Flood estimation report: Land at North West Bicester, Oxfordshire.

Introduction

This report template is a supporting document to the Environment Agency's Flood Estimation Guidelines. It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results. This document can be used for one site or multiple sites. If only one site is being assessed, analysts should remove superfluous rows from tables.

Guidance notes (in red text) are included throughout this document in column titles or above tables. These should be deleted before finalising the document. Where relevant, references to specific sections of the Flood Estimation Guidelines document are included to indicate where further useful information can be found.

Note: Column size / page layout can be adapted, where necessary, to best present relevant information, for example, maps do not need to be within the tables if they would be better as a separate page.

Contents

Approval

Note: This table can be amended / removed to suit the need of the organisation undertaking the assessment. A document revision history can be added after the approval table if required.

If a separate method statement stage is not undertaken add N/A to all cells for method statement and also for initial calculations preparation 'Amendments' column. If a separate method statement is generated, text in initial calculations preparation 'Amendments' could be, for example, 'Completion of calculations following method statement approval'. Revision rows are intended for studies where amendments may be required following application of flows to a hydraulic model which leads to estimates / approaches needing to be revisited, for example.

Revision stage	Analyst / Reviewer name & qualifications	Amendments	Date
Method statement preparation	Alejandro Marcotegui	Statistical and ReFH analysis NRFA peak dataset v10	02/05/2023
Method statement sign-off	Simon Mirrams	N/A	15/09/2023
Initial calculations preparation	Alejandro Marcotegui		15/09/2023

Initial calculations sign-off		N/A	
Calculations - Revision 1 preparation	Alejandro Marcotegui	EA first review comments	01/05/2024
Calculations - Revision 1 sign-off		N/A	
Calculations - Revision 2 preparation			N/A
Calculations - Revision 2 sign-off		N/A	

Abbreviations

AEP .... annual exceedance probability
AM .... Annual Maximum
AREA .... Catchment area (km^2)
BFI .... Base Flow Index
BFIHOST .... Base Flow Index derived using the HOST soil classification
CPRE .... Council for the Protection of Rural England
FARL .... FEH index of flood attenuation due to reservoirs and lakes
FEH .... Flood Estimation Handbook
FSR .... Flood Studies Report
HOST .... Hydrology of Soil Types
NRFA .... National River Flow Archive
OS .... Ordnance Survey
POT .... Peaks Over a Threshold
QMED .... Median Annual Flood (with return period 2 years)
ReFH .... Revitalised Flood Hydrograph method
ReFH2 .... Revitalised Flood Hydrograph 2 method
SAAR .... Standard Average Annual Rainfall (mm)
SPR .... Standard percentage runoff
SPRHOST .... Standard percentage runoff derived using the HOST soil classification
Tp(0) .... Time to peak of the instantaneous unit hydrograph
URBAN .... Flood Studies Report index of fractional urban extent
URBEXT1990 .... FEH index of fractional urban extent
URBEXT2000 .... Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH .... Windows Frequency Analysis Package – used for FEH statistical method

1 SUMMARY OF ASSESSMENT

1.1 Summary

This table provides a summary of the key information contained within the detailed assessment in the following sections. The aim of the table 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.

The aim of this table is to provide a summary so keep the text to one or two sentences for each point.

Catchment location	
Purpose of study and scope e.g. for scope just include whether it is simple, routine, moderate, difficult, very difficult	The purpose of this study is to assess the peak flows and design strom of the catchment located north west Bicester, the site is crossed by three ordinary watercourses and at its confluence crosses the Lords Lane (A4095) towards Bicester. Therefore, the calculation of adequate flows shojld help to determine the current flood risk at the development site and the possible mitigation options. The catchment complexity is considered as moderate.
Key catchment features e.g. permeable, urban, pumped, mined, reservoired	The catchment is mostly rural currently greenfield.
Flooding mechanisms e.g. fluvial, surface water, groundwater	The main flooding mechanisnt at this catchment is specifically fluvial for the three watercoruses and its confluence
Gauged / ungauged State if there are flow or level gauges and a very brief indication of quality if there are	According to the NRFA , the unnamed watercourse crossing the development site is an ungagged catchment. None of the three rivers has any gauge.
Final choice of method	The ReFH2 hydrographs has been fitted to the statistical analysis peak flows.
Key limitations / uncertainties in results	

1.2 Note on flood frequencies

The frequency of a flood can be quoted in terms of a return period, which is defined as the average time between years with at least one larger flood, or as an annual exceedance probability (AEP), which is the inverse of the return period.

Return periods are are output by the Flood Estimation Handbook (FEH) software and can be expressed more succinctly than AEP. However, AEP can be helpful when presenting results to members of the public who may associate the concept of return period with a regular occurrence rather than an average recurrence interval. Results tables in this document contain both return period and AEP titles; both rows can be retained or the relevant row can be retained and the other removed, depending on the requirement of the study.

The table below is provided to enable quick conversion between return periods and annual exceedance probabilities.

Annual exceedance probability (AEP) and related return period reference table

AEP (%)	50	20	10	5	3.33	2	1.33	1	0.5	0.1
AEP	0.5	0.2	0.1	0.05	0.033	0.02	0.0133	0.01	0.005	0.001
Return period (yrs)	2	5	10	20	30	50	75	100	200	1,000

2 METHOD STATEMENT

For all but simple or routine projects, establish a break-point in which the method statement is reviewed before work continues. This creates a valuable opportunity to agree on the intended approach and address any difficulties with availability of data or information from previous work.

2.1 Requirements for flood estimates

Overview 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 given as AEP (%) • Climate change allowances with reference to relevant guidance • Potential number of locations for flow estimation • The purpose of the document	The purpose of this study is to set the hydrology of the three watercourses crossing the site up to its confluence and at the downstream section at Bicester, to determine design storm events and peak flows for the hydraulic modelling. Catchment descriptors for the downstream and upstream sections has been acquire from the FEH portal and the subcatchmetns for each of the watercourse has been amended accordingly. Urban extension has been reviewed. The statistical analysis was used to determine peak flows and the ReFH2 h was used to determine peak flows for comparison and the use of the hydrograph to be fitted a the statistical peak flows. 1% AEP 1%AEP + 15%CC (Central), +25%CC (Higher) +49%CC (Upper) estimates and 0.1%AEP events have been calculated. The climate change allowances used are the ones determined for Cherwell and Ray Management Catchment peak river flow. 2080s Central 15%- Higher 25% and Upper 49%.
Project scope What is the complexity of the study – simple, routine, moderate, difficult, very difficult? What analyses need to be included within the study, for example: • Review of existing studies? • Rating reviews / updates? • Simple / detailed flood history review? • ReFH model parameter estimation? • Joint probability?	The complexity of the catchment is considered as moderate as is an upper section of the catchment and it is mostly rural area. The scope of this analysis si to ensure the correct peak flows and design storm to the model of the three watercoruses to determine the current flood risk fo the proposed development site. Other FSR have been studied in the presentation of this report the Land ad North West Bicester (Firethorn Developments Limited-Vectos 2021). Also the Langford Brook (Bicester) & Pingle-Back-Pure model (2010) was analysed for this report. Additionally a Preliminary Opinion Request was requested in February 2023 in order to asses the Model and Flood Study methodology and the request was rejected.

2.2 The catchment

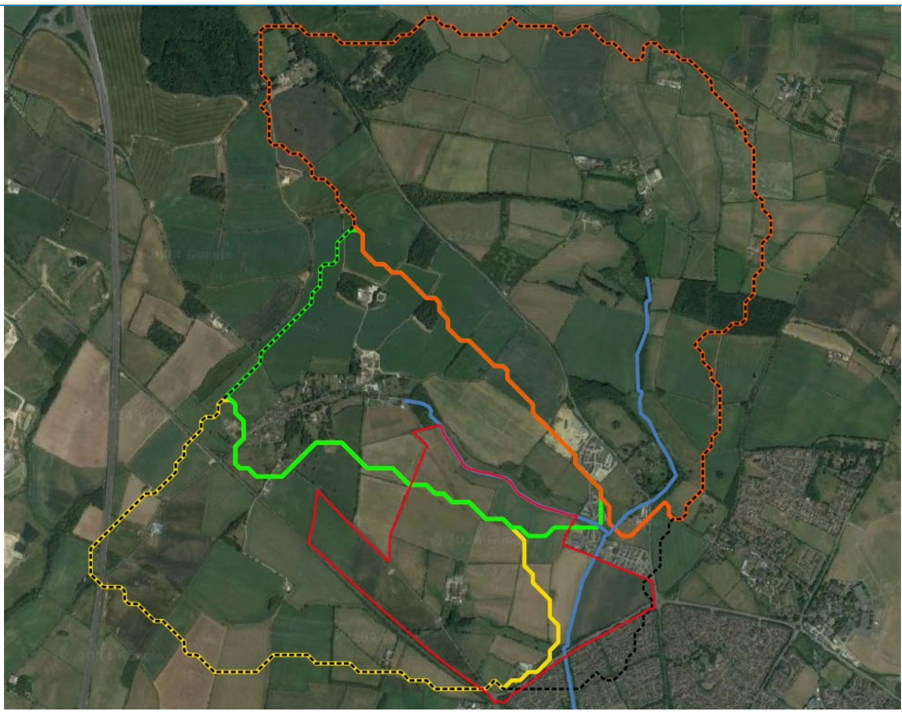
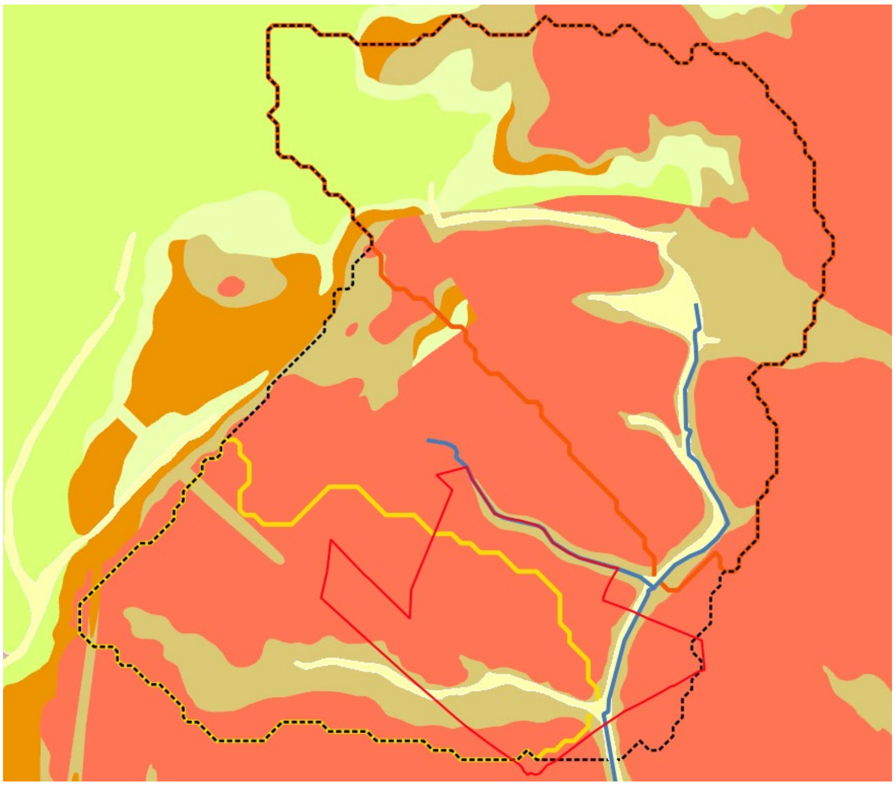
Include a map of the catchment in here, at a minimum showing the river network, catchment boundary and gauging stations, and appropriately labelled / referenced in a legend. Additional information which could be included is the model extent or locations of unusual / interesting features, for example. Think about the background mapping being used – scale and colour / greyscale – think about if the reader could easily identify locations from the background mapping.

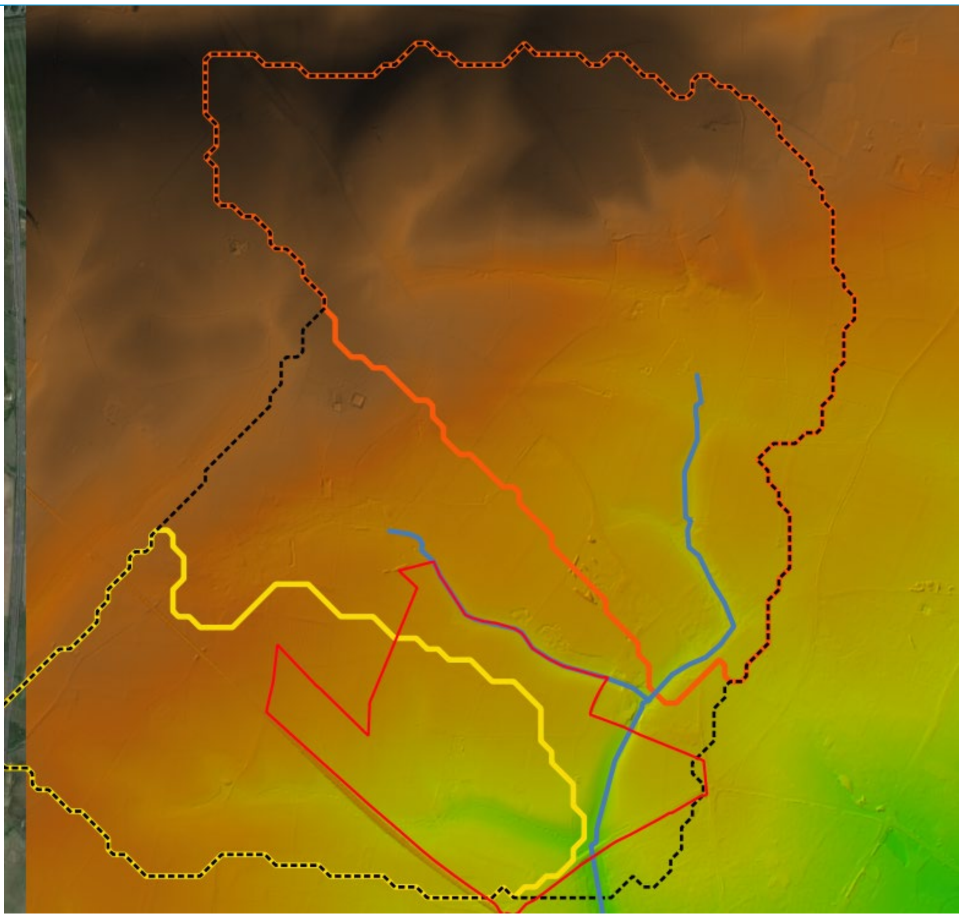
Include more than one map if that would assist in presenting the information, consider including maps using satellite imagery as background if that would better show key catchment features, and consider including photographs if they would help understanding of features identified in the 'Description' 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.

In many cases it will be best to present maps outside of this box. Consider changing the page orientation to landscape and the page size to A3 if necessary.

Description Include topography, climate, geology, soils, land use and	The three ordinary watercourse that cross the site are located within the FEH Catchment 457650, 224000 and drains a total area of 10.53km2.

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. Think about what features are going to affect runoff from the contributing catchment reaching the watercourse.	 The catchment is mostly rural with a URBEXT of 0.0077 for the entire catchment (0.13km2) The gelogy of the catchment it is almost entirely Cornbrash Formation (Limestone)-(pale red) with superficial geology of Alluvium depostins (sand, silt, and gravel) at the river margins (yellow). And Forest Marbe Formation. (brown) Parts fo the upper catchmnt section are White Limestone formation.  Topography the higher section of the catchment is located approximately at 115mAOD at the north west and the lower section approximately at 79mAOD after the crossing of the A4095 road.

2.3 Source of flood peak data

This should be updated to the latest version of the dataset at the time of the assessment.

Source	NRFA peak flows dataset, Version 11.1.1, released in March 2023. Winfap version 5.0.8181

2.4 Gauging stations (flow or level)

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.

Note: 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. It is useful to check this.

Water-course	Station name	Gauging authority number	NRFA number	Catchment area (km²)	Type (rated / ultrasonic / level…)	Start of record and end if station closed
n/a						

2.5 Data available at each flow gauging station in Table 2.4

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.

Station name	Start and end of NRFA flood peak record	Update for this study?	OK for QMED?	OK for pooling ?	Data quality check needed?	Other comments on station and flow data quality
n/a						
Tabulate any updated or revised flood peak series in the Annex and provide a link here. Any flood peak data not in the NRFA (e.g. extra stations, recent data or altered flows) should be provided here or in the Annex. Give link/reference to any further data quality checks carried out. Delete this row if not relevant.						

2.6 Rating equations

This table can be deleted if the catchment is ungauged or if all gauges are in the NRFA and a rating review is not requested in the project brief.

-More information on rating reviews is provided in Section 2.1 of the Flood Estimation Guidelines.

Station name	Type of rating e.g. theoretical, empirical; degree of extrapolation	Rating review needed?	Comments and link to any rating reviews
n/a			

2.7 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available?	Source of data	Details
Check flow gaugings (if planned to review ratings)				
Historical flood data Include chronology and interpretation of flood history in Annex or separate report. 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)	Two different FSR a vectos 2021 and EA 2010 has been review			Vectos study represents only a section of the entire catchment, however some of the assumptions has been analysed and expored. EA model upstream section represents the downstream section of this model therefore some the flow can be compared and adjusted accordingly.
Flow or river level data for events				
Rainfall data for events				
Potential evaporation data This may be required if the ReFH2 Calibration Utility is being used	n/a data not found			

Results from previous studies	Vectos and EA			The data has been analysed and adjusted accordingly
Other data or information (e.g. groundwater, tides, channel widths, low flow statistics, sewer network data)	n/a			

2.8 Hydrological understanding of catchment

This table can be deleted if the catchment is ungauged. The second table (conceptual model and unusual features) should not be deleted as this information is relevant for all catchments / studies.

The table below is an opportunity to assess any catchment river gauge data to provide an understanding of the hydrological behaviour of a watercourse. Examples of information which could be here are:

- Plots of flow data, for example, annual flow hydrographs or example flood events. This 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.
- Plots of stage data. 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.
- Plots of flood peak data. 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. An interpretation of these and other features should be provided. If there is more than one gauge in the study area, correlation plots can help to identify patterns or inconsistencies in the hydrological behaviour. Also consider adding other informative plots, for example, showing the seasonality of floods or the correlation of peak flows at different gauges.

More information is provided in Section 2 of the Flood Estimation Guidelines.

Add rows to the table if required and change titles in the left column if necessary.

Plots of flow data and interpretation	
Plots of flood peak data and interpretation	

Conceptual model Include information on factors such as: • Where are the main sites of interest? • What is likely to cause flooding at those locations? (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) • Might those locations flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? • Is there a need to consider temporary debris dams that could collapse?	The proposed development sites lies at the northwest of Bicester, after crossing the A4095 road, the three watercoruses flowing within the development, therefore the understanding of the fluvial flood characteristing and possible risk zones and flow constraints and junction it is paramount to reduce the flood risk anywhere else (third party land including Bicester) so the junction of each tributary is site of interest.
Unusual catchment features Include information on factors such as: • highly permeable • heavily urbanised • pumped watercourse • major reservoir influence (FARL<0.90) • flood storage areas, particularly those which are normally dry • historical mining or operational mining activities Guidance on methods for unusual catchments is contained in Section 7 of the Flood Estimation Guidelines	The catchment is not highly permeable and as is set previously is considered mostly rural, also there are not any reservoirs or flood strage areas within the are of study nor upstream section.

2.9 Initial choice of approach

Is FEH appropriate? (it may not be for extremely	Yes the FEH method is appropriate, as the catchmetn is

heavily urbanised or complex catchments). If not, describe other methods to be used.	mostly rural. Therefore the use of statistical data fitted to the ReFH2 hydrographs provide reliable results.
Initial choice of method(s) and reasons Think about: (i) the type of problem, (ii) the type of catchment, and (ii) 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? How will hydrograph shapes be derived if needed? e.g. ReFH1 / ReFH2 shapes, average hydrograph shape from gauge data Will the catchment be split into sub-catchments? If so, how? 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?	Statistical analysis Hydrograph and design storm provided by ReFH2 The catchmetn ahs been analysed against topographical contours and created the sub-catchments according to each drainage location. The design storm duration was analysed with ReFH hydrograph and it is considered that 13h storm produce reliable results. Various FEP has been obtained from the different sub-cathcments. FEH analysis is included within thispackage files at the ***Model\1D_FMP\FEH*** files, for each subacthment.
Software to be used (with version numbers) Delete entries in the column on the right as appropriate	FEH Web Service[1] / WINFAP 5[2] / ReFH spreadsheet / ReFH2.2 / Flood Modeller Pro 7.0

[1] CEH 2015. The Flood Estimation Handbook (FEH) Online Service, Centre for Ecology & Hydrology, Wallingford, UK.

[2] WINFAP 4 © Wallingford HydroSolutions Limited 2016.

3 LOCATIONS WHERE FLOOD ESTIMATES REQUIRED

Consider including a map here which shows the locations of flood estimate locations.

The table below lists the locations of subject sites. The site codes listed below are used in all subsequent tables to save space.

Include any intervening areas required for a distributed approach in here as these are necessary to reproduce results.

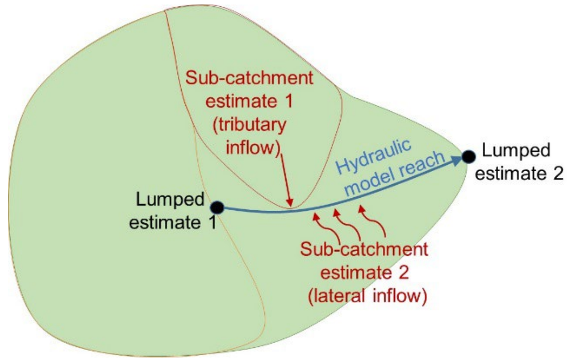
3.1 Summary of subject sites

Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA on FEH CD-ROM (km^2)	Revised AREA if altered
East	L	No name	Watercourse draining south collecting all other tributaries (upper section)	457900	224950	5.26	5.26
West	L	No name	Watercourse flowing east confluence before the crossing with A4095	57550	24250	2.79	2.79
North	L	No name	Flowing east confluence at the north section of the	57800	24950	1.89	1.89
Downstream	L	No name	All the subcatchments	457650	224000	10.53	10.53

Note: 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 semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced.

The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.



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

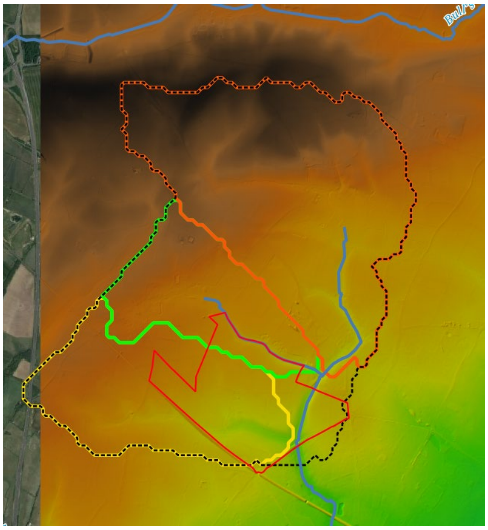
Consider using a different colour text / highlighting to identify catchment descriptors which have been changed from the FEH values.

Include any intervening areas required for a distributed approach in here as these are necessary to reproduce results.

Site code	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 1990 Delete if not required	URBEXT 2000	FPEXT
East	0.949	0.32	0.770	2.64	17.5	654		0.0062	0.0855
West	1.00	0.32	0.845	1.72	14.2	639		0.0040	0.0915
North	1.00	0.32	0.799	1.63	18.4	647		0.0241	0.0614
DS	0.974	0.32	0.857	2.94	16.7	647		0.0077	0.087

Site code	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	**URBEXT 1990** Delete if not required	URBEXT 2000	FPEXT

3.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes Add maps if needed to aid explanation of any changes If changes are made to the catchment boundary (and hence AREA), identify if any other descriptors will be updated and how	Catchmet boundaries have been checked against contours and none of then have been amended.  East (orange) North (green) West (yellow)
Record how other catchment descriptors were checked and describe any changes. Include before/after table if necessary.	No changes
Source of URBEXT Delete as needed. URBEXT1990 is only used for ReFH1 An alternative is the URBAN50k method if URBEXT values need to be substantially revised due to discrepancies between the FEH urban extent layers and current mapping	URBEXT2000 no changes **Box 6.1 Categories of catchment urbanisation** Six categories of catchment urbanisation are distinguished in the FEH, according to their URBEXT values. Essentially rural: 0.000 ≤ *URBEXT* < 0.025 Slightly urbanised: 0.025 ≤ *URBEXT* < 0.050 Moderately urbanised: 0.050 ≤ *URBEXT* < 0.125 Heavily urbanised: 0.125 ≤ *URBEXT* < 0.250 Very heavily urbanised: 0.250 ≤ *URBEXT* < 0.500 Extremely heavily urbanised: 0.500 ≤ *URBEXT* ≤ 1.000
Method for updating of URBEXT Delete as needed (CPRE formula from FEH Volume 4 is for URBEXT1990) An update to the current year is not required when the URBAN50k method is used as it will be implicitly accounted for in the latest mapping	CPRE formula from FEH Volume 4 / CPRE formula from 2006 CEH report on URBEXT2000 n/a

4 STATISTICAL METHOD

4.1 Application of Statistical method

What is the purpose of applying this method? Brief summary of the reasons, specific to this study, for applying the method. For example, lumped estimates at key locations for the purpose of checking modelled peak flow estimates.	All catchmetn analysed in this report are greater that 50ha, additionally the statistical analysis with provide better approach as will use pooling station of catchmetn with similatities as the studied in this report, therefore is expected to bring reliable results. Additionally the requirements of peak flows at the selected FEP can bring estimated parameters fo this study.

4.2 Overview of estimation of QMED at each subject site

If more than one donor is used, use multiple rows for the site and give the weights used in the averaging. Record the weighted average adjustment factor in the penultimate column.

The final estimate of QMED should include any relevant donor and urban adjustment. If QMED is derived directly from AMAX or POT data, an urban adjustment factor should not be applied as this is implicitly included in the estimate and would be double-counted.

Site code	QMED (rural) from CDs (m^3/s)	Final method	Data transfer					Urban adjust-ment factor UAF	Final estimate of QMED (m^3/s)
			NRFA numbers for donor sites used (see 4.3)	Distance between centroids d_{ij} (km)	Moderated QMED adjustment factor, $(A/B)^a$	If more than one donor			
						Weight	Weighted ave. adjustment		
DS	0.429	CD	39002	29				1.020	0.444
East									
North									
West									

Are the values of QMED spatially consistent?	
Method used for urban adjustment for subject and donor sites (delete method in the column to the right as needed)	Kjeldsen (2010)[3] / WINFAP v4[4]

Parameters used for WINFAP v4 urban adjustment if applicable (these are 'standard' values and should be revised if alternative values have been applied)		
Impervious fraction for built-up areas, IF	Percentage runoff for impervious surfaces, PR_{imp}	Method for calculating fractional urban cover, URBAN
0.3	70%	From updated URBEXT2000

Notes

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer (with urban adjustment); CD – Catchment descriptors alone (with urban adjustment); BCW – Catchment descriptors and bankfull channel width (add details); LF – Low flow statistics (add details).

The QMED adjustment factor A/B for each donor site is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial (rural) estimate from catchment descriptors.

Important note on urban adjustment

The method used to adjust QMED for urbanisation published in Kjeldsen (2010)[3] in which PRUAF is calculated from BFIHOST is not correctly applied in WINFAP-FEH v3.0.003. Significant differences occur only on urban catchments that are highly permeable. This is discussed in Wallingford HydroSolutions (2016)[4].

[3] Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. **41**. 391-405.

[4] Wallingford HydroSolutions (2016). WINFAP 4 Urban adjustment procedures.

4.3 Search for donor sites for QMED (if applicable)

Comment on potential donor sites Provide details regarding how potential donors were selected and the reasons why they were chosen / rejected. Include a map if necessary, which shows the location of the study catchment and donor stations under consideration. Section 4 of the Flood Estimation Guidelines provides guidance on selecting a donor(s) for data transfer.	

4.4 Donor sites chosen and QMED adjustment factors

When QMED is estimated from POT data, it should also be adjusted for climatic variation; this is not the same as climate change. Climatic variability can result in flood-rich or flood-poor periods. A short record might only include flood-rich years or flood-poor years, this will distort the QMED estimate. FEH Volume 3, Chapter 20, provides the methodology to adjust QMED for climatic variation. It is recommended that this carried out if the station record is shorter than 14 years.

QMED from catchment descriptors is the 'as rural' value (for rural donors), i.e. with no urban adjustment factor applied.

The adjustment ratio is the adjustment in full, with no distance factor applied.

NRFA no.	Method (AM or POT)	Adjustment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjustment ratio (A/B)
39002	AM	NO			

4.5 Derivation of pooling groups

Try to use as few groups as possible, this avoids step changes in flow estimates between flow estimation points for catchment-wide studies. If all catchments being assessed have AREA <25km^2 and similar SAAR, FARL and FPEXT values, normally use one group.

Section 4.3 of the Flood Estimation Guidelines provides further details on reviewing pooling groups.

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged? (enhanced single site analysis)	Changes made to default pooling group, with reasons (if there are no changes just say "None", although it is helpful to provide details of stations which were investigated even if they were ultimately retained)	Weighted average L-moments L-CV and L-skew, (before urban adjustment)
DS	7011	no	Low data ~9yr	0.491-0.521
DS	26013		Low data @11yr	0.281-0.196
Note: Pooling groups were derived using the procedures from Science Report SC050050 (2008).				

4.6 Derivation of flood growth curves at subject sites

Any relevant frequency plots from WINFAP, 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.

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.

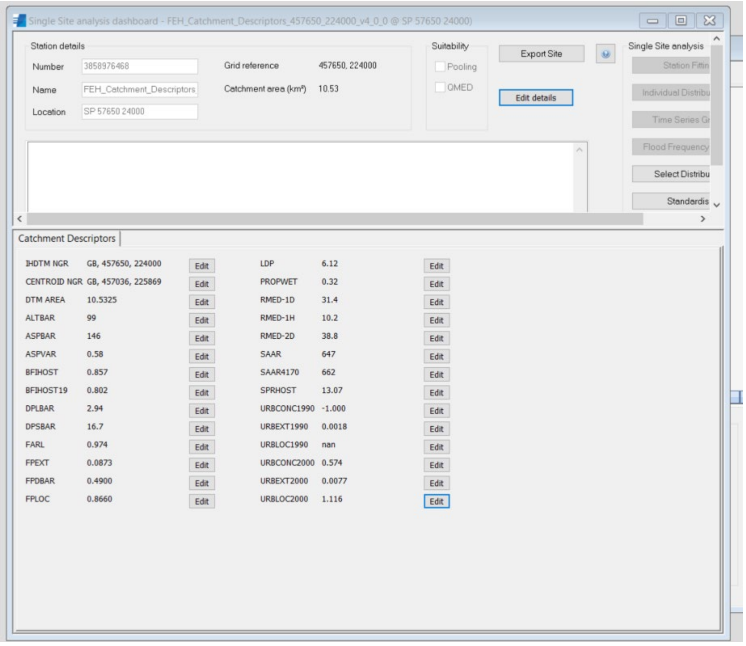
For single-site analysis on a permeable catchment, or a pooled analysis for a group consisting largely of permeable catchments, a permeable adjustment should be applied to the growth curve using the technique described in the FEH Volume 3, Chapter 19 for removing flood-free years by adjusting the L-moments.

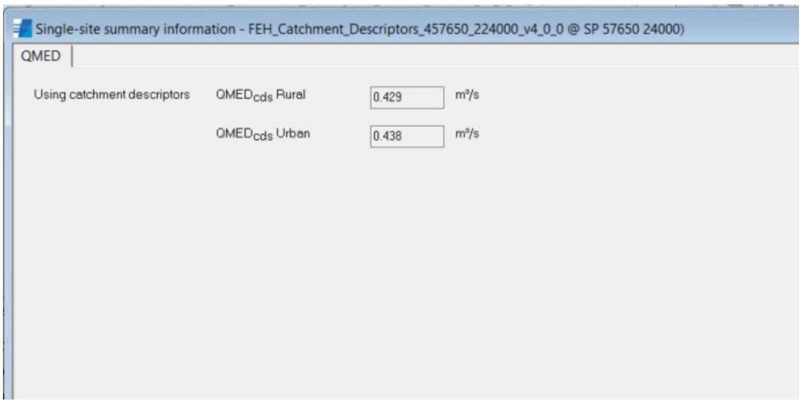
Site code	Method (SS, P, ESS, J)	If P, ESS or J, name of pooling group	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Parameters of distribution (location, scale and shape after adjustments)	Growth factor for 100-year return period / 1% AEP (delete as needed)
27073	P	DS only	GL	-		DS-RURAL 3.060
26016	P		GL	-		DS URBAN 3.056
25019	P		GL	-		
36010	P		GL	-		
27051	P		GL	-		
26014	P		GL	-		
39033	P		GL	-		
33054	P		GL	-		
36004	P		GL	-		
24007	P		GL	-		
27010	P		GL	-		
41020	P		GL	-		
33032	P		GL	-		
53017	P		GL	-		
9006	P		GL	-		

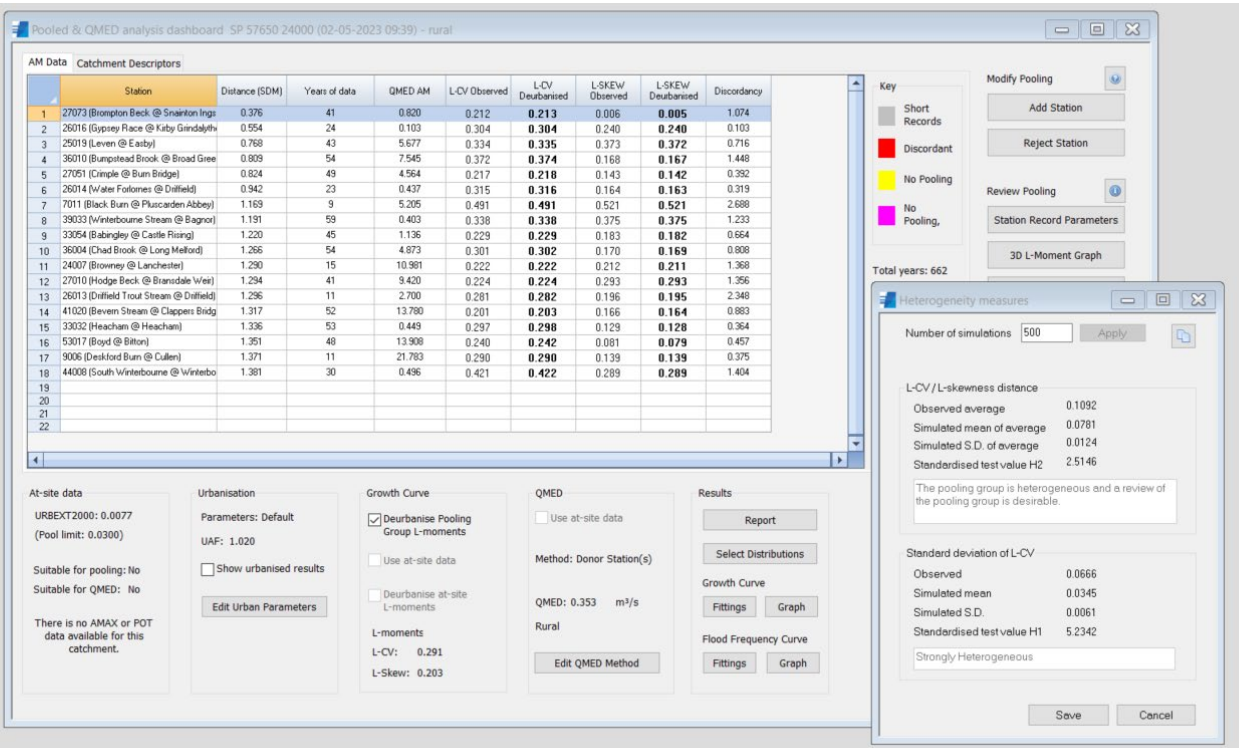
Notes
Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis
Urban adjustments are all carried out using the method of Kjeldsen (2010).
Growth curves were derived using the procedures from Science Report SC050050 (2008).

4.7 Flood estimates from the statistical method

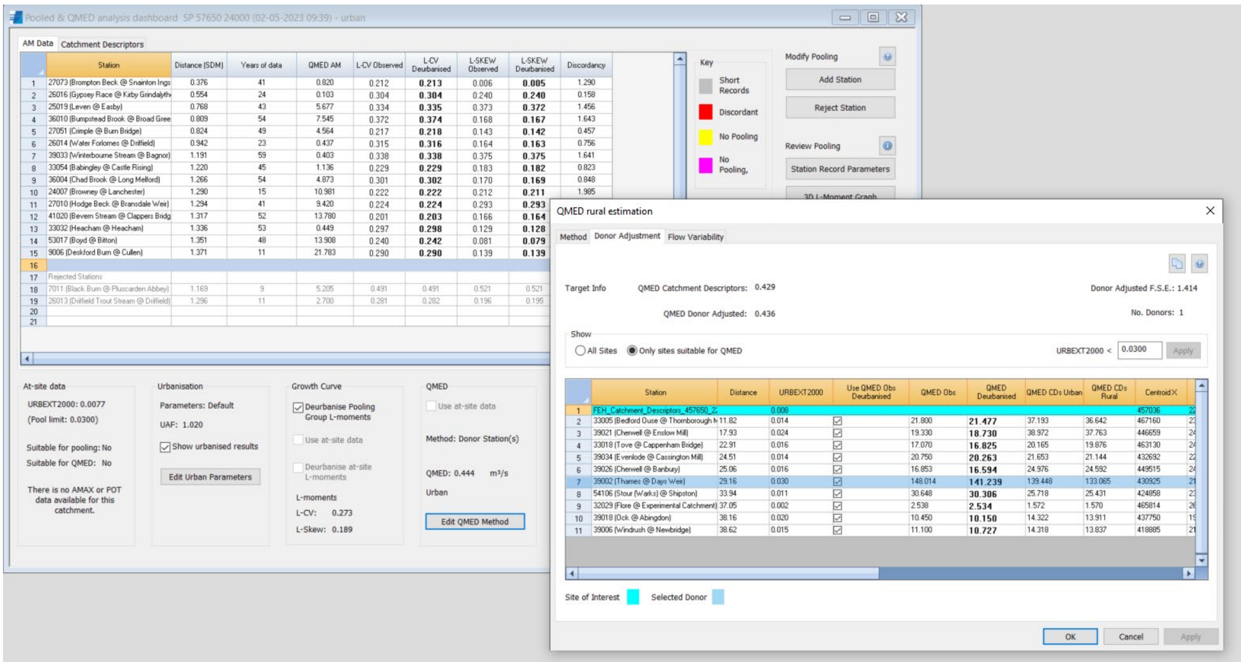
Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	5	10	20	25	30	50	100	500	1000
	Flood peak (m^3/s) for the following AEP (%) events									
DS urban	0.444	0.642	0.784	0.936	0.988	1.03	1.16	1.36	1.92	2.22
East								0.754		1.667
North								0.414		0.799
West								0.244		0.541

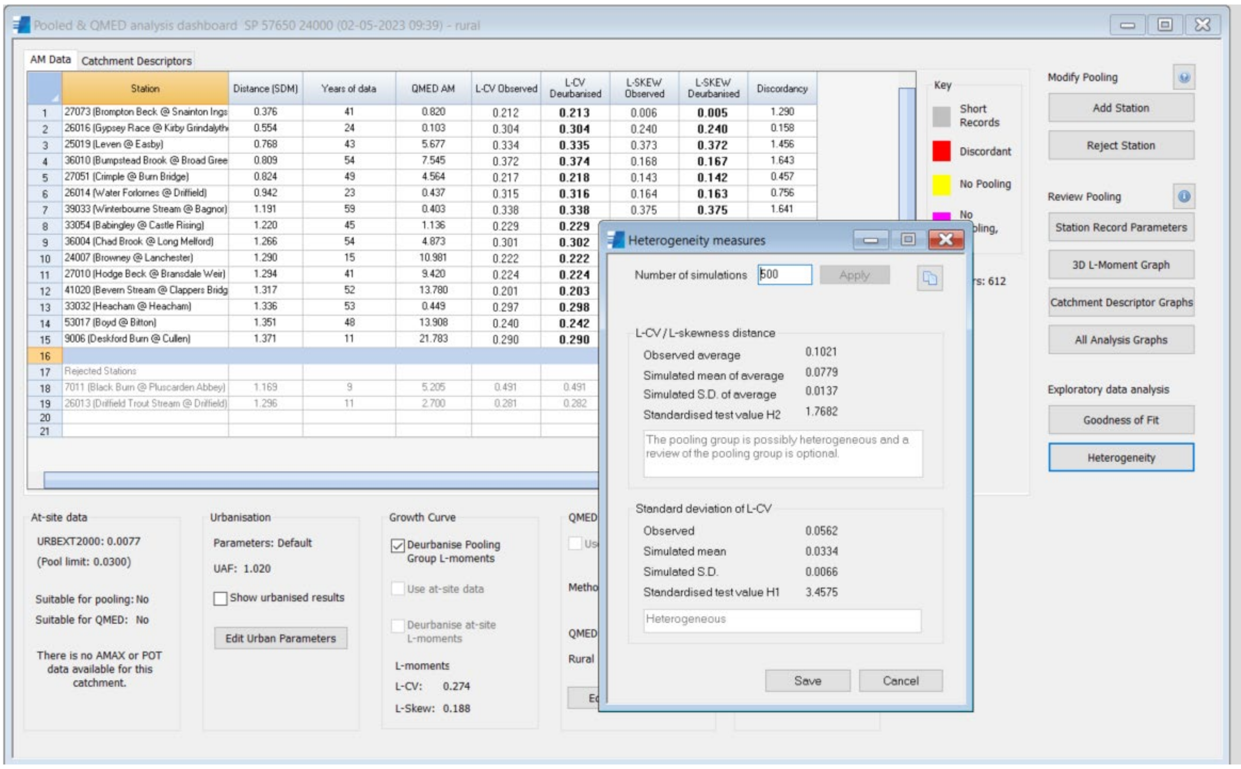

Single Site analysis dashboard - FEH_Catchment_Descriptors_457650_224000_v4_0_0 @ SP 57650 24000)
Station details
Number 3858976468
Name FEH_Catchment_Descriptors
Location SP 57650 24000
Grid reference 457650, 224000
Catchment area (km²) 10.53
Suitability
Pooling
QMED
Export Site
Edit details
Single Site analysis
Catchment Descriptors
IHDTM NGR GB, 457650, 224000
CENTROID NGR GB, 457036, 225869
DTM AREA 10.5325
ALTBAR 99
ASPBAR 146
ASPVAR 0.58
BFIHOST 0.857
BFIHOST19 0.802
DPLBAR 2.94
DPSBAR 16.7
FARL 0.974
FPEXT 0.0873
FPDBAR 0.4900
FPLOC 0.8660
LDP 6.12
PROPWET 0.32
RMED-1D 31.4
RMED-1H 10.2
RMED-2D 38.8
SAAR 647
SAAR4170 662
SPRHOST 13.07
URBCONC1990 -1.000
URBEXT1990 0.0018
URBLOC1990 nan
URBCONC2000 0.574
URBEXT2000 0.0077
URBLOC2000 1.116


Single-site summary information - FEH_Catchment_Descriptors_457650_224000_v4_0_0 @ SP 57650 24000)
QMED
Using catchment descriptors
QMEDcds Rural 0.429 m³/s
QMEDcds Urban 0.438 m³/s


Pooled & QMED analysis dashboard SP 57650 24000 (02-05-2023 09:39) - rural
AM Data
Catchment Descriptors
Station | Distance (SDM) | Years of data | QMED AM | L-CV Observed | L-CV Deurbanised | L-SKEW Observed | L-SKEW Deurbanised | Discordancy
1 27073 (Brompton Beck @ Snainton Ings 0.376 41 0.820 0.212 0.213 0.006 0.005 1.074
2 26016 (Gypsey Race @ Kirby Grindalyth 0.554 24 0.103 0.304 0.304 0.240 0.240 0.103
3 25019 (Leven @ Easby) 0.768 43 5.677 0.334 0.335 0.373 0.372 0.716
4 36010 (Bumpstead Brook @ Broad Gree 0.809 54 7.545 0.372 0.374 0.168 0.167 1.448
5 27051 (Crimple @ Burn Bridge) 0.824 49 4.564 0.217 0.218 0.143 0.142 0.392
6 26014 (Water Forlornes @ Driffield) 0.942 23 0.437 0.315 0.316 0.164 0.163 0.319
7 7011 (Black Burn @ Pluscarden Abbey) 1.169 9 5.205 0.491 0.491 0.521 0.521 2.688
8 39033 (Winterbourne Stream @ Bagnor) 1.191 59 0.403 0.338 0.338 0.375 0.375 1.233
9 33054 (Babingley @ Castle Rising) 1.220 45 1.136 0.229 0.229 0.183 0.182 0.664
10 36004 (Chad Brook @ Long Melford) 1.266 54 4.873 0.301 0.302 0.170 0.169 0.808
11 24007 (Browney @ Lanchester) 1.290 15 10.981 0.222 0.222 0.212 0.211 1.368
12 27010 (Hodge Beck @ Bransdale Weir) 1.294 41 9.420 0.224 0.224 0.293 0.293 1.356
13 26013 (Driffield Trout Stream @ Driffield) 1.296 11 2.700 0.281 0.282 0.196 0.195 2.348
14 41020 (Bevern Stream @ Clappers Bridg 1.317 52 13.780 0.201 0.203 0.166 0.164 0.883
15 33032 (Heacham @ Heacham) 1.336 53 0.449 0.297 0.298 0.129 0.128 0.364
16 53017 (Boyd @ Bitton) 1.351 48 13.908 0.240 0.242 0.081 0.079 0.457
17 9006 (Deskford Burn @ Cullen) 1.371 11 21.783 0.290 0.290 0.139 0.139 0.375
18 44008 (South Winterbourne @ Winterbo 1.381 30 0.496 0.421 0.422 0.289 0.289 1.404
Key
Short Records
Discordant
No Pooling
No Pooling,
Total years: 662
Modify Pooling
Add Station
Reject Station
Review Pooling
Station Record Parameters
3D L-Moment Graph
At-site data
URBEXT2000: 0.0077
(Pool limit: 0.0300)
Suitable for pooling: No
Suitable for QMED: No
There is no AMAX or POT data available for this catchment.
Urbanisation
Parameters: Default
UAF: 1.020
Show urbanised results
Edit Urban Parameters
Growth Curve
Deurbanise Pooling Group L-moments
Use at-site data
Deurbanise at-site L-moments
L-moments
L-CV: 0.291
L-Skew: 0.203
QMED
Use at-site data
Method: Donor Station(s)
QMED: 0.353 m³/s
Rural
Edit QMED Method
Results
Report
Select Distributions
Growth Curve
Fittings
Graph
Flood Frequency Curve
Fittings
Graph
Heterogeneity measures
Number of simulations 500
Apply
L-CV / L-skewness distance
Observed average 0.1092
Simulated mean of average 0.0781
Simulated S.D. of average 0.0124
Standardised test value H2 2.5146
The pooling group is heterogeneous and a review of the pooling group is desirable.
Standard deviation of L-CV
Observed 0.0666
Simulated mean 0.0345
Simulated S.D. 0.0061
Standardised test value H1 5.2342
Strongly Heterogeneous
Save
Cancel

1.1


Pooled & QMED analysis dashboard SP 57650 24000 (02-05-2023 09:39) - urban
AM Data
Catchment Descriptors
Key
Short Records
Discordant
No Pooling
No Pooling.
Modify Pooling
Add Station
Reject Station
Review Pooling
Station Record Parameters
QMED rural estimation
Method
Donor Adjustment
Flow Variability
Target Info
QMED Catchment Descriptors: 0.429
QMED Donor Adjusted: 0.436
Donor Adjusted F.S.E.: 1.414
No. Donors: 1
Show
All Sites
Only sites suitable for QMED
URBEXT2000 <
Apply
Site of Interest
Selected Donor
OK
Cancel
At-site data
URBEXT2000: 0.0077
(Pool limit: 0.0300)
Suitable for pooling: No
Suitable for QMED: No
There is no AMAX or POT data available for this catchment.
Urbanisation
Parameters: Default
UAF: 1.020
Show urbanised results
Edit Urban Parameters
Growth Curve
Deurbanise Pooling Group L-moments
Use at-site data
Deurbanise at-site L-moments
L-moments
L-CV: 0.273
L-Skew: 0.189
QMED
Use at-site data
Method: Donor Station(s)
QMED: 0.444 m³/s
Urban
Edit QMED Method


Pooled & QMED analysis dashboard SP 57650 24000 (02-05-2023 09:39) - rural
AM Data
Catchment Descriptors
Key
Short Records
Discordant
No Pooling
Modify Pooling
Add Station
Reject Station
Review Pooling
Station Record Parameters
3D L-Moment Graph
Catchment Descriptor Graphs
All Analysis Graphs
Exploratory data analysis
Goodness of Fit
Heterogeneity
Heterogeneity measures
Number of simulations 500
Apply
L-CV / L-skewness distance
Observed average 0.1021
Simulated mean of average 0.0779
Simulated S.D. of average 0.0137
Standardised test value H2 1.7682
The pooling group is possibly heterogeneous and a review of the pooling group is optional.
Standard deviation of L-CV
Observed 0.0562
Simulated mean 0.0334
Simulated S.D. 0.0066
Standardised test value H1 3.4575
Heterogeneous
Save
Cancel
At-site data
URBEXT2000: 0.0077
(Pool limit: 0.0300)
Suitable for pooling: No
Suitable for QMED: No
There is no AMAX or POT data available for this catchment.
Urbanisation
Parameters: Default
UAF: 1.020
Show urbanised results
Edit Urban Parameters
Growth Curve
Deurbanise Pooling Group L-moments
Use at-site data
Deurbanise at-site L-moments
L-moments
L-CV: 0.274
L-Skew: 0.188
QMED
Rural

5 REVITALISED FLOOD HYDROGRAPH (REFH) METHOD

5.1 Application of ReFH method

What is the purpose of applying this method? Brief summary of the reasons, specific to this study, for applying the method. For example, lumped estimates at key locations for the purpose of checking modelled peak flow estimates, distributed approach to apply inflows to a hydraulic model, deriving hydrograph shapes only, extending the flood frequency curve out to extreme events (long return periods).	

5.2 Catchment sub-divisions for urban ReFH model

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.

5.3 Parameters for ReFH model (rural catchments)

Lumped and sub-catchment / intervening areas should be included in this table.

Site code	Method	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
East	ReFH2	4.93	906.57	56.43	2.08
North	ReFH2	3.68	1013.7	52.43	2.21
West	ReFH2	4.12	1314.39	56.77	2.51
DS	ReFH2	5.32	906.57	57.77	3.138
Brief description of any flood event analysis carried out (further details should be given in the annex)		All catchment ahas been adjusted to the same design storm.			
Methods: OPT: Optimisation, BR: Baseflow recession fitting, CD: Catchment descriptors, DT: Data transfer (give details)					

5.4 Parameters for ReFH model (urban or mixed urban & rural catchments)

Lumped and sub-catchment / intervening areas should be included in this table.

If applying the method in Flood Modeller Pro, Tp_{urban} values are not directly specified by the user; the model works them out from the supplied URBEXT, DPLBAR, etc. It is simpler just to report Tp rather than separate URBEXT, etc, values for rural and urban portions.

Note: ReFH is also implemented in InfoWorks ICM which does not include the urban component.

Site code	Method	Tp_{rural} (hours)	Tp_{urban} (hours)	C_{max} (mm)	PR_{imp} % runoff for impermeable surfaces	BL (hours)	BR

5.5 Design events for ReFH method: Lumped catchments

This table can be deleted if ReFH is not being applied for lumped catchments. Note: ReFH may be applied for both lumped catchments and sub-catchments in a study; if this is the case both this table and the next should be completed.

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 for comparison with Statistical estimates.

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)
DS	urban	winter	13hr

5.6 Design events for ReFH method: Sub-catchments and intervening areas

This table can be deleted if ReFH 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 model 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 ensure that the results are included in the last row of this table when the testing is complete, 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.

Site code	Season of design event	Storm duration (hours)	Storm area for ARF (if not catchment area)	Reason for selecting storm
All	winter	13	0.966	Maximum peak flow
All				
All				
Results of storm duration testing. This row can be deleted if storm duration testing is not being undertaken.				

5.7 Flood estimates from the ReFH method: lumped catchments

Note: This table is for recording results for lumped catchments. There is no need to record peak flows from sub-catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system.

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	Flood peak (m^3/s) for the following AEP (%) events									

6 REVITALISED FLOOD HYDROGRAPH 2 (REFH2) METHOD

6.1 Application of ReFH2 method

What is the purpose of applying this method? Brief summary of the reasons, specific to this study, for applying the method. For example, lumped estimates at key locations for the purpose of checking modelled peak flow estimates, distributed approach to apply inflows to a hydraulic model, deriving hydrograph shapes only, extending the flood frequency curve out to extreme events (long return periods).	The ReFH method is usually provided good approach for small catchments, when the cathcmetn is more complex and bigger the use of statistical analysis ofr the different subcatchments is preferrable due to the use of large datasets of hydrometric stations that drain catchments with similar characteristics aas the studied in this project. Therefore, the statistical provide robust results for this analysis.However, the ReFH2 will provide suitable design storm and hydrograph for the hydraulic modelling. For the purpose of this study the downstream FEP is used and Area Reduction Factor ARF for te flows has been selected.

6.2 Catchment sub-divisions for ReFH2 model

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.

6.3 Parameters for ReFH2 model

Lumped and sub-catchment / intervening areas should be included in this table.

Note: The lower limit of Tp_{rural} is 1.0hr; Tp_{urban} can drop below this.

Note: ReFH2 is also implemented in InfoWorks ICM which does not include the urban component.

Site code	Method	Tp_{rural} (hours)	Tp_{urban} (hours)	C_{max} (mm)	PR_{imp} % runoff for impermeable surfaces	BL (hours)	BR
East	ReFH2			906.57		56.43	2.08
North	ReFH2			1013.7		52.43	2.21
West	ReFH2			1314.39		56.77	2.51
DS	ReFH2	5.322	3.99	906.57		57.77	3.138
Brief description of any flood event analysis carried out (further details should be given in the annex)							
Methods: OPT: Optimisation, BR: Baseflow recession fitting, CD: Catchment descriptors, DT: Data transfer (give details)							

6.4 Design events for ReFH2 method: Lumped catchments

This table can be deleted if ReFH2 is not being applied for lumped catchments. Note: ReFH2 may be applied for both lumped catchments and sub-catchments in a study; if this is the case both this table and the next should be completed.

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 for comparison with Statistical estimates.

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)
DS	urban	winter	13
East	urban	winter	
North	urban	winter	
West	urban	winter	

6.5 Design events for ReFH2 method: Sub-catchments and intervening areas

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 model 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 ensure that the results are included in the last row of this table when the testing is complete, 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.

Site code	Season of design event	Storm duration (hours)	Storm area for ARF (if not catchment area)	Reason for selecting storm
All	winter	13	0.966	Major peak flow
All				
All				
Results of storm duration testing. This row can be deleted if storm duration testing is not being undertaken.		The 13hr event bring maximum peak flow, however the peak will be adjusted for the Statistical analysis.		

6.6 Flood estimates from the ReFH2 method

Note: This table is for recording results for lumped catchments. There is no need to record peak flows from sub-catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system.

Site code	Flood peak (m^3/s) for the following return periods (in years)									
	2	5	10	30	50	100	200	1000		
	Flood peak (m^3/s) for the following AEP (%) events									
East	0.286	0.399	0.483	0.631	0.712	0.839	0.992	1.484		
North	0.105	0.148	0.181	0.238	0.269	0.317	0.375	0.532		
West	0.090	0.129	0.158	0.210	0.239	0.284	0.338	0.517		
DS	0.527	0.745	0.906	1.195	1.351	1.598	1.895	2.852		

7 DISCUSSION AND SUMMARY OF RESULTS

7.1 Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method at example sites for two key return periods / AEP events. Delete columns which are not required.

Site code	Ratio of peak flow to FEH Statistical peak					
	Return period 2 years / 50% AEP			Return period 100 years / 1% AEP		
	ReFH	ReFH2	Statistical	ReFH	ReFH2	Statistical
East		0.286			0.839	
North		0.105			0.317	
West		0.090			0.284	
DS		0.527	0.444		1.598	1.36

7.2 Final choice of method

Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	The statistical mothos is considered more reliable. However the EA model adjut the parameters at the downstream section, therefore such adjustement will be considered to bring more conservative results at the model
How will the flows be applied to a hydraulic model? If relevant. Will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	Statistical analysis with EA adjustment fitted at the ReFH hydrographs

7.3 Assumptions, limitations and uncertainty

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.

List the main assumptions made (specific to this study)	For the purpose of this study the DS flow with EA adjustment (conservative approach) and ARF for al the subsequent catchments to bring reliable results to the model
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.	The lack of gauge catchment limitate the possibility of sense check the flow records fo the catchment, however the analysis provided in this report and further FSR provide a robust analysis of the catchment including sensitivity analysis considering downstream water levels and flows.
Provide information on the uncertainty in the design peak flow estimates and the methodology used Uncertainty in the peak flow estimates should always be provided. The default is the 95-percentile upper and lower bounds, but other estimates may need to be provided depending on the requirements of the study. Further information can be found in Section 5.4 of the Flood Estimation Guidelines.	The entire flow peak for the North and West sub -catchmetn has been applied to the upper section of the watercourse in order to provide ston reliable results and accurate flow volumes. Confidence intervals 95% is used in this analysis.
Comment on the suitability of the results for future studies, e.g. at	

nearby locations or for different purposes, would a project for scheme design require additional detail, etc.	
Give any other comments on the study, e.g. suggestions for additional work, such as flow monitoring, rating reviews, etc.	

7.4 Checks

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.

Are the results consistent, for example at confluences? This will not be relevant for a study where there is only a single flow estimation point.	Yes the areas have been calculated with topographic contours and the flow properly calculated with ARF.
What do the results imply regarding the return periods / frequency of floods during the period of record? This will only be relevant where there is flow gauge data.	No gauge is located within this studied catchment
What is the range of 100-year / 1% AEP growth factors? Is this realistic?	DS 3.06 growth factor and yes it is realistic
If 1000-year / 0.1% AEP flows have been derived, what is the range of ratios for 1000-year / 0.1% AEP flow over 100-year / 1% AEP flow?	DS 2.22/1.36=1.63 DS EA factor 6.504/3.53=1.84
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred. This will not be relevant if there are no previous hydrological assessments.	
Are the results compatible with the longer-term flood history? This will not be relevant if there is no flow gauge data or historical flooding information.	There is no gauge data for the catchment.the modelled flood extent are consistent with hidtorical flood images .
Describe any other checks on the results, e.g. sense-checking hydraulic model results	Sensitivity analysis including robust downstream variations are applied to the flood analysis and model.

7.5 Final results

Show the final results here for all flow estimation points (unless using a distributed approach, with no lumped catchment flow estimation points, and allowing the hydraulic model to route the flows) and design events, and give any other data or results needed for the next stage of the study.

Site code	Flood peak (m³/s) or volumes (m³) for the following return periods (in years)									
			100	**+15% CC**	**+25% CC**	**+49% CC**	**1000**			
	Flood peak (m³/s) or volumes (m³) for the following AEP (%) events									
East			**1.868**	2.48	2.335	2.783	**3.441**			
North			**0.991**	1.139	1.238	1.476	**1.825**			
West			**0.671**	0.772	0.839	1.000	**1.237**			
DS **EA adjustment**			**3.530**	4.059	4.412	5.260	**6.504**			

7.6 Uncertainty bounds

This table reports the flows derived from the uncertainty analysis detailed in Section 7.3. The 'true' value is more likely to be near the estimate reported in Section 7.5 than the bounds. However, it is possible that the 'true' value could still lie outside these bounds.

Complete this table with the flows from the uncertainty analysis. Some key design events have been added to the table, but these can be amended as required.

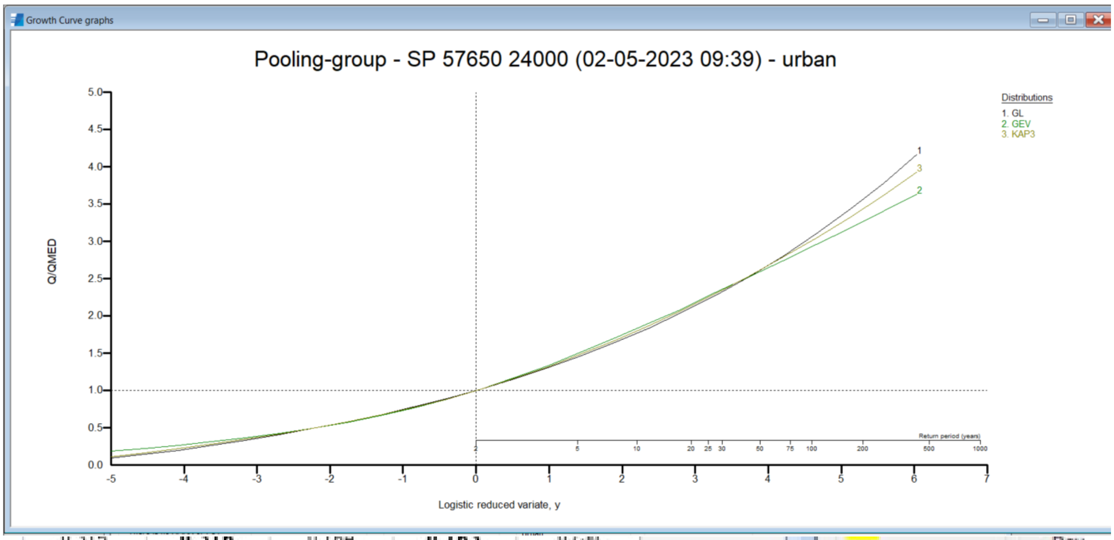
Site code	Flood peak (m^3/s) or volumes (m^3) for the following return periods (in years)							
	2		20		100		1,000	
	Flood peak (m^3/s) or volumes (m^3) for the following AEP (%) events							
	50		5		1		0.1	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
DS	0.177	1.114	0.336	2.583	0.462	3.998	0.643	7.659

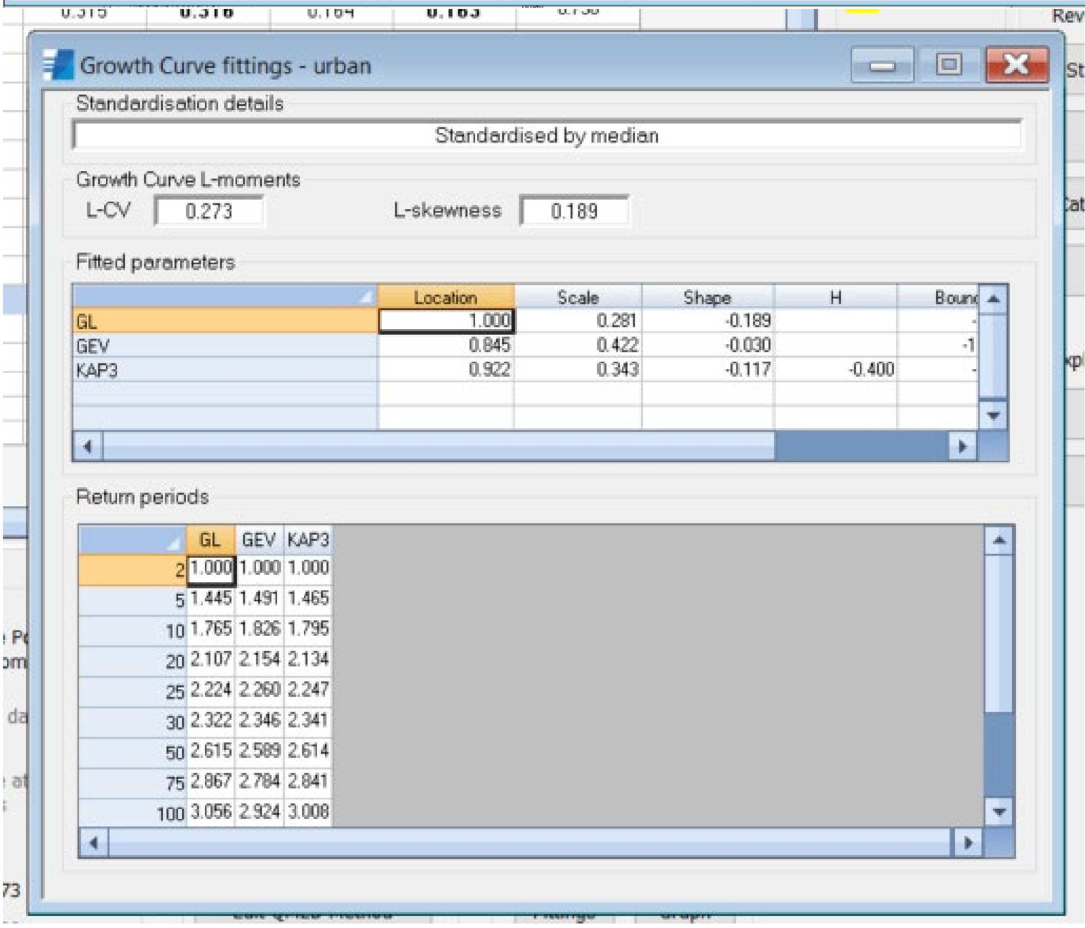
If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, hydraulic model, or reference to table below)	Flood hydrograph ahas been obtained with ReFH2 statistical analysis with EA adsjutment applied to obtain robust and better approach of results.

Return period (years)	No donor		One donor		Six don
Confidence level	68%	95%	68%	95%	68%
2	0.63-1.59	0.39-2.54	0.63-1.58	0.40-2.51	0.63-1.59
5	0.61-1.64	0.37-2.68	0.62-1.62	0.38-2.64	0.61-1.63
10	0.60-1.66	0.36-2.75	0.61-1.64	0.37-2.70	0.61-1.64
20	0.60-1.68	0.36-2.82	0.60-1.66	0.36-2.76	0.60-1.66
50	0.59-1.71	0.34-2.91	0.59-1.69	0.35-2.85	0.59-1.68
100	0.58-1.73	0.33-3.01	0.58-1.72	0.34-2.94	0.59-1.71
200	0.57-1.77	0.32-3.13	0.57-1.75	0.33-3.06	0.58-1.74
500	0.55-1.82	0.30-3.33	0.55-1.80	0.31-3.26	0.56-1.79
1000	0.53-1.88	0.28-3.52	0.54-1.86	0.29-3.45	0.54-1.84

8 ANNEX

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.




Growth Curve fittings - urban

Standardisation details

Standardised by median

Growth Curve L-moments

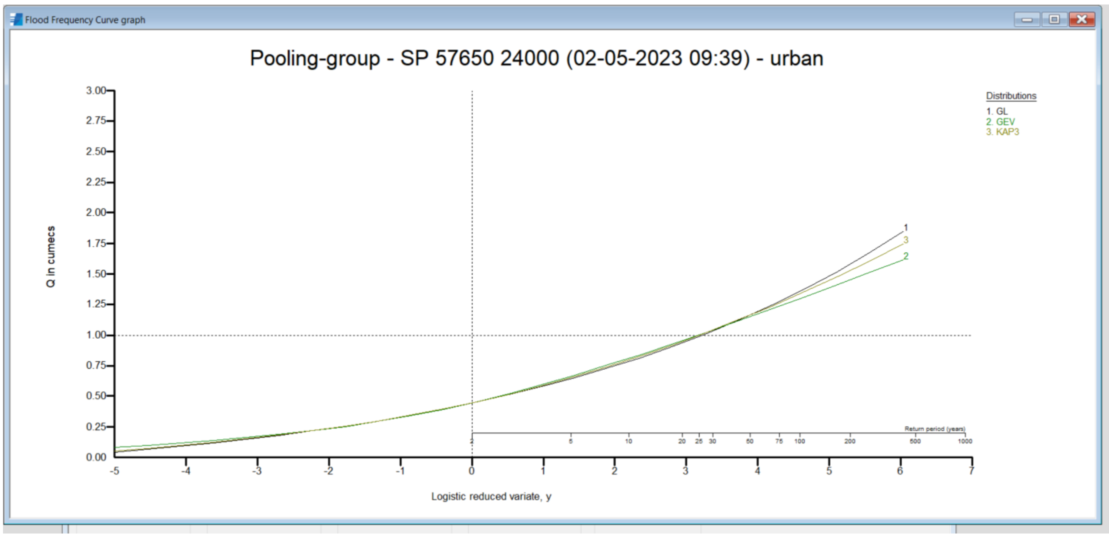
L-CV 0.273 L-skewness 0.189

Fitted parameters

	Location	Scale	Shape	H	Bound
GL	1.000	0.281	-0.189		-
GEV	0.845	0.422	-0.030		-1
KAP3	0.922	0.343	-0.117	-0.400	-

Return periods

	GL	GEV	KAP3
2	1.000	1.000	1.000
5	1.445	1.491	1.465
10	1.765	1.826	1.795
20	2.107	2.154	2.134
25	2.224	2.260	2.247
30	2.322	2.346	2.341
50	2.615	2.589	2.614
75	2.867	2.784	2.841
100	3.056	2.924	3.008

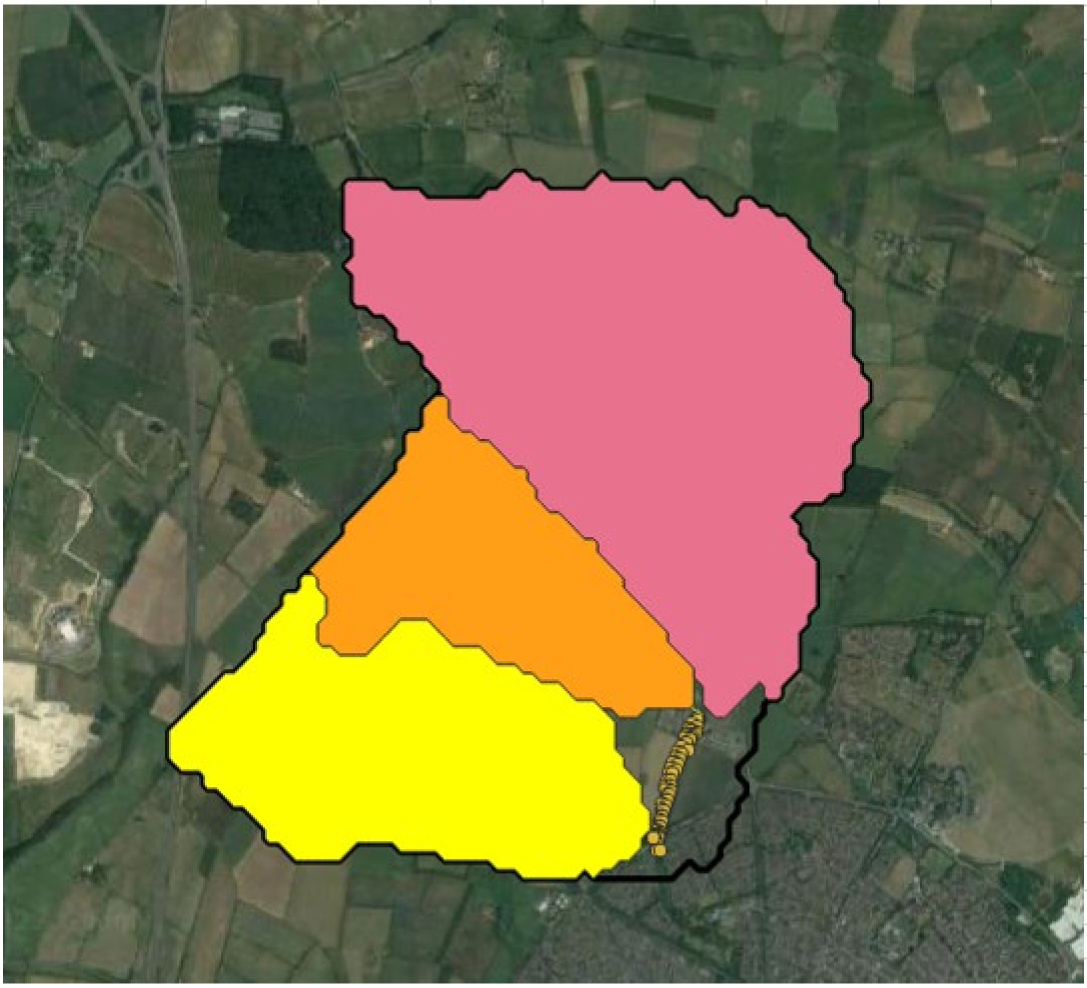


Fittings for Flood Frequency Curve - urban

Return periods

	GL	GEV	KAP3
2	0.444	0.444	0.444
5	0.642	0.663	0.651
10	0.784	0.812	0.797
20	0.936	0.957	0.948
25	0.988	1.004	0.998
30	1.032	1.043	1.040
50	1.162	1.151	1.162
75	1.274	1.237	1.262
100	1.358	1.299	1.337
200	1.580	1.450	1.526
500	1.921	1.654	1.800
1000	2.221	1.812	2.028

				Climate change allownace			
Catchment	Area	%	Q100	15%	25%	49%	Q1000
Downstream	10.53	100%	1.358	1.562	1.698	2.034	2.221
West	1.89	17.9%	**0.244**	**0.280**	**0.305**	**0.365**	**0.541**
North	2.79	26.5%	**0.360**	**0.414**	**0.450**	**0.539**	**0.799**
East	5.26	55.6%	**0.754**	**0.868**	**0.943**	**1.130**	**1.676**
		100.0%	***0.998***	***1.148***	***1.248***	***1.495***	***2.217***



	east	west	north		
	Bis1	**Bis2**	**Bis3**		
100	**1.868**	**0.671**	**0.991**		3.530
100+15	2.148	0.772	1.139	Flow calculated from the EA model.	4.059
100+25	2.335	0.839	1.238		4.412
100+49	2.783	1.000	1.476		5.260
1000	**3.441**	**1.237**	**1.825**		6.504