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Insch Hydrology Report

Final Report

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Contract

This report describes work commissioned by Gavin Penman, on behalf of Aberdeenshire Council, on 10 October 2017 by Purchase Order Number 1095192. Dougall Baillie's representative for the contract was Scott Macphail and Aberdeenshire Council's representative for the contract was Alistair Scotland. Grace Thompson, Briony McIntosh and David Cameron of JBA Consulting carried out this work.

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Purpose

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Executive Summary

This report describes historical flooding and input hydrology estimates developed for use in the Insch Flood Protection Study for Aberdeenshire Council. The Shevock has a history of flooding dating back to at least 1864/5 with the main risk area at Insch. In addition to direct flood risk from the fluvial Shevock, flood risk at Insch is complicated by the influence of three small watercourses (the Valentines, Mill of Rothney and Newton of Rothney Burns). Hydrology estimates were required as input to a linked 1D/2D hydraulic model of the Shevock for use in flood mapping. Those estimates included the following.

- **Peak flow estimates** on the:
  - **The Shevock at the upstream boundary of the model.** The FEH Statistical pooling approach has been adopted with a GL distribution and following investigation of several potential donor sites, the Deveron at Avochie (9001) used to adjust QMED. Peak flows at this location will be input directly to the model. The 0.5% Annual Probability (AP, 200 year flood) event was estimated to be circa 17.71 m^3/s.
  - **The Shevock at the River Urie confluence**. The FEH Statistical pooling method was adopted with a GEV distribution and using the Deveron at Avochie as a donor for QMED. The 0.5% Annual Probability (AP, 200 year flood) was estimated to be circa 24.42 m^3/s for the Shevock. These estimates will be used as a downstream model boundary check and comparisons made with both the GL and GEV distribution flows.
  - **Valentines Burn, Mill of Rothney Burn and Newton of Rothney Burn** at their confluence with the Shevock. A variety of methods were investigated for peak flow estimation, and the adopted method in each case was the FEH Rainfall Runoff method (on the basis of the FEH Rainfall Runoff method yielding similar time to peak values as those calculated from observed data a nearby small catchment gauge, the level only gauge at Mill of Keithfield). The 0.5% Annual Probability (AP, 200 year flood) was estimated to be 4.60 m^3/s, 4.70 m^3/s and 4.02 m^3/s for the Valentines, Mill of Rothney and Newton of Rothney Burns respectively using their default critical storm durations (these will be adjusted during model runs). With respect to modelling for design events, the peak flows from the FEH Rainfall Runoff method will be used to scale hydrographs derived from ReFH units within the model. Catchment areas within the ReFH units will be increased to account for additional inflows between major laterals. In cases where there is no suitable tributary a distributed lateral inflow will be used. Final determination of this will be made at the modelling stage.
- **Fluvial hydrographs and critical storm durations**. All watercourses are ungauged therefore hydrograph inputs into the hydraulic model will be represented by ReFH units scaled to the appropriate design flow. The critical storm duration for the Shevock based on the FEH Rainfall Runoff method is 9.25 h. The tributary watercourses have very different catchment areas and therefore storm durations. However, the difference between peak flows estimated using a long (9.25 h) and short (4.25 h) storm duration was found to be minimal, and a single duration of 9.25 h will be adopted for the hydraulic modelling.

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Abbreviations

1D	One Dimensional (modelling)
2D	Two Dimensional (modelling)
ALTBAR	Mean catchment altitude (m above sea level)
AMAX	Annual Maximum
ARF	Areal Reduction Factor
BFIHOST	Base Flow Index estimated from soil type
CWI	Catchment Wetness Index
DPLBAR	Index describing catchment size and drainage path configuration
DS	Downstream
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FPEXT	FEH index describing floodplain extent
FRM	Flood Risk Mapping
GEV	General Extreme Value Distribution
GL	General Logistic Distribution
mAOD	metres Above Ordnance Datum
NGR	National Grid Reference
OS	Ordnance Survey
OS NGR	Ordnance Survey National Grid Reference
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
RR	Rainfall-Runoff
SAAR	Standard Average Annual Rainfall (mm)
SCF	Spreadsheet compatible format (file from Hydrolog)
SEPA	Scottish Environment Protection Agency
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff estimated from soil type
TBR	Tipping Bucket Raingauge
Tp	Time to Peak
URBEXT	FEH index of fractional urban extent
Z	Statistical significance indicator

1 Introduction

1.1 Report objectives and approach

The purpose of this report is to provide details of the hydrology required to drive the hydraulic modelling and associated flood mapping for The Shevock from just upstream of Insch at approximate Ordnance Survey National Grid Reference (OS NGR) NJ 59800 28380 to its confluence with the River Urie downstream of Insch at OS NGR NJ 66972 28621. Peak flow estimates were required for the following watercourses:

- The Shevock at the upstream and downstream extent of the model. The upstream peak flows will form a direct model input and the downstream peak flows will be used for checking model outputs.
- The Valentine Burn and two unnamed tributaries (Newton of Rothney and Mill of Rothney) at Insch. In addition, during hydraulic modelling, all tributaries >3 km^2 that discharge into The Shevock will be included as lateral inflows e.g. using ReFH units.
- In addition, the Burn of Keithfield was important for storm duration analysis for the small burn catchments.

FEH Statistical and a variety of Rainfall Runoff alternatives were explored for peak flow estimation. The recommended values are provided within the main body of the report with supplementary information provided in the Appendix.

The hydrographs required for the hydraulic modelling will utilise a ReFH hydrograph which will be scaled to the peak flows recommended in this report. This will be undertaken within the modelling software at the modelling stage.

1.2 Catchment summary and relevant hydrometry

The Shevock is a western tributary of the River Urie. It originates approximately 10 km northwest of Insch in the region of Gartly Moor and flows south and then east towards the town. It has a catchment area of approximately 40 km^2 at its confluence with the Urie, approximately 4 km downstream of Insch. In addition to the main Shevock, several sub catchments were of interest in this study including the right bank Mill of Rothney and Newton of Rothney tributaries and the left bank Valentines Burn (Figure 1-1). Historical flooding has been recorded on The Shevock since 1864/5 (section 2). There are no formal or informal flood defences in the area.

Elevation ranges from approximately 420 metres above Ordnance Datum (mAOD) at Gartly Moor to 90 mAOD at the Shevock-Urie confluence. The average annual rainfall is 868 mm (catchment descriptors derived from the FEH CD-ROM v3 for The Shevock at the Urie confluence). The catchment is predominantly rural ($URBEXT_{2000}$ of 0.0078). The underlying bedrock geology is Ordovician to Silurian aged igneous and metamorphic units overlain by superficial glacial deposits[1]. The overall catchment is dominated by relatively impermeable bedrock and superficial deposits and will therefore exhibit a moderate response to rainfall as reflected in the catchment BIFHOST (baseflow index based on soil type) of 0.569 and SPRHOST (standard percentage runoff based on soil type) of 32%. Catchment descriptors for the catchment are summarised in Table 1-1and Table 1-3.

There are no gauging stations within the catchment. The nearest primary gauging station (which records both stage and flow over high and low flows) is the Urie at Pitcaple (SEPA gauging station number 11004) located on the River Urie approximately 7 km downstream of the Shevock- Urie confluence. The Urie at Old Rayne (11007) is a level only gauge on the River Urie located approximately 350 m downstream of the Shevock-Urie confluence. The Mill of Keithfield is a level only gauge located approximately 21 km east of Insch and was used in storm duration analysis for the smaller watercourses. Catchment descriptors of potential QMED donor gauges are provided in Table 1-2. Raingauge coverage is also limited: Insch No.2 at Insch and Old Mill of Newton near the Shevock confluence with the Urie are the closest raingauges. Milton of Noth and Cabrach are located to the west of Insch near the headwaters. Rothienorman to the northeast of Insch was used for storm duration analysis at Mill of Keithfield. A summary of relevant hydrometry is provided in Table 1-4 and the locations of peak flows in Figure 1-2.

1 British Geological Survey http://mapapps.bgs.ac.uk/geologyofbritain/home.html [Accessed: December 2017]

Table 1-1: Catchment Descriptors for the Shevock flow estimation points

Catchment Descriptors	The Shevock at the Urie confluence	The Shevock downstream of Newton of Rothney	The Shevock upstream of the Mill of Rothney	The Shevock at the upstream model boundary
Area (km^2)	40.25 adjusted (39.53 default)	35.65 adjusted (35.09 default)	25.20 adjusted (24.59 default)	21.25 default (21.90 adjusted)
ALTBAR (m above sea level)	204	214	238	247
BFIHOST	0.569	0.569	0.571	0.566
DPLBAR (km)	9.74	6.74	6.99	4.45
FARL	1	1	1	1
FPEXT	0.0417	0.0397	0.03	0.0299
SAAR (mm)	868	874	891	898
SAAR4170 (mm)	867	876	890	896
SPRHOST (%)	32.32	32.45	32.95	33.49
URBEXT 1990	0.007 adjusted (0.0068 default)	0.008 adjusted (0.0077 default)	0.001 adjusted (0.001 default)	0.000 adjusted (0.000 default)
URBEXT 2000	0.008 adjusted (0.0078 default)	0.009 adjusted (0.0087 default)	0.000 adjusted (0.000 default)	0.000 adjusted (0.000 default)

Table 1-2: Catchment Descriptors for the potential QMED donors

Catchment Descriptors	The Deveron at Avochie gauging station (SEPA station no. 9001)	The Bogie at Redcraig gauging station (SEPA station no. 9004)	The Urie at Pitcaple gauging station (SEPA station no. 11004)
Area (km^2)	444.91 default	182.43 default	195.60 adjusted (195.44 default)
ALTBAR (m above sea level)	329	297	206
BFIHOST	0.505	0.567	0.562
DPLBAR (km)	29.26	14.51	15.36
FARL	0.998	0.998	0.996
FPEXT	0.0343	0.0313	0.0458
SAAR (mm)	988	955	0.411
SAAR4170 (mm)	1078	1045	870
SPRHOST (%)	37.32	32.61	882
URBEXT 1990	0.0017 default	0.0012 default	0.003 adjusted (0.0028 default)

Table 1-3: Catchment descriptors for the tributaries

Catchment Descriptors	Valentines Burn	Mill of Rothney	Newton of Rothney	Mill of Keithfield
Area (Km^2)	3.18 adjusted (3.23 default)	3.40 adjusted (3.21 default)	2.76 adjusted (2.69 default)	18.36 default
ALTBAR (m above sea level)	152	173	150	112
BFIHOST	0.561	0.573	0.565	0.587
DPLBAR (km)	1.73	1.99	1.52	3.55
FARL	1	1	1	0.998
FPEXT	0.0558	0.056	0.0613	0.0415
FPDBAR	0.41	1.188	0.397	0.332
SAAR (mm)	833	847	832	831
SAAR4170 (mm)	834	865	833	819
SPRHOST (%)	31.44	30.89	31.26	28.82
URBEXT 1990	0.029 adjusted (0.027 default)	0.000 adjusted (0.000 default)	0.000 adjusted (0.000 default)	0.0003 adjusted (0.0003 default)
URBEXT 2000	0.038 adjusted (0.037 default)	0.000 adjusted (0.000 default)	0.000 adjusted (0.000 default)	0.0001 adjusted (0.0001 default)

Table 1-4: Hydrometry summary

Station number	Watercourse	Name	Type	Periods of record (water years)	Comments
11004	Urie	Pitcaple	Primary	1984 - present	The gauge at Pitcaple is located in an open channel section (with cableway) of the River Urie c. 10 m upstream of a minor road bridge. A further two bridges are located c. 1.8 km downstream of the gauging station. The stilling well is located in the gauging hut on the left bank and provides telemetered level data in real time. The level record dates from 1984. The minor bridge is deemed to have a significant influence on water levels at the gauge. The two downstream bridges are not deemed to influence water levels. During floods, bypassing occurs where water cuts the meander upstream of the gauge flowing over the right-hand floodplain. It re-joins the river downstream of the gauging station. Gaugings pre-1988 referenced to a different datum. A new rating was developed by JBA Consulting on behalf of SEPA using a 1D unsteady hydraulic model. This rating will be checked using linked

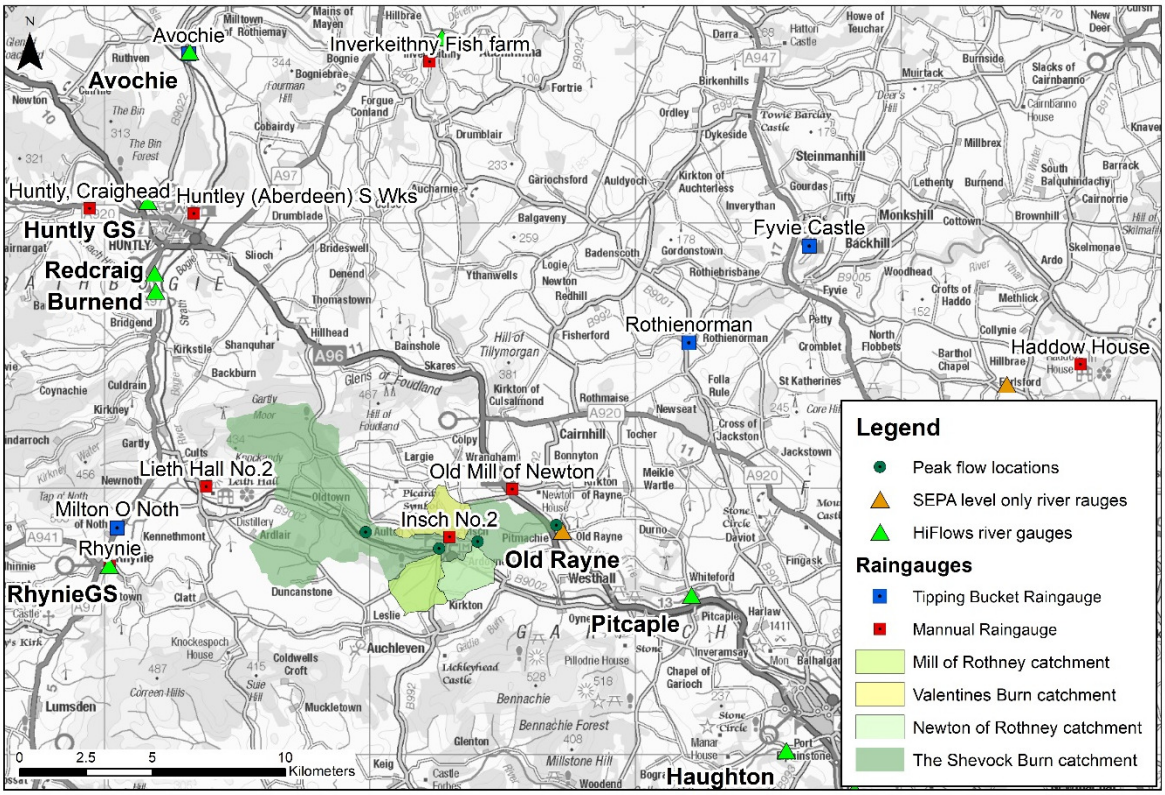
					1D/2D modelling being undertaken for Aberdeenshire Council as part of the Inverurie study.
11007	Urie	Old Rayne	Water level gauge	2009 - 2015	Level only gauge. Site closed due to issues with location. Limited record of suitable data. Non-cableway site. Minimal higher gaugings due to logistics[2].
9004	Bogie	Redcraig	Primary	1980-2016	Considered for use as a QMED donor. The gauge at Redcraig is located in an open channel section with cableway. There is a stable broken rubble weir control. The site is cableway gauged. The peak flow rating was derived from current meter gauging's up to 39 cumecs (about 1.2 QMED); simple extrapolation beyond. It has good low flow calibration but bypassing occurs at flows above 1.8m, water shortcuts the bend of the river on right bank (RB). There is a gauge board record downstream (DS) of site for 1973-1981. The gauge board was lowered in May 1996 and again in November 2003. Two peak flow ratings pre and post change of gauge board have been derived by SEPA[3].
9001	Deveron	Avochie	Primary	1959-2016	QMED donor. The gauge at Avochie is a velocity area station approximately 35 m wide. It is cableway rated with stable rubber weir control, rather insensitive. The inlet pipes periodically silted in early 1980's, extended in March 1985. Peak flow rating was revised in 1999 and a new single rating was judged to be suitable for whole period of record. Well-fitted rating derived from current meter gauging, simple extrapolation beyond. Some gaugings up to 2.1 m. Rating revised in 2016[3].
10004	Keithfield Burn	Mill of Keithfield	Primary	2009 - present	Used in basic LAG analysis to inform storm duration and choice of peak flow estimate method. Level only gauge, non-cableway site. Suffers from weed issues during the summer months. Ratings

2 Email correspondence with Danni Murren (SEPA) dated 09/01/2018.

3 NRFA. http://nrfa.ceh.ac.uk/data/search Accessed April 2018.

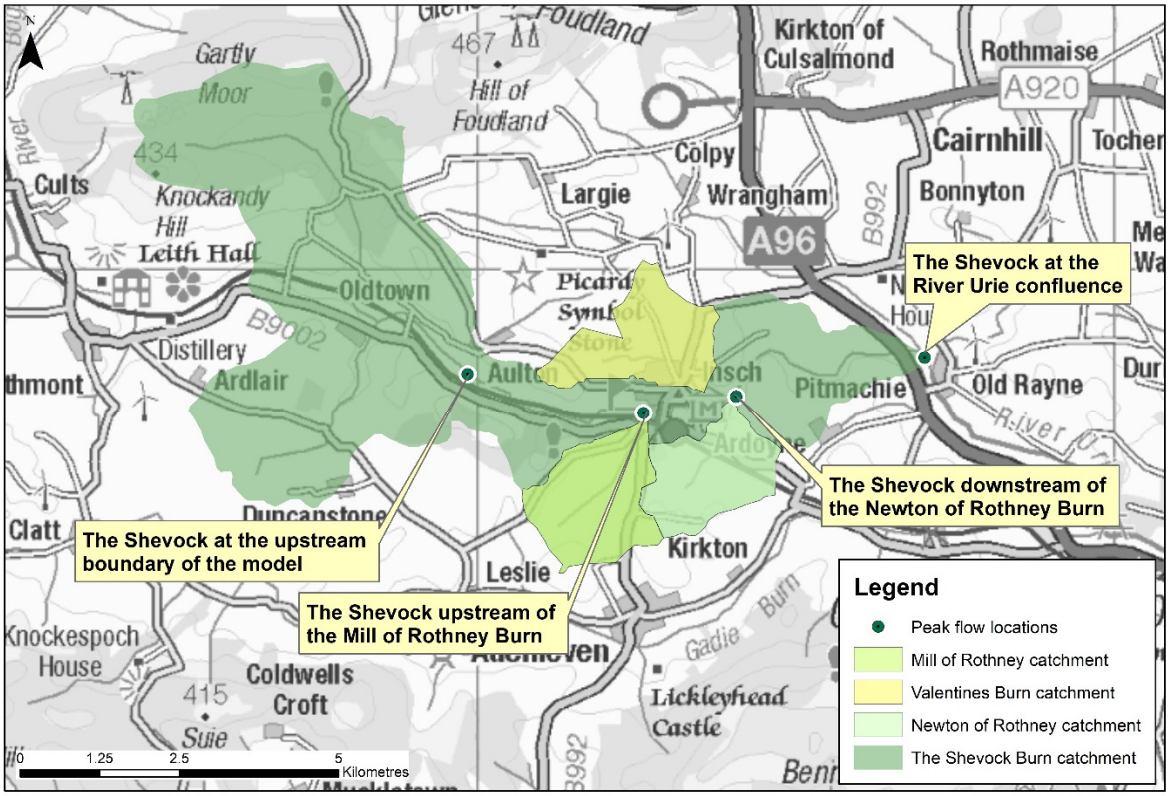
					under review[2].
367364	-	Old Mill of Newton	Raingauge	Tipping bucket raingauge	Raingauge located to the northeast of Insch. Used in basic storm duration analysis along with Old Rayne river gauge.
115239	-	Rothiemorman	Raingauge	Tipping bucket raingauge	Raingauge located 11.5 km to the northeast of Insch. Used in basic storm duration analysis along with Mill of Keithfield river gauge.
	-	Insch No.2	Raingauge	Manual	SEPA raingauge located at Insch to be used for observed rainfall inputs for the laterals.
11523	-	Milton of Noth	Raingauge	Tipping bucket raingauge	High catchment raingauge located in 'frost pocket' areas so suffer more ice and snow than other gauges. Data from 2009[4].
234176	-	Cabrach	Raingauge	Tipping bucket raingauge	Approx. 26 km west of Insch. High catchment raingauge located in 'frost pocket' areas so suffer more ice and snow than other gauges[4].

Figure 1-1: Catchment and hydrometry



4 Email correspondence with Danni Murren (SEPA) email dated 09/03/18.

Figure 1-2: Catchment peak flow locations



2 Flood History

2.1 Introduction

The Shevock has been susceptible to flooding over the past several decades with the earliest recorded flooding dating back to 1864/5 (Table 2-1). Insch falls within Potentially Vulnerable Area (PVA) 06/11 and has a history of flooding. Flood risk is primarily from the Shevock but also the Valentines Burn on the left bank, additionally Insch has experienced pluvial flooding. The worst flooding occurred in November 2002 resulting in evacuation of the nursing home and closure of roads and railway.

A review of historic flooding was carried out using data collected from the following: Aberdeenshire Council, the Scottish Environment Protection Agency (SEPA), the Chronology of British Hydrological Events (CBHE) and readily available internet sources. The historical flood record for Insch is documented in Table 2-1 below.

Table 2-1: Historical Flood Events

Date	Description	Source
1864	Overtopping of Shevock Burn resulting in flooding. *[No specific date given, could be the 1865 flood referenced in terms of water year]*	SEPA FRM Strategy[5]
1865	1865 January: "The Shirach Burn [Urie tributary] at Insch, which, like the dangerous Rothes burn, rises rapidly, was sweeping down on the fields below on Thursday, and must be worse now (Friday morning), as the wind is blowing very strong." - Edinburgh Courant. [R. Don]	CBHE[6] (assumed to refer to the Shevock)
1879	Railway line flooded from a burn in Insch	SEPA FRM Strategy[5]
1903	Overtopping of Shevock Burn resulting in minor damage	SEPA FRM Strategy[5]
1930	Overtopping of Shevock Burn resulting in minor damage	SEPA FRM Strategy[5]
1995	Colloquial evidence of flooding to a nursing home in Insch, although no SEPA evidence to confirm this event	SEPA FRM Strategy[5]
2002	Highest impact flood on record occurred in November 2002, when a nursing home had to be evacuated due to flooding by the Shevock Burn; residential properties were also affected.	SEPA FRM Strategy[5]
	"Flooding has closed a number of roads and a large part of the Aberdeen to Inverness railway line…Heavy rain in the area has made conditions hazardous. Railtrack said the rail line had been closed between Forres and Insch due to four separate instances of flooding."	BBC News http://news.bbc.co.uk/1/hi/scotland/2481223.stm? [Accessed: 16.11.17]
	"At Insch in Aberdeenshire, 41 elderly residents of a nursing home had to be carried to safety by firefighters after the Shevock Burn, a tributary of the River Urie, bust its banks, leaving 3ft of water surrounding the single-storey building."	The Scotsman https://www.scotsman.com/news/worst-flooding-in-30-years-1-629853 [Accessed: December 2017]
	Drumdaroch House and Willow Bank, Insch Flood photos	Supplied by SEPA
2004	June 2004 - Shevock Burn overtopped affecting properties in southwest Insch. Floods were exacerbated by drainage systems being unable to cope with the heavy rain.	SEPA FRM Strategy[5]
	August 2004 - Valentine Burn overtopped affecting	SEPA FRM Strategy[5]

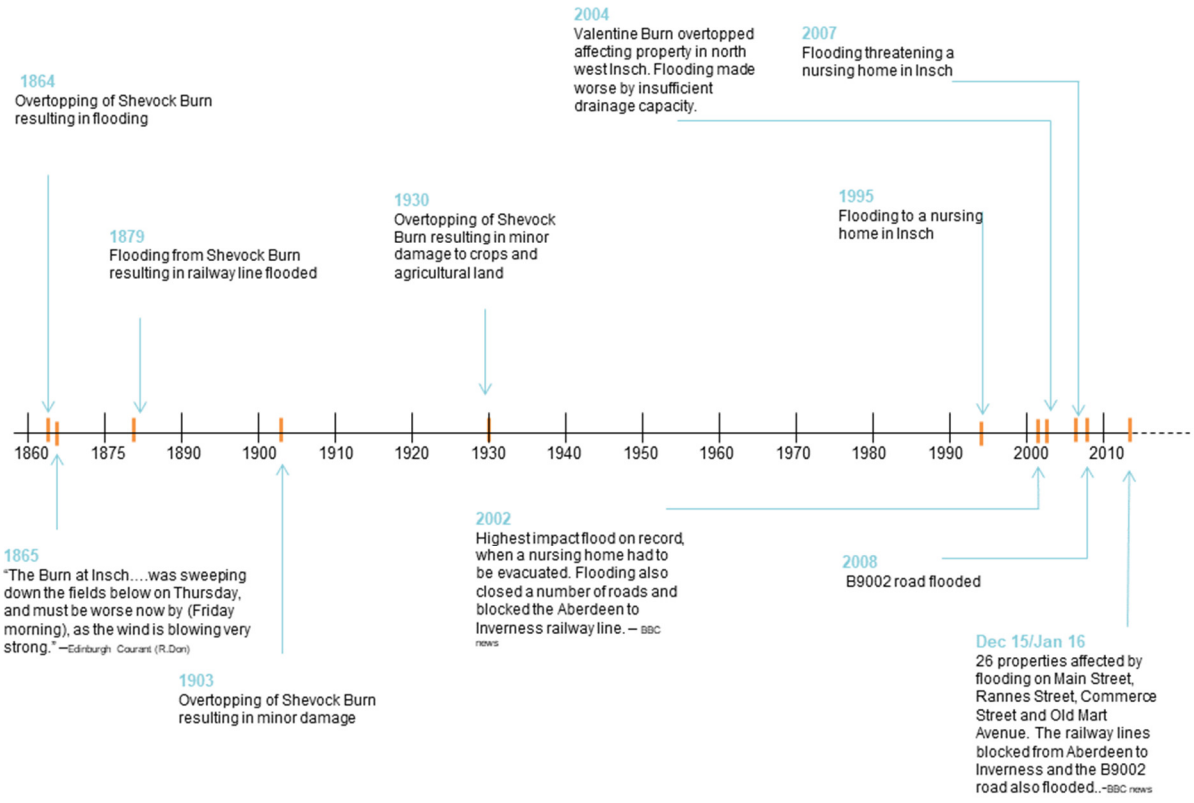
5 North-East Flood Risk Management Strategy http://apps.sepa.org.uk/FRMStrategies/pdf/lpd/LPD_06_Full.pdf [Accessed: 10 November 2017]

6 British Chronology of Hydrological Events http://cbhe.hydrology.org.uk/results.php [Accessed: December 2017]

	property in north west Insch. Floods were exacerbated by drainage systems being unable to cope with the heavy rain.	
2007	"…firefighters had to pump away flood water threatening a nursing home, which has 39 residents, at Insch in Aberdeenshire."	BBC News, found online at: < http://news.bbc.co.uk/1/hi/scotland/north_east/7107078.stm> [Accessed:16.11.17]
2008	B9002 flooded due to surface water flooding	SEPA FRM Strategy[5]
2015	26 properties damaged as a result of flooding events in December 2015	SEPA FRM Strategy[5]
2016	"later flooding near Insch again disrupted rail travel" in January 2016	BBC News < http://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-35254350> [Accessed: 16.11.17]
	Photographs of flooding at Insch Airfield	Grampian Microlight and Flying Club < https://www.gmfc-insch.co.uk/index.php/news/50-flooding-january-2016> [Assessed: 16.11.17]

In summary, Insch has experienced flooding in 1864, 1865, 1879, 1903, 1930, 1995, 2002, 2004, 2007, 2008, 2015 and 2016. Key events are summarised below in Figure 2-1.

Figure 2-1: Key flood events in Insch



2.2 Previous Flood estimates

EnviroCentre undertook a surface drainage network review at Insch in 2005[7]. The study considered the capacity of the drainage network through Insch and included estimation of peak flows on the Shevock and Valentines Burn. A Statistical Pooling and a 'catchment characteristics'[8] approach were considered for peak flow estimation. "On the basis of the diversity in location and limited station year data for a homogenous fit, it [was] decided to adopt a conservative approach and use the higher flows generated by the catchment characteristics methods for design flows"[7]. These peak flow estimates are provided in Table 2-2. It should be noted the catchment area of Shevock was to its confluence with the Valentines Burn.

Table 2-2: Peak flow estimates from the 2005 EnviroCentre study

Return Period (years)	Annual Probability [AP] (T)	The Shevock using catchment descriptors (m^3/s)	Valentines Burn using catchment descriptors (m^3/s)
2	50	10.81	1.68
5	20	14.95	2.39
10	10	17.70	2.83
25	4	22.68	3.51
50	2	26.43	4.06
100	1	30.31	4.74
200	0.5	34.66	5.50
200 +CC	0.5	43.07	6.85

7 Envirocentre. December 2005. Insch Drainage Study. Report No. 1948.

8 No details were provided within the report as to the technique used for the catchment characteristic approach

3 Flood Estimation: The Shevock and Overall Approach

3.1 Peak flows: overall approach

Important inputs into a flood study are the analysis of historic floods (where data are available), and estimation of flood flows for a range of annual probabilities or 'design' events. Flood estimates for catchments of this size and type are undertaken using the Flood Estimation Handbook (FEH). The FEH offers three methods for analysing design flood flows: the Statistical, the Rainfall Runoff, and hybrid methods. The Statistical method combines estimation of the median annual maximum flood (QMED) at the subject site with a growth curve, derived from one of three methods; (a) a pooling group of gauged catchments that are considered hydrologically similar to the subject site, (b) through single site analysis of a nearby gauge, or (c) a combination of the two through the use of enhanced single site. The Rainfall Runoff method combines design rainfall with a unit hydrograph derived for the subject site (the Rainfall Runoff method has recently been updated as ReFH2[9]). Hybrid methods involve a combination of the two. Both the Statistical and Rainfall Runoff procedures require the derivation of catchment descriptors. For this study these were initially abstracted digitally using the FEH CD ROM v3 for the Shevock and FEH Webservice for the tributaries in order to obtain FEH13 rainfall.

Adjustments were then made to the catchment area (using OS background mapping) and URBEXT (using the national growth model through the year of study, 2018, per FEH Volume 5). The FEH CD-ROM BFIHOST values appeared reasonable in comparison to the available geological information.

The Statistical Pooling method was selected as the most appropriate choice of peak flow estimation for The Shevock. This was because of the relatively large (40 km^2) rural nature of the catchment and acceptable homogeneity of the pooling group. For the smaller tributary catchments, comparisons were made between the Statistical method and different Rainfall Runoff methods. Following this comparison, and hydrological analysis of a nearby hydrologically similar catchment at Mill of Keithfield, it was assumed that the most appropriate approach for the Valentines, Newton of Rothney and Mill of Rothney Burns was to use the Rainfall Runoff method. A 24% climate change allowance upon the 3.33% AP (30 year) and 0.5% AP (200 year) event was applied, as per SEPA guidance for Local Authority studies for the Aberdeenshire region[10].

In addition to peak flow estimates, the hydraulic model also required the following information:

- Fluvial hydrographs for the model upstream limit on The Shevock, and also the Valentines Burn, Mill of Rothney Burn and Newton of Rothney Burns.
- Appropriate storm duration(s) for flood mapping.

These items are discussed in the following sections.

9 Wallingford Hydro Solutions (WHS) The Revitalised Flood Hydrograph, ReFH2: Technical Guidance, 2015
10 SEPA Flood Modelling Guidance for Responsible Authorities, Version 1.0.

3.2 The Shevock Flood Estimation

3.2.1 Peak flow estimation

The Shevock is rural and of moderate size (circa 40 km^2 at its confluence with the Urie). The Statistical method was therefore anticipated to be the most appropriate approach for peak flow estimation (Table 3-2). Peak flow estimates were required at:

- Just upstream of the confluence with the Urie (for comparison with model outputs; this is also the model downstream extent).
- Downstream of the Newton of Rothney Burn (for comparison with model outputs and providing an indication of lateral flow amounts).
- The model upstream extent (for direct input to the model).
- Upstream of the Mill of Rothney Burn (for comparison with model outputs and providing an indication of lateral flow amounts).

These estimates are described as follows.

3.2.1.1 Model upstream extent and upstream of the Mill of Rothney

Peak flow estimates for The Shevock were required upstream of the Mill of Rothney tributary (west of Insch) and at the upstream model boundary. A pooling group of catchments deemed hydrologically similar to the catchment of interest upstream of Mill of Rothney was derived within WINFAP. Adjustments were made to the default pooling group to remove sites that were discordant or hydrologically dissimilar (e.g. those with a very high BFIHOST), or add sites until a suitable pooling group size was achieved. WINFAP indicated the final pooling group to have an acceptably homogenous fit and both the General Extreme Value (GEV) and the General Logistic (GL) distributions were considered for use for the growth curve. The Z statistic approach available within WINFAP indicated both the GL and GEV distributions were acceptable, with the GL distribution giving a marginally better fit (0.959 compared to -0.966 respectively).

The Deveron at Avochie gauging station (9001), Bogie at Redcraig (9004) and Urie at Pitcaple (11004) were considered as possible QMED donors. The Urie at Pitcaple is the nearest gauge to the site of interest and is also closest in terms of catchment descriptors (Table 1-2). However, there are few high flow gaugings at Pitcaple and the value of QMED is sensitive to the choice of rating. For example, application of the new rating developed by JBA in December 2017[11] yields a QMED value of 31.15 m^3/s (this rating has yet to be confirmed with SEPA) and application of the existing SEPA rating yields a QMED value of 28.93 m^3/s. Use of Pitcaple would also have resulted in a QMED adjustment factor for the Shevock of less than one which may or may not be correct. Pitcaple was therefore not selected as a donor for The Shevock.

With respect to the alternative donors, the Bogie at Redcraig suffers from possible bypassing[12] and was therefore also deemed unsuitable. The Deveron at Avochie has a long period of record (59 years) and a well fitted rating that was recently updated. The catchment is immediately adjacent to the Urie catchment and similarly to Pitcaple recorded the highest flows on record during the 2009 and 2002 events. The catchment has a fairly similar geology and soil type and a review of the catchment descriptors deemed it suitable for use as the QMED donor, with the exception of area which is considerably greater (442 km^2). Therefore, the Deveron at Avochie was selected as the final QMED donor and resulted in an adjusted QMED of 6.30 m^3/s for The Shevock upstream of the Mill of Rothney. The 0.5% AP (200 year) flow was estimated to be 19.28 m^3/s.

For consistency, peak flow estimates for the upstream model boundary were derived using the same growth curve, distribution and QMED donor. This gives a QMED of 5.80 m^3/s and 0.5% AP (200 year) flow of 17.71 m^3/s at the model upstream boundary. Estimates are provided in Table 3-1 and the growth curves in Figure 3-1. Peak flow estimates at the upstream model boundary were also calculated using the FEH Rainfall Runoff method for comparative purposes only and are given in Table 3-1.

11 2017s6610. River Don Flood Map: Pitcaple Gauging Station Rating Review. Final Report v2.0. December 2017.
12 NRFA. 9004. Bogie at Redcraig. Accessed April 2018.

3.2.1.2 Upstream of the Urie confluence and downstream of the Newton of Rothney Burn

Peak flow estimates for the Shevock were also required at the model downstream boundary (Shevock/ Urie confluence) and downstream of the Newton of Rothney Burn. A different pooling group to that upstream of Mill of Rothney was derived within WINFAP and similarly adjusted to remove discordant sites. The final pooling group was deemed acceptably homogenous. The Z statistic approach available within WINFAP indicated that the GEV distribution had the best goodness of fit compared to the GL (0.750 compared to 3.3453) and the GEV was adopted for the growth curve (Figure 3-2). The Deveron at Avochie was selected as the QMED donor for the reasons stated above and resulted in an adjusted QMED of 9.04 m^3/s for the Shevock at the Urie confluence and a 0.5% AP (200 year) flow of 24.42 m^3/s. Peak flow estimates at the downstream model boundary were also calculated using the FEH Rainfall Runoff method for comparative purposes only and are given in Table 3-2.

Peak flow estimates were also calculated downstream of the Newton of Rothney tributary, at the eastern extent of Insch for the purpose of checking flows downstream of the Insch laterals during the hydraulic modelling exercise. For consistency, these estimates were derived using the same growth curve, distribution and QMED donor as at the downstream point of the Shevock (above). These estimates are provided in Table 3-3. Peak flow estimates at the Urie confluence will be used as a final downstream model boundary check with comparisons made between both the GL and GEV estimates.

3.2.1.3 Summary of flow estimate locations and approaches

To summarise, peak flow estimates were derived for the following locations as follows:

1. The Shevock upstream of the Mill of Rothney Burn derived using the Statistical pooling method but with a different pooling group to the downstream locations, and a GL distribution with the Deveron at Avochie as QMED donor.
2. The upstream model boundary derived using the same growth curve, distribution and donor as the Shevock at Mill of Rothney.
3. The Shevock at the River Urie confluence using the Statistical pooling method with GEV distribution and the Deveron at Avochie as QMED donor
4. The Shevock downstream of the Newton of Rothney Burn using the same growth curve, distribution and QMED donor as the downstream point of the Shevock.

Table 3-1: Peak flow estimates on The Shevock upstream of the Mill of Rothney and upstream model boundary with adjusted area and default storm duration

Annual probability [AP] (%)	Return Period (years)	Upstream of Mill of Rothney Statistical Pooling GEV flow (m^3/s)	Upstream of Mill of Rothney Statistical Pooling GL flow (m^3/s)	Upstream model boundary Statistical Pooling GL flow (m^3/s)	Upstream model boundary FEH Rainfall Runoff flow (m^3/s)
50	2	6.31	6.31	5.80	8.26
20	5	8.76	8.53	7.84	11.5
10	10	10.44	10.14	9.32	13.48
4	25	12.63	12.46	11.45	17.18
3.33	30	13.07	12.96	11.91	17.96
2	50	14.31	14.45	13.28	20.31
1.33	75	15.32	15.74	14.46	21.94
1	100	16.03	16.71	15.35	23.32
0.5	200	17.79	19.28	17.71	26.91
0.2	500	20.19	23.24	21.35	32.52
0.1	1000	22.06	26.75	24.57	38.41
3.33 +cc	30 +cc	16.21	16.07	14.77	22.27
0.5+ cc	200 +cc	22.06	23.90	21.96	33.37

Table 3-2: The Shevock at the River Urie confluence (with adjusted area and default storm duration) peak flow estimates

Annual probability [AP] (%)	Return Period (years)	Statistical Pooling GL flow (m^3/s)	Statistical Pooling GEV flow (m^3/s)	FEH Rainfall Runoff flow (m^3/s)
50	2	9.04	9.04	11.70
20	5	12.39	12.76	16.12
10	10	14.71	15.15	19.53
4	25	17.92	18.12	24.53
3.33	30	18.60	18.69	25.61
2	50	20.58	20.27	28.88
1.33	75	22.26	21.50	31.15
1	100	23.51	22.36	33.06
0.5	200	26.74	24.42	38.05
0.2	500	31.55	27.07	45.81
0.1	1000	35.66	29.03	54.02
3.33 +cc	30 +cc	23.06	23.17	31.76
0.5 +cc	200 +cc	33.15	30.28	47.18

Table 3-3: Peak flow estimates on The Shevock downstream of Newton of Rothney with adjusted area

Annual probability [AP] (%)	Return Period (years)	Statistical Pooling GEV flow (m^3/s)
50	2	8.30
20	5	11.71
10	10	13.91
4	25	16.63
3.33	30	17.15
2	50	18.60
1.33	75	19.73
1	100	20.53
0.5	200	22.41
0.2	500	24.84
0.1	1000	26.64
3.33 +cc	30 +cc	21.27
0.5 +cc	200 +cc	27.79

Figure 3-1: The Shevock upstream of the Mill of Rothney growth curves

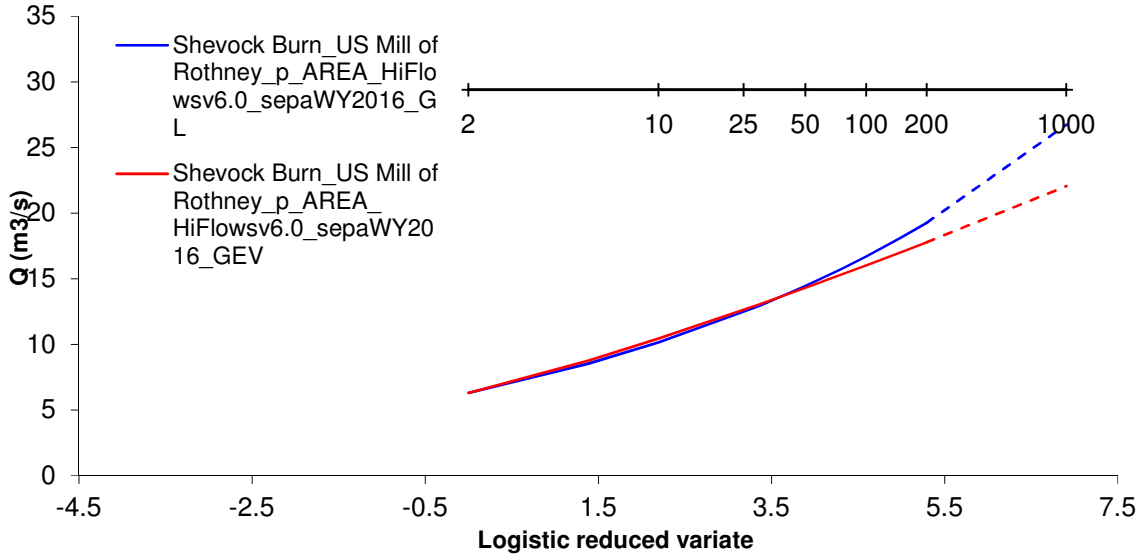
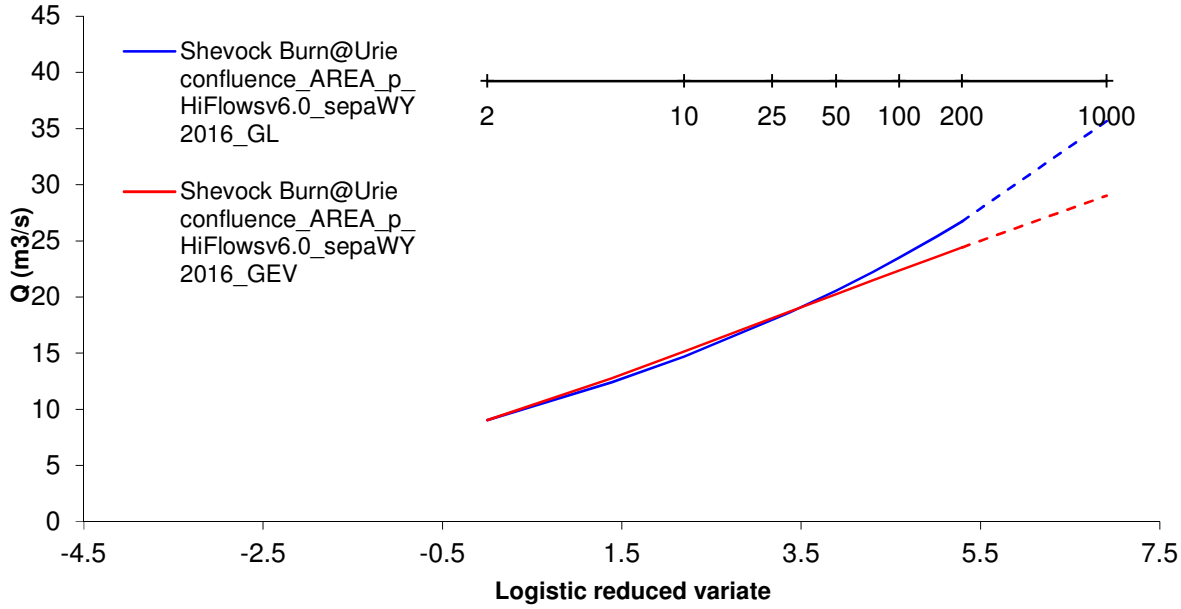


Figure 3-2: The Shevock at the Urie confluence growth curves



4 Flood Estimation: Valentines, Mill of Rothney and Newton of Rothney Burns

4.1 Peak flows: overall approach

The three tributaries at Insch are ungauged and have small catchment areas. A Rainfall Runoff type approach was therefore explored for flood estimation for those catchments, with checks also made using the FEH Statistical method. There are currently two main alternative rainfall runoff approaches which are accepted for use by SEPA in Scotland:

1. **FEH Rainfall Runoff (RR) method.** This is the traditional method which uses FEH99 rainfall information. An assumption of the FEH Rainfall Runoff method is that, for floods with AP values of greater than 0.1% (i.e. more frequent than 1000 years), the AP value of the underlying rainfall event is smaller than that of the flow event. For example, the 0.5% AP (200 year) event is estimated to be generated from a rainstorm with an AP value of 0.41% (247 years). An Areal Reduction Factor (ARF) is used to apply the point storm depth across the catchment and losses (used to calculate net rainfall) are calculated from Standard Percentage Runoff (SPR) and the Catchment Wetness Index (CWI).
2. **ReFH2.** This is the Revitalised Rainfall Runoff method, calibrated for Scotland and using FEH13 rainfall. FEH13 refers to an updated approach to the design rainfall calculation which is based on a more extensive rain gauge network than was available for FEH99 and should therefore be more accurate (ReFH2 can also optionally be run with FEH99 rainfall). In general, for Scotland, FEH13 often generates higher rainfall amounts for short duration storms than FEH99. An assumption of ReFH2 is that the AP value of the underlying rainfall event is equal to that of the flow event. For example, the 0.5% AP (200 year) event is estimated to be generated from a rainstorm with an AP value of 0.5% (200 years). ReFH2 uses both the ARF and also a Seasonal Correction Factor (SCF) to apply seasonally dependant rainfall across the catchment. Losses are calculated using a more formal representation of soil storage than that used in the FEH Rainfall Runoff method.

While both methods were considered for each site, following basic LAG analysis using available hydrometric data in the area (the Keithfield Burn at Mill of Keithfield and Rothienorman TBR), along with statistical pooling analysis, the RR methodology was selected as the most appropriate choice of peak flow.

4.1.1 Basic LAG analysis at Mill of Keithfield and Old Rayne

A search for suitable donor sites for use in storm duration analysis and possible adjustment of rainfall runoff parameters, as well as informing the choice of peak flow estimate method was undertaken. The nearest gauge to the sites of interest was Old Rayne, a level only gauge approximately 350 m downstream of the Shevock-Urie confluence. Basic LAG analysis at Old Rayne using the Old Mill of Newton raingauge (located approximately 2.5 km upstream of Old Rayne) was inconclusive due to issues with raingauge representivity. For example, the Old Mill of Newton raingauge is located low in the catchment at Old Rayne, far from the headwaters and may therefore not be wholly representative of upper catchment rainfall which can be an important indicator of flood response. In addition, the catchment area at Old Rayne is approximately 115 km^2, considerably larger than the tributary watercourses whose areas are < 3.5 km^2. It was therefore concluded that Old Rayne was not wholly suitable as a guide to small catchment response and an alternative, the Keithfield Burn at Mill of Keithfield, was considered.

The Keithfield Burn has a level only gauging station at Mill of Keithfield. This donor site is located approximately 17 km southwest of Insch and has a relatively steep catchment which drains east towards the River Ythan and has a catchment area of approximately 18 km^2. The geology of the area comprises metamorphic bedrock overlain with superficial glacial deposits. Land use is predominantly arable and pasture with some forest habitats. This catchment was therefore selected over Old Rayne because of its size, similarity (Table 1-3) and geographical closeness to the subject sites and for which both rainfall and stage data is available. The TBR at Rothienorman was selected as the source of a 15 min rainfall data. This rain gauge is located circa 9 km northwest of the Keithfield Burn catchment, but it is the neatest TBR to the upper catchment and was therefore used out of necessity (the nearest rain gauges were at Meldrum house and Haddow House, were located further downstream in the catchment away from the Keithfield Burn headwaters and are therefore likely to be less representative of rainfall in the upper catchment which is usually very important in

contributing to flood response; also note that Met Office rain gauge and radar data at the required 15 min interval were not available).

Observed hydrograph information from the Mill of Keithfield gauge was considered together with rainfall data from the Rothienorman TBR in order to provide an estimate of lag time (LAG) and therefore back calculate storm duration. Combined analysis of the top 8 events yielded a geometric mean LAG value of 5.85 h with a range of 2.7 h for the December 2012 event to 8.6 h for the December 2010 event. Back calculation from this LAG value yielded a Tp of 4.72 and a storm duration of 8.64 h. A similar storm duration was estimated at Mill of Keithfield using the FEH Rainfall Runoff method with catchment descriptors (Tp of 4.33 h and storm duration of 8.25 h). The ReFH2 methodology in contrast has a significantly different Tp and storm duration (Table 4-1). As the Keithfield Burn is similar in characteristics to the burns draining to the Shevock, it was assumed that the FEH Rainfall Runoff method would not need modification (with respect to Tp) if it was adopted for peak flow estimation. ReFH2 was less consistent with the observed analysis.

Table 4-1: Storm duration comparison at Mill of Keithfield

	Mill of Keithfield observed data	RR	ReFH2
Geomean LAG	5.85		
Tp	4.72	4.33	3.51
Duration (h)	8.64	8.25	6.50

4.1.2 Peak flow estimates for the Valentines, Mill of Rothney and Newton of Rothney Burns

A comparison of the methods used (statistical and rainfall runoff variants) are provided in the following tables.

In all cases, the following conclusions were made:

- The FEH Rainfall Runoff method gave the highest flow estimates for all the tributaries. For example, for Valentines Burn the 0.5% AP (200 year) event is estimated to be 3.42 m^3/s using the Statistical pooling method and 4.59 m^3/s using the RR method.
- The Rainfall Runoff approach gave the highest estimates, with the FEH Statistical giving similar results and then ReFH2. For example, for the Mill of Rothney Burn the RR method gave a 0.5% AP (200 year) flow of 4.62 m^3/s, Statistical pooling method 3.45 m^3/s and ReFH2 2.58 m^3/s.

Due to the catchment size of the tributaries a Rainfall Runoff approach is preferred, and based on the storm duration analysis at the nearby Mill of Keithfield, the Rainfall Runoff method was deemed more appropriate in this instance on The Shevock tributaries. The FEH RR method was therefore adopted for peak flow estimation for the Burns.

Table 4-2: Valentines Burn with adjusted area and default storm duration peak flow comparison

Annual probability [AP] (%)	Return Period (years)	FEH Rainfall Runoff flow (m^3/s)	ReFH2 with FEH13 rainfall flow (m^3/s)	Statistical Pooling GL flow (m^3/s)	Statistical Pooling GEV flow (m^3/s)
50	2	1.38	0.78	0.96	0.96
20	5	1.95	1.04	1.31	1.35
10	10	2.31	1.25	1.59	1.64
4	25	2.82	1.56	2.02	2.06
3.33	30	2.96	1.63	2.11	2.15
2	50	3.40	1.84	2.40	2.41
1.33	75	3.70	2.02	2.66	2.63
1	100	3.94	2.15	2.87	2.79
0.5	200	4.59	2.52	3.42	3.22
0.2	500	5.61	3.05	4.32	3.84
0.1	1000	6.67	3.48	5.16	4.37
3.33 +cc	30+cc	3.67	2.02	2.62	2.66
0.5+ cc	200+cc	5.69	3.12	4.24	3.99
Critical storm duration (hrs)		4.25	4.50		

Table 4-3: Mill of Rothney with adjusted area and default storm duration peak flow comparison

Annual probability [AP] (%)	Return Period (years)	FEH Rainfall Runoff flow (m^3/s)	ReFH2 with FEH13 rainfall flow (m^3/s)	Statistical Pooling flow GL (m^3/s)	Statistical Pooling flow GEV (m^3/s)
50	2	1.39	0.77	0.95	0.95
20	5	1.96	1.05	1.31	1.35
10	10	2.31	1.27	1.60	1.65
4	25	2.86	1.59	2.03	2.08
3.33	30	3.01	1.66	2.13	2.17
2	50	3.43	1.87	2.43	2.43
1.33	75	3.72	2.06	2.69	2.65
1	100	3.97	2.21	2.89	2.82
0.5	200	4.62	2.58	3.45	3.24
0.2	500	5.63	3.15	4.35	3.87
0.1	1000	6.70	3.61	5.19	4.39
3.33 +cc	30+cc	3.73	2.06	2.64	2.69
0.5+ cc	200+cc	5.73	3.20	4.28	4.02
Critical storm duration (hrs)		4.75	3.50		

Table 4-4: Newton of Rothney with adjusted area and default storm duration peak flow comparison

Annual probability [AP] (%)	Return Period (years)	FEH Rainfall Runoff flow (m^3/s)	ReFH2 with FEH13 rainfall flow (m^3/s)	Statistical Pooling GL flow (m^3/s)	Statistical Pooling GEV flow (m^3/s)
50	2	1.19	0.66	0.78	0.78
20	5	1.68	0.90	1.09	1.12
10	10	2.00	1.09	1.33	1.37
4	25	2.43	1.37	1.69	1.73
3.33	30	2.56	1.43	1.78	1.81
2	50	2.95	1.62	2.03	2.04
1.33	75	3.20	1.78	2.26	2.23
1	100	3.41	1.90	2.43	2.37
0.5	200	3.97	2.23	2.91	2.74
0.2	500	4.86	2.72	3.70	3.30
0.1	1000	5.79	3.13	4.43	3.77
3.33 +cc	30+cc	3.17	1.77	2.20	2.24
0.5+ cc	200+cc	4.92	2.77	3.61	3.40
Critical storm duration (hrs)		4.25	3.25		

4.2 Fluvial hydrographs, storm durations and lateral inflows for modelling of the Shevock

The Shevock is ungauged therefore ReFH unit hydrographs within FloodModeller will be used in the absence of observed hydrographs. The storm duration at the downstream boundary of the model will be based on the default FEH RR duration of 9.25 h. Two storm durations were considered for modelling, these were: 9.25 h based on the Shevock critical storm duration, and 4.25 h based on Valentine and Newton of Rothney critical storm durations. Peak flows for these storm durations using the FEH RR approach are given in the tables below. It can be seen there is a minimal difference in peak flow estimates between the two durations, with the 9.25 h duration giving slightly higher estimates. For example, the 0.5 % AP (200 year) peak flow on the Valentines Burn was 4.60 m^3/s using the 9.25 h storm duration and 4.59 m^3/s using the default 4.25 h duration (Table 4-5). As there is only a small difference between the peak flows estimated using the two durations, only one duration (9.25 h) will be modelled. In addition, as the model will use ReFH units scaled to various estimates (e.g. to the statistical estimate for the model upstream extent for the Shevock and the FEH Rainfall Runoff estimates for the various burns) and not FEH Rainfall Runoff units throughout, the single 9.25 h duration will be retained and no additional adjustments (e.g. optimisation within Flood Modeller) are proposed.

Additional lateral inflows to the Shevock will be modelled using ReFH unit hydrographs within Flood Modeller Pro scaled to the RR estimates for the design runs. Catchment areas within the ReFH units will be increased to account for any additional inflows or unaccounted area between major laterals. Where no suitable tributary is present a distributed lateral inflow will be used. Final determination of this will be made at the point of modelling.

A combined single model will be run for the various return periods for example, the 0.5% AP (200 year) return period event for both the Shevock and tributaries will be modelled simultaneously. The Statistical peak flow estimate at the Urie-Shevock confluence will be used to check flows at the downstream boundary with checks made against both the GL and GEV distribution estimates.

The catchment is ungauged therefore no data is available for calibration of Manning's 'n'. However, where possible, approximate simulation of observed events will be undertaken by running the various ReFH units with observed rainfall. For example, observed rainfall from November 2002 from rain gauges such as Insch No.2, Cabrach or Rothienorman will be used to drive the model and the output checked against the SEPA supplied trash line for that event (in the vicinity of Willowbank Place).

Table 4-5: RR peak flow estimates for the Valentines Burn for the two storm durations

Annual probability [AP] (%)	Return Period (years)	FEH Rainfall Runoff Storm duration 9.25 hours (m^3/s)	FEH Rainfall Runoff Storm duration 4.25 hours (m^3/s)
50	2	1.37	1.38
20	5	1.91	1.95
10	10	2.32	2.31
4	25	2.94	2.82
3.33	30	3.07	2.96
2	50	3.47	3.40
1.33	75	3.75	3.70
1	100	3.98	3.94
0.5	200	4.60	4.59
0.2	500	5.57	5.61
0.1	1000	6.58	6.67
3.33 +cc	30 +cc	3.81	3.67
0.5 +cc	200 +cc	5.70	5.69

Table 4-6: RR peak flow estimates for the Newton of Rothney Burn for the two storm durations

Annual probability [AP] (%)	Return Period (years)	FEH Rainfall Runoff Storm duration 9.25 hours (m^3/s)	FEH Rainfall Runoff Storm duration 4.25 hours (m^3/s)
50	2	1.19	1.19
20	5	1.66	1.68
10	10	2.02	2.00
4	25	2.56	2.43
3.33	30	2.68	2.56
2	50	3.03	2.95
1.33	75	3.27	3.20
1	100	3.48	3.41
0.5	200	4.02	3.97
0.2	500	4.86	4.86
0.1	1000	5.75	5.79
3.33 +cc	30 +cc	3.32	3.17
0.5 +cc	200 +cc	4.98	4.92

Table 4-7: RR peak flow estimates for the Mill of Rothney Burn for the two storm durations

Annual probability [AP] (%)	Return Period (years)	FEH Rainfall Runoff Storm duration 9.25 hours (m^3/s)	FEH Rainfall Runoff Storm duration 4.25 hours (m^3/s)
50	2	1.40	1.37
20	5	1.94	1.92
10	10	2.37	2.27
4	25	3.00	2.77
3.33	30	3.14	2.92
2	50	3.55	3.35
1.33	75	3.83	3.64
1	100	4.07	3.89
0.5	200	4.70	4.53
0.2	500	5.69	5.52
0.1	1000	6.73	6.58
3.33 +cc	30 +cc	3.89	3.62
0.5 +cc	200 +cc	5.83	5.62

5 Comparison with Previous Studies

The 2005 EnviroCentre study[7] compared peak flow estimates from a Statistical pooling and catchment characteristic approach for The Shevock and Valentines Burn. Those estimates, together with the peak flow estimates to be used in this study are listed in the tables below. In summary, the differences are as follows:

- The peak flows calculated using the Statistical pooling method are broadly similar between the 2005 EnviroCentre and 2018 JBA reports. For example, The Shevock 0.5 % AP (200 year) peak flow was estimated to be 29.01 m^3/s in 2005 and 22.41 m^3/s in 2018.
- The 2005 Envirocentre pooling method used a GL distribution while the present study uses a GEV distribution.
- The catchment characteristic and Rainfall Runoff methods gave the largest peak flow estimates. For example, the 0.5 % AP (200 year) peak flow on The Shevock was estimated to be 34.66 m^3/s in 2005 and 38.05 m^3/s in 2018 (Table 3-2).
- For the Valentines Burn the catchment descriptor methods obtained relatively similar results with 0.5 % AP (200 year) peak flow estimated to be 5.50 m^3/s in 2005 and 4.59 m^3/s in 2018. 2018 estimated peak flows were less than this using the ReFH2 and Statistical pooling methods. This also supports the use of the FEH RR method for The Shevock tributaries.

It should be noted there is a difference in study area between the 2005 and present study for The Shevock. The 2005 catchment area was to the confluence with the Valentines Burn covering an area of 32 km^2, compared to a catchment area of 40 km^2 at the Shevock-Urie confluence used in this study. Results above and in Table 5-1 have been quoted for The Shevock downstream of Newton of Rothney as the catchment area (35.65 km^2) is of greater similarity. Furthermore, 11 years of additional HiFlows-UK data with revised ratings and greater number of stations suitable for pooling, were available for the present study. Both of these factors will contribute to the difference in peak flow estimates between reports.

Table 5-1: The Shevock EnviroCentre 2005 and JBA 2018 peak flow comparison

Return Period (years)	Annual Probability [AP]	2005 EnviroCentre study The Shevock using catchment descriptors (m^3/s)	2005 EnviroCentre study The Shevock Statistical pooling (homogenous pooing group) (m^3/s)	2018 JBA study The Shevock downstream of Newton of Rothney Statistical pooling GEV (m^3/s)
2	50	10.81	6.69	8.30
5	20	14.95	9.96	11.71
10	10	17.70	12.49	13.91
25	4	22.68	16.36	16.63
50	2	26.43	19.88	18.60
100	1	30.31	24.04	20.53
200	0.5	34.66	29.01	22.41
200 +CC	0.5	43.07	37.09	27.79

Table 5-2: Valentine Burn EnviroCentre 2005 and JBA 2018 peak flow comparison

Return Period (years)	Annual Probability [AP] (T)	2005 EnviroCentre study Valentines Burn using catchment descriptors (m^3/s)	2005 EnviroCentre study Valentines Burn Statistical pooling (homogenous P group) (m^3/s)	2018 JBA study Valentines Burn Rainfall Runoff method (m^3/s)
2	50	1.68	0.72	1.38
5	20	2.39	1.02	1.95
10	10	2.83	1.26	2.31
25	4	3.51	1.61	2.82
50	2	4.06	1.93	3.40
100	1	4.74	2.30	3.94
200	0.5	5.50	2.75	4.59
200 +CC	0.5	6.85	3.47	5.69

6 Conclusions

The Shevock has a history of flooding dating back to at least 1864/5 with the main risk area at Insch. In addition to direct flood risk from the fluvial Shevock, flood risk at Insch is complicated by the influence of three small watercourses (the Valentines, Mill of Rothney and Newton of Rothney Burns). Hydrology estimates were required as input to a linked 1D/2D hydraulic model of the Shevock for use in flood mapping. Those estimates included the following:

- **Peak flow estimates** on the:
  - **The Shevock at the upstream boundary of the model.** FEH Statistical and Rainfall Runoff methods were investigated for peak flow estimation. The FEH Statistical pooling approach has been adopted with a GL distribution and the Deveron at Avochie (9001) used to adjust QMED. Peak flows at this location will be input directly to the model. The 0.5 % Annual Probability (AP, 200 year flood) event was estimated to be circa 17.71 m^3/s.
  - **The Shevock at the River Urie confluence**. FEH Statistical and Rainfall Runoff methods were investigated for peak flow estimation and the adopted method was the Statistical pooling approach with a GEV distribution and the Deveron at Avochie (9001) used to adjust QMED. The 0.5% AP (200 year flood) was estimated to be circa 24.42 m^3/s. This peak flow estimate will be used as a check at the downstream boundary of the model.
  - **Valentines Burn, Mill of Rothney Burn and Newton of Rothney Burn** at their confluence with The Shevock. A variety of methods were investigated for peak flow estimation, and the adopted method in each case was the FEH Rainfall Runoff method. The 0.5% AP (200 year flood) was estimated to be 4.60 m^3/s, 4.70 m^3/s and 4.02 m^3/s for the Valentine, Mill of Rothney and Newton of Rothney Burns respectively for their given critical storm duration.
- **Fluvial hydrographs and critical storm durations**. All watercourses are ungauged therefore hydrograph inputs into the hydraulic model will be represented by ReFH units scaled to the appropriate design flow. The critical storm duration for the Shevock based on the FEH Rainfall Runoff method is 9.25 h. The tributary watercourses have very different catchment areas and two storm durations were initially considered for modelling: one long (9.25 h, based on the Shevock) and one short (4.25 h, based on the Valentines and Newton of Rothney Burns). However, peak flows estimated using both durations were very similar and only the 9.25 h duration (which yields slightly higher peak flows) will be taken forward to the modelling.

Table 6-1: Summary of design peak flows

Annual Probability [AP] (%)	Return Period (years)	The Shevock at the upstream model boundary Statistical Pooling Method GL flow (m^3/s)	The Shevock at the River Urie confluence Statistical Pooling Method GEV flow (m^3/s)	Valentines Burn FEH Rainfall Runoff flow Storm duration 9.25 hours (m^3/s)	Mill of Rothney FEH Rainfall Runoff flow Storm duration 9.25 hours (m^3/s)	Newton of Rothney FEH Rainfall Runoff flow Storm duration 9.25 hours (m^3/s)
50	2	5.80	9.04	1.37	1.40	1.19
20	5	7.84	12.76	1.91	1.94	1.66
10	10	9.32	15.15	2.32	2.37	2.02
4	25	11.45	18.12	2.94	3.00	2.56
3.33	30	11.91	18.69	3.07	3.14	2.68
2	50	13.28	20.27	3.47	3.55	3.03
1.33	75	14.46	21.50	3.75	3.83	3.27
1	100	15.35	22.36	3.98	4.07	3.48
0.5	200	17.71	24.42	4.60	4.70	4.02
0.2	500	21.35	27.07	5.57	5.69	4.86
0.1	1000	24.57	29.03	6.58	6.73	5.75
3.33 +CC	30 +CC	14.77	23.17	3.81	3.89	3.32
0.5 +CC	200 +CC	21.96	30.28	5.70	5.83	4.98
0.5 specific discharge	200	0.83	0.61	1.45	1.38	1.46
Critical duration for modelling (h)		9.25	9.25	9.25	9.25	9.25

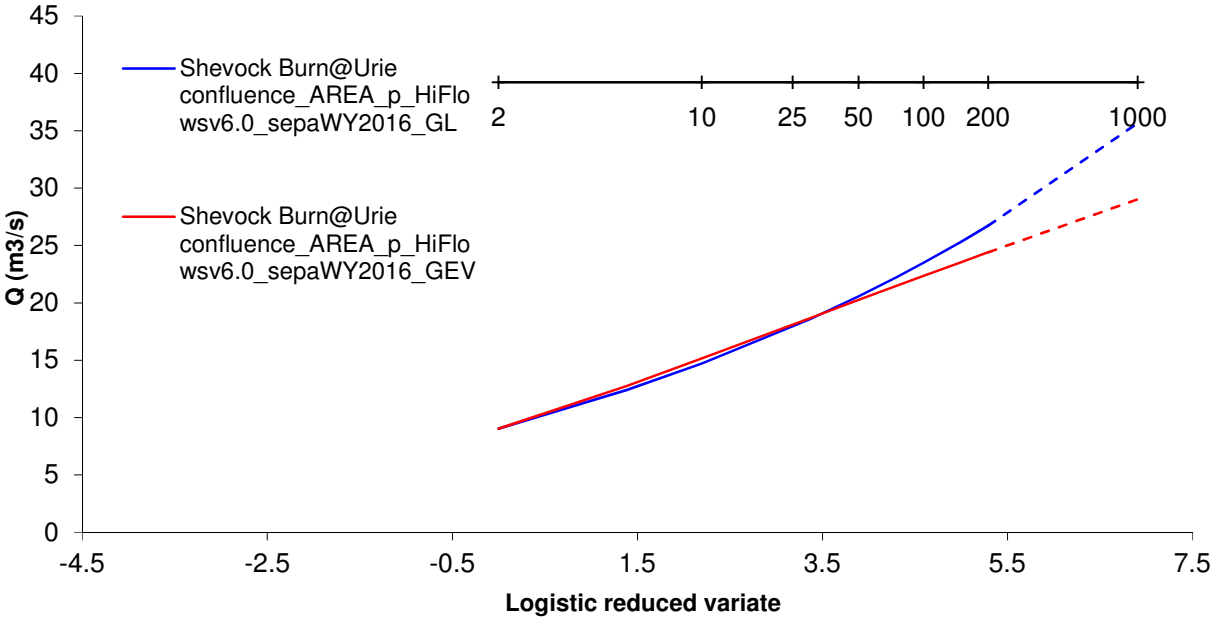
Appendices

A Statistical Method- Additional Outputs

This section provides further information on the statistical method.

A.1 The Shevock at Urie confluence

FEH STATISTICAL FLOOD ESTIMATION SUMMARY SHEET			
Site	Shevock Burn @ Urie conlfuence		
NGR	NJ 669 286		
Type of problem/objective of	Peak flow s for model		
Type of catchment	Rural		
QMED site cd	8.3	m^3/s	
Donor/ Analogue Sites Considered			
Site name	Deveron@Avochie	Bogie@Redcraig	
Station number	9001	9004	
NGR	NJ 53332 46868	NJ 52387 37161	
Proximity (km)	15.99	11.52	
Adjustment	1.0851	0.93	
Site Chosen	Y	N	
QMED site adjusted by data transfer (m^3/s)	9.0	**Specific Q (l/s/ha)**	2.2
Q_{100} growth curve factor	2.47	**Q100/ area (l/s/ha)**	5.6
Q_{100} (m^3/s)	**22.4**		
Summary Data			
FEH catchment area	39.53	km^2	
Adjusted catchment area	40.25	km^2	
URBEXT 1990	0.007		
URBEXT 2010	0.008		
URBEXT Adjustment Method	Urbext2000		
SAAR	868		
Method Used	FEH Statistical Method		
Variation from Chosen Method			
Index Used	BFIHOST		
QMED	9.04	m^3/s	
5	12.76	m^3/s	
10	15.15	m^3/s	
30	18.69	m^3/s	
50	20.27	m^3/s	
75	21.50	m^3/s	
100	22.36	m^3/s	
200	24.42	m^3/s	
1000	29.03	m^3/s	
Climate Change Region	Eastern Scotland		
Climate change adjustment	24.0%		
200 + cc	30.3	m^3/s	
Donor/ Analogues Used			
Calcs by:	Briony McIntosh	Date:	19/03/2018
Checked by:	David Cameron	Date:	23/03/2018



POOLING GROUP DETAILS

Original Default Pooling Group

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
28058 (Henmore Brook @ Ashbourne)	0.205	12	9.006	0.155	-0.064	1.825
53017 (Boyd @ Bitton)	0.31	43	13.820	0.247	0.106	0.202
44011 (Asker @ East Bridge Bridport)	0.365	21	16.800	0.239	0.112	0.281
44003 (Asker @ Bridport)	0.365	14	12.354	0.224	0.17	1.202
24007 (Browney @ Lanchester)	0.382	15	10.981	0.222	0.212	2.235
43806 (Wylye @ Brixton Deverill)	0.394	25	2.080	0.376	0.211	0.97
49004 (Gannel @ Gwills)	0.403	47	15.022	0.258	0.105	0.264
41020 (Bevern Stream @ Clappers Bridge)	0.414	47	13.900	0.205	0.17	0.43
39033 (Winterbourne Stream @ Bagnor)	0.425	54	0.404	0.344	0.386	1.843
28041 (Hamps @ Waterhouses)	0.447	31	26.664	0.220	0.295	1.375
44013 (Piddle @ Little Puddle)	0.452	23	1.103	0.463	0.254	2.367
42011 (Hamble @ Frogmill)	0.477	44	8.282	0.167	0.073	1.005
26803 (Water Forlornes @ Driffield)	0.535	17	0.437	0.300	0.112	0.459
41022 (Lod @ Halfway Bridge)	0.548	46	16.260	0.288	0.181	0.201
49002 (Hayle @ st Erth)	0.548	59	4.649	0.234	0.202	0.561
24006 (Rookhope Burn @ Eastgate)	0.577	20	24.620	0.152	0.117	0.78
Total		518				
Weighted means				0.257	0.171	

Default Pooling Group Catchment Descriptors

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
28058 (Henmore Brook @ Ashbourne)	0.205	38.52	895	0.030	0.977	0.021
53017 (Boyd @ Bitton)	0.310	47.58	807	0.050	0.998	0.016
44011 (Asker @ East Bridge Bridport)	0.365	48.52	924	0.025	0.994	0.015
44003 (Asker @ Bridport)	0.365	48.52	924	0.025	0.994	0.015
24007 (Browney @ Lanchester)	0.382	44.67	797	0.015	1.000	0.001
43806 (Wylye @ Brixton Deverill)	0.394	50.04	968	0.037	1.000	0.003
49004 (Gannel @ Gwills)	0.403	40.83	1046	0.025	0.999	0.007
41020 (Bevern Stream @ Clappers Bridge	0.414	35.48	886	0.076	0.993	0.013
39033 (Winterbourne Stream @ Bagnor)	0.425	45.31	717	0.033	1.000	0.001
28041 (Hamps @ Waterhouses)	0.447	37.04	1085	0.033	1.000	0.004
44013 (Piddle @ Little Puddle)	0.452	34.09	1002	0.016	1.000	0.004
42011 (Hamble @ Frogmill)	0.477	55.25	838	0.044	0.991	0.029
26803 (Water Forlornes @ Driffield)	0.535	32.42	721	0.016	1.000	0.007
41022 (Lod @ Halfway Bridge)	0.548	52.44	857	0.061	0.951	0.009
49002 (Hayle @ st Erth)	0.548	48.58	1076	0.027	0.977	0.008
24006 (Rookhope Burn @ Eastgate)	0.577	36.60	1126	0.018	0.994	0.000

Final Pooling Group

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
53017 (Boyd @ Bitton)	0.310	43.000	13.820	0.247	0.106	0.193
44011 (Asker @ East Bridge Bridport)	0.365	21.000	16.800	0.239	0.112	0.402
44003 (Asker @ Bridport)	0.365	14.000	12.354	0.224	0.170	1.133
24007 (Browney @ Lanchester)	0.382	15.000	10.981	0.222	0.212	1.281
49004 (Gannel @ Gwills)	0.403	47.000	15.022	0.258	0.105	0.432
41020 (Bevern Stream @ Clappers Bridge)	0.414	47.000	13.900	0.205	0.170	0.444
28041 (Hamps @ Waterhouses)	0.447	31.000	26.664	0.220	0.295	2.306
41022 (Lod @ Halfway Bridge)	0.548	46.000	16.260	0.288	0.181	0.559
49002 (Hayle @ st Erth)	0.548	59.000	4.649	0.234	0.202	0.327
24006 (Rookhope Burn @ Eastgate)	0.577	20.000	24.620	0.152	0.117	1.225
20006 (Biel Water @ Belton House)	0.668	28.000	11.748	0.375	0.128	2.772
51003 (Washford @ Beggearn Huish)	0.696	49.000	6.120	0.190	0.076	1.141
47009 (Tiddy @ Tideford)	0.767	47.000	6.466	0.212	0.230	0.824
30004 (Lymn @ Partney Mill)	0.779	54.000	6.983	0.231	0.046	0.962
Total		521.000				
Weighted means		988.000		0.236	0.152	

Final Pooling Group Catchment Descriptors

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
53017 (Boyd @ Bitton)	0.31	47.58	807	0.050	0.998	0.016
44011 (Asker @ East Bridge Bridport)	0.37	48.52	924	0.025	0.994	0.015
44003 (Asker @ Bridport)	0.37	48.52	924	0.025	0.994	0.015
24007 (Browney @ Lanchester)	0.38	44.67	797	0.015	1.000	0.001
49004 (Gannel @ Gwills)	0.40	40.83	1046	0.025	0.999	0.007
41020 (Bevern Stream @ Clappers Bridge	0.41	35.48	886	0.076	0.993	0.013
28041 (Hamps @ Waterhouses)	0.45	37.04	1085	0.033	1.000	0.004
41022 (Lod @ Halfway Bridge)	0.55	52.44	857	0.061	0.951	0.009
49002 (Hayle @ st Erth)	0.55	48.58	1076	0.027	0.977	0.008
24006 (Rookhope Burn @ Eastgate)	0.58	36.60	1126	0.018	0.994	0.000
20006 (Biel Water @ Belton House)	0.67	57.55	742	0.019	0.981	0.001
51003 (Washford @ Beggearn Huish)	0.70	36.70	1151	0.005	0.982	0.003
47009 (Tiddy @ Tideford)	0.77	37.40	1276	0.024	1.000	0.011
30004 (Lymn @ Partney Mill)	0.78	60.09	686	0.060	0.979	0.006

DERIVING A POOLED GROWTH CURVE			
Site	Shevock Burn	√	Ungauged site
NGR	NJ 66750 28600		Gauged site

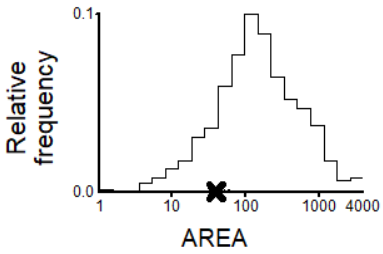
Attached Printouts	
	WINFAP-FEH station details
	WINFAP-FEH summary information if gauged site

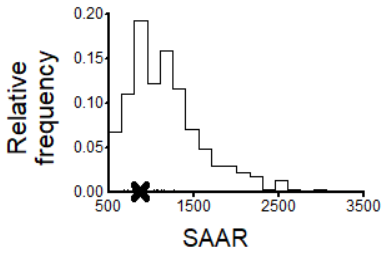
Initial Pooling Group Details	
Name	p_sepa_Shevock_Urie_confluence_default
Site of interest	Urie confluence
Return period of interest	2, 5, 10, 25, 30, 50, 75, 100, 200, 500, 1000, 200 +CC years
Other information	
Version of WIN-FAP FEH	Version 3.0
Data Files	Other
If 'Other' chosen in Data Files enter file path here	HiFlows v6.0 SEPA WY2016

Adjustment/ Changes made to Default Pooling Group.
Also note sites that were investigated but retained in the group (i.e. for discordancy)

Station number	Name	Addition/ Deletion/ Move/ Investigate	Reason
44013	Piddle@LittlePuddle	D	BFIHOST >0.85
43806	Wylye@BrixtonDeverill	D	BFIHOST >0.85
26803	WaterForlornes@Driffield	D	BFIHOST >0.85
42011	Hamble@Frogmill	D	URBEXT >0.025
20006	BielWater@BeltonHouse	A	increase record length
51003	Washford@BeggearnHuish	A	increase record length
47009	Tiddy@Tideford	A	increase record length
28058	HenmoreBrook@Ashbourne	D	L-moment skew
30004	Lymn@PartneyMill	A	increase record length
39033	WinterbourneSteam@Bangor	D	Moderately high BFIHOST causing poor heterogenity and steep growth curve

Final Pooling Group Details	
Heterogeneity Measure	
H1	Heterogeneous
H2	Acceptably Homogeneous
Goodness of Fit	
Acceptable Fit	**Distribution**
	Generalised Logistic
√	Generalised Extreme Value
√	Pearson Type iii
	Generalised Pareto
Growth Curve Fittings	
Attached print outs	WINFAP-FEH growth curve fittings
	WINFAP-FEH growth curve
Name of Final Pooling Group	p_sepa_Shevock_Urie_confluence_adj


Relative frequency
AREA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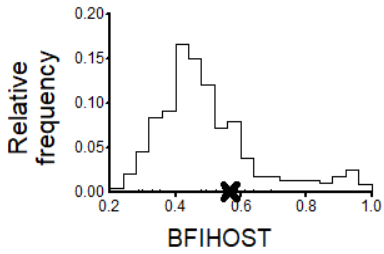
SAAR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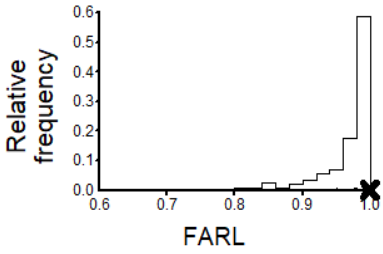
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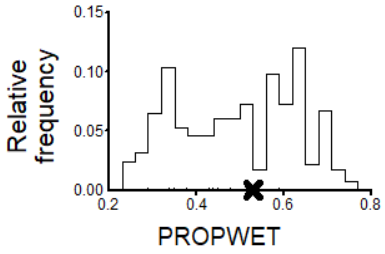
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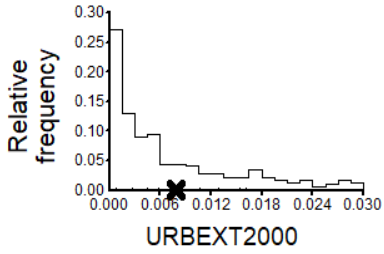
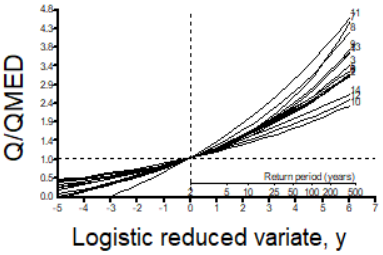
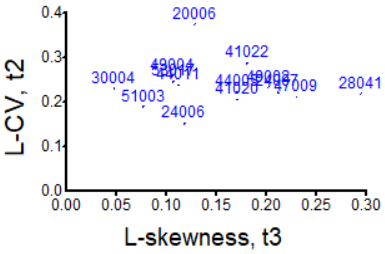
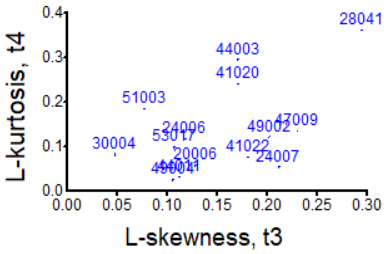
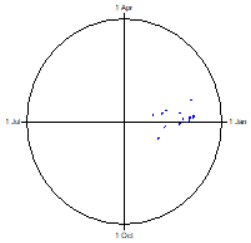
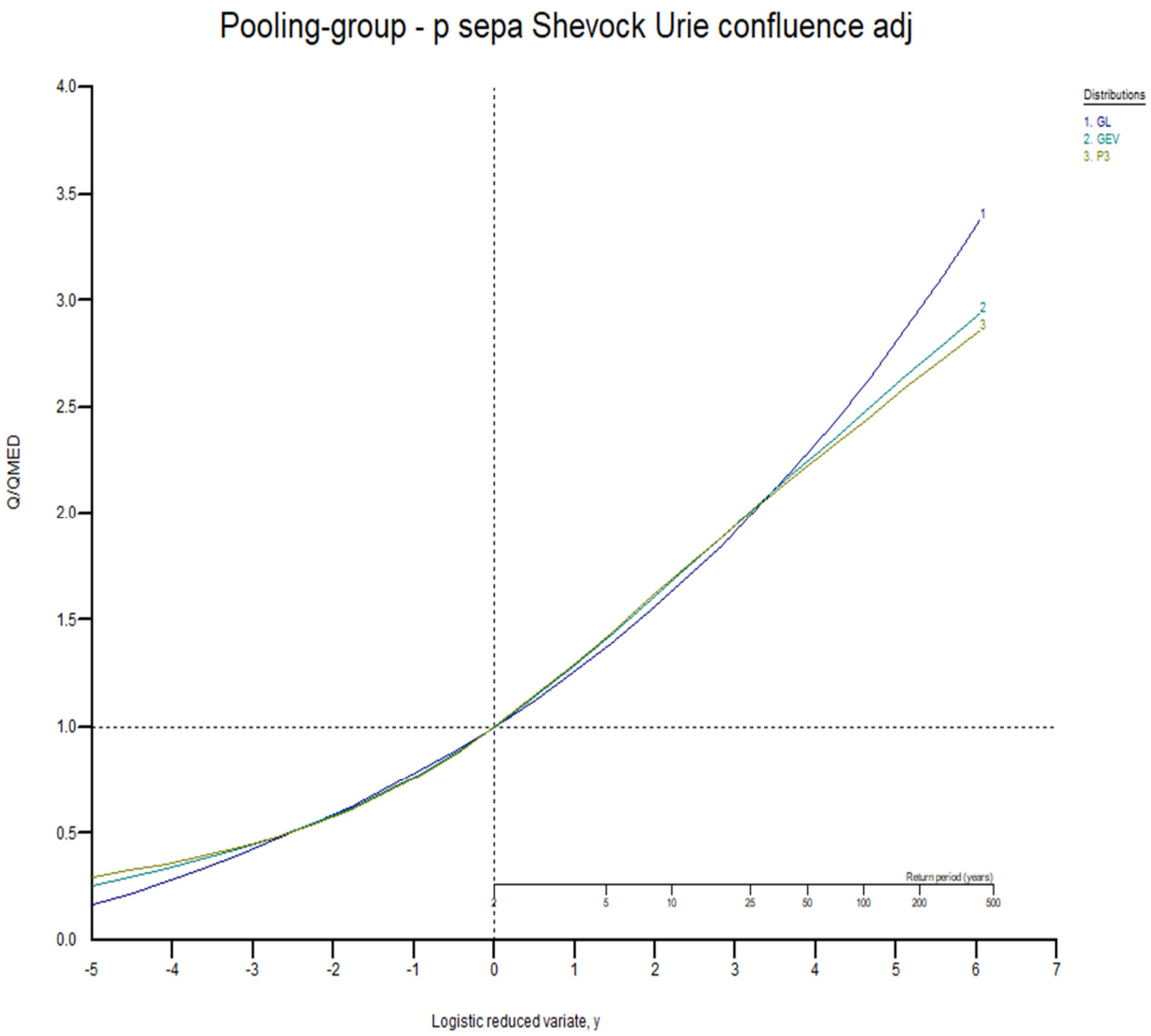

Relative frequency
URBEXT2000


Q/QMED
Logistic reduced variate, y
Return period (years)


L-CV, t2
L-skewness, t3
20006
41022
30004
51003
24006
28041

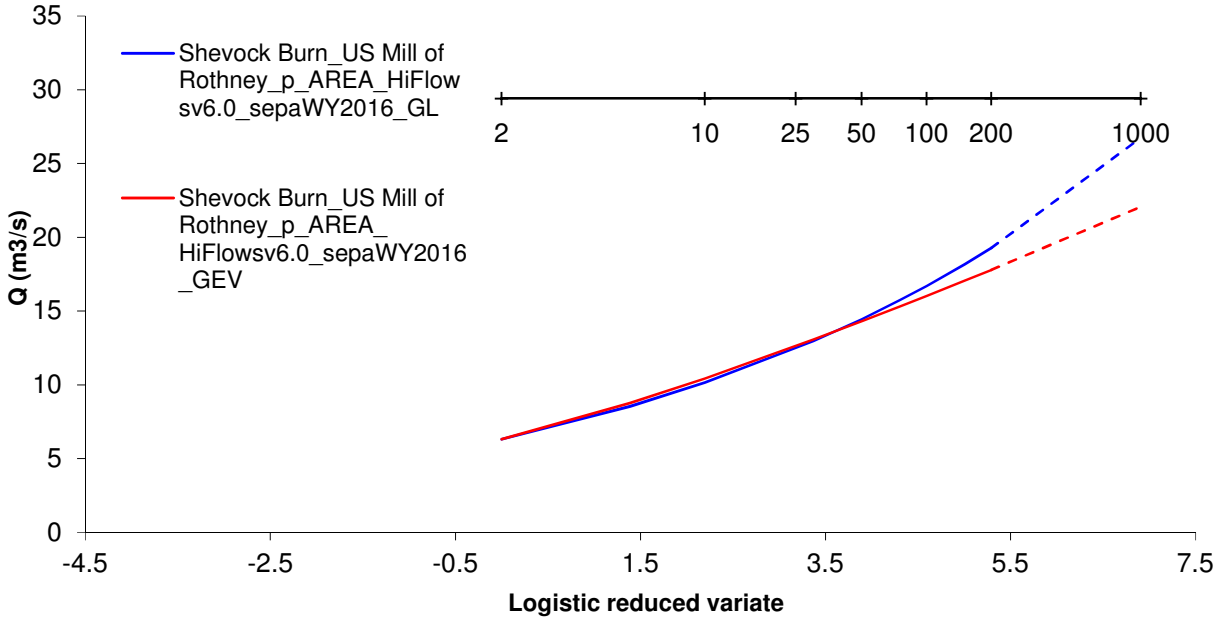

L-kurtosis, t4
L-skewness, t3
28041
44003
41020
51003
30004
41022
24007




Pooling-group - p sepa Shevock Urie confluence adj
Distributions
1. GL
2. GEV
3. P3
Q/QMED
Logistic reduced variate, y
Return period (years)
2
5
10
25
50
100
200
500
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7

A.2 The Shevock Upstream of the Mill of Rothney Burn

FEH STATISTICAL FLOOD ESTIMATION SUMMARY SHEET			
Site	Shevock Burn US Mill of Rothney		
NGR	NJ 625 277		
Type of problem/objective of	Peak flow s for model		
Type of catchment	Rural		
QMED site cd	5.8	m^3/s	
Donor/ Analogue Sites Considered			
Site name	Deveron@Avochie	Bogie@Redcraig	Urie@Pitcaple
Station number	9001	9004	11004
NGR	NJ 53332 46868	NJ 52387 37161	NJ 721 259
Proximity (km)	13.85	9.43	4
Adjustment	1.0891	1.09	0.95
Site Chosen	Y	N	N
QMED site adjusted by data transfer (m^3/s)	5.8	Specific Q (l/s/ha)	2.3
Q_{100} growth curve factor	2.65	Q100/ area (l/s/ha)	6.6
Q_{100} (m^3/s)	**16.7**		
Summary Data			
FEH catchment area	24.59	km^2	
Adjusted catchment area	25.20	km^2	
URBEXT 1990	0.001		
URBEXT 2010	0.000		
URBEXT Adjustment Method	Urbext2000		
SAAR	891		
Method Used	FEH Statistical Method		
Variation from Chosen Method			
Index Used	BFIHOST		
QMED	6.31	m^3/s	
5	8.53	m^3/s	
10	10.14	m^3/s	
30	12.96	m^3/s	
50	14.45	m^3/s	
75	15.74	m^3/s	
100	16.71	m^3/s	
200	19.28	m^3/s	
1000	26.75	m^3/s	
Climate Change Region	Eastern Scotland		
Climate change adjustment	24.0%		
200 + cc	23.9	m^3/s	
Donor/ Analogues Used			
Calcs by:	Briony McIntosh	Date:	16/03/2018
Checked by:	David Cameron	Date:	21/03/2018



POOLING GROUP DETAILS

Original Default Pooling Group

44008 (South Winterbourne @ Winterbourn	0.405	37	0.448	0.416	0.326	1.036
22003 (Usway Burn @ Shillmoor)	0.45	13	16.170	0.282	0.311	1.785
27010 (Hodge Beck @ Bransdale Weir)	0.481	41	9.420	0.224	0.293	0.679
44013 (Piddle @ Little Puddle)	0.534	23	1.103	0.463	0.254	1.849
203046 (Rathmore Burn @ Rathmore Bridg	0.574	34	10.788	0.146	0.136	0.558
26803 (Water Forlornes @ Driffield)	0.582	17	0.437	0.300	0.112	0.466
28058 (Henmore Brook @ Ashbourne)	0.644	12	9.006	0.155	-0.064	1.673
49005 (Bollingey Stream @ Bolingey Cocks	0.674	6	6.511	0.265	0.063	1.331
28041 (Hamps @ Waterhouses)	0.686	31	26.664	0.220	0.295	1.348
26802 (Gypsey Race @ Kirby Grindalythe)	0.688	17	0.116	0.274	0.24	0.078
25019 (Leven @ Easby)	0.706	38	5.333	0.338	0.391	1.076
41020 (Bevern Stream @ Clappers Bridge)	0.726	47	13.900	0.205	0.17	0.602
24006 (Rookhope Burn @ Eastgate)	0.728	20	24.620	0.152	0.117	0.586
73015 (Keer @ High Keer Weir)	0.774	25	12.239	0.174	0.191	0.455
49004 (Gannel @ Gwills)	0.774	47	15.022	0.258	0.105	0.345
51003 (Washford @ Beggearn Huish)	0.803	49	6.120	0.190	0.076	1.129
36010 (Bumpstead Brook @ Broad Green)	0.827	49	7.585	0.365	0.173	2.002
Total		506				
Weighted means				0.264	0.198	

Default Pooling Group Catchment Descriptors

44008 (South Winterbourne @ Winterbou	0.405	20.18	1012	0.015	1.000	0.004
22003 (Usway Burn @ Shillmoor)	0.450	21.88	1056	0.006	1.000	0.000
27010 (Hodge Beck @ Bransdale Weir)	0.481	18.82	987	0.009	1.000	0.001
44013 (Piddle @ Little Puddle)	0.534	34.09	1002	0.016	1.000	0.004
203046 (Rathmore Burn @ Rathmore Bric	0.574	22.50	1043	0.072	1.000	0.000
26803 (Water Forlornes @ Driffield)	0.582	32.42	721	0.016	1.000	0.007
28058 (Henmore Brook @ Ashbourne)	0.644	38.52	895	0.030	0.977	0.021
49005 (Bollingey Stream @ Bolingey Cocl	0.674	16.08	1044	0.023	0.991	0.006
28041 (Hamps @ Waterhouses)	0.686	37.04	1085	0.033	1.000	0.004
26802 (Gypsey Race @ Kirby Grindalythe)	0.688	15.85	757	0.030	1.000	0.000
25019 (Leven @ Easby)	0.706	15.09	830	0.020	1.000	0.004
41020 (Bevern Stream @ Clappers Bridge	0.726	35.48	886	0.076	0.993	0.013
24006 (Rookhope Burn @ Eastgate)	0.728	36.60	1126	0.018	0.994	0.000
73015 (Keer @ High Keer Weir)	0.774	30.04	1158	0.074	0.976	0.003
49004 (Gannel @ Gwills)	0.774	40.83	1046	0.025	0.999	0.007
51003 (Washford @ Beggearn Huish)	0.803	36.70	1151	0.005	0.982	0.003
36010 (Bumpstead Brook @ Broad Greer	0.827	27.58	588	0.045	0.999	0.007

Final Pooling Group

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
22003 (Usway Burn @ Shillmoor)	0.450	13.000	16.170	0.282	0.311	1.144
27010 (Hodge Beck @ Bransdale Weir)	0.481	41.000	9.420	0.224	0.293	0.547
203046 (Rathmore Burn @ Rathmore Bridg	0.574	34.000	10.788	0.146	0.136	0.808
28041 (Hamps @ Waterhouses)	0.686	31.000	26.664	0.220	0.295	1.573
25019 (Leven @ Easby)	0.706	38.000	5.333	0.338	0.391	2.337
41020 (Bevern Stream @ Clappers Bridge)	0.726	47.000	13.900	0.205	0.170	0.268
24006 (Rookhope Burn @ Eastgate)	0.728	20.000	24.620	0.152	0.117	0.694
73015 (Keer @ High Keer Weir)	0.774	25.000	12.239	0.174	0.191	0.402
49004 (Gannel @ Gwills)	0.774	47.000	15.022	0.258	0.105	1.865
51003 (Washford @ Beggearn Huish)	0.803	49.000	6.120	0.190	0.076	0.672
72014 (Conder @ Galgate)	0.844	49.000	16.646	0.212	0.082	0.697
47021 (Kensey @ Launceston Newport)	0.873	14.000	13.778	0.257	0.103	2.471
24007 (Browney @ Lanchester)	0.878	15.000	10.981	0.222	0.212	0.690
47009 (Tiddy @ Tideford)	0.905	47.000	6.466	0.212	0.230	0.220
72007 (Brock @ Upstream of a6)	0.917	38.000	29.438	0.195	0.231	0.611
Total		508				
Weighted means		978		0.219	0.196	

Final Pooling Group Catchment Descriptors

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
22003 (Usway Burn @ Shillmoor)	0.45	21.88	1056	0.006	1.000	0.000
27010 (Hodge Beck @ Bransdale Weir)	0.48	18.82	987	0.009	1.000	0.001
203046 (Rathmore Burn @ Rathmore Bric	0.57	22.50	1043	0.072	1.000	0.000
28041 (Hamps @ Waterhouses)	0.69	37.04	1085	0.033	1.000	0.004
25019 (Leven @ Easby)	0.71	15.09	830	0.020	1.000	0.004
41020 (Bevern Stream @ Clappers Bridge	0.73	35.48	886	0.076	0.993	0.013
24006 (Rookhope Burn @ Eastgate)	0.73	36.60	1126	0.018	0.994	0.000
73015 (Keer @ High Keer Weir)	0.77	30.04	1158	0.074	0.976	0.003
49004 (Gannel @ Gwills)	0.77	40.83	1046	0.025	0.999	0.007
51003 (Washford @ Beggearn Huish)	0.80	36.70	1151	0.005	0.982	0.003
72014 (Conder @ Galgate)	0.84	28.99	1183	0.082	0.975	0.006
47021 (Kensey @ Launceston Newport)	0.87	34.83	1298	0.022	0.998	0.017
24007 (Browney @ Lanchester)	0.88	44.67	797	0.015	1.000	0.001
47009 (Tiddy @ Tideford)	0.91	37.40	1276	0.024	1.000	0.011
72007 (Brock @ Upstream of a6)	0.917	31.51	1361	0.053	1.000	0.000

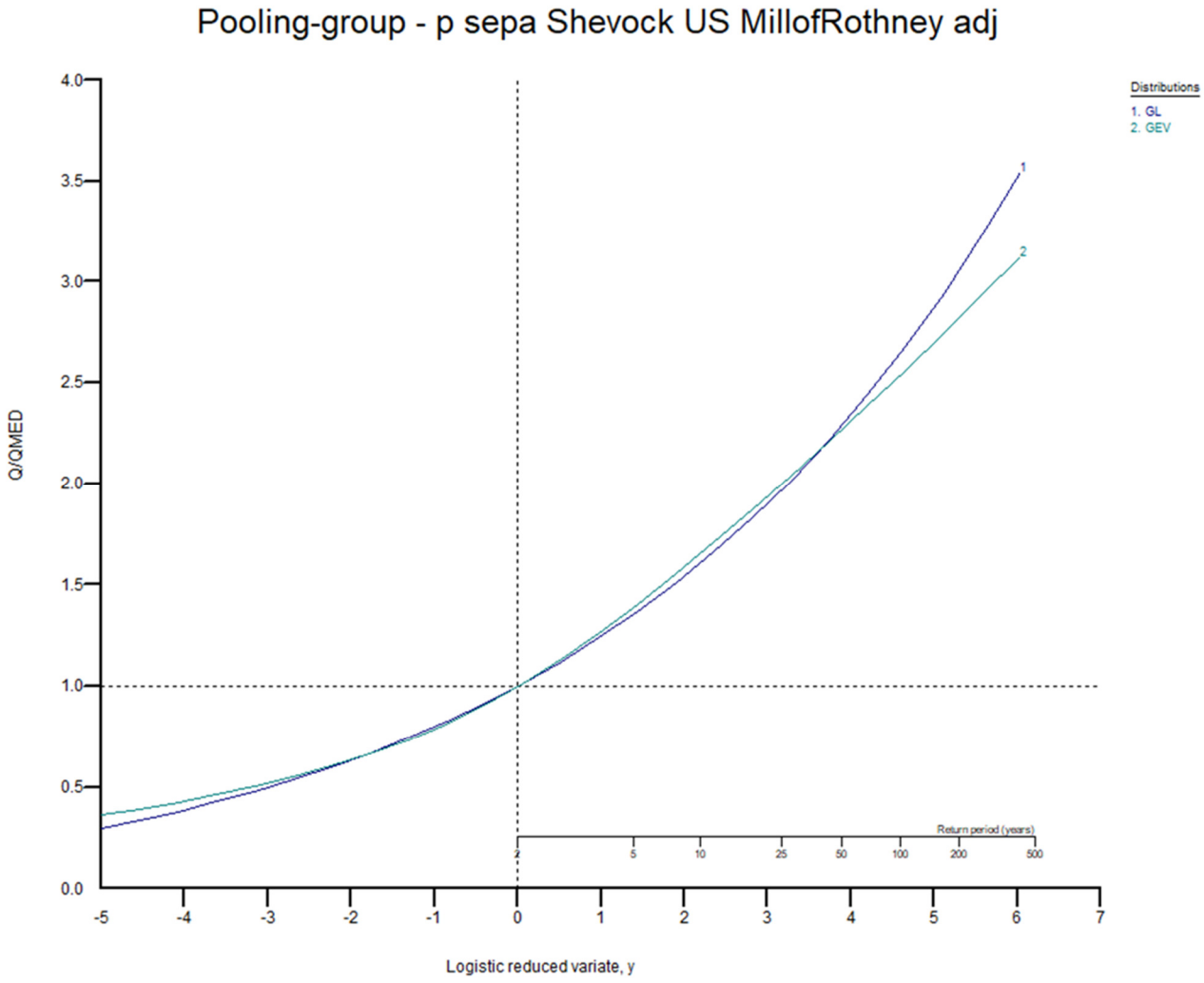
DERIVING A POOLED GROWTH CURVE			
Site	Shevock Burn US Mill of Rothney	√	Ungauged site
NGR	NJ 625 277		Gauged site
Attached Printouts			
	WINFAP-FEH station details		
	WINFAP-FEH summary information if gauged site		
Initial Pooling Group Details			
Name	p_sepa_Shevock US MillofRothney_default		
Site of interest	US Mill of Rothney		
Return period of interest	2, 5, 10, 25, 30, 50, 100, 200, 500, 1000, 200+CC		
Other information			
Version of WIN-FAP FEH	Version 3.0		
Data Files	Other		
If 'Other' chosen in Data Files enter file path here	HiFlows v6.0 SEPA WY2016		

Adjustment/ Changes made to Default Pooling Group.
Also note sites that were investigated but retained in the group (i.e. for discordancy)

Station number	Name	Addition/ Deletion/ Move/ Investigate	Reason
26802	GypseyRace@KirbyGrindalythe	D	BFIHOST >0.85
26803	WaterForlornes@Driffield	D	BFIHOST >0.85
44013	Piddle@LittlePuddle	D	BFIHOST >0.85
72014	Condor@Galgate	A	increase record length
47021	Kensey@LauncestonNewport	A	increase record length
44008	SouthWinterbourne@WinterbourneSteepleton	D	High BFIHOST (0.811)
24007	Browney@Lanchester	A	increase record length
47009	Tiddy@Tidefrod	A	increase record length
49005	BolingeyStream@BolingeyCocksBridge	D	short record length
36010	BumpsteadBrook@BroadGreen	D	Low SAAR (588) and PROPWET (0.270) compared to site

Final Pooling Group Details	
Heterogeneity Measure	
H1	Heterogeneous
H2	Acceptably Homogeneous
Goodness of Fit	
Acceptable Fit	**Distribution**
√	Generalised Logistic
√	Generalised Extreme Value
	Pearson Type iii
	Generalised Pareto

Growth Curve Fittings		
Attached print outs		WINFAP-FEH growth curve fittings
		WINFAP-FEH growth curve
Name of Final Pooling Group		p_sepa_Shevock US MillofRothney_adj


Pooling-group - p sepa Shevock US MillofRothney adj
Distributions
1. GL
2. GEV
Q/QMED
Logistic reduced variate, y
Return period (years)
2
5
10
25
50
100
200
500
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-5
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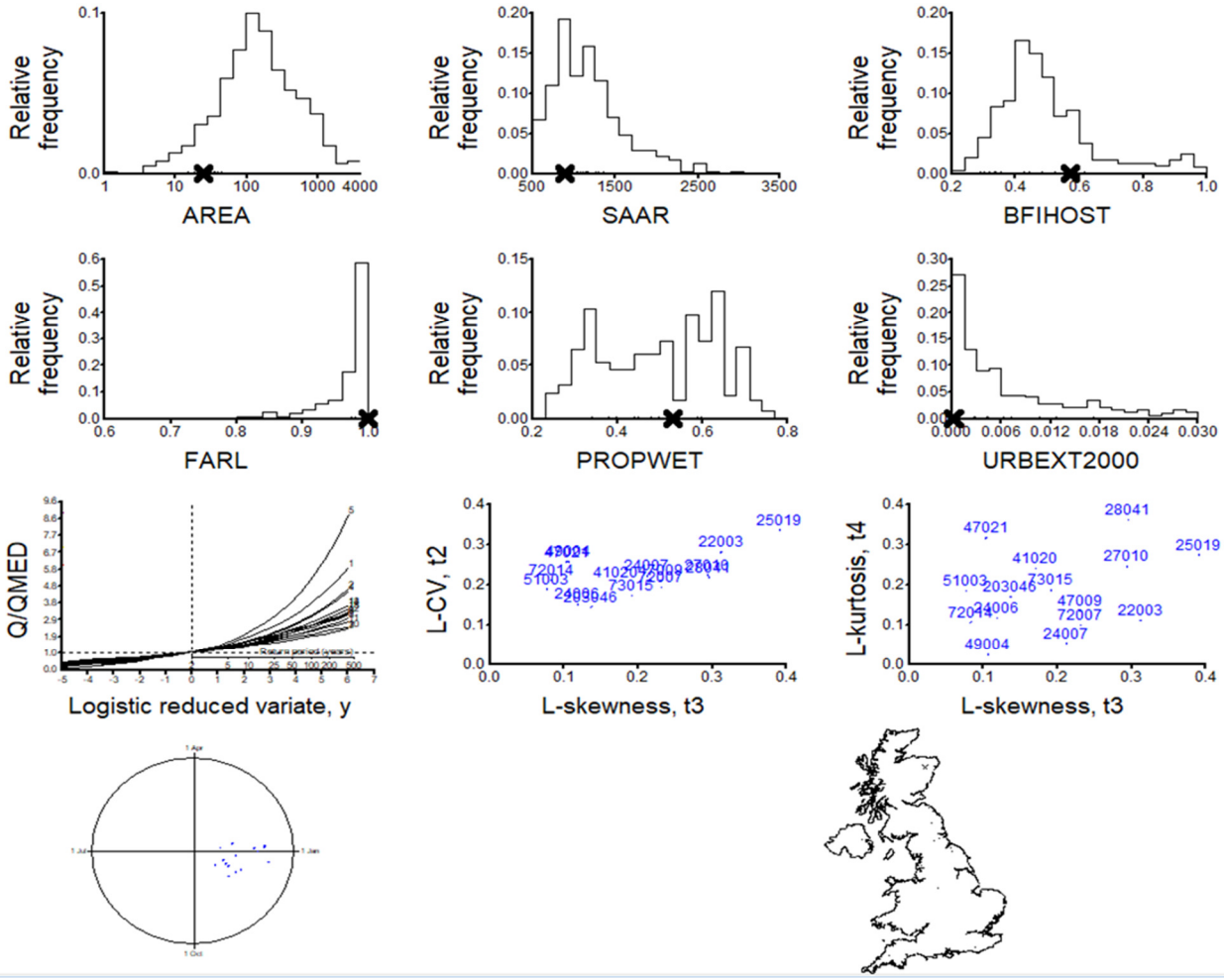
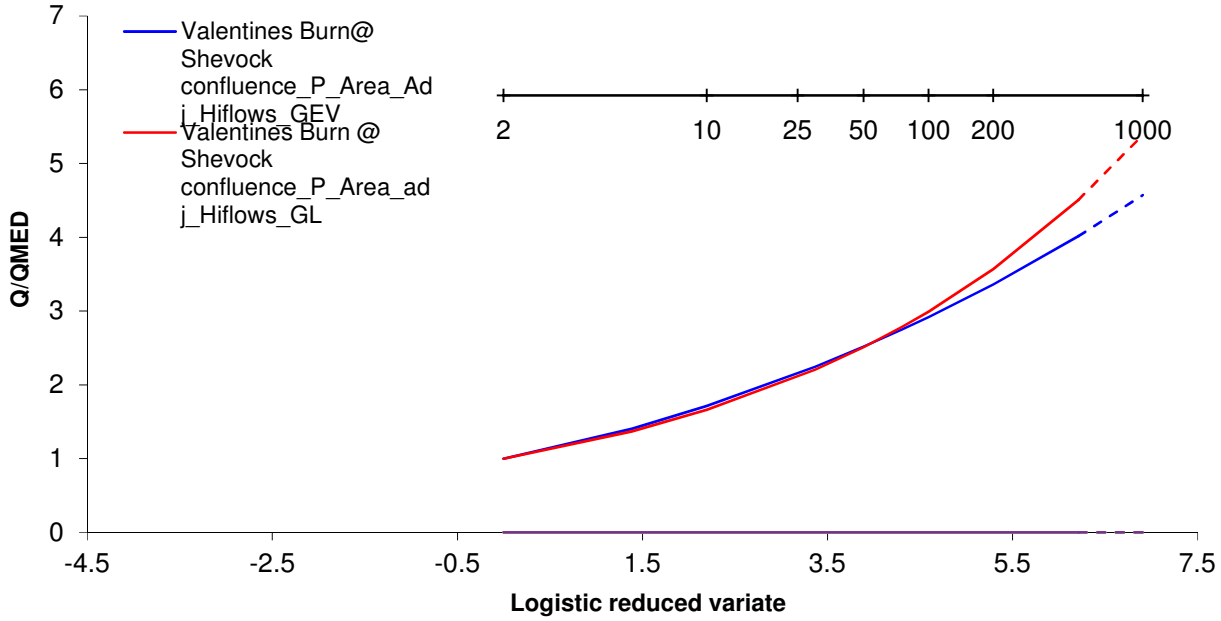
0
1
2
3
4
5
6
7


Relative frequency
AREA
SAAR
BFIHOST
FARL
PROPWET
URBEXT2000
Q/QMED
Logistic reduced variate, y
L-CV, t2
L-skewness, t3
L-kurtosis, t4
L-skewness, t3

A.3 Valentines Burn at Shevock confluence

FEH STATISTICAL FLOOD ESTIMATION SUMMARY SHEET			
Site	Valentines Burn@ Shevock confluence		
NGR	NJ 63491 28114		
Type of problem/objective of	Peak flows for model		
	2, 5, 10, 25, 30, 50, 75, 100, 200, 200cc, 500, 1000		
Type of catchment	Rural		
QMED site cd	0.89	m^3/s	
Donor/ Analogue Sites Considered			
Site name	Urie@Pitcaple	Ythan@Ardlethen	Deveron@Avochie
Station number	11004	10001	9001
NGR			
Proximity (km)	0.32	21.46	18
Adjustment	0.954	1.01	1.08
Site Chosen	N	Y	N
QMED site adjusted by data transfer (m^3/s)	1.0	**Specific Q (l/s/ha)**	3.0
Q_{100} growth curve factor	2.99	**Q100/ area (l/s/ha)**	9.0
Q_{100} (m^3/s)	**2.9**		
Summary Data			
FEH catchment area	3.23	km^2	
Adjusted catchment area	3.18	km^2	
URBEXT 1990	0.027		
URBEXT 2010	0.037		
URBEXT Adjustment Method	Urbext2000		
SAAR	833		
Method Used	FEH Statistical Method		
Variation from Chosen Method			
Index Used	BFI		
QMED	1.00	m^3/s	
5	1.31	m^3/s	
10	1.59	m^3/s	
25	2.02	m^3/s	
50	2.40	m^3/s	
100	2.87	m^3/s	
200	3.42	m^3/s	
500	4.32	m^3/s	
1000	5.16	m^3/s	
Climate Change Region	Eastern Scotland		
Climate change adjustment	24.0%		
200 + cc	4.2	m^3/s	
Donor/ Analogues Used			
Calcs by:	Grace Thompson	Date:	27/03/2018
Checked by:	David Cameron	Date:	27/03/2018



POOLING GROUP DETAILS

Original Default Pooling Group

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.106	38	1.84	0.165	0.33	1.13
45816 (Haddeo @ Upton)	1.359	22	3.49	0.314	0.42	0.92
27051 (Crimple @ Burn Bridge)	1.384	43	4.51	0.219	0.15	0.27
28033 (Dove @ Hollinsclough)	1.646	36	4.23	0.240	0.42	0.50
25019 (Leven @ Easby)	2.194	37	4.99	0.342	0.39	1.79
49006 (Camel @ Camelford)	2.205	9	11.50	0.129	-0.25	2.85
26802 (Gypsey Race @ Kirby Grindalythe)	2.251	16	0.11	0.274	0.27	0.60
25011 (Langdon Beck @ Langdon)	2.259	28	15.88	0.238	0.32	1.20
47022 (Tory Brook @ Newnham Park)	2.288	22	7.23	0.262	0.09	0.96
49005 (Bollingey Stream @ Bolingey Cocks	2.317	5	5.78	0.288	0.26	0.95
71003 (Croasdale Beck @ Croasdale Flum	2.331	37	10.90	0.212	0.32	0.24
25003 (Trout Beck @ Moor House)	2.375	42	15.14	0.172	0.29	0.66
27073 (Brompton Beck @ Snainton Ings)	2.415	34	0.82	0.198	0.06	0.71
91802 (Allt Leachdach @ Intake)	2.431	34	6.35	0.153	0.26	1.23
206006 (Annalong @ Recorder)	2.532	48	15.33	0.189	0.05	1.81
27010 (Hodge Beck @ Bransdale Weir)	2.54	41	9.42	0.224	0.29	0.09
54022 (Severn @ Plynlimon Flume)	2.561	38	14.99	0.156	0.17	1.12
Total		530				
Weighted means				0.222	0.238	

Default Pooling Group Catchment Descriptors

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	1.106	1.63	1096	0.074	1.00	0.00
45816 (Haddeo @ Upton)	1.359	6.81	1210	0.011	1.00	0.01
27051 (Crimple @ Burn Bridge)	1.384	8.17	855	0.013	1.00	0.01
28033 (Dove @ Hollinsclough)	1.646	7.92	1346	0.007	1.00	0.00
25019 (Leven @ Easby)	2.194	15.09	830	0.02	1.00	0.00
49006 (Camel @ Camelford)	2.205	12.52	1418	0.013	1.00	0.00
26802 (Gypsey Race @ Kirby Grindalythe)	2.251	15.85	757	0.03	1.00	0.00
25011 (Langdon Beck @ Langdon)	2.259	12.79	1463	0.012	1.00	0.00
47022 (Tory Brook @ Newnham Park)	2.288	13.43	1403	0.023	0.94	0.01
49005 (Bollingey Stream @ Bolingey Cocl	2.317	16.08	1044	0.023	0.99	0.01
71003 (Croasdale Beck @ Croasdale Flu	2.331	10.71	1882	0.016	1.00	0.00
25003 (Trout Beck @ Moor House)	2.375	11.4	1905	0.041	1.00	0.00
27073 (Brompton Beck @ Snainton Ings)	2.415	8.06	721	0.237	1.00	0.01
91802 (Allt Leachdach @ Intake)	2.431	6.54	2554	0.003	0.99	0.00
206006 (Annalong @ Recorder)	2.532	14.44	1704	0.023	0.98	0.00
27010 (Hodge Beck @ Bransdale Weir)	2.54	18.82	987	0.009	1.00	0.00
54022 (Severn @ Plynlimon Flume)	2.561	8.75	2481	0.01	1.00	0.00

Final Pooling Group Catchment Descriptors

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.106	38	1.84	0.165	0.331	1.423
45816 (Haddeo @ Upton)	1.359	22	3.489	0.314	0.415	1.019
27051 (Crimple @ Burn Bridge)	1.384	43	4.514	0.219	0.154	0.384
28033 (Dove @ Hollinsclough)	1.646	36	4.225	0.24	0.415	0.775
25019 (Leven @ Easby)	2.194	37	4.989	0.342	0.39	1.952
26802 (Gypsey Race @ Kirby Grindalythe)	2.251	16	0.112	0.274	0.274	0.87
25011 (Langdon Beck @ Langdon)	2.259	28	15.878	0.238	0.318	1.641
47022 (Tory Brook @ Newnham Park)	2.288	22	7.227	0.262	0.093	1.483
71003 (Croasdale Beck @ Croasdale Flum	2.331	37	10.9	0.212	0.323	0.303
25003 (Trout Beck @ Moor House)	2.375	42	15.142	0.172	0.293	0.803
27073 (Brompton Beck @ Snainton Ings)	2.415	34	0.816	0.198	0.056	1.235
27010 (Hodge Beck @ Bransdale Weir)	2.54	41	9.42	0.224	0.293	0.102
203046 (Rathmore Burn @ Rathmore Bridg	2.755	33	10.77	0.136	0.104	1.333
22003 (Usway Burn @ Shillmoor)	2.77	13	16.17	0.282	0.311	1.487
49003 (de Lank @ de Lank)	2.952	49	14.324	0.227	0.214	0.15
41020 (Bevern Stream @ Clappers Bridge)	3.361	46	13.78	0.208	0.178	1.04
Total		537				
Weighted means				0.231	0.258	

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	1.106	1.63	1096	0.074	1.00	0.00
45816 (Haddeo @ Upton)	1.359	6.81	1210	0.011	1.00	0.01
27051 (Crimple @ Burn Bridge)	1.384	8.17	855	0.013	1.00	0.01
28033 (Dove @ Hollinsclough)	1.646	7.92	1346	0.007	1.00	0.00
25019 (Leven @ Easby)	2.194	15.09	830	0.02	1.00	0.00
26802 (Gypsey Race @ Kirby Grindalythe)	2.251	15.85	757	0.03	1.00	0.00
25011 (Langdon Beck @ Langdon)	2.259	12.79	1463	0.012	1.00	0.00
47022 (Tory Brook @ Newnham Park)	2.288	13.43	1403	0.023	0.94	0.01
71003 (Croasdale Beck @ Croasdale Flu	2.331	10.71	1882	0.016	1.00	0.00
25003 (Trout Beck @ Moor House)	2.375	11.4	1905	0.041	1.00	0.00
27073 (Brompton Beck @ Snainton Ings)	2.415	8.06	721	0.237	1.00	0.01
27010 (Hodge Beck @ Bransdale Weir)	2.54	18.82	987	0.009	1.00	0.00
203046 (Rathmore Burn @ Rathmore Bric	2.755	22.5	1043	0.072	1.00	0.00
22003 (Usway Burn @ Shillmoor)	2.77	21.88	1056	0.006	1.00	0.00
49003 (de Lank @ de Lank)	2.952	21.61	1628	0.064	1.00	0.00
41020 (Bevern Stream @ Clappers Bridge	3.361	35.48	886	0.076	0.99	0.01

DERIVING A POOLED GROWTH CURVE			
Site	Valentines Burn@Shevock confluence	√	Ungauged site
NGR	NJ 63491 28114		Gauged site

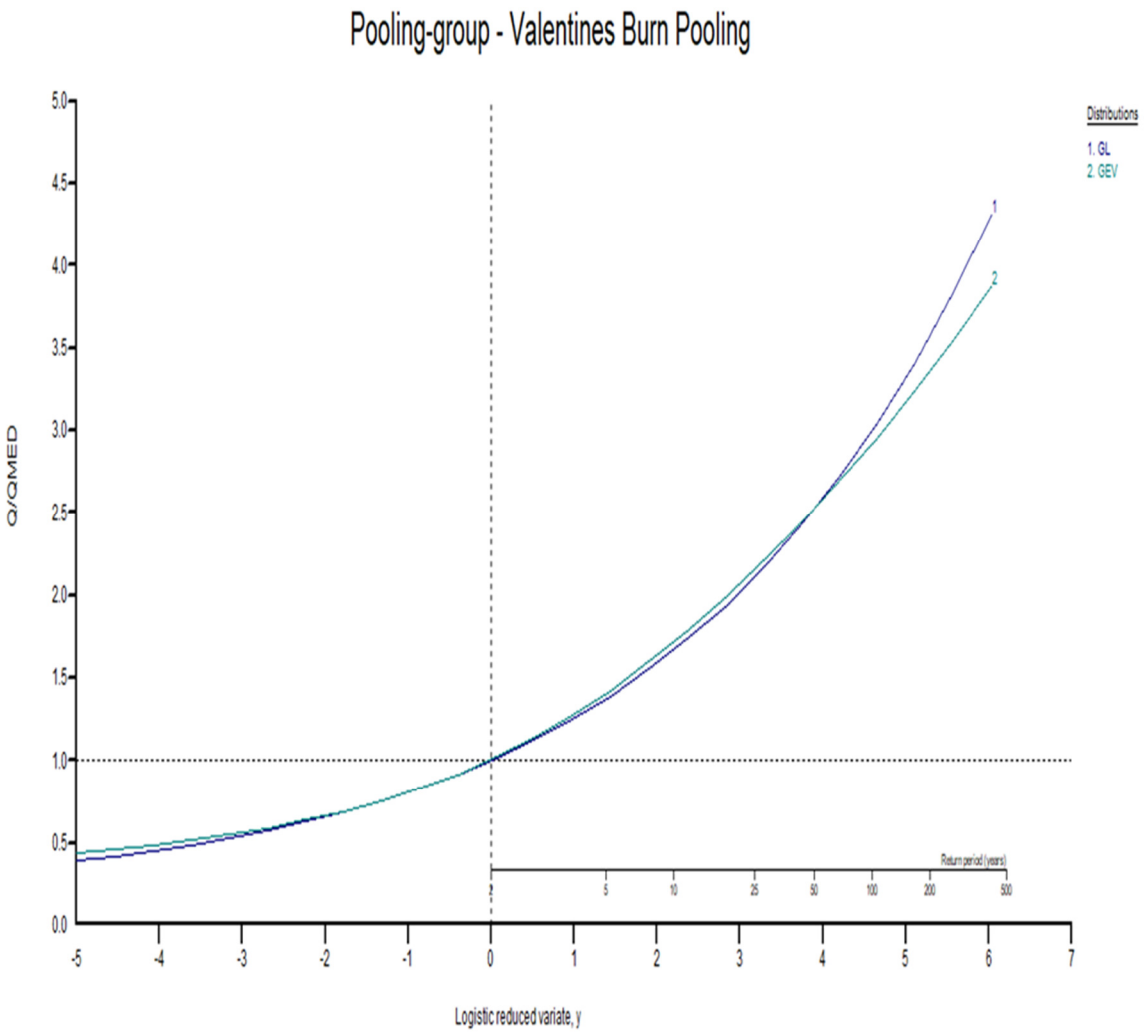
Attached Printouts	
	WINFAP-FEH station details
	WINFAP-FEH summary information if gauged site

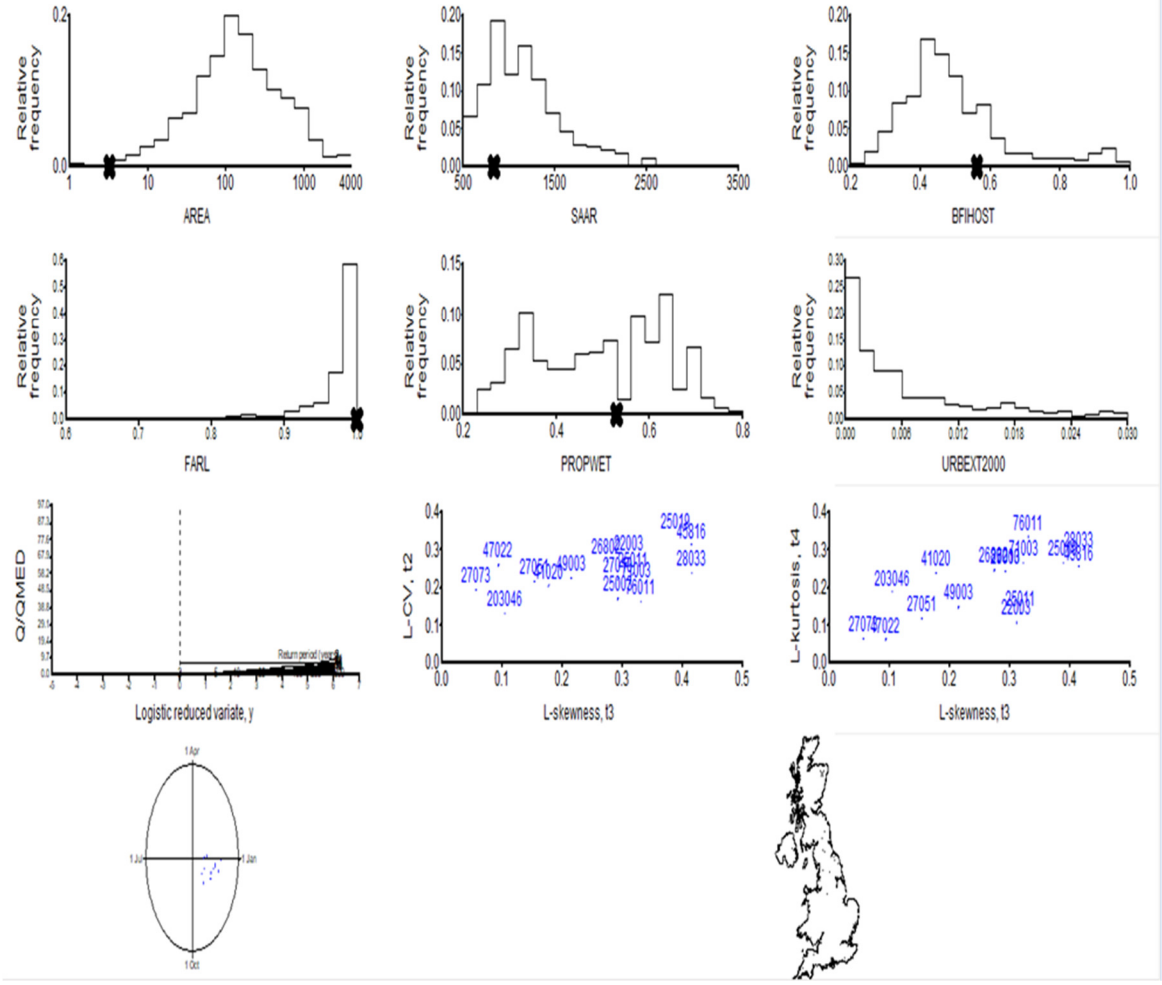
Initial Pooling Group Details	
Name	Valentines Burn
Site of interest	Valentines Burn@Shevock confluence
Return period of interest	2, 5, 10, 25, 30, 50, 75, 100, 200, 200cc, 500, 1000
Other information	
Version of WIN-FAP FEH	Version 3.0
Data Files	Other
If 'Other' chosen in Data Files enter file path here	HiFlows v6.0, SEPA gauges through WY2016

Adjustment/ Changes made to Default Pooling Group.
Also note sites that were investigated but retained in the group (i.e. for discordancy)

Station number	Name	Addition/ Deletion/ Move/ Investigate	Reason
49005	ngey Stream @ Bollingey Cock Br	D	Only 5 years of data
54022	Severn @ Plynlimon Flume	D	SAAR 2481
91802	Allt Leachdach @ Intake	D	SAAR 2554
49006	Camel @ Camleford	D	Outlier on Lmoments
206006	Annalong @ Recorder	D	Historical
22003	Usway Burn @ Shilmoor	A	Increase record length
49003	de Lank @ de Lank	A	Increase record length
203046	Rathmore Burn @ Rathmore Bridge	A	Increase record length
41020	Bevern Stream @ Clappers Bridge	A	Increase record length

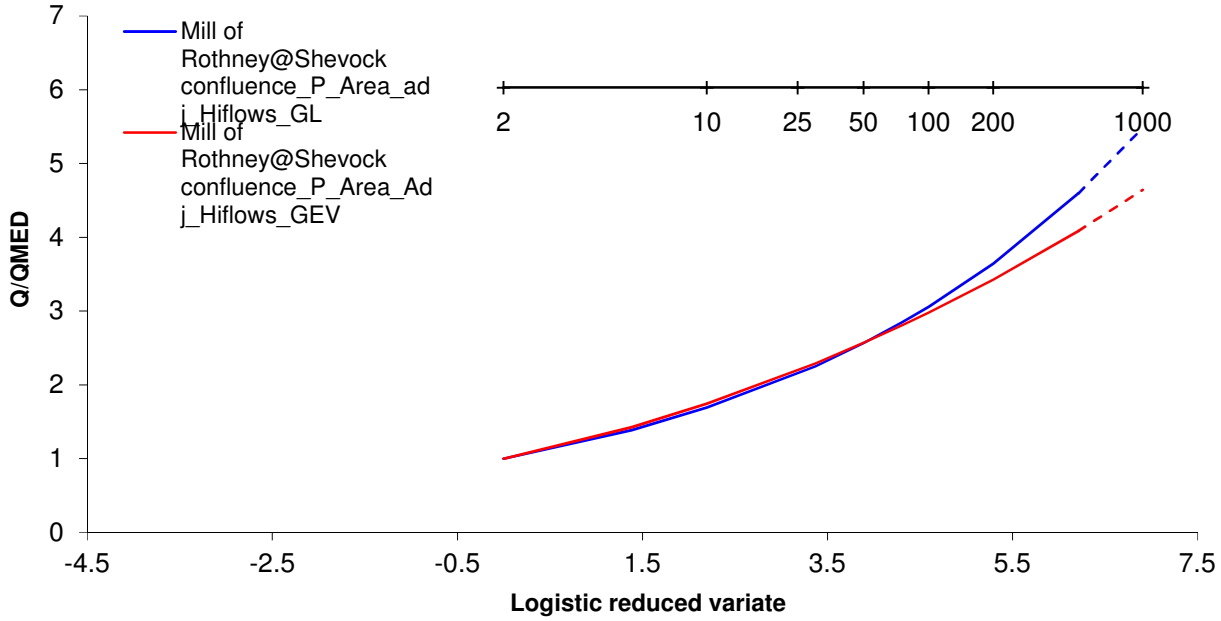
Final Pooling Group Details	
Heterogeneity Measure	
H1	Heterogeneous
H2	Acceptably Homogeneous
Goodness of Fit	
Acceptable Fit	**Distribution**
√	Generalised Logistic
√	Generalised Extreme Value
	Pearson Type iii
	Generalised Pareto
Growth Curve Fittings	
Attached print outs	WINFAP-FEH growth curve fittings
	WINFAP-FEH growth curve
Name of Final Pooling Group	Valentines Burn Pooling


Pooling-group - Valentines Burn Pooling
Q/QMED
Logistic reduced variate, y
Distributions
1. GL
2. GEV
Return period (years)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
2
5
10
25
50
100
200
500


Relative frequency
AREA
SAAR
BFIHOST
FARL
PROPWET
URBEXT2000
Q/QMED
Logistic reduced variate, y
L-CV, t2
L-skewness, t3
L-kurtosis, t4
L-skewness, t3

A.4 Mill of Rothney at Shevock confluence

FEH STATISTICAL FLOOD ESTIMATION SUMMARY SHEET			
Site	Mill of Rothney @ Shevock confluence		
NGR	NJ 62618 27705		
Type of problem/objective of	Peak flows for model		
	2, 5, 10, 25, 30, 50, 100, 200, 200cc, 500, 1000		
Type of catchment	Rural		
QMED site cd	0.94	m^3/s	
Donor/ Analogue Sites Considered			
Site name	Ythan@Ardlethen	Urie@Pitcaple	Deveron@Avochie
Station number	10001	11004	9001
NGR			
Proximity (km)	23.29	2.44	18
Adjustment	1.009	0.97	1.01
Site Chosen	Y	N	N
QMED site adjusted by data transfer (m^3/s)	0.90	**Specific Q (l/s/ha)**	2.6
Q_{100} growth curve factor	3.06	**Q100/ area (l/s/ha)**	8.1
Q_{100} (m^3/s)	**2.8**		
Summary Data			
FEH catchment area	3.21	km^2	
Adjusted catchment area	3.40	km^2	
URBEXT 1990	0.000		
URBEXT 2010	0.000		
URBEXT Adjustment Method	Urbext2000		
SAAR	847		
Method Used	FEH Statistical Method		
Variation from Chosen Method			
Index Used	BFI		
QMED	0.90	m^3/s	
5	1.31	m^3/s	
10	1.60	m^3/s	
25	2.03	m^3/s	
50	2.43	m^3/s	
100	2.89	m^3/s	
200	3.45	m^3/s	
500	4.35	m^3/s	
1000	5.19	m^3/s	
Climate Change Region	Eastern Scotland		
Climate change adjustment	24.0%		
200 + cc	4.3	m^3/s	
Donor/ Analogues Used			
Calcs by:	Grace Thompson	Date:	27/03/2018
Checked by:	David Cameron	Date:	27/03/2018



POOLING GROUP DETAILS

Original Default Pooling Group

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.086	38	1.84	0.165	0.331	1.133
45816 (Haddeo @ Upton)	1.348	22	3.489	0.314	0.415	0.915
27051 (Crimple @ Burn Bridge)	1.389	43	4.514	0.219	0.154	0.265
28033 (Dove @ Hollinsclough)	1.633	36	4.225	0.24	0.415	0.495
49006 (Camel @ Camelford)	2.195	9	11.5	0.129	-0.252	2.851
25019 (Leven @ Easby)	2.2	37	4.989	0.342	0.39	1.789
25011 (Langdon Beck @ Langdon)	2.249	28	15.878	0.238	0.318	1.197
26802 (Gypsey Race @ Kirby Grindalythe)	2.259	16	0.112	0.274	0.274	0.6
47022 (Tory Brook @ Newnham Park)	2.279	22	7.227	0.262	0.093	0.957
71003 (Croasdale Beck @ Croasdale Flum	2.315	37	10.9	0.212	0.323	0.241
49005 (Bollingey Stream @ Bolingey Cocks	2.316	5	5.777	0.288	0.256	0.95
25003 (Trout Beck @ Moor House)	2.358	42	15.142	0.172	0.293	0.659
91802 (Allt Leachdach @ Intake)	2.406	34	6.35	0.153	0.257	1.229
27073 (Brompton Beck @ Snainton Ings)	2.42	34	0.816	0.198	0.056	0.708
206006 (Annalong @ Recorder)	2.519	48	15.33	0.189	0.052	1.81
54022 (Severn @ Plynlimon Flume)	2.539	38	14.988	0.156	0.171	1.115
27010 (Hodge Beck @ Bransdale Weir)	2.542	41	9.42	0.224	0.293	0.085
Total		530				
Weighted means				0.222	0.238	

Default Pooling Group Catchment Descriptors

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	1.086	1.63	1096	0.074	1.000	0.000
45816 (Haddeo @ Upton)	1.348	6.81	1210	0.011	1.000	0.005
27051 (Crimple @ Burn Bridge)	1.389	8.17	855	0.013	1.000	0.006
28033 (Dove @ Hollinsclough)	1.633	7.92	1346	0.007	1.000	0.000
49006 (Camel @ Camelford)	2.195	12.52	1418	0.013	1.000	0.003
25019 (Leven @ Easby)	2.2	15.09	830	0.02	1.000	0.004
25011 (Langdon Beck @ Langdon)	2.249	12.79	1463	0.012	1.000	0.001
26802 (Gypsey Race @ Kirby Grindalythe)	2.259	15.85	757	0.03	1.000	0.000
47022 (Tory Brook @ Newnham Park)	2.279	13.43	1403	0.023	0.942	0.014
71003 (Croasdale Beck @ Croasdale Flu	2.315	10.71	1882	0.016	1.000	0.000
49005 (Bollingey Stream @ Bolingey Cocl	2.316	16.08	1044	0.023	0.991	0.006
25003 (Trout Beck @ Moor House)	2.358	11.4	1905	0.041	1.000	0.000
91802 (Allt Leachdach @ Intake)	2.406	6.54	2554	0.003	0.992	0.000
27073 (Brompton Beck @ Snainton Ings)	2.42	8.06	721	0.237	1.000	0.008
206006 (Annalong @ Recorder)	2.519	14.44	1704	0.023	0.981	0.000
54022 (Severn @ Plynlimon Flume)	2.539	8.75	2481	0.01	1.000	0.000
27010 (Hodge Beck @ Bransdale Weir)	2.542	18.82	987	0.009	1.000	0.001

Final Pooling Group Catchment Descriptors

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.086	38	1.84	0.165	0.331	1.509
45816 (Haddeo @ Upton)	1.348	22	3.489	0.314	0.415	1.042
27051 (Crimple @ Burn Bridge)	1.389	43	4.514	0.219	0.154	0.404
28033 (Dove @ Hollinsclough)	1.633	36	4.225	0.24	0.415	0.66
25019 (Leven @ Easby)	2.2	37	4.989	0.342	0.39	1.958
25011 (Langdon Beck @ Langdon)	2.249	28	15.878	0.238	0.318	1.063
26802 (Gypsey Race @ Kirby Grindalythe)	2.259	16	0.112	0.274	0.274	0.581
47022 (Tory Brook @ Newnham Park)	2.279	22	7.227	0.262	0.093	1.265
71003 (Croasdale Beck @ Croasdale Flum	2.315	37	10.9	0.212	0.323	0.324
25003 (Trout Beck @ Moor House)	2.358	42	15.142	0.172	0.293	0.902
27073 (Brompton Beck @ Snainton Ings)	2.42	34	0.816	0.198	0.056	1.255
206006 (Annalong @ Recorder)	2.519	48	15.33	0.189	0.052	2.704
27010 (Hodge Beck @ Bransdale Weir)	2.542	41	9.42	0.224	0.293	0.106
22003 (Usway Burn @ Shillmoor)	2.771	13	16.17	0.282	0.311	1.065
49003 (de Lank @ de Lank)	2.943	49	14.324	0.227	0.214	0.163
Total		506				
Weighted means		963		0.236	0.259	

Final Pooling Group Catchment Descriptors

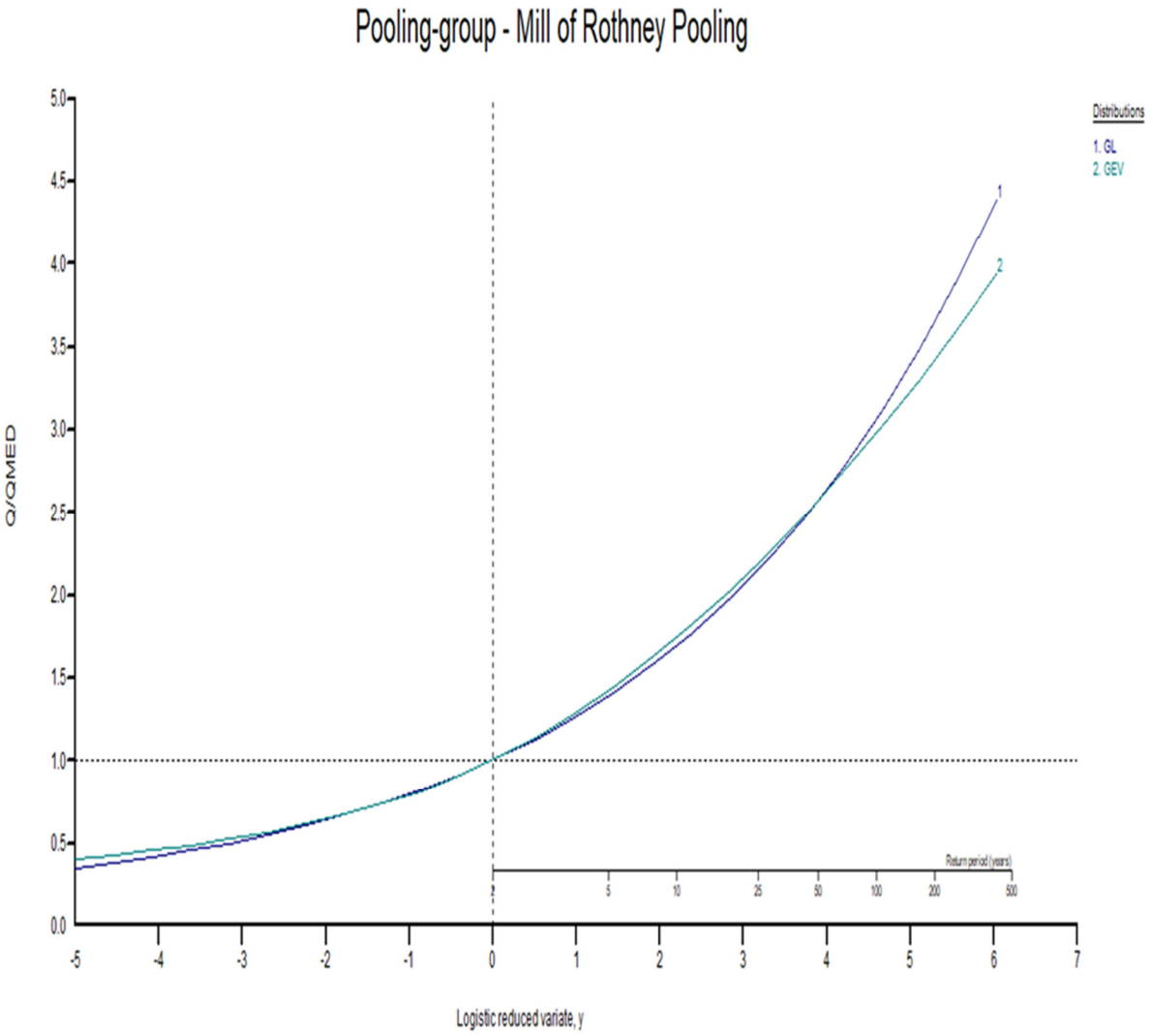
Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	1.086	1.63	1096	0.074	1.000	0.000
45816 (Haddeo @ Upton)	1.348	6.81	1210	0.011	1.000	0.005
27051 (Crimple @ Burn Bridge)	1.389	8.17	855	0.013	1.000	0.006
28033 (Dove @ Hollinsclough)	1.633	7.92	1346	0.007	1.000	0.000
25019 (Leven @ Easby)	2.2	15.09	830	0.02	1.000	0.004
25011 (Langdon Beck @ Langdon)	2.249	12.79	1463	0.012	1.000	0.001
26802 (Gypsey Race @ Kirby Grindalythe)	2.259	15.85	757	0.03	1.000	0.000
47022 (Tory Brook @ Newnham Park)	2.279	13.43	1403	0.023	0.942	0.014
71003 (Croasdale Beck @ Croasdale Flu	2.315	10.71	1882	0.016	1.000	0.000
25003 (Trout Beck @ Moor House)	2.358	11.4	1905	0.041	1.000	0.000
27073 (Brompton Beck @ Snainton Ings)	2.42	8.06	721	0.237	1.000	0.008
206006 (Annalong @ Recorder)	2.519	14.44	1704	0.023	0.981	0.000
27010 (Hodge Beck @ Bransdale Weir)	2.542	18.82	987	0.009	1.000	0.001
22003 (Usway Burn @ Shillmoor)	2.771	21.88	1056	0.006	1.000	0.000
49003 (de Lank @ de Lank)	2.943	21.61	1628	0.064	0.998	0.000

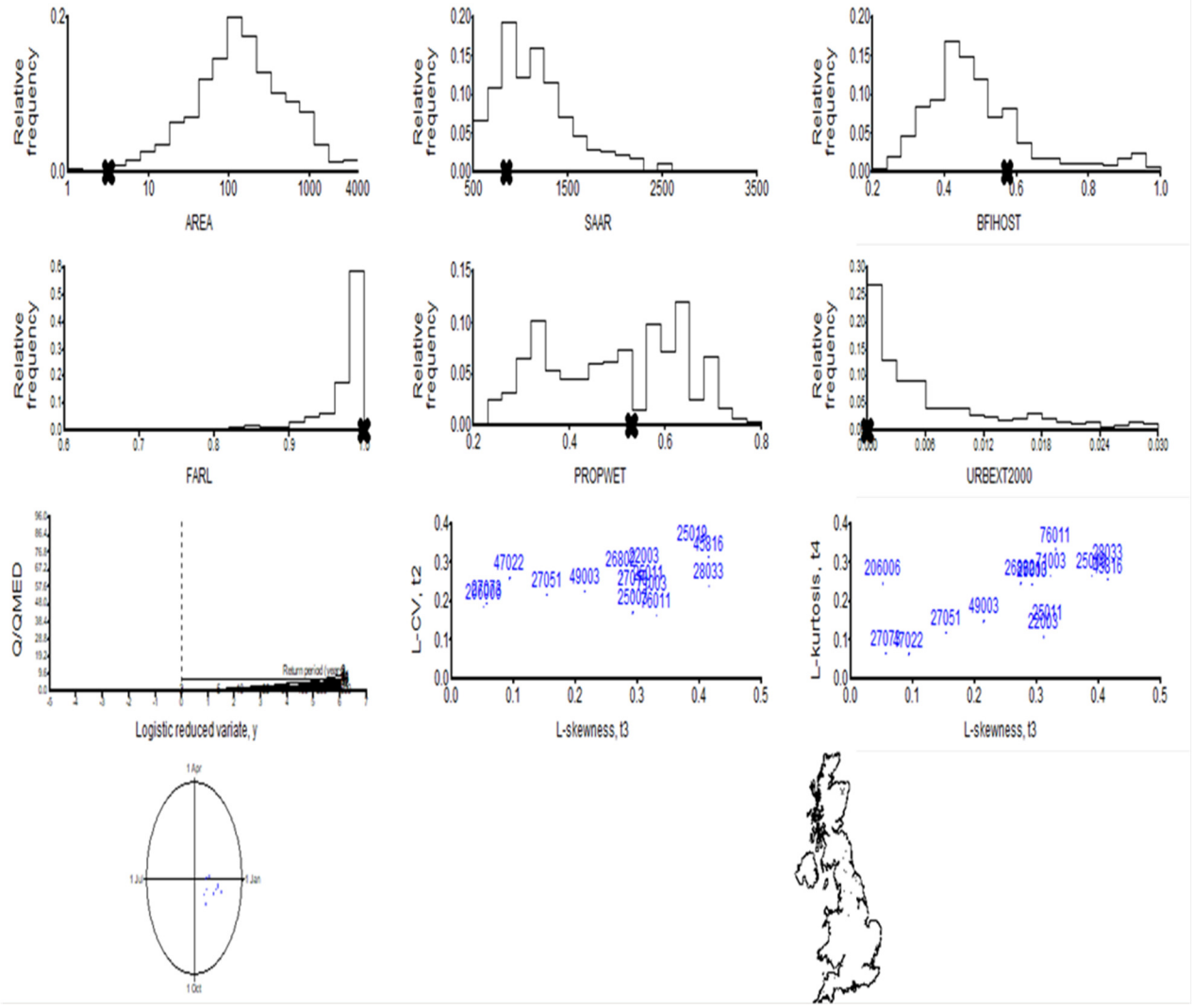
DERIVING A POOLED GROWTH CURVE			
Site	Mill of Rothney @ Shevock confluence	√	Ungauged site
NGR	NJ 62618 27705		Gauged site
Attached Printouts			
	WINFAP-FEH station details		
	WINFAP-FEH summary information if gauged site		
Initial Pooling Group Details			
Name	Mill of Rothney		
Site of interest	Mill of Rothney @ Shevock confluence		
Return period of interest	2, 5, 10, 25, 30, 50, 100, 200, 500, 1000, 200+CC years		
Other information			
Version of WIN-FAP FEH	Version 3.0		
Data Files	Other		
If 'Other' chosen in Data Files enter file path here	HiFlows v6.0, SEPA gauges through WY2016		

Adjustment/ Changes made to Default Pooling Group.
Also note sites that were investigated but retained in the group (i.e. for discordancy)

Station number	Name	Addition/ Deletion/ Move/ Investigate	Reason
91802	Allt Leachdach @ Intake	D	SAAR 2554
54022	Severn @ Plynimon Flume	D	SAAR 2481
49005	Bollingey Stream @ Bolingey Cock Bridge	D	Only 5 years of data
49006	Camel @ Camelford	D	Outlier on Lmoments
206006	Annalong @ Recorder	D	Historical record
22003	Usway Burn @ Shilmoor	A	Increase record length
49003	de Lank @ de Lank	A	Increase record length

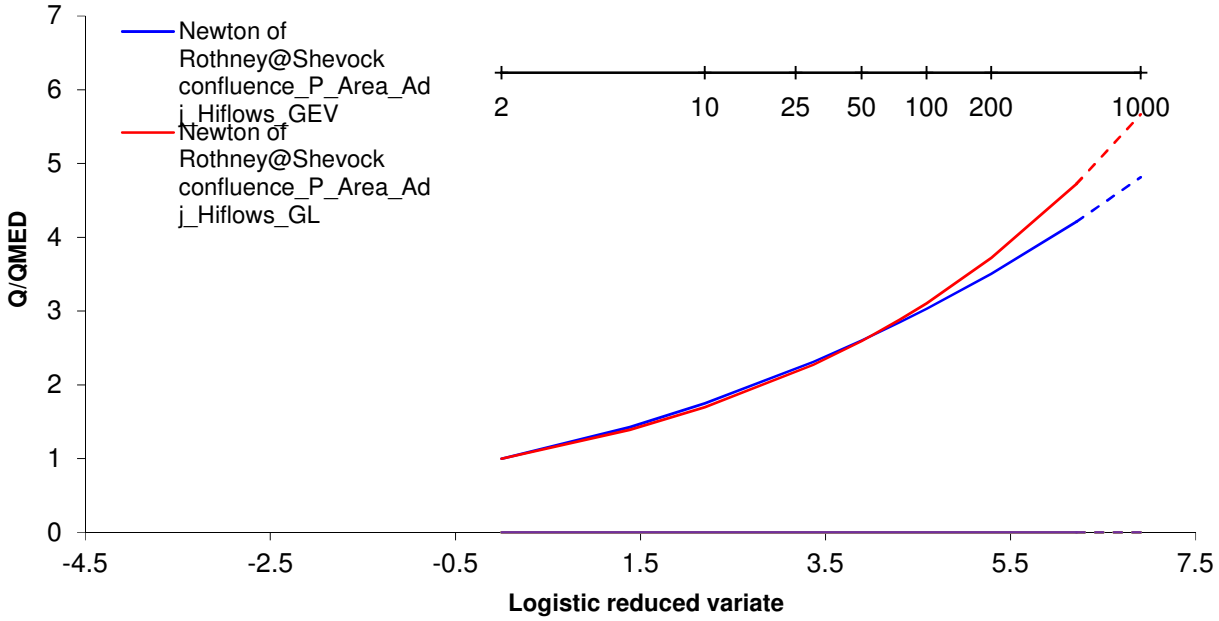
Final Pooling Group Details	
Heterogeneity Measure	
H1	Possibly Heterogeneous
H2	Possibly Heterogeoeous
Goodness of Fit	
Acceptable Fit	**Distribution**
√	Generalised Logistic
√	Generalised Extreme Value
	Pearson Type iii
	Generalised Pareto
Growth Curve Fittings	
Attached print outs	WINFAP-FEH growth curve fittings
	WINFAP-FEH growth curve
Name of Final Pooling Group	Mill of Rothney Pooling


Pooling-group - Mill of Rothney Pooling
Q/QMED
Logistic reduced variate, y
Distributions
1. GL
2. GEV
Return period (years)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
2
5
10
25
50
100
200
500


Relative frequency
AREA
SAAR
BFIHOST
FARL
PROPWET
URBEXT2000
Q/QMED
Logistic reduced variate, y
L-CV, t2
L-skewness, t3
L-kurtosis, t4
L-skewness, t3
1 Apr
1 Jul
1 Jan
1 Oct

A.5 Newton of Rothney at Shevock confluence

FEH STATISTICAL FLOOD ESTIMATION SUMMARY SHEET			
Site	Newton of Rothney @ Shevock confluence		
NGR	NJ 63293 27854		
Type of problem/objective of	Peak flows for model		
	2, 5, 10, 25, 30, 50, 75, 100, 200, 200cc, 500, 1000		
Type of catchment	Rural		
QMED site cd	0.77	m^3/s	
Donor/ Analogue Sites Considered			
Site name	Ythan@ Ardlethen	Urie@Pitcaple	Deveron@Avochie
Station number	10001	11004	9001
NGR			
Proximity (km)	21.60	2.49	20
Adjustment	1.010	0.97	1.08
Site Chosen	Y	N	N
QMED site adjusted by data transfer (m^3/s)	0.78	**Specific Q (l/s/ha)**	2.8
Q_{100} growth curve factor	3.11	**Q100/ area (l/s/ha)**	8.8
Q_{100} (m^3/s)	**2.4**		
Summary Data			
FEH catchment area	2.69	km^2	
Adjusted catchment area	2.76	km^2	
URBEXT 1990	0.000		
URBEXT 2010	0.000		
URBEXT Adjustment Method	Urbext2000		
SAAR	832		
Method Used	FEH Statistical Method		
Variation from Chosen Method			
Index Used	BFI		
QMED	0.78	m^3/s	
5	1.09	m^3/s	
10	1.33	m^3/s	
25	1.69	m^3/s	
50	2.03	m^3/s	
100	2.43	m^3/s	
200	2.91	m^3/s	
500	3.70	m^3/s	
1000	4.43	m^3/s	
Climate Change Region	Eastern Scotland		
Climate change adjustment	24.0%		
200 + cc	3.6	m^3/s	
Donor/ Analogues Used			
Calcs by:	Grace Thompson	Date:	27/03/2018
Checked by:	David Cameron	Date:	27/03/2018



POOLING GROUP DETAILS

Original Default Pooling Group

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	0.887	38	1.84	0.165	0.331	1.133
45816 (Haddeo @ Upton)	1.584	22	3.489	0.314	0.415	0.915
27051 (Crimple @ Burn Bridge)	1.644	43	4.514	0.219	0.154	0.265
28033 (Dove @ Hollinsclough)	1.867	36	4.225	0.24	0.415	0.495
49006 (Camel @ Camelford)	2.44	9	11.5	0.129	-0.252	2.851
25019 (Leven @ Easby)	2.455	37	4.989	0.342	0.39	1.789
25011 (Langdon Beck @ Langdon)	2.492	28	15.878	0.238	0.318	1.197
26802 (Gypsey Race @ Kirby Grindalythe)	2.509	16	0.112	0.274	0.274	0.6
27073 (Brompton Beck @ Snainton Ings)	2.51	34	0.816	0.198	0.056	0.708
47022 (Tory Brook @ Newnham Park)	2.523	22	7.227	0.262	0.093	0.957
71003 (Croasdale Beck @ Croasdale Flum	2.533	37	10.9	0.212	0.323	0.241
91802 (Allt Leachdach @ Intake)	2.562	34	6.35	0.153	0.257	1.229
49005 (Bollingey Stream @ Bolingey Cocks	2.573	5	5.777	0.288	0.256	0.95
25003 (Trout Beck @ Moor House)	2.575	42	15.142	0.172	0.293	0.659
54022 (Severn @ Plynlimon Flume)	2.722	38	14.988	0.156	0.171	1.115
206006 (Annalong @ Recorder)	2.755	48	15.33	0.189	0.052	1.81
27010 (Hodge Beck @ Bransdale Weir)	2.799	41	9.42	0.224	0.293	0.085
Total		530				
Weighted means				0.221	0.238	

Default Pooling Group Catchment Descriptors

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	0.887	1.63	1096	0.074	1.000	0.000
45816 (Haddeo @ Upton)	1.584	6.81	1210	0.011	1.000	0.005
27051 (Crimple @ Burn Bridge)	1.644	8.17	855	0.013	1.000	0.006
28033 (Dove @ Hollinsclough)	1.867	7.92	1346	0.007	1.000	0.000
49006 (Camel @ Camelford)	2.44	12.52	1418	0.013	1.000	0.003
25019 (Leven @ Easby)	2.455	15.09	830	0.02	1.000	0.004
25011 (Langdon Beck @ Langdon)	2.492	12.79	1463	0.012	1.000	0.001
26802 (Gypsey Race @ Kirby Grindalythe)	2.509	15.85	757	0.03	1.000	0.000
27073 (Brompton Beck @ Snainton Ings)	2.51	8.06	721	0.237	1.000	0.008
47022 (Tory Brook @ Newnham Park)	2.523	13.43	1403	0.023	0.942	0.014
71003 (Croasdale Beck @ Croasdale Flu	2.533	10.71	1882	0.016	1.000	0.000
91802 (Allt Leachdach @ Intake)	2.562	6.54	2554	0.003	0.992	0.000
49005 (Bollingey Stream @ Bolingey Cocl	2.573	16.08	1044	0.023	0.991	0.006
25003 (Trout Beck @ Moor House)	2.575	11.4	1905	0.041	1.000	0.000
54022 (Severn @ Plynlimon Flume)	2.722	8.75	2481	0.01	1.000	0.000
206006 (Annalong @ Recorder)	2.755	14.44	1704	0.023	0.981	0.000
27010 (Hodge Beck @ Bransdale Weir)	2.799	18.82	987	0.009	1.000	0.001

Final Pooling Group Catchment Descriptors

Station name	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	0.887	38	1.84	0.165	0.331	1.549
45816 (Haddeo @ Upton)	1.584	22	3.489	0.314	0.415	1.076
27051 (Crimple @ Burn Bridge)	1.644	43	4.514	0.219	0.154	0.435
28033 (Dove @ Hollinsclough)	1.867	36	4.225	0.24	0.415	0.709
25019 (Leven @ Easby)	2.455	37	4.989	0.342	0.39	1.972
25011 (Langdon Beck @ Langdon)	2.492	28	15.878	0.238	0.318	1.527
26802 (Gypsey Race @ Kirby Grindalythe)	2.509	16	0.112	0.274	0.274	0.799
27073 (Brompton Beck @ Snainton Ings)	2.51	34	0.816	0.198	0.056	1.395
47022 (Tory Brook @ Newnham Park)	2.523	22	7.227	0.262	0.093	1.405
71003 (Croasdale Beck @ Croasdale Flum	2.533	37	10.9	0.212	0.323	0.31
25003 (Trout Beck @ Moor House)	2.575	42	15.142	0.172	0.293	0.883
27010 (Hodge Beck @ Bransdale Weir)	2.799	41	9.42	0.224	0.293	0.115
22003 (Usway Burn @ Shillmoor)	3.028	13	16.17	0.282	0.311	1.455
49003 (de Lank @ de Lank)	3.182	49	14.324	0.227	0.214	0.159
41020 (Bevern Stream @ Clappers Bridge)	3.611	46	13.78	0.208	0.178	1.211
Total		504				
Weighted means				0.236	0.269	

Station	Distance SDM	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	0.887	1.63	1096	0.074	1.00	0.00
45816 (Haddeo @ Upton)	1.584	6.81	1210	0.011	1.00	0.01
27051 (Crimple @ Burn Bridge)	1.644	8.17	855	0.013	1.00	0.01
28033 (Dove @ Hollinsclough)	1.867	7.92	1346	0.007	1.00	0.00
25019 (Leven @ Easby)	2.455	15.09	830	0.02	1.00	0.00
25011 (Langdon Beck @ Langdon)	2.492	12.79	1463	0.012	1.00	0.00
26802 (Gypsey Race @ Kirby Grindalythe)	2.509	15.85	757	0.03	1.00	0.00
27073 (Brompton Beck @ Snainton Ings)	2.51	8.06	721	0.237	1.00	0.01
47022 (Tory Brook @ Newnham Park)	2.523	13.43	1403	0.023	0.94	0.01
71003 (Croasdale Beck @ Croasdale Flu	2.533	10.71	1882	0.016	1.00	0.00
25003 (Trout Beck @ Moor House)	2.575	11.4	1905	0.041	1.00	0.00
27010 (Hodge Beck @ Bransdale Weir)	2.799	18.82	987	0.009	1.00	0.00
22003 (Usway Burn @ Shillmoor)	3.028	21.88	1056	0.006	1.00	0.00
49003 (de Lank @ de Lank)	3.182	21.61	1628	0.064	1.00	0.00
41020 (Bevern Stream @ Clappers Bridge	3.611	35.48	886	0.076	0.99	0.01

DERIVING A POOLED GROWTH CURVE			
Site	Newton of Rothney @ Shevock confluence	√	Ungauged site
NGR	NJ 63293 27854		Gauged site
Attached Printouts			
	WINFAP-FEH station details		
	WINFAP-FEH summary information if gauged site		

Initial Pooling Group Details	
Name	Newton of Rothney
Site of interest	Newton of Rothney @ Shevock confluence
Return period of interest	2, 5, 10, 25, 30, 50, 100, 200, 500, 1000, 200+CC years
Other information	
Version of WIN-FAP FEH	Version 3.0
Data Files	Other
If 'Other' chosen in Data Files enter file path here	HIFlows v6.0, SEPA gauges through WY2016

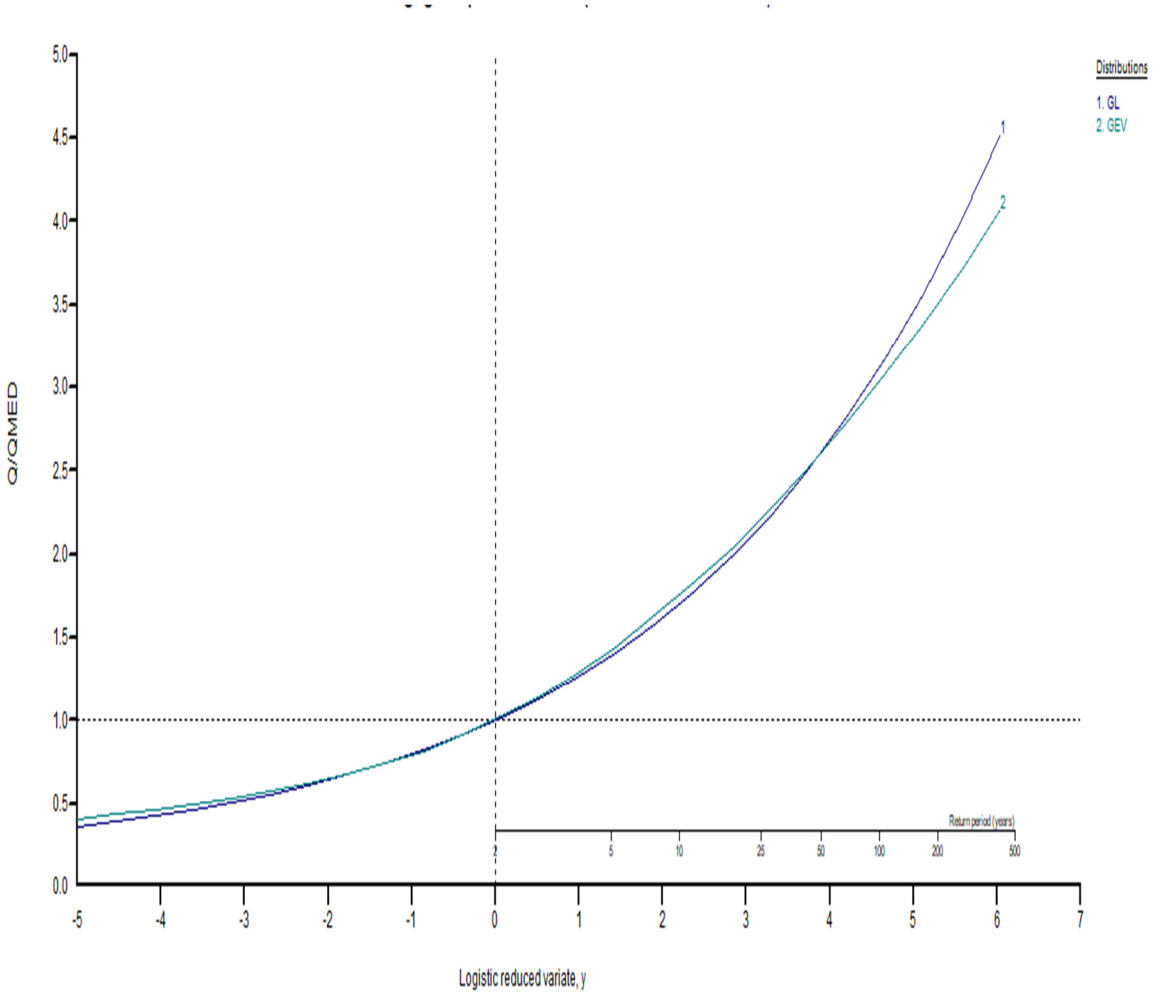
Adjustment/ Changes made to Default Pooling Group.
Also note sites that were investigated but retained in the group (i.e. for discordancy)

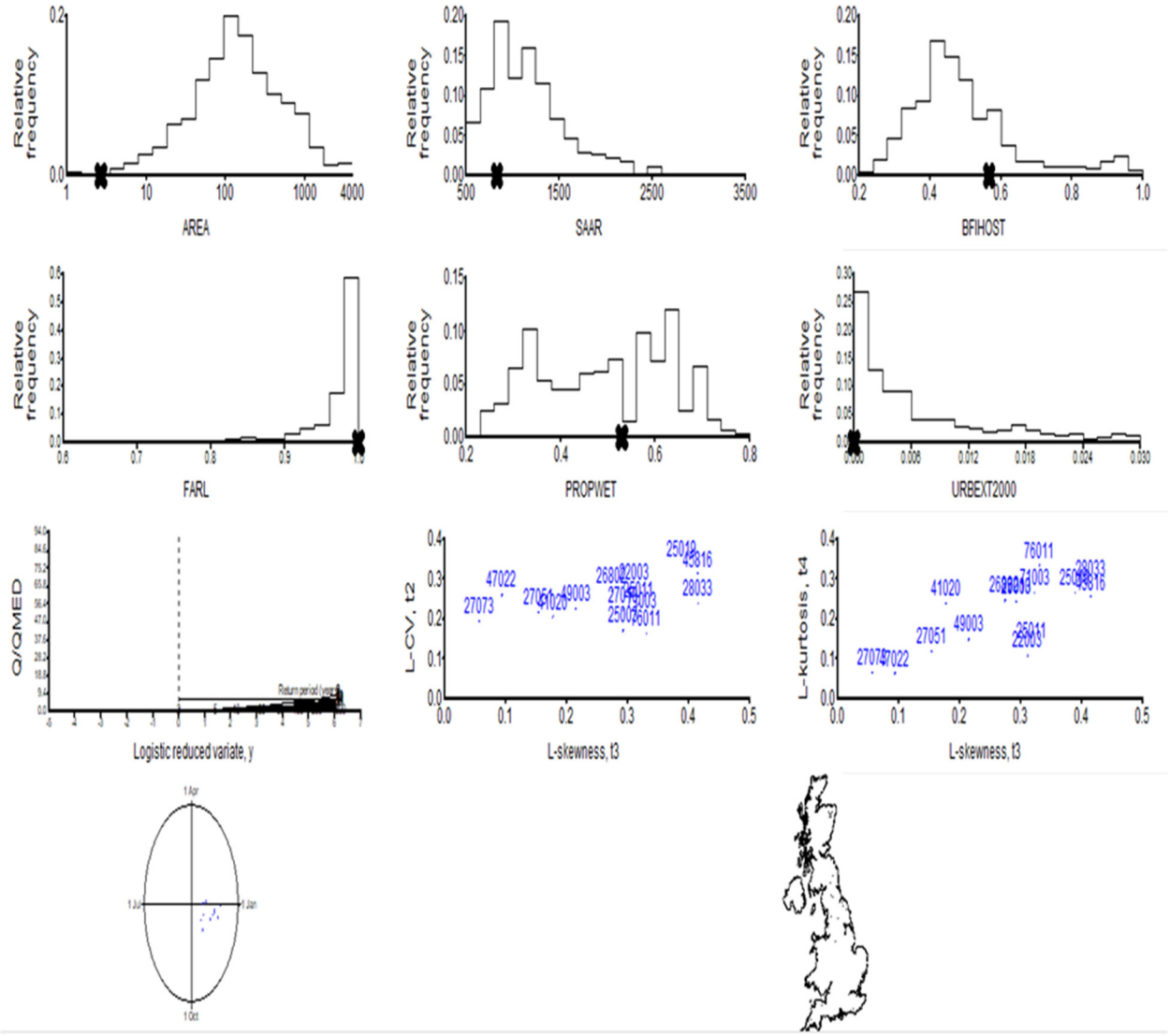
Station number	Name	Addition/ Deletion/ Move/ Investigate	Reason
49005	Bollingey Stream @ Bollingey Cock Bridge	D	Only 5 years of data
54022	Severn @ Plynlimon Flume	D	SAAR 2481
91802	Allt Leachdach @ Intake	D	SAAR 2554
49006	Camel @ Camelford	D	Outlier on Lmoments
206006	Annalong @ Recorder	D	Historical record
22003	Usway Burn@ Shilmoor	A	Increase record length
41020	Bevern Stream @ Clappers Bridge	A	Increase record length
49003	de Lank @ de Lank	A	Increase record length

Final Pooling Group Details	
Heterogeneity Measure	
H1	Possibly Heterogeneous
H2	Acceptably Homogeneous

Goodness of Fit	
Acceptable Fit	**Distribution**
√	Generalised Logistic
√	Generalised Extreme Value
	Pearson Type iii
	Generalised Pareto

Growth Curve Fittings		
Attached print outs		WINFAP-FEH growth curve fittings
		WINFAP-FEH growth curve
Name of Final Pooling Group		Newton of Rothney Pooling


Distributions
1. GL
2. GEV
Q/QMED
Logistic reduced variate, y
Return period (years)
2
5
10
25
50
100
200
500


Relative frequency
AREA
SAAR
BFIHOST
FARL
PROPWET
URBEXT2000
Q/QMED
Logistic reduced variate, y
L-CV, t2
L-skewness, t3
L-kurtosis, t4
L-skewness, t3

B ReFH2 Additional Outputs

B.1 Valentines Burn

UK Design Flood Estimation

Generated on 29 January 2018 12:13:02 by jflownw
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 98F9-6210

Site name: Valentines_Burn
Easting: 363500
Northing: 828100
Country: Scotland
Catchment Area (km²): 3.18 [3.23]*
Using plot scale calculations: No
Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 2013 (mm):	63.90	Total runoff (ML):	36.71
Total Rainfall (mm):	44.12	Total flow (ML):	77.49
		Peak flow (m³/s):	2.52
Peak Rainfall (mm):	12.00		

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	04:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.71	No
ARF (Areal reduction factor)	0.97	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	101.32	No
Cmax (mm)	485.96	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	2.21	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m³/s)	0.07	No
BL (hr)	23.21	No
BR	1.22	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km²)	0.18	No
Urbext 2000	0.04	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km²)	0.00	Yes
Sewer capacity (m³/s)	0.00	Yes

B.2 Mill of Rothney Burn

UK Design Flood Estimation

Generated on 29 January 2018 12:19:16 by jflownw
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 39CC-17C4

Site name: Mill of Rothney
Easting: 362600
Northing: 827700
Country: Scotland
Catchment Area (km²): 3.4 [3.21]*
Using plot scale calculations: No
Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 2013 (mm):	60.35	Total runoff (ML):	32.91
Total Rainfall (mm):	40.54	Total flow (ML):	73.68
		Peak flow (m³/s):	2.58
Peak Rainfall (mm):	13.70		

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	03:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.7	No
ARF (Areal reduction factor)	0.96	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	98.72	No
Cmax (mm)	498.47	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	2.01	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m³/s)	0.08	No
BL (hr)	24.04	No
BR	1.24	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km²)	0	No
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km²)	0.00	Yes
Sewer capacity (m³/s)	0.00	Yes

B.3 Newton of Rothney Burn

UK Design Flood Estimation

Generated on 29 January 2018 12:24:36 by jflownw
Printed from the ReFH Flood Modelling software package, version 2.2.6029.28099

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: F6CA-8B32

Site name: Newton of Rothney
Easting: 363950
Northing: 827900
Country: Scotland
Catchment Area (km²): 2.75 [2.69]*
Using plot scale calculations: No
Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 2013 (mm):	58.85	Total runoff (ML):	26.31
Total Rainfall (mm):	39.07	Total flow (ML):	58.49
		Peak flow (m³/s):	2.23
Peak Rainfall (mm):	7.62		

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	03:15:00	No
Timestep (hh:mm:ss)	00:15:00	No
SCF (Seasonal correction factor)	0.69	No
ARF (Areal reduction factor)	0.96	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	100.45	No
Cmax (mm)	490.1	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	1.88	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m³/s)	0.06	No
BL (hr)	22.45	No
BR	1.22	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km²)	0	No
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km²)	0.00	Yes
Sewer capacity (m³/s)	0.00	Yes

C Technical Review Certificate

Technical Review Certificate

Project Name	Ellon, Inverurie and Insch FPS
Project Number	2017s6743
Project Manager	Caroline Anderton
Work Carried Out by	Grace Thompson and Briony McIntosh
Reviewer	David Cameron
Subject of Review	Peak flow estimates for the Shevock and 3 tributaries
Date	21 March 2018
Revision	1.1
Documents used in Review	..\4.Statistical\2017s6743_Shevock_Burn_v2.xlsm ..\4.Statistical\2017s6743_Mill_of_Rothney_v2.xlsm ..\4.Statistical\2017s6743_Newton_of_Rothney_v2.xlsm ..\4.Statistical\2017s6743_Valentines_Burn_v2.xlsm ..\AIZ-JBAU-IN-00-CA-HM-0001-Flood-estimate-method-comparison-Insch-S0-P01.02.xlsx ..\..\..\Graphics\M2\Projects\AIZ-JBAU-IN-00-M2-HM-0001-Hydrology.mxd
Applicable Standards or Guidance	

Use the following colour scheme to record recommendations:

Green – suggestion for improved / good practice but which is unlikely to change the project outcomes.

Amber – non-standard method or method not following guidance but unlikely to have impacted on results

Red – omission that could make the findings subject to challenge and which requires correction/further work.

SCOPE OF REVIEW:

Review FEH estimates (FEH RR, ReFH2 with FEH13 and FEH Statistical) for the Shevock, Valentine Burn, Mill of Rothney and Newton of Rothney.

DETAILED REVIEW COMMENTS:

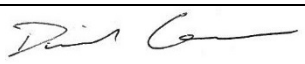
Suitable approach comparing 3 FEH methods.

RECOMMENDATIONS:

Overall approach is suitable, but amber and red comments below need to be addressed before sign off.

PRELIMINARY CERTIFICATE (only required when comments are raised).

In respect of the project design described above, I have carried out a Review and consider the technical output sound, subject to the comments and recommendations listed above. Please inform me when you have considered these comments so that I may complete the Final Certificate.

Signature of Reviewer	
Name of Reviewer	David Cameron
Date	21 March 2018

	Aspect	Y/N	Comments
General	Has the appropriate calculation record been completed?	Y	Y. Shevock: The Shevock workbook includes estimates at two different locations using two different pooling groups. It would be easier to follow (and also for reporting) if two workbooks were used – one for the Shevock US of Mill of Rothney and one for the US of the Urie confluence (including the DS of Mill of Rothney as it uses the same growth curve as US Mill of Rothney). *Two workbooks have been created 'Shevock Burn US MoR' and 'Shevock_v3' - BM* QMED tab for the Shevock should be tidied up - multiple entries for same donors. *QMED tabs tidied in new workbooks - BM* Summary tab for the Shevock includes the Bogie at Redcraig with incorrect proximity, and adjustment values. These should be corrected Summary tab, cell B8 should have the Catchment Descriptor QMED. *Amended in new workbooks - BM* Summary tab could do with adding the location of the Shevock in the site description e.g US of Urie confluence. Data tab for the Shevock – why are columns AY to BC in different colours? *Formatting issue – amended in new workbook - BM* Data tab – the selected distribution is the GL; but the best fit was from the GEV and P3. Of the options on the data tab, the GEV should be used. *GEV distribution selected in new workbook - BM* Name of final pooling group is missing from the Derivation tab *Amended in new workbook - BM* Other watercourses: The naming of the sites on the FEH Statistical sheets for the Valentines Burn, Mill of Rotheny and Newton of Rothney, needs to be corrected before they are included in a report. Amended in Version2 -GT
	Has a method statement been produced?	N	To be included as text in the report
	Does the analysis (or an accompanying report) include a description of the catchment and its flooding processes?	Y	To be included as text in the report
	Are there any unusual features of the catchment and how they will be taken into account?	N	No unusual features.
	Aspect	**Revision required? (Y,N,N/A)**	**Comments**
Data Review & Checks	Has a review of existing data been carried out?	N	Ungauged catchments.
	Are flow and level stations present, and closed stations as well as current ones?	N	Ungauged catchments.
	Have stations outside the HiFlows-UK	N	Mill of Keithfield and Old Rayne level gauges used for Tp

	dataset been considered, e.g. temporary loggers?		estimation.
	Is it appropriate to update the flood peak series from those in HiFlows-UK, if so has this been done?	N	SEPA records updated.
	Is there a potential donor site? Within / outside the reach?	N	Shevock: Deveron at Avochie has been selected and is appropriate
	Is the data quality reviewed – at a minimum HiFlows-UK classification	N	Ungauged catchments.
	Is more detailed review of data and ratings appropriate for this study, has this been carried out?	N	Ungauged catchments. Urie at Pitcaple has been subject to a rating review.
	Has a historical review of data been carried out?	N	Included within main report.
	Does the report include plots and interpretation of flood peak time series and flood event data?	N	Included within main report.
	Appropriate choice of flow calculation point?	N	Appropriate.
	Has catchment boundary been checked and area revised?	N	Yes.
	What other catchment descriptors have been checked - is this appropriate?	N	URBEXT modified via national growth method.
	What method has been chosen?	N	FEH Statistical pooling for Shevock; FEH RR for other watercourses.
	Is chosen method appropriate?	N	Yes, given catchment sizes.
Statistical Method	Has the standard methodology been adjusted?	N	Not adjusted.
	QMED checked? Has the revised QMED equation been used (CEH, 2008)?	N	Revised equation used.
	Has the revised method of data transfer (CEH, 2008) been used?	N	Revised method used.
	Choice of donor appropriate?	Y	Potentially yes – Deveron at Avochie has been used for the Shevock and the Ythan at Ardlethen has been used for the other sites. However, a check should also be made against the Urie at Pitcaple in all cases (it is accepted that the rating for this site has not been fully accepted by SEPA and maybe subject to change, but a check should still be made); and also Avochie for the smaller watercourses. For the smaller watercourses the Urie at Pitcaple would also be suitable however not fully accepted by SEPA Hence Ythan at Ardlethen used. The Deveron at Avochie less suitable for the smaller watercourses.
	Choice of adjustment factor appropriate?	N	Yes, assuming donors appropriate.
	Have QMED estimates been checked for consistency with upstream and downstream gauges?	N	Ungauged catchments.
	Local data being used to full potential?	Y	Unclear – see comment on choice of donor and Pitcaple.
	Choice of adjustment factor appropriate?	N	Yes, assuming donors appropriate.
	Estimation of growth factor appropriate?	N	Yes, circa 3 in all cases.
	Growth factor Q2-Q100 is 1.8-3.0	N	Yes, but Mill of Rothney slightly larger than 3.
	Pooling group reviewed and details given?	N	Yes

	Has the removal and retention of sites in the pooling group been justified?	N	Yes
	Are there any flood peak records suitable for the derivation of single site growth curves?	N	No
	Has enhanced single site analysis been carried out? (rural sites)	N	N/A ungauged sites.
	Has a comparison of the pooled, single site and enhanced growth curves been undertaken?	N	N/A ungauged sites.
	Climate change considered?	N	Yes
Rainfall Runoff	Has the standard methodology been adjusted?	N	Standard methods used.
	Has FEH rainfall runoff method been used or ReFH?	N	FEH RR and ReFH2 with FEH13 rainfall applied to Burns.
	Have any parameters been adjusted?	N	Parameters not adjusted, but comparison of Tp made at Mill of Keithfield level only site (Old Rayne not suitable). Tp at this site was v. similar between FEH RR with catchment descriptors and observed Tp. FEH RR with catchment descriptors therefore retained.
	Has lag analysis been undertaken?	N	See previous comment.
	Climate change considered?	N	Yes
Unusual Catchments or Small Catchments	Have non FEH methods been used for small catchment estimates? If so have these been justified and limitations acknowledged?	N	N/A
	If the catchment is heavily urbanised ($URBEXT_{2000}$>0.150)	N	N/A
	If there is a significant reservoir influence (FARL<0.9, with reservoirs not kept permanently full), and there is inadequate flood peak data available downstream of the reservoirs	N	N/A
	If the catchment is permeable (SPRHOST<20%), has the statistical method been used, with growth curves adjusted to remove non-flood annual maximum flows?	N	N/A
	Is the catchment is pumped?	N	N/A
Final Checks	Have results for all methods been summarised for comparison?	N	Yes on spreadsheet and in report.
	Is choice of method justified?	N	Yes.
	Have the design flows been checked for spatial consistency, e.g. at confluences and along reaches?	N	Ungauged catchments.
	Have they been checked against flood peaks in the gauged record, and any longer-term flood history?	N	Flood history considered in report.
	Have the specific runoff rates been checked for spatial consistency?	N	Smaller watercourses similar.
	Have the results been compared with any from other studies	N	To be included in report if available.
	Does the report comment on uncertainty in the design flows?	N	To be included in report.
	Are the assumptions and limitations of the methods acknowledged?	N	To be included in report.

RESPONSE (only required when a Preliminary Certificate is raised)

I have addressed the comments raised under the Preliminary Certificate.

Signature	

Name	
Date	27/03/18 19/03/2018

FINAL CERTIFICATE In respect of the project design described above, I have carried out a Review and consider the technical output sound, and any comments raised under a Preliminary Certificate have been satisfactorily addressed.	
Signature of Reviewer	
Name of Reviewer	David Cameron
Date	02/05/2018

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