Flood estimation report

Introduction

This report template is based on 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.

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Revision History

Revision reference	Date issued	Amendments	Issued to
V1.0	March 2018		Eastleigh Borough Council
V2.0	May 2018	Hydrograph shapes added to final section	Eastleigh Borough Council

Abbreviations

AM.................................. Annual Maximum

AREA .... Catchment area (km^2)

BFI .... Base Flow Index

BFIHOST .... Base Flow Index derived using the HOST soil classification

CFMP.............................. Catchment Flood Management Plan

CPRE.............................. Council for the Protection of Rural England

FARL............................... FEH index of flood attenuation due to reservoirs and lakes

FEH................................. Flood Estimation Handbook

FSR................................. Flood Studies Report

HOST .... Hydrology of Soil Types

NRFA .... National River Flow Archive

POT................................. Peaks Over a Threshold

QMED .... Median Annual Flood (with return period 2 years)

ReFH .... Revitalised Flood Hydrograph method

SAAR .... Standard Average Annual Rainfall (mm)

SPR................................. Standard percentage runoff

SPRHOST .... Standard percentage runoff derived using the HOST soil classification

Tp(0) .... Time to peak of the instantaneous unit hydrograph

URBAN .... Flood Studies Report index of fractional urban extent

URBEXT1990 .... FEH index of fractional urban extent

URBEXT2000 .... Revised index of urban extent, measured differently from URBEXT1990

WINFAP-FEH .... Windows Frequency Analysis Package – used for FEH statistical method

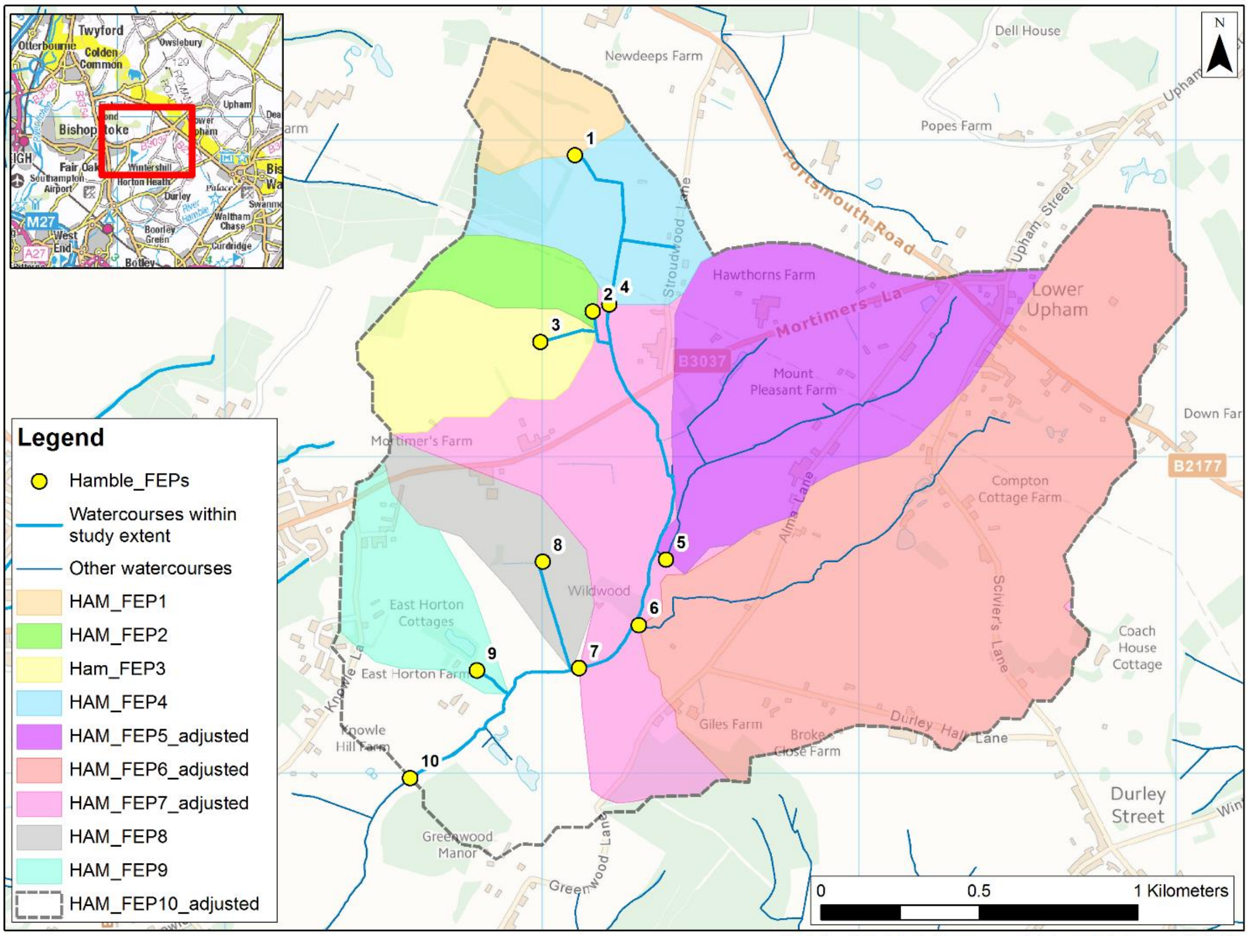
1 Method statement

1.1 Requirements for flood estimates

Overview • Purpose of study • Peak flows or hydrographs? • Range of return periods and locations	The purpose of this study is to derive peak flow estimates and hydrographs for Horton Heath stream (Ford Lake), a tributary of the River Hamble. These will then be used in a hydraulic model to better understand hydrological sensitivity of the headwaters within a potential development area. Peak flow estimates are required for the 50%, 5%, 1% and 0.1% annual exceedance probability (AEP) events. Several locations are required for flood estimation in the headwaters of the catchment; these are shown in the figure in section 1.2.

1.2 The catchment

Map (Include river network, catchment boundary and gauging stations)



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Description Include topography, climate, geology, soils, land use and any unusual features that may affect the flood hydrology.	The tributaries within the site of interest flow into Horton Heath stream which flows into the Upper Hamble just south of Bishop's Waltham. The Horton Heath Streams catchment lies largely over the London Clay member and is considered to have low permeability in its underlying geology. The land use is primarily rural, with a few small farm dwellings occupying the floodplain. The largest settlement in the catchment is the village of Lower Upham, located in the north-east. The catchments are small; however, there are no unusual features such as permeable soils, urbanisation or significant attenuation in the catchment, which might affect the flood hydrology.

1.3 Source of flood peak data

Source	NRFA peak flows dataset, Version 5, April 2017. This contains data up to water year 2014-15 for England, Wales and Northern Ireland and 28 gauges in Scotland and up to water year 2005-6 for the remaining gauges in Scotland.

1.4 Gauging stations (flow or level)

(at or very near to the sites of flood estimates)

Water-course	Station name	Gauging authority number	NRFA number	Catchment area (km²)	Type (rated / ultrasonic / level…)	Start of record and end if station closed
The study watercourse is un-gauged.						

1.5 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)	No	No		
Historic flood data Include chronology and interpretation of flood history in Annex or separate report.	Yes	No		
Flow or river level data for events	Yes	No		
Rainfall data for events	No	No		
Potential evaporation data	No	No		
Results from previous studies	Not relating to Horton Heath Stream			
Other data or information (e.g. groundwater, tides, channel widths, low flow statistics)	No	No		

1.6 Hydrological understanding of catchment

Outline the conceptual model, addressing questions 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 main sites of interest are the headwater streams which located primarily within the western half of the catchment; these fall within the eastern extent of the study site, along with the Itchen headwater streams (the approach to deriving the hydrology for these is detailed in a separate Technical Note). There are some isolated urban dwellings and farms within the study area; however, the majority of the catchment is rural with the only village being Lower Upham in the north-eastern part of the catchment.
Any unusual catchment features to take into account? e.g. • highly permeable – avoid ReFH if BFIHOST>0.65,	No unusual features; however, some of the FEP catchments are smaller than 0.5km^2.

consider permeable catchment adjustment for statistical method if SPRHOST<20% • highly urbanised – seek local flow data; consider method that can account for differing sewer and topographic catchments • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence (FARL<0.90) – consider flood routing, extensive floodplain storage – consider choice of method carefully	

1.7 Initial choice of approach

Is FEH appropriate? (it may not be for extremely heavily urbanised or complex catchments) If not, describe other methods to be used.	Yes
Initial choice of method(s) and reasons How will hydrograph shapes be derived if needed? Will the catchment be split into sub-catchments? If so, how?	The FEH Statistical will be used. However, some of the catchments are very small (less than 0.5km^2) and FEH methods are not intended for catchments smaller than this size. There is no ideal approach for catchments smaller than 0.5km^2, especially in the absence of any gauge data; it will therefore be essential to check the catchment descriptors and ensure they are representative. Hydrograph shapes will be derived using ReFH, given that observed data is not available for this catchment. The ReFH1 method will also be used to derive peak flow estimates for comparison against the FEH Statistical flows.
Software to be used (with version numbers)	FEH CD-ROM v3.0[1] WINFAP-FEH v3.0.003[2] In-house FEH spreadsheet v5.0 ReFH boundary in Flood Modeller Pro

[1] FEH CD-ROM v3.0 © NERC (CEH). © Crown copyright. © AA. 2009. All rights reserved.
[2] WINFAP-FEH v3 © Wallingford HydroSolutions Limited and NERC (CEH) 2009.

2 Locations where flood estimates required

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

2.1 Summary of subject sites

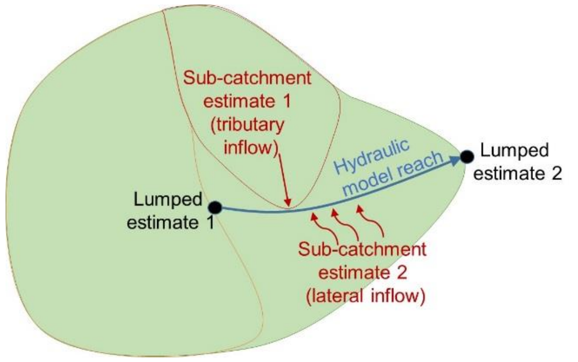
Site code	Type of estimate L: lumped catchment S: Sub-catchment	Watercourse	Name or description of site	Easting	Northing	AREA on FEH CD-ROM (km^2)	Revised AREA if altered
HAM_FEP 1	L	Ford Lake	Upstream extent, near Stroudwood Lane	451104	119953	0.50	0.13
HAM_FEP 2	L	Ford Lake tributary	Un-named right-bank tributary, near Stroudwood Lane	451160	119460	0.50	0.10
HAM_FEP 3	L	Ford Lake tributary	Un-named right-bank tributary, near Stroudwood Lane	450995	119364	0.50	0.23
HAM_FEP 4	L	Ford Lake	Check flow point, near Stroudwood Lane	451212	119484	0.50	0.39
HAM_FEP 5	S	Ford Lake tributary	Un-named left-bank tributary, downstream of Mount Pleasant Farm	451390	118676	0.97	0.71
HAM_FEP 6	S	Ford Lake tributary	Un-named left-bank tributary, downstream of Compton Cottage Farm	451305	118469	0.94	1.44
HAM_FEP 7	L	Ford Lake	Check flow point, downstream of Wildwood (between 6 and 8 tributaries)	451117	118334	3.70	3.43
HAM_FEP 8	L	Ford Lake tributary	Un-named right-bank tributary, near Wildwood	451001	118670	N/A	0.19
HAM_FEP 9	L	Ford Lake tributary	Un-named right-bank tributary, draining East Horton Cottages	450794	118326	N/A	0.21
HAM_FEP 10	L	Ford Lake	Downstream extent, near Greenwood Manor	450825	118163	4.40	4.25

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

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.



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

The FEPs at the top of the catchment (1 through to 4) are loosely covered by the FEH CD-ROM; however, the catchment boundaries had to be re-drawn to suit the FEP catchments. HAM_FEP5, HAM_FEP6, HAM_FEP7 and HAM_FEP10 are all defined on the FEH CD-ROM; however, their boundaries also had to be revised to suit topographical boundaries shown in LIDAR data. No catchment descriptors were defined for HAM_FEP8 and HAM_FEP9, so donor descriptors from HAM_FEP1 have been used for these.

Site code	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2000	URBEXT 1990	FPEXT
HAM_FEP 1	1.00	0.33	0.197	0.55 / 0.17	20.7	801	0.000	0.000	0.0995
HAM_FEP 2	1.00	0.33	0.197	0.55 / 0.14	20.7	801	0.000	0.000	0.0995
HAM_FEP 3	1.00	0.33	0.197	0.55 / 0.28	20.7	801	0.000	0.000	0.0995
HAM_FEP 4	1.00	0.33	0.197	0.55 / 0.44	20.7	801	0.000	0.000	0.0995
HAM_FEP 5	1.00	0.33	0.188	1.31 / 0.83	18.6	808	0.049	0.017	0.1410
HAM_FEP 6	1.00	0.33	0.183	0.92 / 1.63	32.6	808	0.009 / 0.026	0.000 / 0.020	0.0800
HAM_FEP 7	1.00	0.33	0.195	1.52	23.2	807	0.025	0.005	0.1256
HAM_FEP 8	1.00	0.33	0.197	0.55 / 0.24	20.7	801	0.000 / 0.010	0.000/ 0.007	0.0995
HAM_FEP 9	1.00	0.33	0.197	0.55 / 0.26	20.7	801	0.000 / 0.047	0.000/ 0.036	0.0995
HAM_FEP 10	1.00	0.33	0.220	1.96	26.7	806	0.022	0.007	0.1102

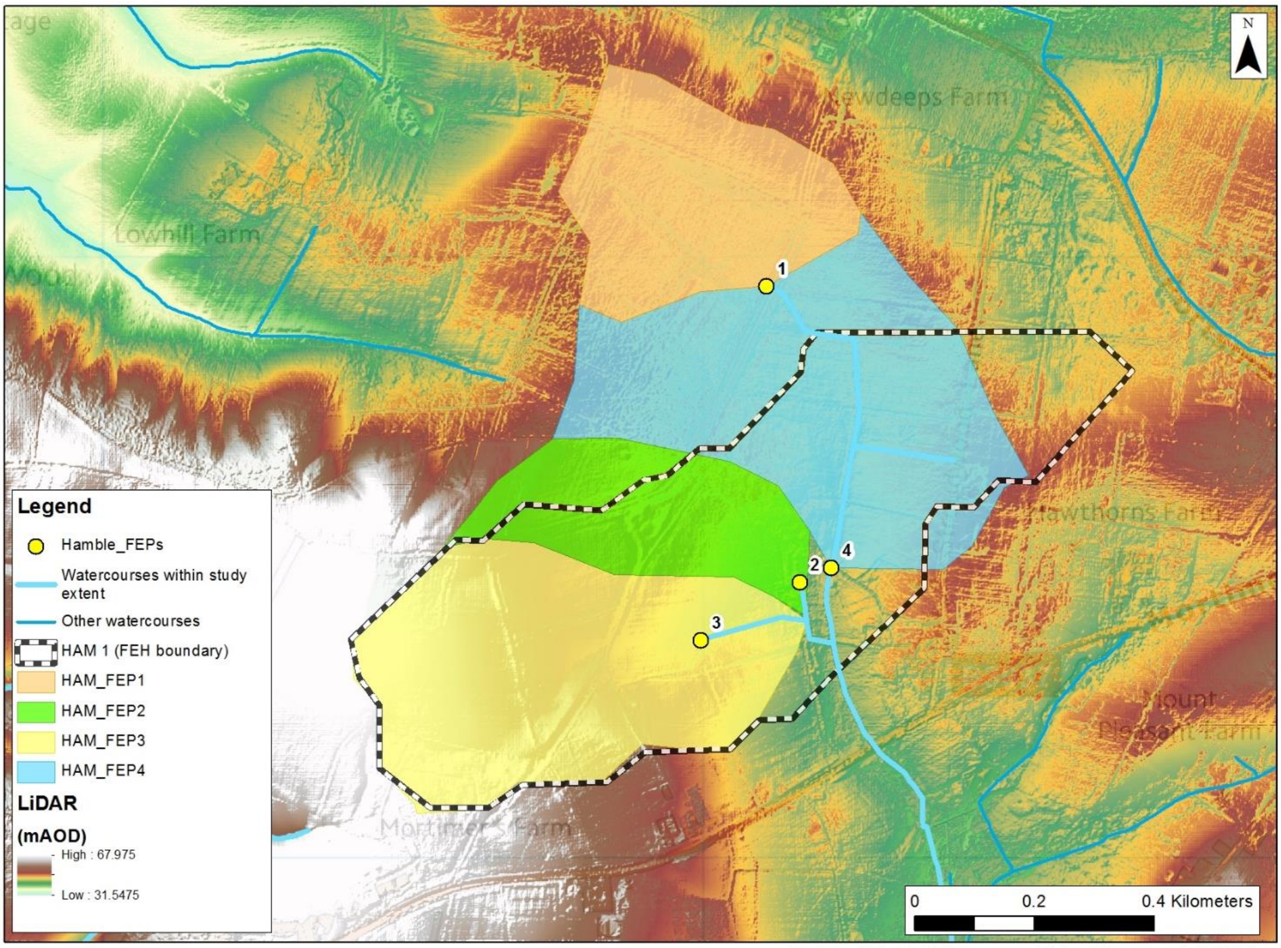
Notes:

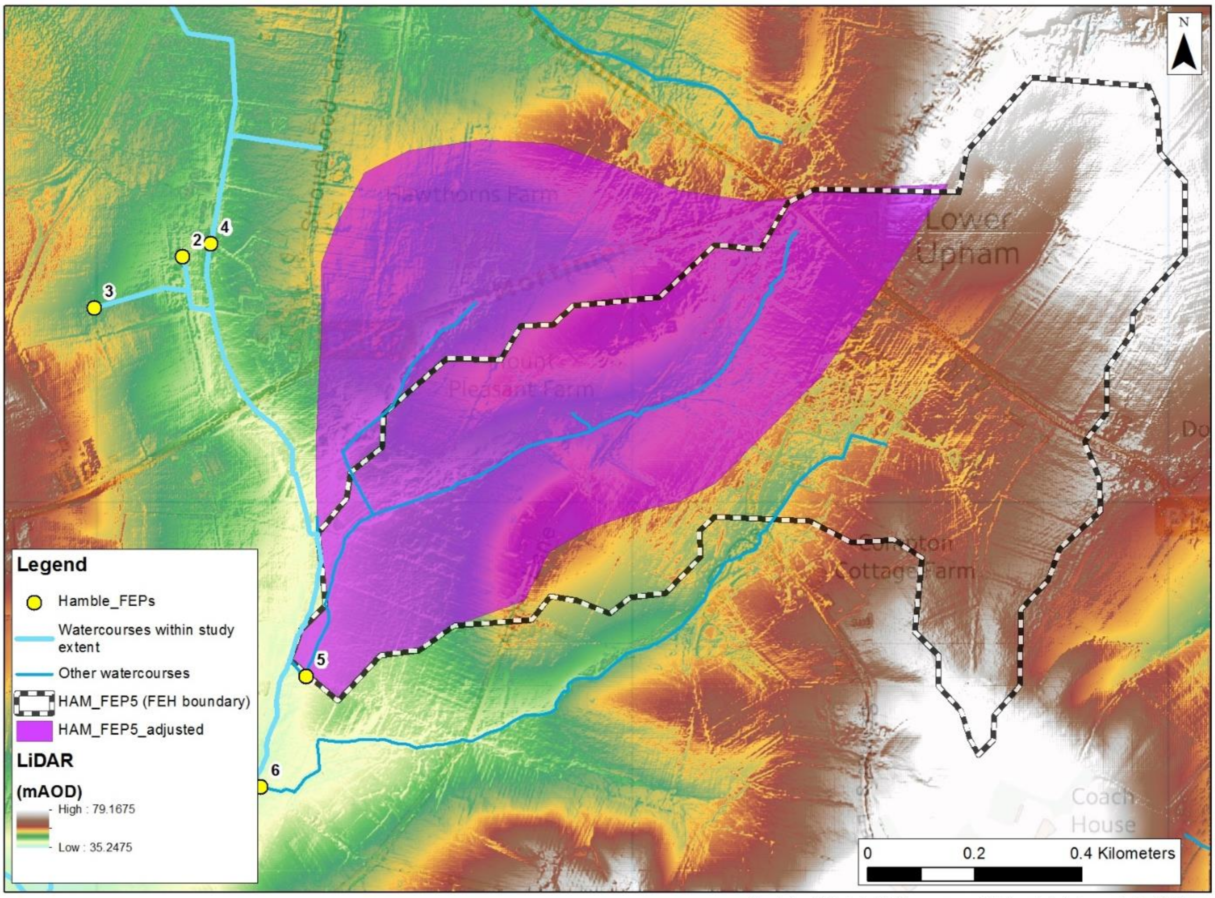
Adjusted catchment descriptors are shown next to the FEH descriptor in red.

DPLBAR and URBEXT values only updated where there is between a 10% - 20% change in area (and even then, some URBEXT values were not changed as they were very similar to the FEH value).

2.3 Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (add maps if needed)	Catchment boundaries from the FEH CD-ROM were digitised in ArcGIS and compared against 1m and 2m LIDAR data (openly available through the data.gov.uk website). For all catchments, particularly the smaller ones, topographic data shown by the LIDAR disagreed with the FEH boundaries. Catchment boundaries were revised to reflect these topographic boundaries; a comparison of the boundaries is shown below.
Record how other catchment descriptors were checked and describe any changes. Include before/after table if necessary.	Catchment descriptors were checked against UK soil maps and the Britich Geological Survey geology map. The BFIHOST values for the Horton Heath stream and its tributaries range between 0.183 and 0.220, suggesting impermeable underlying strata. This correlates with the geology data which indicates the catchment is underlain by the London Clay Formation, comprising clay, silt and sand. Soils are typically loamy and clayey with slow permeability. A check of OS mapping suggests minimal attenuation in the catchment, correlating well to FEH's FARL values of 1.000.
Source of URBEXT	URBEXT1990
Method for updating of URBEXT	CPRE formula from FEH Volume 4 CPRE formula from 2006 CEH report on URBEXT2000





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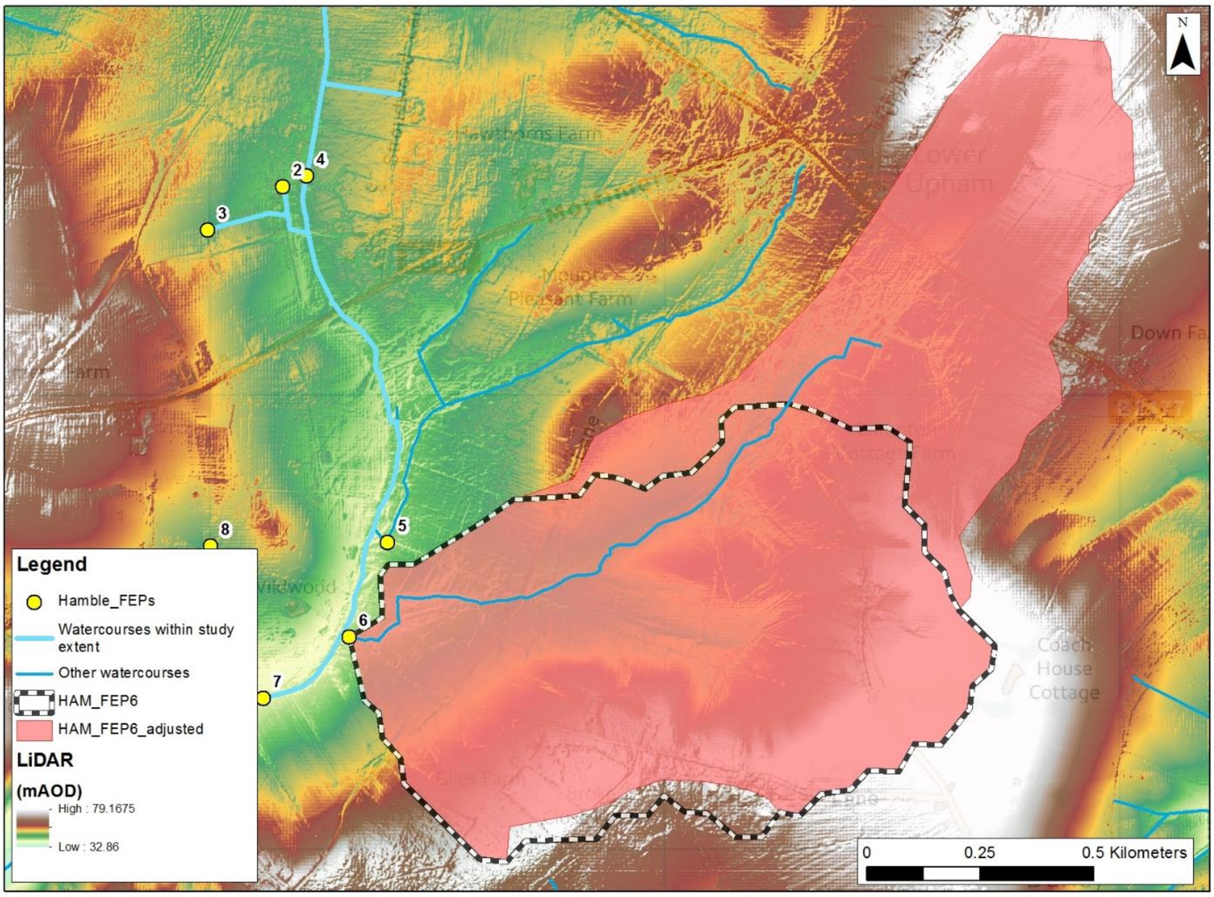

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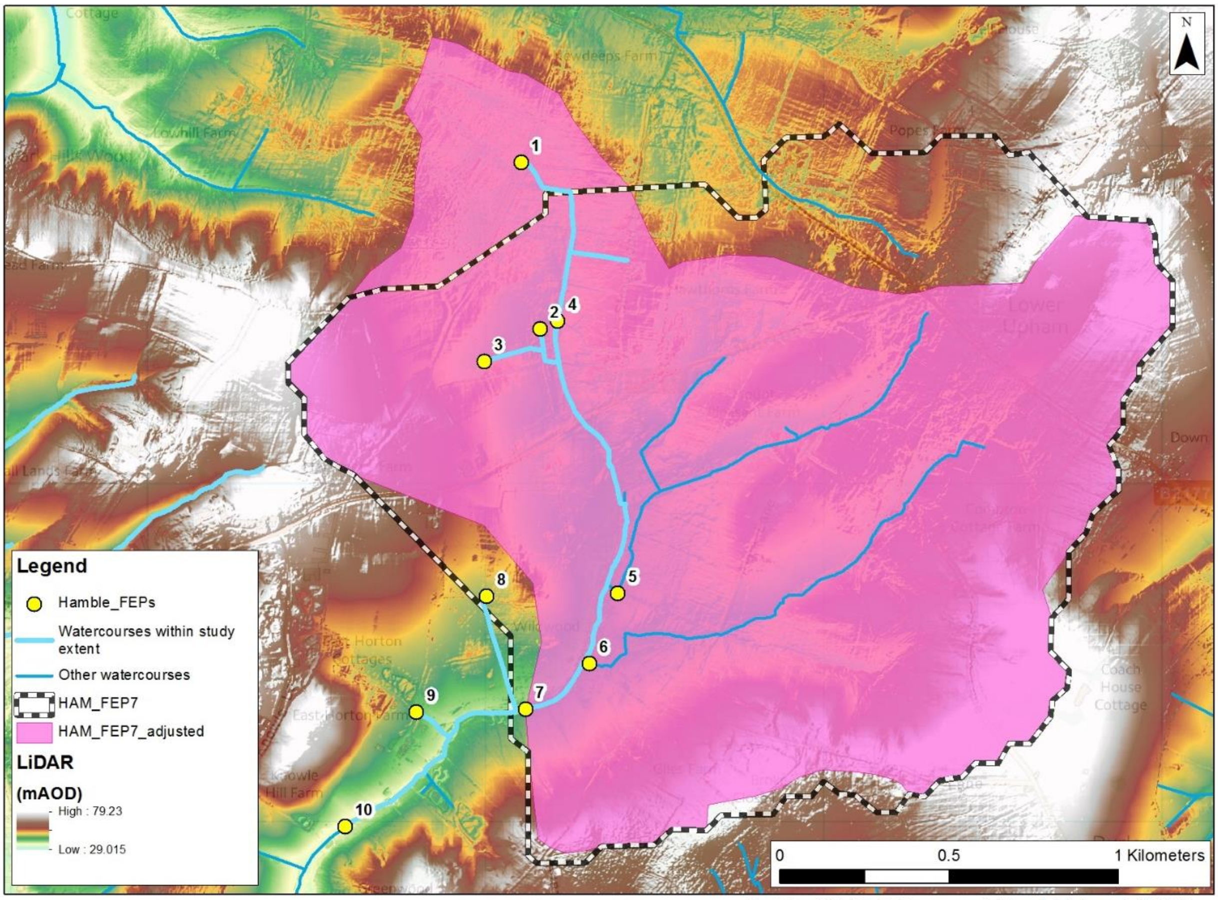

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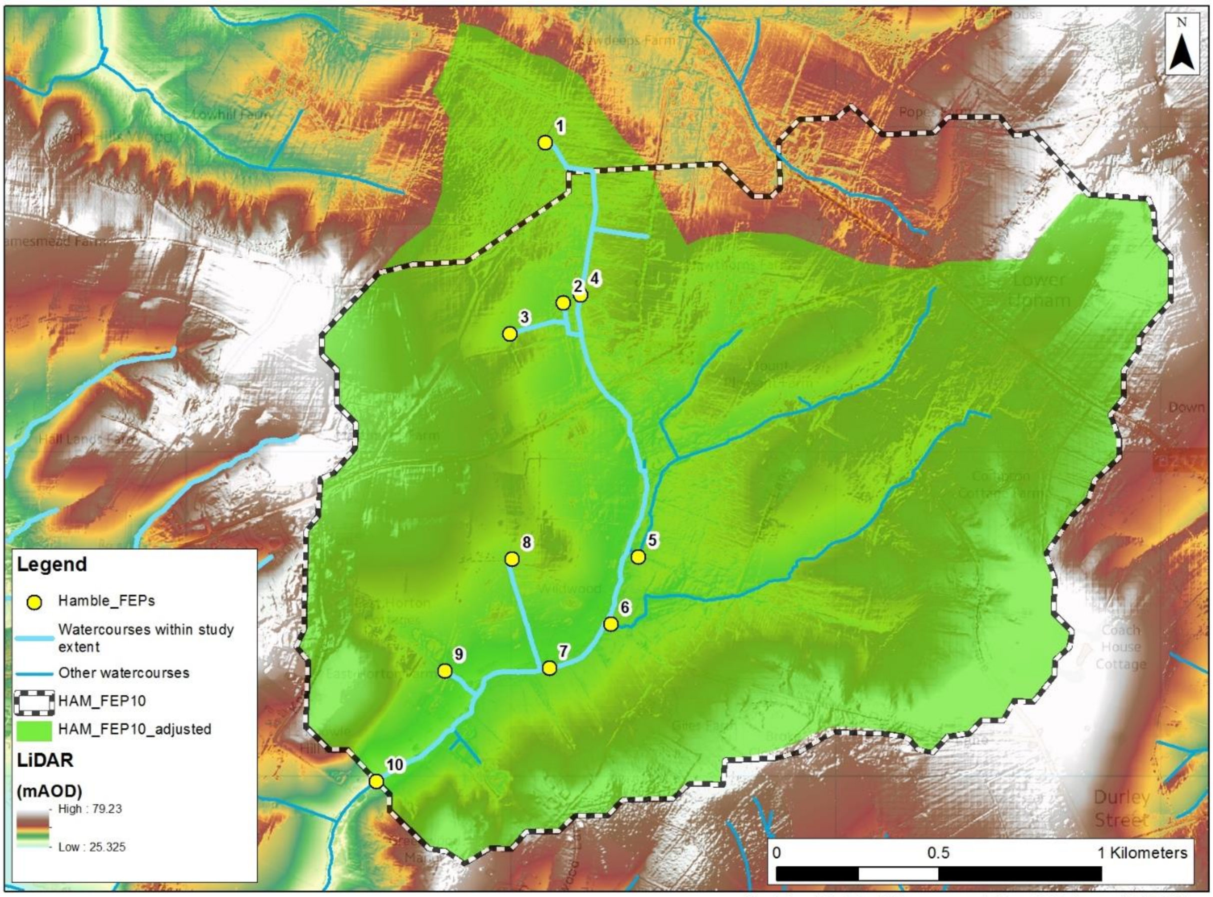

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3 Statistical method

3.1 Overview of estimation of QMED at each subject site

Site code	QMED (rural) from CDs (m^3/s)	Final method	Data transfer: NRFA numbers for donor sites used (see 3.3)	Distance between centroids d_{ij} (km)	Moderated QMED adjustment factor, $(A/B)^a$	If more than one donor: Weight	If more than one donor: Weighted ave. adjustment	Urban adjust-ment factor UAF	Final estimate of of QMED (m^3/s)
HAM_FEP 1	0.1	CD	N/A					1.000	0.1
HAM_FEP 2	0.1	CD	N/A					1.000	0.1
HAM_FEP 3	0.2	CD	N/A					1.000	0.2
HAM_FEP 4	0.3	CD	N/A					1.000	0.3
HAM_FEP 5	0.5	CD	N/A					1.037	0.6
HAM_FEP 6	1.0	CD	N/A					1.019	1.0
HAM_FEP 7	2.2	CD	N/A					1.019	2.2
HAM_FEP 8	0.2	CD	N/A					1.008	0.2
HAM_FEP 9	0.2	CD	N/A					1.036	0.2
HAM_FEP 10	2.4	CD	N/A					1.018	2.4

Are the values of QMED spatially consistent?	Yes
Method used for urban adjustment for subject and donor sites	WINFAP v4[3]

Parameters used for WINFAP v4 urban adjustment if applicable

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 given in Table 3.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

Important note on urban adjustment

The method used to adjust QMED for urbanisation published in Kjeldsen (2010)[4] 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.

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

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

3.2 Search for donor sites for QMED (if applicable)

Comment on potential donor sites Include a map if necessary. Note that donor catchments should usually be rural.	The study watercourses are un-gauged. Several potential donor sites within an approximate 20km^2 buffer zone were investigated for QMED adjustment. Only catchments with areas less than 60km^2 and which were suitable for QMED adjustment were considered. The Hamble at Frogmill (42011) gauge is on the study watercourse, but downstream of the study catchment. Whilst it is nearly 10 times the size of the largest study catchment (AREA: 55.25km^2), it was considered for use because of being on the same watercourse. However, the catchment draining to this gauging station is far more permeable than the study catchment, with a BFIHOST value of 0.747, and is therefore considered unsuitable to serve as a donor site. Similarly, both the Alre at Drove Lane Alresford (42007) and the Wallop Brook at Broughton (42005), were discounted for being too dissimilar to the study catchment in terms of their catchment characteristics. Both have exceptionally high BFIHOST values (0.964 and 0.955 respectively), indicating they are highly permeable. The Alre at Drove Lane catchment also has more attenuation than the study catchment, indicated by a FARL value of 0.864, and both are approximately 10 times the study catchment's area. Whilst the Hermitage Stream at Havant (42017) is slightly outside the 20km^2 buffer zone (but within 25km^2), it was considered for donor adjustment due to its relatively small catchment area (17.3km2). It is also impermeable like the study catchments (BFIHOST: 0.245) and has similar FARL and DPSBAR values. However, the URBEXT1990 value of 0.1675 suggests the catchment is heavily urbanised, and is therefore not suitable to use as a donor catchment.

3.3 Donor sites chosen and QMED adjustment factors

NRFA no.	Reasons for choosing	Method (AM or POT)	Adjustment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjustment ratio (A/B)
No donor gauges appropriate for QMED adjustment were found within a suitable distance to the study catchments (see section 3.2 for more detail).						

3.4 Derivation of pooling groups

Several subject sites may use the same pooling group.

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	Weighted average L-moments, L-CV and L-skew, (before urban adjustment)
HAM_PG	HAM_FEP10	No	Stations removed: • *Bollingey Stream @ Bolingey Cocks Bridge (49005)* – removed for having less than 8 years of data Stations investigated: • *Camel @ Camelford (49006)* – investigated for having a very shallow growth curve and negative L-Skewness, thought to be due to a short record (9 years) but which is above the recommended limit. Total number of years: 522	L-CV: 0.234 L-SKEW: 0.239
Note: Pooling groups were derived using the procedures from Science Report SC050050 (2008).				

3.5 Derivation of flood growth curves at subject sites

Site code	Method (SS, P, ESS, J)	If P, ESS or J, name of pooling group (Error! Reference source not found.)	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
HAM_FEP 1	P	HAM_PG	GL and GEV are both acceptable distributions; the z-value for GL is closest to zero and it is the recommended distribution for UK catchments, therefore GL was used.	Growth curve adjusted using v.3 urban adjustment and no permeable adjustment made.	Location: 1.000 Scale: 0.234 Shape: -0.239	2.95
HAM_FEP 2	P	HAM_PG			Location: 1.000 Scale: 0.234 Shape: -0.239	2.95
HAM_FEP 3	P	HAM_PG			Location: 1.000 Scale: 0.234 Shape: -0.239	2.95
HAM_FEP 4	P	HAM_PG			Location: 1.000 Scale: 0.234 Shape: -0.239	2.95
HAM_FEP 5	P	HAM_PG			Location: 1.000 Scale: 0.225 Shape: -0.248	2.93
HAM_FEP 6	P	HAM_PG			Location: 1.000 Scale: 0.229 Shape: -0.244	2.94
HAM_FEP 7	P	HAM_PG			Location: 1.000 Scale: 0.229 Shape: -0.244	2.94
HAM_FEP 8	P	HAM_PG			Location: 1.000 Scale: 0.232 Shape: -0.241	2.95
HAM_FEP 9	P	HAM_PG			Location: 1.000 Scale: 0.225 Shape: -0.248	2.93
HAM_FEP 10	P	HAM_PG			Location: 1.000 Scale: 0.230 Shape: -0.243	2.94

Notes

Methods: SS – Single site; P – Pooled; ESS – Enhanced single site; J – Joint analysis

A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters.

Urban adjustments are all carried out using the method of Kjeldsen (2010).

Growth curves were derived using the procedures from Science Report SC050050 (2008).

3.6 Flood estimates from the statistical method

Site code	Flood peak (m^3/s) for the following annual exceedance probability (%) events			
	50	5	1	0.1
HAM_FEP1	0.1	0.3	0.4	0.6

Site code	Flood peak (m^3/s) for the following annual exceedance probability (%) events			
	50	5	1	0.1
HAM_FEP2	0.1	0.2	0.3	0.5
HAM_FEP3	0.2	0.4	0.6	1.0
HAM_FEP4	0.3	0.6	0.9	1.6
HAM_FEP5	0.6	1.1	1.7	2.9
HAM_FEP6	1.0	2.0	3.0	5.2
HAM_FEP7	2.2	4.5	6.6	11.5
HAM_FEP8	0.2	0.3	0.5	0.9
HAM_FEP9	0.2	0.4	0.6	1.0
HAM_FEP10	2.4	4.9	7.2	12.5

4 Revitalised flood hydrograph (ReFH) method

4.1 Parameters for ReFH model (rural catchments)

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer (give details)	Tp (hours) Time to peak	C_{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
HAM_FEP1	CD	0.774	166.363	14.723	0.435
HAM_FEP2	CD	0.689	166.363	14.135	0.435
HAM_FEP3	CD	1.044	166.363	16.350	0.435
HAM_FEP4	CD	1.369	166.363	17.978	0.435
HAM_FEP5	CD	1.953	159.134	19.117	0.414
HAM_FEP6	CD	2.476	155.111	21.540	0.402
HAM_FEP7	CD	2.740	164.758	22.839	0.431
HAM_FEP8	CD	0.930	166.363	15.500	0.435
HAM_FEP9	CD	0.887	166.363	14.472	0.435
HAM_FEP10	CD	3.054	184.763	25.390	0.490
Brief description of any flood event analysis carried out (further details should be given in the annex)		N/A			

4.2 Design events for ReFH or Urban ReFH method

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)	Storm area for ARF (if not catchment area)
HAM_FEP1	Rural	Winter	1.4	N/A
HAM_FEP2	Rural	Winter	1.25	N/A
HAM_FEP3	Rural	Winter	1.9	N/A
HAM_FEP4	Rural	Winter	2.5	N/A
HAM_FEP5	Rural	Winter	3.5	N/A
HAM_FEP6	Rural	Winter	4.5	N/A
HAM_FEP7	Rural	Winter	4.9	N/A
HAM_FEP8	Rural	Winter	1.7	N/A
HAM_FEP9	Rural	Winter	1.65	N/A
HAM_FEP10	Rural	Winter	5.5	N/A
Are the storm durations likely to be changed in the next stage of the study, e.g. by optimisation within a hydraulic model?			Yes; a uniform storm duration will be applied to the inflow hydrographs for application to the hydraulic model.	

4.3 Flood estimates from the ReFH 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 annual exceedance probability (%) events			
	50	5	1	0.1
HAM_FEP1	0.1	0.2	0.4	0.7

Site code	Flood peak (m^3/s) for the following annual exceedance probability (%) events			
	50	**5**	**1**	**0.1**
HAM_FEP2	0.1	0.2	0.3	0.6
HAM_FEP3	0.2	0.4	0.6	1.1
HAM_FEP4	0.3	0.6	0.8	1.6
HAM_FEP5	0.4	0.9	1.3	2.5
HAM_FEP6	0.8	1.6	2.3	4.5
HAM_FEP7	1.9	3.8	5.5	10.7
HAM_FEP8	0.2	0.3	0.5	1.0
HAM_FEP9	0.2	0.4	0.6	1.1
HAM_FEP10	2.1	3.9	5.8	10.9

5 Discussion and summary of results

5.1 Comparison of results from different methods

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

Site code	Ratio of peak flow to FEH Statistical peak					
	Return period 2 years			Return period 100 years		
	ReFH	Other method	Other method	ReFH	Other method	Other method
HAM_FEP1	0.9	N/A	N/A	1.0	N/A	N/A
HAM_FEP2	0.9	N/A	N/A	1.0	N/A	N/A
HAM_FEP3	0.9	N/A	N/A	0.9	N/A	N/A
HAM_FEP4	0.8	N/A	N/A	0.9	N/A	N/A
HAM_FEP5	0.8	N/A	N/A	0.8	N/A	N/A
HAM_FEP6	0.8	N/A	N/A	0.8	N/A	N/A
HAM_FEP7	0.9	N/A	N/A	0.8	N/A	N/A
HAM_FEP8	0.9	N/A	N/A	1.0	N/A	N/A
HAM_FEP9	0.9	N/A	N/A	1.0	N/A	N/A
HAM_FEP10	0.8	N/A	N/A	0.8	N/A	N/A

5.2 Final choice of method

Choice of method and reasons Include reference to type of study, nature of catchment and type of data available.	The difference between the peak flow estimates derived from the FEH Statistical method and the ReFH method ranges from 0 to 24%. The peak flow estimates for the smaller catchments (with areas <0.25km^2) are the most similar, with peak flows differing by less than 15%. The FEH Statistical method rendered slightly higher peak flow estimates than the ReFH method. There is considerable uncertainty estimating peak flows for very small catchments (<0.5km^2) and FEH methods were not originally developed with the intension of applying them to catchments smaller than this size. However, FEH methods are regarded as more appropriate than alternatives for small catchments. Furthermore, the FEH Statistical method is considered more suitable for rural catchments and benefits from an up-to-date flood peak dataset, sourcing flow estimates on growth curves from hydrologically similar catchments (pooled analysis). The similarities in the results produced by both methods for these catchments, increases confidence in the peak flow estimates despite the uncertainties surrounding flood estimation on very small catchments. It was not considered necessary to scale the flow estimates for the 0.1% event using the ReFH ratio, sometimes used to improve estimates of the more extreme events. Whilst neither ReFH or the Statistical method is recommended by the FEH for long return periods due to the uncertainty, the Statistical method often produces a shallower growth curve than ReFH. However, in this case, the FEH Statistical estimates are slightly higher than the ReFH estimates for some of the FEPs. For the FEPs that aren't higher with the Statistical method, the difference is less than 15%.
How will the flows be applied to a hydraulic model?	Hydrograph shapes will be obtained by using ReFH boundaries in ISIS / Flood Modeller and scaled to match the FEH Statistical peak flows.

If relevant. Will model inflows be adjusted to achieve a match with lumped flow estimates, or will the model be allowed to route inflows?	The following flow estimates and hydrographs will be applied to the model as the main inflows to the modelled watercourses, at their upstream extent: • HAM_FEP1 • HAM_FEP2 • HAM_FEP3 • HAM_FEP8 • HAM_FEP9 HAM_FEP5 and HAM_FEP6 will be applied as point inflows to the Horton Heath stream. The intervening areas between HAM_FEP4, HAM_FEP7 and HAM_FEP10 will be applied to the Horton Heath stream as lateral inflows. If the model flows are significantly different to the downstream check inflows estimated in this assessment, it may be necessary to adjust intervening area inflows in the model.

5.3 Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	It is assumed that: • Pooling groups are representative of study catchments. • Catchments included in pooling groups are statistically homogeneous so that their (standardised) AMAX flows can be fitted by a single distribution. For pooling group analysis undertaken for permeable catchments, a number of stations included in the pooling group were less permeable and therefore may differ in their flood generating characteristics.
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed.	There is no catchment flow data for the River Hamble tributaries to verify the peak flow estimates generated by this assessment
Give what information you can on uncertainty in the results, e.g. confidence limits from Kjeldsen (2014).	The uncertainty will depend on many factors, for example, how unusual the study catchment is relative to the pooling group and donor catchment, and the uncertainty in flow measurement at other gauges. However, a UK average measure of uncertainty has been produced by Kjeldsen (2014). The 95% confidence limits for a 1% AEP flood estimate are: • Without donor adjustment of QMED: 0.42 – 2.37 times the best estimate • With donor adjustment of QMED: 0.45 – 2.25 times the best estimate A R&D project into FEH, local data and uncertainty (Environment Agency funded consortium of JBA, CEH and others) has been undertaken and published to develop user guidance on uncertainty.
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	The design peak flow estimates and hydrographs have been derived for the purposes of this modelling study. If peak flow estimates and hydrographs are required for different purposes it is recommended that, at a minimum, a review of the results is carried out and any recent flow data incorporated into the calculations.
Give any other comments on the study, e.g. suggestions for additional work.	N/A

5.4 Checks

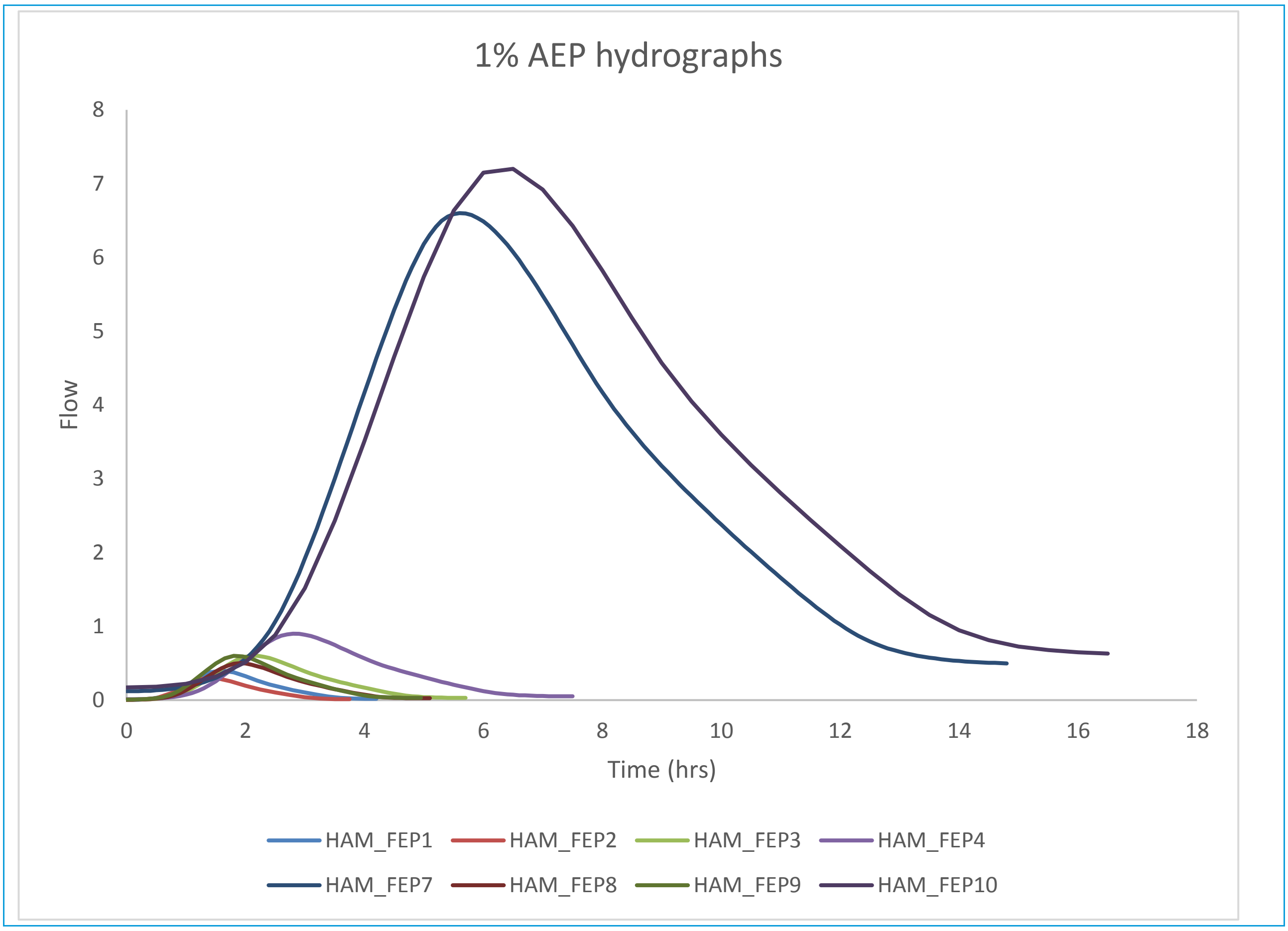
Are the results consistent, for example at confluences?	Yes
What do the results imply regarding the return periods of floods during the period of record?	Given that there is no flow data in the catchment, it is not possible to check the flow estimates derived against gauge data. Sensibility checks will be applied to the flood outlines once the flows have been routed through the model to ensure the flow inputs result in realistic outputs.
What is the range of 100-year growth factors? Is this realistic?	The 1% AEP (100-year) growth factor for the statistical method ranges between 2.93 to 2.95. This value is within the expected range for small catchments (<20km^2).
If 1000-year flows have been derived, what is the range of ratios for 1000-year flow over 100-year flow?	The 0.1% / 1% AEP (1000 / 100-year return period) ratios when using the FEH Statistical method is 1.7. The typical range of 0.1% / 1% AEP ratios is 1.7 to 1.8 so the 0.1% AEP flows are within the expected range.
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	To date, there is not believed to be any other studies undertaken on the Horton Heath streams (tributary of the River Hamble upstream of Ford Lake).
Are the results compatible with the longer-term flood history?	No evidence of flooding was found in relation to the Horton Heath stream and there are no flow records to set the flows in context.
Describe any other checks on the results	Flood outlines will be sensitivity checked during the hydraulic modelling phase, however, model calibration will not be possible due to a lack of gauge data or flood history data.

5.5 Final results

Final design estimates for HAM_FEP5 and HAM_FEP6 have been excluded, as they represent sub-catchments outside of the hydraulic model extent.

Site code	Flood peak (m^3/s) for the following annual exceedance probability (%) events			
	50	**5**	**1**	**0.1**
HAM_FEP1	0.1	0.3	0.4	0.6
HAM_FEP2	0.1	0.2	0.3	0.5
HAM_FEP3	0.2	0.4	0.6	1.0
HAM_FEP4	0.3	0.6	0.9	1.6
HAM_FEP7	2.2	4.5	6.6	11.5
HAM_FEP8	0.2	0.3	0.5	0.9
HAM_FEP9	0.2	0.4	0.6	1.0
HAM_FEP10	2.4	4.9	7.2	12.5

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 hydrographs are required for the hydraulic modelling and will be provided in ISIS / Flood Modeller data files. The 1% AEP hydrographs for each of the FEPs are shown below for reference.


1% AEP hydrographs
Flow
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
16
18
Time (hrs)
HAM_FEP1
HAM_FEP2
HAM_FEP3
HAM_FEP4
HAM_FEP7
HAM_FEP8
HAM_FEP9
HAM_FEP10

6 Annex

Pooling Group composition

HAM_PG

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW
27051 (Crimple @ Burn Bridge)	1.421	43	4.514	0.219	0.154
45816 (Haddeo @ Upton)	1.502	22	3.489	0.314	0.415
76011 (Coal Burn @ Coalburn)	1.519	38	1.840	0.165	0.331
27073 (Brompton Beck @ Snainton Ings)	1.693	34	0.816	0.198	0.056
28033 (Dove @ Hollinsclough)	1.742	36	4.225	0.240	0.415
25019 (Leven @ Easby)	2.041	37	4.989	0.342	0.390
26802 (Gypsey Race @ Kirby Grindalythe)	2.047	16	0.112	0.274	0.274
49006 (Camel @ Camelford)	2.153	9	11.500	0.129	-0.252
47022 (Tory Brook @ Newnham Park)	2.188	22	7.227	0.262	0.093
25011 (Langdon Beck @ Langdon)	2.206	28	15.878	0.238	0.318
25003 (Trout Beck @ Moor House)	2.281	42	15.142	0.172	0.293
71003 (Croasdale Beck @ Croasdale Flume)	2.323	37	10.900	0.212	0.323
27010 (Hodge Beck @ Bransdale Weir)	2.397	41	9.420	0.224	0.293
203046 (Rathmore Burn @ Rathmore Bridge)	2.418	33	10.770	0.136	0.104
206006 (Annalong @ Recorder)	2.436	48	15.330	0.189	0.052
44008 (South Winterbourne @ Winterbourne Steepleton)	2.462	36	0.434	0.418	0.344
Total		522			
Weighted means		522		0.234	
Total		522			

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