ATKINS	CALCULATION CONTROL SHEET
PROJECT: Scarborough Borough Council – Cloughton/Burniston Becks – Project Appraisal	**Job No. 5002531**
PART OF PROJECT: Hydrological Analysis	**Calc. Ref. No. 5002531/85/ca/03**
CALCULATION TITLE: FEH Calculation Record	**No. Calc. Shts.**
FILE LOCATION: P:\GBWAE\Water\Rivers & Coastal\Projects\5002531 Scarborough\60-70 Work Processes\FEH\Burniston\Burniston FEH Calc record.doc	

CALCULATION SUMMARY

This report provides a record of the calculations and decisions made during design flood estimation using the techniques of the Flood Estimation Handbook (Institute of Hydrology, 1999).

Purpose of Calculations

1. To derive inflows to hydraulic model
2. To derive flow estimates for various return periods

Notes for Analyst:

This report does not attempt to cover all aspects of the hydrological study: its aim is to enable your work to be reproduced. In the main project report, you should consider adding information not given here, such as details of the rating review, the flood history and a comparison with previous studies.

All analysts doing work for the Environment Agency should have read Part 2 of the Agency guidelines on use of the FEH. You should also ensure that your copy of the FEH is up-to-date by checking the corrigenda page on the FEH website, www.nwl.ac.uk/ih/feh. Check there also for any reported errors in the software that you should be aware of.

REVISION HISTORY

Revision Ref./ Date Issued	Date	Purpose and description of Amendments	Re-issued to

CHECKING AND REVIEW STATUS

D1	Draft	E Ainsworth	O Drieu	T Ishaq	K Tilford	05 Nov 2003	
Rev	Purpose	Originated	Checked	Reviewed	Authorised	Date	Client
	Description	WS ATKINS					

1 CONTENTS

1 METHOD STATEMENT

Table 1.1: Overview of study

Item	Comments
Purpose of study	To derive flow estimates for Burniston Beck, Cloughton Beck and Quarry Beck at a range of return periods for input to an ISIS hydraulic model
Description of catchment	Jurassic s'st, l'st and shales. Predominantly rural catchment with substantial forest cover. Flood regime strongly affected by a major drainage diversion, the Sea Cut (27033) which intercepts flood flows from 95% of the catchment. Not used in FEH analyses.
Flood estimates required	5, 10, 25, 50, 75, 100
Approx. time available for study	

Table 1.2: Flow or level data available - None

(at the sites of flood estimates or for nearby donor catchments)

Watercourse	Station	Gauging authority number	NWA number (used in FEH)	Grid reference	Rating?	Period of data in WINFAP-FEH	Period of additional data
Comments on data quality and any checks made							

Table 1.3: Other data available - None

Item	Comments
Flow gaugings (if planned to update rating curve)	
Historic flood data	.
Extra data for other sites in pooling groups (if a major study)	

Table 1.3: Other data available - None

Item	Comments
Flood event data (if planned to use rainfall-runoff method)	
Rainfall event data (if planned to use rainfall-runoff method)	

Table 1.4: Initial choice of approach

Item	Comments
Statistical, rainfall-runoff or hybrid approach?	Hybrid
If statistical, single-site or pooled analysis?	Pooled Analysis
Review and update rating curves?	N/A
Any unusual factors to take into account? (e.g. highly permeable or urban catchment)	No

2 LOCATIONS WHERE FLOOD ESTIMATES REQUIRED

Table 2.1: Summary of subject sites

Site code	Watercourse	Site	Easting	Northing	Catchment area from FEH CD-ROM (km^2)	Any adjustments to catchment descriptors extracted from FEH CD-ROM 1999
01	Burniston Beck	d/s extent	501800	490500	21.02	URBEXT increased to 2003
02	Cloughton Beck	d/s extent/confluence with Burniston Beck	500750	493800	2.89	URBEXT increased to 2003
03	Quarry Beck	d/s extent/confluence with Burniston Beck	500700	493750	13.48	URBEXT increased to 2003
Record how catchment descriptors checked	Catchment area and URBEXT checked with OS Maps in MapInfo. All other catchment descriptors checked for accuracy and reasonability.					

3 RECORD OF DATA USED

Table 3.1 details the catchment descriptors for the catchments representing the 3 summary sites

Table 3.1 – Catchment Descriptors

Catchment Descriptors	Burniston Beck	Cloughton Beck	Quarry Beck
NGR	501800 490500	500750 493800	500700 493750
AREA	21.02	2.89	13.48
FARL	1	1	1
PROPWET	0.33	0.31	0.38
ALTBAR	105	121	120
ASPBAR	145	130	159
ASPVAR	0.22	0.53	0.17
BFIHOST	0.426	0.463	0.445
DPLBAR	6.79	2.28	3.67
DPSBAR	73.1	94.2	79.1
LDP	12.01	4.27	7.5
RMED-1H	10.7	10.8	10.8
RMED-1D	34.7	34.4	35.1
RMED-2D	44.8	44	45.4
SAAR	765	750	794
SAAR4170	781	786	801
SPRHOST	35.2	29.4	34.5
URBCONC	0.564	0.226	-999999
URBEXT2003	0.017	0.012	0.004
URBLOC	0.538	0.69	-999999
C	-0.022	-0.022	-0.022
D1	0.367	0.365	0.369
D2	0.42	0.414	0.426
D3	0.236	0.234	0.236
E	0.291	0.291	0.291
F	2.389	2.385	2.394
C(1km)	-0.021	-0.022	-0.022
D1(1km)	0.358	0.367	0.367
D2(1km)	0.399	0.42	0.42
D3(1km)	0.241	0.234	0.234
E(1km)	0.29	0.291	0.291
F(1km)	2.375	2.374	2.374

4 STATISTICAL METHOD

See Appendices C.2, C.3 and C.4 for pooling group details

Table 4.1: Estimate of QMED

Site Code	Method: AM – Annual maxima DT – Catchment descriptors with data transfer	Initial estimate of QMED (m^3/s)	If DT, numbers of donor/analogue sites used (see Table 4.2)	Adjustment ratio derived from average of analogue catchments	Final estimate of QMED (m^3/s)
01	DT	5.793	1, 2, 3, 4, 5	1.33	7.71
02	DT	0.833	2, 6, 1, 3, 7	1.157	0.96
03	DT	3.855	2, 3, 4, 7, 5	1.296	5.00

Table 4.2: Donor and analogue sites for QMED

No.	Watercourse	Station	NWA number	Method (AM or POT)	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjustment ratio (A/B)
1	Henmore Brook	Ashbourne	28058	AM	16.219	11.647	1.393
2	Leven	Easby	25019	AM	2.965	3.104	0.955
3	Riccal	Crookhouse Farm	27058	AM	11.028	8.902	1.239
4	Dove	Kirkby Mills	27042	AM	30.01	14.176	2.117
5	Hodge Beck	Cherry Farm	27054	AM	12.63	13.329	0.947
6	Crimple	Burn Bridge	27051	AM	4.032	4.118	0.979
7	Hodge Beck	Bransdale Weir	27010	AM	9.419	7.717	1.221

Table 4.3: Check of QMED using Channel Dimensions

Site Code	Watercourse	Location (eq model chainage)	BCW (Bankfull Channel Width in metres)	QMED from Channel Dimensions	Comment /comparison with estimate above	Final value of QMED used
1	Burniston Beck	BUR01_00010	7.97	11.09	Overestimate	7.71
2	Cloughton Beck	CLO01_00383	2.93	1.53	Overestimate	0.96
3	Quarry Beck	QUA01_00236	5.468	5.26	Overestimate	5.00
See FEH Volume 3 Section 5.2 (page 24)						

Table 4.4: Derivation of pooling groups

Name	Site code for which group initially derived	Target return period (years)	Changes made to default pooling group produced by WINFAP-FEH using the flood peak data now stored on the CD. Note also any sites that were investigated but retained in the group.
Burniston	01	100	**Added Sites:**.27054, 68015, 36004, 206, 38026, 32003 **Removed Sites:** 32029, 22008 (short record) 24007, 12004 (high PROPWET) 52025, 28055 (long gap in record) 20004, 21002 (Flood Seasonality outlier) 68011, 21002 (skewness outlier) 41026, 41016 (skewness/kurtosis outlier) 40809 (low FARL)
Cloughton	02	100	**Added Sites:**.27010, 30012, 53017, 9927044, 15002 **Removed Sites:** 45801, 32029, 54058 (short record) 52020 (long gap in record) 15809, 12004 (high PROPWET) 41026, 40809 (low FARL) 68011 (skewness outlier) 41807, 20004 (steep growth curve)
Quarry	03	100	**Added Sites:** 27054, 2006, 36010, 30012 **Removed Sites:** 32029, 22008 (short record) 52025 28055 (long gap in record) 12004 (high PROPWET) 41026, 40809 (low FARL) 68011, 21002 (skewness outlier) 20004 (steep growth curve)
			Added Sites: **Removed Sites:**
			Added Sites: **Removed Sites:**
			Added Sites: **Removed Sites:**

Table 4.5: Derivation of flood growth curves at each subject site

See Appendices C.8, C.9 and C.10 for Flood Growth Curves

Site code	Method: SS – Single site P – Pooled A – Average of the two H – Incorporating historical data	If P or A, code of pooling group? (see Table 4.3)	Distribution(s) chosen and reason	Parameters of chosen distribution(s)
01	P	01	Generalised Logistic	L-moments
02	P	02	Generalised Logistic	L-moments
03	P	03	Generalised Logistic	L-moments
General Notes:				

Table 4.6 Statistical Method Estimate of Peak Flows

Name	Site code	Flood peak (m^3/s) for the following percentage chance of an event occurring in any one year (with return periods in years in brackets).							
		50% (2)	20% (5)	10% (10)	4% (25)	2% (50)	1.33% (75)	1% (100)	0.5% (200)
Burniston	**1**	7.71	10.86	12.91	15.58	17.68	18.96	19.88	22.22
Cloughton	**2**	0.96	1.50	1.91	2.55	3.12	3.50	3.80	4.61
Quarry	**3**	5.00	7.465	9.28	11.93	14.26	15.72	16.86	19.89

5 RAINFALL-RUNOFF METHOD

Table 5.1: Derivation of parameters for rainfall-runoff model

Methods: FEA : Flood event analysis (see Table 5.3)
LAG : Catchment lag (see Table 5.3)
DT : Catchment descriptors with data transfer from donor catchment
CD : Catchment descriptors alone
BFI : SPR derived from baseflow index calculated from flow data

Site code	Rural (R) or urban (U)	Tp(0): method	Tp(0): value (hours)	SPR: method	SPR: value (%)	BF: method	BF: value (m^3/s)	If DT, numbers of donor sites used (see Table 5.2) and reasons
1								
2								
3								

Table 5.2: Donor sites for rainfall-runoff parameters – N/A

No.	Watercourse	Station	Tp(0) from data (A)	Tp(0) from CDs (B)	Adjustment ratio for Tp(0) (A/B)	SPR from data (C)	SPR from CDs (D)	Adjust-ment ratio for SPR (C/D)
1								
2								
3								

Table 5.3: Availability of river and rainfall event data – None Available

Station name	Station number	Flood event date							
Gauging stations									
Event raingauges									

Table 5.4: Inputs to and outputs from rainfall-runoff model – assuming critical storm duration is used.

Site code	Design storm duration (hours)	Storm area (if not individual catchment area)	Flood peak (m^3/s) for the following percentage chance of an event occurring in any one year (with return periods in years in brackets).							
			50% (2)	20% (5)	10% (10)	4% (25)	2% (50)	1.33% (75)	1% (100)	0.5% (200)
1	10.486		5.979	8.268	10.478	13.639	16.388	17.906	19.158	22.540
2	5.748		0.967	1.367	1.674	2.275	2.788	3.073	3.310	3.954
3	7.185		4.944	6.935	8.633	11.409	13.815	15.147	16.248	19.231

Table 5.5: Inputs to and outputs from rainfall-runoff model – assuming a catchment wide storm duration (and storm area) is used.

Site code	Design storm duration (hours)	Storm area (if not individual catchment area)	Flood peak (m^3/s) for the following percentage chance of an event occurring in any one year (with return periods in years in brackets).							
			50% (2)	20% (5)	10% (10)	4% (25)	2% (50)	1.33% (75)	1% (100)	0.5% (200)
1	10.486		5.979	8.268	10.478	13.639	16.388	17.906	19.158	22.540
2	10.486	21.02	0.930	1.291	1.656	2.183	2.644	2.899	3.111	3.683
3	10.486	21.02	4.932	6.875	8.703	11.347	13.649	14.920	15.970	18.804
4										
5										
6										

6 RATIONAL METHOD

As an additional check flows were calculated for each hydrological inflow using the Rational Method

Q = 0.278 C i A

Where Q flow (m^3/s)
C runoff coefficient
i rainfall intensity (mm)
A catchment area (km^2)

Runoff coefficients were derived from the land use/urbext value and also vary with runoff intensity and return period. The rainfall intensity was taken from the design storm depth and duration for a catchment wide storm. Table 6.1 summarises the runoff coefficients used and Table 6.2 summarises the flow estimates

Table 6.1: Rational method runoff coefficients

Site code	AREA (km^2)	urbext2003	100 year Runoff Coefficient C100
All Burniston	21.02	0.017	0.38
Cloughton	2.89	0.007	0.41
Quarry	13.48	0.004	0.34

Table 6.2: Rational method flow estimates

Site code	Flood peak (m^3/s) for the following percentage chance of an event occurring in any one year (with return periods in years in brackets).						
	20% (5)	10% (10)	4% (25)	2% (50)	1.33% (75)	1% (100)	0.5% (200)
All Burniston	6.7	8.5	11.2	14.3	15.7	17.0	20.3
Cloughton	1.0	1.3	1.8	2.3	2.7	2.9	3.6
Quarry	5.0	6.4	8.5	10.9	12.0	13.0	15.6

7 SUMMARY OF RESULTS

Table 7.1: Overview of results

Item	Comments
Final choice of method and reasons	A comparison of the different flow estimates are represented graphically in Appendix C10, C11 and C12. The rainfall runoff flow estimates are lower than the statistical flow estimates for all the points where flows have been estimated. There is a good comparison between the flow estimates using the Rational Method and the Statistical Method for Cloughton Beck. However, for Quarry Beck and Burniston Beck flow estimates derived using the Rational Method are much lower than either the Statistical or Rainfall Runoff Method. The validity of the FEH statistically derived flow regime is heavily dependent upon how suitably the adopted pooling group represents the catchment of interest. The catchments within the pooling group appear to compare well with the Cloughton, Quarry and Burniston Beck catchments and the Statistical Method is considered to be the preferred method. The Statistical Method provides only peak flow for a particular return period but a full hydrograph is required for an unsteady hydrodynamic model. Therefore, the rainfall runoff method with a catchment wide storm will be used to derive inflows into the hydraulic model and will be scaled to the statistical method peaks.

Table 7.2: Final flood estimates for each site

See Table 5.5

Name	Site Code	Method Code	Flood peak (m^3/s) for the following percentage chance of an event occurring in any one year (with return periods in years in brackets).						
			50% (2)	20% (5)	10% (10)	4% (25)	2% (50)	1% (100)	0.67% (150)
	1								
	2								
	3								
	4								
	5								
	6								