11.54
BB02	0.46	0.63	0.75	0.88	0.98	1.11	1.25	1.36	1.67	2.42
BB03	0.36	0.50	0.60	0.71	0.78	0.90	1.01	1.10	1.34	1.93
BB04	3.04	4.13	4.91	5.78	6.37	7.27	8.15	8.87	10.82	15.56
BB04_I	0.51	0.70	0.84	1.00	1.11	1.27	1.43	1.56	1.91	2.77
FEH22										
BB01	2.43	3.48	4.19	4.91	5.34	5.91	6.40	6.79	7.90	12.17
BB02	0.50	0.72	0.86	1.01	1.10	1.23	1.33	1.41	1.65	2.59
BB03	0.39	0.57	0.69	0.81	0.88	0.98	1.06	1.13	1.31	2.04
BB04	3.27	4.68	5.63	6.58	7.16	7.93	8.59	9.11	10.61	16.36
BB04_I	0.50	0.74	0.91	1.07	1.17	1.30	1.41	1.50	1.76	2.75

TECHNICAL NOTE

DATE:	25 April 2025	CONFIDENTIALITY:	Public
SUBJECT:	Hydrology 2025 Addendum		
PROJECT:	Cambridge to Cambourne TWOA	AUTHOR:	S Haberfield
CHECKED:	J Chambers	APPROVED:	J Southon

The upper and lower confidence bounds for both the 68% and 95% confidence levels are shown in **Table 4** below for BB04 (the downstream study catchment) using the FEH22 rainfall model. **Table 4** shows that the original peak flows using the FEH13 rainfall model fall within both confidence intervals indicating that the original hydrology calculated is still considered to be appropriate when considering the current flood datasets and software.

Table 4 – Upper and lower confidence bounds for ReFH peak flows

Site Code	Confidence Level (%)	Flood peak (m ³ /s) for the following return periods (in years)			
		2		100	
		Lower	Upper	Lower	Upper
BB04 (9hr Storm Duration)	68	2.21	4.65	6.09	13.54
BB04 (9hr Storm Duration)	95	1.54	6.74	4.09	20.27
BB04 (15hr Storm Duration)	68	2.26	4.74	6.10	13.57
BB04 (15hr Storm Duration)	95	1.57	6.87	4.10	20.32

TECHNICAL NOTE

DATE:	25 April 2025	CONFIDENTIALITY:	Public
SUBJECT:	Hydrology 2025 Addendum		
PROJECT:	Cambridge to Cambourne TWOA	AUTHOR:	S Haberfield
CHECKED:	J Chambers	APPROVED:	J Southon

Hydraulic Model

-Software version

The hydraulic model was re-run using Flood Modeller v7.2 and TUFLOW version 2025.0.2 for the 1 in 100 annual exceedance probability event including climate change for the baseline scenario. The original 2022 hydrology was retained.

The results are shown in **Table 6** below.

Table 6 – Comparison of peak water levels for the 1:100 AEP event including climate change as a result of hydraulic model software version

Software version	Peak water level (mAOD) 1:100 AEP event + climate change using 2022 flow							
	BB01_1189	BB01_0796	BB01_0628	BB01_0541	BB01_0461	BB01_0403	BB01_329	BB01_0049
Chainage from proposed bridge	-648m (South of Gough Way estate)	-255m (north of Gough Way estate)	-87m	0m (location of proposed crossing)	+80m (Hershel Rd crossing in grounds of Clare Hall)	+138m (Sylvester Rd crossing)	+191m (Robinson College access road crossing)	+471m (Grange Rd crossing)
National Grid Reference	543270, 257741	543487, 258067	543560, 258219	543600, 258297	543623, 258360	543682, 258375	543753, 258367	544005, 258450
FMv5.1 and TUFLOWv2023.03	10.103	9.416	9.361	9.374	9.373	9.346	9.196	7.722
FMv7.2 and TUFLOWv2025.0.2	10.103	9.416	9.361	9.374	9.373	9.346	9.196	7.722

Note that modelled peak water levels are quoted to three decimal places for illustration of model sensitivity only as this reflects the level of precision reported in the model results. They should not be relied upon to be 1mm accurate absolute values as this is beyond the confidence limits of the results.

As can be seen from the results in table 6 the software release version has no impact on modelled water levels.

TECHNICAL NOTE

DATE:	25 April 2025	CONFIDENTIALITY:	Public
SUBJECT:	Hydrology 2025 Addendum		
PROJECT:	Cambridge to Cambourne TWOA	AUTHOR:	S Haberfield
CHECKED:	J Chambers	APPROVED:	J Southon

Conclusions

From the information presented above it can be seen that:

- The peak flows from ReFH2 have a minor sensitivity to software version (from ReFH2.2 compared to ReFH2.3) when using the same rainfall (FEH13).
- The peak flows from ReFH2 have moderate sensitivity to the change from FEH13 to FEH22 rainfall – approximately 7.5% in the 1 in 2 annual exceedance event and 3% in the 1 in 100 annual exceedance event.
- The peak flows from ReFH2 are moderate sensitivity to a consistent storm duration being used across the study catchment. However, there is no consistent pattern across all study catchments and all return periods that would clearly indicate a preference for critical duration.
- The peak flows used in the 2022 study are within the confidence bounds of the flow estimates prepared using 2025 software versions and datasets indicating that the original hydrology calculated is still considered to be appropriate when considering the current flood datasets and software.
- The hydraulic model results are not sensitive to the versions of Flood Modeller and TUFLOW used.

It should be noted that it is reasonable to expect that updated hydrology and modelling software versions will continue to be released at regular intervals and the NRFA peak flow dataset updated at least annually with additional data for live sites. However, as demonstrated by the work reported in this note, while these changes have some moderate potential for absolute change in predicted flood levels for the area of interest (e.g. a small shift in the baseline flood levels as a result of updated flows) they are shown to have negligible impact on the relative change assessment when comparing a like for like baseline and proposed scenario.

Given the length of time required to prepare, submit and conclude a TWOA application it is to be expected that multiple software and data updates may be released during the lifetime of the assessment. However, it is not practical to continually update the evidence base of the assessment with every software and data release, especially where these occur during consultation, examination or determination periods. The priority should be a consistent evidence base that clearly communicates the forecast relative impacts of the scheme.

7. ENVIRONMENT AGENCY CORRESPONDENCE JULY 2025

RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

From Alison Craggs <[REDACTED]>

Date Fri 2025-07-25 13:38

To Jo M Baker <[REDACTED]>; Southon, Jack <[REDACTED]>

Cc Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK - Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann <[REDACTED]>

 2 attachments (14 MB)

LIT 17617 - Cambourne to Cambridge Hydraulic Model Review_Arcadis_23072025.xlsx; LIT 66039 - Flood Estimation Calculation Review Template_Cambourne_Arcadis_24072025.xlsx;

Hi all,

We have received the completed review from our modelling team. Please see the attached completed review spreadsheets and summary below. If you would like more time to review and absorb the details, George and I have some availability on Monday afternoon.

Hydrology

Though it is appreciated that the planning process timescales have contributed to the current situation, EA guidance standards consider a 6 month timeframe is reasonable for transitioning to using new methods and data. Given that 3 years have now lapsed and the evidence presented is not considered to demonstrate that changes to the hydrology in the intervening time are not significant, several outstanding aspects (red and amber comments) remain that need to be addressed. Green comments throughout are also recommended to be addressed to align with best practice.

Red Comments

1. Use the FEH22 rainfall for ReFH2, as the results presented in the addendum note are considered to be significantly different to those previously generated using FEH13 rainfall (see items 1.1.2 and 2.5.5).
2. Undertake a statistical method assessment using the latest software and datasets (see item 1.1.2).
3. Compare the updated ReFH2 and updated statistical method results, reconsidering the most appropriate overall method to use (see item 1.1.2).

Amber Comments

1. Consider urbanisation in each catchment and provide pooling group and growth curve fittings (item 4.3.1).
2. Confirm rural ReFH2 flow estimates for relevant catchments (item 7.1.2).
3. Confirm ReFH2 flow estimates based on a critical storm duration across all catchments (items 7.3.2 and 7.3.4).

Hydraulic Model

The model is currently not suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.

Red Comments

- The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs.
- Please update the zpoints, as the zpoints on the banklines and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.
- The commentary on local flood modelling in comparison to other data sources was not provided in the modelling report. Additionally, it is unclear whether the model results have been compared with the NaFRA2 model. Please include a commentary in the modelling report discussing the modelling results in relation to the NaFRA2 data.
- The report does not include full results, and more details need to be added in term of assumptions made to model the structures.

Amber Comments

- Please provide a 1D/2D structure log with reference to the surveyed cross sections including naming convention. The structures log should also include the assumptions considered to model the structures and the spills, along with the justifications of the omitted structures from the model. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered.
- Please revisit the approach to model the 1d channel under Robinsons College Building.
- Structures roughness sensitivity testing has not been applied correctly. Please revisit the structures roughness sensitivity testing and provide commentary in the modelling report.
- Provide detailed commentary in the report on changes in results due to sensitivity tests. Please provide a commentary in the modelling report regarding the confidence limits of the modelling results as well as the assumptions used in the model.
- XMDF results files have not been provided, these would help understand the hydraulic mechanism and will aid the reviewing process.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE



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From: Jo M Baker <[REDACTED]>

Sent: 25 July 2025 10:35

To: Alison Craggs <[REDACTED]>; Southon, Jack (Guest)

<[REDACTED]>

Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; George

Fuhrmann <[REDACTED]>

Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Dear Alison

I will send an invite for 4 if that's OK

Given the impending inquiry and the time this review has taken I think that we need to try to agree the way forward irrespective of whether or not EA is now in agreement, not in agreement or has still not received the modelling

Best regards

Jo

Jo Baker

Project Manager | [Greater Cambridge Partnership](#)

[REDACTED]



From: Alison Craggs <[REDACTED]>

Sent: 25 July 2025 10:02

To: Jo M Baker <[REDACTED]>; Southon, Jack (Guest) <[REDACTED]>

Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -

Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; George

Fuhrmann <[REDACTED]>

Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

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Hi Jo and Jack,

We are still expecting to receive the modelling response today.

What would you like to discuss? I am available for a quick call this afternoon, however it's unlikely technical colleagues would be able to attend given the short notice.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE

[REDACTED]



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From: Jo M Baker <[REDACTED]>
Sent: 24 July 2025 16:24
To: Southon, Jack (Guest) <[REDACTED]>; Alison Craggs <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; George
Fuhrmann <[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]
Importance: High

Alison

Please can we aim to meet tomorrow afternoon in any event.

Best regards

Jo

Jo Baker
Project Manager | [Greater Cambridge Partnership](#)



From: Southon, Jack <[REDACTED]>
Sent: 24 July 2025 16:19
To: Alison Craggs <[REDACTED]>; Jo M Baker
<[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; George
Fuhrmann <[REDACTED]>
Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

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Hi Alison,

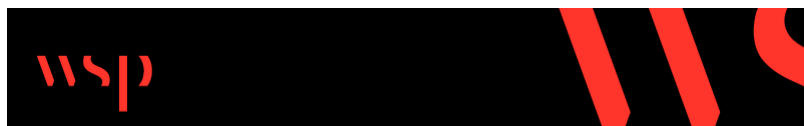
I just wanted to check in ahead of us reaching the updated deadline to check if you are still expecting the review to be returned tomorrow.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)



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From: Alison Craggs <[REDACTED]>
Sent: Tuesday, July 1, 2025 13:35
To: Jo M Baker <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; Southon, Jack
<[REDACTED]>; George Fuhrmann <[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Jo,

Thanks for your email. I have checked in with the modelling team. They have accepted Jack's email below and are proceeding with the review however we now have an updated deadline of 25th July. Unfortunately, due to pressures on internal capacity we are unable to deliver this review any sooner. I apologise for the delay.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE



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From: Jo M Baker <[REDACTED]>
Sent: 01 July 2025 09:21
To: Southon, Jack (Guest) <[REDACTED]>; George Fuhrmann <[REDACTED]>; Alison Craggs <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK - Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Dear Alison and George

Are you able to provide us with an update both on Jack's email below and on the assessment overall

Best regards

Jo

Jo Baker
Project Manager | [Greater Cambridge Partnership](#)



From: Southon, Jack <[REDACTED]>
Sent: 20 June 2025 11:50
To: George Fuhrmann <[REDACTED]>; Jo M Baker <[REDACTED]>; Alison Craggs <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK - Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>
Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

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Hi George,

Please find attached the two initial conditions files we used in the modelling - both of these files were supplied in the ZIP folder recently provided

Please can you confirm if the request for "**BB01_008_Prop_initial_conditions.iic**" is a transposition of "**BB01_Prop_008_initial_conditions.iic**" as previously supplied as we don't appear to have a file of that name and from review of the IEF files provided for the re-review (listed below) I note that they all reference BB01_008_initial_conditions.iic only and that the these initial conditions are unchanged from January 2024 (and the file BB01_Prop_008_initial_conditions.iic is unchanged since August 2022 - albeit not used in the latest round of model runs).

BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19_012_15sd_FEH22.ief
CD26-01-APP-W9-3 page 130 of 192

BB01_BSC_100yrCC19_012_9sd.ief
BB01_BSC_100yrCC19_012_9sd_FEH13.ief
BB01_BSC_100yrCC19_012_15sd.ief
BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19_012_9sd_FEH13.ief
BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19_012_9sd_FEH22.ief

Additionally looking back at the last review the comments related to model initial conditions were "IIC file has been used for the Baseline model, and a separate IIC file used for the Proposed model. Spot check of the sections does not show any issues with the initial conditions." classed as OK (no future action required).

All this is a long winded way of saying I can't find any references to a file *BB01_008_Prop_initial_conditions.iic* in any of the recent work and it isn't referenced in any of the model runs the FRA etc rely upon so I don't think there is a missing file.

However if your reviewer still thinks they have a missing file please can they confirm where they think this is referenced and I'd be happy to have another look to resolve.

I hope this explanation addresses the request below.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)

[Redacted]



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From: George Fuhrmann <[Redacted]>
Sent: Friday, June 20, 2025 10:58
To: Jo M Baker <[Redacted]>; Alison Craggs <[Redacted]>; Southon, Jack <[Redacted]>
Cc: Giesler, Nick <[Redacted]>; Haberfield, Stephanie <[Redacted]>;
UK - Cambourne to Cambridge <[Redacted]>; Higgins, Graham <[Redacted]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order
[ENVPAC/1/EAN/00709]

Hi both,

The review is underway but requires a missing file to continue. Can you please send me the following so I can pass it on:

BB01_008_Prop_initial_conditions.iic

The final deadline for the 2nd review is the 5th of July, with the aim to have it completed sooner than that. Please send the missing file when able.

Kind regards,

George Fuhrmann

FCRM Advisor – Growth and Regulation

Partnerships and Strategic Overview Team

East Anglia Area (Great Ouse catchment)

Environment Agency | Brampton Office, Bromholme Ln, Brampton, Huntingdon PE28 4NE

[REDACTED]



From: Jo M Baker <[REDACTED]>

Sent: 20 June 2025 10:49

To: Alison Craggs <[REDACTED]>; Southon, Jack (Guest)

<[REDACTED]>

Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Higgins, Graham <[REDACTED]>; George
Fuhrmann <[REDACTED]>

Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Dear Alison

Is there any update on this. Just to appraise you that we are heading towards a public inquiry starting on September 16 with proofs of evidence to be largely completed by the end of July.

If we cannot resolve the matter I would welcome an urgent meeting with you and your colleagues to discuss how we might best proceed.

Best regards

Jo

Jo Baker

Project Manager | [Greater Cambridge Partnership](#)



From: Alison Craggs <[REDACTED]>
Sent: 16 June 2025 08:19
To: Southon, Jack (Guest) <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Higgins,
Graham <[REDACTED]>; George Fuhrmann <[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

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Hi Jack,

Apologies for the delay, I have chased the modelling team but didn't hear back last week. I will let you know timescales as soon as I can.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE



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From: Southon, Jack <[REDACTED]>

Sent: 13 June 2025 16:57

To: Alison Craggs <[REDACTED]>

Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -

Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Higgins,

Graham <[REDACTED]>; George Fuhrmann <[REDACTED]>

Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Alison,

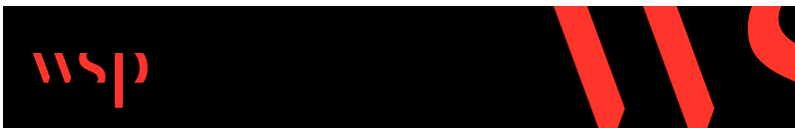
Please can you kindly confirm receipt of the model files we uploaded on the 21st May and if there is any ETA on when the model review may be concluded.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)



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From: Southon, Jack <[REDACTED]>
Sent: Tuesday, June 10, 2025 14:08
To: Alison Craggs <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
<[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>
Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Alison,

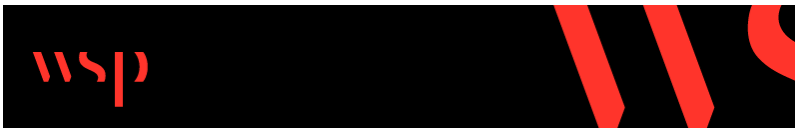
Just checking in to see if there was any update.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)



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From: Southon, Jack <[REDACTED]>
Sent: Friday, May 30, 2025 13:10
To: Alison Craggs <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
<[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>
Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Alison,

Just to follow up on previous correspondence to check that you received the files we uploaded to the link below the other week.

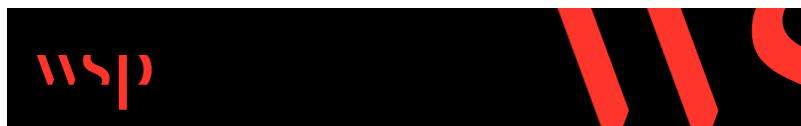
And to see if we could get a provision date in the diary for a follow up call for a time when you think your review may be concluded.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)



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From: Alison Craggs <[REDACTED]>
Sent: Friday, May 16, 2025 14:47
To: Southon, Jack <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
<[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Jack,

Thanks, I will check in with modelling team. To clarify we would consider the sensitivity model files an addendum to support the model review and therefore would consider it a follow up rather than a

new review.

Please upload your file here: [DEFRA file sharing service](#)

If you have any issues please let me know.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE

[REDACTED]

[REDACTED]

[REDACTED]



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From: Southon, Jack <[REDACTED]>

Sent: 16 May 2025 13:26

To: Alison Craggs <[REDACTED]>

Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
(Guest) <[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>

Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Alison,

Just to confirm we are seeking agreement that we have sufficiently addressed the comments in the previous model review.

To this end we undertook a range of sensitivity tests to demonstrate that our modelling and hydrology assessment was sound and the conclusions of our FRA were not materially impacted by any perceived uncertainty in the modeling or hydrology assessment.

As indicated below we would be happy to supply full copies of the sensitivity models and results to evidence the results of the sensitivity tests reported in our summary note. However, we would characterise this as a re-review and we are not requesting a full review of the sensitivity models themselves as these have only been produced to respond to the suggested uncertainty raised by the external review.

I believe we have previously supplied the model files for the design scenarios via EA-ShareFile. If you can kindly provide an EA ShareFile upload link we can furnish you with a copy of the sensitivity test model that supports our previously supplied technical note.

If on receipt you conclude that a full 4-week review is required, then I am pleased to confirm I have full availability on the 24th or 25th of June.

However we hope you agree that it would be appropriate to limit the scope of the re-review to those outstanding matters and focus on the technical note.

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)

[Redacted signature]



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From: Alison Craggs <[REDACTED]>
Sent: Friday, May 16, 2025 12:00
To: Southon, Jack <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
<[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>
Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Jack,

Thanks for your email.

We will need to carry out a review to sign off the model. Please do send anything further you think would be helpful for the reviewer.

Our standard timeframe for review is 4 weeks, so I would suggest booking in a meeting w/c 23rd or 30th June.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE

[REDACTED]



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From: Southon, Jack <[REDACTED]>
Sent: 13 May 2025 16:46
To: Alison Craggs <[REDACTED]>
Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
(Guest) <[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>
Subject: Re: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Alison,

Thank you for the update.

I hadn't anticipated that you would need to go back out to the external consultant so kept the hydrology and hydraulic response note fairly high level to support conversational resolution of the points raised. If you are sending it back out I suspect Arcadis may want to see the 'nuts and bolts' behind our note, if this is the case I can supply the sensitivity testing model files and raw results for their satisfaction. I'm happy to do this proactively so there aren't any future delays - the worst outcome for us would be for Arcadis to turn around and say they are happy with our approach / justification but want to see the model files and another 10 days go by.

Given bank holidays etc. can I suggest we book a place holder follow up call for a time after you reasonably expect the external review to be returned? We can always cancel if not required or postpone if there is an unforeseen delay in the external review but it would be unfortunate to get towards the end of the month, find we would all benefit from a short call only to find we have scheduling conflicts.

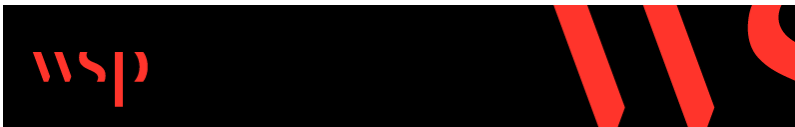
I have good availability w/c 27-28/05 and 06/06

Kind Regards,

Jack Southon

Technical Director

Pronouns (He / Him)



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From: Alison Craggs

Sent: Tuesday, May 13, 2025 15:06

To: Southon, Jack

Cc: Giesler, Nick; Haberfield, Stephanie; UK - Cambourne to Cambridge; Jo M Baker; Garratt, Lee; Higgins, Graham; George Fuhrmann

Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Jack,

I've discussed this further with the modelling team and a meeting at this time would not be productive. The model was previously reviewed by an external consultant and the follow-up will likely also be undertaken by them. However our external consultants are not able to attend meetings. If we were to host a meeting in 10 working days, we would not be able to provide the most up-to-date response as the review will be in progress. This would be a duplication of work as well as potentially contradictory (if the external reviewer finds something in their detailed review).

I have submitted the hydrology and hydraulic response, including the sensitivity test, to the team. I suggest that we wait for the outcome of the review and then arrange a meeting if necessary.

I hope this approach is acceptable, please get in touch if you have any questions.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE

[REDACTED]

[REDACTED]

[REDACTED]



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From: Alison Craggs

Sent: 07 May 2025 13:23

To: Southon, Jack <[REDACTED]>

Cc: Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK -
Cambourne to Cambridge <[REDACTED]>; Jo M Baker <[REDACTED]>; Garratt, Lee
(Guest) <[REDACTED]>; Higgins, Graham <[REDACTED]>; George Fuhrmann
<[REDACTED]>

Subject: RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

Hi Jack,

Thanks for sending this over. I was on leave yesterday so only picked this up today.

Our modelling team require 10 working days between receiving submissions and a meeting;
therefore we would be looking at 22nd May onwards. I will check with the team on their availability
and let you know.

Kind regards,

Alison Craggs

Sustainable Places Advisor

East Anglia Area (West)

Environment Agency, Bromholme Lane, Brampton, Huntingdon, Cambs. PE28 4NE

[REDACTED]

[REDACTED]

[REDACTED]



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contact for you at the EA, giving you detailed specialist advice within guaranteed delivery dates. This early

engagement can significantly reduce uncertainty and delays to your project. More information can be found on our website [here](#).

RAG COMMENT CLASSIFICATION GRADING SYSTEM

The following RAG system is used to classify comments and identify appropriate report:

N/A - not relevant to this study.

OK – Good practice.

Minimum expected response: No minimum.

Maximum expected response: No maximum.

Planning: No Objection.

Green – Negligible impact on the results that is unlikely to change the outcome.

Taking action to address issues would be expected and some issues may be addressed.

Minimum expected response: Acknowledge the comment in the spreadsheet and update the report.

Maximum expected response: Actions done to address the issue identified.

Planning: No Objection.

Amber – Potential impact on the results that may change the outcome of the study.

Taking action to address issues should be undertaken, some issues may be addressed.

Minimum expected response: Comments justifying the approach taken and updated the report.

Maximum expected response: Actions done to address the issue identified.

Planning: Consider objecting to the application based on comments highlighted.

Red – Has an impact on the results that may significantly change the outcome of the study.

If no action is taken the response must clearly demonstrate why the issue raised is justified backed up with evidence. If issues highlighted red are ignored, then subsequent issues may be raised.

Minimum response: Comments thoroughly justifying approach from applicant based on the report if action is not addressed.

Maximum expected response: Actions done to address the issue identified.

Planning: Objection - Application to be objected if comments are highlighted in the report.



1. Summary of assessment

Summary											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
1.1.1	Does the report include a summary at the start that covers: ●Catchment location ●Purpose of study and complexity ●Key catchment features ●Flooded mechanisms ●Gauging stations ●Final choice of method ●Key limitations and uncertainties	●This section provides a summary of the key information contained within the detailed assessment in the following sections. ●The aim is to enable quick and easy identification of the type of assessment undertaken. This should assist in identifying an appropriate reviewer and the ability to compare different studies more easily. ●Keep the text to one or two sentences for each point.	Green	No summary sheet has been provided. It is considered that the key information is largely covered in the relevant sections of the body of the FEH calculation record.	Provide a summary sheet at the beginning of the document that details the key information contained within the assessment, to enable future users more efficient identification of the assessment methodologies and to allow for easier comparisons to different studies.	The use of the FEH calculation record format is specifically designed to allow for easy comparison between different studies. As acknowledged the key information is set out in the FEH calculation record. An additional 'summary sheet' would seem superfluous. If this is considered best practice then we would recommend it is incorporated into the next update to the FEH Calculation record template produced by the Environment Agency. No future action proposed	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
	Stop and think! What has changed since the calculations were undertaken or previously reviewed? Consider if there have been any changes in methods, software and/or data that could significantly change the outcome of the study.	These guidelines are not absolute and there may be some circumstances where a different approach is warranted. Decisions over methods and data should be justified with supporting evidence and proportionate to the project scope, impacts and risk. Please contact the National Flood Hydrology team for further support. In general, a 6 months' timeframe is considered reasonable for transitioning to using new methods and data (see National Flood Hydrology transition guidelines). However, sometimes a faster transition is needed if there are significant impacts on flood estimates. In other cases, new methods and data may have little impact on individual studies outcomes and older hydrological analysis may still be appropriate.		The NRFA peak flow data set referenced to be used is Version 10. As per EA guidelines, the most up to date NRFA peak data set should be used, which is now 13.0.1		The Hydrology study was prepared and undertaken in 2022 and made use of NRFA peak flow data set v10 which was the most recent version at the time of the study. It should be noted that the hydrology study concludes by recommending the flow estimates from ReFH2 in preference to the Statistical method as the ReFH2 method peak flow estimates are higher in comparison to the peak flow estimates produced by the Statistical method. ReFH2 does not use the NRFA peak flow data set so even updating this to use NRFA peak flow data set v13 (which is the current version as of the time of writing), would not impact on the flow estimates used in the model. The use of 'ReFH' to specifically reference Revitalised Flood Hydrograph rainfall-runoff method version 2 or ReFH2 is now common parlance in hydrology studies and is generally an acceptable alternative to 'ReFH2, some 10 years after ReFH2 was released with ReFH(1) being largely defunct and no longer in common use. This is consistent with how the Environment Agency's template FEH calculation record's use of abbreviations. There is one incorrect reference to ReFH2.3 (version 3.1.7439); this should read ReFH2.2 (version 3.2.7650.24314). This will be corrected in any future revisions and a clarification attached to the FRA to confirm this. As noted above the study was prepared in 2022 prior to the release of ReFH2.3 and therefore used the most up to date methods and data available at the time of preparation. As set out in the FEH calculation record and FRA the study is to show the relative impact on baseline flood risk conditions as a result of the introduction of development works, principally a new bridge and road embankment. Therefore the focus is on relative change. Provided consistent hydrology was applied to the baseline and proposed models it is not considered that the use of ReFH2.3 (and FEH22) compared to ReFH2.2 (and FEH19) has the potential to 'significantly change the outcome of the study'. We would stipulate that this should be a green comment as it has 'negligible impact on the results that is unlikely to change the outcome of the study' but should be 'consider[ed] for future studies'.		It is appreciated that the hydrology was originally undertaken in 2022 with the latest guidance at the time. Given that this template states that 'in general, a 6 months' timeframe is considered reasonable for transitioning to using new methods and data' and 3 years have now lapsed, the first review comments stand and a thorough check should be made on all aspects that are now significantly out of date.	Undertake Statistical method assessment using latest software and data (detailing all study specific parameters used), compare against ReFH2 estimates following updates to this methodology also, and justify final flows.		
1.1.2	Changes could include: ●A recent large flood in the catchment being modelled ●New datasets, such as an updated NRFA dataset version. Although single year changes are expected to be small, the impacts of several years or more of changes could be more significant. ●New methods, such as the FEH22 rainfall depth-duration-model, the updated ReFH2.3-FEH22 model, and the small catchments pooling method. ●New software that includes bug fixes or changes to methods.	Consultants can support this review action by providing sensitivity analysis or residual uncertainty analysis to take into account the potential impacts of using new methods or data. For example, a sensitivity test could use the latest data and methodologies to estimate lumped flow at one key location assessed in the study for the 1% AEP event for comparison with the original analysis: ●If flows or volumes are increased by more than 20% , do not proceed further with this review. Mark this row as Red and request the calculations are updated using the latest data and methodologies. ●If flows or volumes are increased by 10 – 20%, mark this row as Amber. Continue with the review and check that the potential impacts of this change are allowed for within the sensitivity analysis or residual uncertainty analysis. ●If flows or volumes are increased by less than 10%, mark this row as Green. Note that best practice would be to use the latest methodologies and data, but these are unlikely to change the outcome of the study. Check that the potential impacts of the change are allowed for within the sensitivity analysis or residual uncertainty analysis.	Red	WINFAPS is stated to have been used. Inconsistent referencing of ReFH is given throughout the report with ReFH2.2 mentioned predominately. The latest calibration of the ReFH2.3 model was released in 2023 to utilise the FEH22 design rainfall.	Update the hydrology undertaken using FEH22 (in latest version ReFH2.3 version 4) and most up to date peak flows (Version 13).		Red	Though the ReFH2 peak flows were previously higher than the Statistical peak flows, it is possible that the new peak flow dataset will result in Statistical peak flows that are higher than the ReFH2 peak flows, which may influence the final choice of method. This specific aspect needs to be checked. Though only the relative difference between baseline and proposed scenarios may be critical, the fact that the updates are being diluted does not mean that the difference could not now become significant.			
1.1.3	(Additional space for other items checked)	N/A									



2. Method Statement

2.1 Requirements for flood estimates											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
2.1.1	Does the method statement include an overview of the project, its scope and hydrological complexity?	<ul style="list-style-type: none">•The content and level of detail provided in this section will depend on the scope of the study. The following should be included as a minimum:<ul style="list-style-type: none">•Purpose of study•Peak flows or hydrographs?•Design events for which flow estimates are to be made (AEP %)•Climate change allowances with reference to relevant guidance•Potential number of locations for flow estimation•The purpose of the document•What is the complexity of the study – simple, routine, moderate, difficult, very difficult?•What does the client's scope specify for inclusion in the study, e.g., review of existing studies, rating reviews / updates, simple / detailed flood history review, ReFH model parameter estimation, joint probability?•Include a reference to any modelling reports which this flood estimation calculation record supports.	Green	<p>The method statement provides the relevant project details. However, there is no note regarding the complexity of the study.</p> <p>There is no reference to the hydraulic modelling report which this study supports.</p> <p>No climate change allowance included and no reference made to the latest climate change allowances guidance.</p> <p>The hydraulic model report notes that the bridge will be designed to the 1 in 100 year plus climate change allowance of 19% for the catchment (correct percentage for the basin) but this is not referenced in the FEH calculation record itself. There is also reference made to the 1 in 1000 year plus 19% allowance for climate change event within the model report, which is not reflected in the calculation record.</p>	Update the report to include complexity of the study, a reference to the hydraulic modelling report and the climate change allowances to be used with references to the relevant guidance.	Both the FEH Calculation record and the Hydraulic modelling report form appendices to the Flood Risk Assessment. Climate change allowances and the relevant guidance are clearly set out therein and as such when read together as intended there is no ambiguity in this regard. No action proposed.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
2.1.2	(Additional space for other items checked)	N/A									
2.2 The catchment											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
2.2.1	Does the method statement include maps showing the catchment and key locations and hydrological features?	<ul style="list-style-type: none">•Include a map of the catchment in here, at a minimum showing the river network, catchment boundary and gauging stations, and appropriately labelled / referenced in a legend. Additional information which could be included is the model extent or locations of unusual / interesting features, for example. Think about the background mapping being used – scale and colour / greyscale – think about if the reader could easily identify locations from the background mapping.•Include more than one map if that would assist in presenting the information, consider including maps using satellite imagery as background if that would better show key catchment features, and consider including photographs if they would help understanding of features identified in the 'Description' section. For permeable catchments, consider including a hydrogeological map showing groundwater equipotential lines.•Remember to give all figures a number and title and refer to them in the text.•Consider changing the page orientation to landscape and the page size to A3 if necessary or including maps as a separate digital appendix	Green	<p>The mapping in Figure 1 and Figure 2 could more clearly define and label the river network. The locations of the Flood Estimation Points on Figure 2 in the mapping provided are not clearly definable.</p> <p>It would be useful to show the location of the lakes relevant to the catchment boundaries to corroborate the FARL values in Section 2.</p> <p>This will aid future readers to better understand the key catchment characteristics used in the derivation of the hydrological estimates.</p>	Update Figure 1 and Figure 2 to include a clearer river network. Update Figure 2 to include the locations of the FEP, as opposed to just the catchments. Include the reservoirs on Figure 2.	Figure 1 has lakes and watercourse labelled. The River network is shown on the OS mapping used as the basemap. Figure 2 includes catchments, FEP locations could be added for future studies but this information (easting and northing) for each FEP is clearly set out in section 2.1. No action proposed	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
2.2.2	Does the method statement describe the catchment and its hydrological features, including how runoff is generated during flood events and any unusual features that might affect the flood hydrology.	<ul style="list-style-type: none">•Think about how runoff will be generated and what features are going to affect runoff from the contributing catchment reaching the watercourse. Include:<ul style="list-style-type: none">•Topography•Climate•Geology•Soils•Land use•Any unusual features (e.g., reservoirs, historic mining) that may affect the flood hydrology.•In some cases, it may be useful to include reference to things such as amount of modelled reach that is culverted but remember that this is not a hydraulic modelling report and detail on hydraulic features, such as weir and culvert sizes, is not required.	Green	<p>The method statement describes the key catchment and hydrological features and particular reference is made to the online lakes.</p> <p>There is no description of climate or rainfall received by the catchment. No assessment of historic mining in the catchment. Whilst it is acknowledged that incorporation of this in any future changes wouldn't affect the outcome of the study, it would help to provide a more conclusive picture of the catchment for readers.</p>	Add climate data for the catchment and investigate any historic mining in the catchment.	As per response to 2.1.1 climate change discussed in main FRA to which the FEH calculation record forms an appendix. Mining noted for future studies.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
2.2.3	(Additional space for other items checked)	N/A									
2.3 Hydrometric data											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
2.3.1	Are the sources of flood peak data listed? Is the latest version of the NRFA database used?	<ul style="list-style-type: none">•This should be updated to the latest version of the dataset at the time of the assessment.	Amber	The NRFA peak flow dataset is not the most up to date (Version 10 being used instead of the current Version 13).	Update the hydrology with the latest peak flow dataset (Version 13) or perform a sensitivity analysis on the implications of this.	Please see response to 1.1.2	Amber	The latest NRFA peak flow dataset may result in Statical method peak flows that are higher than the ReFH2 peak flows, and therefore potentially impacting the final flows to use. Please check this and justify the final flows.	Please see response to 1.1.2.		
2.3.2	Are the type and record length of flow and level gauging stations listed, including stations outside the NRFA peak flows dataset and closed stations as well as current ones?	<ul style="list-style-type: none">•You only need to include gauges at or very near to the sites of flood estimates unless there is an exceptional reason to include other gauges.•If you have data extracted from WISKI the datafile may only provide the digital data period of record, and the actual operating period of the gauge may be longer. You should check this using the NRFA website.	Green	There is an EA level gauge located on the Bin Brook, in close proximity to the BB01 FEP. This and the data quality and potential uses need to be included within Table 1.4	Provide details of the Bin Brook level gauge in Table 1.4.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
2.3.3	Is the data available at each flow gauging station summarised, including data type, record length, data quality, and what further updates and checks are needed in this study?	<ul style="list-style-type: none">•This table can be deleted if the study catchment is ungauged.•A quality check of the data is not required if the gauge is in the NRFA, unless specifically called for in the project brief.•There is no need to repeat everything in the NRFA station description, for example, weir length, wingwall height. Just add the key factors which will affect the quality of flood flow measurement and hence confidence in the data. For more detailed studies consider looking for other sources of information, for example, gauging authority rating review reports, station files held at CEH Wallingford, or reports on earlier flood studies.•Any flood peak data not in the NRFA (e.g., extra stations, recent data or altered flows) should be provided in the appendix.•Provide details of how peaks-over-threshold (POT) data has been derived in the appendix.	Green	There is a level gauge located on the Bin Brook, in close proximity to the BB01 FEP, which could be used for Lag analysis.	Provide summary of data available at the Bin Brook gauging station and consider if it can be used for Lag analysis. If so, update the ReFH2 flows accordingly.	please see response to 2.3.2	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
2.3.4	Is it appropriate to update the flood peak data (e.g. to include additional water years or a new rating) and if so has this been done?	<ul style="list-style-type: none">•Tabulate any updated or revised flood peak series in the appendix and provide a summary here.	N/A	Not applicable.							
2.3.5	Have data quality checks been carried out, at minimum giving the NRFA peak flows classification? Is a more detailed review of data appropriate for this study and if so has it been done?	<ul style="list-style-type: none">•Provide full details of data quality checks in the appendix and summarise findings here.	N/A	Not applicable.							
2.3.6	Are rating equations summarised and is a more detailed rating review needed?	<ul style="list-style-type: none">•The Flood Estimation Guidelines provide suggestions on the information that should be collated and assessed for rating reviews (Section 2.1 'Rating reviews and improvements').•A site visit is an important component of any rating review.	N/A	Rating review out of scope.							
2.3.7	Have any changes to ratings been reported? (see additional tab 2a)	<ul style="list-style-type: none">•Provide full details of rating updates in an additional report or the appendix.	N/A	Rating review out of scope.							
2.3.8	Has other relevant data been sought and presented in the report? Has data quality been reviewed? Have any flood alleviation schemes been carried out or other significant catchment changes which could affect the relevance of older data?	<ul style="list-style-type: none">•Check flow gaugings / spot flow gaugings are only required if you are reviewing a rating•Historical flood data: a chronology and interpretation of the flood history should be included in the appendix or in an additional report (add references). The detail included will depend on requirements in the project scope. If there is a flow gauge within the study reach (or close by), consider if the historical flood data could be used to extend the systematic gauge record (see FEH Local guidance for more information).•Potential evaporation data may be required if the ReFH Calibration Utility is being used.•Other data or information could include groundwater, tides, channel widths, low flow statistics, sewer network data, or any other data used in your analysis. Add extra rows to the table if needed.	N/A	None identified.							
2.3.9	Does the report conclude by clearly explaining what the data at each gauging station will be used for?	N/A	Green	Reference to Item 2.3.2 and Item 2.3.3. Conclusions should be made on the use of the data on the assessment.	Conclude on the use of the level gauge in assessment.	please see response to 2.3.2	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		

2.3.10	(Additional space for other items checked)	N/A								
2.4 Hydrological understanding of the catchment										
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response RAG 3
2.4.1	Are plots of flood peak data included and interpreted?	<ul style="list-style-type: none"> This could be the AMAX series or the POT series. Usually examine the time series and identify if there are, for example, outliers, apparent truncation of the flood peaks, trends or fluctuations in the data, step changes in the data, or unusually small flows. You should include an interpretation of these and other features. If there is more than one gauge in the study area, correlation plots can help to identify patterns or inconsistencies in the hydrological behaviour. You could add informative plots, for example, showing the seasonality of floods or the correlation of peak flows at different gauges. 	N/A	Not applicable.						
2.4.2	Are plots of flow data included and interpreted?	<ul style="list-style-type: none"> This could include, for example, annual flow hydrographs or flood events. Plots should be followed by an interpretation of the plots, for example, discussion of catchment processes, response time, propagation of a flood, and contributions from tributaries. If there is more than one gauge in the study area it can be useful to plot the data for all gauges on the same graph as this can aid understanding of the relationship between flow at different locations. These plots can be useful for checking the quality of the data and it is often helpful to plot flow and rainfall together as this may identify problems. 	N/A	None provided.						
2.4.3	Are plots of stage data included and interpreted?	<ul style="list-style-type: none"> Many catchments do not have flow gauges, but stage / level data may be available. This data can provide valuable information on the catchment response in the absence of flow data, for example estimating T_p from lag analysis. 	N/A	None provided.						
2.4.4	Has a conceptual model for the catchment flooding processes been described?	<ul style="list-style-type: none"> See Section 3.3 of the Flood Estimation Guidelines. Include information on factors such as: <ul style="list-style-type: none"> Where are the main sites of interest? What is likely to cause flooding at those locations? (e.g., peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides...) Might those locations flood from runoff generated on part of the catchment only, e.g., downstream of a reservoir? Is there a need to consider temporary debris dams that could collapse? 	OK	The conceptual model for flooding is provided.						
2.4.5	Have unusual catchment features been identified? What is their impact on choice of method and conceptual model? E.g.: <ul style="list-style-type: none"> Urbanisation: impacts on local flood generating processes and influence of the urban drainage network. Reservoirs: the potential need for reservoir routing calculations. Highly permeable catchments: hydrogeological setting and influence on flood generation. Pumped: alternative rainfall-runoff methods. 	<ul style="list-style-type: none"> See Section 7 of the Flood Estimation Guidelines. Include information on factors such as: <ul style="list-style-type: none"> Highly permeable soils or geology Heavily urbanised land use Pumped watercourse Major reservoir influence (FARL<0.90) Flood storage areas, particularly those which are normally dry Historical mining or operational mining activities 	Green	<p>Unusual catchment characteristics have been identified such as the impact of lakes (BB02 Has FARL of 0.9).</p> <p>However, BB04_I has a particularly high URBEXT value (0.311) and this is not highlighted nor the impact on choice of method (i.e. summer storm profile for URBEXT >0.3 (0.311)).</p>	Note the impact that the URBEXT value has on choice of method and conceptual model in Section 1.8.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
2.4.6	(Additional space for other items checked)	N/A								
2.5 Initial choice of approach										
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response RAG 3
2.5.1	Are FEH methods appropriate?	<ul style="list-style-type: none"> FEH methods may not be appropriate, e.g., for extremely heavily urbanised or complex catchments). Explain your decision. 	Green	<p>FEH methods are considered broadly appropriate. However, see items 2.4.5 above and 2.5.2. below, where further rationale behind choice is required.</p> <p>Also, ReFH2.2 referenced in initial choice of method and later software referenced as ReFH2.3. ReFH2.3 should be used in line with best practice.</p>	Update FEH method in line with latest best practice guidance.	See response to 1.1.2	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
2.5.2	Is an initial choice of method(s) included with adequate reasons? Have unusual catchment features been considered and choices of methods justified?	<ul style="list-style-type: none"> See Section 3 of the Flood Estimation Guidelines. Think about: <ul style="list-style-type: none"> the type of problem the type of catchment the type of data available Which methods are appropriate? If more than one method is considered and choices of methods justified? <ul style="list-style-type: none"> Which methods are appropriate? If more than one method is considered and choices of methods justified? Will non-stationary methods be applied? Will different storm durations need to be considered / tested? 	Green	<p>Initial choice of method provided. However, further explanation is required. EA Guidance notes that the statistical method is 'particularly preferable if there are lakes or other water bodies in the catchment and you are not planning to use flood routing to represent them. Their influence will be represented in a general way via the FARL descriptor, which is used in the statistical method but not in design event methods.' The guidance also notes that a rainfall runoff approach 'might be favoured for estimating the more extreme floods' required under the scope of the assessment (200 to 1000 years). No evidence of hybrid method for higher return periods was provided.</p>	Revise reasoning of initial choice of method considering unusual catchment features, and update Table 1.8 to reflect this.	<p>Noted for future studies. It is observed that the higher FARL value is only observed on FEP BB02 which is a minor tributary (1.05km2 catchment compared to 17.32km2 for the downstream extent). FARL for the area of interest in this study is expected to be ~0.99. For the avoidance of doubt in this case both FEH statistical method and ReFH2 method were taken forwards to prepare estimates for the FEPs. The final choice of method was based on ReFH2 being more conservative (higher) flow estimates. Therefore the initial choice of method has no bearing on the outcome of the study. It would also seem disingenuous to retrospectively update the initial choice of method when this should in our view document the thinking at the time of the assessment. Where ReFH2 already provides the higher estimates and is adopted for being conservative it would not seem appropriate to adopt a hybrid approach.</p>	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
2.5.3	How will hydrograph shapes be derived if needed?	<ul style="list-style-type: none"> For example, ReFH1 or ReFH2 shapes, average hydrograph shape from gauged data. If using average hydrograph shapes, how will inflows from different tributaries be phased? 	Green	No detail on derivation of hydrograph shape is provided. No gauged data available, so hydrograph shape is produced using ReFH2	Update Table 1.8 to state that hydrograph shape will be produced via ReFH2.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
2.5.4	Will the catchment be split into sub-catchments? If so, how?	<ul style="list-style-type: none"> If the hydrological assessment is being undertaken to supply inflows to a hydraulic model, it is likely that a distributed approach will be taken, with the catchment split into sub-catchments and design flows routed from each sub-catchment. Think about what the split into sub-catchments will be based on, e.g., tributary confluences, changes in geology / urbanisation, key areas of interest, sewer outfalls. Will intervening area hydrographs be required and how will these be derived? If the catchment area changes significantly over the study reach, or tributaries are also being modelled, will different storm durations need to be considered / tested? 	Green	No reference to split of the catchment has been made in Section 1.8 of the FEH Calculation Record. The catchment map (Figure 2) provided in Section 1.2 shows that the catchment comprises one upstream FEP representing the inflow to the top of the model extent, two tributary inflows and an intervening area to the downstream lumped catchment. No information on hydrograph derivation for intervening area is provided. No consideration of any necessary changes to storm duration made (tributaries have a shorter storm duration than upstream and lumped downstream catchments).	Update Table 1.8 to include that the catchment will be split into sub-catchments.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
2.5.5	What software will be used?	<ul style="list-style-type: none"> See Section 1.2 of the Flood Estimation Guidelines Include version numbers Include software used for non-stationary analysis, if undertaken. 	Red	Software used is ReFH2.2.2, which is not the latest software.	Update the hydrology undertaken using FEH22 (in latest version ReFH2.3).	Please see response to 1.1.2	Red	Checks comparing FEH13 and FEH22 reported. These show a significant increase that needs to be considered further. While some FEH13-FEH22 increases are small, they are significant when taken in the context with the range across events. For example, the FEH22 20yr peak flow is greater than the FEH13 30yr peak flow.	Please see Section 7.3.2.	
2.5.6	(Additional space for other items checked)	N/A								



3. Locations where flood estimates are required

3.1 Summary of subject sites											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
3.1.1	Have locations where flood estimates are required been tabulated and shown on a map, clearly distinguishing between lumped catchments and sub-catchments (intervening areas) and explainint the purpose for which they have been created?	<ul style="list-style-type: none">●Include a map which shows the locations of the subject sites.●Use site codes in all subsequent tables for clarity and to save space.●Lumped catchments (L) are complete catchments draining to points at which design flows are required.●Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a distributed model. Details of these need to be included so that results can be fully reproduced and checked.	Green	Catchments are delineated for corresponding FEPs but the FEPs themselves are not labelled on maps as noted in section 2.2.1. It would be useful to add the model extents and the position of the bridge to the mapping for context.	Add FEPs, model extent and bridge location to Figure 3.	See response to 2.2.1	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
3.1.2	Do you agree with the choice of flood estimation points? Do they cover the main locations of interest (e.g. confluences, areas of known flood risk, gauging stations, model boundaries) without including an excessive number of subcatchments or very similar catchments?	N/A	OK	Suitable choice of flood estimation points							
3.1.3	(Additional space for other items checked)	N/A									
3.2 Catchment descriptors											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
3.2.1	Are the final catchment descriptors tabulated for every subject site, indicating where changes have been made from default values?	<ul style="list-style-type: none">●Include any changes made. Use a different colour to identify catchment descriptors which have been changed from the default values.●Refer to Section 2.3 of the Flood Estimation Guidelines for suggestions on how to check and amend catchment descriptors. Any changes made must be recorded fully so that they can be checked and are reproducible.●Include sub-catchments and intervening areas required for a distributed approach.	Green	<p>The FARL for BB04_I is missing.</p> <p>A final catchment descriptor table was provided. It would aid future users to highlight what the changes were.</p> <p>The text notes that the BB04_I catchment value was taken from BB02, as the proportion of the pond to the catchment area is similar. The BFIHOST and SPRHOST values for BB04_I were taken from those derived for BB04 and checked.</p>	Update Section 2.2, to include the FARL and highlight which catchment descriptors were updated and provide the original values.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
3.2.2	Have FEH catchment boundaries been checked against high resolution LIDAR, sewer network, and OS data and refined where appropriate? If catchment area has been changed, have catchment descriptors been adjusted appropriately?	<ul style="list-style-type: none">●Add maps if needed to aid explanation of any changes.	Green	It would be useful to show the revision to the catchment boundaries on the same mapping to the existing FEH boundaries and with the relevant LiDAR data as background mapping to verify the changes appropriately.	Add catchment boundary delineation changes and existing FEH boundaries draining to Figure 3. Provide a figure of the LiDAR data.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
3.2.3	Does the calculation record state whether URBEXT1990 or URBEXT2000 has been used? Has the correct value been identified for the method(s) to be applied? Have the URBEXT values been updated to the current year or revised using the URBAN50k method if a discrepancy between the FEH urbanisation layer and current OS mapping has been identified?	<ul style="list-style-type: none">●Explain the source of URBEXT used in the analysis (e.g., URBEXT1990, URBEXT2000, manually derived using URBAN50k). URBEXT1990 should only be used in ReFH1.●If URBEXT values need to be substantially revised due to development or catchment boundary changes, see the URBAN50k method in Section 2.3 of the Flood Estimation Guidelines.●Default URBEXT1990 and URBEXT2000 values should always be updated to the current year. Explain what method has been used (e.g., CPRE formula, manual derivation) and where (e.g., edited catchment descriptor files, updated within WinFAP software, updated within ReFH2 software).	Amber	<p>In Table 2.2 and in most locations in the report, URBEXT is stated but no distinction between 2000 or 1990 is made. It is assumed that URBEXT2000 is used.</p> <p>The incremental BB04_I catchment value was calculated using area weighting and was checked using an URBAN value of 0.5. However, 10k OS mapping has been used instead of 50k mapping in line with EA guidelines.</p> <p>URBEXT was updated to 2022 but this is now out of date, and should be to 2025.</p>	Update or check URBAN calculations using 50k mapping. Confirm URBEXT2000 was used and update each value to current year.	As noted in 1.1.2 the study was prepared in 2022 and as such is reflective of the latest data available at the time. No significant urbanisation between 2022 and 2025 identified from review of aerial photography.	OK	Satisfied that 2022 value will be suitable if checks on areal photography confirm no significant sprawl.			
3.2.4	Has BFIHOST19 been used in preference to BFIHOST? Have values been checked against other soil or geological data? Has BFI been derived from local data?	<ul style="list-style-type: none">●BFIHOST19 should be used in the ReFH2 calculations, since the current release (ReFH2.3) was calibrated using BFIHOST19, and also in the FEH Statistical method, since this has been found to improve the results.●Soil association maps can be used to check BFIHOST values, especially if significant changes have been made to catchment boundaries. Any changes made must be recorded fully so that they can be checked and are reproducible.●If using other BFIHOST data, explain what has been used, why, and how it has been derived.	OK	BFIHOST19 was reported as used in the FEH Calculation record and checked against mapping.							
3.2.5	How have other catchment descriptors been checked and revised? How have catchment descriptors for sub-catchments been derived (particularly FARL, DPLBAR and URBEXT)?	<ul style="list-style-type: none">●Refer to Section 2.3 of the Flood Estimation Guidelines for suggestions on how to check and amend catchment descriptors.●Any changes made must be recorded fully so that they can be checked and are reproducible.●Include before and after tables if appropriate.	OK	Catchment descriptors form FEH were used and checked in Table 2.2							
3.2.6	(Additional space for other items checked)	N/A									



4. Stationarity statistical methods

4.1 Method overview											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
4.1.1	Is the reason for using this methods explained?	● Include a brief summary of the reasons, specific to this study, for applying the method.	OK	Whilst not reported in this Section, Section 2.5 outlines why the stat method was selected.							
4.1.2	What methods will be used to estimate QMED and growth curves? Has local data been used to its full potential?	● Include a brief summary of what methods will be used at which subject sites. ● More than one method may be tested at each site (e.g., comparing single site and pooled growth curves at a gauged site). ● Include all methods tested, even those ultimately rejected.	OK	Ungauged site. In line with EA guidelines, a pooled analysis based on a lumped downstream catchment was undertaken.							
4.1.3	(Additional space for other items checked)	N/A									

4.2 Estimating QMED											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
4.2.1	Has QMED been estimated at gauged sites appropriately? Have short records been adjusted for climatic variation?	●See Section 4.2 of the Flood Estimation Guidelines. ●When QMED is estimated from short records (less than 14 years), it should also be adjusted for climatic variation. Refer to FEH Volume 3, chapter 20. Provide full details of the adjustment in the appendix. ●If you estimate QMED from peaks-over-threshold (POT) or low flow duration curve statistics (LF), add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●More than one method may be used at each site. Use a different row for each method.	N/A	Ungauged site.							
4.2.2	Has QMED been estimated at ungauged sites appropriately?	●See Section 4.2 of the Flood Estimation Guidelines. ●Only fill in the cells needed. ●If you estimate QMED from bankfull channel width, add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●More than one method may be used at each site. Use a different row for each method.	Green	Small catchments procedure was undertaken. The donor method undertaken updates the URBEXT2000 value to 0.04. This is assumed to cover more gauges but the reasoning given is "URBEXT 2000 <0.04 to reflect the relatively rural nature of the study catchment." However, the distance from the donor to the FEP's has not been given.	Update Table 2 to include the distance from the donor sites to the FEPs.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
4.2.3	What method and parameters have been used for urban adjustment of subject and donor sites? Is this appropriate?	●List the method used for urban adjustment of subject and donor sites, if applicable (e.g., Kjeldsen (2010), WinFAP v4, WinFAP v5). ●List the parameters used for the urban adjustment. The standard values are listed below, and any amendments must be explained. ●Impervious fraction for built-up areas, IF: 0.3 ●Percentage runoff for impervious surfaces, PRimp: 70% ●Method for calculating fractional urban cover, URBAN: updated URBEXT 2000	OK	Urban adjustment applied in WINFAP.							
4.2.4	How were donor sites identified and selected? What urbanisation threshold was used? Has the use of urbanised donor sites been avoided unless appropriate for the catchment being assessed? Has the choice and number of donor sites been justified?	●Provide details regarding how potential donors were selected and the reasons why they were chosen / rejected. ●Include a map if helpful, which shows the location of the study catchment and donor stations under consideration. ●Section 4.2 of the Flood Estimation Guidelines provides guidance on selecting a donor(s) for data transfer. ●Consider using POT and low flow stations as donors, especially if used as gauged subject sites. ●If using WinFAP to search for donor sites: the default URBEXT2000 threshold value for donors in WinFAP v5 is 0.03. Explain if you have changed the threshold, for example to enable a more urbanised donor site to be used.	Green	The text states that the nearest gauge was used for donor estimation. However, the tabulated donor station information does not include distances from subject site. Choice of single donor closest to site is in line with guidance. However, there is no evidence that the closest site has been chosen as no distances are noted.	Provide distances for donor stations relative to subject site. Update if any closer but more urbanised gauges could have been considered.	see 4.2.2	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
4.2.5	Was QMED estimated at donor sites appropriately? If donor sites are upstream or downstream of subject sites, have the adjusted QMED estimates been checked for consistency and averaged adjustment factors been used?	●See Section 4.2 of the Flood Estimation Guidelines. ●When QMED is estimated from short records (less than 14 years), it should also be adjusted for climatic variation. Refer to FEH Volume 3, chapter 20. Provide full details of the adjustment in the appendix. ●If you estimate QMED from flow duration curve statistics (LF), add sufficient details in the appendix of the data sources and calculations to allow these to be fully reproduced. ●QMED from catchment descriptors is the 'as rural' value, i.e., with no urban adjustment factor applied. For urban donors, record whether and how the observed value of QMED has been "de-urbanised" for comparison with the as-rural estimate from catchment descriptors. ●The adjustment ratio in the table below is the adjustment in full, with no distance factor applied.	OK	Small catchment procedure, in line with guidance, was used.							
4.2.6	(Additional space for other items checked)										

4.3 Estimating growth curves											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3

4.3.1	Have growth curves been derived at subject sites using appropriate methods, distributions, adjustments and parameters? Where flood peak records are available, has single site and enhanced single site analysis been carried out? Has historical analysis been considered? Have urban and non-flood years adjustments been applied?	<ul style="list-style-type: none">●See the Flood Estimation Guidelines Section 4.2.●List all flood growth curves compared, including those ultimately rejected.●If using historical methods, provide full calculation details in the appendix.●An individual urban adjustment should be applied even if the same pooling group (including enhanced single-site analysis) has been applied to several sites, as each site is likely to have a different URBEXT2000 value and hence a different urban adjustment.●A non-flood years adjustment (previously known as the "permeable" adjustment) should be considered if there are non-flood years in the stations in the pooling group that may make a significant difference to the results. Adjustments to remove the influence of non-flood years are carried out using the method in FEH Volume 3, chapter 19. This is valid only for the GLO distribution.●More than one method may be used at each site. Use a different row for each method.●Edit the list of methods if any alternatives were used and highlight the changes made.	Amber	GL chosen due to best fit and in line with guidance. No record of the best fit values provided though. Permeable adjustment has been carried out but no calculations have been provided to verify this adjustment. One pooling group (calculated at BB04) was used which is in line with EA guidelines. However, the consideration for the urbanisation of each of the catchments has not been given. This is because BB04_1 has an URBEXT2000 value of 0.311. When applying growth curves from another FEP, an urban adjustment needs to be undertaken.	Provide evidence of best fit values for distribution. Add details on permeable adjustment. Recalculate the final peak flows at each catchment taking into account the urbanisation levels of each of the catchments.	For this study FEH Stats method was not taken forward for use in design runs. Comparison of BB04 results for ReFH2 and FEH stats in section 6.2 show ReFH2 to be the more conservative method. Consequently update to the other FEPs as suggested would not impact on the outcome of the study and is therefore noted for future updates but no action proposed.	Amber	Though the ReFH2 method was previously taken over the Statistical method, the results of an update (peak flow dataset and parameters) could have a bearing on this decision.	Please reassess statistical peak flows using UAF and latest NRFA peak flow dataset. Provide pooling group details and growth fittings along with flow estimates.		
4.3.2	Are flood frequency curve plots included?	<ul style="list-style-type: none">●Any relevant frequency plots, particularly showing any comparisons between single-site, enhanced single-site, and pooled growth curves (including flood peak data on the plot), should be shown here.	Green	No flood frequency curves provided.	Add flood frequency curves into the appendix.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
4.3.3	Have pooling groups been derived appropriately? Was the small catchment pooling procedure used, if appropriate? If there are several similar flow estimation points, have they used a single pooling group to aid simplicity and consistency?	<ul style="list-style-type: none">●Try to use as few groups as possible, this avoids step changes in flow estimates between flow estimation points for catchment-wide studies.●Section 4.2 of the Flood Estimation Guidelines provides further details on reviewing pooling groups.●Provide initial and final pooling group compositions in the appendix.●If you increase the URBEXT2000 threshold from the default value of 0.03, include a justification and compare the results with those from an all-rural pooling group.●L-moments are deurbanised by default in WinFAP v5.	Green	Single pooling group applied based on catchment size and hydrological similarity. Used sites above>0.04. Permeable adjustment has been made owing to the permeability of the stations in the pooling group (no evidence has been provided).	Update the report to detail the permeable adjustment calculations undertaken.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
4.3.4	Is the composition of the pooling group recorded? How has pooling group composition been reviewed and adjusted? Has the removal or retention of sites been adequately justified, especially discordant sites?	<ul style="list-style-type: none">●If no changes were made, just say "none", although it is helpful to provide details of stations which were investigated even if they were ultimately retained.●Provide original and final pooling group compositions in the appendix.●Weighted L-moments should be the pooling group L-CV and L-Skew, after any changes were made to composition, but before any urban or non-flood years adjustments.	Green	Composition of the pooling group is not recorded. No adjustments were made but we cannot see a record of the pooling group stations to check if the stations are appropriate. Table 3.4 "Derivation of pooling groups" has a site code "LB04" this is assumed to be "BB04".	Add composition of pooling group into the appendix and record changes made. Update Table 3.4 to be "BB04".	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
4.3.5	(Additional space for other items checked)	N/A									
4.4 Final choice of QMED and growth curves											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
4.4.1	Has the final choice of method for QMED and growth curves been explained and justified?	<ul style="list-style-type: none">●Record your final choices of method for QMED and growth curves.●Consider spatial consistency. Check values to ensure they are consistent with observations at upstream or downstream gauging stations. In some situations, using the data transfer method and switching between pooling groups can lead to unrealistic step changes. See Flood Estimation Guidelines Section 4.2.	Amber	A permeable adjustment, in line with EA guidelines, one donor based on small catchment procedure is used. The final flood estimates show that BB02 has a smaller flow than BB03, whereas the area of BB02 is 40% larger than that of BB03. Confirmation on if the correct catchment parameters are applied is required or to aid future users of the hydrology a note on why there is potential spatial inconsistency should be added.	Update the statistical method with the correct model parameters or add an explanation in Section 6 or Section 4 of the possible spatial inconsistency.	see 4.3.1 would not impact on the outcome of the study and is therefore noted for future updates but no action proposed.	Amber	An update/correction here could significantly change the statistical flow estimates to the point where they are deemed more appropriate than the ReFH2 flow previously used. This is exactly what is needed to be able to confirm whether this has a bearing on the outcome of the study.	Re-run statistical method using latest NRFA peak flow dataset and updated parameters discussed above.		
4.4.2	Have the final flood estimates been tabulated?	<ul style="list-style-type: none">●Add or remove columns as needed to change the return periods to those used in the study.	Amber	Whilst final flood estimates are tabulated in Section 3.6, they will need to be revised based on comments in item 4.3.1.	See item 4.3.1.	see 4.3.1 would not impact on the outcome of the study and is therefore noted for future updates but no action proposed.	Amber	Revised Statistical method flows need to be provided following the re-run.	Provide updated Statistical Method flows		
4.4.3	(Additional space for other items checked)	N/A									



7. Revitalised flood hydrograph 2 (ReFH2) method

7.1 Method overview											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
7.1.1	What is the purpose of applying this method? Has the method been avoided for large catchments?	•Include a brief summary of the reasons, specific to this study, for applying the method.	Green	ReFH2 was used to produce estimates to be compared with the statistical method. No mention of the use of ReFH2 being used to derive hydrograph shape.	Update Section 4 to include the reason for using ReFH2.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
7.1.2	Are rural and urban sub-divisions used?	•This section can be deleted if the catchment is essentially rural. •If the catchment is urban: •Did you calculate paved areas using a method other than from URBEXT using the standard equations? •Did you allow for transfer of water via sewers across the topographic catchment boundary? •If yes to either of these questions provide details which give sufficient information to understand the process applied and any assumptions made. It may be useful to include a map of sub-catchments here, if not provided earlier in the report.	Amber	BB01, BB02, BB03 and BB04 are all rural catchments (slightly to moderately urbanised catchments" yet are treated as urban). As per EA guidelines, they should be treated as rural. It is acknowledged that the intervening area does have an URBEXT value of 0.311 and so should be treated as urban.	Rerun ReFH2 analysis using the rural catchments as rural.		Amber	No 1st review response provided.	Please use rural ReFH2 flow estimates for relevant catchments.		
7.1.3	(Additional space for other items checked)	N/A									

7.2 Model parameters											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
7.2.1	What methods were used to estimate model parameters? Have model parameters been listed? If flow estimation points are at or near a gauging station, have model parameters been estimated from observed data?	<ul style="list-style-type: none">•List parameters for all site codes, including intervening areas and sub-catchments.•Include a brief summary of what methods will be used at which subject sites. See Section 4.3 of the Flood Estimation Guidelines.•More than one method may be tested at each site. Include all methods tested, even those ultimately rejected.•See the Flood Estimation Guidelines for recommended approaches for modelling urbanised catchments. You only need to provide the urban area, TP urban scaling factor, IF, IRF and DS parameters if modelling as urbanised.•ReFH2 treats BR (baseflow recharge) as a state variable rather than a parameter, setting it automatically in order to conserve volume. The values of BR vary with return period and so are not reported here.	OK	Catchment descriptor method applied and noted in the record. Model parameters are listed. No observed data used to estimate model parameters.							
7.2.2	What analysis was undertaken to derive model parameters?	<ul style="list-style-type: none">•For any methods other than catchment descriptors, provide a description here and include full calculation details in the appendix.	N/A	Catchment descriptors method applied.							
7.2.3	(Additional space for other items checked)	N/A									

7.3 Model inputs for design events											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
7.3.1	What rainfall DDF model has been used (e.g. FEH99, FEH13 or FEH22)? Have rainfall data and initial conditions been amended from default values?	•Model inputs include rainfall data and initial conditions. These are a complete package and should only be amended in some circumstances. See Section 4.3 of the Flood Estimation Guidelines.	Red	No reference to rainfall DDF model (assume FEH13 as FEH22 was released afterwards). No notation if any initial conditions were amended from default	Update using FEH22 rainfall in the latest ReFH2.3.	As per 1.1.2 the study was undertaken in 2022 and FEH22 was not available at the time therefore study used FEH13 rainfall and ReFH 2.2 which was the latest available at the time of the study.	Amber	The increase in ReFH2 peak flows using the FEH22 rainfall over the FEH13 has resulted in increases in peak flows up to 7.5%. It is difficult to understand how significant the implications of this will be on depths and extents to areas at risk without it being run through the hydraulic model, but a corresponding 7.5% increase is very likely to have a significant impact. In some cases, FEH22 smaller events produce higher flows than FEH13 larger events (see Section 2.5.5 2nd review comments). On the basis of the information provided it is considered that this could be significant and that these new/higher flows should be taken forward. The decrease in flow for the 0.5% event when this is increasing for all other events seems highly unusual and no justification as to why this has occurred has been provided.	Compare FEH22 flows with new Statistical method flows and justify final flows to use. Investigate decrease in 0.5% decrease in flow, especially if still using ReFH2 for final flows.		
7.3.2	Have different design events been used when considering lumped and sub-catchment sites? Does the report acknowledge that a single design storm will need to be applied to all inflow hydrographs in a distributed modelling approach?	•ReFH2 may be applied for both lumped catchments and sub-catchments in a study. Different design events will be needed when considering lumped and sub-catchment sites. Complete the relevant sections as appropriate for your study.	Amber	Two different design events are used (storm duration of 9hrs or 15hrs). A consistent storm duration is needed.	Rerun using a consistent storm duration.	Acceptable to inform choice of method but design runs should be of consistent storm duration. Design estimates for consistent 9 and 15 hour storm duration to be prepare for all FEPs and sensitivity tested in the model. Final design hydrographs to be appended to FEH Calculation record	Amber	None of the ReFH2 peak flows in the Technical Note Table 2 and Table 3 match the flood estimates in the Report section 4.3 table of final ReFH2 flows	Confirm final ReFH2 flow estimate parameters for each catchment (rural/urban, storm duration and seasonality).		
7.3.3	What design events are listed for lumped catchments? Are the choices suitable?	•Storm durations detailed here should be the values for the individual catchments. Lumped flows should be generated using the storm duration relevant to each lumped catchment. •A summer storm should be used if the catchment is heavily urbanised (URBEXT2000 between 0.15 and 0.3) AND highly permeable (BFHOST19>0.65). •Cini and BFO values only need to be listed if amended from default values. •This section can be deleted if ReFH2 is not being applied for lumped catchments.	Amber	The record reports on two different storm durations applicable across the FEPs (9 hours and 15 hours).The reasoning is not explained. The report does not acknowledge that a single design storm will need to be applied to all inflow hydrographs and no sensitivity analysis has been carried out. No note to define default storm duration.	Update the flows using a consistent storm duration based on the critical catchment.	see 7.3.2	Amber	See section 7.3.3.	See section 7.3.3.		
7.3.4	What design events are listed for subcatchment and intervening areas? Are the choices suitable?	•This table can be deleted if ReFH2 is not being applied for sub-catchments. •This table is included to identify the storm which will be applied to all inflows to a distributed model (see Section 6.1 of the Flood Estimation Guidelines) and avoid the scenario of using a different storm for each inflow to the model. •If there are multiple flood risk areas throughout the model it may be necessary to allow for different storms in different parts of the model by carrying out multiple runs. Each model run should use the same storm applied to all inflows. •Use one row for each storm to be applied. If only one storm is to be applied, delete the additional rows. •If storm duration testing using the hydraulic model is being undertaken add details of the results, for example, which duration(s) has been selected and why, what the process will be in terms of presenting model results if more than one duration is selected.	Amber	Further information required, as multiple storm durations are being used and this is not in line with best practice (15 hours storm duration applied for upstream inflow and downstream lumped catchment and then smaller sub catchments representing tributary inflows in addition to intervening area have 9 hours storm durations). It is acknowledged by the reviewers that BB04_I is classified as urban and so a summer season storm should be applied. However, since BB04 is the critical catchment a winter season storm is acceptable.	Update the flows using a consistent storm duration based on the critical catchment.	see 7.3.2	Amber	1st Review RAG and Comments stand as the recommended action has not been carried out.	Update the flows using a consistent storm duration following testing of this.		
7.3.5	Has storm duration testing been undertaken using the hydraulic model?		Amber	No storm duration testing has been undertaken. The flows are produced to compare against the FEH Statistical values.	Update the flows using a consistent storm duration based on the critical catchment.	see 7.3.2	Amber	The comparison between a 9hr and 15hr storm duration does provide some storm duration testing with the 15hr flows higher for the main downstream catchment (BB04). This will need to be re-done following the other updates.	Use critical duration for ReFH2 flows when comparing against Statistical method flows.		
7.3.6	(Additional space for other items checked)	N/A									

7.4 Final choice of ReFH2 flow estimates											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
7.4.1	Has the final choice of design inputs and model parameters been recorded? Are the choices suitable?	•Record your final choices of method for model parameters and design inputs. You may have multiple choices of methods for lumped and distributed modelling.	Amber	As per items 7.1.2, 7.3.1 to 7.3.5, a consistent storm duration is required, alongside rural catchments should be rural as per EA guidelines.	Update in line with review comments.	see 7.3.2	Amber	Various further updates need to be made before overall method comparison can be undertaken.	Please see sections 7.1.2, 7.3.1 and 7.3.4.		

7.4.2	Are the final flood estimates from the ReFH2 method reported?	<div>■Add or remove columns as needed to change the return periods to those used in this study.</div> <div>■Results only need to be provided here for lumped catchments, for comparison to other methods. Results for distributed catchments can be provided digitally but must still be provided to allow for checking.</div> <div>■If you have modelled a catchment as urban, make sure you record the urbanised flows rather than the as-rural flows.</div>	Amber	Final flood estimates are tabulated. However, owing to the issues concerning urban or rural classification and the inconsistent storm duration these would need updating.	Update accordingly.	see 7.3.2	Amber	Various further updates need to be made before overall method comparison can be undertaken.	Please see sections 7.1.2, 7.3.1 and 7.3.4.		
7.4.3	(Additional space for other items checked)	N/A									



9. Discussion and summary of results

9.1 Comparison of results from different methods										
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response RAG 3
9.1.1	Are peak flows from different methods compared?	•Compare peak flows from preferred methods at key sites for selected return periods / AEP events.	OK	Peak flows are compared from the FEH Stat and ReFH2.3 methods.						
9.1.2	(Additional space for other items checked)	N/A								
9.2 Final choice of method										
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response RAG 3
9.2.1	Is the choice of method justified by discussing the type of problem, the type of catchment and the type of data?	•Include reference to type of study, nature of catchment and type of data available. •If different methods are chosen for different site codes or return periods, explain why.	Amber	Since ReFH and statistical flows will need to be recalculated the final choice of method may need to be reassessed. Hence, this item has been left as Amber. The justification is weighted heavily by the fact that the ReFH2 flows were higher than the flows derived from the FEH Statistical and therefore the approach is conservative. However, guidance states that higher estimates should not be the sole justification to chose a method. It is acknowledged that the conservative approach may be considered warranted owing to the higher flows being used in the model to define the design of the bridge.	If required update Section 6.2 to include a new final choice of method.	Choice of method is based primarily on comparison of flow estimation at BB04. This review raises quires regarding other FEPs that are largely immaterial to the choice of method. The choice of a conservative method to inform bridge design and undertake comparative impact assessment is considered sufficient justification.	Amber	Choice of method based on most conservative flow estimates at BB04 is understandable.	Re-assess choice of method once ReFH2 and Statistical method flows have been updated.	
9.2.2	Does the report explain how hydrograph shapes or volumes have been derived?	N/A	Green	No explanation of how hydrograph shape has been derived but is assumed to be from ReFH2.	Update Section 6 to include an explanation of how the hydrograph shapes are derived.	As per 7.3.2 - Design estimates for consistent 9 and 15 hour storm duration to be prepare for all FEPs and sensitivity tested in the model. Final design hydrographs to be appended to FEH Calculation record noting hydrograph shape is from ReFH2	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
9.2.3	How will the 0.1% AEP flows be estimated?	•You may choose a different method for the 0.1% AEP event (see Section 6.6 of the Flood Estimation Guidelines). Explain how growth factors and peak flows have been calculated, if using a hybrid method.	Green	Application of hybrid method has not been applied. EA guidelines note that "If you choose ReFH2 for the longer return periods, to avoid a discontinuity in the results, you could consider using ReFH2 to obtain the ratio of the 1000-year flow to the (say) 100-year flow. You can then multiply that ratio by the preferred estimate of the 100-year flow, which may be from the statistical method."	Update the final 0.1% flows with the hybrid method or provide reasoning for using ReFH2.	Use of ReFH2 as conservative as noted above in 9.2.1	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
9.2.4	How will the flows be applied to the hydraulic model?	•For example, will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	Green	No explanation provided within the FEH Calculation record.	Update the calculation record to include how the final flows will be applied to the model.	See 9.2.2 above	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
9.2.5	(Additional space for other items checked)	N/A								
9.3 Final results										
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response RAG 3
9.3.1	Have the final peak flow results been provided for all flow estimation points and design events?	•Include subcatchment and intervening catchment flows here or in digital files, to allow checking of the hydraulic model. •If scaling factors have been used in a distributed model, provide full details of the original and final flows below or in the appendix.	OK	Final peak flow results have been provided for all flow estimation points and design events (no allowance for climate change as noted previously).						
9.3.2	Have any other information, data or results needed for the next stage of the study been provided?	N/A	N/A							
9.3.3	If appropriate, what design storms have been applied in the hydraulic model?	•Use this section if appropriate to record the ReFH1 or ReFH2 design storm parameters applied in the hydraulic model, if they are different to those recorded in the ReFH1 and ReFH2 sections of this report. •You must apply a uniform storm duration and areal reduction factor across all subcatchments. Refer to the Flood Estimation Guidelines Section 6.1. This may result in a number of different design storms being modelled to give critical results at different locations in the catchment. List all details below.	Amber	Storm duration, SCF and ARF for BB04_I are based on the flow estimation point BB03. The SCF and ARF for BB02 are based on flow estimation point BB03. The storm duration for the upstream BB01 is 15 hours, compared to the other FEPs that have a storm duration of 8 hours. No further discussion is made in relation to the storm duration and how these are applied in the model.	Update the flows with a consistent storm duration.	See 9.2.2 above	Amber	Section 7.3.2 1st review response states that 'Final design hydrographs to be appended to FEH Calculation record' but the parameters to be used for this have not been confirmed.	Confirm parameters being used in ReFH2 flow estimates.	
9.3.4	What climate change allowances have been applied and how?	•Refer to online guidance on climate change allowances for flood risk assessments and projects. •Provide information on: •What climate change allowances have been applied, e.g., rainfall and/or flow allowances, source of data, river basin, epoch, and percentiles. •How the climate change allowances have been applied, e.g., applied to rainfall / flow hydrographs within the hydraulic modelling software using scaling factors. •For non-stationary methods, refer to the practitioner guidance available on the FCERM R&D web page and provide full details and justification for the approach chosen.	Green	No climate change allowance has been recorded in the FEH Calculation record results. However, this is covered in the model report and so to aid future users of the hydrology should be included within Section 6.	Add climate change allowances into the report.	See 2.1.1	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
9.3.5	(Additional space for other items checked)									
9.4 Checks on final results										
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response RAG 3
9.4.1	Are checks on results included?	•See Section 3.5 of the Flood Estimation Guidelines. •These checks are important as a way of ensuring that everything has been considered and that the results are sensible. •All relevant sections should be completed for every study. Where sections are not relevant (where there are no flow gauges or previous studies, for example) a comment should be added to this effect rather than leaving a blank space.	Green	The relevant checks as outlined in the guidance have been undertaken. No reference to if the results are spatially consistent between upstream and downstream FEPs is made, which as per item 4.4.1 is required.	Update the report to include reference to spatial consistency inline with the actions from item 4.4.1.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
9.4.2	Have the 1% and 0.1% AEP growth factors been derived and sense-checked? If the 1% AEP growth factor is outside the typical range, has a justification been provided?	•What is the range of 1% AEP (100-year) growth factors? Is this realistic? •What is the range of ratios for the 0.1% AEP (1000-year) over 1% AEP (100-year) flow? •What reasons are there for variations in ratios between sites?	OK	Range of 1% AEP growth factors is between 2.91 and 3.07, which is in line with acceptable range of 2.1 to 4.0 Range of ratios for 1000-year flow over 100-year flow is 1.75 to 1.82.						
9.4.3	Has the specific discharge (l/s/ha) been derived, and are variations between locations explained?	•What specific discharge (flow in l/s/ha) do the results equate to? Can you explain variations in specific discharges between different locations across the study area?	Green	Specific runoffs have only been provided for the downstream lumped catchment and not the component catchments.	Add specific runoffs for component catchments.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	
9.4.5	Have the design flows been checked for spatial consistency, e.g. at confluences and along reaches?	•This will not be relevant for a study where there is only a single flow estimation point. •See Section 6.1 of the Flood Estimation Guidelines. FEH methods are intended for application at individual sites and may not give spatially consistent results if applied to multiple sites along a river system. •You should particularly check for consistency between upstream and downstream points and at confluences.	Green	No checks for spatial consistency referenced within the FEH Calculation Record.	As per item 9.4.1 add note on spatial consistency.	see 9.4.1	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.	

9.4.6	Have return periods for notable historic floods been calculated?	•What do the results imply regarding the return periods / frequency of major events in the gauged record? This can help justify the choice of flood growth curve. •If there is no flow data available, you can compare your design event hydraulic modelling results to observed level and flood extent data if available for major events.	N/A	No historic floods recorded.							
9.4.7	Are results compatible with the longer term flood history?	•Consider whether the implied frequency of flooding from your design event hydraulic modelling results is compatible with what is known of the flood history of the study area.	Green	As per items 2.3.2 and item 2.3.3, a level gauge is present on the Bin Brook which could be used as a check flow in the modelling.	Use the level gauge as a check in the hydraulic modelling.	As there is no upstream observed flow and only one level gauge it would require the inclusion of observed rainfall into ReFH2 which has its own set of uncertainties about a priori conditions that would limit the effectiveness of this exercise	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
9.4.8	Have results been compared with previous studies?	•Explain any differences and conclude which results should be preferred. •This will not be relevant if there are no previous hydrological assessments.	N/A	Not within the scope of the study.							
9.4.9	Have the hydraulic model results been checked against lumped flow estimates?	•Are flows generated by the hydraulic model consistent with those estimated from a lumped catchment FEH estimate at locations within the model reach? •Have any scaling factors been applied to reconcile model results to the preferred flow estimates?	OK	Whilst not in the report, the reviewers have checked the flows are correct in the model.							
9.4.10	(Additional space for other items checked)	N/A									
9.5 Assumptions, limitations and uncertainty											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
9.5.1	Are assumptions, limitations and uncertainty reported?	•Careful thought should be put into identifying the specific assumptions and limitations applicable to the design peak flow estimates (and design hydrographs). •Assessing and reporting on the uncertainty in the estimates is also very important. •These sections should be completed for every study and never left blank.	OK	Assumptions, uncertainty and project specific limitations associated with the hydrology have been reported.							
9.5.2	Are the assumptions acknowledged and specific to the study?	•See Section 5.2 of the Flood Estimation Guidelines. •Assumptions should be specific to the study, have a large effect on the results, and can be tested. General assumptions do not need listing.	Green	Standard FEH assumptions' noted as being applied. However, assumptions specific to the study should be stated.	Add detailed assumptions that are specific to project.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
9.5.3	Are the limitations acknowledged and specific to the study?	•See Section 5.3 of the Flood Estimation Guidelines. •This could include applying methods outside of the range of catchment characteristics or return periods for which they were developed.	Green	Lack of suitable gauged data and suitable donor is acknowledged. No discussion of limitations pertaining to the presence of the lakes within the catchment and the representative FARL values is provided.	Add limitations of assessment.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
9.5.4	Does the report comment on uncertainty in the design flows?	•See Section 5.4 of the Flood Estimation Guidelines. •Uncertainties in the peak flow estimates should always be quantified if it is possible to do so for the method applied. •Note that the confidence limits given in the Flood Estimation Guidelines assume that the AMAX flows follow a generalised logistic distribution. If you have fitted a different distribution, these confidence limits will not be applicable. •Complete the table with flows from the uncertainty analysis. The default is the 95th percentile upper and lower bounds, but other estimates may need to be provided depending on the requirements of the study.	OK	Uncertainty bands are reported on.							
9.5.5	Is the suitability of the results for future studies considered?	•With reference to the assumptions, limitations and uncertainties, comment on the suitability of these calculations for future studies, e.g., at nearby locations, or for different purposes such as detailed scheme design.	Green	The calculation record does not comment on the suitability of the results for future studies.	Update Section 6 to include comments about the suitability of the results for future studies.	Noted in the event of a future update.	Green	1st Review RAG and Comments stand as the recommended action has not been carried out.	See original action in first review.		
9.5.6	Are recommendations made for future work?	•Make recommendations for how assumptions, limitations and uncertainties could be reduced in future work, for example flow monitoring, rating reviews, etc.	OK	Recommendations provided for installation of a flow gauge (temporary or permanent) which would help to verify and improve flow estimates for all of the study catchments.							
9.5.7	(Additional space for other items checked)	N/A									



10. Appendix

10.1 Digital files											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
10.1.1	Are input data, output data and profile files available to provide evidence of calculations?	●If you are submitting work commissioned by the Environment Agency or for review by the Environment Agency, you should be prepared to submit as digital files your input data, output data and project files (where these exist) from the software you have used in the flood estimation. Refer to Section 8.1 of the Flood Estimation Guidelines. ●Use this section to list the files you are submitting, if relevant.	OK	Reports provided only.							
10.1.2	Do the digital files use the same input data and parameters, and give the same results, as listed in the report?	N/A					Green	It would be useful to have the final data files available so that any parameters can be cross checked.	Please provide statistical and ReFH2 data files.		
10.2 Other supporting information											
Item No.	Item Checked	Guidance Note	RAG 1	1st Review Comments	1st Review Actions	1st Review Response	RAG 2	2nd Review Comments	2st Review Actions	2nd Review Response	RAG 3
10.2.1	Is other supporting information included as needed, complete and accurate?	●Include any additional information which best sits here rather than in the section text, for example, flood peak series, details of historical flood events, rating reviews, pooling groups, or details of flood event analysis. Include important information in the section text, for example, comparison of growth curves, or results of flood event analysis.									
10.2.2	(Add additional items checked here and below as needed, to review the supporting information included in the Appendix or separate reports.)										
10.2.3	(Additional space for other items checked)										
10.2.4	(Additional space for other items checked)										
10.2.5	(Additional space for other items checked)										
10.2.6	(Additional space for other items checked)										
10.2.7	(Additional space for other items checked)										

NON-REAL TIME HYDRAULIC MODEL REVIEW



Type of review

Fluvial/tidal 1D-2D model

Project	Cambourne to Cambridge	Job Number		Required coastal standard (if applicable)	
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Model Type	1D/2D	Software	FMP/TuFlow	2nd review	3rd review	4th review
Revision		Date	02/11/2023	18/03/2025	23/07/2025	
Area Client		Reviewer	Arcadis Consulting Ltd	Arcadis Consulting Ltd	Arcadis Consulting Ltd	

REVIEW SUMMARY/CONCLUSION

Is the model suitable for intended use?	<p>The model is currently unsuitable for the intended use. There are queries relating to the 1D model, 2D model and 1D2D linking that require addressing. The representation of the bank lines and structures needs reviewing. The 1,000-year +19% CC event glasswalls against the model boundary.</p> <p>Additional information/clarification is required to increase confidence in the model outputs and some elements of the models (especially clarification around the elevation values being used at structures) need revisiting. The provision of a model log with all modelling decisions would aid the review procedure along with a standard model user report.</p> <p>As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice. Furthermore, comments, such as the need to represent the post-development scenario, may require revisiting following the proposed updates, as they may result in change the flood mechanisms.</p>
Is the model suitable for intended use?	<p>2nd Review Summary - March 2025</p> <p>The model is not currently suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.</p> <p>Red Comments</p> <ul style="list-style-type: none">• There is still some glass walling in 2d domain, please extend the code boundary accordingly.• The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs.• Have the model results been compared with Flood Zones maps as well? Please provided evidence of the comparison in the report and discuss why the differences with the previous modelling occur.• Please update the zpoints as the zpoints on bankline and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.• The report does not include full results, and more details need to be added in term of assumptions made to model the structures. <p>Amber Comments</p> <ul style="list-style-type: none">• Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.• Surveyed cross sections should be referenced in the model/.dat file and a structures table/log should be provided to enable the checks on structures dimensions.• Please update the report to include how inflows have been applied in the model. A figure of the catchment boundary should be included in the report.• Please include justification to omit those footbridges. If unavailability of survey is the prime reason, some assumptions can be applied to consider the losses. Also, provide structures log for the omitted structures.• Please provide a structure log with reference to the surveyed cross section including naming convention. The structures log should also include the assumptions considered to model the structures. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the dimensions for BB01_1034cd culvert were defined, as the survey does not contain this information.• Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m.• Please revisit the approach to model the 1d channel under Robinsons College Building.• Overflow Ditch Channel length and culvert dimension needs to be updated, and height contraction coefficient need to be defined for the culvert• The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream.• The slope has been updated, and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.• Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?• It is not clear which option is the final one for the proposed case scenario, please clarify that for example copm1 and comp2 results are not provided to review. XMDF files have not been provided, these would help the reviewing process.

Is the model suitable for intended use?	<p>3rd Review Summary - July 2025</p> <p>The model is currently not suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.</p> <p>Red Comments</p> <ul style="list-style-type: none">• The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs.• Please update the zpoints, as the zpoints on the banklines and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.• The commentary on local flood modelling in comparison to other data sources was not provided in the modelling report. Additionally, it is unclear whether the model results have been compared with the NaFRA2 model. Please include a commentary in the modelling report discussing the modelling results in relation to the NaFRA2 data.• The report does not include full results, and more details need to be added in term of assumptions made to model the structures. <p>Amber Comments</p> <ul style="list-style-type: none">• Please provide a 1D/2D structure log with reference to the surveyed cross sections including naming convention. The structures log should also include the assumptions considered to model the structures and the spills, along with the justifications of the omitted structures from the model. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered.• Please revisit the approach to model the 1d channel under Robinsons College Building.• Structures roughness sensitivity testing has not been applied correctly. Please revisit the structures roughness sensitivity testing and provide commentary in the modelling report.• Provide detailed commentary in the report on changes in results due to sensitivity tests. Please provide a commentary in the modelling report regarding the confidence limits of the modelling results as well as the assumptions used in the model.• XMDF results files have not been provided, these would help understand the hydraulic mechanism and will aid the reviewing process.
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MODEL REVIEW PROCESS
<p>Hydraulic Model reviews are an essential component of the Hydraulic Modelling Quality Assurance (QA) process that provides confidence in a model’s suitability for its intended purpose. Evidence that the model has undergone QA may be requested by external parties and hence all reviews should be written with an expectation that they could be read externally.</p> <p>Should any issue(s) be raised during the review process, which require attention, the reviewer should detail the action(s) required in sufficient detail to allow the modeller to complete the changes as appropriate. Completion of this Model Review document does not automatically constitute model approval. Once the suggested changes have been completed, the reviewer may require that the model be resubmitted for further review to establish whether the actions have been completed satisfactorily. Only once all the amendments have been completed satisfactorily, will the model be approved and the quality assured by the reviewer.</p> <p>It is recommended that the reviewer makes good use of the fluvial design guide chapter 7 and the user manual/help guides for the appropriate modelling software.</p> <p>Depending on the work being reviewed some questions or entire sections may not be relevant, in which case they can be deleted. On completion of the review the reviewer may choose to use the following colour coding system to alert the modeller to the priority of the actions required (if any).</p> <p>Colour coding used:</p> <p>OK – Good practice. Minimum response: No minimum. Maximum expected response: No maximum. Planning: No Objection.</p> <p>Green – Consider for future studies. Negligible impact on the results that is unlikely to change the outcome of the study. Minimum response: Acknowledge the comment in the spreadsheet and update the limitation section of the report. Maximum expected response: Actions done to address the issue identified. Planning: No Objection.</p> <p><i>Note: Taking action to address issues would be expected and some issues may be addressed coincidentally by work on others.</i></p>

Summary

<p>Amber – Follow recommendation. Potential impact on the results that may change the outcome of the study. Minimum response: Comments justifying the approach taken and update the limitation section of the report if not sorted. Maximum expected response: Actions done to address the issue identified. Planning: Consider objecting to the application based on comments highlighted in this category.</p> <p><i>Note: Taking action to address issues should be undertaken, some issues may be addressed coincidentally by work on others.</i></p> <p>Red – Must do. Has an impact on the results that may have a significant impact on the outcome of the study. Minimum response: Comments thoroughly justifying approach from applicant based on evidence and update the limitation section of the report if not sorted. Maximum expected response: Actions done to address the issue identified. Planning: Objection - Application to be objected if comments are highlighted in this category. <i>Note: If no action is taken the response must clearly demonstrate why the issue raised is not relevant and the approach employed is justified backed up with evidences. If issues highlighted red are ignored, then submissions should always be sent back.</i></p>

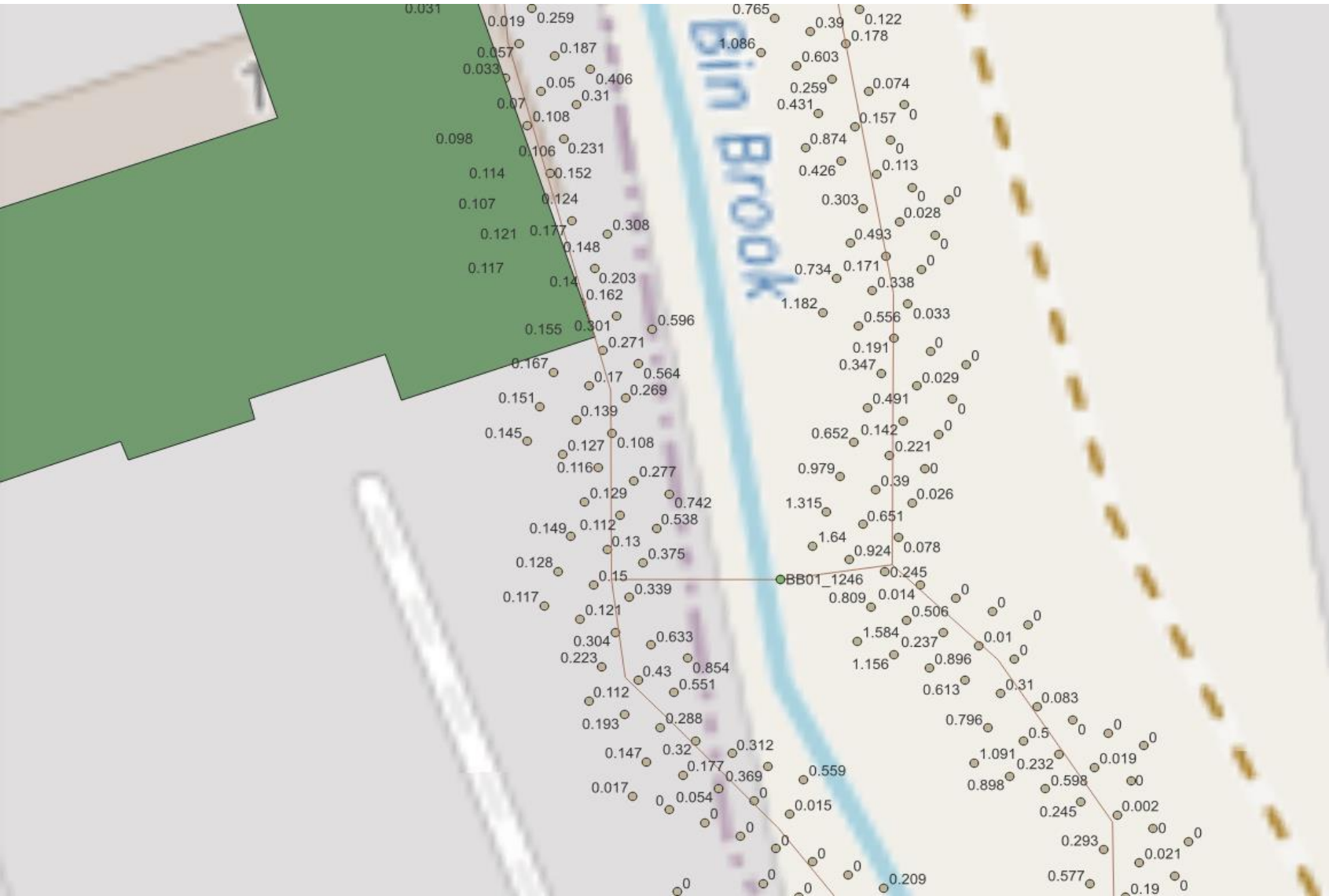
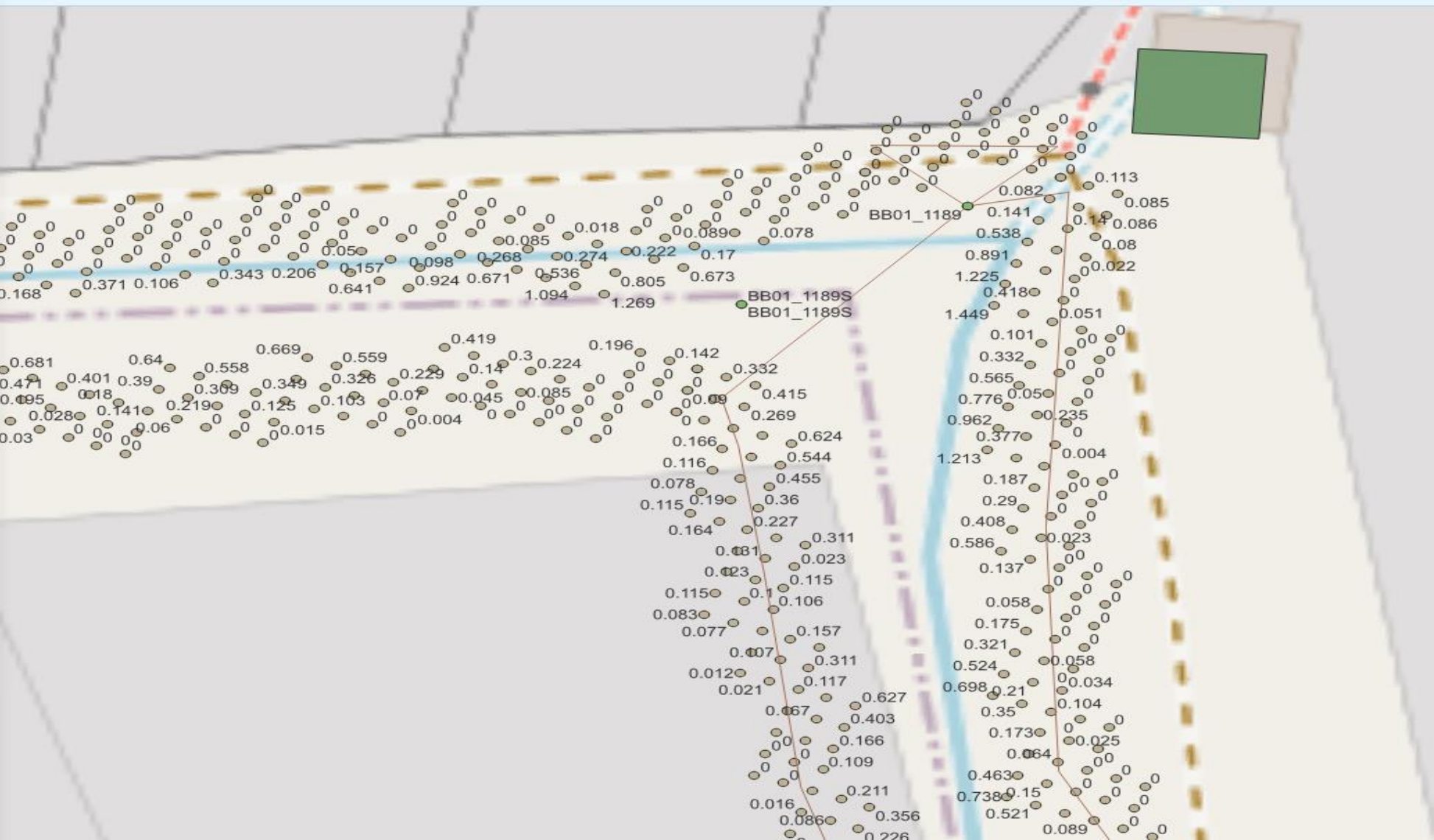


Figure 1: Examples showing large discrepancies (dz) the difference between the Lidar and the assigned bank levels throughout the model.

Figures_3rd Review_July_2025



Figure 2: glass walling at the north west 2D code boundary



Figure 3: glass walling at the downstream left bank where no HQ boundary has been applied.

Figures_3rd Review_July_2025

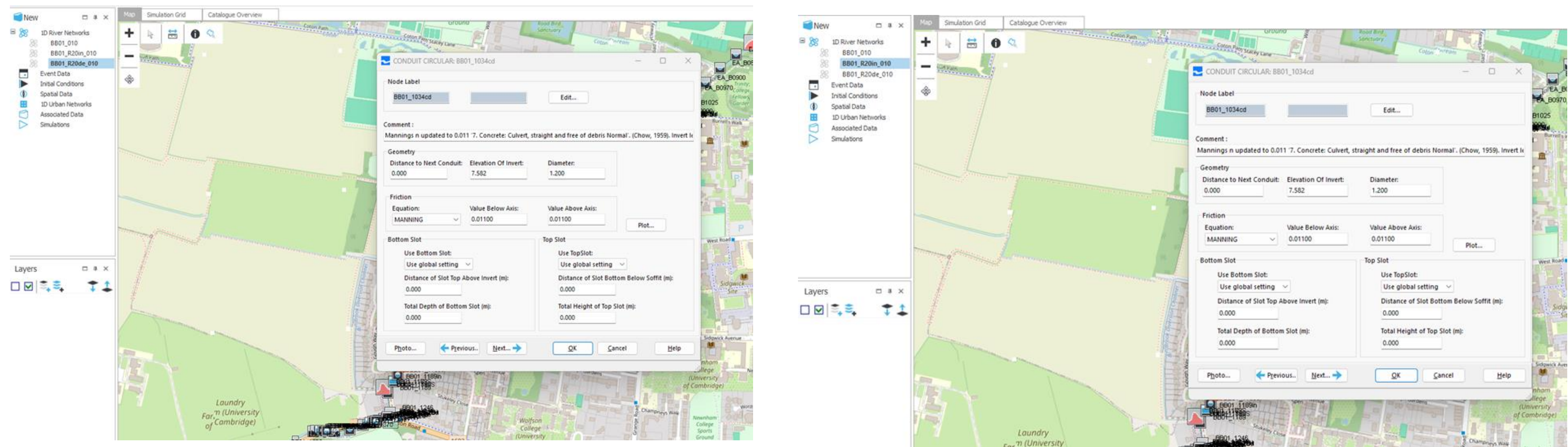
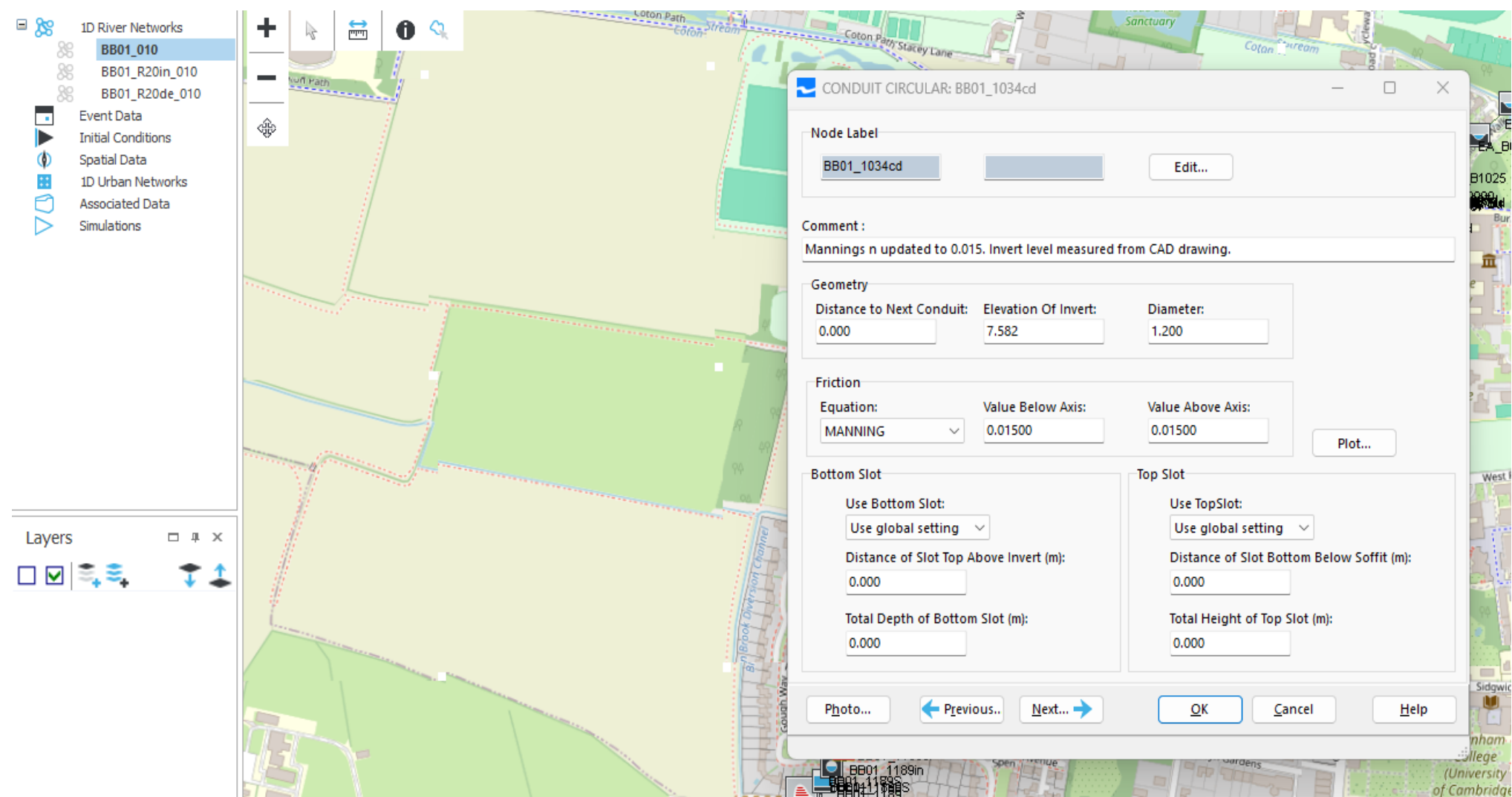


Figure 4: Example on structures' roughness applied in the Baseline model and roughness sensitivity models.



Runs

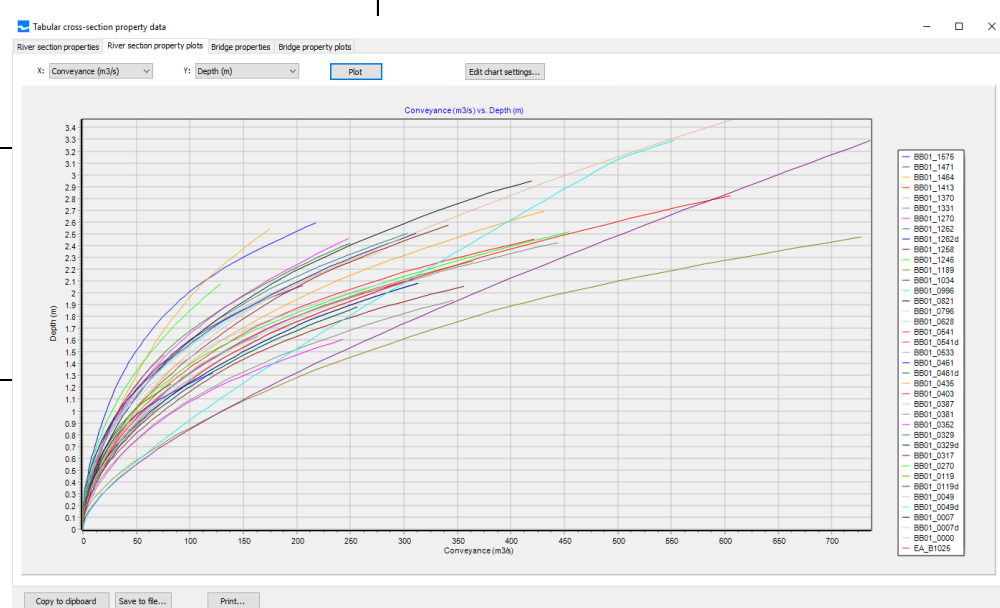
Name	Description	Provided
BB01_BSC_100yrCC19	Baseline scenario - 100-year +19% CC	✓
BB01_BSC_1000yrCC19	Baseline scenario - 1,000-year +19% CC	✓
BB01_BSC_100yrCC19DSde	Baseline scenario with a 20% decrease in DS boundary event scenario - 100-year +19% CC	✓
BB01_BSC_100yrCC19DSin	Baseline scenario with a 20% increase in DS boundary event scenario - 100-year +19% CC	✓
BB01_BSC_R20de_100yrCC19	Baseline scenario with a 20% decrease in roughness sensitivity test - 100-year +19% CC	✓
BB01_BSC_R20in_100yrCC19	Baseline scenario with a 20% increase in roughness sensitivity test - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_Comp1_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and Floodplain compensation area 1 - 100-year +19% CC	✖
BB01_Prop_10mSpan_FBRem_Comp2_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and Floodplain compensation area 2 - 100-year +19% CC	✖
BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and no compensation - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_NoComp_1000yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge and no compensation - 1,000-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_R20de_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% decrease in roughness scenario - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_R20in_100yrCC19	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% increase in roughness scenario - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_xx_100yrCC19DSde	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% decrease in DS boundary event scenario - 100-year +19% CC	✓
BB01_Prop_10mSpan_FBRem_xx_100yrCC19DSin	Proposed scenario (10m bridge span) with the removal of downstream footbridge with a 20% increase in DS boundary event scenario - 100-year +19% CC	✓



PROJECT BACKGROUND AND APPROACH

PROJECT DESCRIPTION & REQUIREMENTS												
		Flood risk modelling has been undertaken to inform the design of the proposed bus route connecting Cambridge to Cambourne. The study uses an existing model of the Bin Brook and has been updated using topographic survey data and the designs of the bridge. Both a Baseline and a Proposed scenario are represented and have been reviewed.										
MODEL APPROACH & SUMMARY												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
1.1	What model approach has been adopted? Is it appropriate? (e.g. new 1D/2D build, existing model truncation, 1d only?).	OK	Existing EA 1D-2D FM TUFLOW model of the Bin Brook has been used and updated to assess the scheme. The model has been updated with topographic survey from the upstream extent of the survey down to Burrell's Walk (northeast of Grange Road), these are all sections called BB01_XXXX. This leaves only five original cross sections, called EA_BXXXX. Therefore, a full review of the model has been conducted.									
1.2	Software used, including versions?	Green	Model has been run with FM VER=5.1.0.8423 and TUFLOW 2020-10-AD-ISP-w64. This is not the latest version of the modelling software available, the latest is Flood Modeller 6.2 and TUFLOW 2023-03-AC.	Please use the latest software versions for future runs.	The updated software would provide no or minimal change to water levels. It is more important that both pre and post scenarios are run utilising the same version of software rather than the version.	Amber	Tuflow version 2023-03-AC-ISP-w64 and Flood Modeller VER=5.1.0.8423 have been used for latest runs. The Using Modelling for Flood Risk Assessments guidance (www.gov.uk/guidance/using-modelling-for-flood-risk-assessments) states that applicants should "build and run models in the latest versions of software, or provide robust justification and testing if this is not possible" and "It's your responsibility to check the suitability of an existing model for your development". Please either update the models to use latest software or, if this is not possible, provide robust justification and testing which demonstrates that results are not impacted by the software versions used.	Model was run with supported versions of the relevant software at the time of the assessment. The 1% AEP event to be re-run using Tuflow 2025 and Flood Modeller 7 to provide confirmation of no change in results. There are no significant matters listed in the release notes for either software that would impact on results from this study.	Green	Ok, noted. Please use the latest software versions for the next submission.		
1.3	Model Version Reviewed	Red	The version of the model has only been defined in the TUFLOW section of the model (which uses v.011 for the .tbc and .tgc, and v.028 for the .ecf and .tcf). Nothing has been used for the 1D files which is not best practise. Note, the naming convention is not the same for all scenarios (e.g. the DS boundary sensitivity tests are defined as an event (-e1 100yr19ccDSde) where as the roughness tests are defined as a scenario with the event separately (-s4 R20de -e1 100yr19cc). This is confusing. In addition, the IEF file for the COMP1 and COMP2 writes results called BB01_Prop_10mSpan_FBRem_NoComp_100yrCC19' in the 1D, which will overwrite. This needs to be fixed so all results can be produced for all events.	Fix the naming convention so it follows the same pattern, and define versions for the 1D files. Fix the results file paths for the COMP1 and COMP2 1D results so all model results can be outputted correctly.	Updated 1D files with version numbers where necessary. Updated naming for the sensitivity tests. The .ief for the COMP1 and COMP2 has been updated to write out separate results.	OK	The naming convention appears fine now, although the .ief COMP1 and COMP2 have not been provided and hence not reviewed.					
1.4	Are all model files provided?	OK	All model run files are provided.									
1.5	Does the model run?	OK	As part of this review, the model has been run using FM 6.2 and TUFLOW 2023-03-AC-ISP-w64 which are the latest versions. As in 1.3, the IEF file for the COMP1 and COMP2 results saved the 1D results with the wrong name. All other runs completed.						OK	The model has been run using FM 7.2.9049.30229 and TUFLOW 2025-0-03-ISP-w64.		

EVENTS & SCENARIOS												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
2.1	What events have been simulated (Q5, Q100, Q100CC, Q1000)? Are they sufficient to meet the project requirements?	Green	Two events modelled, the 100-year +19% CC and the 1,000-year +19% CC. Note the Model Report states the model was run for the 100-year +19% CC only in Section 2.3.4.	Update the Model Report to include reference to the 1,000-year + 19% CC event.	Updated.	OK	The report has been updated.					
2.2	Is a development being modelled? If so are appropriate scenarios modelled to assess the impact?	Green	Yes, both the Baseline and a Proposed scenario have been modelled, both are being modelled for the 100-year +19% CC and 1,000-year +19% CC events. For the Proposed scenario, the Model Report in Section 2.2.6 references three different bridge spans (10m, 16m and 21m), along with a removal of the downstream footbridge scenario, a retainment of the downstream footbridge scenario and floodplain compensation areas 1 & 2. Only the 10m span with the downstream footbridge being retained scenario has been provided and reviewed here.	The requirement to review the other scenarios (wider bridge spans and downstream footbridge retainment) should be revisited following model updates flagged in this review.	Only the 10m span opening is proposed and therefore only that model has been supplied. The outcome from the minor modifications shows that the 10m option is still to be taken forward.	OK	Thank you for clarifying.					
2.3	Flood Mapping scenarios?	OK	No									
2.4	Have climate change runs been undertaken?	OK	All runs have 19% climate change allowance applied, which is the Higher bound to 2080.									
2.5	Has a study for quantifying uncertainty been undertaken? If yes, what are the results?	OK	Both the Baseline and the Proposed model has been run for the Manning's ±20% and the downstream boundary ±20% for the 100-year +19% CC event. See Section 16 for comments on the results.									

1D MODEL BUILD												
1D NETWORK												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
3.1	Model overview: Node Summary 1d length	OK	Baseline model has 103 nodes and the Proposed model has 98 nodes. The difference in nodes is the removal of the bridge BB01_0541Bu and associated junctions, spill unit and downstream cross section in the Proposed model, which is in line with the results and control files provided. Both models are 1.798km in length. The FMP 1D model summary tool shows that the average spacing between nodes is around 50m. This spacing seems appropriate to capture changes in bed levels along the watercourse.									
3.2	Have appropriate distances between sections and/or nodes been used (dx)?	OK	FMP Summary tool shows the Baseline model has 6 nodes fail the erratic node spacing check, and 7 nodes fail in the Proposed scenario. This should not impact the model results.									
3.3	Are out of bank flows represented in 1d? If so, how has it been done and is it appropriate?	OK	Out of bank flows have been represented in 2D.									
3.4	Is the model geo-referenced?	Green	Model can be opened in both Flood Modeller and QGIS. Note, when displaying the locations of the cross sections as a line, a large number of the cross sections are only partially georeferenced. Ideally XY co-ordinates should be added to the cross sections so it is fully georeferenced.	Please georeference accordingly.	This has been retained.	Green	Cross-section are partially georeferenced but this does not impact on results. Ideally, the model should be fully georeferenced.	Noted for future	Green	Comment not addressed, remains green.		
3.5	Do the cross sections and bed profiles look reasonable?	Red	Cross sections and bed profiles of Bin Brook look largely sensible, with no unexplained steps or drops in the channel. A review of bank locations has been carried out, most are correct but not all. Section BB01_1246 should be deactivated at the top of banks (see Figure 6 in the 'Figures' tab). Section BB01_1370 looks significantly narrower than the upstream and downstream sections and is glass walling (Figure 7). No comments have been provided in the cross sections to indicate the source of the data - the topographic survey has been collected with cross sections being called 'Cross Section 1.XX' and the model having sections BB01_XXXX - comments added to reference which section in the model relates to which survey section would aid the review process. Looking at the surveyed cross sections and the model cross sections, it appears the model cross sections have been extended, but there is no reference to this in either the cross section comments or the Model Report.	Comments should be added through the model to clarify what data was used where. Section widths need to be reviewed and adjusted to make them consistent upstream downstream and with the 2D width. Clarify if sections have been extended and if so, the method used.	BB01_1246 deactivated at the top of banks. All banks have been reviewed and updated where appropriate. Channel length has been extended for BB01_1370. Sections which have been extended using LiDAR have had comments added to the FMP node in the baseline model network. These were extended prior to our current phase of work on the model so we can't provide any reason for why this was carried out, but most likely due to glasswalling if the model was previously run 1D only, or to keep more water in the 1D domain to aid model stability when running as a linked model.	Green	Section BB01_1246 has been deactivated appropriately and section BB01_1370 has been extended to match the 2d width and elevation (see Figure 14). Comment has been added to baseline model for extended section. However, naming convention of the surveyed sections should be included as a comment on the sections to aid the checking process.	Noted for future	Green	Comment not addressed, remains green.		
3.6	Chainage – compared to surveyed sections	Amber	Cannot be assessed due to the labelling of the cross sections compared to the labelling of the model sections.	Please provide naming convention and a cross sections and structures table, clarifying the source data for each model section.	This request does not provide assistance in checking model length v survey and therefore has not been undertaken. Model length can be simply measured from the map against model long section length.	Amber	"41094NOLS-Bin Brook Part 1 Main.CSV" and "41094NOLS-Bin Brook Part 1 Overflow.CSV" has included chainage and modelled sections naming conventions and chainage seems to match with surveyed sections. However, this should be referenced in the model/dat file and a structures table/log should be provided to enable the checks on structures dimensions.	We do not agree that this comment has 'potential impact on the results that may change the outcome of the study'. We recognise that this may aid the reviewer in their work however it does not have the potential to impact on the results. The resources provided are sufficient to undertake the checks outlined. We will consider for future studies.	OK	Yes, the model vertical chainage matches the chainage based the survey provided.		
3.7	Does conveyance look appropriate?	Red	Conveyance plots mostly look appropriate. The section between BB01_0119d and BB01_0049 show the channel tapering along a 70m section of channel. Survey suggests this is a uniform channel and therefore channel conveyance will be underestimated here. Please check the reorientation of this section of channel is correct. In addition sections BB01_0119d and BB01_0049 appear to be U-shaped channels. The modelling manning's 'n' for the vertical walls does not appear to be applied correctly. A single hybrid manning's 'n' for the U-shaped channel would be more appropriate to estimate conveyance.	Check and correct the channel sections and conveyance.	We have updated elevations along this reach of the model and widened BB01_0119d as appropriate. Consistent Mannings values have been applied to the channel.	OK	The section has been updated along with manning values.					
3.8	If gauged flow is available, is there good flow reconciliation between the statistical estimates and the modelled, for given return periods?	N/A	Not available.									
3.9	Bank Markers. Are they used and if so, are they suitably located?	Red	Left and right bank markers have been applied at most cross sections, these are placed on the top of bank most are appropriate. Panel markers have also been used at changes in roughness and changes in geometry, these have mostly been applied appropriately. See comments 3.5 and 3.7 for issues associated with cross section with and panel marker application.	See comments in 3.5 and 3.7	Bank/panel markers have been updated at cross-sections where necessary. Channel section between BB01_0119d and BB01_0049 have been updated. Conveyance curves assessed to be suitable.	Green	Sections updated, please see action in 3.5.	Comments in 3.5 relate to cross section naming conventions and have no bearing on bank markers. This reference seems misplaced. No actions proposed	OK	Noted and agree, thank you.		
3.10	What approach to channel roughness has been used?	OK	The Model Report states in Section 2.2.2 and 2.2.3 that Manning's values based on Chow (1959) have been applied to the channel banks and bed.									
3.11	What manning's n value(s) have been used for the channel? If it is 1d only what values and how have they been applied in the flood plain?	OK	In general, the river sections have a roughness of 0.035 applied to the channel bed, with a value of 0.05 applied to the banks of the channel. A survey photo has been provided for each surveyed cross section. The values applied look to be appropriate.									
3.12	What method has been used to estimate roughness (USGS, Chow, etc. based on survey, photographs)? Are they appropriate	OK	Chow (1959) and photos taken by the surveyor. See comments above.									



1D BOUNDARY CONDITIONS												
1D BOUNDARY CONDITIONS												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
4.1	1d boundary model domain; is there glass walling anywhere in the modelled reaches?	OK	Out of bank flows are represented in the 2d. Representation is appropriate.									
4.2	How have the inflows boundaries been applied?	Amber	Three QT boundaries applied. BB01_1575 has been applied at the upstream of the model, with BB02 applied downstream of Barton Road (on the downstream face of the footbridge) and BB04_I applied at Clare Hall, just downstream of the area of interest. In the 100-year +19% CC event, BB01_1575 has a peak of 7.822m³/s, BB02 has a peak of 1.744m³/s and BB04_I has a peak of 2.022m³/s. Only the upstream QT boundary has been referenced in the reporting. No information has been provided on whether these boundaries are part of the original model received from the EA or if they are newly applied boundaries for the modelling.	Clarify whether these inflows have been updated as part of this study. Reference to all three inflows should be included in the reporting.	The three inflows have now been included in the report.	Amber	The report has been updated. However, why these inflow have been applied has not been defined in the report. Moreover, a figure of the catchment boundary should be included in the report.	The modelling report forms an appendix to the FRA along with the FEH calculation record. Collectively they provide a comprehensive discussion of the flow estimation and application to the model. As the purpose of the study is to assess the relative change between a baseline and developed scenario we would propose that the provided consistent boundaries are applied to both the baseline and proposed models then this comment dose not have the "potential impact on the results that may change the outcome of the study" and as such should be a green.	Green	Noted. Please define the inflow boundaries in the modelling report.		
4.3	How is the downstream boundary(s) applied?	Amber	A single NC boundary has been applied at the downstream of the river, set to a slope value of 0.002 (1 in 500). The modelling report states this has been based upon the preceding river sections, but no information on which river sections. A check of the slope of the sections labelled EA_### shows a slope value of around 0.0008. No information has been provided on whether the slope value applied at the boundary is part of the original model received from the EA or if it is a newly calculated slope value for this modelling. There is also a HT boundary applied at the Bin Brook Diversion Channel, this does not appear to link to anything in the 2D domain or have any water levels applied to it.	Clarify whether the outflow has been updated as part of this study. Clarify the purpose of the HT boundary and include reference to it in the reporting. Justification of the slope value applied needs to be provided.	Outflow has been updated as part of this study. Purpose of the HT boundary is to represent the Bin Brook overflow diversion ditch. Updated the slope value at the downstream to 0.00082.	Green	The slope has been updated based on preceding EA section. However, the approach to model the overflow ditch has not been defined in the report - please add.	The linking of a 1D 2D model via an HT boundary is a well established principal that can be clearly seen from the model files and confirmed to have worked via the model results files. It is not considered a necessity to describe every standard 1D-2D link in the model.	Green	Comment not addressed, remains green.		
4.4	If tidal - how has the boundary been derived?	N/A										
4.5	Have appropriate locations been chosen for the downstream model extents?	OK	The downstream boundary is 780m downstream of the site, and the spill unit BB01_0119Su is controlling water levels along the watercourse. There is therefore no impact at the site due to the downstream boundary and consequently the location is appropriate.									



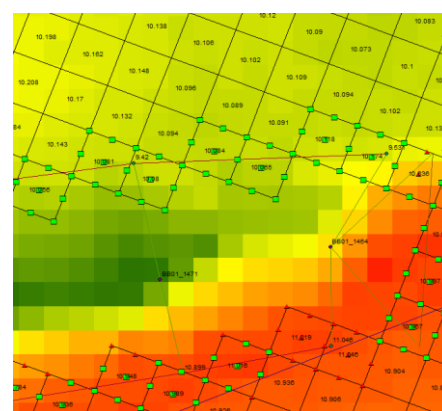
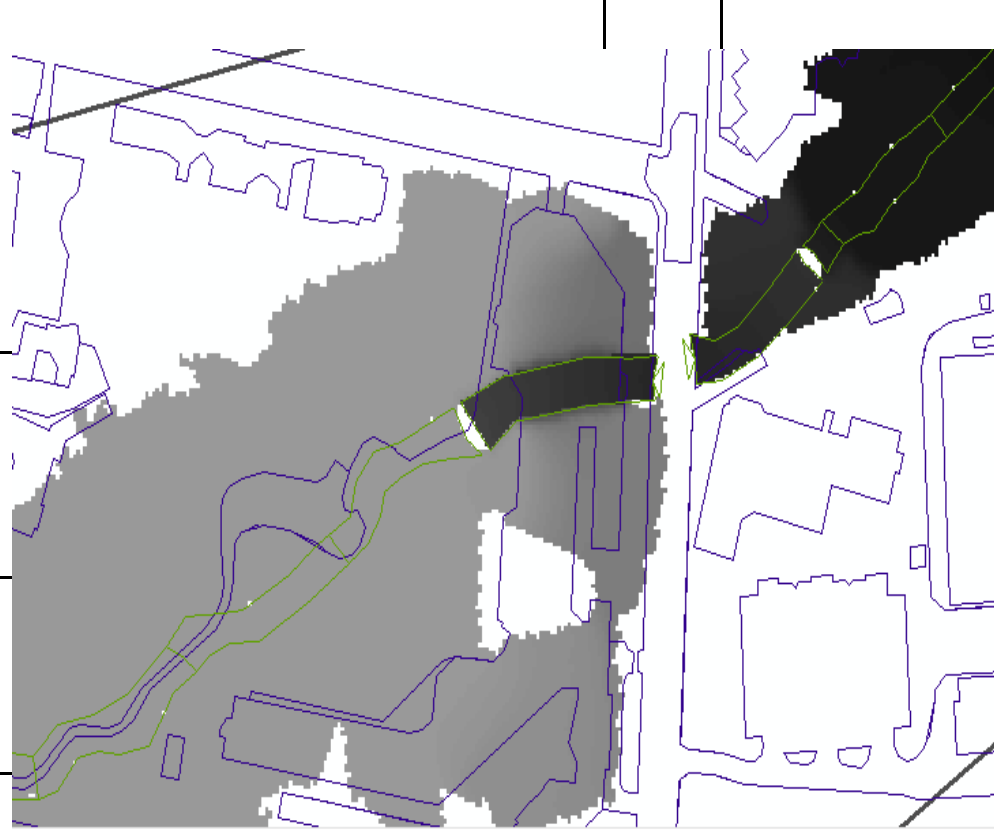
1D STRUCTURES														
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Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4	4th Review Comments	4th Review Response (DATE)	
5.1	Are all structures represented? If not have explanations for structures not modelled been given in the Log/report?	Amber	<p>A check of the topographic survey shows that all the surveyed sections have been included in the model, this includes five culverts, six bridges and a weir for the Baseline model (one of the bridges has been removed in the Proposed model). There appear to be two footbridges which have been omitted from both the survey and the model, at the downstream extent of the Bin Brook diversion channel (NGR 543488, 258057) and at Clare Hall (NGR 543601, 258334).</p> <p>No model log has been provided, and no model comments have been added at structure sections to identify which model section relates to which surveyed cross section, which would have aided the review procedure.</p> <p>Three bridges (BB01_1262Bu, BB01_0461Bu and BB01_0007Bu) have been included in the model as USBPR bridges to represent small footbridges over the channel - the equations were intended for large clear spanning bridges based off those in the USA. Generally, an arch bridge unit would be more appropriate for small bridges such as these. The bridge over Grange Road (BB01_0049Bu) has been included as an arch bridge.</p>	<p>Add comments in the model and provide the model log to add clarity over which surveyed cross section has been used for each model cross section.</p> <p>Justify the omitting of the two footbridges.</p> <p>Update or provide justification as to the use of USBPR bridge units instead of Arch Bridge units.</p>	<p>Survey was not taken for the footbridges therefore they have not been included in the model.</p> <p>The Arch Bridges have been to replace the USBPR bridges in the model and the model has been re-run.</p>	Amber	<p>It is acknowledged that three structures are not included in the model (consistent for baseline and proposed) these are -</p> <p>1 downstream extent of the Bin Brook diversion channel (NGR 543488, 258057)</p> <p>2 Clare Hall (NGR 543601, 258334</p> <p>3 BB01_0170(Robinsons college) (NGR 534883,258403).</p> <p>Structure one is a clear span foot bridge with a thin deck (pictured) with a slatted wooden parapet that is not continuous beyond the bride deck. In the event of the bridge being surcharged it would be locally bypassed by out flanking flood flows and therefore was not considered to have a material impact on the flood modelling results. Structure of this nature that bypass early are often a source of model instability and therefore it is common place to exclude them where the impact on modelled flood levels is likely to be minimal and local to the structure.</p> <p>Structure two was observed in the Environment Agency baseline model to have a spill lower than the soffit of the orifice unit it is representing. It is observed to be an ornamental foot bridge with a soffit higher than the banks either side that would be subject to local bypass in the event of a flood. Based on review of the existing model this structure was excluded for the same reason as structure one above.</p> <p>Structure three is a circular foot path in the grounds of Robinson College over the widened Bin Brook which forms an online pond in this location. This structure is similarly excluded from the existing Environment Agency model. Water levels in this location are controlled by a downstream sluice (represented in the model as a spill unit). The foot bride is not considered to be hydraulically significant. It is a approximately 350m downstream of the areas of development.</p>	Amber	<p>Thank you for the justification and the photos. The original EA model has not been provided to independently check the original representation and the changes performed. The comment remains amber until this is checked.</p> <p>It is best practice (green comment) to also provide a detailed structures log, including evidence to demonstrate that omitting these defined structures from the model will not impact the study results and to add the justification provided in the report for future users.</p>	  				
5.2	Are invert levels correct compared to survey data?	Amber	<p>Review of each structure has been undertaken, issues are commented below.</p> <p>First culvert under A603 (BB01_1464ci) - the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed.</p> <p>Second culvert under A603 (BB01_1331ci) - As above, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The trash screen has not been represented.</p> <p>Footbridge (BB01_1262Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance (Figure 12). See comment above on the use of USBPR units.</p> <p>Culvert under houses (BB01_1189ci) - As above, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The surveyed drawing labels the downstream invert as 7.582m which is above the modelled invert yet this is not how it is shown in the drawing. The upstream trash screen has not been represented or commented on in the report. There is no survey photo of culvert exit, does this culvert actually reduce in size from 1.8m to 1.2m diameter, the long section plot of the survey does not show the culvert decreasing in size?</p> <p>Footbridge (BB01_0541Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. See comment above on the use of USBPR units.</p> <p>Footbridge (BB01_0461Bu) - same comments as previous footbridge, the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. Junctions are not needed. See comment above on the use of USBPR units.</p> <p>Culvert at Needham Research Institute (BB01_0403Ci) - confirmation of where the soffit elevations have been taken from is needed.</p> <p>Second culvert at Needham Research Institute (BB01_0381Ci) - again, confirmation of where the soffit elevations have been taken from is needed.</p> <p>Footbridge (BB01_0329Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance.</p> <p>Weir (BB01_0119Su) - the junctions are not needed, the spill unit representing the weir can be directly linked to the river units. Confirmation of where the elevation of the weir crest has been derived from is needed. The unit is modelled using a default spill coefficient but looks to be more like a sharp crested weir (Figure 10.)</p> <p>Bridge at Grange Road (BB01_0049Bu) - cannot determine which cross section has been used to define this, confirmation is needed. Junctions are not needed.</p> <p>Footbridge (BB01_0007Bu) - the bridge deck elevation not labelled on the survey. Embankment markers should be added to improve conveyance. See comment above on the use of USBPR units.</p> <p>Spill at Diversion Channel (BB01_1189LS) - confirmation of what this is representing is needed.</p> <p>A blanket value of 0.02 has been applied at all culverts, but the culverts are constructed from different materials (corrugated metal vs. concrete), justification of the blanket value needs to be provided.</p>	<p>Confirmation of where invert / soffit levels have been derived from needs to be provided at all structure sections.</p> <p>Missing length at BB01_1331ci and BB01_1189ci needs justifying.</p> <p>Justify not representing trash screens.</p> <p>Embankment markers should be added at all bridges to improve conveyance.</p> <p>Justify the use of the USBPR bridge units instead of Arch Bridge units.</p> <p>Justification of the blanket value of 0.02 set at all culverts despite the different materials used in the construction needs to be provided.</p>	<p>The invert/soffit levels have been derived from structure surveys. The levels have been derived through utilising annotated invert/soffit levels if provided, utilising lowest/most appropriate bed levels on the cross section, measured in CAD between invert and a know elevation point or the long section drawing. All levels have come from the survey information.</p> <p>Trash screens have been included for two bridges.</p> <p>Embankment markers have been added to bridges to improve conveyance.</p> <p>Arch Bridges have been utilised to replace the USBPR bridges.</p> <p>Updated Mannings value for culverts have been utilised in the model, no longer just a blanket 0.02 value for all.</p> <p>The spill at the diversion channel is to help define the elevation at which water spills between the channels.</p>	Amber	<p>The dimensions have been measured using survey data for most of the structure and they seem appropriate. A structure log with reference of the surveyed cross section including naming convention should be provided. The structure log should also include the assumptions considered to model the structures. The bridge units have been updated as arch bridge units, embankment markers have been applied appropriately and trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. The survey data do not include these dimensions. Also, how the culvert dimensions for BB01_1034cd culvert were defines, as the survey does not contain this information. Please see Figure 13 for the trash screens and the downstream face of the culvert.</p> <p>BB01_0119Su weir coefficient has been updated to 1.6 which is appropriate.</p> <p>BB01_1189LS spill elevation seem appropriate and checked against survey.</p> <p>The roughness values have been updated according to culvert material defined in the comments (see Figure 15).</p>	<p>We do not agree that this comment has 'potential impact on the results that may change the outcome of the study'. We recognise that this may aid the reviewer in their work however it does not have the potential to impact on the results. The resources provided are sufficient to undertake the checks outlined. We will consider for future studies.</p>	Amber	<p>We reiterate the comment made in the second review that the assumptions regarding the representation of structures have not been highlighted in either the modelling report or the structures model log. As a result, this item could not be checked. For instance, the assumptions made regarding how trash screens were considered in the model are unclear, particularly since the provided survey data does not include the dimensions of the trash screens. The accurate representation of the trash screens may impact the results and the flow through the culverts and therefore this comment remains amber. Please provide structure log for the next submission.</p>				
5.3	Do bridges surcharge? If so has orifice flow been enabled?	OK	All bridges have orifice flow enabled, with all parameters for the upper and lower transition distances set to 0.1m, with the orifice discharge coefficient set to 1. This seems to be appropriate.											
5.4	Are there spills around the structure or over the top represented appropriately?	Amber	<p>There is a mismatch with how overtopping methods have been represented, some of the bridges use 1D spill units to represent the overtopping methodology and some use HX lines in the 2D domain. This should be justified. All culverts use HX lines to represent the overtopping methods, Figure 12.</p> <p>No elevations are provided in the survey for the bridge decks where spill units are used, confirmation of how the elevations have been derived is needed.</p>	<p>Confirmation of where levels which have been to derive the spill levels needs to be provided</p> <p>Justify the mismatch in representation of overtopping (1D spills vs. 2D HX lines).</p>	<p>Bridge spill units have been updated to be representative of the same overtopping methodology. Generally, for structures of less length than 2-3 cells length, decks are represented in 1D, those with longer decks (in direction of flow) are modelled in 2D.</p> <p>Elevations of bridge decks are based on surveyed levels and adjacent LiDAR levels.</p>	Amber	<p>Please revisit the approach for spills, e.g. survey suggest that structure BB01_0541 has length of 3.93 m. Also provide structures log for all the assumptions made on the elevations/dimensions.</p>	Amber	<p>All spills either represented in 1D or 2D. Where in the 2D the distance between upstream and downstream active area may have been expanded to separate HX lines.</p>					
5.5	If there are any movable structures have they been modelled correctly?	N/A	None in the model.											
5.6	Structure coefficients - Have they been changed from default values?	Amber	<p>Spill representing the weir at Robinson College is set to default (1.2). broad crested weir the weir appears to be sharp crested and therefore different to the default.</p> <p>The inlet unit for the first culvert under A603 (BB01_1464ci) is set up for a circular corrugated metal pipe which is projecting, the pipe is not projecting. The Ki value has been updated from default of 0.9 to 0.5.</p>	<p>Update the spill weir coefficient to a more appropriate value at Robinson College BB01_0119.</p> <p>Justification for the values applied for the inlet unit at BB01_1464ci (culvert is not projecting, Ki value updated) is needed.</p>	<p>Increased weir coefficient from 1.2 to 1.6.</p> <p>Reviewed culvert inlet loss using the culvert wizard in Flood Modeller Pro. Values have been updated using parameters: Circular > Corrugated Metal > Headwall. Based on site photos of BB01_1464ci structure.</p>	OK	<p>The weir coefficient has been updated and Ki value of 5 has been applied.</p>							



1D RUN PARAMETERS

1D RUN PARAMETERS									
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3
6.1	What time step has been used for the 1D model? Is it appropriate?	OK	1D timestep (0.5s) is half the 2D timestep (1.0s). This is appropriate.						
6.2	What initial conditions have been used? Steady state, hotstart file?	OK	IIC file has been used for the Baseline model, and a separate IIC file used for the Proposed model. Spot check of the sections does not show any issues with the initial conditions.						
6.3	Have any of the parameters and advanced parameters been changed from the default. If so, has it been justified?	Green	Dflood has been increased from the default of 3 to 5. This has not been justified.	Justify the increase in dflood.	Changed back to default	OK	Dflood restored to default value.		

2D MODEL BUILD

DIGITAL TERRIAN MODEL														
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4	4th Review Comments	4th Review Response (DATE)
7.1	Number of domains?	OK	One 2D domain.											
7.2	Area of 2d domain/s	Red	55 hectares. There is glass walling occurring in the 1,000-year +19% CC results near Clare Hall Gym and Pool in both the Baseline and Proposed modelling.	The code layer needs to be extended to prevent glass walling.	Code layer extended upstream.	Red	There is still some glass walling - please see Figure 16.	Figure 16 shows two cells where the modelled flood extent in the 0.1% + CC AEP event reaches the boundary of the model domain. The maximum modelled water level in this area in the baseline scenario is 9.62mAOD and in the proposed scenario is 9.53mAOD. The ground level in these cells is 9.61mAOD and 9.45mAOD. This means that for the two cells there is 0.01m and 0.17m of glass walling in the worst case. From review of Lidar the ground levels continue to rise beyond the model boundary. The image to the right shows the active model boundary as a grey line, the baseline 0.1% + CC AEP event depth grid in black and the LIDAR for the area categorised as below 9.53mAOD (Blue), between 9.53 and 9.62mAOD (Yellow,) and above 9.62mAOD (Red). As can be seen there is potential to extend into an area of approximately 34m2 beyond the active domain. Due to the small plan area (~34m2) and very small depth (0.01-0.17m) including this area within the model domain is likely to have an extremely limited impact on model results (estimated to be on the scale of 0.001m or less). As this is a feature of both the baseline and proposed models this will not have an impact on the outcome of the study and as such should not be a red comment. It is reasonable to flag as a green comment for action alongside any other planned future model updates where the 0.01% + CC AEP event results are required.	Green	Noted, thank you. Please amend the 2D code for future submissions. Please include figures in a separate tab, so they do not get deformed and the point can be made better.				
7.3	What dataset has been used to define the DTM elevations? LIDAR, Photogrammetric DTM?	Green	1m LIDAR has been used to define the floodplain. The Model Report states in Section 1.3.5 this was downloaded from the EA webpage in May 2022, no date of when the LIDAR was flown is referenced.	Include reference to year data was flown in the Model Report.		Green	No action or acknowledgement, remains green.	Noted for future	Green	Comment not addressed, remains green.				
7.4	What grid resolution has been used? Is it suitable to accurately represent flow paths, e.g. between buildings?	OK	A 2m grid resolution has been used, this seems appropriate for the modelling outcomes.											
7.5	Has the DTM been rotated to optimise flow route representation?	N/A	Modelling report does not state that DTM has been rotated.											
7.6	Is there any obstruction to flow?	Amber	The A603 at the upstream extent of the model forms an obstruction to flow, nothing else of note. Bin Brook flows under the Robinson College building, BB01_0049. It is possible that this building could impede the overland flows to a greater extent than currently modelled, Figure 11. The filtered lidar creates flood storage in this location that may not be correct.	Review the representation of the Robinsons College building to confirm flows can pass through the building as currently modelled.	Updated so that flow constrictor shapefiles have been set up for the Robinson Building. Flow constricted by 90% with Mannings value of 0.05 applied. The central Robinson College area applies a minimum elevation of 8.2mAOD. Something similar has also been applied for Needham Research Institute and all other buildings within the model domain.	Amber	2d_FCSH has been applied with 90 % blockage. However, the representation of the 1d channel is still not updated as the flow is unlikely to come out of bank where the building is located. Please revisit the approach to model the 1d channel under Robinsons College Building. The representation used for Needham Research Institute looks more appropriate, i.e. use of culvert with no spills.	Review of Water surface elevation grid results show the impact on the Robinson College sluice on in channel water levels. Water levels in the culvert under the college building are below the minimum elevation applied to the building foot print. Any flooding of the building is from flow that comes out of back up stream of the sluice. As such the flow is not coming out where the building is located. results form the 0.1% + CC AEP event shown to the right.	Amber	We reiterate the second review comment, noting that the source of flooding and the flow mechanism cannot be determined without examining the XMDf results. Furthermore, the maximum 0.1% + CC AEP water level result of 8.19 mAOD in the channel where the building is located is very close to the building's invert level applied in the model (8.2 mAOD). Please revisit the approach used to model the 1D channel under Robinsons College Building and provide the XMDf results so that the 1D/2D hydraulic mechanism can be assessed.				
7.7	Has additional site specific topographic survey data been used?	OK	Survey data has been used to define channel sections, nothing applied in the 2D domain.											
7.8	How have buildings been represented within the DTM?	Amber	Buildings have then been applied using the materials file taken from OS MasterMap using a high roughness value of 0.5, which in the most part seems appropriate however see 7.6 for comments on the Robinson College building.		See comment above.	Amber	See action above.	See 7.6	Amber	See 7.6				
7.9	Are defences/embankments/bank crests accurately represented?	Red	The banks are represented using zlines and zpoints, for both Bin Brook and the ditch which appear to be taken from survey. There are also zlines and zpoints representing the levels of the spills. See 2D_Structures 10.3 for comments on these structures. No other defences or embankments are formally represented. The bankline representation ZSH check shows significant bank raising which appears to be artificially bunding the watercourse Figure 8. Further justification for the bank raising is required.	Check and confirm the bank raising applied at the 1D2D link location is appropriate. Also see comments in 10.3.	Banklines have been updated to better represent height where there was a large discrepancy between Lidar and bank levels from the model. Checked using zln zpt check layer and reviewing the dZ value.	Red	Please see action in 10.3.	Unclear why there is a red comment here referring to 10.3 (an amber comment). As stated previously Z lines based on survey to supersede LIDAR (the same approach as was adopted by the EA model when updating the 2010 model which used lidar based HX lines). Minor inconsistency for BB01_1471 and BB01_1464 where left bank panel marker has been read in to z2 line rather than left deactivation marker value. As the Max command is used this Z line has no impact on model geometry. From review of LIDAR it can be seen that ground levels rise away from the channel and the there is no negative impact from the ZLine. This is noted for future revisions of the model but dose not have the potential to impact the outcome of the study as it impacts both the baseline and proposed equally.	Red	The inconsistency referred to in the second review response is not limited to BB01_1471 and BB01_1464. Significant discrepancies have been identified between the LIDAR data and the assigned bank levels throughout the model (see Figure 1). Please address these discrepancies throughout the model for the next submission.				
7.10	If post-development scenarios are required have the proposed ground levels and building been represented appropriately?	Amber	One post development model has been provided as part of this review, the 10m span bridge with the downstream footbridge removed. This has been set to an elevation of 10.5m as per the Model Report. However no consideration has been given to a change in roughness.	Confirm if a change of roughness as part of the proposed model is needed.	No needed to increase roughness, even in the highest flood event, the embankment is not at risk of flooding up to the 10.5mAOD.	Green	Thank you noted. This will need to be revisited after the hydrology is signed off, in case the maximum stage changes. Ideally the roughness changes need to be captured or mentioned in the model limitations in the report if higher events, i.e. the 0.1% AEP needs to be modelled for future uses of the model.	Noted for future	Green	Comment not addressed, remains green.				

2D ROUGHNESS														
Item No.	Item Checked	RAG	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG	2nd Review Comments	2nd Review Response (DATE)	RAG	3rd Review Comments	3rd Review Response (DATE)	RAG	4th Review Comments	4th Review Response (DATE)
8	What manning's n values have been used to define floodplain roughness? Have they been applied correctly?	OK	OS Master Map is used to define roughness. The background roughness across the 2D domain has been set to 0.06, this is listed in the trmf as 'General Green Areas/Natural Roadside'. All areas within the active model domain have a defined roughness.											
8.1	What methods have been used to estimate roughness?	OK	See above											
8.2	Is the representation of different roughness areas sufficiently accurate and detailed?	OK	A review of the 2d_mat layer shows that the different roughness areas are sufficiently detailed and capture the different land use types as are all defined by the OS MasterMap shapefile.											



2D BOUNDARIES

2D BOUNDARY CONDITIONS												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
9.1	Have any boundaries been used in the 2D domain? If so detail.	Red	<p>One inflow QT boundary has been applied in the drain, there is no indication if this has been updated as part of this modelling study. Check files show the boundary is being read in correctly, and applying the correct inflow.</p> <p>There is also a HQ downstream boundary with a slope value of 0.03432 set, the Model Report states this is based on the Lidar. The boundary is not snapped to the code layer.</p>	<p>Indicate whether either of these boundaries have been updated as part of the study and justify slope value.</p> <p>Snap the downstream boundary to the code layer.</p>	<p>The hydrological boundaries have been updated as part of this modelling study.</p> <p>The downstream boundary has been updated to snap to the code layer.</p>	Red	<p>The downstream boundary has been snapped to the 2d_code layer. The HQ boundary needs to applied at the left bank along the code layer, where glassing walling occurs, see Figure 17.</p>	See 7.2	Red	<p>The justification provided in item 7.2 primarily focuses on the glass walling at the northwest boundary of the 2D code (see Figure 2). However, there is no explanation as to why the HQ boundary has been applied downstream only on the right bank, while it has not been applied on the left bank, despite the presence of glass walling on the left bank as well (see Figure 3). Please apply the HQ boundary at the downstream boundary left bank.</p>		
9.2	Is the model boundary suitably large? i.e. the flood extent should not reach the boundary.	Red	<p>There is glass walling at the downstream extent of the model as the downstream boundary is not snapped to the 2d_code layer, and also does not extend far enough east, see Figure 1 in the 'Figures' tab.</p> <p>There is also glass walling in all three events at the upstream boundary, see Figure 5 in 'Figures' tab.</p> <p>No other glass walling.</p>	<p>Extend the downstream boundary eastwards to cover the full extent of the flooding.</p> <p>Justify the presence of glass walling at the upstream extent of the model.</p>	<p>The downstream boundary has been updated to snap to the code layer.</p> <p>Extended upstream extent of the model to prevent glass walling.</p>	Red	<p>There is still some glass walling - please see Figure 16.</p>	See 7.2	Green	<p>Noted, thank you. Please amend the 2D code for future submissions.</p>		
9.3	Has rainfall been applied directly to the 2d model domain?	N/A										
9.4	Coastal - How has the wave overtopping been applied?	N/A										



2D STRUCTURES

2D STRUCTURES												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
10.1	Have any structures been included in the 2D domain? If so how have they been represented?	OK	The Bin Brook Diversion channel has been included in the 2D domain using network lines and 1d_tab file for the cross sections. The diversion channel is linked to the 1D model using a X1DQ link, which links the flow to and from the FM model to the ESTRY section.									
10.2	Are invert levels correct compared to survey data?	Amber	Spot checks show the channel sections match the survey levels for the cross sections. At the culvert, the length and the width do not match the survey, the elevation of invert at both the upstream and downstream sections is not labelled on the survey, confirmation of where the values have been taken from is needed. The Manning's value has been set to 0.013, this is different to the generic 0.02 applied to the culverts in the 1D domain, and different to the Manning's value applied to the rest of the diversion channel (0.017). The height contraction coefficient has also not been set.	Review the culvert in the Diversion channel against the topographic survey, and justify / correct values applied.	The culvert matches what has been surveyed. See 5.2	Amber	Roughness values seem appropriate. Channel length and culvert dimension needs to be updated and height contraction coefficient need to be defined, see Figure 18.	Channel length is correct when measured from centre of channel, not from schematised spill location. Default heigh contraction assumed. Unlikely to be orifice flow due to high downstream water level. Noted for futre work.	Amber	The modelling report does not specify the assumptions made or how the structures have been represented. Additionally, the structure log has not been provided, which currently makes it impossible to properly review this item. Please provide the structure model log detailing the assumptions made to represent the 2D structures, or include this information in the modelling report to enable proper check of this item.		
10.3	How have defences been represented? Zline? If there are flood zone scenarios have the defences been excluded adequately?	Amber	Three features have been included in the 2D domain, the first being zlines and zpoints along the banks of Bin Brook representing the bank levels, the second zlines and zpoints along the banks of the drain, and the third zlines and zpoints representing the spill levels over structures. At all three features, the zline is snapped to the 2d_bc_hxi bank line and zpoints placed along it, this could be represented as just bank lines and points (all included in the 2d_bc_hxi). All lines have been applied as THICK, this is working as needed. The points applied in the 2D domain for the banks of Bin Brook do not match with the 1D cross sections, there should be a match. There is no indication where the values for the Bin Brook diversion channel or the spills along the main Bin Brook channel have been taken from, this needs to be clarified.	1D cross sections should match the 2D bank points, the cross sections should be updated to match. Confirmation of the method used to determine levels for the spill bank points and the Bin Brook Diversion channel is needed.	1D and 2D bank points match. These have been spot checked throughout. Bin Brook diversion channel ditch levels have been taken from watercourse survey document 'Bin Brook Overflow'	Amber	The zpoints and 1d-cross sections do not match see Figure 19. Please review all the cross sections.	see 7.9	Amber	Significant discrepancies have been identified between the LiDAR data and the assigned bank levels throughout the model (see Figure 1). These discrepancies impact the representation of embankments, defenses, and, consequently, the modeling results. Please address these discrepancies across the entire model in the next submission.		
10.4	Have appropriate loss coefficients and roughness values been used?	N/A	None applied.									



2D RUN PARAMETERS

INITIAL CONDITONS & OTHER RUN PARAMETERS						
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2
11.1	What time step has been used for the 2D model? Is it appropriate?	OK	Cell size is 2m, the 2D timestep has been set as 1 second and the 1D timestep to 0.5 seconds. The timestep is appropriate.			
11.2	Have initial water levels been applied? Are they correct?	OK	None applied in the 2D domain.			
11.3	Are the other 2D model parameters reasonable (e.g. flooding & drying, eddy viscosity). Are they different from default?	OK	No additional parameters have been applied			



1D/2D MODEL LINKS

MODEL LINKS												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
12.1	How have the 1D/2D models been coupled, is it appropriate?	Red	The 1D and 2D domains have been linked using HX and CN lines. Connections have mostly been digitised appropriately. The upstream of the model should be snapped to the code boundary (see Figure 2 in the 'Figure' tab). The HX lines at the structures throughout the model and the link to the ditch need to be reviewed, many should be closed so a single HX line is applied (see Figure 3 in the 'Figures' tab as an example).	Please amend throughout the model.	Gaps in the 1D and 2D domains have been closed.	OK	The code boundary is snapped with the upstream boundary. The gaps have been closed					
12.2	Is the digitisation of the links acceptable?	Red	Bank points have been added at the river cross sections from the 1D domain, but not at interpolate nodes. Some bank level points need revisiting. The 1D top of banks do not always agree with the TUFLOW zpoints used. This might over/under estimate out of bank flooding. Bank points also should be added at the interpolate units using the LiDAR data, and at changes in bank elevations.	Please justify or amend accordingly.	Update zpts along the banks to give better representation of the banks for areas where there were long sections with no bank survey points in-between.	Red	Bank points for interpolates need to be updated as these are not applied for interpolates and in between - see Figure 20. Also, see action in 10.3.	See 7.9 - as stated previously Zpts for banks are based on survey - no survey is avail for interpolates therefore zpts for banks are also interpolated at these locations.	Red	The interpolates at the specified locations are not accurately represented due to discrepancies identified between the LiDAR data and the bank levels applied in the model (refer to item 7.9). Please address this issue as outlined in item 7.9.		
12.3	Is the 2d representation of the river channel comparable in width with the 1d model cross sections?	Amber	In some locations, there is a good match between the width of the channel in the 2d domain and the 1D model cross sections, however in others, there is not. Looking at the locations of the 1D cross sections and the 1d_nodes / CN lines in the TUFLOW domain, there are also locations where cross sections have been moved upstream or downstream in the 2D domain, see Figure 4 in the 'Figures' tab. Note a large number of the cross sections are not fully georeferenced in the 1D domain.	Please justify or amend accordingly.	The 2d links and CN lines are now in a more appropriate location.	Amber	The width of the 1d and 2d cross-sections are matching now. The cross sections are not georeferenced fully and section BB01_1575 has been connected on HX lines ~230m upstream. Please explain the reasoning behind this approach and why the model has not been extended upstream - see Figure 21.	HX line at Upstream extent has been extended to allow lumped inflow at top of model to adequately spread out to avoid glass walling at the upstream extent of the model. Consistent in both baseline and development model - no impact on outcome of study	Green	Ok, noted. However, the schematization near section BB01_1575 is not in line with best practice. This section is connected through the HX line ~230m upstream. Please revisit the schematization near section BB01_1575 for future submissions in order to comply with the best practice.		
12.4	Representation of 1D output in 2D domain	Green	There are no water level lines applied down the channel, therefore no results are displayed in the channel. This does not impact model results, but does create display issues.	Water level lines should be applied so results are being displayed fully. This should be updated in line with best practice, particularly as results are being used in figures.	WLLs have been created and the TufLOW model results now display these properly.	OK	WLL have been applied.					
12.5	Have any default link parameters been changed (i.e. to improve stability)?	N/A	No changes to default link parameters									



MODEL OUTPUTS & CALIBRATION

CALIBRATION/VERIFICATION												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
15.1	Have calibration runs been completed? Is data for calibration available? Gauge data, extents, anecdotal etc.	N/A	No calibration has been carried out. Hydraulic Modelling Report states there are no gauges to calibrate against or any historical flood data available.									
15.2	Are the simulated hydrograph peaks reasonably similar to the recorded peaks?	N/A										
15.3	Is the shape of the simulated hydrograph and therefore the volume suitably similar?	N/A										
15.4	Are simulated floodplain extents similar to recorded extents? Are flow routes similar?	N/A										
15.5	Has suitable effort been made to attempt and improve calibration. Have attempted changes been documented with a quantification of impact?	N/A										
15.6	If no historic data is available, are the simulated flood outputs similar or very different from past modelling in the area? If there is a large difference, does it seem sensible?	Red	Nothing has been provided to compare to. As this model is based on a previous model as a minimum in the absence of any other validation data the model results should be compared to previous model results as a sense check.	Please justify or amend accordingly.	Previous results are much less extensive as they are without 19%CC. The upstream end of the 2017 model results show a different distribution of flooding, with nothing coming out of the right bank as it does in the updated model, otherwise the pattern of flooding is generally the same (other than width of flooding due to increased volume).	Red	Have the model results been compared with Flood Zones maps as well? Please provided evidence of the comparison in the report and discuss why the differences occur.	commentary on local flood modelling compared to other sources of data in FRA. Model runs include climate change. Flood zones do not. Therefore limited insight to be gained from comparing them in this instance. No impact on conclusion of study	Red	The FRA has not been provided, therefore the commentary on local flood modeling in comparison to other data sources was not reviewed. Additionally, it is unclear whether the model results have been compared with the NaFRA2 maps. Please include a commentary in the modeling report discussing the modeling results in relation to NaFRA2 data.		



MODEL SENSITIVITY

SENSITIVITY TESTING & UNCERTAINTY												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
16.1	Have appropriate model parameters been chosen for sensitivity testing? Typical tests include: □ Sensitivity to roughness ± 20% (Manning's "n" both in 1D and 2D) □ Sensitivity to flows ± 20% (From central estimate) □ Sensitivity to downstream boundary □ Key structure blockage(s)	Amber	A number of sensitivity tests have been carried out including Manning's ±20 and the downstream boundary ±20% for both the Baseline and Proposed modelling. However this has only been applied in the 1D domain, not the 2D domain. A slope value of 0.0025 has been applied in to the downstream boundary +20%, however a 20% increase is actually 0.0024. Again, in the downstream boundary -20%, the value applied is 0.00166667 but the calculated value should be 0.0016. A check of the Manning's sensitivity .DAT files for the baseline shows the change in roughness has been applied to the river sections correctly, but not to the culvert sections. The change in roughness has been applied to the culverts in the proposed Manning's sensitivity tests.	Justify not sensitivity testing the 2D domain. Justify the slope values applied. Justify the approach to changing / not changing the roughness values applied to the culverts in the Manning's sensitivity tests.	The slope value for the downstream boundary has been updated to 0.00082. The 20% decrease and increase change for the downstream boundary has therefore been updated to 0.000656 and 0.000984 respectively. The change in roughness has not be applied to the culverts in the model due to instability issues that occurred when these were changed. Therefore as much of the model was changed as possible without impeding the model to crash and return any results.	Amber	The slope has been updated and sensitivity test has been only performed in the 1d domain. No changes to the 2d domain have been conducted for both roughness and boundary sensitivity tests. The culverts roughness changes have not been applied - was there any particular culvert which is sensitive to roughness changes, please specify and discuss the possible impact on the results.	See 16.2	Amber	Structures roughness sensitivity testing has not been applied correctly (see Figure 4). Please revisit the structures roughness sensitivity testing and provide commentary in the modelling report.		
16.2	Do the results of the tests show the models to be particularly sensitive to certain parameters?	OK	The model results show the site is not sensitive to any changes made to Manning's or the downstream boundary.			Green	Please specify which culverts/structure are sensitive and to which parameters.	Model stability sensitive at culvert locations. Not able to identify specific culverts where flood results were sensitive to parameter change due to the instability.	Green	Please provide more information in the modelling report regarding the model stability being sensitive to the culvert locations.		
16.3	Have confidence limits for model results (+/- mm) been presented? How were they derived and does this seem sensible?	Amber	Confidence limits have not been presented	Please provide	There is no defined modelling tolerance within either FMP or Tuflow. We have used the best available data for boundary slopes, hydrology, cross sections, and LiDAR. All assumptions are listed. Confidence limits are requested for Environment Agency procured studies which this is not.	Amber	Provide detailed commentary in the report on changes in results due to sensitivity tests. It would be useful to quantify the impact of the development in the sensitivity to various parameters, i.e. how the sensitivity to roughness changes with the addition of the development?	It is not considered appropriate to combined sensitivity testing with the assessment of impact of a development option therefore it is recommended that sensitivity testing discussion be limited to baseline only going forward.	Amber	Confidence limits for the model results, along with the modelling assumptions, have not been included in the modelling report. Please provide a commentary in the modelling report regarding the confidence limits of the modelling results as well as the assumptions used in the model.		



MODEL STABILITY

1D MODEL STABILITY												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
13.1	Errors/Comments/Warnings?	Amber	There are a number of warning related to different values for Manning's n encountered in same panel. There are also a large number of messages related to poor model convergence at BB01_1189LS, this is the spill unit into the diversion channel.	Add panel markers at changes in roughness in the 1D model to remove warning messages.	Panel markers have been added to the model to improve this	OK	The issue has been resolved.	<div>Cum ME (%) BBK_032_10m_FBRem_xx_xx_100yr19cc_MB2D</div>				
13.2	Convergence	Amber	The mass balance error in the Baseline 100-year +19% CC is 21.77%. In the proposed 10m span with no footbridge downstream model, the 100-year +19% CC mass balance error is -9.48% and in the 1,000-year +19% CC is -41.78%. This indicates the model has some stability issues.	The changes recommended through this review should be completed and a review of the 1D model stability carried out again.	Updated results provided which have addressed these issues. MB and 2DMB plots shown for ME% to the left showing they are within tolerance	OK	The ME is within the tolerance of +/-1%.	<div>Cum ME (%) BBK_032_10m_FBRem_xx_xx_100yr19cc_MB2D</div>				
13.3	Does a basic check of animations and graphed outputs give an indication of good model stability?	Amber	The animations and the graphs show some issues on the rising limb of both the Baseline and Proposed results, with fluctuations in the water levels noticed. This also indicates the model has stability issues.	The changes recommended through this review should be completed and a review of the 1D model stability carried out again.	Updated results provided which address these issues	OK	No major issue observed.					

2D MODEL STABILITY												
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (DATE)	RAG 3	3rd Review Comments	3rd Review Response (DATE)	RAG 4
14.1	Is mass balance within tolerable limits?	OK	All Baseline and Proposed models show a spike up in the mass balance error as the model wets up. However the error is within the ±1% bounds which indicates a healthy model after 5.5 hours of model simulation.					Simulation FINISHED				
14.2	Are CE and dV values relatively stable and remain so once the run has got going.	OK	Spot checks of the tif files show the CE and dV values are stable throughout the simulation.					TUFLOW 1D Negative Depths: 0 Classic 2D Negative Depths: 0 WARNINGS prior to simulation: 238 [0 not in _messages layer] WARNINGS during simulation: 0 [0 not in _messages layer] CHECKS prior to simulation: 4 [0 not in _messages layer] CHECKS during simulation: 0 [0 not in _messages layer]				
14.3	Errors/Comments/Warnings?	Amber	<p>There is a message which should be fixed, the CHECK 2099 - Ignored repeat application of boundary to 2D cell.</p> <p>The WARNING 1100 - Structure ditch_0649C crest/invert (8.079) is below bed (8.143) of primary upstream channel ditch_0733 also needs to be reviewed to check the schematisation is correct.</p>	<p>Review the locations of the CHECK 2099 messages and fix cells.</p> <p>Review the WARNING 1100 against the survey and fix or justify.</p>	<p>2099 error fixed by moving the spill HX line into an adjacent cell.</p> <p>The 1100 warning has been investigated but the ditch is modelled as per survey. The warnings merely highlighting there could be an error and it should be checked, having checked the data and schematisation is correct therefore these warnings remain (but with a justifiable reasoning)</p>	OK	The invert is correct as per survey.					
14.4	Negative Depths	Amber	<p>There are a large number of negative depths between 4 and 5 hours at ditch_0091, the downstream of the diversion channel. This indicates a stability issue at this location.</p> <p>No other negative depths.</p>	<p>Review ditch_0091 and surrounding sections or justify the negative depth messages.</p>	The model no longer contains negative depths	OK	No negative depth observed with the updated model.					
14.5	Does a basic check of animations and graphed outputs give an indication of good model stability?	Green	<p>The 2D results animations show good stability, nothing of concern noted,</p> <p>Note there are display issues with the animations due to the lack of water level lines which mean the channel is not displayed.</p> <p>There are no PO lines in the model this aim checking 2D results and calculation of the mass conservation through the model.</p>	<p>Add WLLs to display results in the channel.</p>	<p>Wlls have been added so that the watercourse is shown flooding</p>	OK	WLL have been included.					
14.6	2d extents and outputs	Green	The model does not output grids (as ascii files), this would aid in the review process.	<p>Output grids for depth, velocity and water levels.</p>	<p>Raw outputs are provided. There is no need to provide a full suite of outputs grids as they are not needed for the FRA which this model supports. Raw data has been provided so the reviewer can extract additional items if they wish.</p>	OK	Grids have been provided.					



AUDIT TRAIL											
AUDIT TRAIL											
Item No.	Item Checked	RAG 1	1st Review Comments	1st Review Actions	1st Review Response (DATE)	RAG 2	2nd Review Comments	2nd Review Response (April 2025)	RAG 3	3rd Review Comments	3rd Review Response (DATE)
17.1	Was a model run log provided?	Amber	No	Model log to be provided to see model history and decision making process	Model log created and provided	OK	Model log has been provided.				
17.2	Was a suitable file naming, structure & management system used?	OK	Yes, standard FMP and TUFLOW folder structure.								
17.3	Were check files provided?	OK	Provided for the Baseline 100-year +CC event and the Proposed a 10m bridge span with the downstream footbridge removal 100-year +CC scenarios only.								
17.4	Were comments provided within the model?	Green	No comments within the model to identify what has been updated / remained as is.	Add comments to the model to identify where updates have take place to aid the review process.	The updates are discussed in the associated reporting						
17.5	Was there good version control? Is the model history detailed where applicable?	Amber	Not detailed, so cannot comment. There is no version number for the model.	Model log to be provided to see model history and decision making process	Model log has been provided	OK	Model log with version updates has been provided.				
17.6	Were Errors / comments / warnings made available?	OK	Yes, the model results files for FM and log files for TUFLOW have been provided so checks of the messages could be completed.								
17.7	Was a technical overview of the model and its background provided	OK	Yes - technical overview and background info have been provided in the modelling report.								
17.8	Were notes on how the model operates under different flow conditions provided?	OK	Section 3 of the modelling report details the impacts of the baseline flooding and the inclusion of the bridge .								
17.9	Was an explicit statement of any concerns about the accuracy of the model or its ability to represent reality provided?	Red	There is no summary in the report of the modelling assumptions and limitations, this should be included.	Add an Assumptions and Limitations section to the Hydraulic Modelling Report.	This has been included in the reporting	OK	Assumptions and specifications have been included in section 4.2.				
18	Is there anything else missing or are there suggestions for additional information or clarification?	Amber	Twelve different scenarios have been run, but the reporting does not comment on many of them.	Add information on the results of all scenarios modelled to the report.	It is not common practice to report on options that are not taken forward, the reporting is to provide information of what is being proposed not an appraisal of options and outcomes therefore this is not supplied (it is not of any value). 100 and 1000 (both CC) year results for baseline and scheme are provided along with 100+CC sensitivity tests only	Amber	It is not clear which option is the final one for the proposed case scenario, please clarify that for example copm1 and comp2 results are not provided to review.XMDF files have not been provide, these would help in checking process	Comp 1 and Comp2 are redundant. Option model clearly set out in report and FRA.	Amber	XMDF results still have not been provided along with the FRA.	
18.1	Comment on the quality of the reports:	Red	The supplied memo is insufficient and lacks information about the location of the updates to the model etc.. A model report should include: an overview of model build including a model schematic, hydraulic roughness (including photographs) and representation of any defence networks or use of non-standard elements discussion of structures (including photographs and details of how they have been modelled) comment on model stability and measure taken to improve stability justification of any remaining errors and warning messages produced etc..	A model report detailing all relevant information should accompany the model.	The report has been updated to provide the sailient information required to support the update to the hydraulic model. The baseline hydraulic model was supplied by the Environment Agency.	Red	The report does not include full results and more details need to be added in term of assumptions made to model the structures.	Full results will be provided directly to interested parties negating the need to present tabularised tables of water levels. Long section plots to be produced following agreement on final model version.	Red	Full results have not been provided. Remains red.	
18.2	is a freeboard analysis necessary? If yes have you review the report? What are is the agreed freeboard?	N/A	Not applicable to this study								

8. WSP CORRESPONDENCE JULY 2025

RE: Completed review - Cambourne to Cambridge busway TWA Order [ENVPAC/1/EAN/00709]

From Higgins, Graham <[REDACTED]>

Date Tue 2025-07-29 12:20

To Alison Craggs <[REDACTED]>

Cc Jo M Baker <[REDACTED]>; Southon, Jack <[REDACTED]>; Giesler, Nick <[REDACTED]>; Haberfield, Stephanie <[REDACTED]>; UK - Cambourne to Cambridge <[REDACTED]>; George Fuhrmann <[REDACTED]>

 1 attachment (72 KB)

CtoC_FloodModellingandHydrology_2025 TN2_V1.0.docx;

Alison,

Thanks for the discussion with yourself and George last Friday.

Please find attached Modelling and Hydrology Technical note 2 in response to your latest review.

We look forward to discussing the issues further this Friday.

Regards

Graham

TECHNICAL NOTE

DATE:	29 July 2025	CONFIDENTIALITY:	Public
SUBJECT:	Modelling and Hydrology Technical note 2 July 2025		
PROJECT:	Cambridge to Cambourne TWOA	AUTHOR:	S Haberfield and J Southon
CHECKED:	S Willis	APPROVED:	S Willis

Introduction

This Technical Note (TN) has been prepared following receipt of updated model and hydrology review comments on 25/07/2025 from the Environment Agency. It seeks to address the comments provided via email and the supplied review documents “LIT 17617 - Cambourne to Cambridge Hydraulic Model Review_Arcadis_23072025” and “LIT 66039 - Flood Estimation Calculation Review Template_Cambourne_Arcadis_24072025”.

It should be considered an addendum to the Flood Estimation Handbook (FEH) Calculation Record prepared in 2022 and the previous Flood modelling report in response to the Environment Agency’s review of the hydrology calculated to support the Cambridge to Cambourne (CtoC) Transport and Works Act (TWOA) application.

Hydrology

The following comments are made

<i>EA comment from email</i>	Applicant Response
<i>Though it is appreciated that the planning process timescales have contributed to the current situation, EA guidance standards consider a 6 month timeframe is reasonable for transitioning to using new methods and data. Given that 3 years have now lapsed and the evidence presented is not considered to demonstrate that changes to the hydrology in the</i>	<p>The impact on flow estimates from changes in data availability and guidance are discussed below. These are not considered to be ‘significant’ because:</p> <ul style="list-style-type: none"> • they are all within the existing confidence bounds of the ReFH2 estimates used; • the same assumptions are present in the baseline and the ‘as proposed’ option and therefore the relative impact assessment to look at flood risk resulting from the proposed works is valid, and • a 300mm free board is included in the scheme design to account for uncertainty and therefore the absolute assessment to show the scheme will be flood free for its lifetime is valid. <p>As such the change in data availability and guidance are not material to the FRA, ES or acceptability of the scheme.</p> <p>Additionally, it is noted that a significant further update is proposed to Environment Agency hydrology guidance later this year. Guidance and data availability are not static, and we have shown that the changes to date do not materially impact on the conclusions of the assessment.</p> <p>A review of using more recent data has been undertaken and provided in “CtoC_FloodModellingandHydrology_2025 TN_V0.3” in May 2025. The review</p>

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<p><i>intervening time are not significant, several outstanding aspects (red and amber comments) remain that need to be addressed. Green comments throughout are also recommended to be addressed to align with best practice.</i></p>	<p>concluded that using the more recent data did not make a significant difference to the original hydrology.</p>
<p><i>Red Comments</i></p>	
<p><i>1. Use the FEH22 rainfall for ReFH2, as the results presented in the addendum note are considered to be significantly different to those previously generated using FEH13 rainfall (see items 1.1.2 and 2.5.5).</i></p>	<p>The results as presented in Technical Note 1 (CtoC_FloodModellingandHydrology_2025 TN_V0.3) which assesses the sensitivity to FEH13 to FEH22 rainfall show a 3% variance in the 1% AEP event. The difference in the 0.1% AEP event is 5%. The largest difference in any return period event is the 10% AEP event which shows a 15% sensitivity. The same flows are used in the baseline and proposed options for the impact assessment.</p> <p>The design event is the 1% AEP + 19% climate change. As shown in Table 4 of the Technical Note 1, these sensitivities are comfortably within the 68% and 95% confidence levels for the assessment.</p> <p>In addition, the scheme design includes 300mm for freeboard to account for uncertainty such as this. It is considered that the 300mm freeboard is sufficient to account for the 0.1% AEP event, which is equivalent to an increase in flows of 33% from the 1% +19%CC AEP event. This results in an increase less than 200mm.</p> <p>The proposed design and acceptability would not be impacted by the move from FEH13 to FEH22 rainfall therefore the impact on results should be viewed as non-significant.</p>

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2. Undertake a statistical method assessment using the latest software and datasets (see item 1.1.2).

The 2022 assessment concluded that ReFH2 flow estimates should be used in preference to Statistical Method estimates as ReFH2 provided more conservative (higher) peak flow estimates. A sensitivity test was undertaken on the downstream catchment (BB04) using the same pooling group configuration as the 2022 study but with the updated v13 National River Flow Archive Peak Flows dataset to see if this would materially change the flow estimates and therefore the conclusion as to the use of ReFH2 as the preferred method. Urbanisation was applied to the v13 dataset through URBEXT and the UAF as part of the sensitivity test. **Table 1** below shows the results of the sensitivity test using the updated v13 National River Flow Archive Peak Flows dataset. The additional three years of peak flow data has slightly increased the peak flows across all of the return periods, but the ReFH2 peak flows are still higher in comparison and therefore appropriate to use.

Table 1 – Comparison of peak flows between NRFA Peak flows v10 and v13

NRFA peak flows	Flood peak (m³/s) for the following return periods (in years)									
	2	5	10	20	30	50	75	100	200	1000
V10	2.38	3.64	4.51	5.41	5.96	6.70	7.33	7.79	8.99	12.30
V13	2.38	3.67	4.62	5.66	6.09	7.00	7.56	7.92	9.07	12.45

NRFA Peak flows v14 is expected to be released in September 2025.

3. Compare the updated ReFH2 and updated statistical method results, reconsidering the most appropriate overall method to use (see item 1.1.2).

As noted above – while the updated ReFH2 and Statistical flow estimates are slightly higher than their respective 2022 values (3% for the 1% AEP event) they are not materially different and the same conclusion from the 2022 study stands. The ReFH2 values remain the conservative values and therefore ReFH2 remains the preferred method for flow estimation for this study.

	Flood peak (m³/s) for the following return periods (in years)									
	2	5	10	20	30	50	75	100	200	1000
Stats estimates using NRFA peak	2.38	3.67	4.62	5.66	6.09	7.00	7.56	7.92	9.07	12.45

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	flows V13										
	ReFH2 estimates using FEH22 rainfall	3.27	4.68	5.63	6.58	7.16	7.93	8.59	9.11	10.61	16.36
<i>Amber Comments</i>											
<p><i>1. Consider urbanisation in each catchment and provide pooling group and growth curve fittings (item 4.3.1).</i></p>		<p>For the Stats estimates a single pooling group and growth curve have been applied to all catchments due to their size and hydrological similarities. The ReFH2 flows are more conservative than the Stats flows and were taken forward in the assessment. Amendments to the pooling groups and growth curve fittings are unlikely to change this approach.</p> <p>The sensitivity test using the updated v13 National River Flow Archive Peak Flows dataset also showed that the Stats peak flows remain comprehensively below the ReFH2 peak flows. The sensitivity test applied urbanisation to the v13 dataset through URBEXT and the UAF.</p>									
<p><i>2. Confirm rural ReFH2 flow estimates for relevant catchments (item 7.1.2).</i></p>		<p>The use of rural ReFH2 ignores all presence of urbanisation in the catchment and if this approach was to be used it would rightly be criticised for ignoring this element. Where catchments are predominantly rural the URBEXT2000 parameter has little impact on flows and so is equivalent, albeit slightly larger than the rural only flows. The use of urban flows for all catchments is considered appropriate. For the overall catchment (BB04) the 2 year rural peak flow is 3.19m³/s and the urban peak flow is 3.27 m³/s.</p>									
<p><i>3. Confirm ReFH2 flow estimates based on a critical storm duration across all catchments (items 7.3.2 and 7.3.4)."</i></p>		<p>As part of the 2025 sensitivity analysis a comparison between the 9hr and 15hr storm duration and applying these across all of the catchments was undertaken as these were the two critical storm durations.</p> <p>The results showed the peak water levels at the bridge are the same to 2 decimal places for both the 9hr storm duration and 15 hour storm duration for the FEH22 events and the 9hr storm duration for the FEH13 rainfall event.</p>									

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Hydraulic Model

<p>The model is currently not suitable for its intended use. As a minimum, all amber and red comments throughout must be addressed and it is recommended that green comments are addressed to ensure the model is in line with best practice.</p>	<p>Comments addressed individually below</p>
<p>Red Comments</p>	
<ul style="list-style-type: none"> • The HQ boundary needs to be applied at the left bank along the code layer, where glassing walling occurs. 	<p>Glass walling previously discussed in LIT17617 review section 7.2 (2d Model build) is now a green comment in the latest review; 3rd review comment states “Noted, thank you. Please amend the 2D code for future submissions.”</p> <p>No further action proposed based on justification provided for this point.</p> <p>Section 9.1 (2D boundary) highlights a small area of the downstream boundary where a small area of glass walling exists.</p> <p>The impact of the downstream boundary configuration is expected to have an extremely limited impact on model results at the site of interest (estimated to be on the scale of 0.001m or less) because</p> <ul style="list-style-type: none"> • The downstream boundary is a considerable distance downstream of the site of interest (over 750m) • There is a 2m difference in peak modelled water level between the site of interest and the downstream boundary. • There are significant weirs, online ponds and other restrictions between the site of interest and the downstream boundary. <p>Additionally, it is observed that because this is a feature of both the baseline and proposed models this will not have an impact on the outcome of the study and as such should not be a red comment. It is reasonable to</p>

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	flag as a green comment for action alongside any other planned future model updates where the 0.01% + CC AEP event results are required.
<p>• Please update the zpoints, as the zpoints on the banklines and 1d-cross sections do not match. Please review all the cross sections. Bank points for interpolates need to be updated as these are not applied for interpolates and in between.</p>	<p>There will always be uncertainty in bank top elevations when interpolating crest levels between surveyed cross section data. For the requirements of this study:</p> <ul style="list-style-type: none"> • If the elevations artificially raised by this process, this will have constrained flows within bank and resulted in a conservative peak water level estimate at the bridge. • If the elevations are elevations artificially lowered by this process but ground levels are consistent (which is the case here), then only one cell width of additional channel volume is included in the model which will have limited impact. • If the elevations are elevations artificially lowered by this process along the location of a defence (which is not the case here) then this could have an impact. <p>We suggest a sensitivity test to confirm the impact on using LIDAR only as the bank levels to resolve this query.</p> <p>On a separate note, the reviewer’s approach to checking the consistency of bank levels with the LIDAR is not appropriate. The reviewer has extracted elevations from the edge of all cells that have been adjusted to bank elevations. The model process applies a fixed width across a whole cell (in this instance 2mx2m). The LIDAR data is 1mx1m. There will therefore obviously be discrepancies between the model and LIDAR when using this approach to check a model, particularly near the banks of watercourses where sharp changes in elevations will occur.</p>
<p>• The commentary on local flood modelling in comparison to other data sources was not provided in the modelling report. Additionally, it is unclear whether the model results have been compared with the NaFRA2 model. Please</p>	<p>NAFRA2 results were published 3 months ago. The model was submitted for review before Narfa2 was released. Given the extensive time it has taken for the 3rd party model reviewer to return the review it is considered unreasonable to make a red comment on the basis of a lack of comparison with a dataset that was only released during the period of review (post submission)</p> <p>Comparisons of the modelled results with the published flood mapping available flood zones at the time of preparing the FRA.</p>

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<p>include a commentary in the modelling report discussing the modelling results in relation to the NaFRA2 data.</p>	<p>The FRA has been provided to the Environment Agency but it appears has not been provided to the 3rd party model reviewer hence this comment.</p> <p>It is reasonable to be a green comment in relation to the FRA to update commentary to include NAFRA2 should future revisions be required – however we note that NAFRA2 flood zones are present day flood risk and the focus of the flood modelling is on flood risk including climate change (19% increase) so they are not directly comparable.</p>																																													
<p>• The report does not include full results, and more details need to be added in term of assumptions made to model the structures.</p>	<p>Full results files have been provided with the model.</p> <p>Selected results in the area of interest are quoted in the FRA such as with the table below which shows peak modelled water level at the site of interest and at selected locations up and down stream.</p> <table><tr><th></th><th colspan="8">Peak water level (mAOD) 1:100 AEP event + climate change using 2022 flow</th></tr><tr><th></th><th>BB01_1 189</th><th>BB01_0 796</th><th>BB01_0 628</th><th>BB01_0 541</th><th>BB01_0 461</th><th>BB01_0 403</th><th>BB01_3 29</th><th>BB01_0 049</th></tr><tr><td>Chainage from proposed bridge</td><td>-648m (South of Gough Way estate)</td><td>-255m (north of Gough Way estate)</td><td>-87m</td><td>0m (location of proposed crossing)</td><td>+80m (Hershel Rd crossing in grounds of Clare Hall)</td><td>+138m (Sylvester Rd crossing)</td><td>+191m (Robinson College access road crossing)</td><td>+471m (Grange Rd crossing)</td></tr><tr><td>National Grid Reference</td><td>543270, 257741</td><td>543487, 258067</td><td>543560, 258219</td><td>543600, 258297</td><td>543623, 258360</td><td>543682, 258375</td><td>543753, 258367</td><td>544005, 258450</td></tr><tr><td>1% AEP + 19% climate change</td><td>10.103</td><td>9.416</td><td>9.361</td><td>9.374</td><td>9.373</td><td>9.346</td><td>9.196</td><td>7.722</td></tr></table> <p>It is not considered appropriate or necessary in a site specific FRA to list the model results for every node and interpolate in the model where selected results are representative and provide a clearer illustration of the risk of flooding to and from the development.</p>		Peak water level (mAOD) 1:100 AEP event + climate change using 2022 flow									BB01_1 189	BB01_0 796	BB01_0 628	BB01_0 541	BB01_0 461	BB01_0 403	BB01_3 29	BB01_0 049	Chainage from proposed bridge	-648m (South of Gough Way estate)	-255m (north of Gough Way estate)	-87m	0m (location of proposed crossing)	+80m (Hershel Rd crossing in grounds of Clare Hall)	+138m (Sylvester Rd crossing)	+191m (Robinson College access road crossing)	+471m (Grange Rd crossing)	National Grid Reference	543270, 257741	543487, 258067	543560, 258219	543600, 258297	543623, 258360	543682, 258375	543753, 258367	544005, 258450	1% AEP + 19% climate change	10.103	9.416	9.361	9.374	9.373	9.346	9.196	7.722
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	Similarly a full structures list is not considered to be a critical requirement when the representation of structures, other than where explicitly acknowledged as being amended by the scheme are unchanged between the baseline and the proposed model so the same assumptions and any potential limitations are consistent.
Amber Comments	
<ul style="list-style-type: none"> • Please provide a 1D/2D structure log with reference to the surveyed cross sections including naming convention. The structures log should also include the assumptions considered to model the structures and the spills, along with the justifications of the omitted structures from the model. Trash screens have been included in the model. However, it is not known how the dimensions of the trash screens have been considered. 	<p>As noted above a structures log / full structures list is not considered to be a crucial requirement for a site specific flood risk assessment.</p> <p>Assumptions listed within the existing reporting.</p> <p>Model representation is consistent between existing and as proposed option modelling other than in the ways described.</p>
<ul style="list-style-type: none"> • Please revisit the approach to model the 1d channel under Robinsons College Building. 	<p>This has been previously discussed and justified. It is noted that the channel / culvert under Robinsons College is approximately 190m downstream of the site of interest and notably downstream of the online pond and weir next to Robinson College. In the 1% AEP + 19% CC run there is an approximately 0.3m head loss in this vicinity due to the pond water level management structures and therefore the representation of flow under Robinson College building is not material to the site specific flood risk assessment.</p>

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<ul style="list-style-type: none"> Structures roughness sensitivity testing has not been applied correctly. Please revisit the structures roughness sensitivity testing and provide commentary in the modelling report. 	<p>Sensitivity test add to the confidence in the model results but are not used in the assessment of flood risk impact to the site or assessing the impact of flood risk on the site.</p> <p>The sensitivity testing provided shows the impact of an increase BB01_1464, BB01 0403, and BB01_0381) decrease in the Manning’s ‘n’ value on open channel sections and some structures. Three culverts in the model (BB01_1464, have not had their roughness value changed for stability reasons. The channel either site of theses structures and all other open channel have had their Mannings’ ‘n’ changed. This is considered a suitably robust assessment to indicate the sensitivity of the model to Manning’s ‘n’.</p>
<ul style="list-style-type: none"> Provide detailed commentary in the report on changes in results due to sensitivity tests. Please provide a commentary in the modelling report regarding the confidence limits of the modelling results as well as the assumptions used in the model. 	<p>300mm freeboard added to design event (1% AEP event + 19% climate change) to account for modelling uncertainty to address flood risk to scheme.</p> <p>Model confidence is the same for baseline and ‘as proposed’ scheme with focus on relative impact.</p> <p>Analysis and reporting is considered appropriate for the intended purpose of informing the scheme design and assessing the impact of the scheme.</p> <p>Assumptions included in existing reporting.</p>
<ul style="list-style-type: none"> X MDF results files have not been provided, these would help understand the hydraulic mechanism and will aid the reviewing process. 	<p>The following X MDF files were provided to the Environment Agency:</p> <p>May 2025</p> <p>BBK_032_10m_FBRem_xx_xx_100YR19C09SDFEH13</p> <p>BBK_032_10m_FBRem_xx_xx_100YR19C15SDFEH22</p> <p>BBK_032_10m_FBRem_xx_xx_100YR19C09SDFEH22</p> <p>BBK_032_10m_BSC_xx_xx_100YR19C09SDFEH12</p> <p>BBK_032_10m_BSC_xx_xx_100YR19C09SDFEH22</p> <p>BBK_032_10m_BSC_xx_xx_100YR19C15SDFEH22</p>



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9. ENVIRONMENT AGENCY CORRESPONDENCE AUGUST 2025

Cambourne to Cambridge busway TWAO - Environment Agency position

From Alison Craggs <[REDACTED]>
Date Fri 2025-08-08 12:24
To Southon, Jack <[REDACTED]>
Cc George Fuhrmann <[REDACTED]>; Jo M Baker
<[REDACTED]>; Higgins, Graham <[REDACTED]>

Hi Jack,

Following recent discussions, we can confirm that the Environment Agency considers the model used for the Cambourne to Cambridge busway acceptable for assessing flood risk in the area of interest. While there are some technical issues identified, including minor increases in flood depths in already inundated open fields, these do not appear to materially affect the flood risk evaluation. There are also modest reductions in flood depths in built-up areas downstream of the bridge. Post-development modelling will need to demonstrate that any increase in flood risk remains within the red line boundary of the application and, where possible, that the structure delivers an overall improvement in flood risk. It is important to note that although the model is suitable for supporting the TWA Order and Flood Risk Assessment, it would not meet internal Environment Agency standards for updating the flood map without addressing the issues highlighted in the review. However, for planning purposes it is acceptable and therefore we intend to withdraw our objection on flood risk grounds. We will write to the Inspector by 19th August with a detailed position.

Kind regards,

Alison Craggs

Sustainable Places Planning Specialist

East Anglia Area (West)

Environment Agency, Bromholme Lane, Bampton, Huntingdon, Cambs. PE28 4NE



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