Jacobs Flood Study Summary FEH Pooling Group and Single Site Analysis

River Windrush at Worsham

Rev 1.1

8 July 2008

JACOBS

Flood study summary
FEH pooling group and single site analysis Rev 1.1
River Windrush at Worsham

Project details

Project title:	Cogges Link Road
Project number:	B0834600
Work Stage:	023 Flood modelling
Client:	Oxfordshire Highways
Flood study site:	Windrush at Worsham
Office:	Leatherhead

Originator: Marcus Francis Signature…… Date 30 June 2008

Checker: Julian Smith Signature……Date 8 July 2008

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1 General

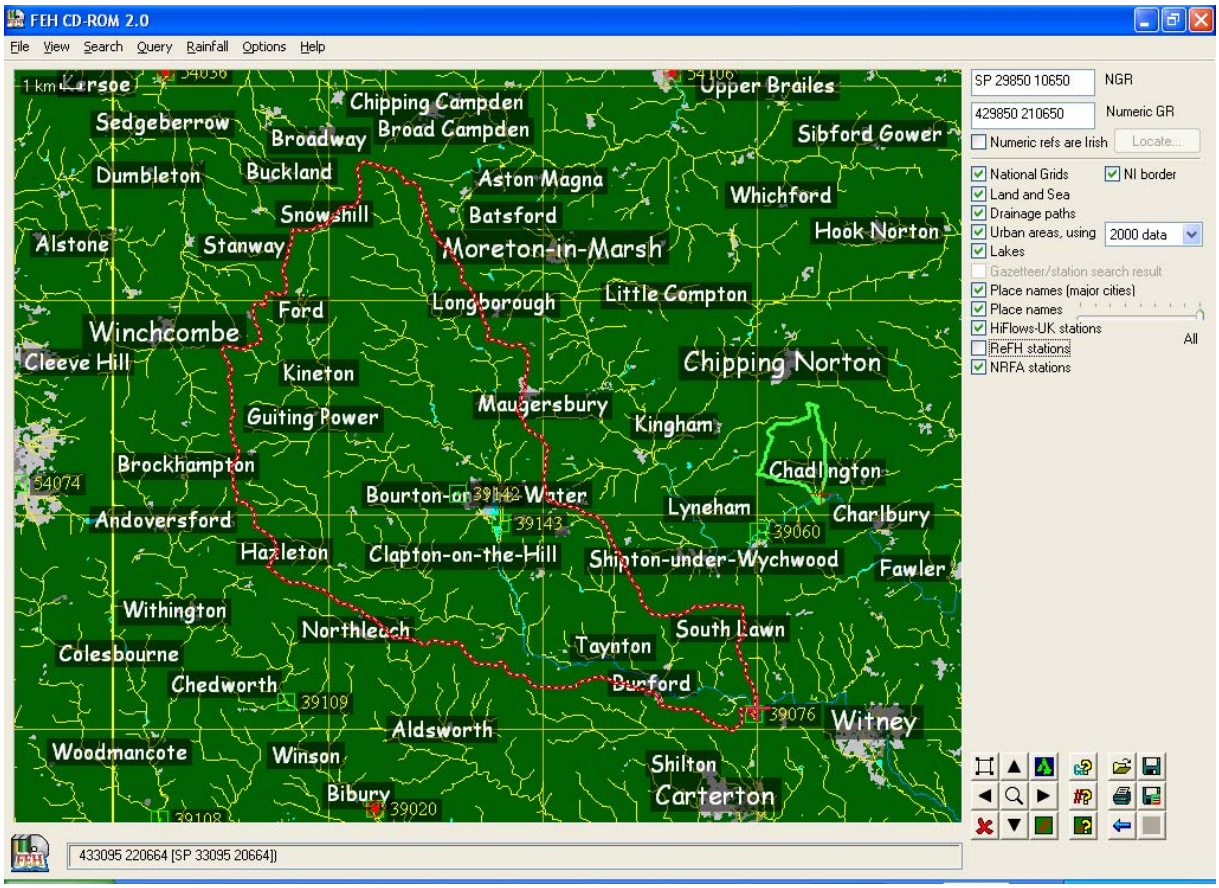
The following analysis was carried out using the FEH CD-ROM v2.0 and Winfap-FEH v2.0.002 which takes into account the HIFLOWS data.

2 Catchment description

Grid Reference at outflow: SP 29850 10650

2.1 FEH catchment descriptors:

DTM AREA	294.07
ALTBAR	195
ASPBAR	133
ASPVAR	0.18
BFIHOST	0.816
DPLBAR	28.62
DPSBAR	67.9
FARL	0.970
LDP	48.69
PROPWET	0.33
RMED-1D	34.5
RMED-1H	10.7
RMED-2D	43.2
SAAR	763
SAAR4170	785
SPRHOST	15.33
URBCONC1990	0.472
URBEXT1990	0.0089
URBLOC1990	0.874
URBCONC2000	0.690
URBEXT2000	0.0073
URBLOC2000	0.798



Catchment map from FEH CD-RM 2.0

2.2 Presence of significant land use factors:

Land use	Comment	Potential Significance
Reservoir\lake	Some offline former gravel pits in floodplain upstream near Bourton on the Water.	Not likely to have a major impact.
Urban	Flows through Burford and Bourton on the Water further upstream.	Impact likely to be minor
Afforestation	Unknown	Assumed to be negligible
Land drainage	Unknown	Assumed to be negligible
(Other)	N/A	Not known

2.3 Flow record:

Gauged \ ~~Ungauged~~ ?

Attribute			Comment
Quality\suitability of record for flood analysis	Good	x	Gauge at site since 1942. High flows unreliable prior to installation of ultrasonic gauge in 1995. Data since 1995 reputed to be good.
	Adequate		
	Not adequate		
Number of years of data	1995 - 2007 12 years of data		(Indicate years, the use and source of updated data, reasons for periods of record not being used, perhaps reference to land-use changes etc) Data requested but not initially available.

3 Estimation of QMED

3.1 Approach used

Used*	Condition	Approach followed
	N >=30	Estimate QMED using annual maxima
	14=< N =<29	Estimate QMED from annual maxima & optionally adjust for climatic variation
	2=< N= <13	Estimate QMED from POT data & adjust for climatic variation
	N <2 & suitable donor site with 20 years or more of record	Ignore record at subject site; transfer QMED from donor site
	N <2 & suitable donor with 10 to 19 years of record & 12 month overlap between records	Estimate QMED using procedure based on flood peak regression
	N <2 & suitable donor with 10 to 19 years of record but no 12 month overlap	Ignore record at subject site; transfer QMED from donor site
	N <2 & no long-record site nearby	Estimate QMED from very short POT record
	N <2 & no long-record site nearby	Treat site as ungauged catchment
	N <2 & no long-record site nearby	Defer analysis until longer flow record available
	N <2 & no long-record site nearby	(Abstract flood event information and apply the UH rainfall-runoff model as an alternative, to the pooling group procedure. Particularly recommended when site is urbanised)
✓1	Ungauged catchment	Estimate QMED from catchment descriptors
✓2	Ungauged catchment	Estimate QMED by data transfer from donor catchment
✓3	Ungauged catchment	Estimate QMED by data transfer from analogue catchment
	Ungauged catchment	Estimate QMED from channel dimensions

*If more than 1 approach has been used then indicate the relative suitability of the approaches (if possible) using a numbering system in which “1” represents the most suitable.

3.2 QMED estimation from catchment descriptors

Attribute	Value
AREA	294.07
SAAR	763
FARL	0.970
SPRHOST	15.33
BFIHOST	0.816

$QMED_{Catchment\ descriptors\ –\ rural}$ = 11.18 m^3/s

3.3 QMED estimation by data transfer

	Subject site	Donor site	Analogue site 1	Analogue site 2
NAME	Worsham	39006	39020	54106
AREA	294.07	362.6	106.7	185.2
SAAR	763	744	821	677
FARL	0.970	0.9089	0.968	0.993
SPRHOST	15.33	17.2	12.17	41.27
BFIHOST	0.816	0.79	0.858	0.454
QMED cd's	17.4	20.05	5.40	35.68
QMED data	Not available	11.30	3.75	20.49

Ratio of Donor/Analogue site QMED data to QMED cd's = **0.61** (geometric mean).

Application of this value to subject site QMED cd's gives subject site:
QMED adjusted = 10.6 m^3/s.

The choice of donor sites was limited to 39006 downstream on the Windrush. No other sites are available within the catchment of the Windrush.

The choice of analogue sites was driven by considerations of proximity to the target site, common geology (oolitic limestone), comparable catchment area, and acceptability for use for QMED transfer.

It should be noted that it is possible that sufficient data is available at Worsham from gauge 39076 to allow a direct derivation of QMED either from AMAX or POT. This data was not available at the time of this analysis. It is strongly recommended that the analysis be re-visited when this data is made available to confirm and if necessary revise the QMED value and hence the predicted return period events.

4 Construction and analysis of pooling group

4.1 General

4.1.2 Name of saved .feh group file: Worsham pg1.feh

4.1.3 Max target return period (years) 500

4.2 Initial pooling group details

4.2.1 Total number of sites: 76 Total number of years: 2475

4.2.2 Total number of initial high discordancy sites

Number removed	10
List	39034, 30011, 39037, 33049, 39008, 41023, 39018, 43801, 44002, 44003

4.2.3 Total number of short records (< 7 years) removed

Number removed	1
List	31006

4.2.4 Total number removed that are unsuitable for pooling group formation

Number removed	23
List	27056, 29001, 29003, 30005, 33006, 33024, 33044, 34003, 34004, 34011, 34018, 39027, 39029, 39032, 39040, 41011, 42005, 43004, 44001, 44004, 44810, 54044, 66004

4.2.5 Number of pooled years after sites removed: 1529 (from 42 sites)

4.3 Subject site details

Is subject site included as Rank 1 in pooled group:yes/no (Data not available)

4.4 Test statistics on validity of pooling group for flood frequency analysis

4.4.1 Heterogeneity test H2 value= 5.22

Review not necessary		H2 < 1
Review optional		1 < H2 < 2
Review desirable		2 < H2 < 4
Review essential	**x**	H2 > 4

4.4.2 Goodness-of-fit test

Distribution	Acceptability	Z value
GL	Acceptable/not acceptable	0.3111
GEV	Acceptable/not acceptable	-4.446
PT3	Acceptable/not acceptable	-3.965
Other		

(Note: GL is favoured distribution for use)

4.5 Flood frequency analysis of initial pooling group

4.5.1 Distributions selected

Distribution	Selection
GL	**x**
GEV	
PT3	
Other	

4.5.2 Construct flood frequency curve

4.5.3 URBEXT updated yes/no

4.5.4 QMED derived from AMAX
POT
CD's
Data transfer

4.3.3 Urban adjustment yes/no

4.3.4 Value of QMED = 10.6 m^3/s

4.3.5 Initial flood growth curve and flood frequency curve

Fittings for Growth Curve	
GL	
Return P's	Growth factors
2	1.000
5	1.322
10	1.526
25	1.790
50	1.995
100	2.208
200	2.431
500	2.742

Fittings for Flood Frequency Curve	
GL	
Return P's	Design flows
2	10.6
5	14.0
10	16.2
25	19.0
50	21.1
100	23.4
200	25.8
500*	29.1

4.6 Revision of pooling group

4.6.1 Site removed

Sites removed	Justification
42007	FARL = 0.864
39035	FARL = 0.890
42010	URBEXT = 0.0289
42011	URBEXT = 0.0285
33029	High negative skew = -0.095
53028	High negative skew = -0.153
33021	High negative skew = -0.158
42008	High positive skew = 0.357
42009	High positive skew = 0.367
27087	High positive skew = 0.301
29002	High positive skew = 0.325
41015	High positive skew = 0.257

Number of pooled years after sites removed: 1108 (from 30 sites)

4.6.2 Test statistics on validity of pooling group for flood frequency analysis

Heterogeneity test: H2 value= 1.62

Review not necessary		H2 < 1
Review optional	**x**	1 < H2 < 2
Review desirable		2 < H2 < 4
Review essential		H2 > 4

Goodness-of-fit test

Distribution	**Acceptability**	**Z value**
GL	Acceptable/not acceptable	1.115
GEV	Acceptable/not acceptable	-3.34
PT3	Acceptable/not acceptable	
Other		

4.6.3 Flood growth curve and flood frequency curve from donor QMED

Fittings for Growth Curve		
GL		
Return Period	Growth factors	
Years	V 2	V 2.2
2	1.000	1.000
5	1.322	1.336
10	1.528	1.553
20	1.731	1.767
25	1.797	1.837
50	2.006	2.060
100	2.225	2.294
200	2.455	2.541
500	2.779	2.891
1000	3.040	3.175

Fittings for Flood Frequency Curve		
GL		
Return Period	Design flows	
Years	V 2	V 2.2
2	10.6	10.6
5	14.0	14.2
10	16.2	16.5
20	18.3	18.7
25	19.0	19.5
50	21.3	21.8
100	23.6	24.3
200	26.0	26.9
500	29.5	30.6
1000	32.2	33.7

It may be noted that there is little change in the predicted growth factors between the initial and final growth curves despite the removal of a large number of sites form the pooling group and the reduction in the H2 statistic from 5.2 to 1.6. It may be concluded that the prediction of the flood growth curve is fairly robust.

Since the above analysis, the HiFlows data set has been updated to version 2.2. There has been no change in the status of the stations in the pooling group but there are now 1197 years of data in the 30 selected stations. The pooling group details with version 2 and version 2.2 of HiFlows are shown below. There are no major changes to the data.

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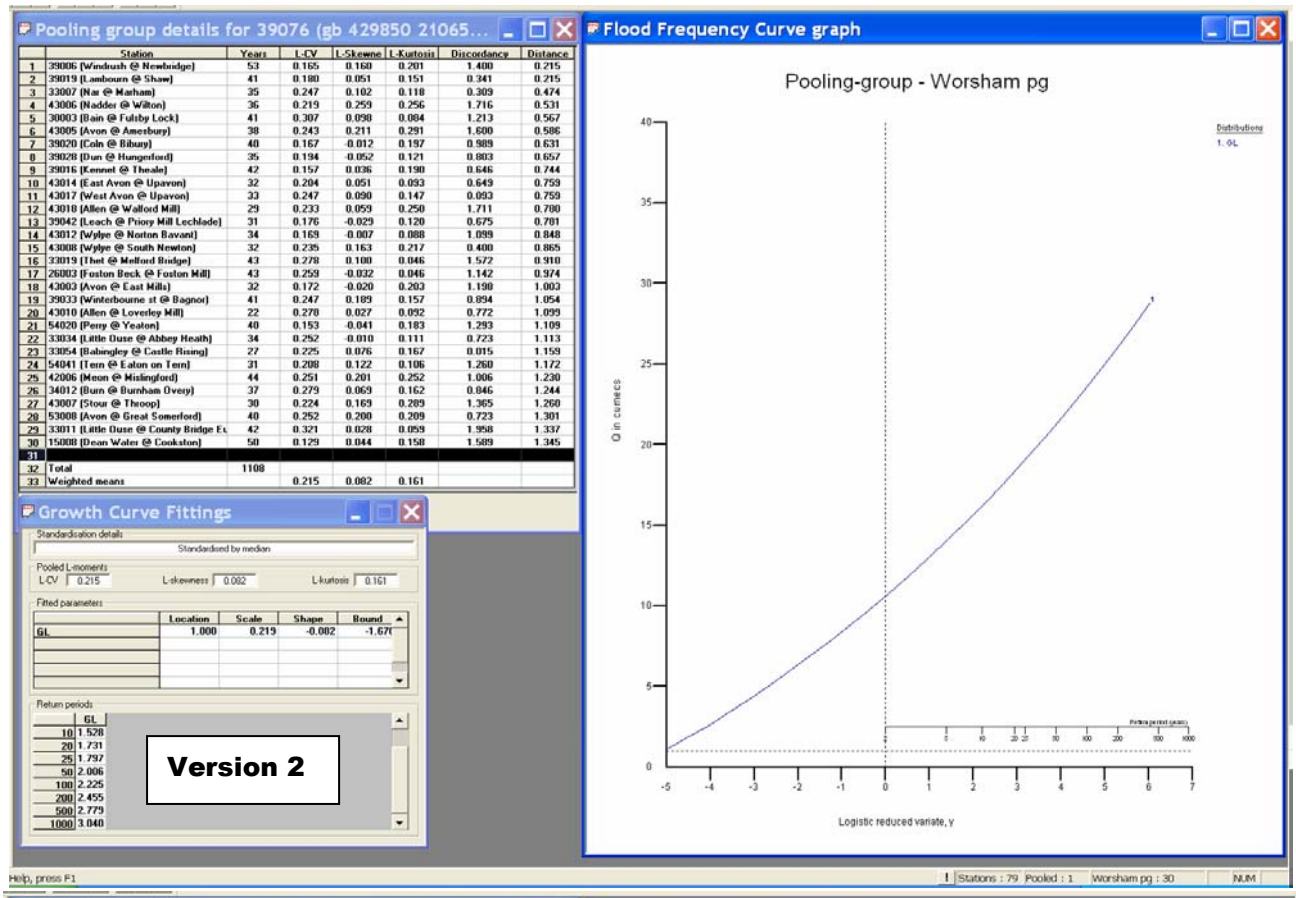

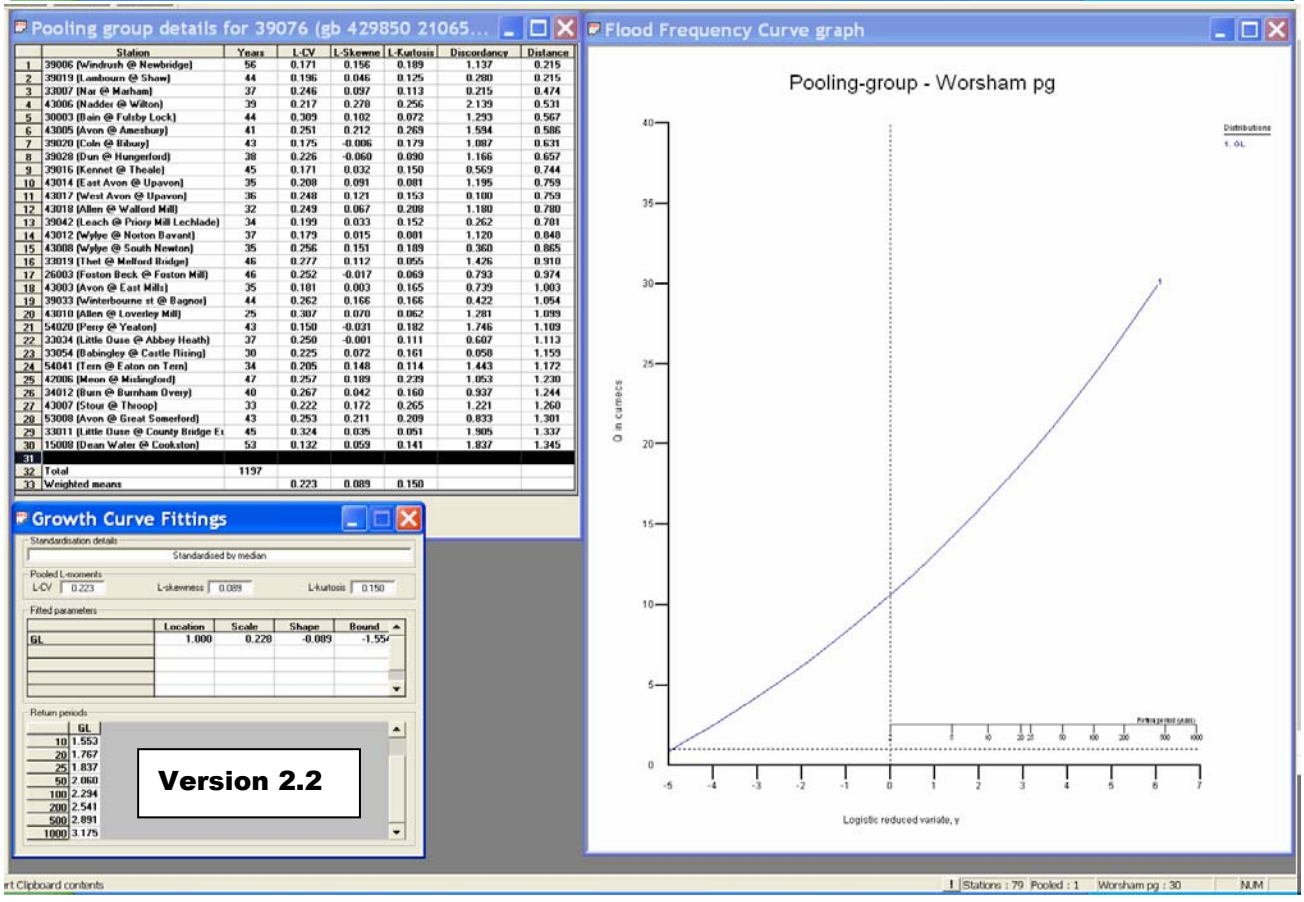

4.6.3 Flood growth curve from observed QMED

Annual maximum data has been provided for the Worsham gauge for the period 1987/88 to 2006/07. 1/10/2006 is indicated as missing but we have the July 2007 peak already to hand which would be the 2006/07 value. The data as supplied has numerous observations on the reliability of the values but it is assumed that the relative magnitudes are reliable and that the QMED is well within the optimum range of the gauge. QMED may be derived as follows for the whole series and for the data since 1996 when the ultrasonic gauge was commissioned:

Data as supplied		Whole series			From 1996 (Ultrasonic)		
Date	AMAX (m^3/s)	Date	AMAX (m^3/s)	Rank	Date	AMAX (m^3/s)	Rank
02/09/1988	1.91	21/07/2007	29.26	1	21/07/2007	29.26	1
30/11/1988	3.13	09/02/1990	18.7	2	13/12/2000	17.2	2
09/02/1990	18.7	04/12/1992	18.4	3	21/01/1999	16.6	3
08/03/1991	9.53	13/12/2000	17.2	4	03/01/2003	14.5	4
15/04/1992	8.52	21/01/1999	16.6	5	26/12/1999	12.4	5
04/12/1992	18.4	03/01/2003	14.5	6	05/02/2002	**9.86**	**6**
19/12/1993	7.27	26/12/1999	12.4	7	04/01/1998	9.76	7
20/01/1995	8.22	05/02/2002	9.86	8	01/02/2004	8.58	8
23/12/1995	9.56	04/01/1998	9.76	9	03/12/2005	7.97	9
25/02/1997	6.59	23/12/1995	**9.56**	**10**	25/02/1997	6.59	10
04/01/1998	9.76	08/03/1991	**9.53**	**11**	18/04/2005	4.12	11
21/01/1999	16.6	01/02/2004	8.58	12	-	-	-
26/12/1999	12.4	15/04/1992	8.52	13	-	-	-
13/12/2000	17.2	20/01/1995	8.22	14	-	-	-
05/02/2002	9.86	03/12/2005	7.97	15	-	-	-
03/01/2003	14.5	19/12/1993	7.27	16	-	-	-
01/02/2004	8.58	25/02/1997	6.59	17	-	-	-
18/04/2005	4.12	18/04/2005	4.12	18	-	-	-
03/12/2005	7.97	30/11/1988	3.13	19	-	-	-
01/10/2006	missing	02/09/1988	1.91	20	-	-	-
21/07/2007	29.26	-	-	-	-	-	-

QMED may thus be estimated initially as 9.55m^3/s from the whole series or 9.86m^3/s from the recent data. The former figure is based on potentially less reliable data. The latter, is based on a better gauge but would increase significantly if the next AMAX value recorded were to exceed 12.4m^3/s. Being based on a short series it could also be subjected to a climate adjustment. It is concluded that it is appropriate to use the QMED from the full data set to define the T-year floods based on the pooling group analysis and to use the QMED from the donor-site analysis as a measure of sensitivity.

Alternative Growth Curves						
Return Period:	Growth factors		**Whole period QMED**		1996 to date QMED	
Years			**(m^3/s)**		(m^3/s)	
	V 2	V 2.2	**V 2**	**V 2.2**	V 2	V 2.2
2	1	1	**9.55**	**9.55**	9.86	9.86
5	1.322	1.336	**12.63**	**12.76**	13.03	13.17
10	1.528	1.553	**14.59**	**14.83**	15.07	15.31
20	1.731	1.767	**16.53**	**16.87**	17.07	17.42
25	1.797	1.837	**17.16**	**17.54**	17.72	18.11
50	2.006	2.06	**19.16**	**19.67**	19.78	20.31
100	2.225	2.294	**21.25**	**21.91**	21.94	22.62
200	2.455	2.541	**23.45**	**24.27**	24.21	25.05
500	2.779	2.891	**26.54**	**27.61**	27.40	28.51
1000	3.04	3.175	**29.03**	**30.32**	29.97	31.31

5 Single site analysis

5.1 Data used

The Worsham gauge was reconstructed in 1995 and is considered to be of high quality since then. It is an ultrasonic gauge and even the July 2007 flood appears to have been contained within the gauging section. When asked for a AMAX series, the EA provided data from 1987 to 2006 from which it can be assumed that they have reasonable confidence in the peak flows over that period.

The data provided is listed in section 4.6.3, above. For the single site analysis, the 2006/07 hydrological year peak is the July 2007 flood so the "missing" 2006 entry is replaced by that value.

5.2 Data issues considered in analysis

The 1987 value seems extremely low for a river which is generally responsive to rainfall so the sensitivity of the analysis to omitting that value is considered on the basis that it may be an error rather than a genuine low magnitude flood.

The 2007 value is suggested by the pooling group analysis to have had a return period in excess of 500 years. This would make it an outlier in a single site analysis so the effect of omitting that item has been considered.

The new gauge installation may have given systematically different readings to the previous installation so the effect of limiting the period considered to readings since 1995 is considered.

5.3 Permeable catchment issues

The SPRHOST parameter for the catchment to Worsham is 15.33% which is within the band (less than 20%) for which the permeable catchment adjustment might be applied. The Worsham gauge shows, however, a clear, response to rainfall events and it is considered reasonable to expect the AMAX series to be dominated by direct responses to rainfall, though many events will have substantial contributions from the recessions of preceding events. As noted above, the recorded 1987 flood value seems low enough to challenge this assessment so its omission provides some indication of the sensitivity of the results to this assumption.

5.4 Alternative analyses

The following images illustrate the alternative single site analyses:

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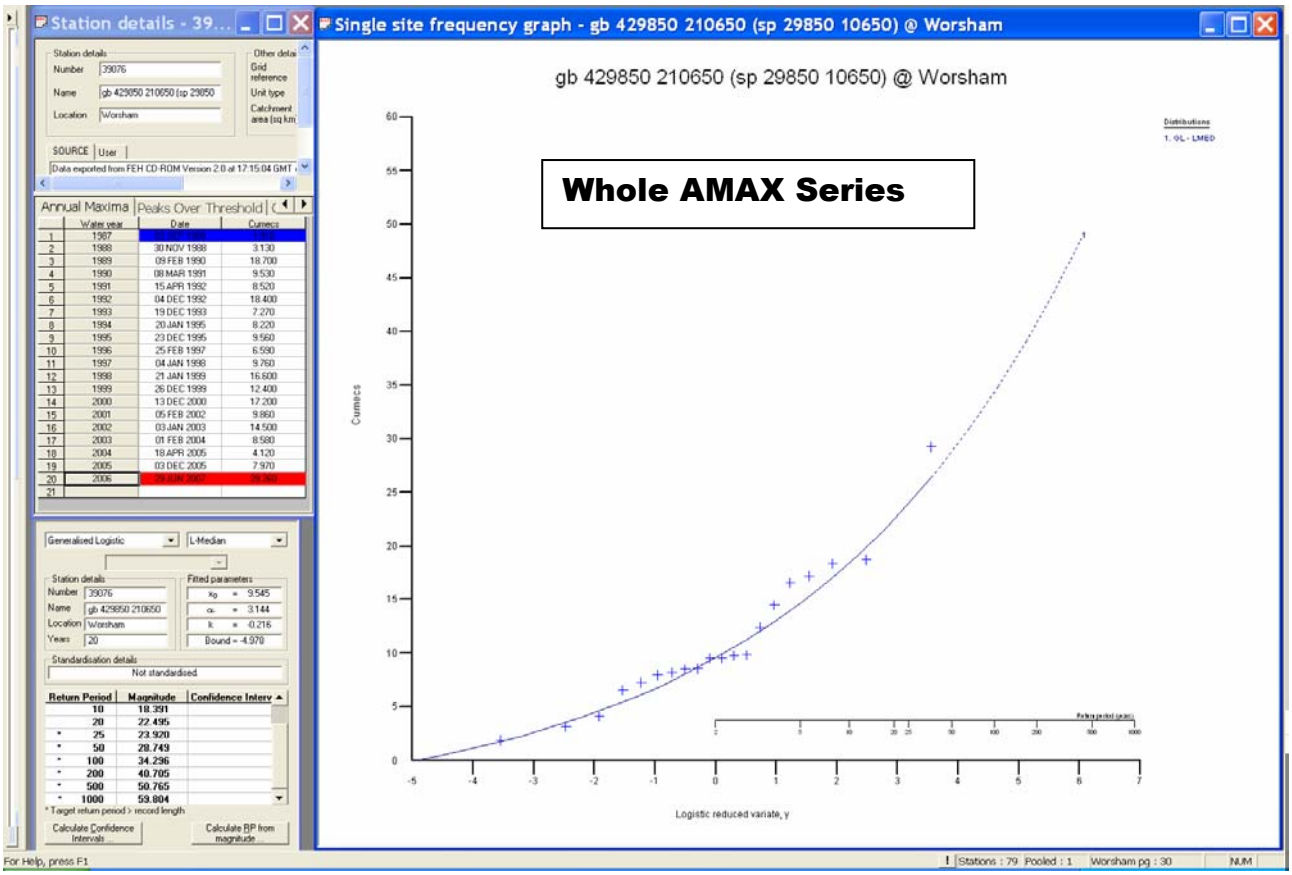

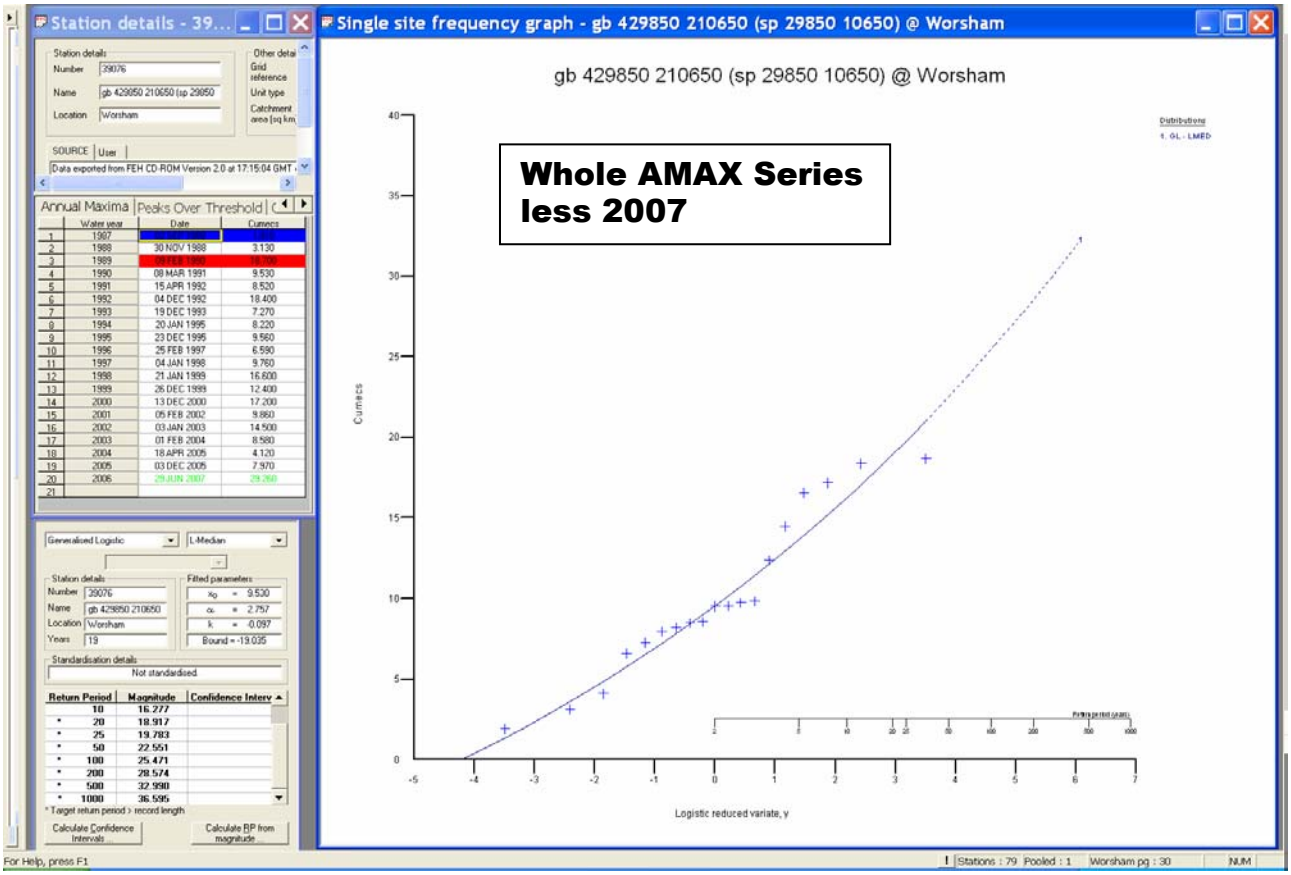

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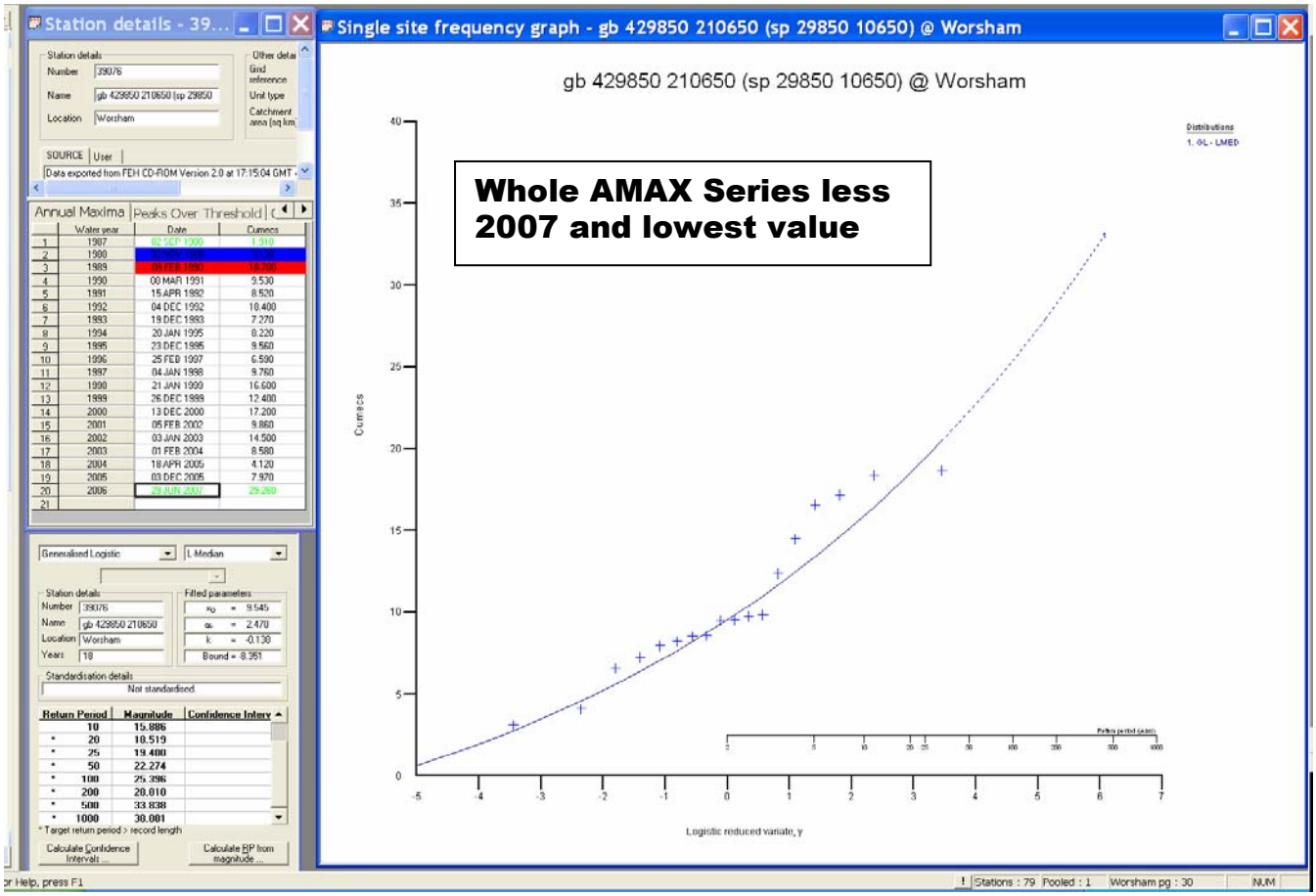

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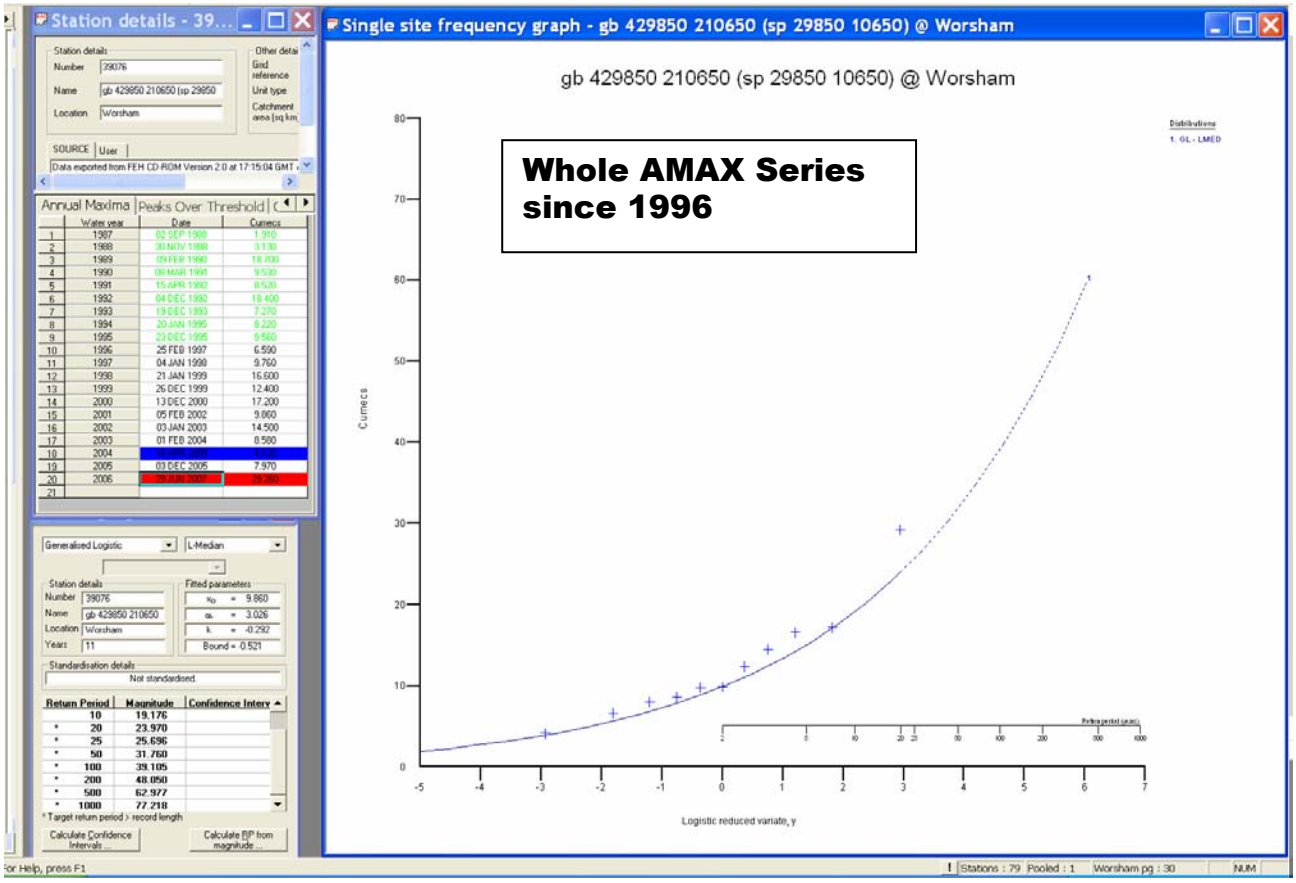

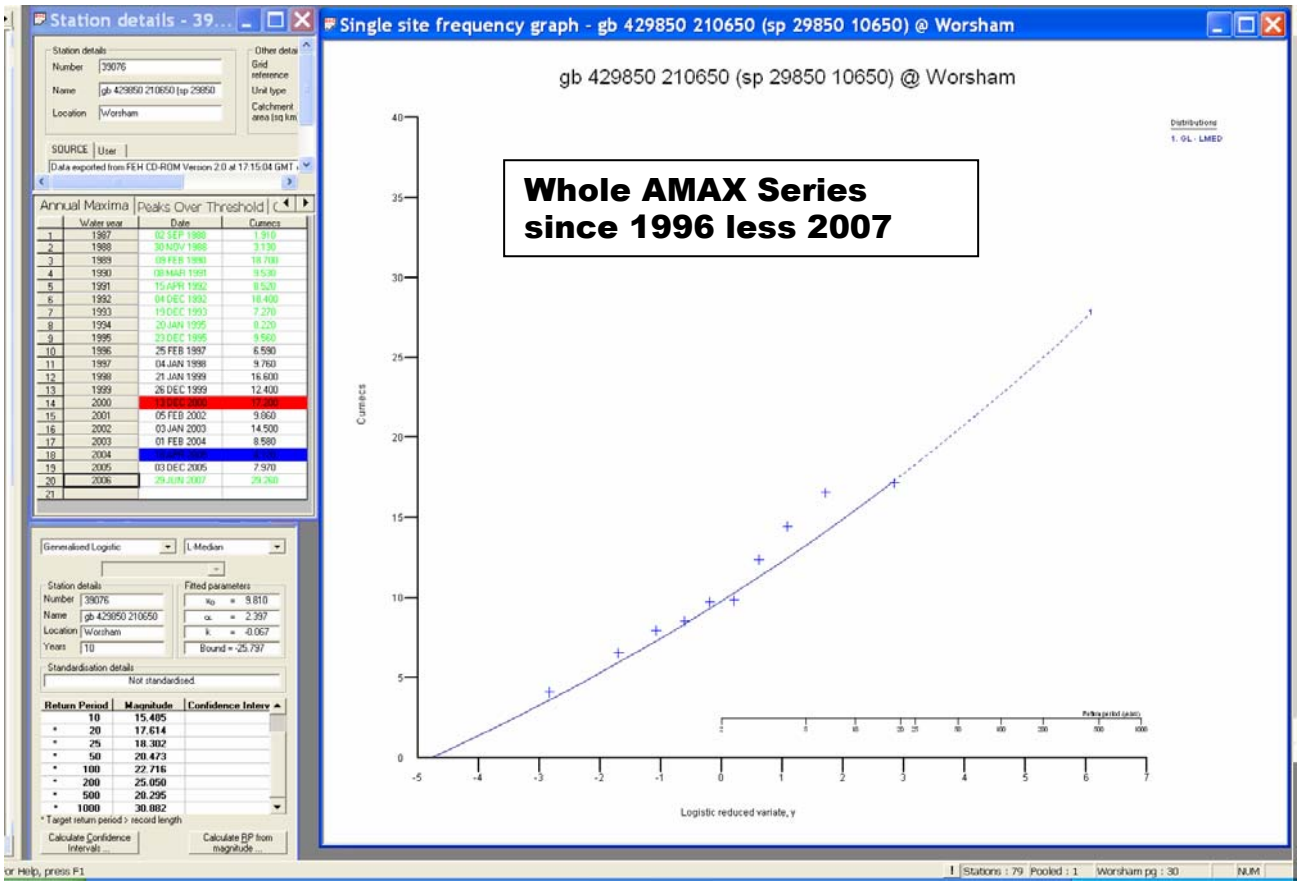

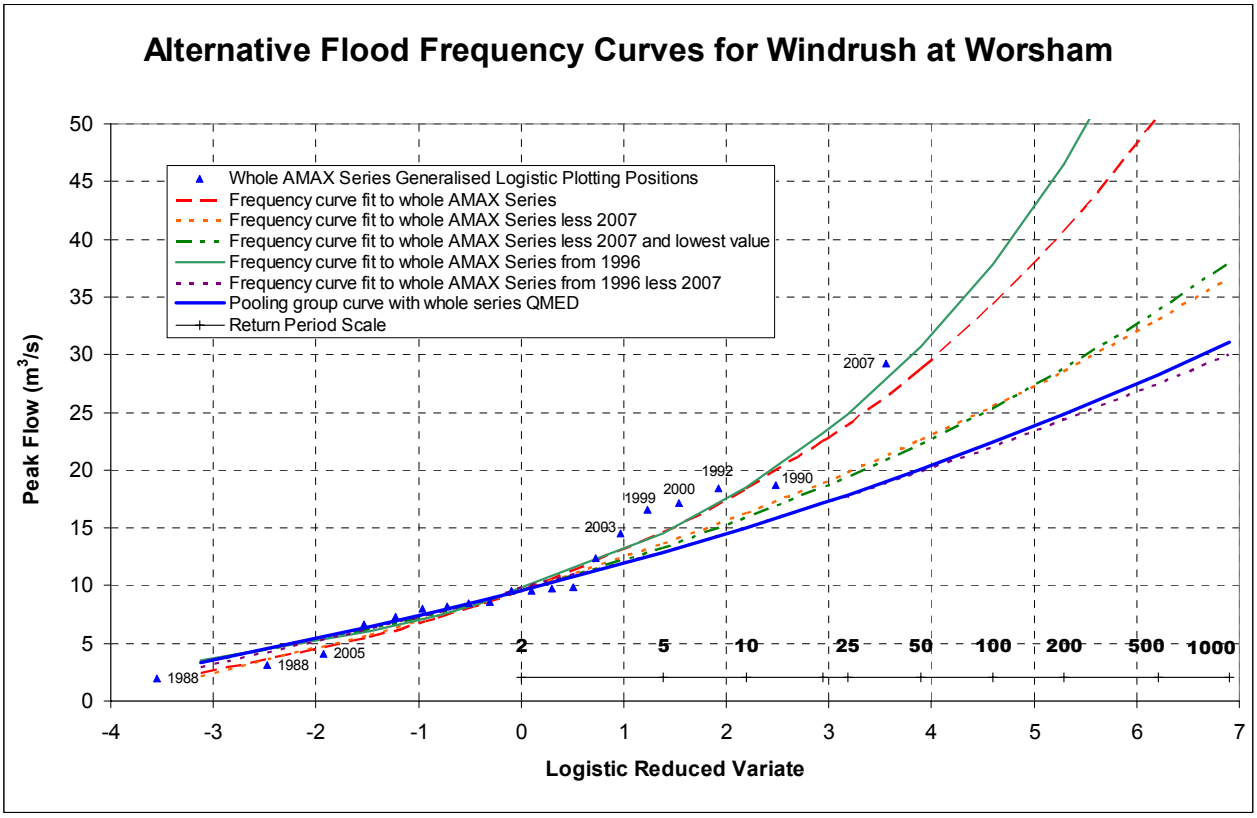

6 Conclusions

6.1 Recommended Frequency Curve

The pooling group curve is similar to the curve based on the short period from 1996 to 2006 omitting the 2007 peak flood. Including the 2007 peak in the AMAX-based analysis changes the curve dramatically – the pooling group curve suggests the 2007 flood had a return period of between 500 and 1000 years whilst the curves fitted to data including the 2007 event give it a return period of 50 years or less. The pooling group line also suggests rather high return periods for the five events at the top of the ranking (2003, 1999, 2000, 1992 and 1990). The most appropriate compromise appears to be to adopt the "censored" single station fit for the full AMAX series with the highest (2007) and lowest (1988) values omitted.

Date	AMAX (m^3/s)	Return Period from pooling group	Return Period from plotting position	Return Period from censored single station analysis
21/07/2007	29.26	635	36	220
09/02/1990	18.7	33	13	21
04/12/1992	18.4	30	8	20
13/12/2000	17.2	20	6	14
21/01/1999	16.6	19	4	12
03/01/2003	14.5	9	4	7

6.2 Proposed Design Flows

Using the recommended frequency curve, the design peak flows become:

Return Period (years)	Peak Flow (m^3/s)
2	9.55
5	13.30
10	15.86
20	18.49
25	19.37
50	22.24
100	25.35
200	28.76
500	33.78
1000	38.01

A 20% allowance for climate change above the 100 year flood would be 30.4m3/s, which would have a return period of about 273 years under current conditions.