B.3 Comparison of flood frequency curves

Initially, both single-site and pooled growth curves were fitted at all gauging stations on watercourses not impacted by the reservoir and with at least ten years of reliable flood peak data. At each gauge a preferred growth curve has been selected. There is a large amount of guidance available on the choice between single-site and pooled growth curves, including FSU WP 2.2, Gaume (2006)[3] and Environment Agency (2012)[4]. Factors that have been considered include:

- The length of the flood peak dataset at the gauge;
- The quality of the rating curve for measurement of high flows;
- The degree to which the catchment is unusual and therefore likely to be less well represented by other catchments in the pooling group;
- Information available from longer-term flood history, including quantitative data such as longer flow datasets at nearby gauges and more qualitative data from reports of earlier floods;
- The degree to which the curves fit the plotted flood peak data, bearing in mind the uncertainty of the plotting positions used to control where the data displays on the return period axis.
- The implied exceedance probabilities for the highest floods on record according to each distribution, and whether these are likely given what is known of the impact of the floods.

As an example of this last point, if the pooled growth curve is less steep than the single-site curve, it might imply that the highest couple of floods recorded at the site both have annual probabilities lower than 1%. While this is theoretically possible it is highly unlikely, and a more likely explanation would be that the pooled growth curve underestimates the true growth curve for the catchment in question.

At the other extreme, a pooled curve that is much steeper than the single-site curve would imply high probabilities for the top few floods on record. Historical events are analysed to help determine the most appropriate growth curve at each gauge.

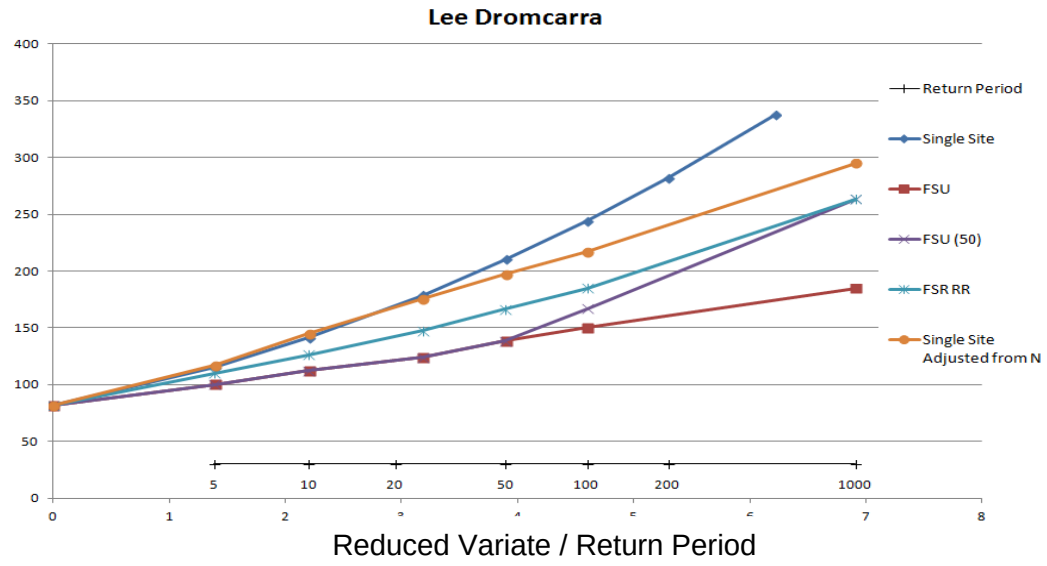
B.3.1 Comparison of flood frequency curves for the tributaries

Each individual growth curve developed by the methods outlined in Section B.2 was plotted at each gauged location. An example for Lee Dromcarra is shown in Figure B-7. Flood peak analysis summary sheets for each gauge is included at the end of this appendix. Lee Dromcarra is discussed here as an example.

3 Gaume, E. (2006) On the asymptotic behaviour of flood peak distributions. Hydrol. Earth Syst. Sci, 10, 233-243.

4 Environment Agency (2012) Flood estimation guidelines. Operational instruction 197_08, issued June 2012.

Figure B-7: Flood Frequency Curve for Dripsey



In order to select the most appropriate growth curve, historical events were analysed. The return period for the four highest recorded events were examined and are shown in Table B-12.

Table B-12: Historical Events at Lee Dromcarra

Event	19/11/2009	07/12/1978	14/03/1989	06/08/1986
Historical Rank	1	2	3	4
Flow m3/Sec	203.42	157.21	132.23	125.26
Growth Curves				
FSU	>1000	458	53	39
FSU Adjusted From 50	390	105	50	30
Winter RR	170	35	12	9
Single Site (22 Years)	42	14	7	6
Adjusted from N	61	13	6	5

It can be seen that FSU and the FSU adjusted curves at all sites have a very shallow gradient in comparison to the single site analysis/FSR Rainfall Runoff curve. The single site at all the gauged sites has data and quality limitations. The length of validated record is short and the rating curves are poor. There are no flow gaugings in excess of Qmed at any of the stations leading to uncertainty in the extrapolation of higher flows.

The FEH suggests that single site analysis is likely to offer the best estimate of flows up to a return period of 0.5N, where N equals the number of years in record, therefore, at Lee Dromcarra the 22 years record should provide robust estimates of flow up to almost the 11-year event. FSU methodology suggests single site analysis can provide accurate estimates up to 2N.

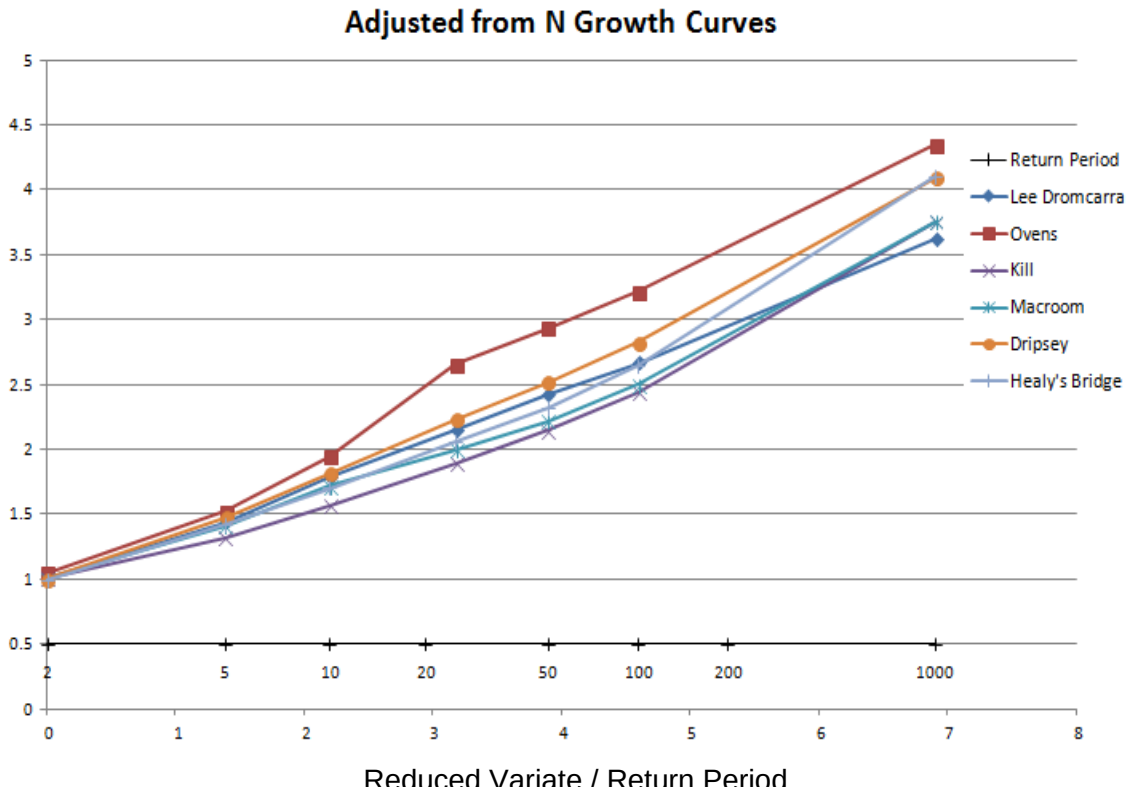
Therefore, single site estimate will only be used up to N years of validated record. Above this the FSR Rainfall runoff growth curve will be applied. Details of each gauging site are outlined in the summary sheets. Applying single site up to N years of data and FSR rainfall runoff above gives the following growth factors at the gauged catchments as shown in Table B-13 and plotted in Figure B-8.

Table B-13: Adjusted from N Single Site Analysis - Growth Factors

Return Period	Lee Dromcarra	Healy's Bridge	Ovens	Kill	Dripsey	Macroom
2	1.00	1.00	1.05	1.00	1.00	1.00

5	1.44	1.42	1.52	1.32	1.47	1.41
10	1.78	1.70	1.94	1.56	1.81	1.72
25	2.15	2.06	2.65	1.89	2.23	2.00
50	2.42	2.32	2.94	2.14	2.51	2.22
100	2.66	2.64	3.22	2.43	2.82	2.50
1000	3.62	4.11	4.35	3.75	4.09	3.76

Figure B-8: Adjusted for N Growth Curves



B.3.1 Final gauged flow estimates

Final gauged flows for each gauging station have been calculated by multiplying the estimates of Qmed listed in Table B-4 by the appropriate growth factor and are outlined in Table B-14. These values are compared against the results of the continuous simulation model in Section 8 of the main report to ensure that the continuous simulation is representative of the statistical analysis completed at the gauged tributaries.

Table B-14: Final Gauged Flows

Return Period	Lee Dromcarra	Healy's Bridge	Ovens	Kill	Dripsey	Macroom
2	81.51	62.64	26.63	50.17	40.96	148.05
5	117.37	88.95	40.45	66.22	60.29	208.34
10	145.09	106.55	51.77	78.27	74.22	254.26
20	175.35	128.98	70.65	94.85	91.53	295.71
50	197.61	145.30	78.16	107.60	103.00	328.28
100	217.17	165.34	85.62	122.15	115.69	369.74
1000	295.07	257.42	115.71	188.38	167.71	556.28

B.4 Estimated flows at the Waterworks Weir

The 1% AEP estimate was estimated at the Waterworks Weir prior to the construction of the reservoirs by simulating a scenario that removes the influence of the reservoirs on the hydrological calculations. This 1% AEP flow has been calculated using the FSU Qmed regression equation based on catchment characteristics prior to the construction of the reservoir. It will be compared with the 100-year design flow generated using the 1000 years of stochastic rainfall and the PDM models in Section 8 to ensure that the continuous simulation method is representative of the statistical understanding of floods in this region

B.4.1 Selection of FARL values

The FSU FARL value was calculated based on a catchment characteristics without the presence of reservoirs in order to try calculate the flow in the Cork City prior to the construction of the dams. Three scenarios were analysed:

a) A FARL of 0.882, the current FARL value at the Waterworks Weir and representing present day scenario.

b) A FARL of 1, representing the removal of any influence of Reservoirs and Lakes in an attempt to remove the influence of the reservoirs in Qmed Calculation.

c) A FARL of 0.995, this represents some influence of small lakes along the watercourse. The Bride has a FARL value of 0.994 when it joins the Lee, the Shournagh has a FARL value of 0.997 at its confluence with the Lee at Leemount. Upstream of the reservoir, Lough Allua has a significant influence on the FARL value of the Lee generating a FARL value of 0.895 when it enters Carrigadrohid Reservoir. This influence will be greatly reduced as Waterworks Weir is approximately 43km downstream of entry into Carrigadrohid Reservoir.

B.4.2 Calculation of Qmed

The Southern Bride and the Shournagh join the Lee below the reservoirs and upstream of Waterworks Weir. Based on gauged catchment analysis on hydrometric gauges in the area, a catchment adjustment factor of 1.73 was found between single site analysis and FSU Qmed estimation. Ovens was found to be significantly lower at 1.23.

Qmed has been calculated by two different means:

a) FSU calculation for Qmed at the Waterworks Weir and application of the overall catchment adjustment factor of 1.71

b) Calculation of contributing flow from the Bride catchment applying its respective Qmed adjustment factor (1.23) and then applying the catchment average of 1.71 to the remaining flow.

It should be noted that a very limited record at Inniscarra Tail Race (19013) exists between 1942 and 1951 before commencement of the construction of the dams. This short record generates a Qmed of 281m^3/sec. This record is Amax only data, so it is not possible to calculate a peak over threshold Qmed estimate. This Qmed approximation does not include the contributing flows downstream of Bride and Shournagh.

B.4.3 Estimated Flows at Waterworks Weir

Due to the karst presence in the Bride catchment and its significant difference on hydrological properties to the remainder of the catchment a Qmed adjustment factor different from the catchment average should be applied to contributing flow from the Bride catchment. Therefore, an adjustment factor of 1.23 is applied to the contributing flow from the Bride catchment and the catchment average of 1.71 to the remaining flow. In relation to FARL, it is feasible to assume that there will be some influence of smaller lakes in the catchment so a FARL estimate of 0.995 is deemed appropriate. Historic Maps confirms the presence of a small impoundment upstream of Inniscarra prior to the construction of the reservoir which would provide attenuation. This would lead to a Qmed Estimation of 360.5m^3/s prior the construction of the reservoirs.

Figure B-9 shows an estimation of flow at Waterworks Weir prior to the construction of the reservoir when the catchment flood frequency curve is applied (Q100 equals a growth factor of

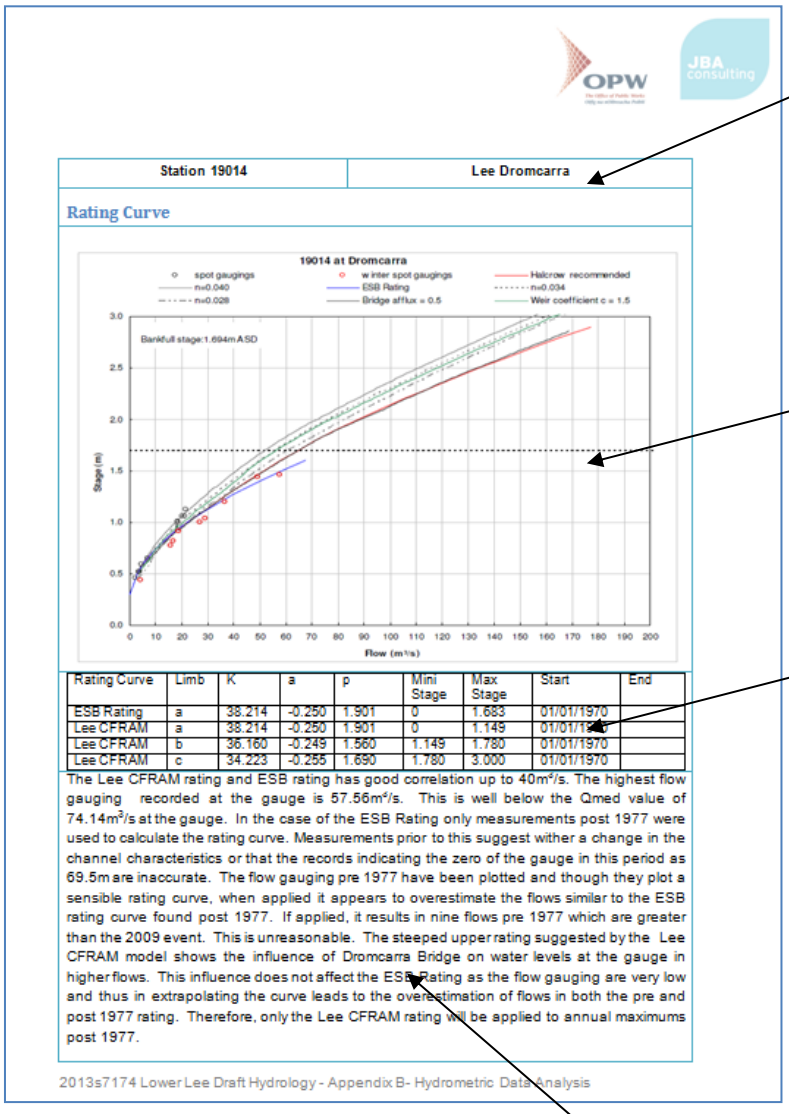
2.62). This flow of 944.5m^3/s will be compared with the 100 year design flow determined from the use of the 1000 years of stochastic rainfall and the PDM model in Section 8.

Figure B-9: Estimated Flows at Waterworks Weir Pre-Construction of Reservoir (Statistical Methods)

FARL 0.995 Prior to the Installation of Reservoirs, Alllowance made for presence of Lakes	Qmed Estimation			100 Year Estimated Flow (m^3/sec)
	Qmed (m^3/sec)	Adjustment Factor	Qmed adjusted (m^3/sec)	
100 Year Return Period Growth Factor (Catchment Adjustment Factor)				2.62
Contributing Flow from Bride	21.7	1.23	26.7	
Contributing Flow from Main Lee	195.2	1.71	333.8	
Total Flow at Waterworks Weir			**360.5**	944.5

This summary sheets provide results from analysis of flood peak data at gauging stations. It provides data on analysis carried out during the estimation of d flows

Information provided in the summary sheets



Station 19014	Lee Dromcarra

Rating Curve

Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
ESB Rating	a	38.214	-0.250	1.901	0	1.683	01/01/1970	
Lee CFRAM	a	38.214	-0.250	1.901	0	1.149	01/01/1970	
Lee CFRAM	b	36.160	-0.249	1.560	1.149	1.780	01/01/1970	
Lee CFRAM	c	34.223	-0.255	1.690	1.780	3.000	01/01/1970	

The Lee CFRAM rating and ESB rating has good correlation up to 40m³/s. The highest flow gauging recorded at the gauge is 57.56m³/s. This is well below the Qmed value of 74.14m³/s at the gauge. In the case of the ESB Rating only measurements post 1977 were used to calculate the rating curve. Measurements prior to this suggest wither a change in the channel characteristics or that the records indicating the zero of the gauge in this period as 69.5m are inaccurate. The flow gauging pre 1977 have been plotted and though they plot a sensible rating curve, when applied it appears to overestimate the flows similar to the ESB rating curve found post 1977. If applied, it results in nine flows pre 1977 which are greater than the 2009 event. This is unreasonable. The steeped upper rating suggested by the Lee CFRAM model shows the influence of Dromcarra Bridge on water levels at the gauge in higher flows. This influence does not affect the ESB Rating as the flow gauging are very low and thus in extrapolating the curve leads to the overestimation of flows in both the pre and post 1977 rating. Therefore, only the Lee CFRAM rating will be applied to annual maximums post 1977.

2013s7174 Lower Lee Draft Hydrology - Appendix B- Hydrometric Data Analysis

Name and Station Number

Rating Curve Plots

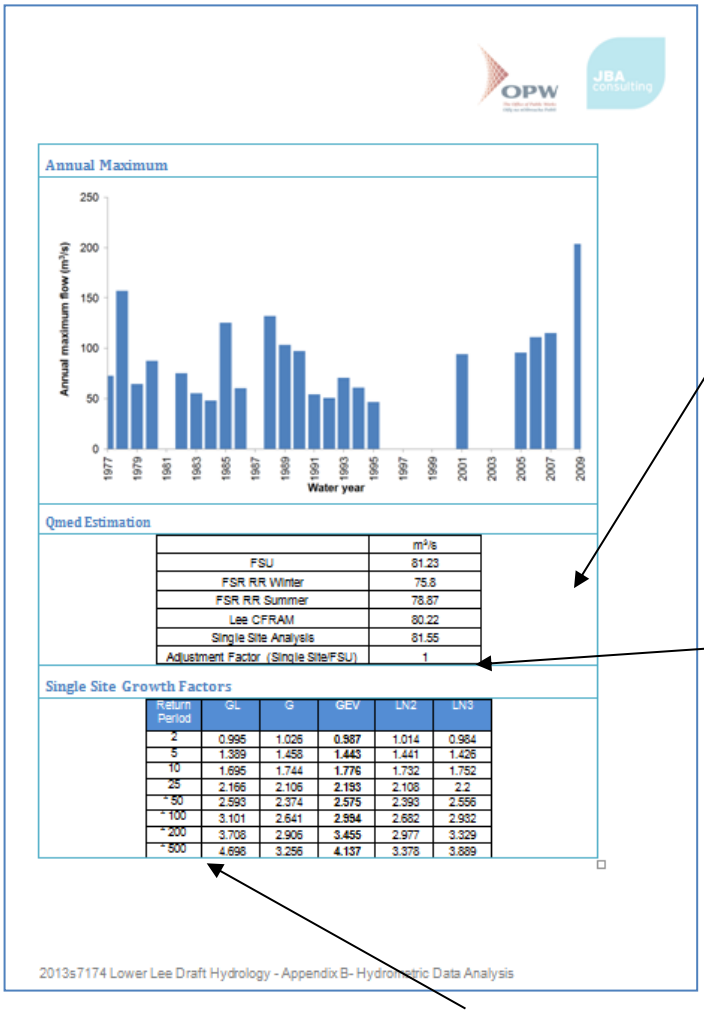
Shows the rating curves available at the gauging site. These include rating curves developed by the ESB, rating curves developed by the Lower CFRAM and some rating curves developed from flow gaugings during this study.

Rating Curve Details

Provides details of the rating curve coefficients , Minimum and maximum stage and valid time period

Rating Curve discussion

Details the selection of the most appropriate rating curve, the quality of the rating curve and the limitations of such a rating curve application.



QMED Estimation

Provides results of different means of estimating Qmed.

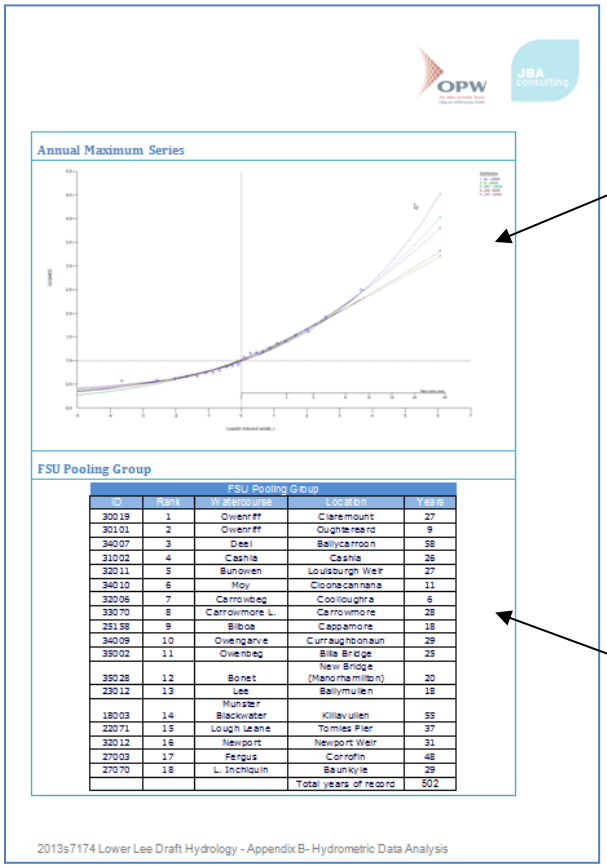
- FSU - FSU Qmed 6 variable regression equation
- FSR Rainfall Runoff - Winter Profile
- FSR Rainfall Runoff - Summer Profile
- Lee Cfram Qmed Estimation
- Single site analysis - The median of the AMAX flows

An adjustment factor between single site and the FSU method was also calculated and is listed

Single Site Growth Factors

Shows the results of the growth factors from single site analysis using five different plotting distributions applied with the WINFAP-FEH software version 3.0.003

- Gumbel - Extreme Variate I
- General Logistic
- General Extreme Value
- 2-parameter log normal
- 3-parameter log normal



Flood frequency analysis

The graph shows single-site flood frequency curves fitted to the AMAX data. The x axis is the Gumbel reduced variate, with a parallel axis showing the equivalent return period, T. This can be converted to annual exceedance probability, AEP, expressed as a percentage, using AEP = 100/T.

Five curves are shown, representing the Gumbel (G) , General Logistic (GL), 2-parameter log normal (LN2), 3-parameter log normal (LN3) General Extreme Value (GEV) distributions. They are fitted using the L-moments for all distributions with the exception of LN2 where it was fitted using moments. They were applied within the WINFAP-FEH software.

FSU Pooling Group

List the gauges selected on the basis of their similarity with the subject catchment according to three catchment descriptors, i.e. AREA, SAAR and BFIsoil. Pooling groups were selected using JFes, JBA's web based flood estimation software.

Growth Factors

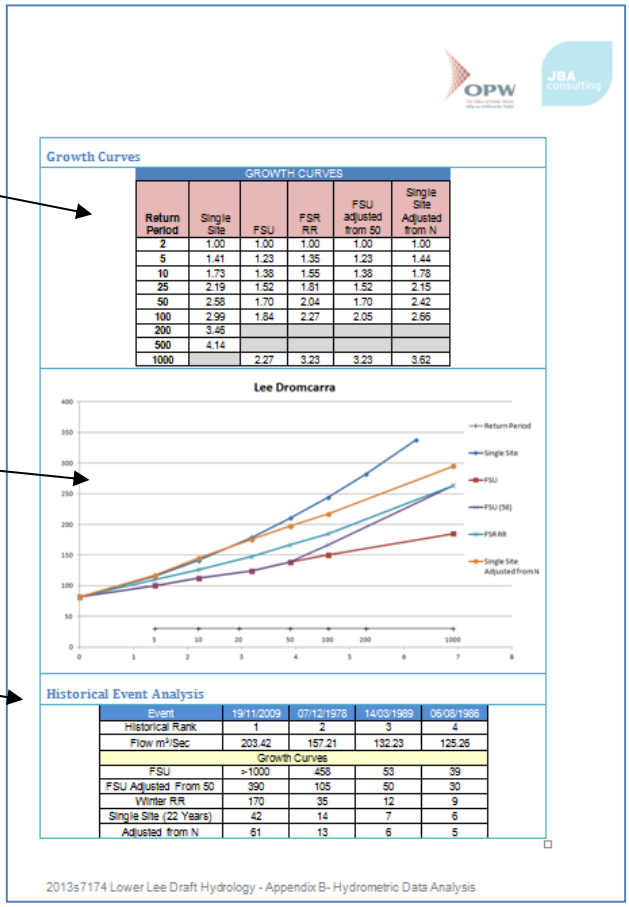
Shows the results of growth factors from pooled analysis and single site

Growth Curves

Shows a plot of the individual frequency curves and plots the 2009 event where recorded (yellow) and the largest recorded event at that gauge (red).

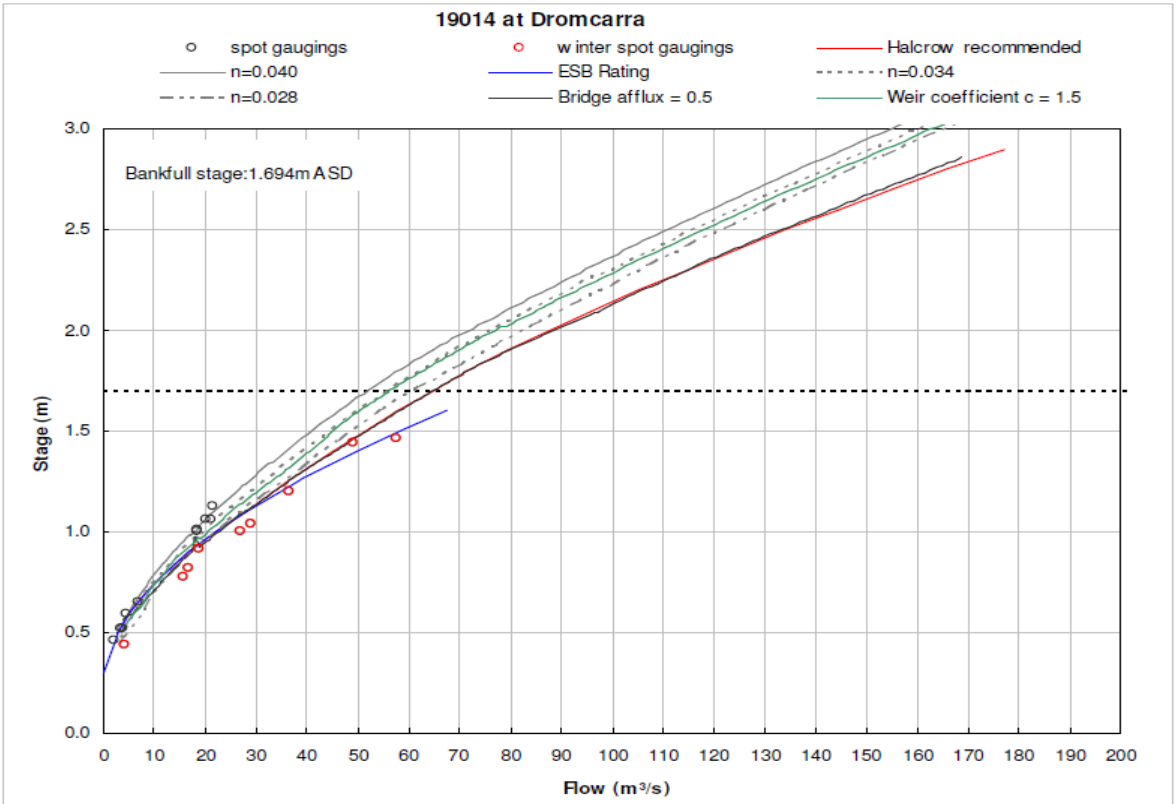
Historical Event Analysis

The return period for the four highest magnitude AMAX events is estimated from single-site analysis and pooled growth curve methods. Also details the rain storm that generated the event.



Station 19014	Lee Dromcarra

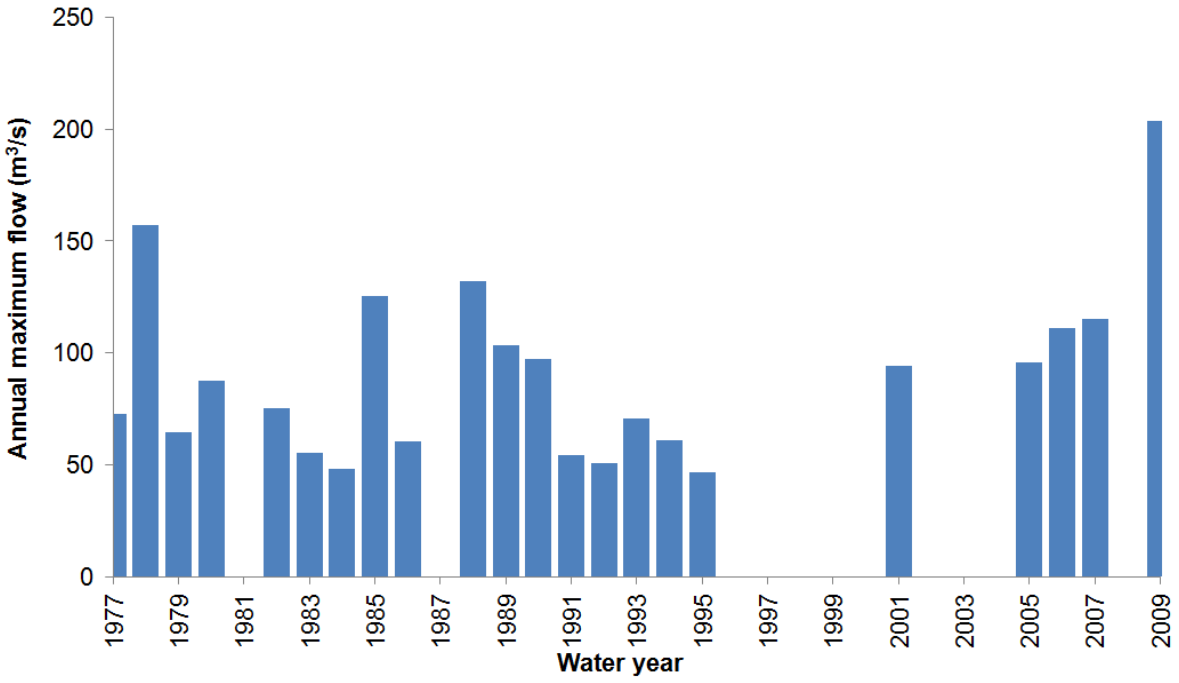
Rating Curve



Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
ESB Rating	a	38.214	-0.250	1.901	0	1.683	01/01/1970	
Lee CFRAM	a	38.214	-0.250	1.901	0	1.149	01/01/1970	
Lee CFRAM	b	36.160	-0.249	1.560	1.149	1.780	01/01/1970	
Lee CFRAM	c	34.223	-0.255	1.690	1.780	3.000	01/01/1970	

The Lee CFRAM rating and ESB rating has good correlation up to 40m^3/s. The highest flow gauging recorded at the gauge is 57.56m^3/s. This is well below the Qmed value of 74.14m^3/s at the gauge. In the case of the ESB Rating only measurements post 1977 were used to calculate the rating curve. Measurements prior to this suggest wither a change in the channel characteristics or that the records indicating the zero of the gauge in this period as 69.5m are inaccurate. The flow gauging pre 1977 have been plotted and though they plot a sensible rating curve, when applied it appears to overestimate the flows similar to the ESB rating curve found post 1977. If applied, it results in nine flows pre 1977 which are greater than the 2009 event. This is unreasonable. The steeped upper rating suggested by the Lee CFRAM model shows the influence of Dromcarra Bridge on water levels at the gauge in higher flows. This influence does not affect the ESB Rating as the flow gauging are very low and thus in extrapolating the curve leads to the overestimation of flows in both the pre and post 1977 rating. Therefore, only the Lee CFRAM rating will be applied to annual maximums post 1977.

Annual Maximum



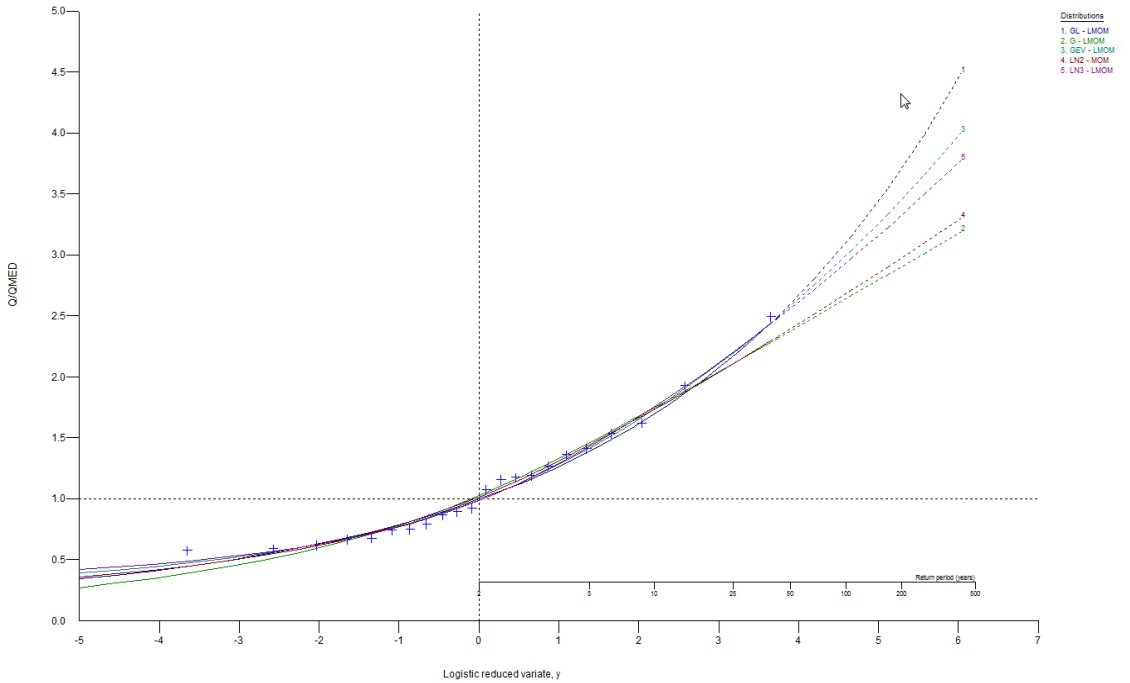
Qmed Estimation

	m³/s
FSU	81.23
FSR RR Winter	75.8
FSR RR Summer	78.87
Lee CFRAM	80.22
Single Site Analysis	81.55
Adjustment Factor (Single Site/FSU)	1

Single Site Growth Factors

Return Period	GL	G	**GEV**	LN2	LN3
2	0.995	1.026	**0.987**	1.014	0.984
5	1.389	1.458	**1.443**	1.441	1.426
10	1.695	1.744	**1.776**	1.732	1.752
25	2.166	2.106	**2.193**	2.108	2.2
* 50	2.593	2.374	**2.575**	2.393	2.556
* 100	3.101	2.641	**2.994**	2.682	2.932
* 200	3.708	2.906	**3.455**	2.977	3.329
* 500	4.698	3.256	**4.137**	3.378	3.889

Annual Maximum Series

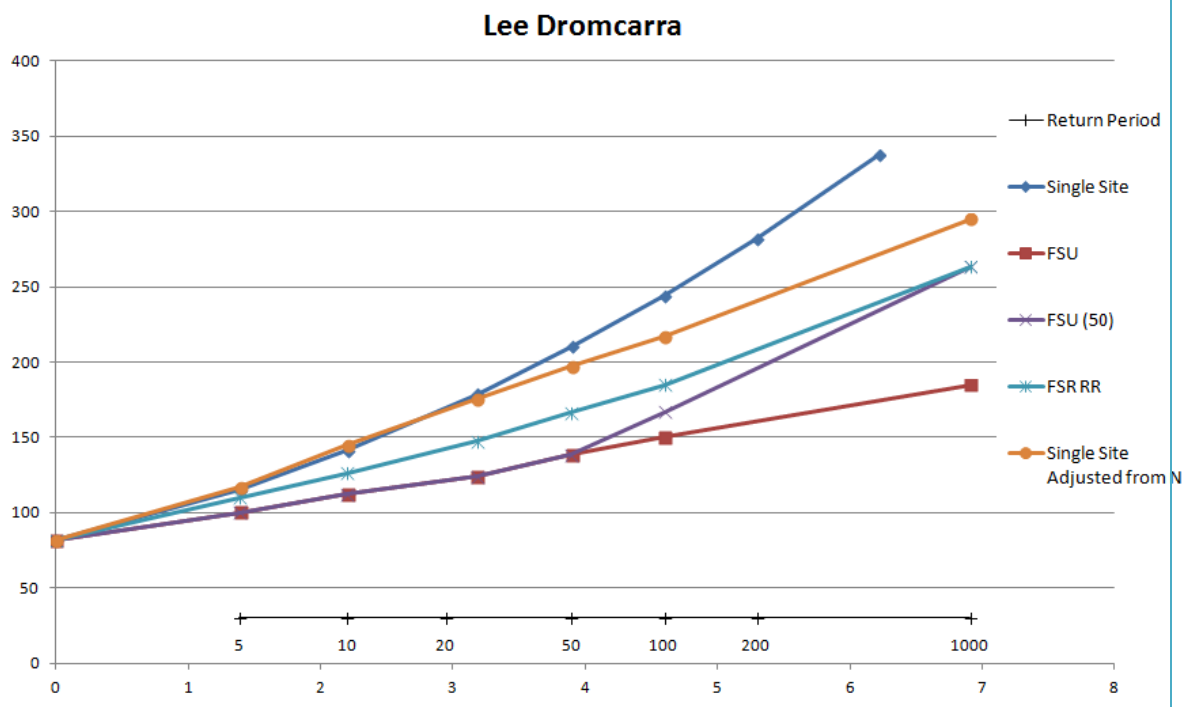


FSU Pooling Group

FSU Pooling Group				
ID	Rank	Watercourse	Location	Years
30019	1	Owenriff	Claremount	27
30101	2	Owenriff	Oughtereard	9
34007	3	Deel	Ballycarroon	58
31002	4	Cashla	Cashla	26
32011	5	Bunowen	Louisburgh Weir	27
34010	6	Moy	Cloonacannana	11
32006	7	Carrowbeg	Coolloughra	6
33070	8	Carrowmore L.	Carrowmore	28
25158	9	Bilboa	Cappamore	18
34009	10	Owengarve	Curraughbonaun	29
35002	11	Owenbeg	Billa Bridge	25
35028	12	Bonet	New Bridge (Manorhamilton)	20
23012	13	Lee	Ballymullen	18
18003	14	Munster Blackwater	Killavullen	55
22071	15	Lough Leane	Tomies Pier	37
32012	16	Newport	Newport Weir	31
27003	17	Fergus	Corrofin	48
27070	18	L. Inchiquin	Baunkyle	29
			Total years of record	502

Growth Curves

GROWTH CURVES					
Return Period	Single Site	FSU	FSR RR	FSU adjusted from 50	Single Site Adjusted from N
2	1.00	1.00	1.00	1.00	1.00
5	1.41	1.23	1.35	1.23	1.44
10	1.73	1.38	1.55	1.38	1.78
25	2.19	1.52	1.81	1.52	2.15
50	2.58	1.70	2.04	1.70	2.42
100	2.99	1.84	2.27	1.9	2.66
200	3.46				
500	4.14				
1000		2.27	3.23	2.69	3.62

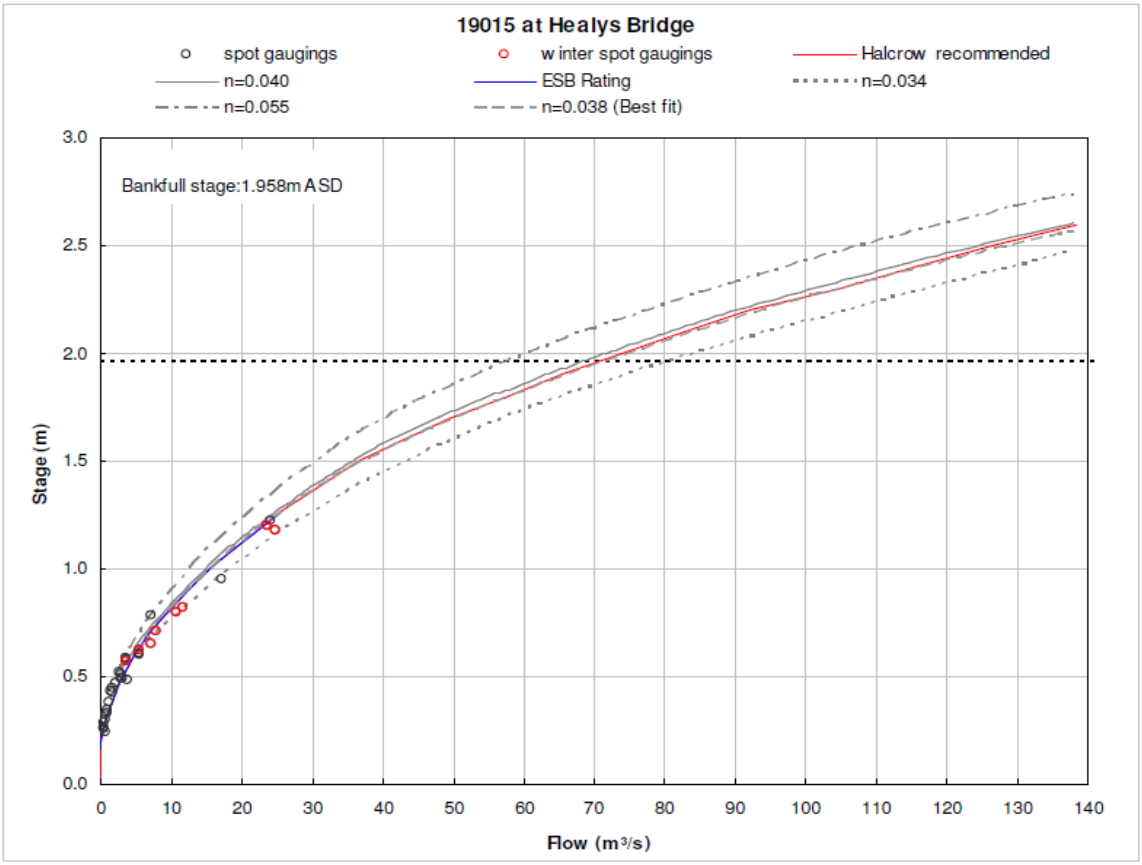


Historical Event Analysis

Event	19/11/2009	07/12/1978	14/03/1989	06/08/1986
Historical Rank	1	2	3	4
Flow m^3/Sec	203.42	157.21	132.23	125.26
Growth Curves				
FSU	>1000	458	53	39
FSU Adjusted From 50	390	105	50	30
Winter RR	170	35	12	9
Single Site (22 Years)	42	14	7	6
Adjusted from N	61	13	6	5

Station 19015	Healy's Bridge (Shournagh)

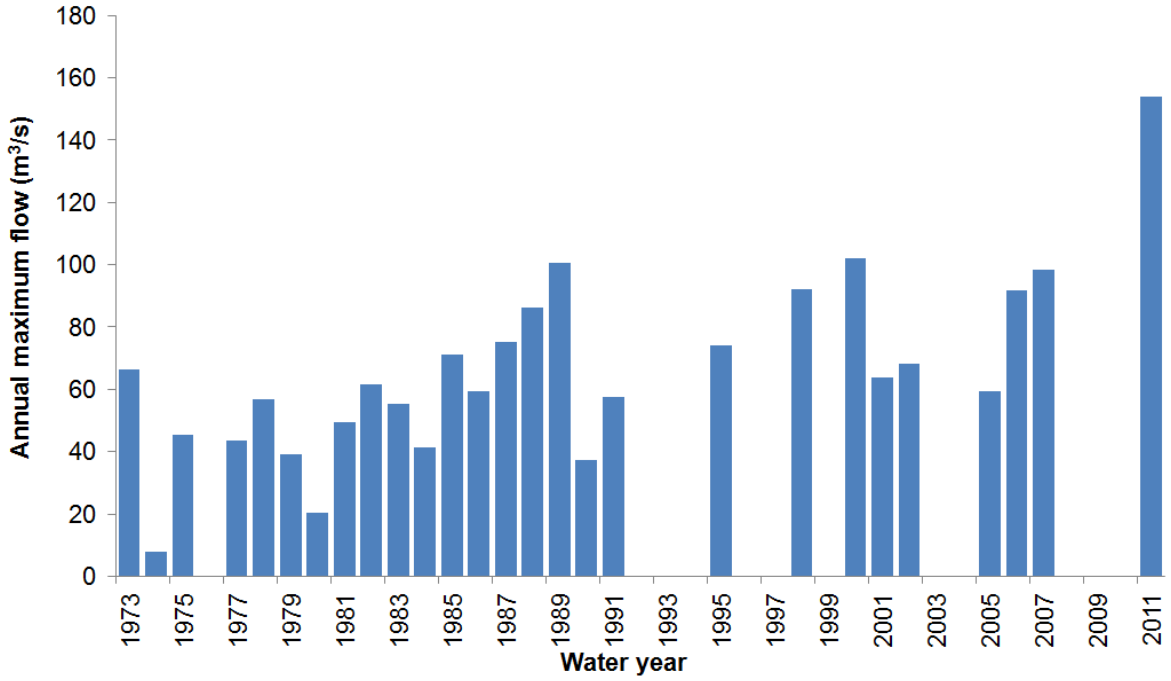
Rating Curve



Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
ESB Rating	a	20.977	-0.150	1.885	0	1.264	01/01/1949	
Lee CFRAM	a	20.997	-0.150	1.855	0	1.264	01/01/1949	
Lee CFRAM	b	20.957	-0.150	1.855	1.264	1.553	01/01/1949	
Lee CFRAM	c	20.200	-0.132	1.985	1.553	1.710	01/01/1949	
Lee CFRAM	d	19.870	-0.159	2.150	1.710	2.300	01/01/1949	
Lee CFRAM	e	19.870	-0.139	2.155	2.300	2.700	01/01/1949	

The Lee CFRAM and the ESB rating curve was compared against each other and it was found that the ESB Rating gave more reasonable results for high flows (eg on 28th of June 2012). The Qmed at Healy's Bridge is 62.2m^3/sec and the highest recorded flow gauging is substantially lower than this at 27.40m^3/sec. Due to the lack of substantial flow gaugings there is a large degree of uncertainty with the higher extrapolated flows and it is recommended that regular flow gaugings at high flows be taken the future.

Annual Maximum



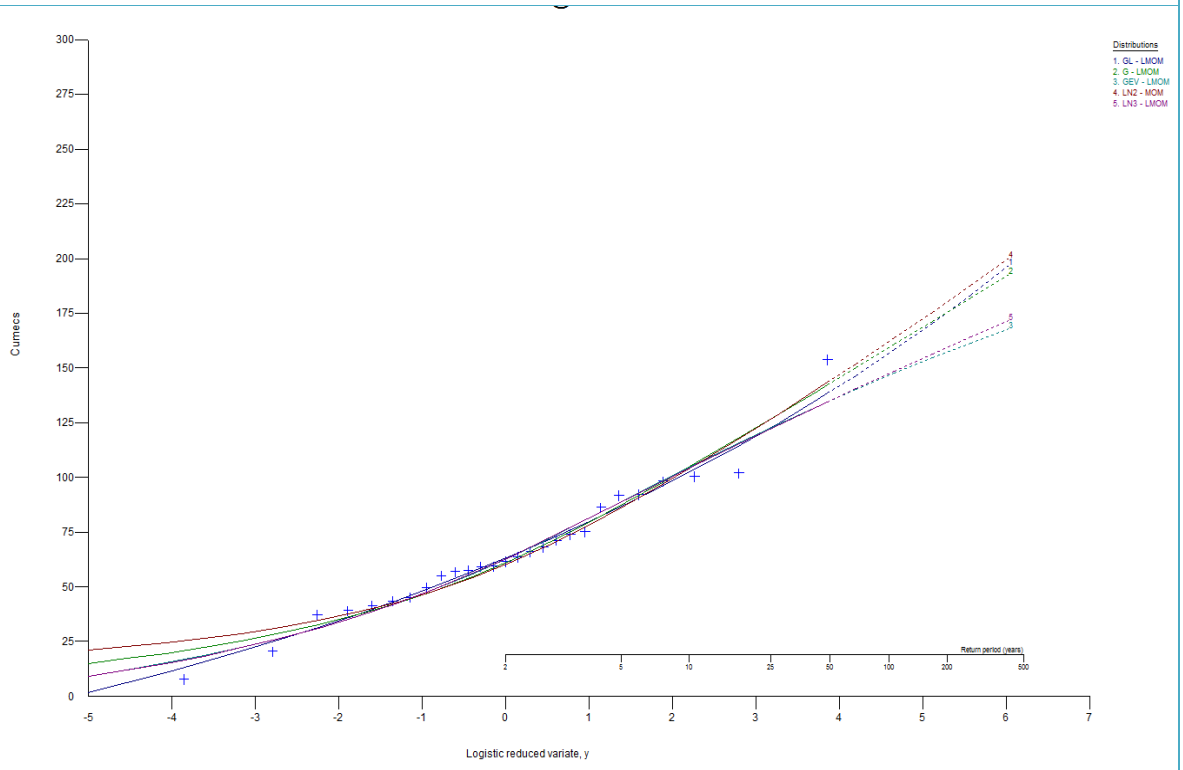
Qmed Estimation

	m^3/s
FSU	40.85
FSR RR Winter	66.33
FSR RR Summer	68.26
Lee Cfram	70.50
Single Site Analysis	62.64
Adjustment Factor (Single Site/FSU)	1.53

Single Site Growth Factors

Return Period	GL	G	GEV	LN2	LN3
2	1.024	0.990	1.018	0.977	1.020
5	1.408	1.418	1.442	1.398	1.439
10	1.659	1.701	1.697	1.686	1.691
25	1.994	2.059	1.992	2.058	1.988
* 50	2.261	2.324	2.193	2.342	2.196
* 100	2.543	2.587	2.379	2.630	2.395
* 200	2.846	2.850	2.551	2.925	2.588
* 500	3.280	3.196	2.761	3.326	2.837

Annual Maximum Series

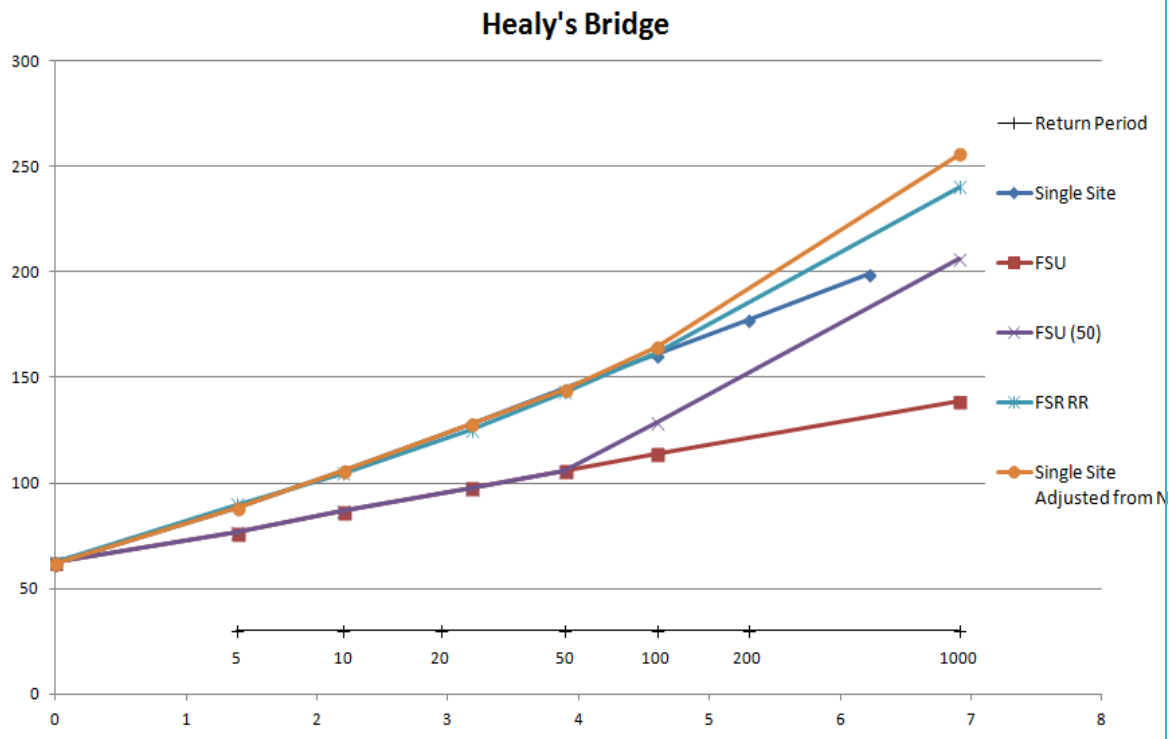


FSU Pooling Group

FSU Pooling Group				
ID	Rank	Watercourse	Location	Years
29007	1	L. Cullaun	Craughwell	27
6012	2	Fane	Clarebane	40
6070	3	Muckno L	Muckno	27
35003	4	Unshin	Ballygrania	45
6011	5	Fane	Moyles Mill	53
26108	6	Boyle	Boyle Abbey Bridge	20
19020	7	Owennacurra	Ballyedmond	28
29004	8	Clarinbridge	Clarinbridge	37
25029	9	Nenagh	Clarianna	38
35071	10	L. Melvin	Lareen	35
7004	11	(Kells) Blackwater	Stramatt	24
29011	12	Dunkellin	Kilcolgan	27
27002	13	Fergus	Ballycorey	56
26018	14	Owenure	Bellavahan	54
			Total years of record	511

Growth Curves

GROWTH CURVES					
Return Period	Single Site	FSU	FSR RR	FSU adjusted from 50	Single Site Adjusted from N
2	0.99	1.00	1.00	1.00	0.99
5	1.42	1.23	1.44	1.23	1.42
10	1.70	1.39	1.68	1.39	1.70
25	2.06	1.57	2.01	1.57	2.06
50	2.32	1.70	2.30	1.70	2.32
100	2.59	1.83	2.60	1.92	2.64
200	2.85				
500	3.20				
1000		2.23	3.86	2.56	4.11

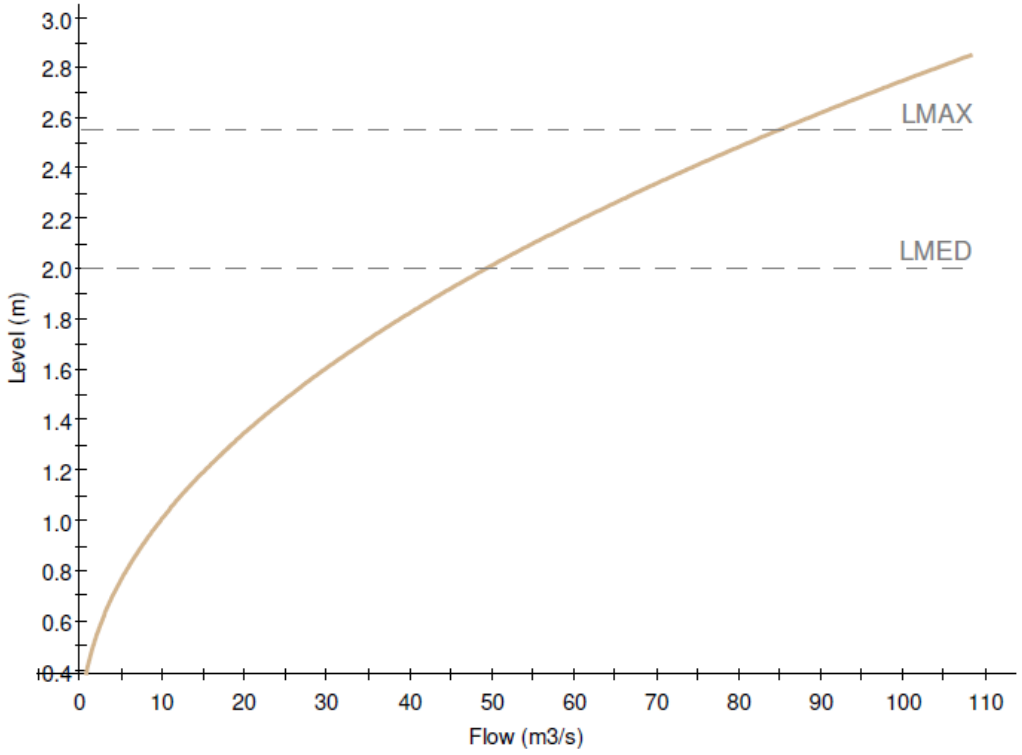


Historical Event Analysis

Event	28/06/2012	05/11/2000	06/02/1990	10/01/2008
Historical Rank	1	2	3	4
Flow m^3/Sec	153.9	102	100.5	98.34
Growth Curves				
FSU	>1000	31	28	20
FSU Adjusted from 50	182	31	28	20
Winter RR	61	7	6	5
Single Site (27 Years)	60	7	6	5
Adjusted from N	58	7	6	5

Station 19027	Kill (Laney)

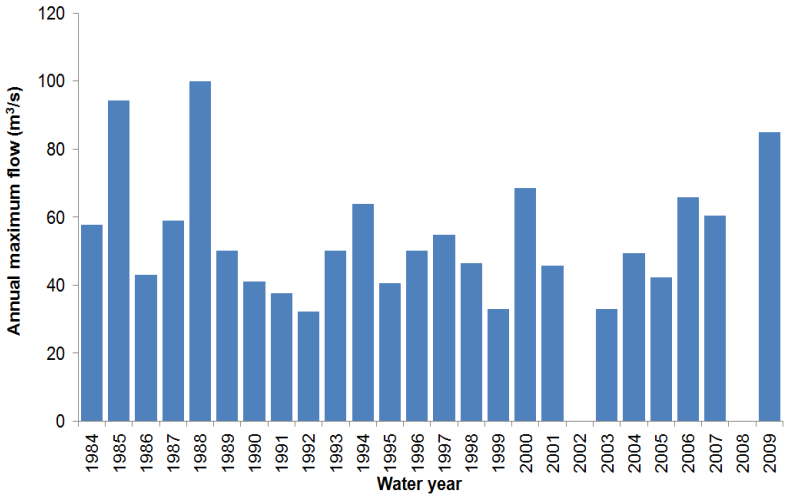
Rating Curve



Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
ESB Rating	a	13.579	-0.15	2.088	0	1.992	01/01/1984	

Kill was not modelled during the Lee CFRAM and therefore no Lower Lee CFRAM rating curve was developed based on a calibrated model. A gauge was install at Kill in 1984 and the highest flow gauging taken since then is 27.84m3/s. The Qmed at this station has been calculated to be 50.17m^3/s, so the highest flow gauging is significantly less. In the absence of any model rating curve the ESB rating curve has been applied for this study. Further flow estimates are required to update the rating curve (channel liable to change due to dense vegetation on clayey banks) and to extend it to a higher flood level range.

Annual Maximum



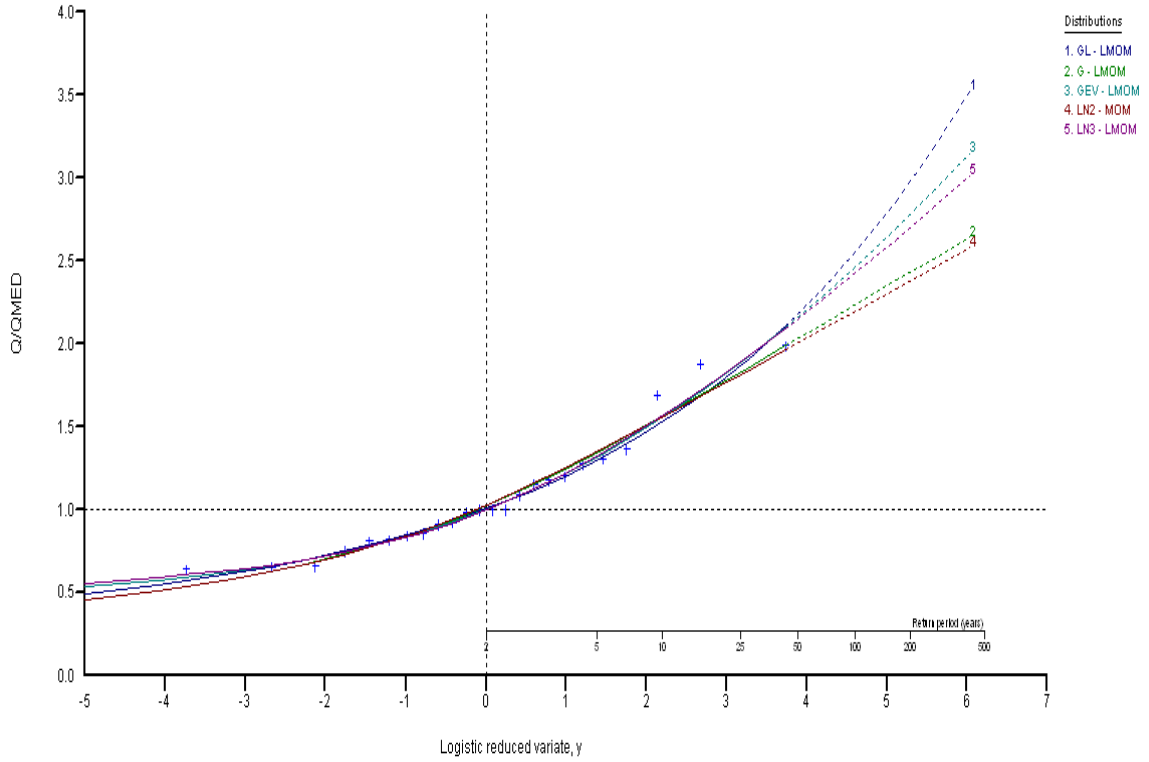
Qmed Estimation

	m^3/s
FSU	30.06
FSR RR Winter	44.36
FSR RR Summer	45.99
Lee Cfram	
Single Site Analysis	50.17
Adjustment Factor (Single Site/FSU)	1.67

Single Site Growth Factors

Return Period	GL	G	GEV	LN2	LN3
2	1.00	1.02	1.00	1.03	1.00
5	1.30	1.35	1.32	1.35	1.33
10	1.53	1.56	1.56	1.56	1.57
25	1.87	1.83	1.89	1.82	1.89
* 50	2.18	2.04	2.16	2.01	2.15
* 100	2.55	2.24	2.46	2.19	2.42
* 200	2.98	2.44	2.78	2.38	2.70
* 500	3.67	2.70	3.25	2.63	3.09

Annual Maximum Series

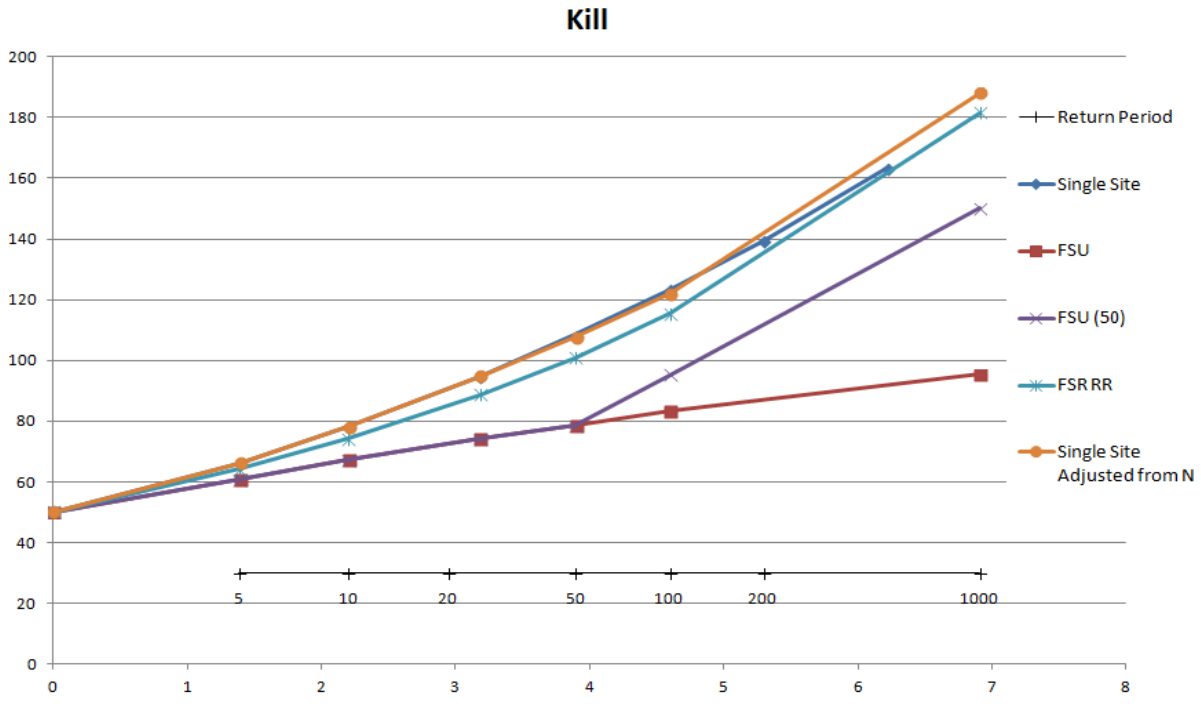


FSU Pooling Group

FSU Pooling Group				
ID	Rank	Watercourse	Location	Years
27070	1	L. Inchiquin	Baunkyle	29
27003	2	Fergus	Corrofin	48
32012	3	Newport	Newport Weir	31
35028	4	Bonet	New Bridge (Manorhamilton)	20
33070	5	Carrowmore L.	Carrowmore	28
35071	6	L. Melvin	Lareen	35
35002	7	Owenbeg	Billa Bridge	25
31002	8	Cashla	Cashla	26
25158	9	Bilboa	Cappamore	18
32006	10	Carrowbeg	Coolloughra	6
34018	11	Castlebar	Turlough	34
29071	12	L. Cutra	Cutra	36
35012	13	Garvogue	New Bridge	10
25044	14	Kilmastulla	Coole	40
35073	15	Lough Gill	Lough Gill	30
30019	16	Owenriff	Claremount	27
30101	17	Owenriff	Oughtereard	9
19020	18	Owennacurra	Ballyedmond	28
16005	19	Multeen	Aughnagross	35
			Total years of record	515

Growth Curves

GROWTH CURVES					
Return Period	Single Site	FSU	FSR RR	FSU adjusted from 50	Single Site Adjusted from N
2	1	1	1	1	1.00
5	1.32	1.21	1.41	1.21	1.32
10	1.56	1.34	1.64	1.34	1.56
25	1.89	1.48	1.94	1.48	1.89
50	2.16	1.57	2.21	1.57	2.14
100	2.46	1.66	2.48	1.76	2.43
200	2.78				
500	3.25				
1000		1.90	3.61	2.56	3.75

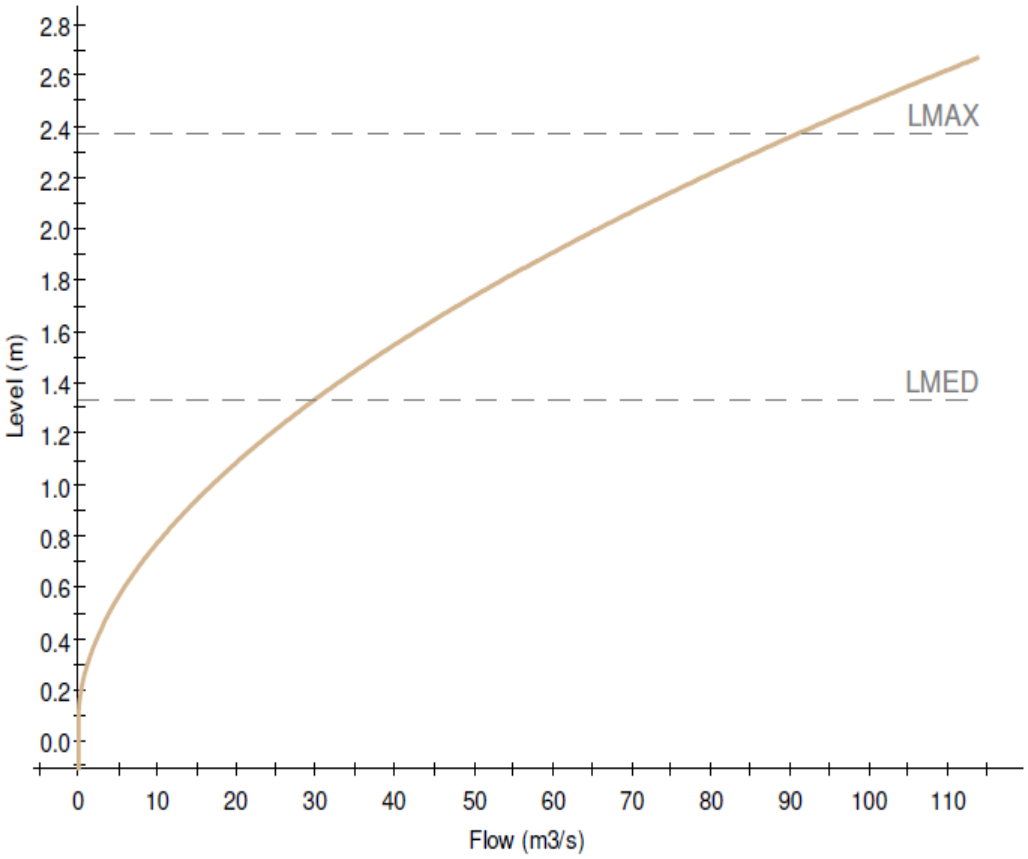


Historical Event Analysis

Event	14/10/1988	06/08/1986	19/11/2009	03/12/2006
Historical Rank	1	2	3	4
Flow m^3/Sec	99.84	94.315	84.84	68.45
Growth Curves				
FSU	572	238	57	8
FSU Adjusted from 50	93	74	51	8
Winter RR	46	33	18	6
Single Site (24 Years)	31	23	13	5
Adjusted from N	32	23	13	5

Station 19028	Dripsey

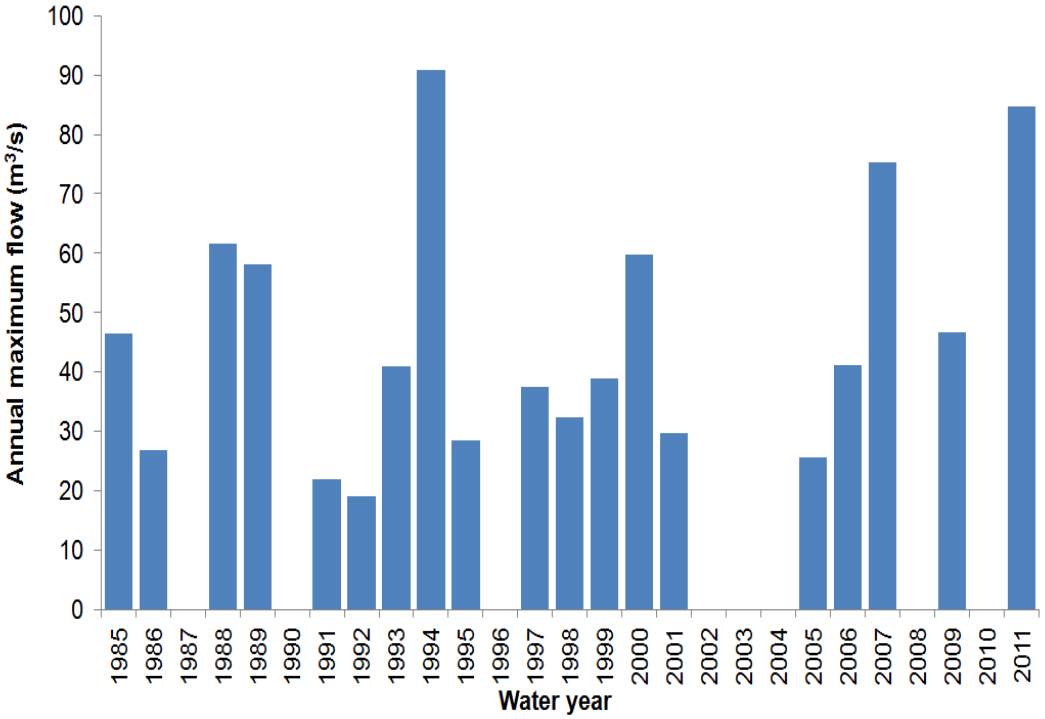
Rating Curve



Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
ESB Rating	a	20.212	-0.1	1.83	0	1.145	01/01/1984	

Dripsey was not modelled during the Lee CFRAM and therefore no Lower Lee CFRAM rating curve was developed based on a calibrated model. A gauge was install at Dripsey in 1984 and the highest flow gauging taken since then is 15.87m3/s. The Qmed at this station has been calculated to be 40.96m^3/s, so the highest flow gauging is significantly less. In the absence of any model rating curve the ESB rating curve has been applied for this study. Further flow estimates are required to update the rating curve and to extend it to a higher flood level range with more accuracy.

Annual Maximum



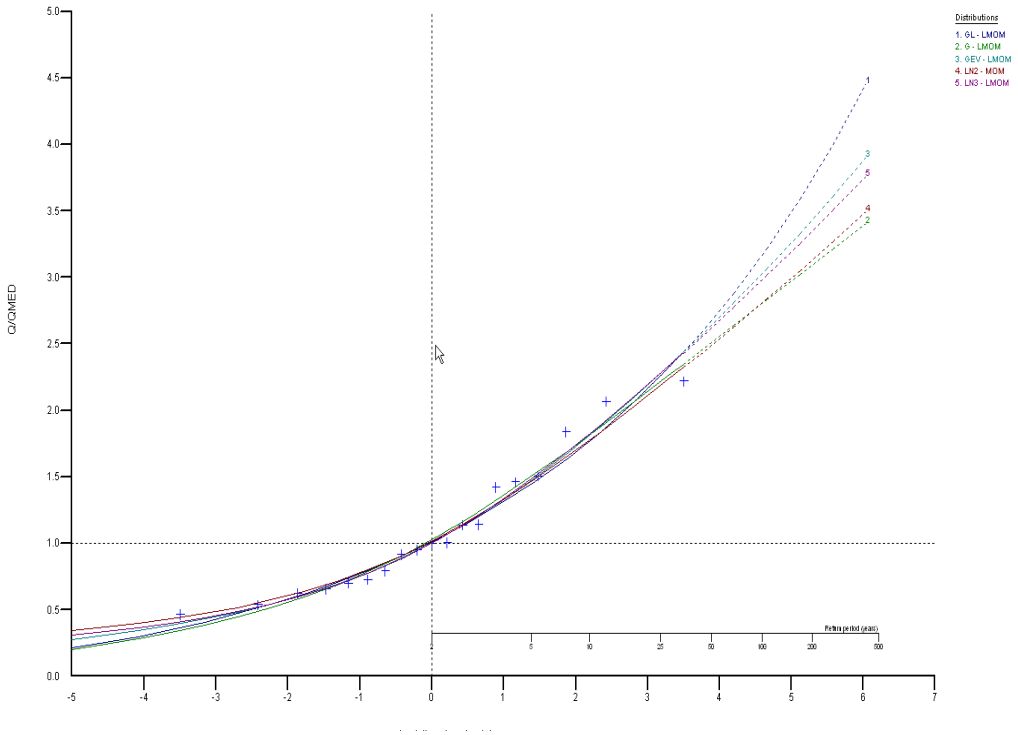
Qmed Estimation

	m^3/s
FSU	20.14
FSR RR Winter	35.48
FSR RR Summer	36.49
Lee Cfram	
Single Site Analysis	40.96
Adjustment Factor (Single Site/FSU)	2.03

Single Site Growth Factors

Return Period	GL	G	GEV	LN2	LN3
2	1.008	1.025	0.999	1.011	0.997
5	1.443	1.501	1.472	1.463	1.482
10	1.768	1.816	1.812	1.775	1.823
25	2.25	2.214	2.273	2.181	2.273
* 50	2.674	2.509	2.641	2.491	2.621
* 100	3.165	2.802	3.028	2.808	2.979
* 200	3.736	3.094	3.437	3.133	3.35
* 500	4.639	3.48	4.016	3.578	3.86

Annual Maximum Series

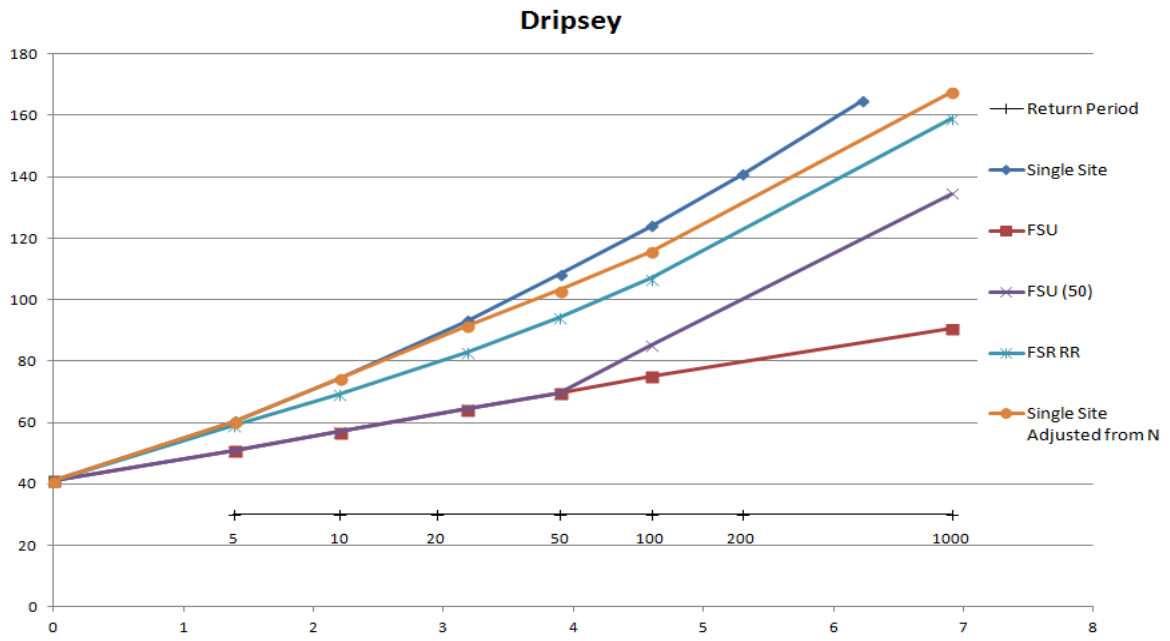


FSU Pooling Group

FSU Pooling Group				
ID	Rank	Watercourse	Location	Years
19020	1	Owennacurra	Ballyedmond	28
34018	2	Castlebar	Turlough	34
27070	3	L. Inchiquin	Baunkyle	29
27003	4	Fergus	Corrofin	48
35071	5	L. Melvin	Lareen	35
35003	6	Unshin	Ballygrania	45
35073	7	Lough Gill	Lough Gill	30
29004	8	Clarinbridge	Clarinbridge	37
35012	9	Garvogue	New Bridge	10
6070	10	Muckno L	Muckno	27
6012	11	Fane	Clarebane	40
26018	12	Owenure	Bellavahan	54
29007	13	L. Cullaun	Craughwell	27
32012	14	Newport	Newport Weir	31
25044	15	Kilmastulla	Coole	40
			Total years of record	515

Growth Curves

GROWTH CURVES					
Return Period	Single Site	FSU	FSR RR	FSU adjusted from 50	Single Site Adjusted from N
2	0.999	1	1	1	1.00
5	1.472	1.24	1.44	1.24	1.47
10	1.812	1.39	1.69	1.39	1.81
25	2.273	1.57	2.02	1.57	2.23
50	2.641	1.7	2.3	1.7	2.51
100	3.028	1.83	2.61	1.93	2.82
200	3.437				
500	4.016				
1000		1.90	3.88	2.87	4.09

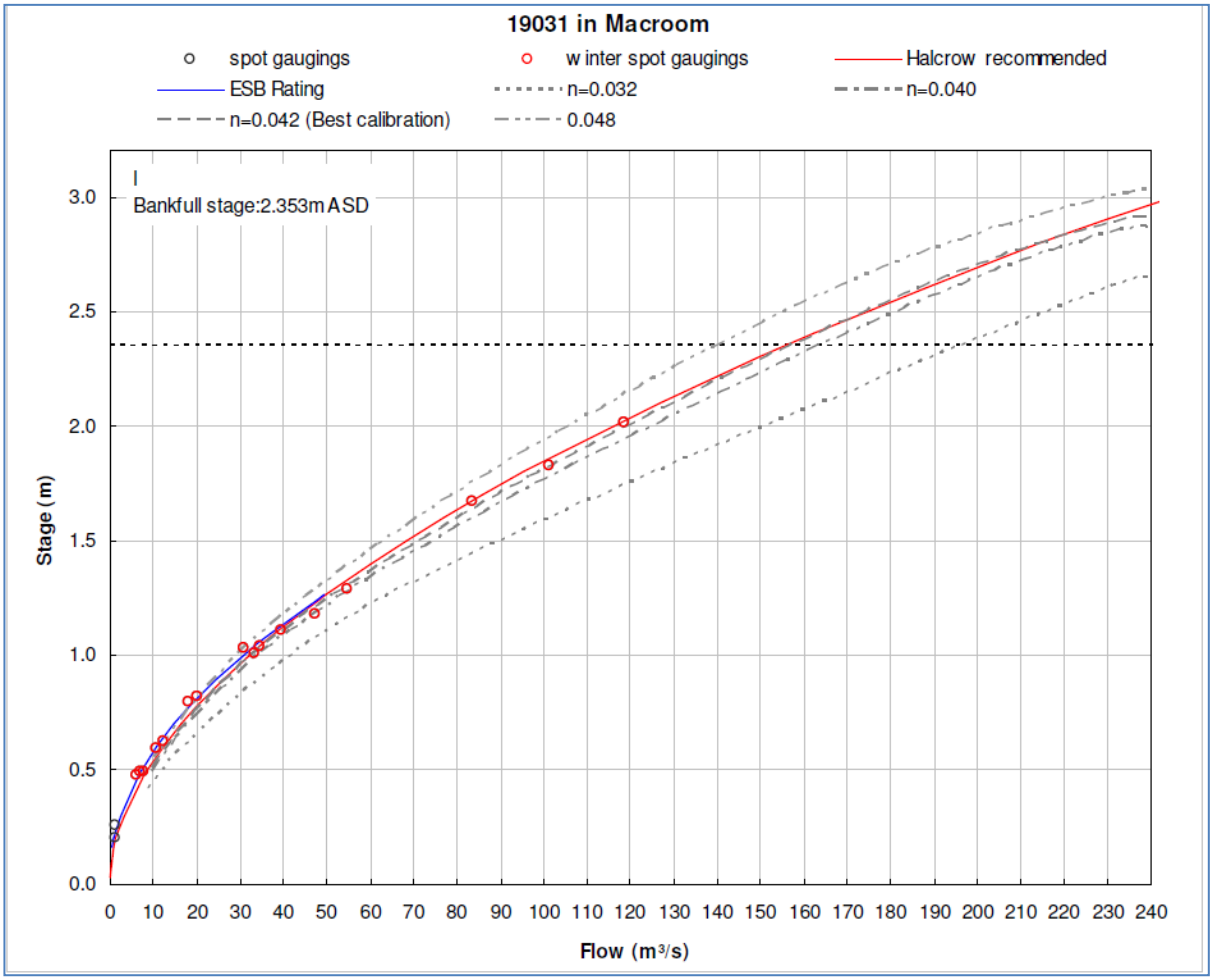


Historical Event Analysis

Event	09/03/1995	28/06/2012	10/01/2008	14/10/1998
Historical Rank	1	2	3	4
Flow m^3/Sec	153.9	102	100.5	98.34
Growth Curves				
FSU	>1000	31	28	24
FSU Adjusted from 50	182	31	28	24
Winter RR	61	7	6	5
Single Site (27 Years)	60	7	6	5
Adjusted from N	58	7	6	5

Station 19031	Macroom (Sullane)

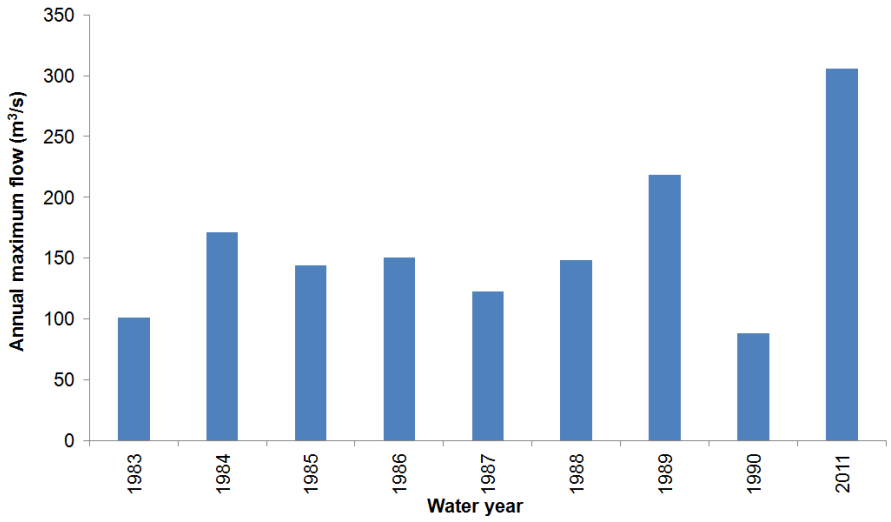
Rating Curve



Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
ESB Rating	a	33.976	-0.05	1.911	0	2.286	01/01/1983	
Lee CFRAM	a	33.976	-0.03	1.811	0	2.900	01/01/1983	
Lee CFRAM	b	34.076	-0.06	1.829	2.90	3.100	01/01/1983	

The Macroom rating for the upper extrapolated flows should give grounds for concern. The highest flow gauging is 118m^3/s. Extrapolation above this leads to a lack of confidence in the calculated flows. There is also some confusion regarding the change of its location. It is stated by ESB that a change in location took place during the 1990's and its staff gauge zero datum has not been validated. The Lee CFRAM rating has been applied in this study for the Macroom gauge alone. It has been excluded from catchment average Qmed adjustment factor and flood frequency curve due the lack of flow gaugings, uncertainty over the change in location of the gauge and its timing and the exclusion of the river laney that joins just upstream of the gauging location in the Lee CFRAM rating model.

Annual Maximum



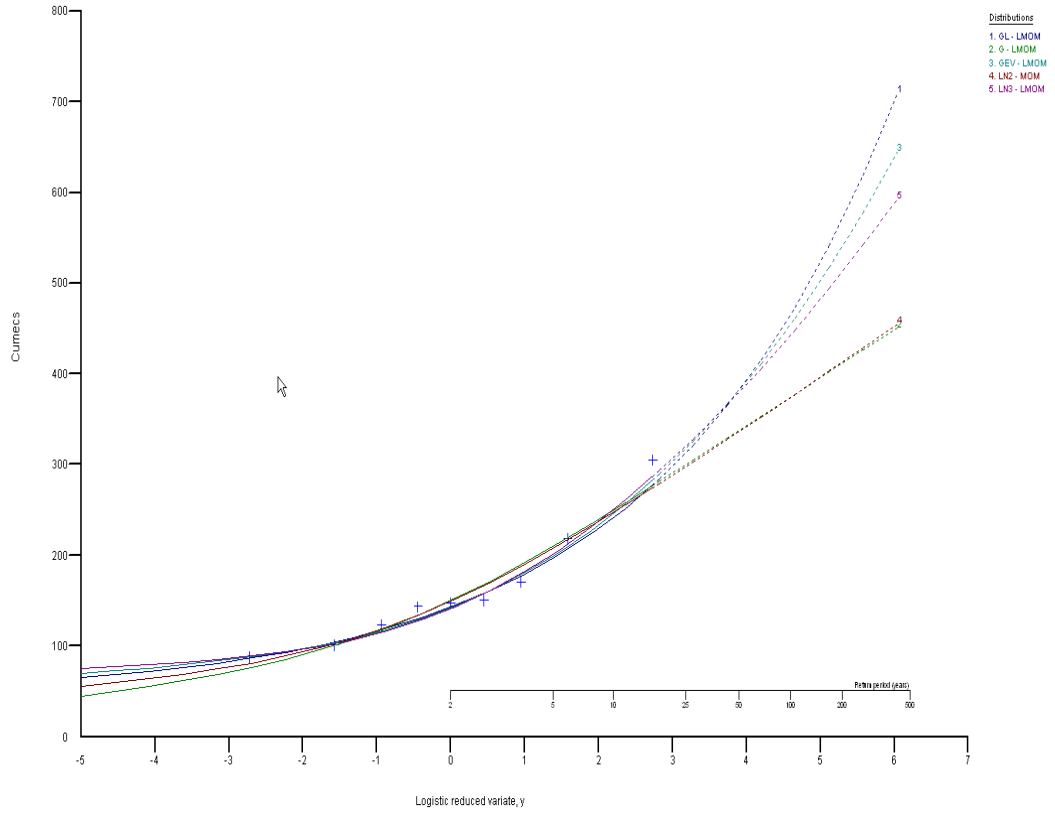
Qmed Estimation

	m^3/s
FSU	80.23
FSR RR Winter	98.82
FSR RR Summer	102.17
Lee Cfram	141.70
Single Site Analysis	148.00
Adjustment Factor (Single Site/FSU)	1.84

Single Site Growth Factors

Return Period	GL	G	GEV	LN2	LN3
2	1.00	1.00	1.00	1.00	1.00
5	1.38	1.40	1.41	1.39	1.43
10	1.69	1.67	1.74	1.66	1.78
25	2.19	2.00	2.24	2.00	2.27
* 50	2.67	2.25	2.69	2.25	2.69
* 100	3.26	2.50	3.20	2.51	3.14
* 200	3.98	2.74	3.80	2.77	3.63
* 500	5.23	3.07	4.74	3.12	4.35

Annual Maximum Series

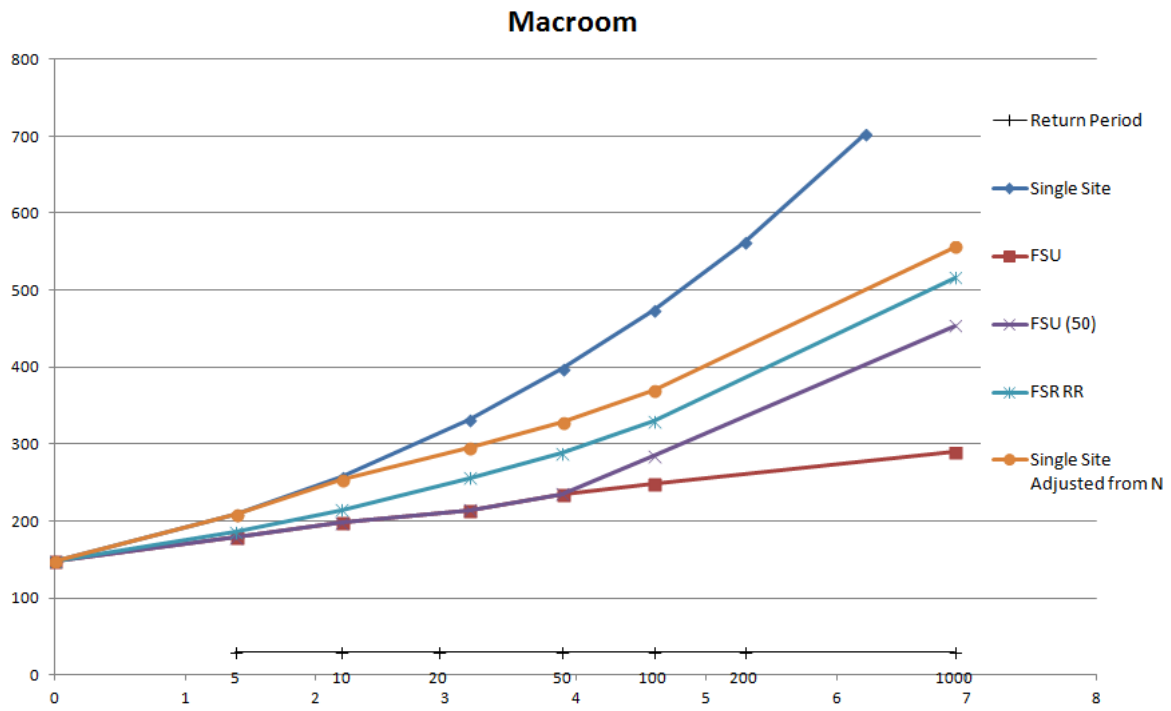


FSU Pooling Group

FSU Pooling Group				
ID	Rank	Watercourse	Location	Years
32012	1	Newport	Newport Weir	31
27003	2	Fergus	Corrofin	48
27070	3	L. Inchiquin	Baunkyle	29
35028	4	Bonet	New Bridge (Manorhamilton)	20
22071	5	Lough Leane	Tomies Pier	37
31002	6	Cashla	Cashla	26
33070	7	Carrowmore L.	Carrowmore	28
30019	8	Owenriff	Claremount	27
30101	9	Owenriff	Oughtereard	9
25158	10	Bilboa	Cappamore	18
35002	11	Owenbeg	Billa Bridge	25
35071	12	L. Melvin	Lareen	35
32006	13	Carrowbeg	Coolloughra	6
35012	14	Garvogue	New Bridge	10
27002	15	Fergus	Ballycorey	56
29071	16	L. Cutra	Cutra	36
35073	17	Lough Gill	Lough Gill	30
25030	18	Graney	Scarriff Bridge	53
			Total years of record	524

Growth Curves

GROWTH CURVES					
Return Period	Single Site	FSU	FSR RR	FSU adjusted from 50	Single Site Adjusted from N
2	1.00	1	1	1	1.00
5	1.41	1.21	1.39	1.21	1.41
10	1.74	1.34	1.6	1.34	1.72
25	2.24	1.45	1.89	1.45	2.00
50	2.69	1.59	2.14	1.59	2.22
100	3.20	1.68	2.40	1.78	2.50
200	3.80				
500	4.74				
1000		1.96	3.47	2.58	3.76

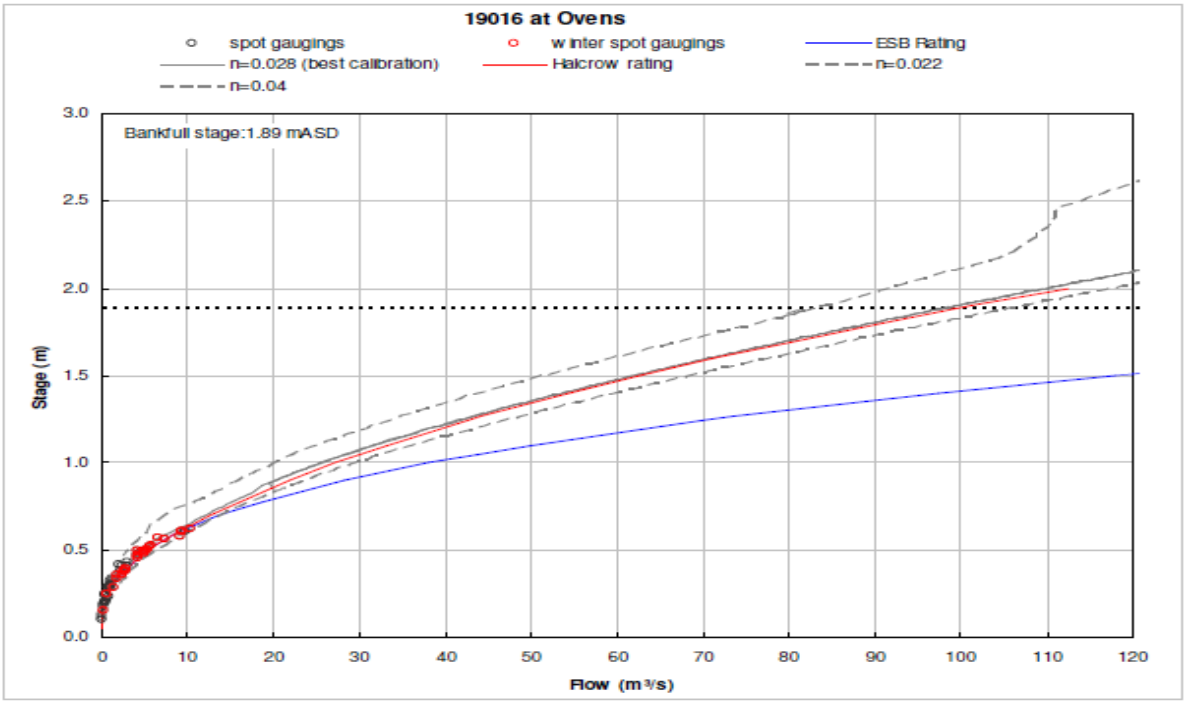


Historical Event Analysis

Event	03/12/2001	04/02/1990	29/11/1984
Historical Rank	1	2	3
Flow m^3/Sec	305.41	218.76	171.06
Growth Curves			
FSU	>1000	23	3
FSU Adjusted from 50	132	23	3
Winter RR	65	10	2
Single Site (9 Years)	15	5	2
Adjusted from N	29	5	2

Station 19016	Ovens

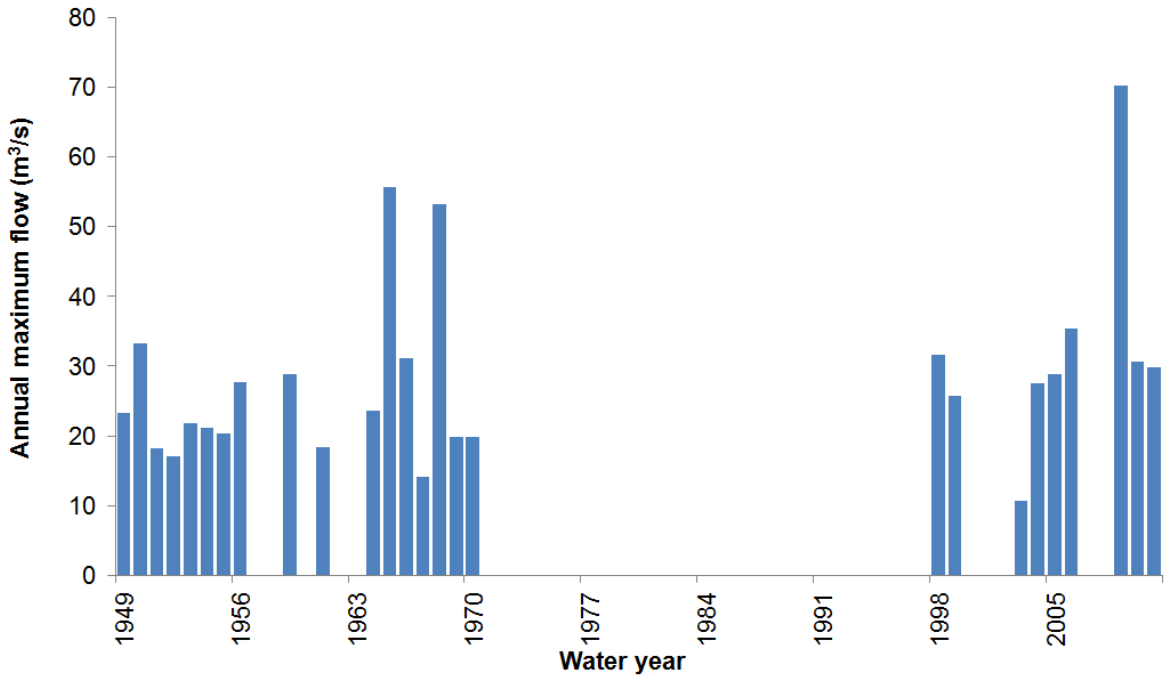
Rating Curve



Rating Curve	Limb	K	a	p	Mini Stage	Max Stage	Start	End
LowerLeeStudy	a	27.00	-0.09	1.802	0	1.028	01/01/1949	31/12/1962
LowerLeeStudy	a	9.95	0.05	1.950	0	0.668	01/01/1963	31/12/1965
LowerLeestudy	a	15.212	0.05	1.966	0	1.238	01/01/1965	31/12/1970
ESB Rating	a	11.721	-0.05	1.811	0	0.27	01/08/1984	
ESB Rating	b	43.602	-0.05	2.679	0.27	1.60	01/08/1984	
Lee CFRAM	a	11.721	-0.05	1.811	0	0.27	01/08/1984	
Lee CFRAM	b	43.602	-0.05	2.679	0.27	0.60	01/08/1984	
Lee CFRAM	c	30.000	-0.05	1.980	0.60	2.00	01/08/1984	

A fixed gauge was situated 5m upstream of Oven's Bridge from 1948 to July 63. From June '64 to 1971, the fixed gauge was erected at Oven's House, approximately 800m downstream of Oven's Bridge. This fixed gauge was never related to Ordnance datum. In May 1976, the fixed gauge was re-erected at 5m upstream of Oven's Bridge and all measurements since then are related to this gauge. The control immediately downstream of the recorder / fixed gauge was altered in July 1963 by reconstruction works at Oven's Bridge and again in August 1984 due to alteration of the weir and fish pass at the bridge. Due to the changes in the channel in 1984 the rating curve produced by the Lee CFRAM is only valid post 1984, the largest flow gauging taken since 1984 was 10.23m^3/s. A series of rating curves have been produced for 1948- 1963(largest gauging 29.62m^3/) and 1964-1971 (largest flow gauging 20.91m^3/s). Due the lack of significant ratings it was not possible to generate a rating curve for the time period 1971-1984 (largest flow gauging 8.763m^3/s). The Qmed at the site is 26.63m^3/s. Again, it is recommended that flow gaugings be taken regularly at high flows to improve the current ratings at reduce the large uncertainty that currently exists in extrapolating high flows.

Annual Maximum



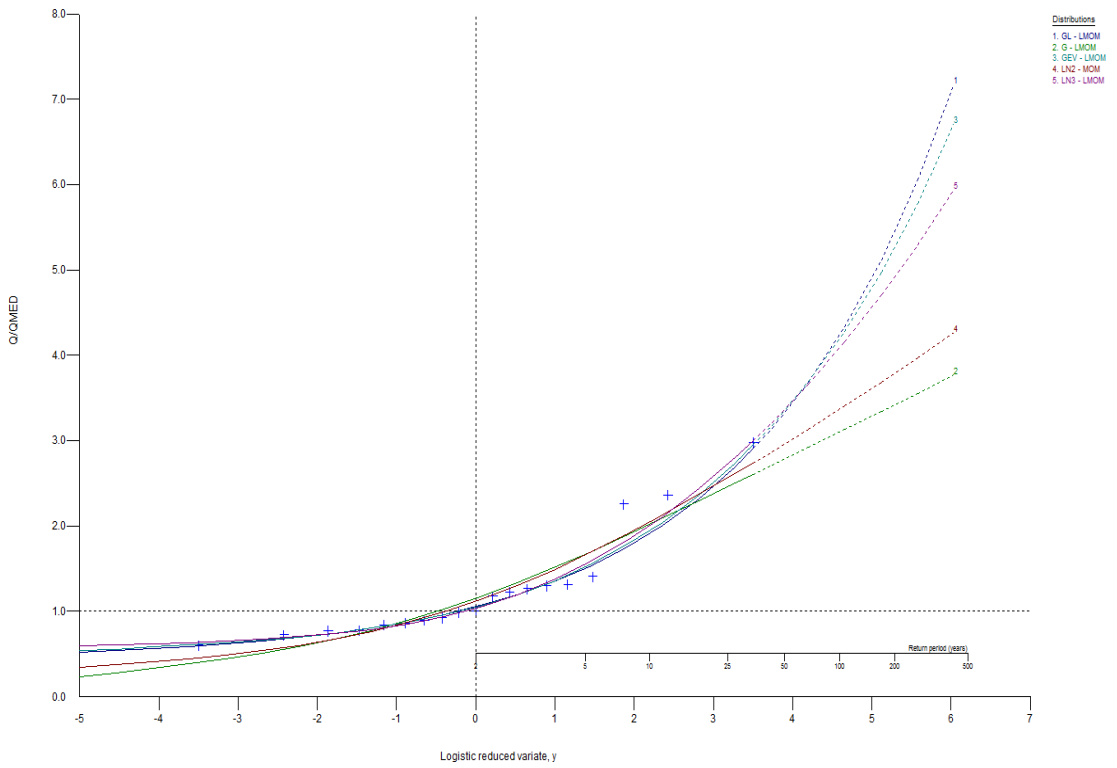
Qmed Estimation

	m³/s
FSU	21.70
FSR RR Winter	39.57
FSR RR Summer	40.65
Lee Cfram	29.50
Single Site Analysis	26.60
Adjustment Factor (Single Site/FSU)	1.23

Single Site Growth Factors

Return Period	GL	G	GEV	LN2	LN3
2	1.05	1.15	1.05	1.11	1.03
5	1.50	1.67	1.52	1.66	1.55
10	1.91	2.02	1.94	2.05	2.00
25	2.60	2.46	2.65	2.56	2.72
* 50	3.31	2.78	3.34	2.96	3.36
* 100	4.24	3.10	4.20	3.37	4.09
* 200	5.45	3.42	5.27	3.79	4.92
* 500	7.66	3.85	7.11	4.38	6.20

Annual Maximum Series

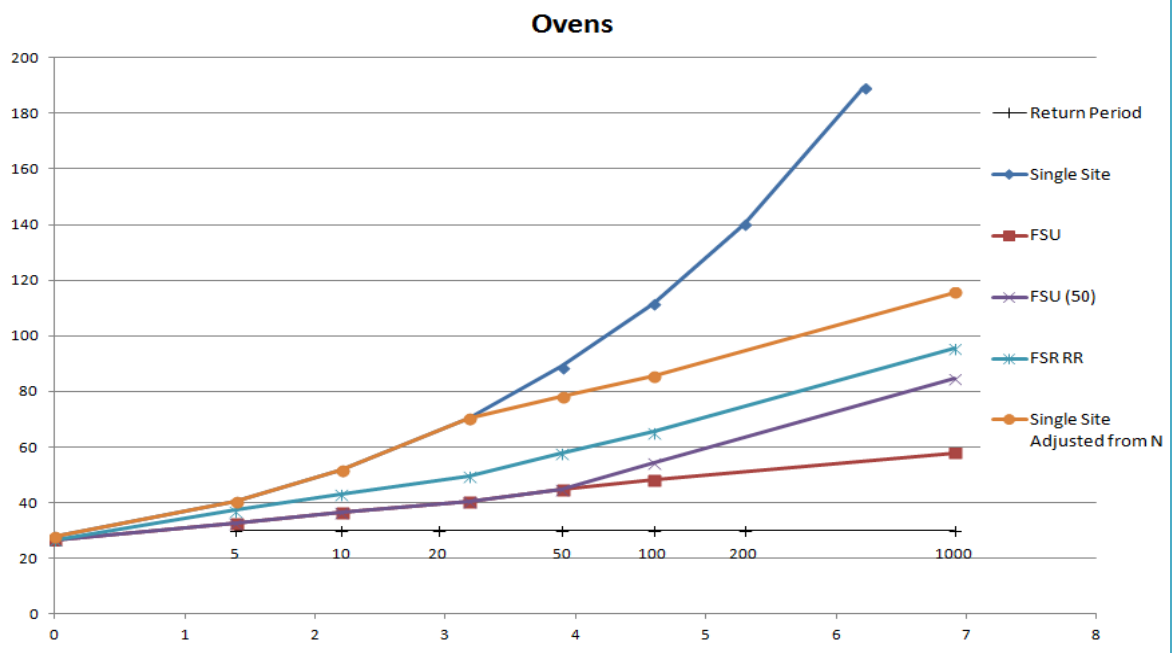


FSU Pooling Group

FSU Pooling Group				
ID	Rank	Watercourse	Location	Years
19020	1	Owennacurra	Ballyedmond	28
29004	2	Clarinbridge	Clarinbridge	37
35071	3	L. Melvin	Lareen	35
6070	4	Muckno L	Muckno	27
6012	5	Fane	Clarebane	40
29007	6	L. Cullaun	Craughwell	27
35003	7	Unshin	Ballygrania	45
26018	8	Owenure	Bellavahan	54
6011	9	Fane	Moyles Mill	53
34018	10	Castlebar	Turlough	34
27003	11	Fergus	Corrofin	48
25029	12	Nenagh	Clarianna	38
27070	13	L. Inchiquin	Baunkyle	29
25014	14	Silver	Millbrook Bridge	55
			Total years of record	550

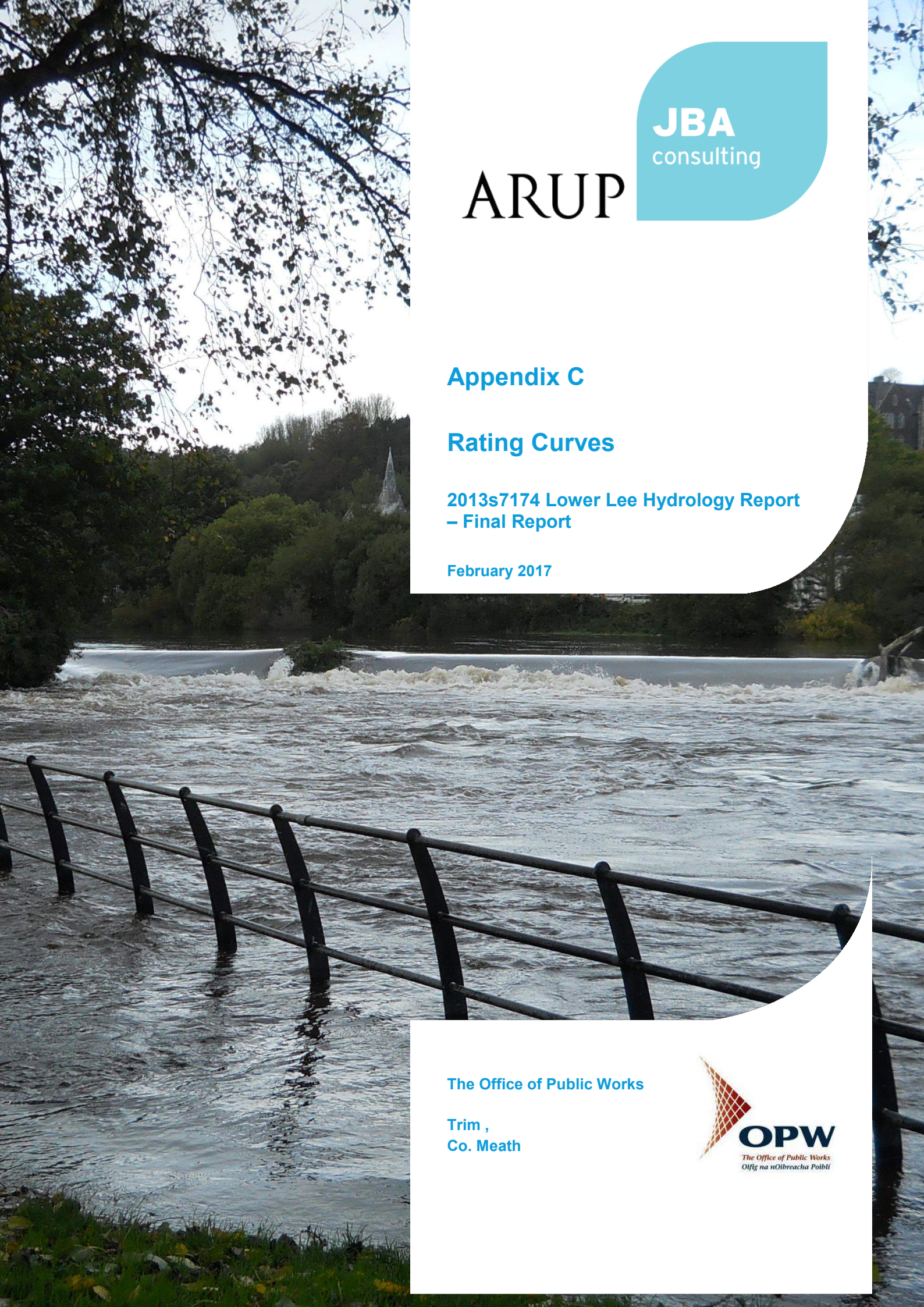
Growth Curves

GROWTH CURVES					
Return Period	Single Site	FSU	FSR RR	FSU adjusted from 50	Single Site Adjusted from N
2	1.045	1	1	1	1.05
5	1.519	1.23	1.4	1.23	1.52
10	1.944	1.38	1.62	1.38	1.94
25	2.653	1.52	1.86	1.52	2.65
50	3.34	1.69	2.18	1.69	2.94
100	4.197	1.81	2.46	1.91	3.22
200	5.269				
500	7.11				
1000		2.18	3.59	2.78	4.35



Historical Event Analysis

Event	19/11/2009	15/02/1966	20/01/1969	11/01/2001
Historical Rank	1	2	3	4
Flow m^3/Sec	70.17	55.71	53.13	35.32
Growth Curves				
FSU	>1000	585	319	7
FSU Adjusted from 50	332	110	90	7
Winter RR	143	40	33	3
Single Site (26 Years)	19	11	10	3
Adjusted from N	19	11	10	3



ARUP

JBA consulting

Appendix C

Rating Curves

2013s7174 Lower Lee Hydrology Report – Final Report

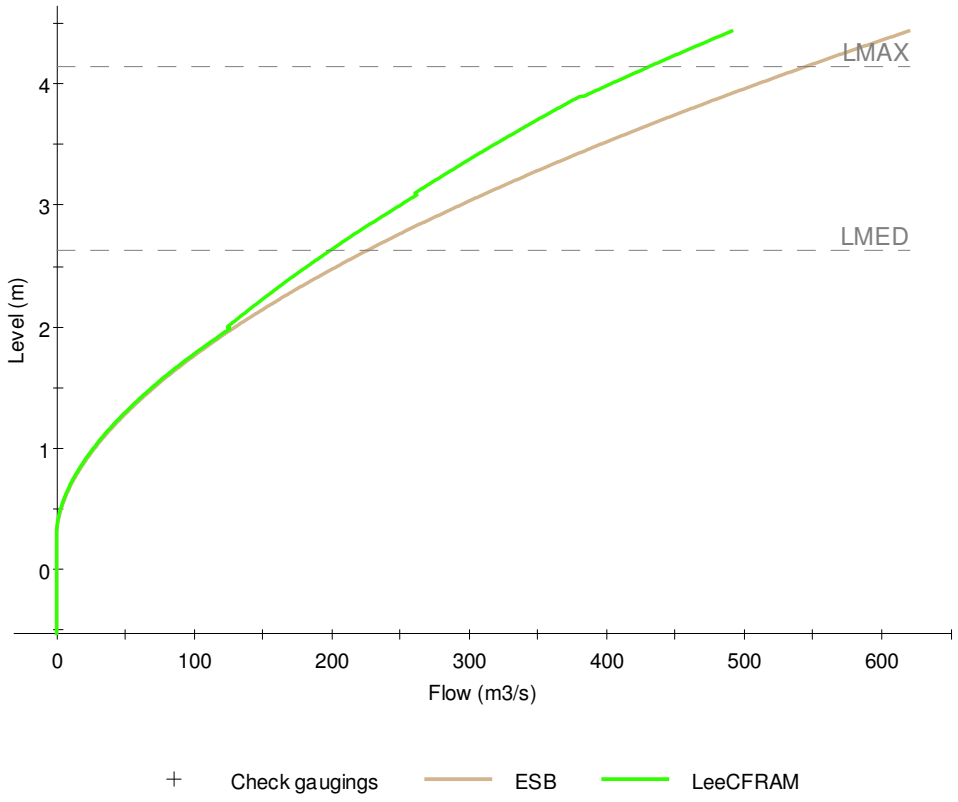
February 2017

The Office of Public Works

Trim ,
Co. Meath

OPW
The Office of Public Works
Oifig na nOibreacha Poibli

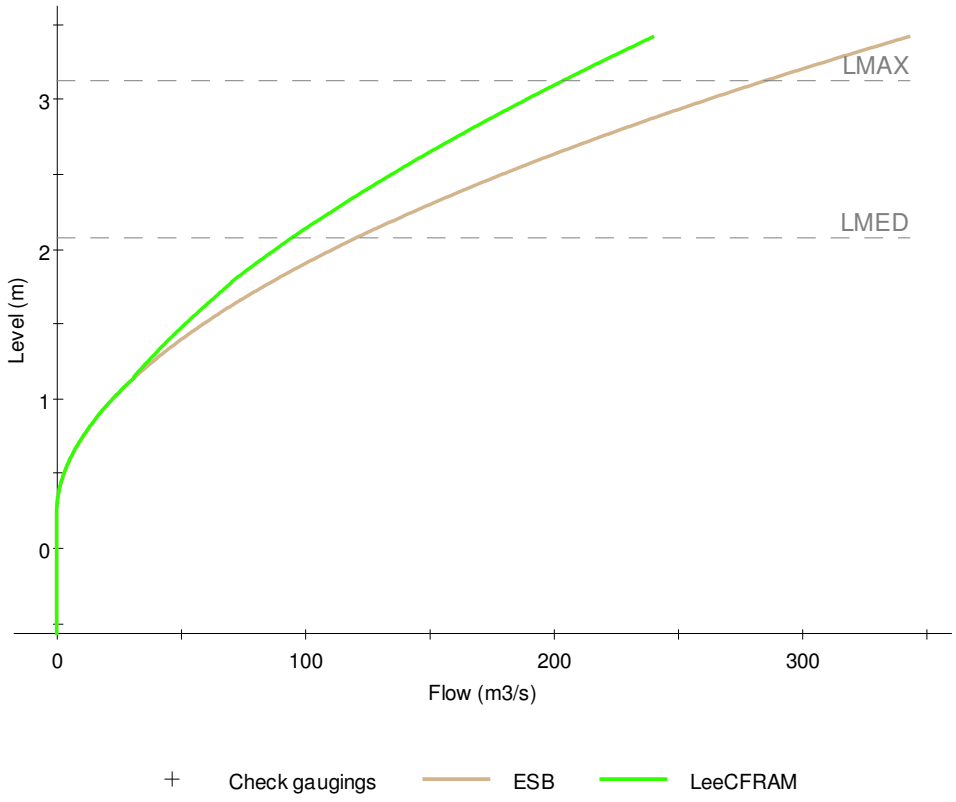
Rating report for : Leemount Upstream (19011_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19011_irlSG	Name	Leemount Upstream				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
375	a	ESB	50.576	-0.300	1.764	2.773	01/01/1950	01/01/1951
449	a	LeeCFRAM	50.576	-0.315	1.764	2.000	01/01/1970	31/12/3999
449	b	LeeCFRAM	41.955	-0.088	1.664	3.100	01/01/1970	31/12/3999
449	c	LeeCFRAM	31.681	0.202	1.760	3.900	01/01/1970	31/12/3999
449	d	LeeCFRAM	38.076	-0.280	1.794	4.200	01/01/1970	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				

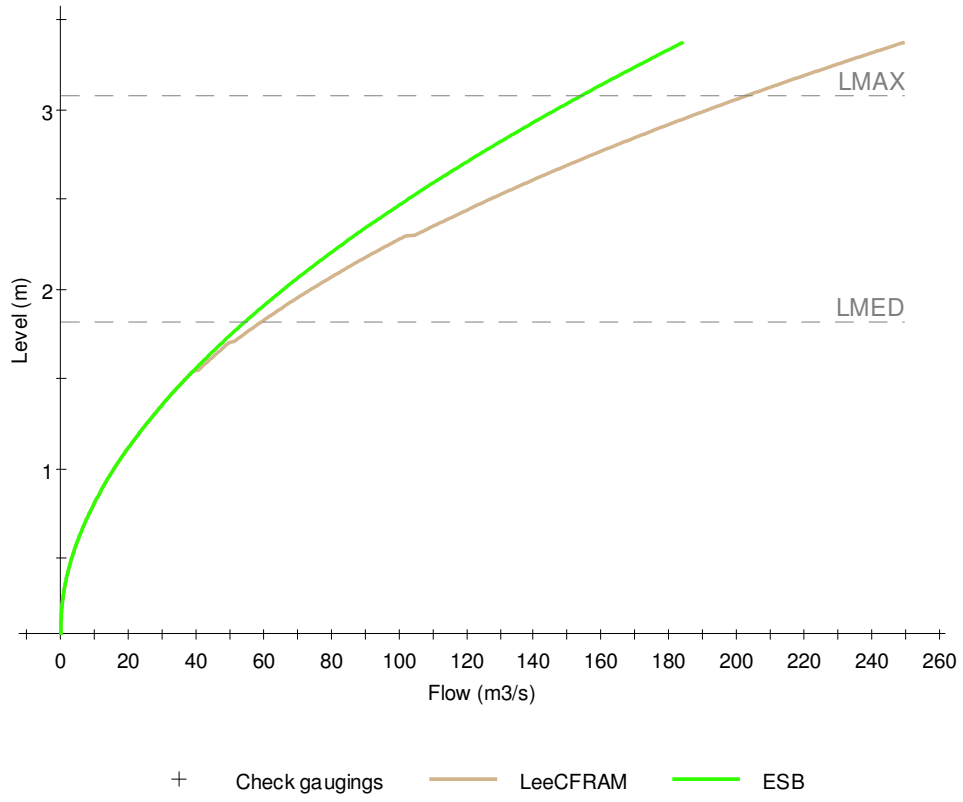
Rating report for : Dromcarra (19014_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19014_irlSG	Name	Dromcarra				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
373	a	ESB	38.214	-0.250	1.901	1.683	01/01/1950	01/01/1951
450	a	LeeCFRAM	38.214	-0.250	1.901	1.149	01/01/1970	31/12/3999
450	b	LeeCFRAM	36.160	-0.249	1.560	1.780	01/01/1970	31/12/3999
450	c	LeeCFRAM	34.223	-0.255	1.690	3.000	01/01/1970	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				

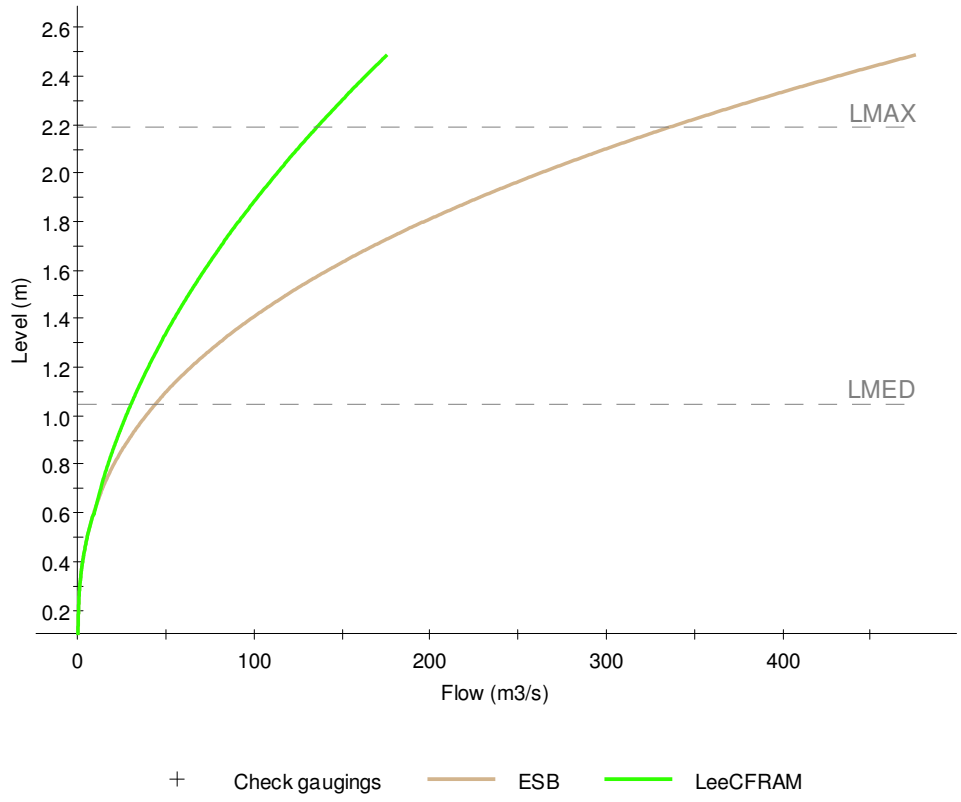
Rating report for : Healy's Bridge (19015_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19015_irlSG	Name	Healy's Bridge				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
450	a	LeeCFRAM	20.977	-0.150	1.855	1.264	01/01/1950	01/01/1951
450	b	LeeCFRAM	20.957	-0.150	1.855	1.553	01/01/1950	01/01/1951
450	c	LeeCFRAM	20.200	-0.132	1.985	1.710	01/01/1950	01/01/1951
450	d	LeeCFRAM	19.870	-0.159	2.150	2.300	01/01/1950	01/01/1951
450	e	LeeCFRAM	19.870	-0.139	2.155	2.700	01/01/1950	01/01/1951
357	a	ESB	20.977	-0.150	1.855	1.264	01/01/1970	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				

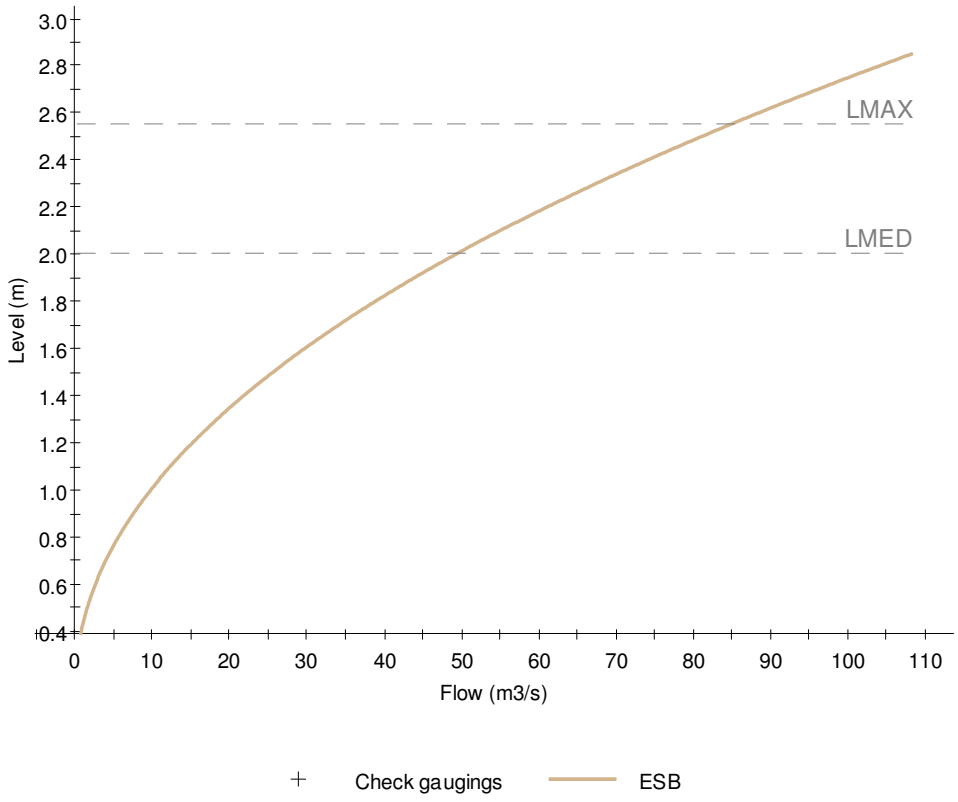
Rating report for : Ovens (19016_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19016_irlSG	Name	Ovens				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
372	a	ESB	11.721	-0.050	1.811	0.270	01/01/1753	21/10/1949
372	b	ESB	43.602	-0.050	2.679	1.600	01/01/1753	21/10/1949
450	a	LeeCFRAM	11.721	-0.050	1.811	0.270	22/10/1949	31/12/3999
450	b	LeeCFRAM	43.602	-0.050	2.679	0.600	22/10/1949	31/12/3999
450	c	LeeCFRAM	30.000	-0.050	1.980	2.000	22/10/1949	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				

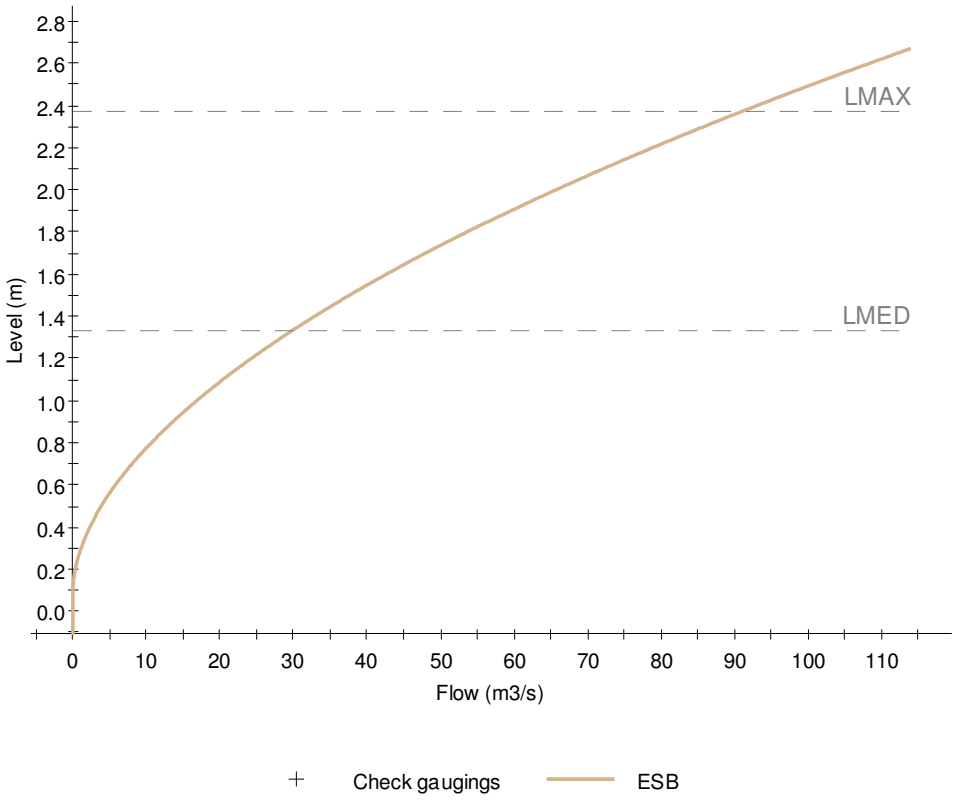
Rating report for : Kill (19027_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19027_irlSG	Name	Kill				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
368	a	ESB	13.579	-0.150	2.088	1.992	01/01/1753	24/08/3999
Gauged range								
Min	n/a		**Max**	n/a				

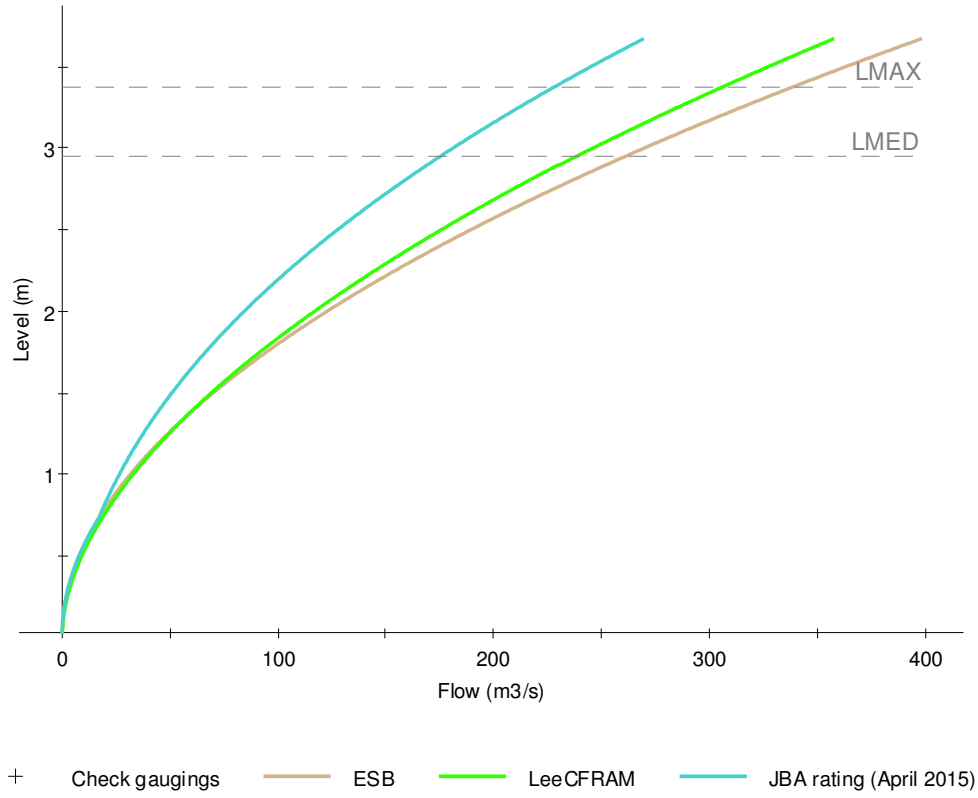
Rating report for : Dripsey (19028_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19028_irlSG	Name	Dripsey				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
367	a	ESB	20.212	-0.100	1.830	1.145	01/01/1753	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				

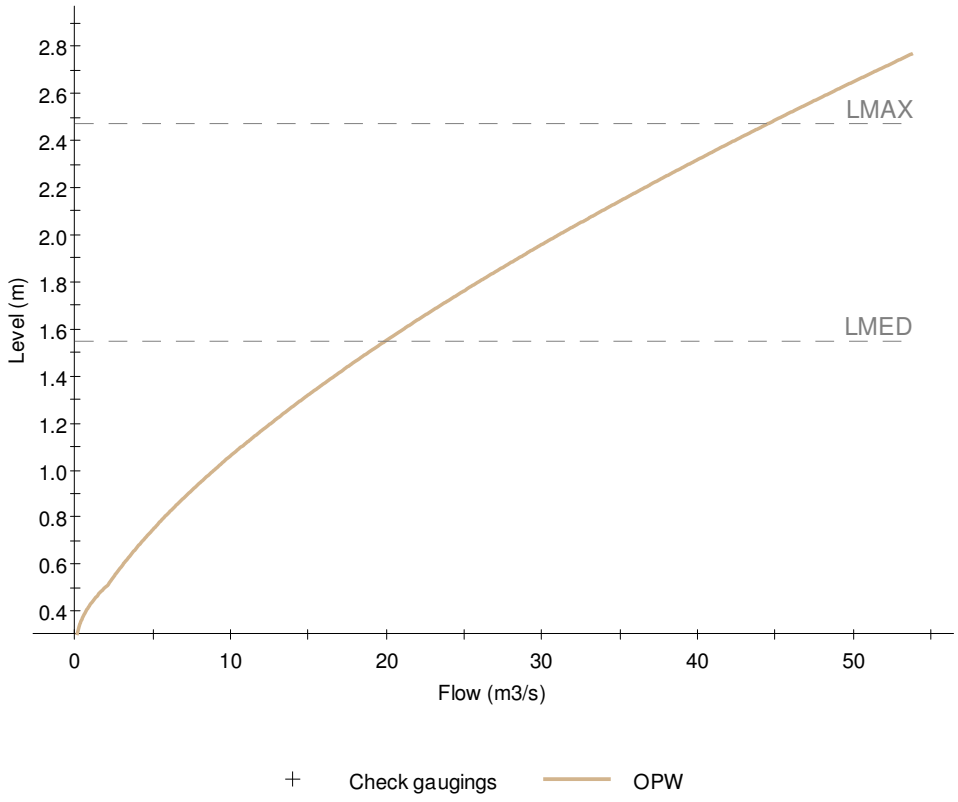
Rating report for : Macroom (19031_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

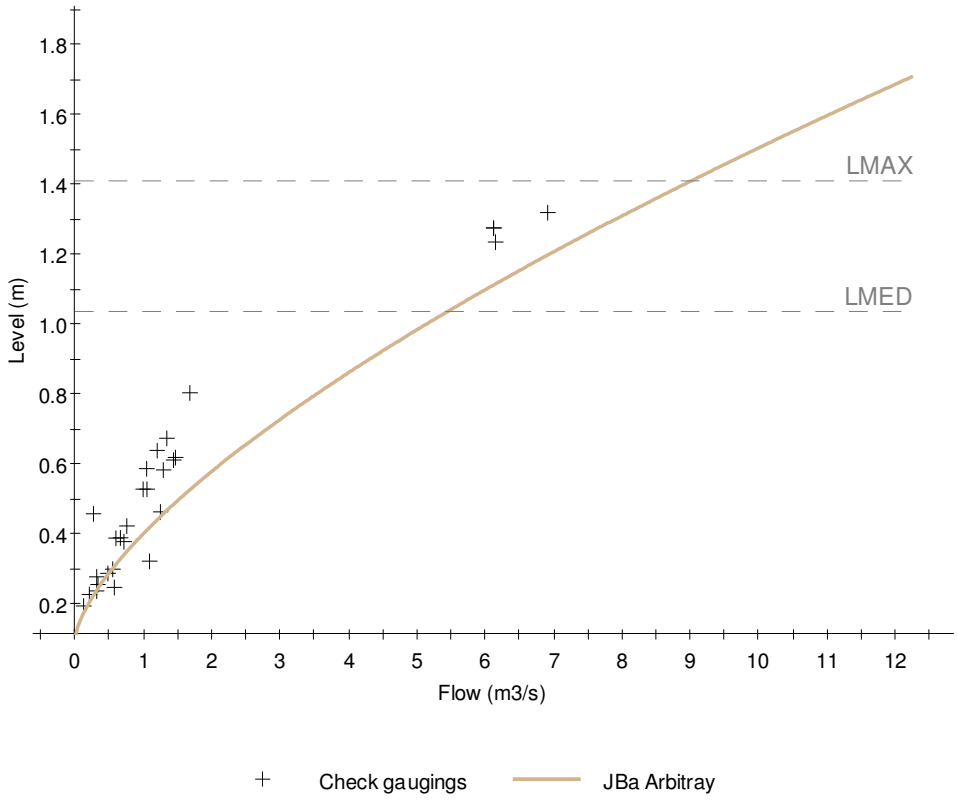
Gauge Ref		19031_irlSG	Name	Macroom				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
362	a	ESB	33.976	-0.050	1.911	2.286	01/01/1950	01/01/1951
450	a	LeeCFRAM	33.976	-0.030	1.811	2.900	01/01/1970	01/01/1970
450	b	LeeCFRAM	34.076	-0.060	1.829	3.100	01/01/1970	01/01/1970
999	a	JBA rating (April 2015)	33.976	-0.050	1.911	0.743	01/01/1980	31/12/3999
999	b	JBA rating (April 2015)	10.705 84	0.47878	2.26501	999.000	01/01/1980	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				

Rating report for : Kilmona Bridge (19044_irlSG)



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19044_irlSG	Name	Kilmona Bridge				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
421	a	OPW	40.000	-0.200	2.560	0.518	01/01/1753	31/12/3999
421	b	OPW	12.500	-0.200	1.545	2.400000 01	01/01/1753	31/12/3999
Gauged range								
Min	n/a		**Max**	n/a				



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref		19045_irlSG	Name	Gothic Bridge				
No.	**Limb**	**Description**	**K**	**a**	**p**	**Max stage**	**Start**	**End**
1	a	JBa Arbitray	6.000	-0.100	1.500	0.100	01/01/1753	31/12/3999

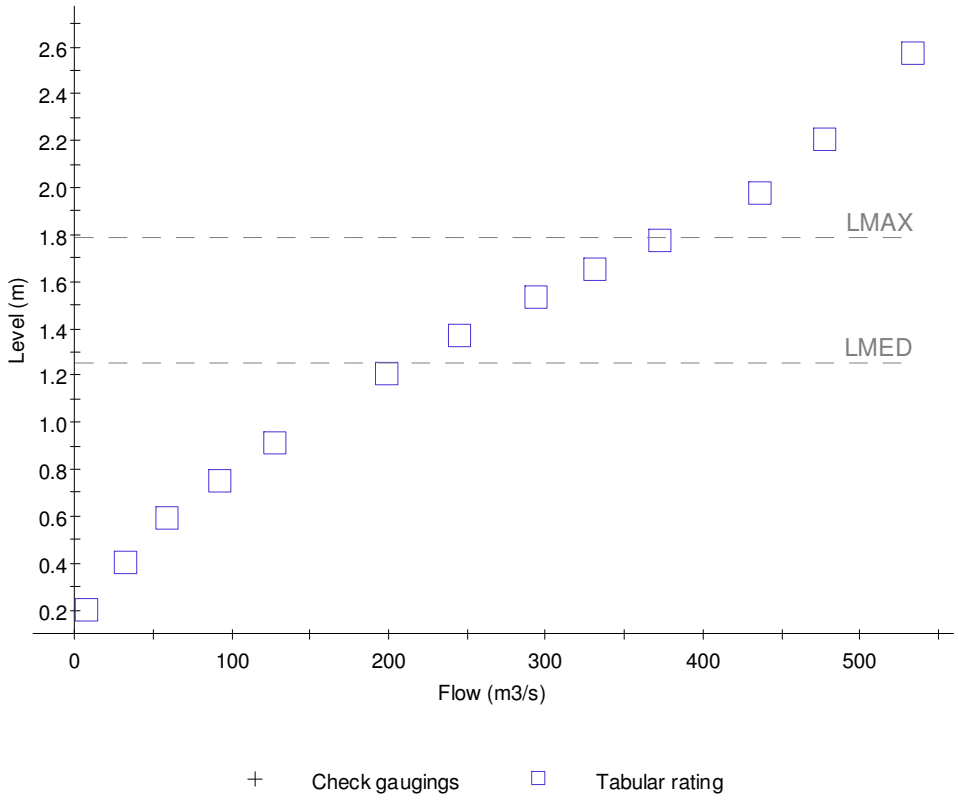
Gauged range

Min	m3/s ()	**Max**	6.9m3/s ()

Notes

1 Gothic Bridge Rating

No ratings information or sufficient flow data were available at Gothic Bridge, therefore an arbitrary rating was derived by JBA Consulting. Flows at Gothic Bridge were scaled from flows at Kilmona using catchment area. Flow at Gothic was then plotted against stage at Gothic as a scatter plot. A function was added to the graph in the form of a rating curve equation [k*(H+a)^p]. Starting with a commonly observed exponent (1.5) from other rating curves, the rating for Gothic Bridge was iteratively calibrated alongside the PDM.



Rating equation is Q = K(H + a)^p, where H is stage

Gauge Ref	WaterworksWeir_irlSG	Name	WaterworksWeir

No.	Limb	Description	K	a	p	Max stage	Start	End
450								

Gauged range

Min	n/a	Max	n/a

Notes

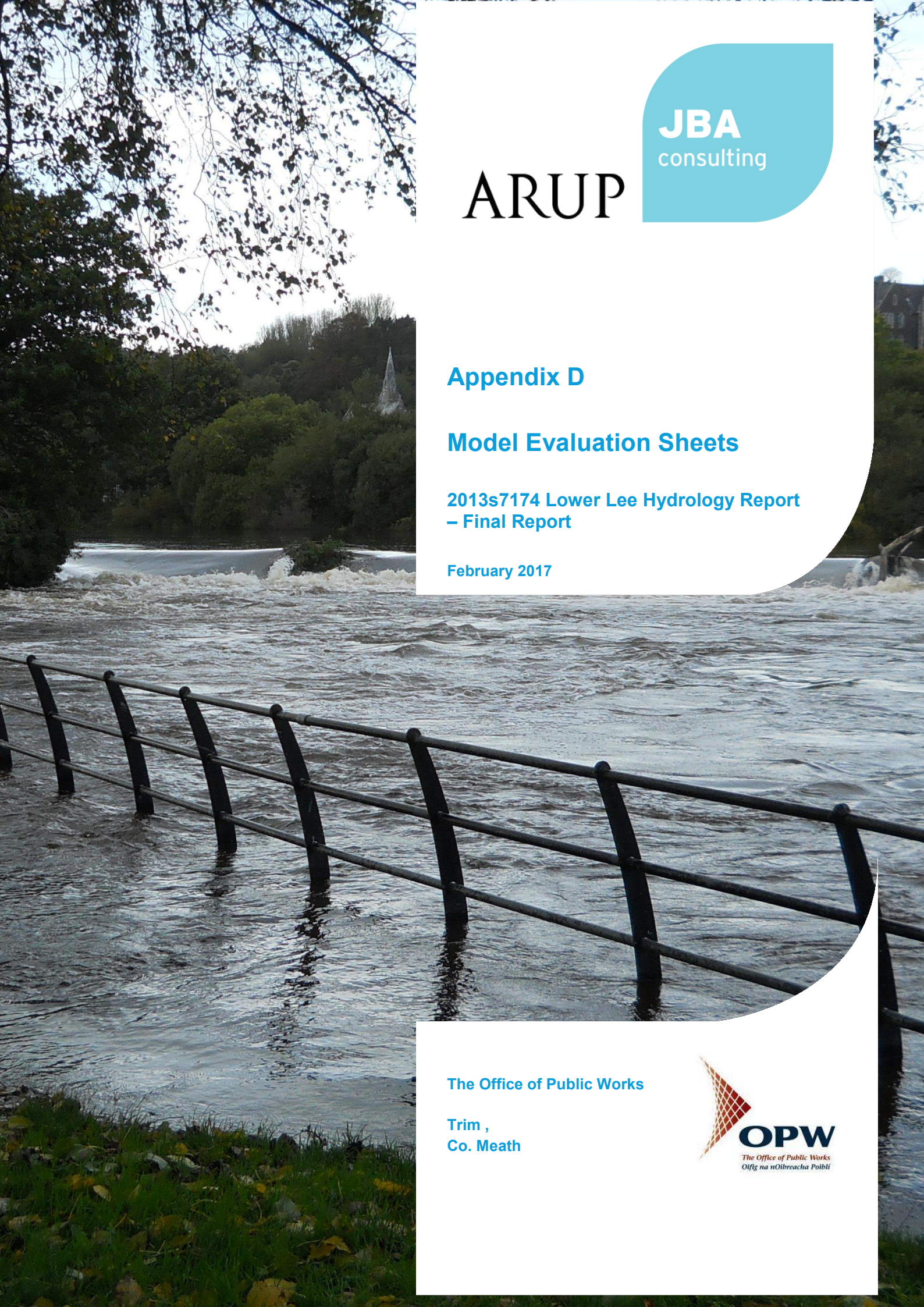
1 Waterworks Weir Rating

No ratings information or flow data were available at Waterworks Weir, therefore a tabular rating was extracted from the Lee CFRAM hydraulic model by JBA Consulting. This rating was then checked against observed levels at Waterworks Weir with flows from Inniscarra where impact of tributaries on the weir was negligible so essentially only flow from Inniscarra was observed at Waterworks Weir.

Rating tabulation:

Rating report for : WaterworksWeir (WaterworksWeir_irISG)

Stage	Flow
0.0	0.0
0.207	7.37
0.409	32.35
0.598	58.54
0.754	92.15
0.917	127.12
1.211	198.27
1.374	244.59
1.537	293.19
1.654	330.73
1.778	371.91
1.98	435.49
2.208	476.82
2.573	532.98



ARUP

JBA consulting

Appendix D

Model Evaluation Sheets

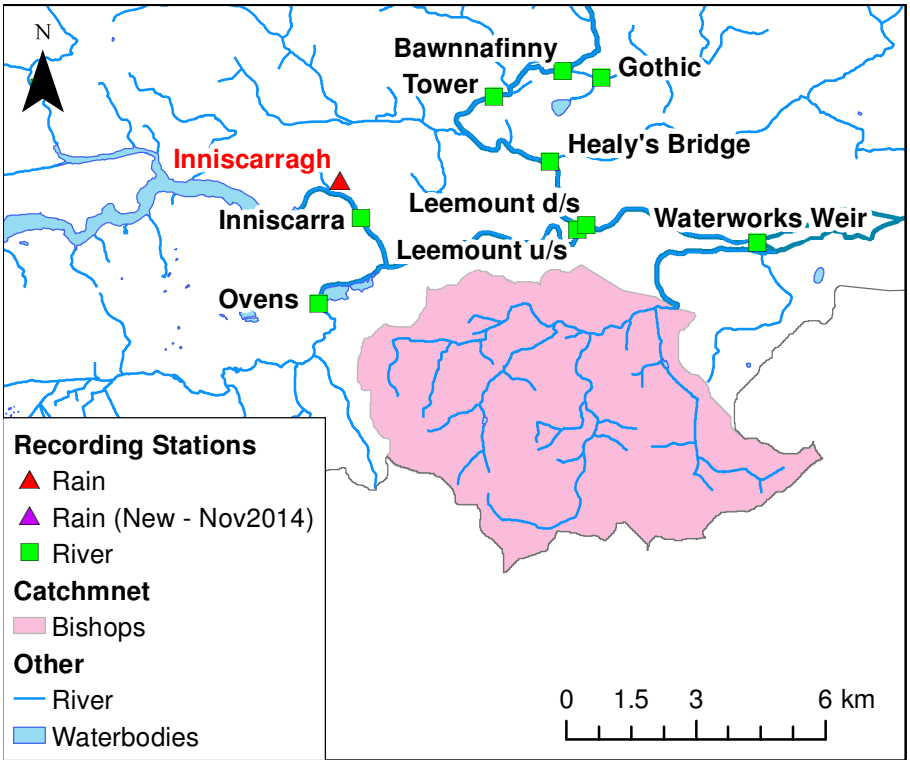
2013s7174 Lower Lee Hydrology Report – Final Report

February 2017

The Office of Public Works

Trim ,
Co. Meath

OPW
The Office of Public Works
Oifig na nOibreacha Poibli



Raingauges used

TBR Ref	Name	Weight
BweengPHREev	Bweeng Pump House	0
Inniscarra_irlREev	Inniscarra	1

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
46.29	1	0	60	2	2.5	500	1.7	0	3	n/a	36.8	0	0

Calibration Notes

1 Bishopstown House PDM

1.1 Catchment description

Bishopstown House PDM is situated on the River Curraheen upstream of the confluence of the River Curraheen with the southern branch of the River Lee at Bishopstown House river gauge. The catchment covers an area of approximately 47km$_2$ and is significantly urbanised in comparison to the majority of the Lower Lee catchment. Geology is largely impermeable consisting sandstone and siltstone.

1.2 Rainfall and evaporation inputs

The Curraheen catchment to Bishopstown House receives an annual average precipitation of 1100mm. There are no rain gauges situated within the catchment; the nearest is Inniscarra to the north of the catchment.

Rainfall inputs to the PDM are taken from Inniscarra and Bweeng Pump House. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Bweeng Pump House has been included for this purpose and as such has no weight assigned to it initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 2.5.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 60mm and a Cmin of 0mm with the exponent of the soil store capacity, b (2) favouring shallower soils.

Both linear stores have surface routing constants (K_1) of 3 hours. Drainage parameters are Kg = 500 and Bg = 1.7. This combination means drainage to the baseflow store is very quick and is slightly sensitive to soil moisture state.

The baseflow routing time constant (Kb) is 36.8hmm$_2$. The depth of water retained by soil under tension (St) was set at 0mm.

Model Evaluation Sheet : CarrigInput (Q.simulated)

Data summary

200 peaks analysed at CarrigInput (Q.simulated) (CarrigInputs - ModelVsObs.csv) from a continuous states run between 01 Jul 2004 and 01 Nov 2014 from :

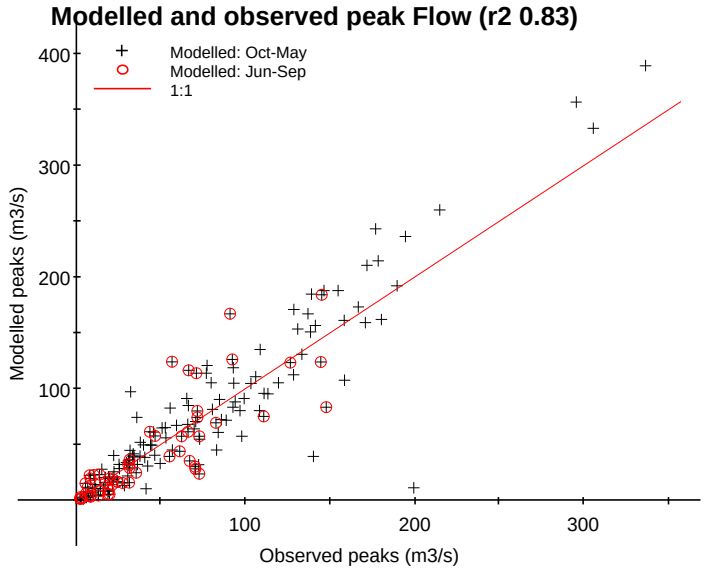
`N:\2013\Projects\2013s7330 - JBA Consulting - Lower Lee Scheme\Calculations\08 Config\CarrigInputs - ModelVsObs.csv`

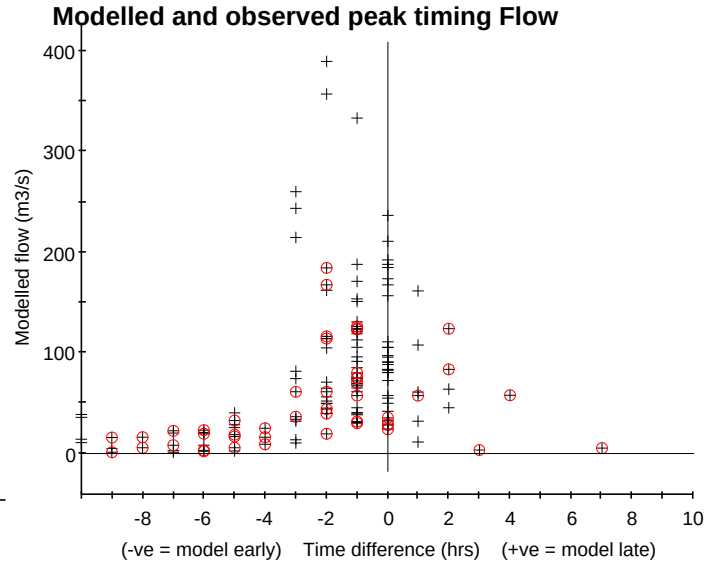
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	25/10/2013 06:00	335.9	25/10/2013 04:00	389.0	16%	-2.0	0.833	40.963	0.939
2	19/11/2012 09:00	305.3	19/11/2012 08:00	332.8	9%	-1.0	0.880	29.432	0.959
3	30/12/2013 08:00	295.1	30/12/2013 06:00	356.5	21%	-2.0	0.585	50.205	0.939
4	14/12/2013 20:00	214.7	14/12/2013 17:00	259.8	21%	-3.0	0.616	35.375	0.890
5	14/02/2014 17:00	199.2	14/02/2014 18:00	11.3	-94%	1.0	-5.188	116.356	0.382
6	03/02/2014 09:00	194.2	03/02/2014 09:00	236.1	22%	0.0	0.706	24.417	0.960
7	19/12/2012 08:00	189.5	19/12/2012 08:00	192.0	1%	0.0	0.950	12.829	0.977
8	23/02/2014 11:00	180.2	23/02/2014 09:00	161.8	-10%	-2.0	0.681	23.478	0.964
9	18/12/2013 22:00	178.3	18/12/2013 19:00	214.3	20%	-3.0	0.704	21.748	0.948
10	12/01/2014 19:00	176.8	12/01/2014 16:00	243.1	37%	-3.0	0.615	29.934	0.965

Model scores

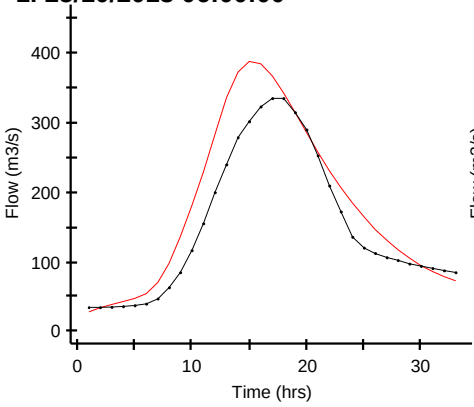
	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score
Modelled	1.78	0.49	0.43	1.02	0.07	0.25	0.91	0.95



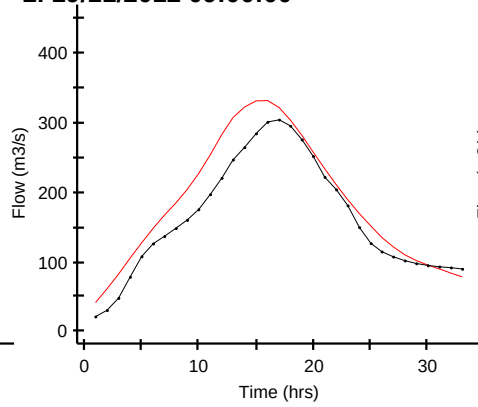


Model Evaluation Sheet : CarrigInput (Q.simulated)

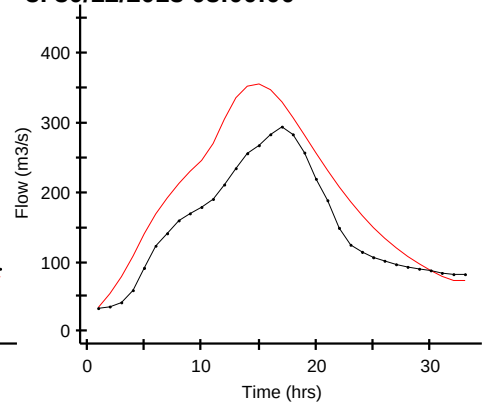
1. 25/10/2013 06:00:00



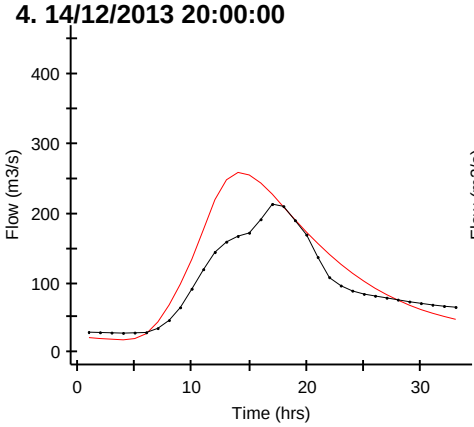
2. 19/11/2012 09:00:00



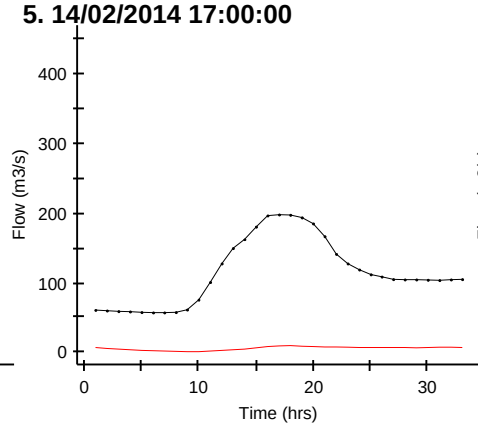
3. 30/12/2013 08:00:00



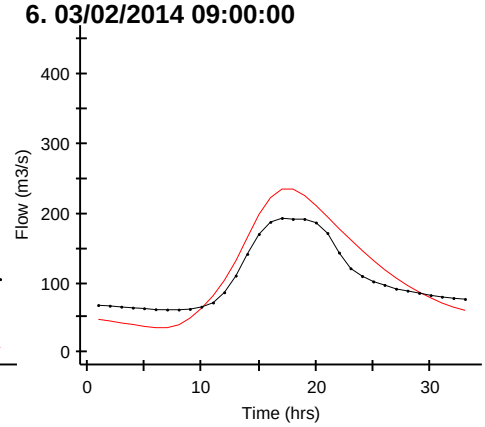
4. 14/12/2013 20:00:00



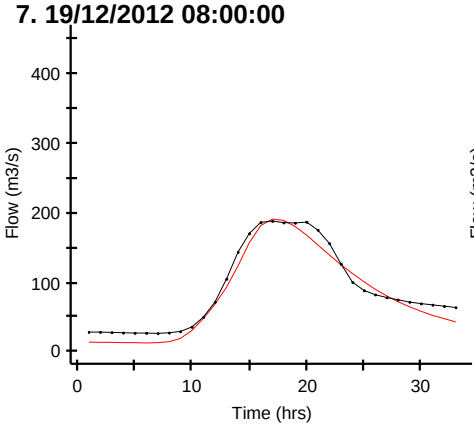
5. 14/02/2014 17:00:00



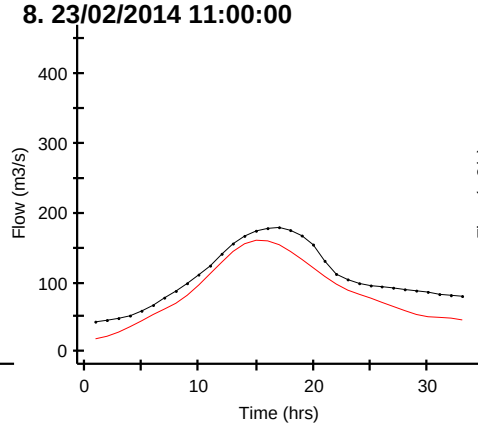
6. 03/02/2014 09:00:00



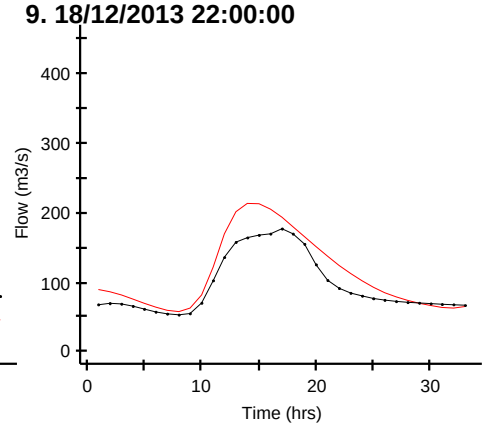
7. 19/12/2012 08:00:00



8. 23/02/2014 11:00:00



9. 18/12/2013 22:00:00

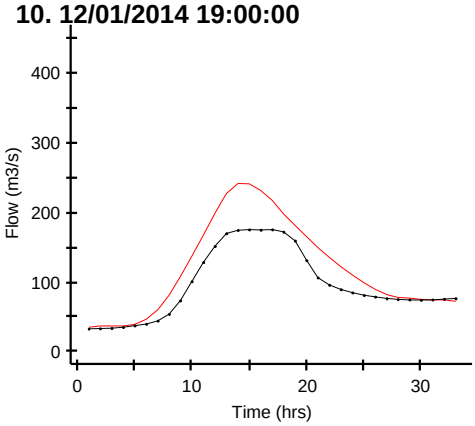


Key

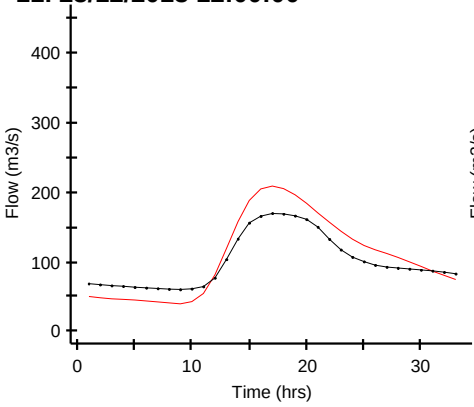
Modelled

Observed

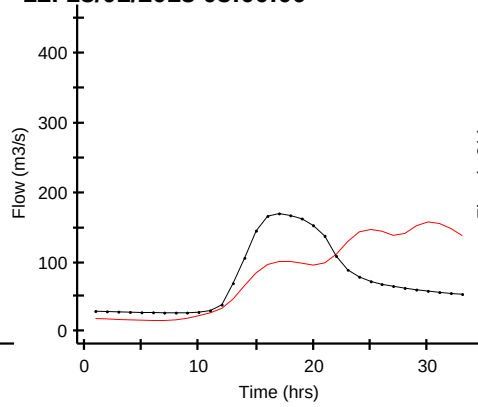
10. 12/01/2014 19:00:00



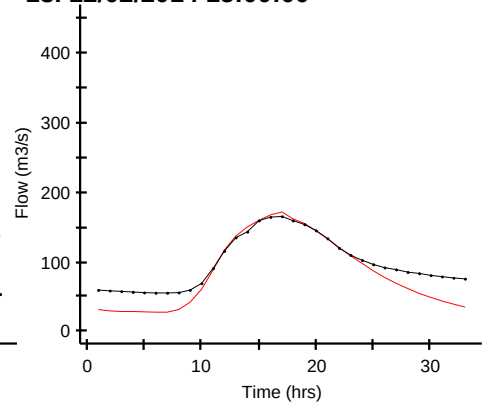
11. 23/12/2013 12:00:00



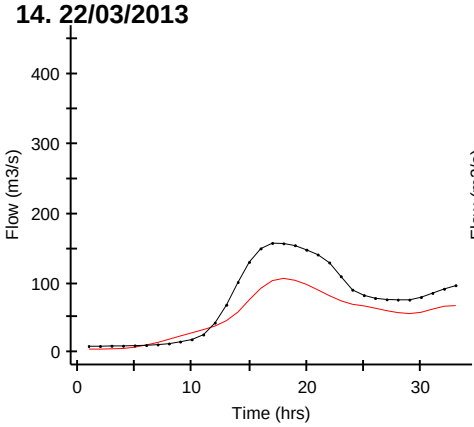
12. 18/01/2013 03:00:00



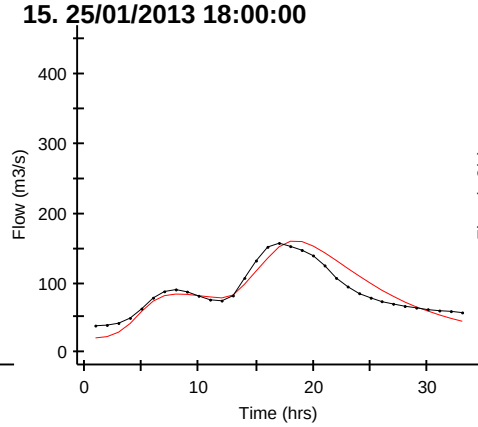
13. 12/02/2014 15:00:00



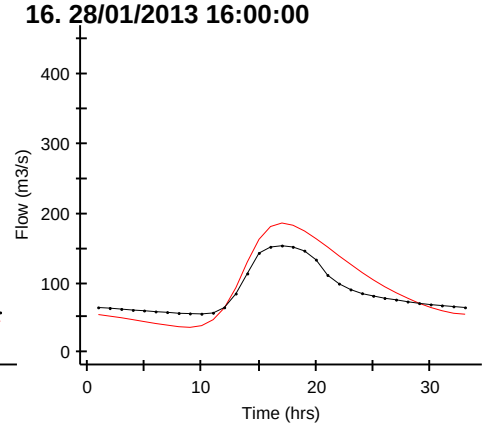
14. 22/03/2013



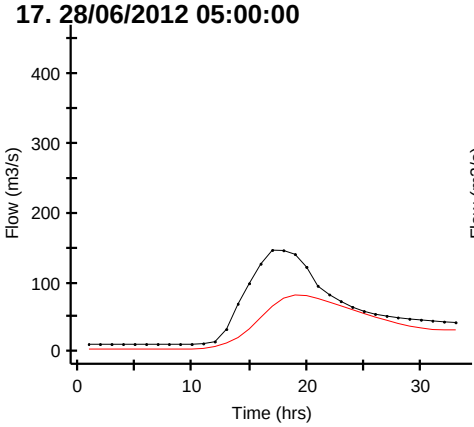
15. 25/01/2013 18:00:00



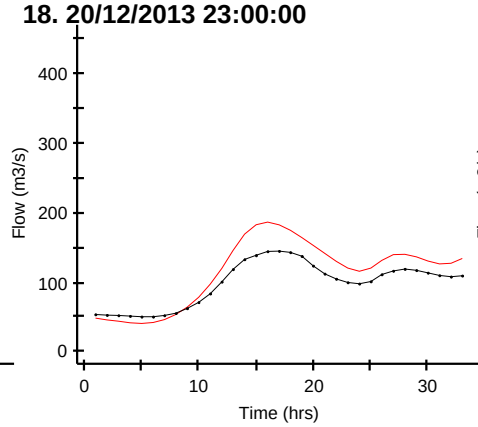
16. 28/01/2013 16:00:00



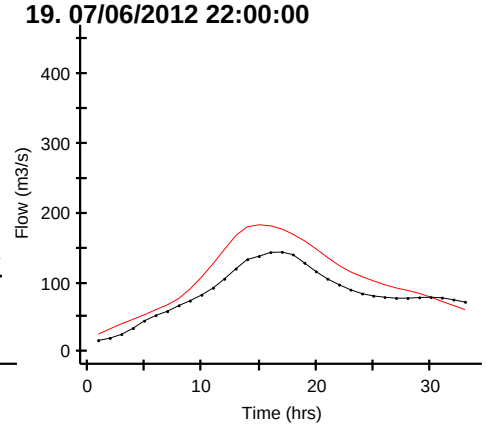
17. 28/06/2012 05:00:00



18. 20/12/2013 23:00:00



19. 07/06/2012 22:00:00



Key

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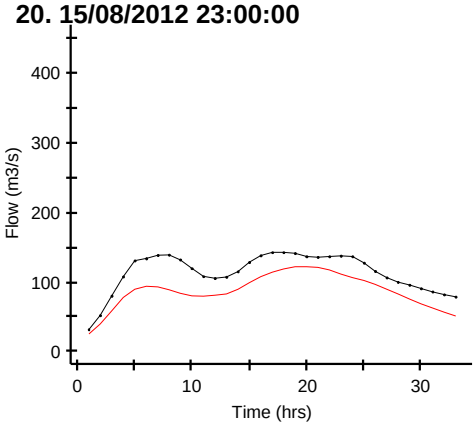
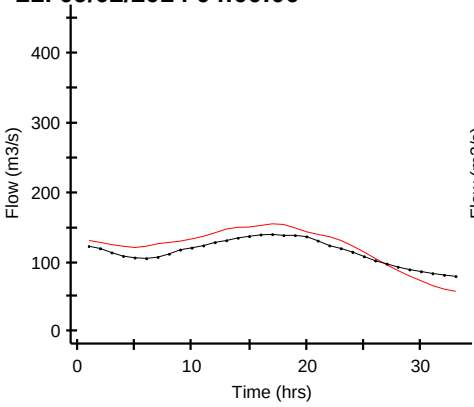
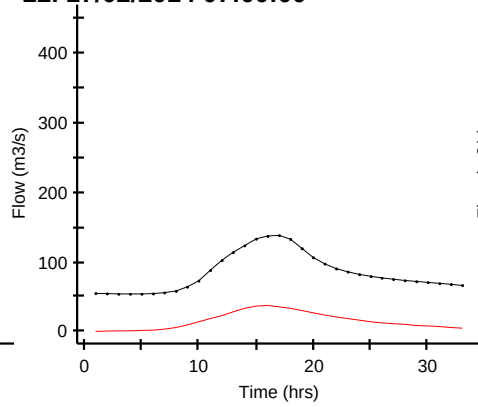
20. 15/08/2012 23:00:00



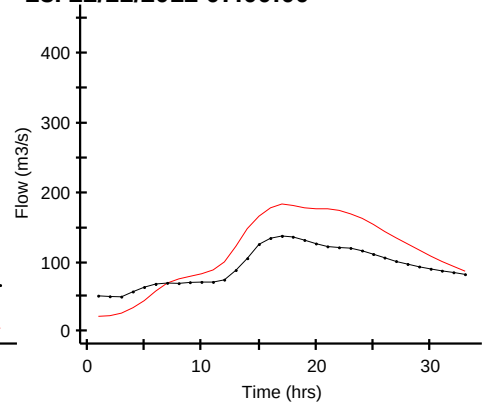
21. 09/02/2014 04:00:00



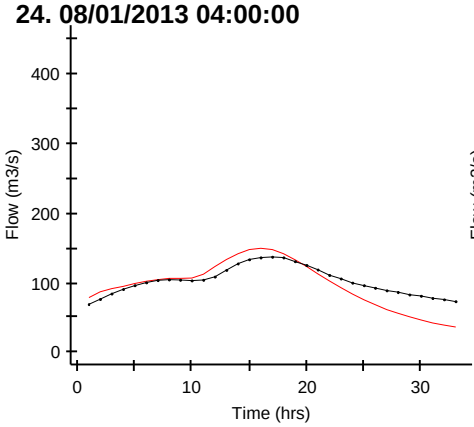
22. 17/02/2014 07:00:00



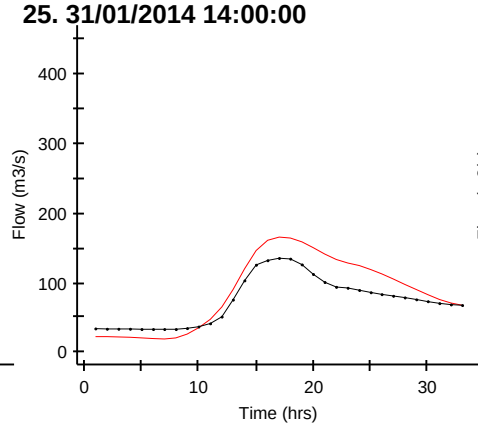
23. 22/11/2012 07:00:00



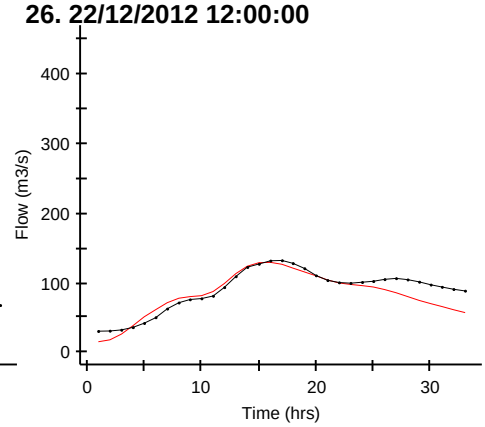
24. 08/01/2013 04:00:00



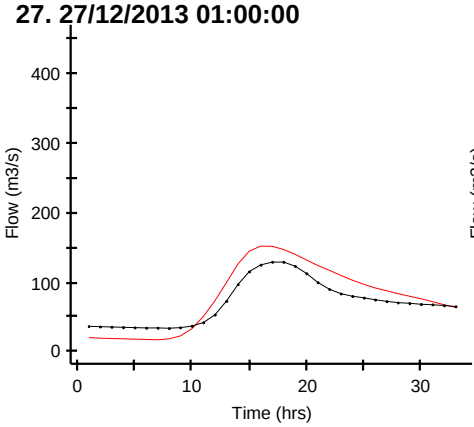
25. 31/01/2014 14:00:00



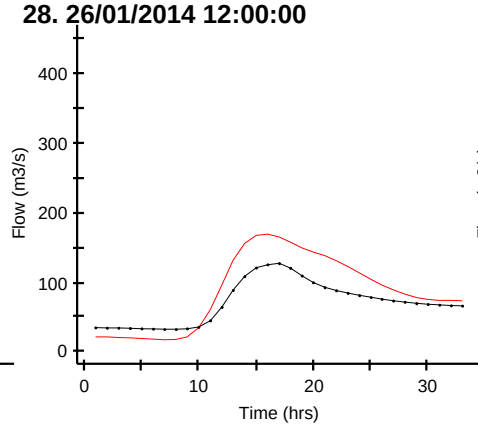
26. 22/12/2012 12:00:00



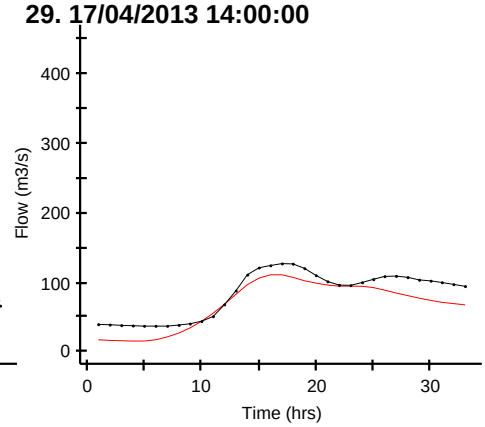
27. 27/12/2013 01:00:00



28. 26/01/2014 12:00:00



29. 17/04/2013 14:00:00



Key

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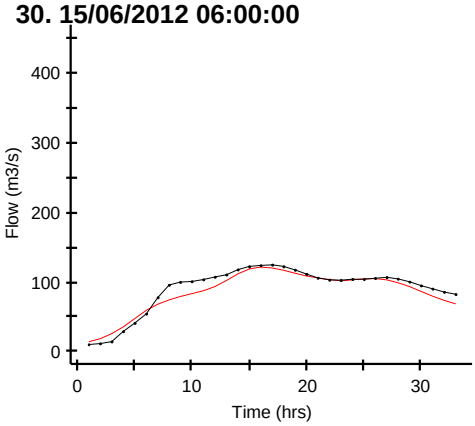
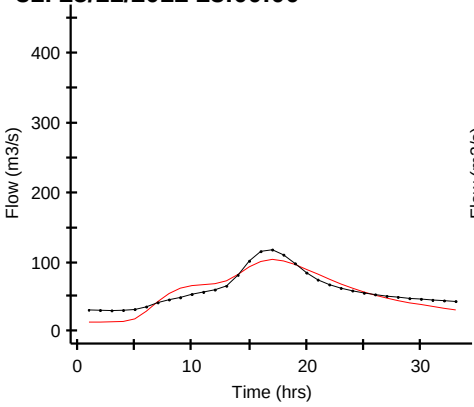
Observed

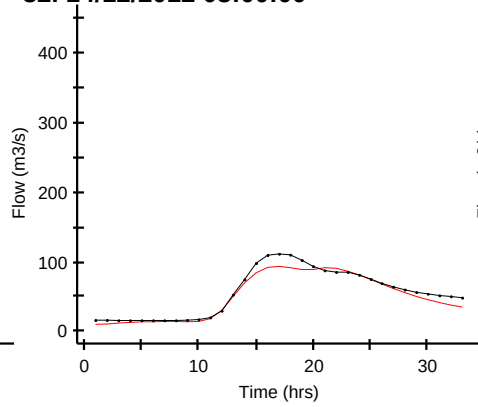
30. 15/06/2012 06:00:00



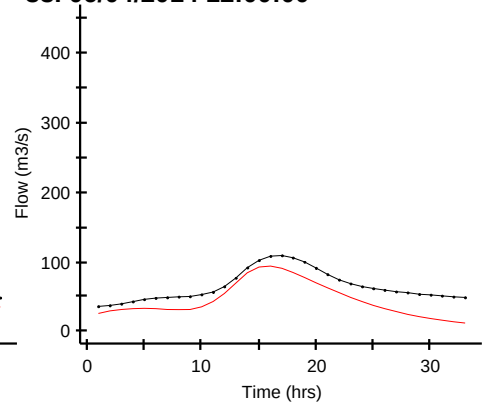
31. 25/11/2012 23:00:00



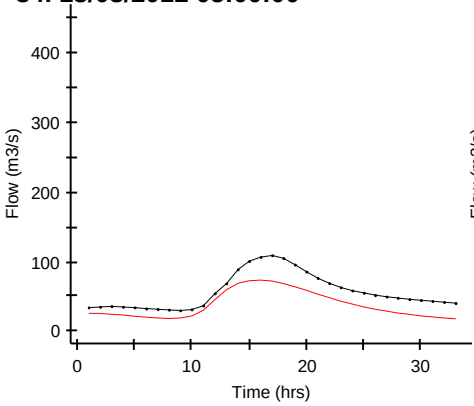
32. 14/12/2012 08:00:00



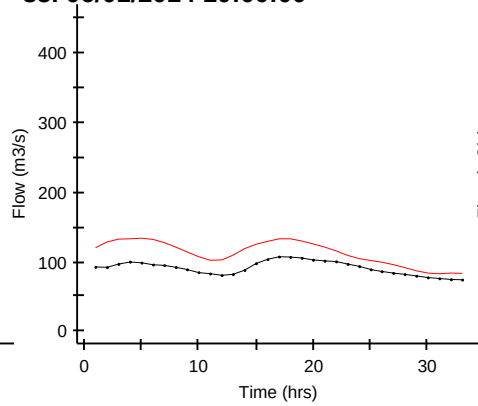
33. 06/04/2014 12:00:00



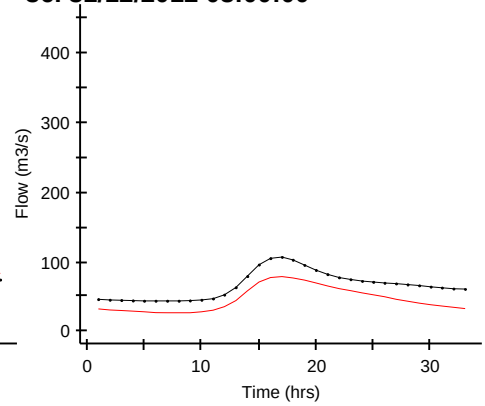
34. 13/08/2012 05:00:00



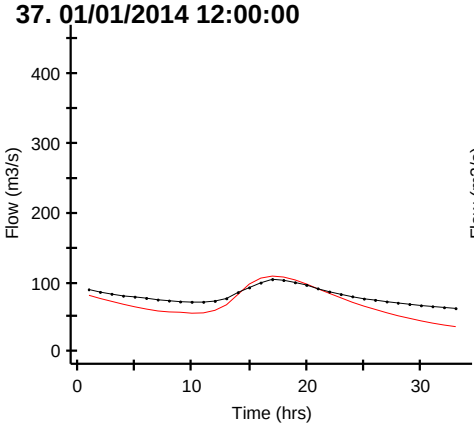
35. 06/01/2014 10:00:00



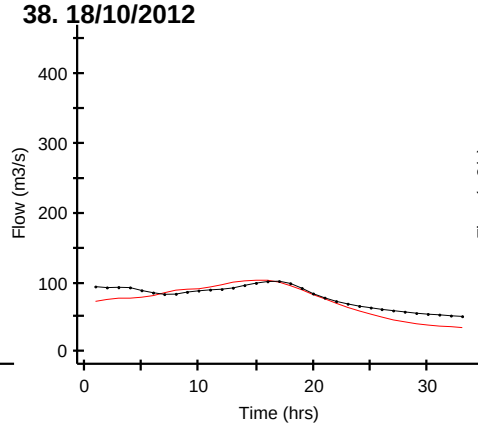
36. 31/12/2012 08:00:00



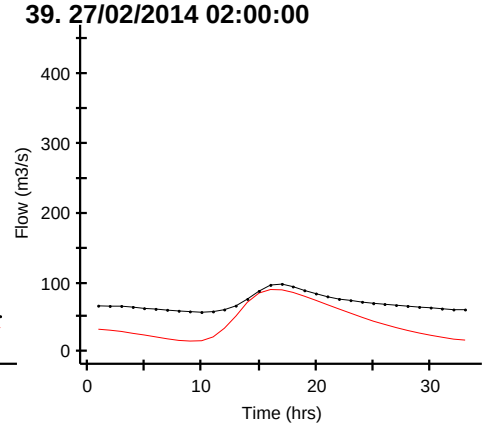
37. 01/01/2014 12:00:00



38. 18/10/2012



39. 27/02/2014 02:00:00



Key

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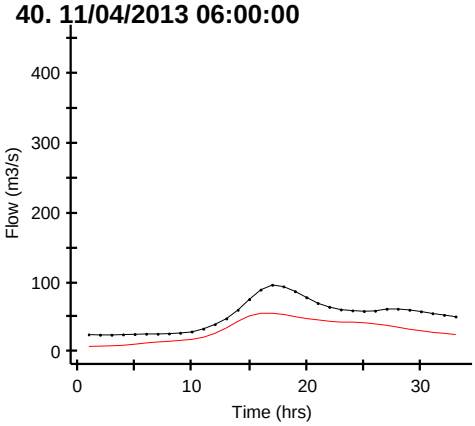
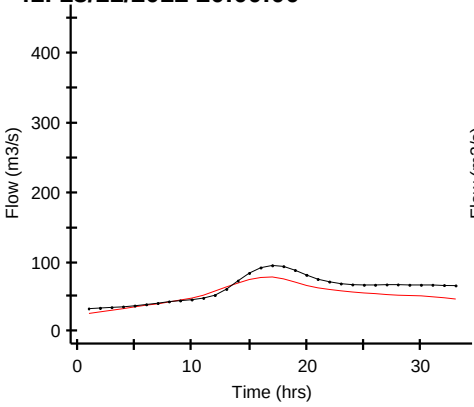
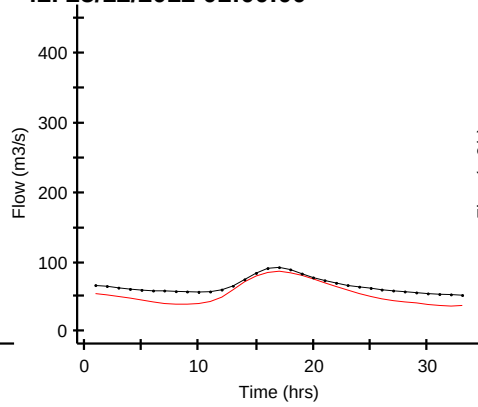
40. 11/04/2013 06:00:00



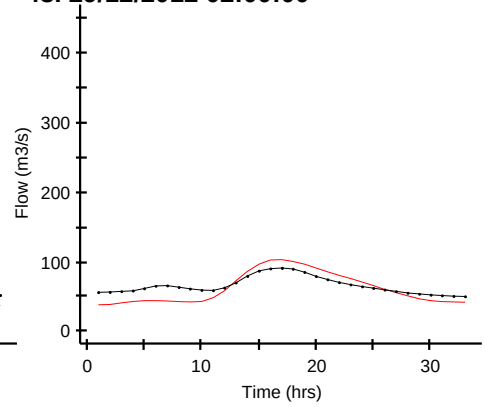
41. 13/11/2012 20:00:00



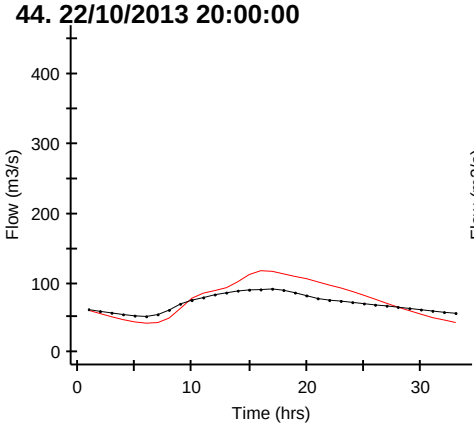
42. 25/12/2012 01:00:00



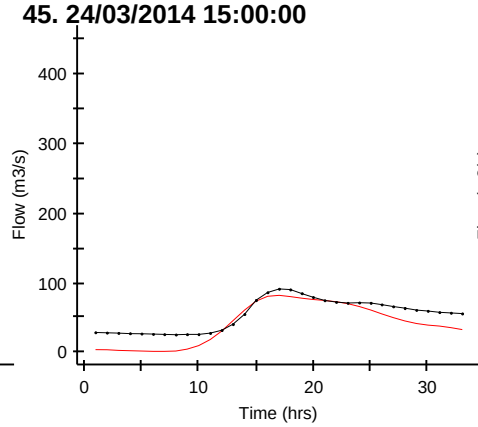
43. 29/12/2012 02:00:00



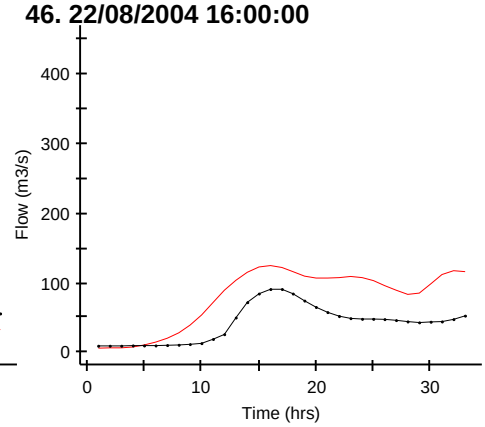
44. 22/10/2013 20:00:00



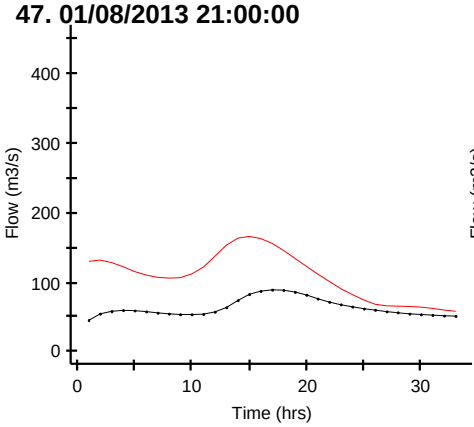
45. 24/03/2014 15:00:00



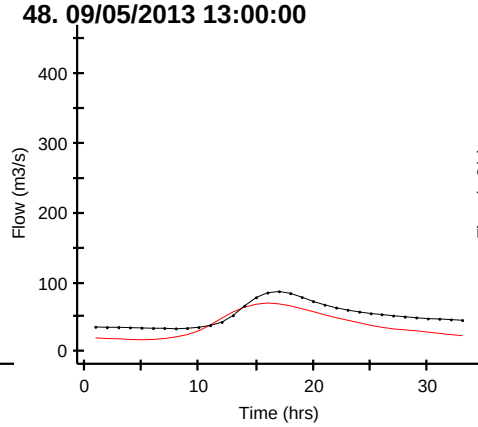
46. 22/08/2004 16:00:00



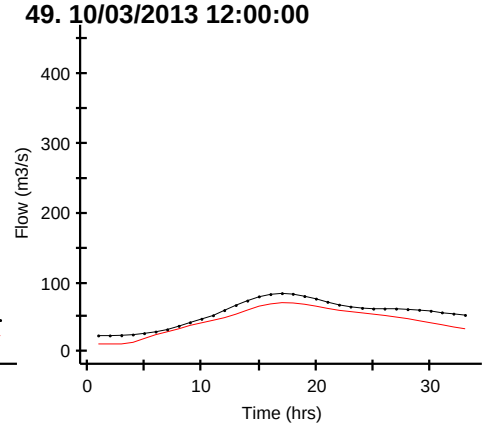
47. 01/08/2013 21:00:00



48. 09/05/2013 13:00:00



49. 10/03/2013 12:00:00



Key

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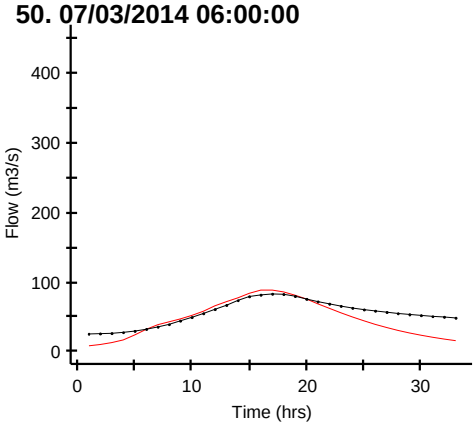
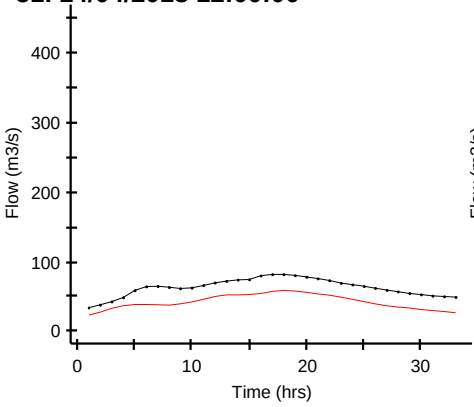
Observed

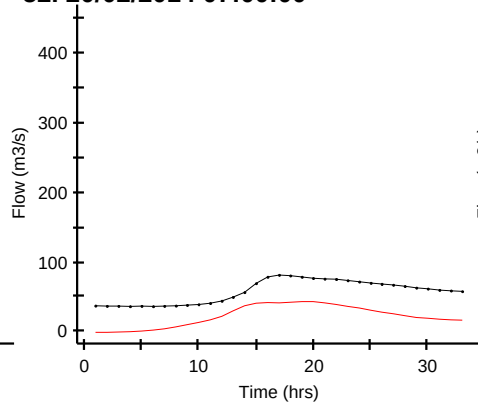
50. 07/03/2014 06:00:00



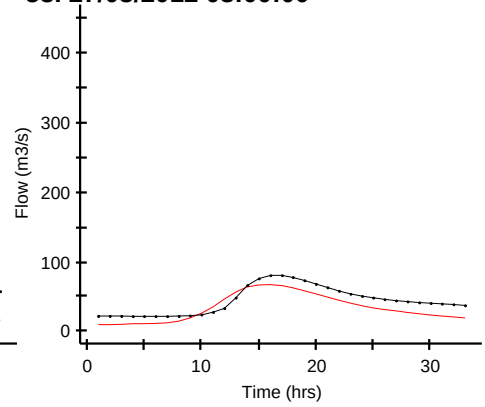
51. 14/04/2013 12:00:00



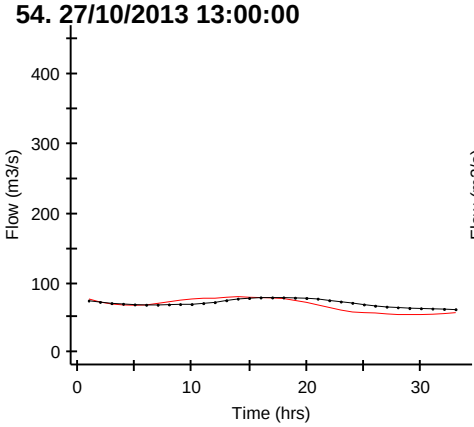
52. 20/02/2014 07:00:00



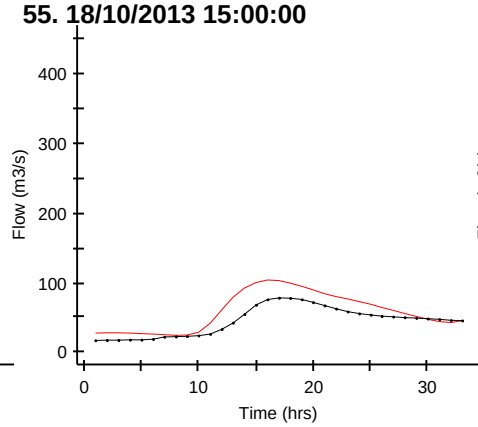
53. 27/08/2012 08:00:00



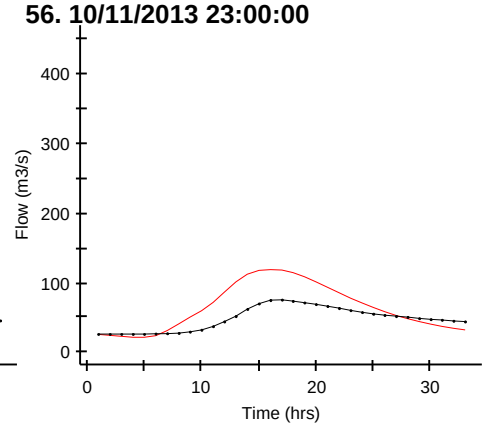
54. 27/10/2013 13:00:00



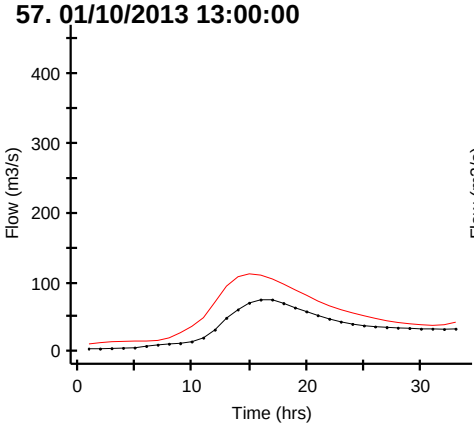
55. 18/10/2013 15:00:00



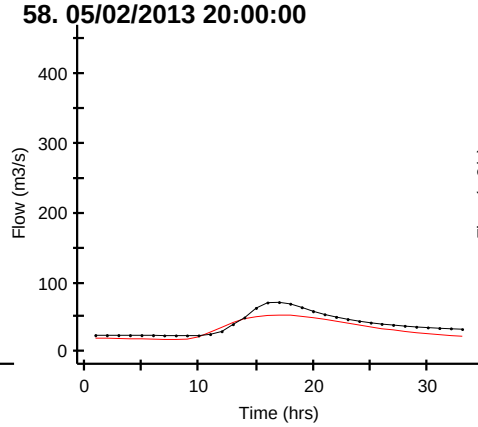
56. 10/11/2013 23:00:00



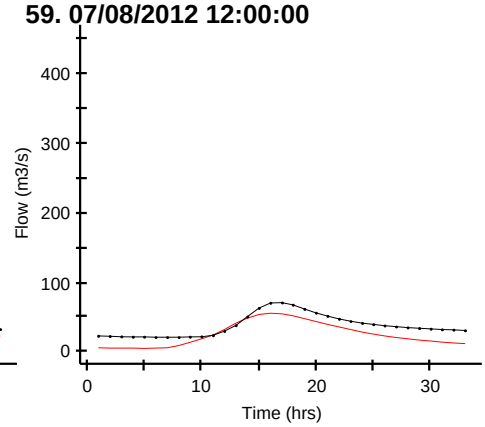
57. 01/10/2013 13:00:00



58. 05/02/2013 20:00:00



59. 07/08/2012 12:00:00



Key

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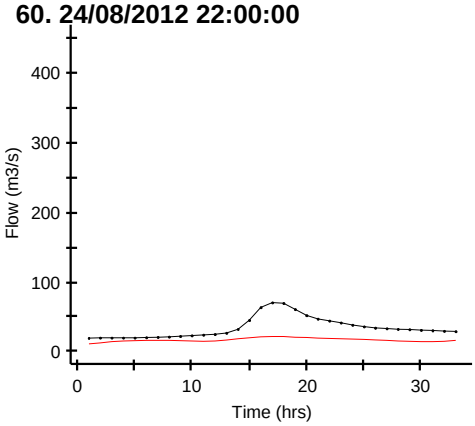
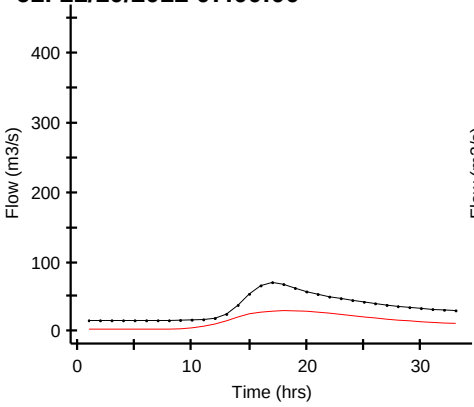
Observed

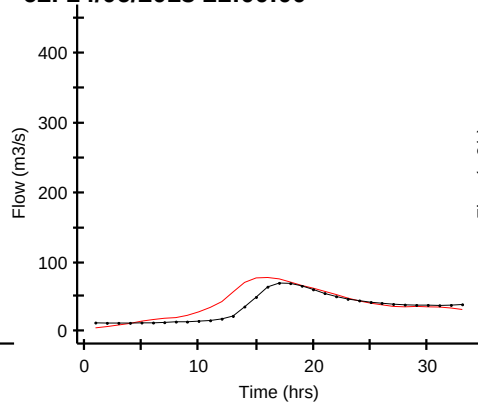
60. 24/08/2012 22:00:00



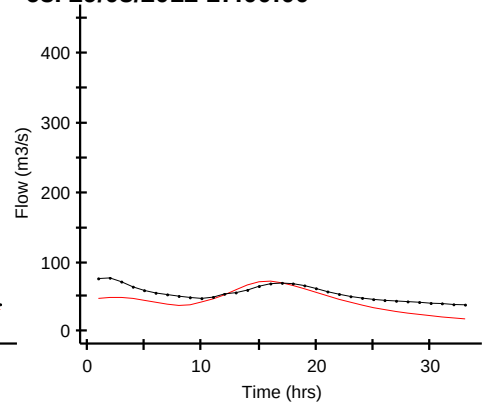
61. 11/10/2012 07:00:00



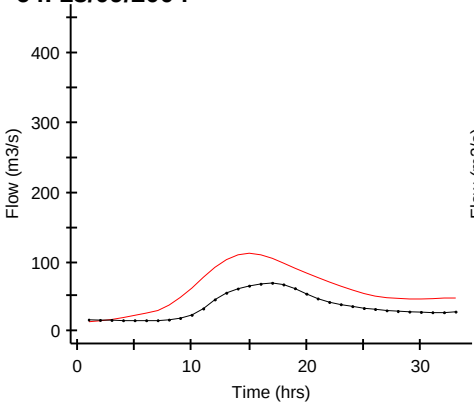
62. 14/06/2013 21:00:00



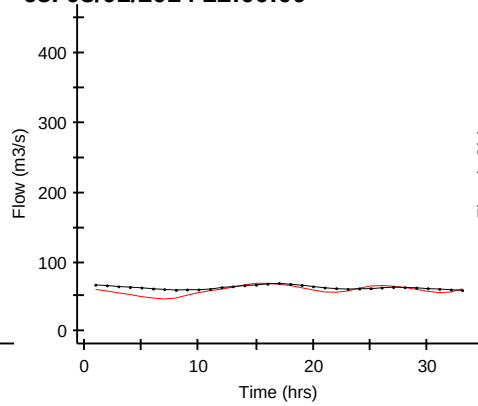
63. 29/08/2012 17:00:00



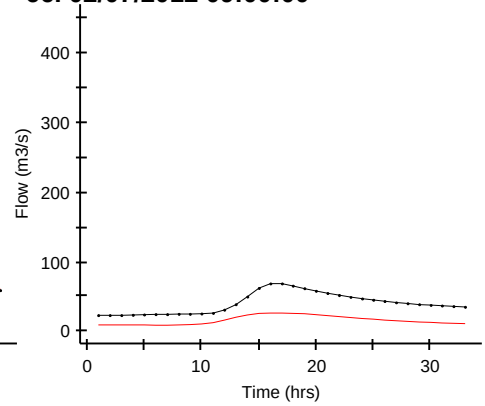
64. 13/09/2004



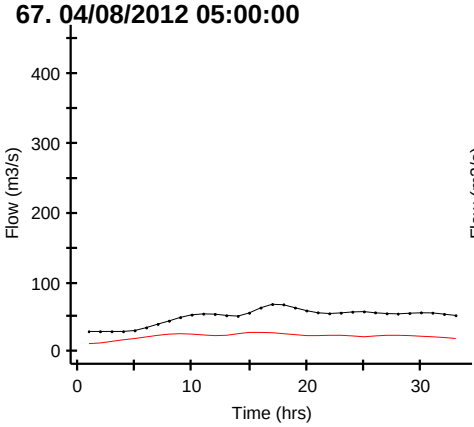
65. 03/01/2014 22:00:00



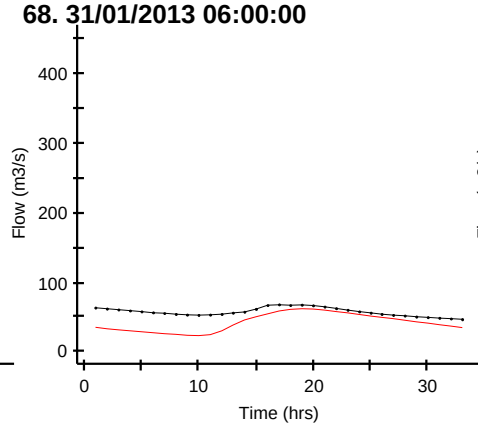
66. 02/07/2012 09:00:00



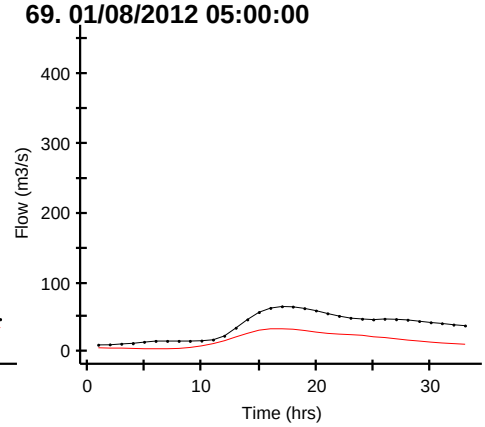
67. 04/08/2012 05:00:00



68. 31/01/2013 06:00:00



69. 01/08/2012 05:00:00

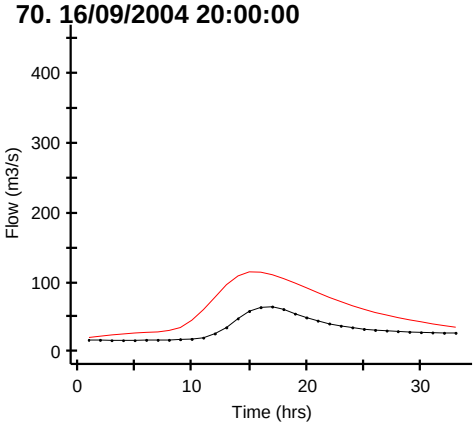


Key

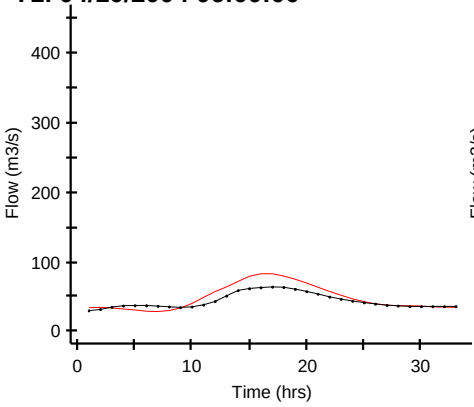
Modelled

Observed

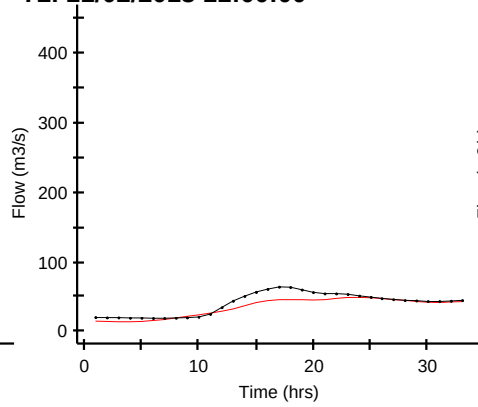
70. 16/09/2004 20:00:00



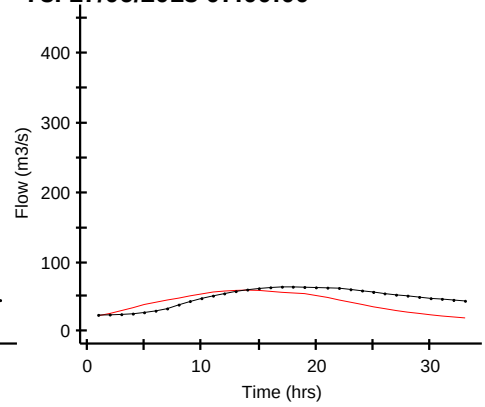
71. 04/10/2004 06:00:00



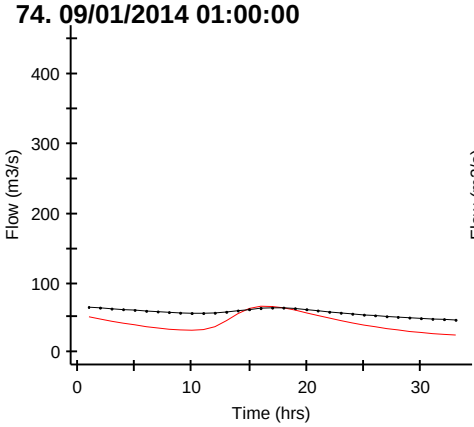
72. 11/02/2013 11:00:00



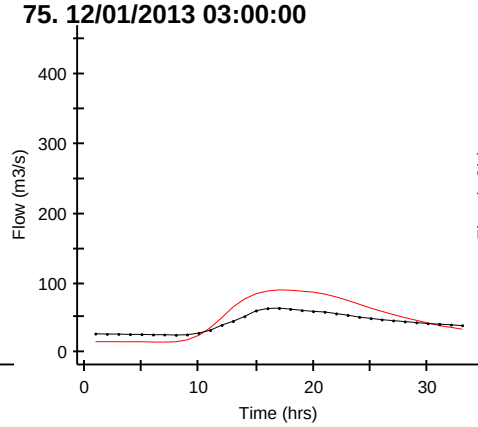
73. 17/06/2013 07:00:00



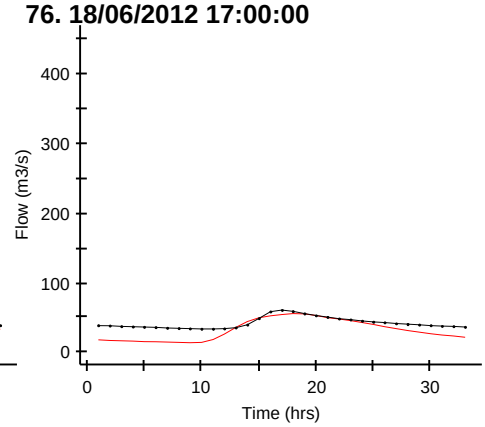
74. 09/01/2014 01:00:00



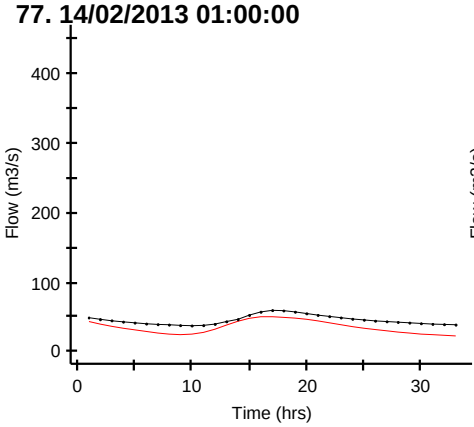
75. 12/01/2013 03:00:00



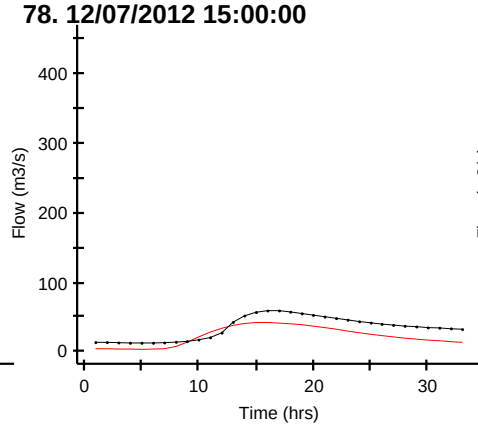
76. 18/06/2012 17:00:00



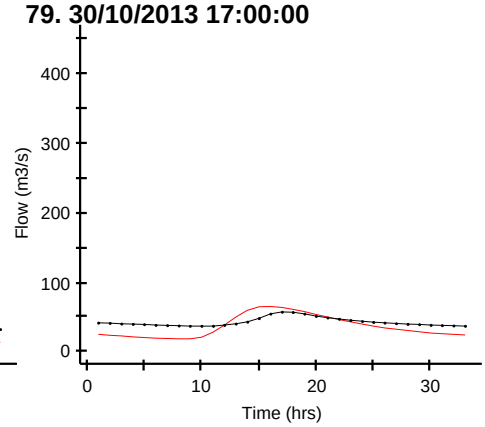
77. 14/02/2013 01:00:00



78. 12/07/2012 15:00:00



79. 30/10/2013 17:00:00



Key

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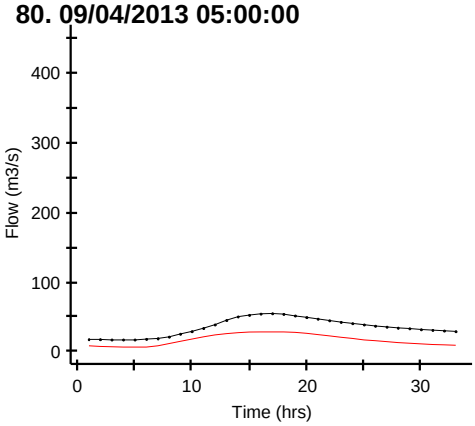
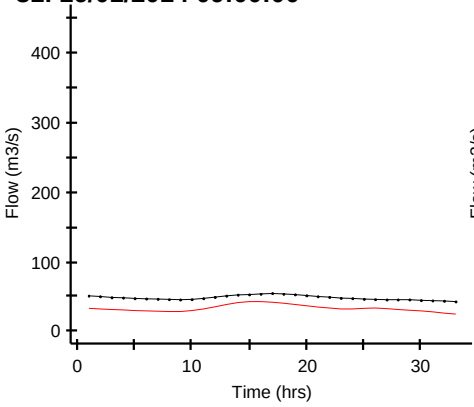
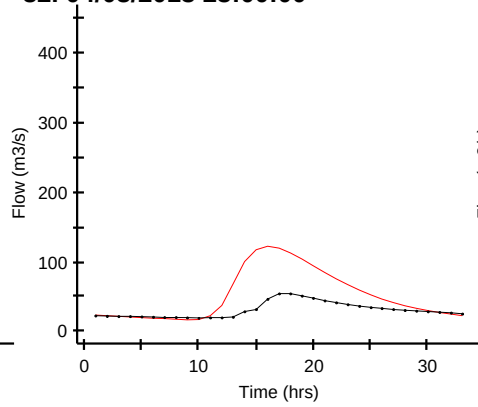
80. 09/04/2013 05:00:00



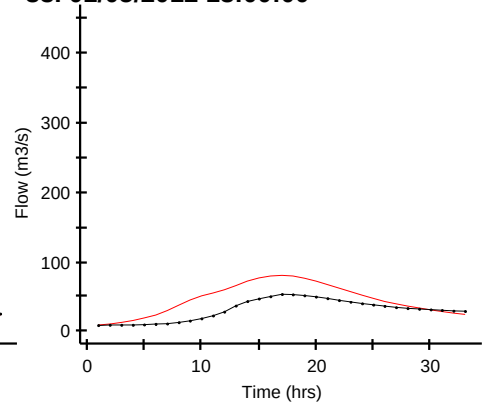
81. 16/01/2014 09:00:00



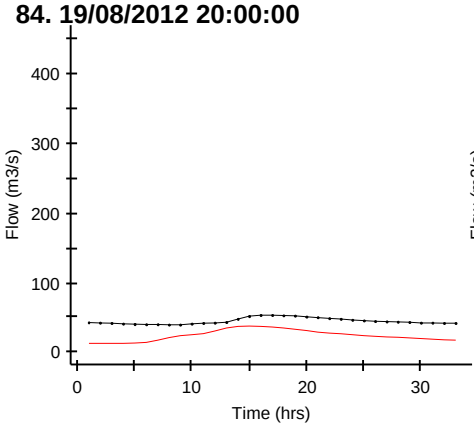
82. 04/08/2013 23:00:00



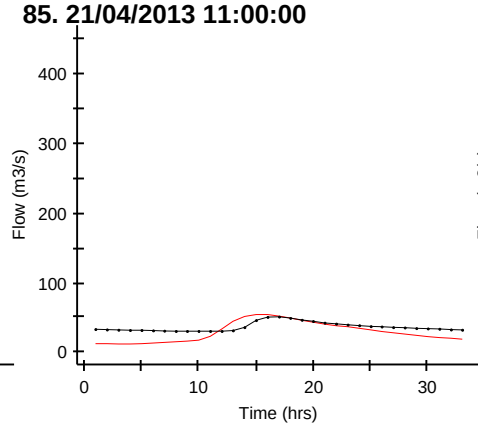
83. 01/05/2012 18:00:00



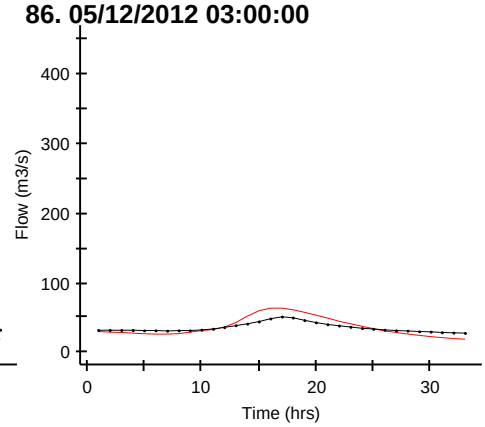
84. 19/08/2012 20:00:00



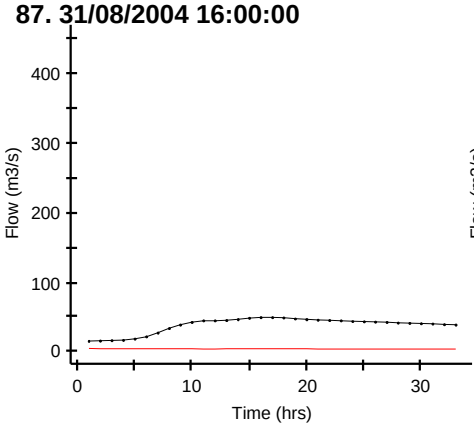
85. 21/04/2013 11:00:00



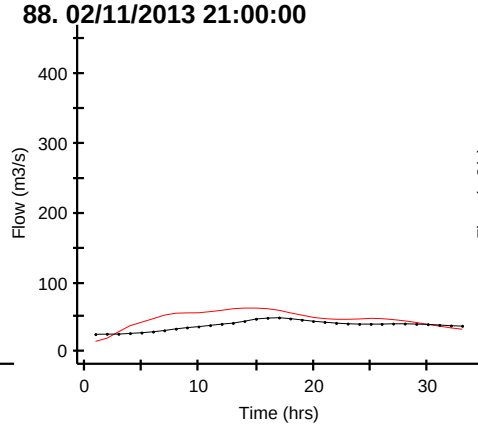
86. 05/12/2012 03:00:00



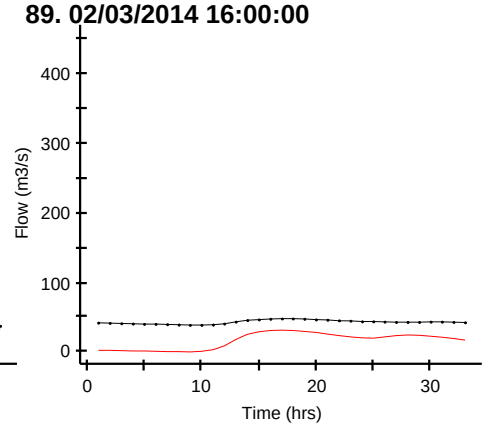
87. 31/08/2004 16:00:00



88. 02/11/2013 21:00:00



89. 02/03/2014 16:00:00

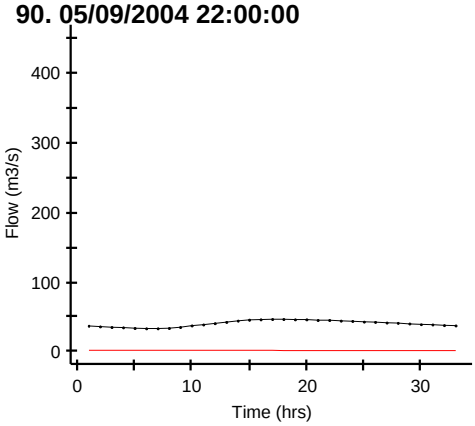


Key

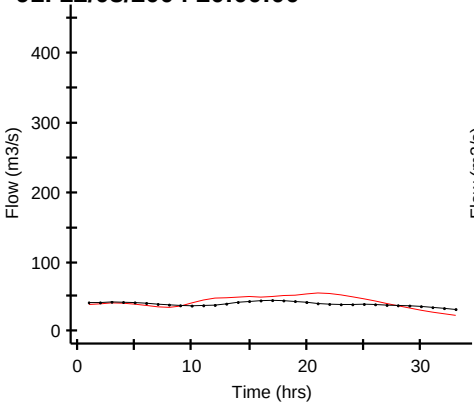
Modelled

Observed

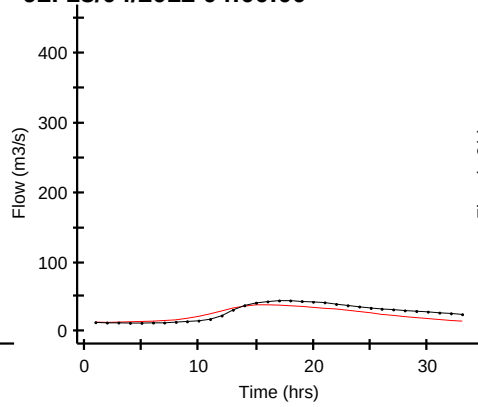
90. 05/09/2004 22:00:00



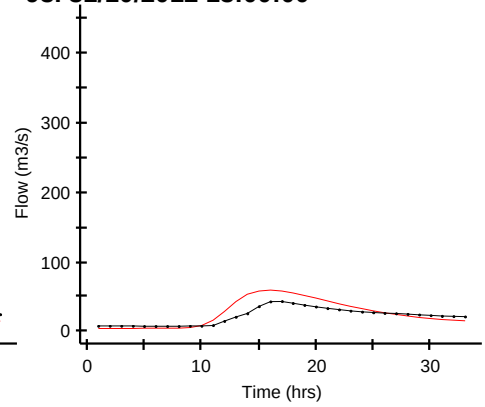
91. 12/08/2004 20:00:00



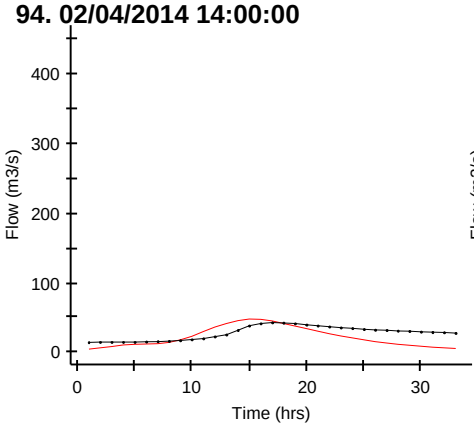
92. 18/04/2012 04:00:00



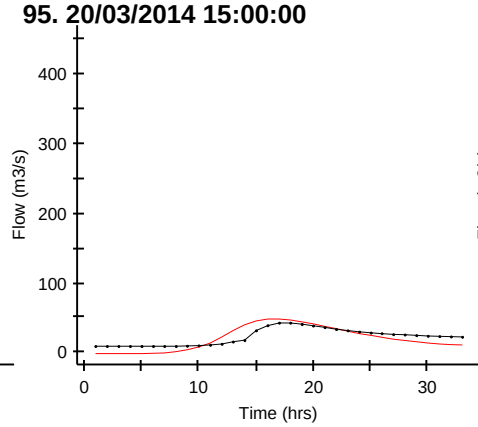
93. 31/10/2012 13:00:00



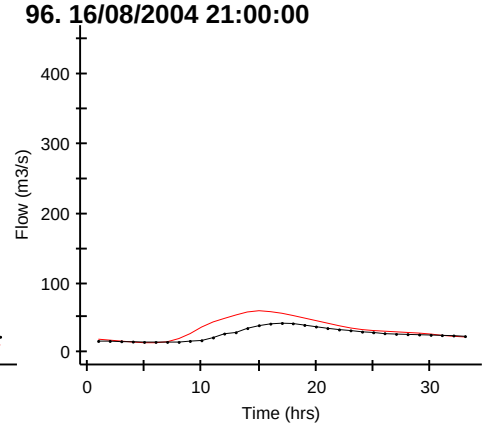
94. 02/04/2014 14:00:00



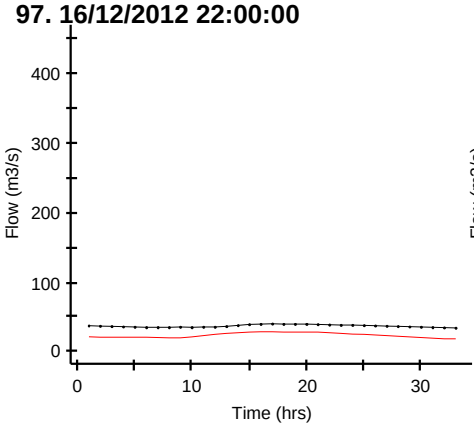
95. 20/03/2014 15:00:00



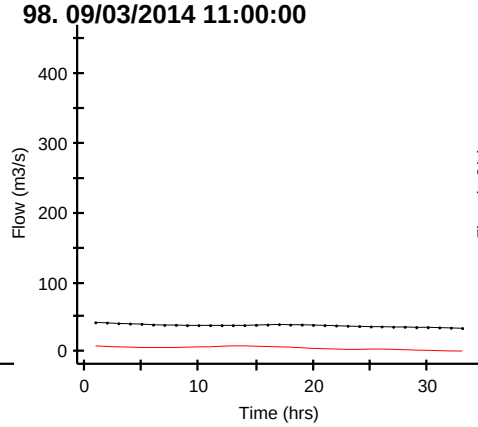
96. 16/08/2004 21:00:00



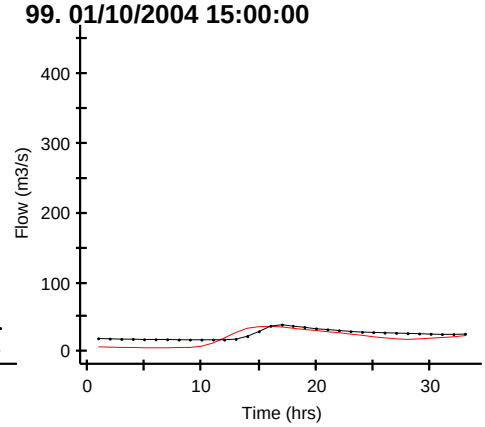
97. 16/12/2012 22:00:00



98. 09/03/2014 11:00:00



99. 01/10/2004 15:00:00



Key

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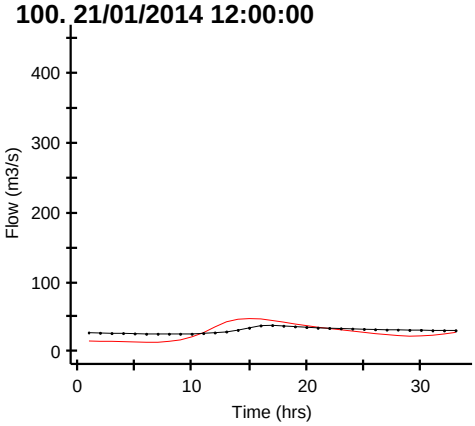
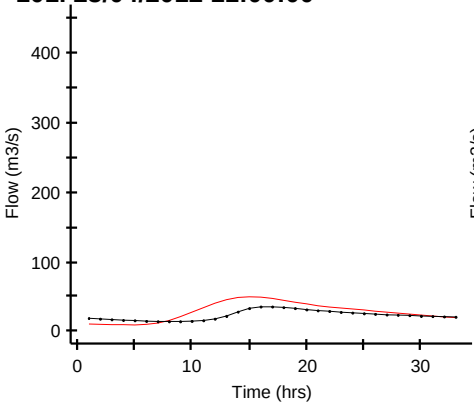
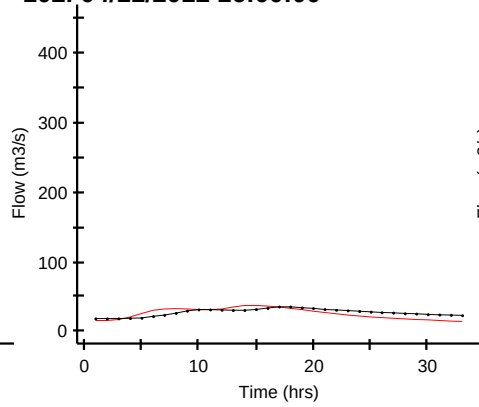
100. 21/01/2014 12:00:00



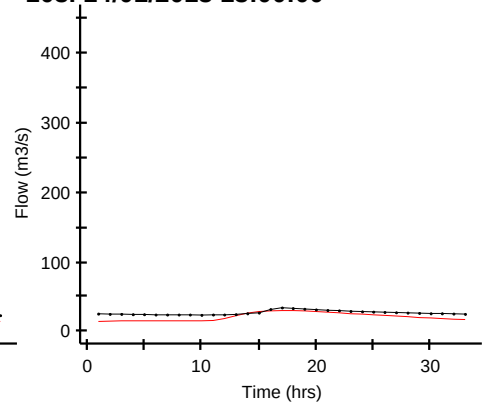
101. 23/04/2012 11:00:00



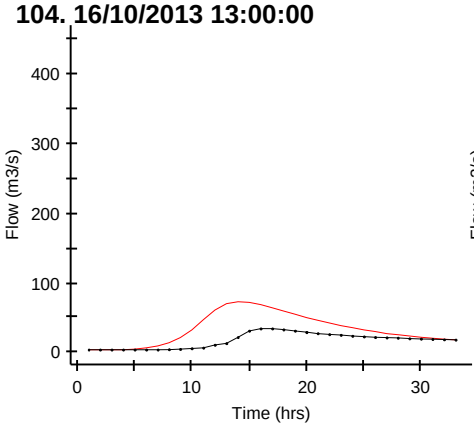
102. 04/11/2012 16:00:00



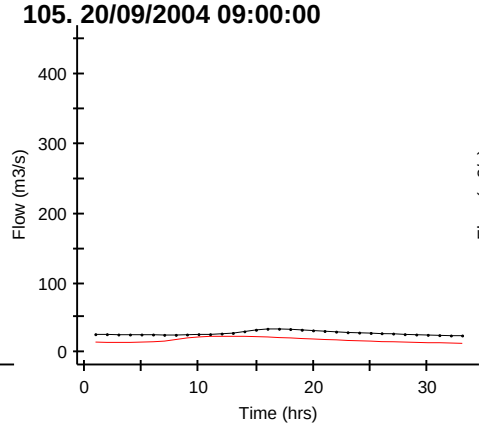
103. 14/01/2013 13:00:00



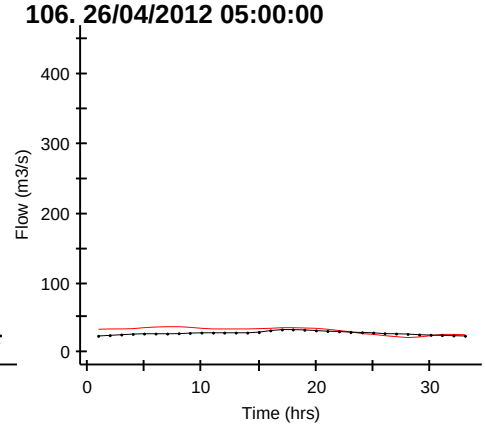
104. 16/10/2013 13:00:00



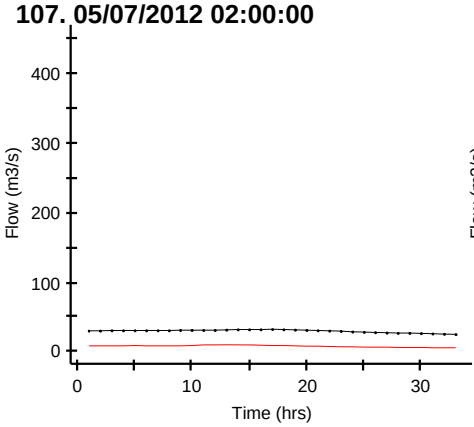
105. 20/09/2004 09:00:00



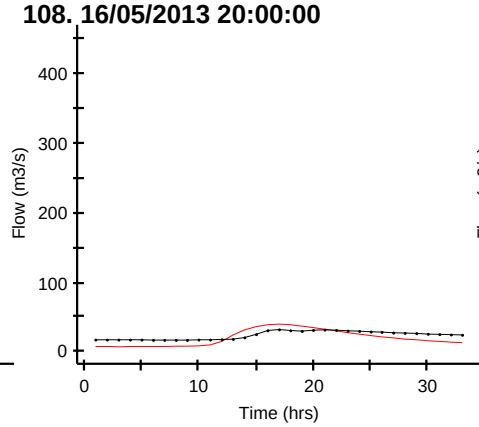
106. 26/04/2012 05:00:00



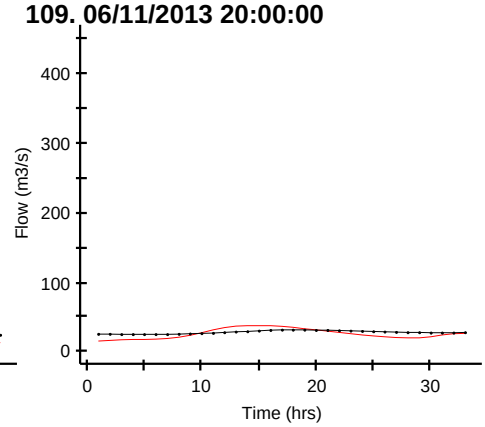
107. 05/07/2012 02:00:00



108. 16/05/2013 20:00:00



109. 06/11/2013 20:00:00



Key

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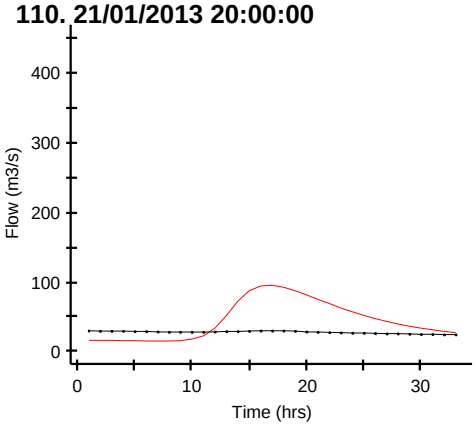
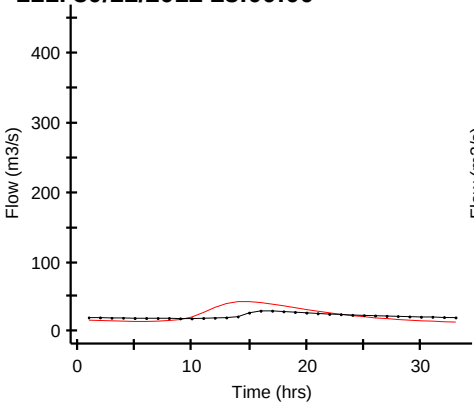
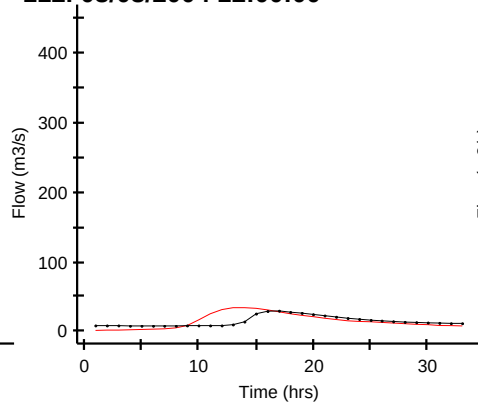
110. 21/01/2013 20:00:00



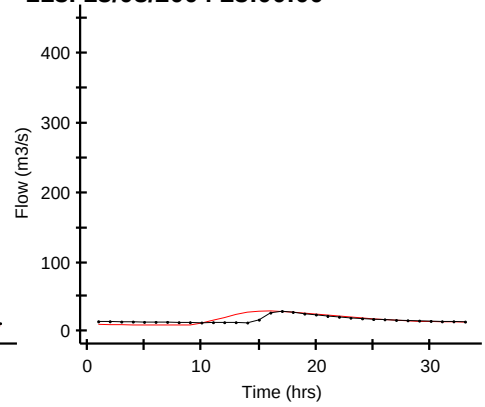
111. 30/11/2012 23:00:00



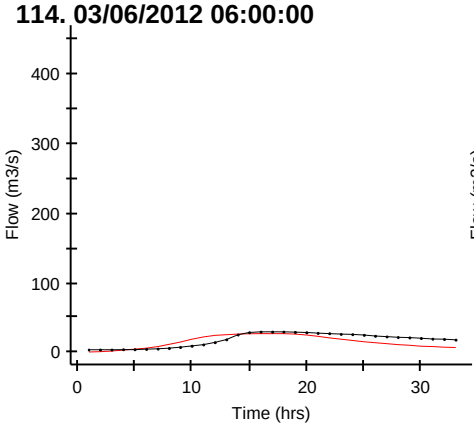
112. 08/08/2004 12:00:00



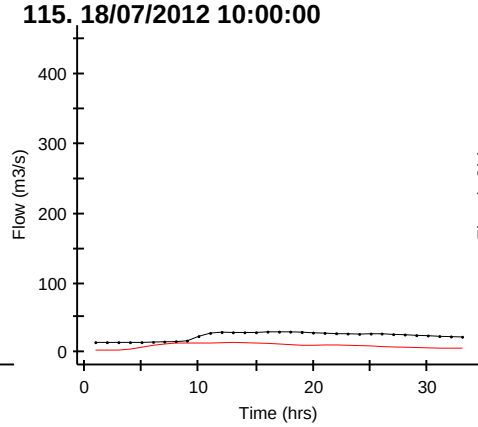
113. 18/08/2004 23:00:00



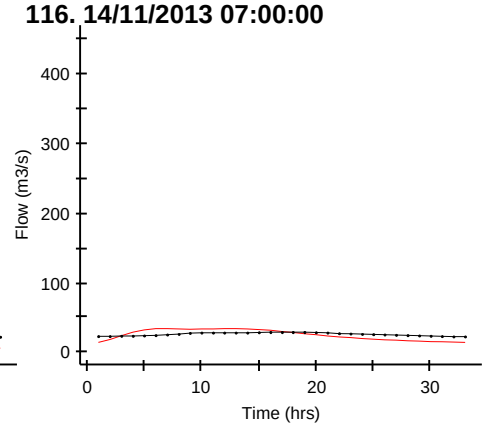
114. 03/06/2012 06:00:00



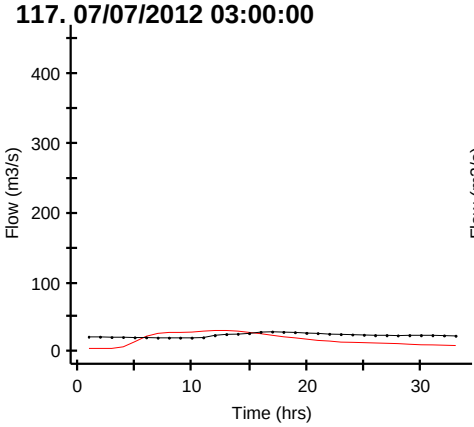
115. 18/07/2012 10:00:00



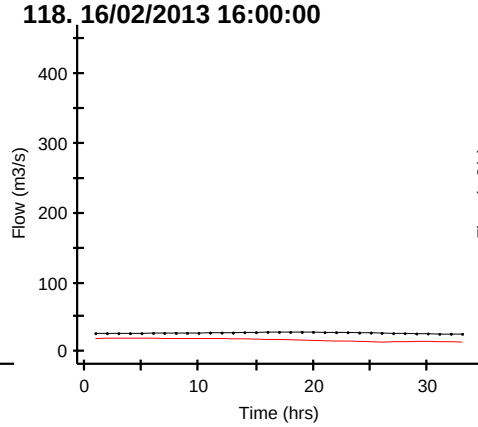
116. 14/11/2013 07:00:00



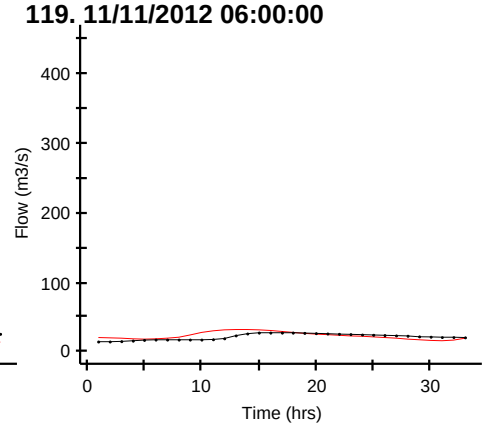
117. 07/07/2012 03:00:00



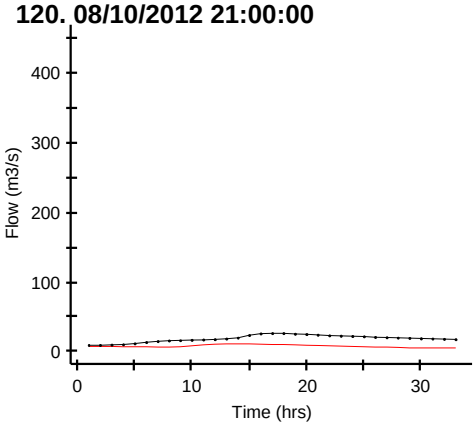
118. 16/02/2013 16:00:00

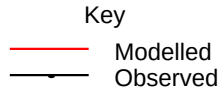


119. 11/11/2012 06:00:00

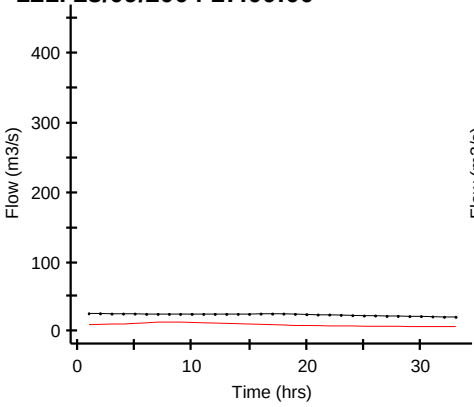


120. 08/10/2012 21:00:00

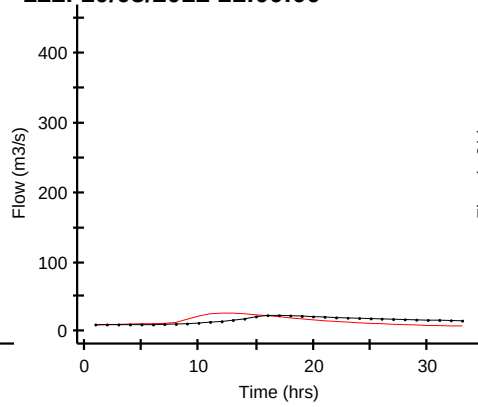




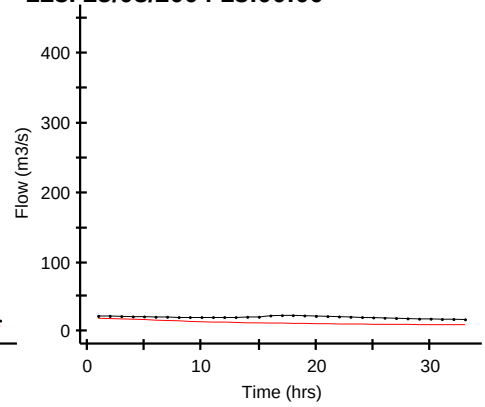
121. 23/09/2004 17:00:00



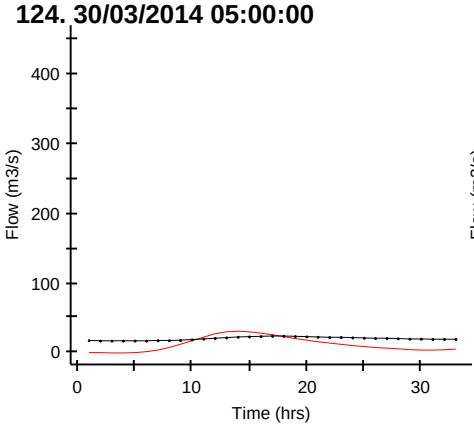
122. 10/05/2012 11:00:00



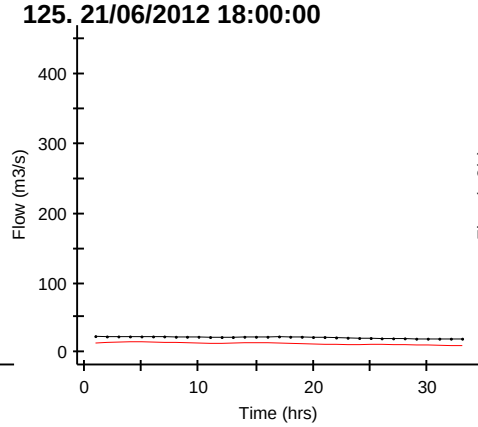
123. 25/08/2004 18:00:00



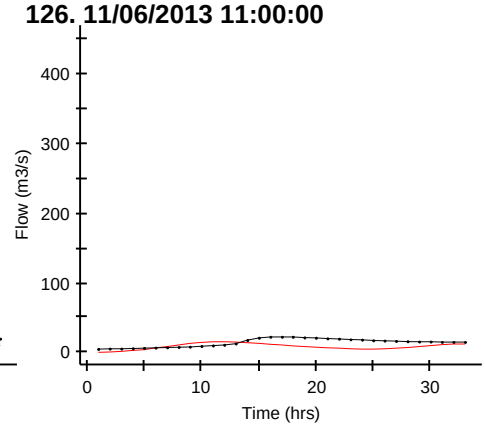
124. 30/03/2014 05:00:00



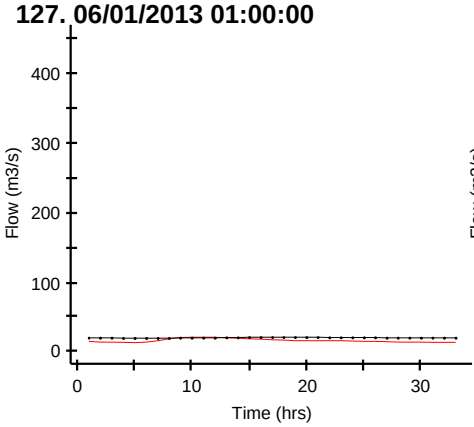
125. 21/06/2012 18:00:00



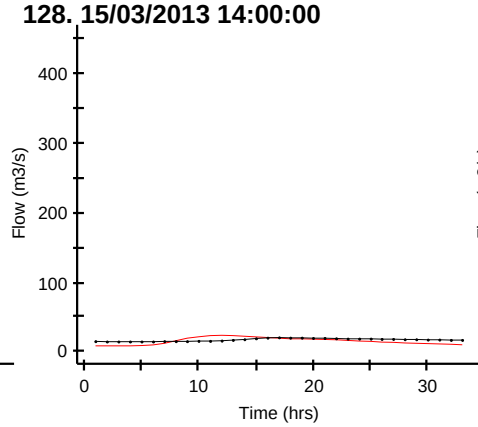
126. 11/06/2013 11:00:00



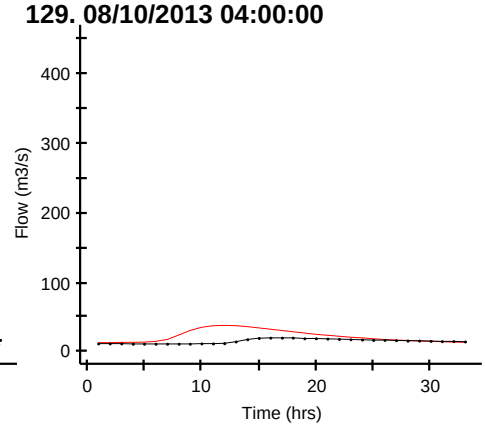
127. 06/01/2013 01:00:00



128. 15/03/2013 14:00:00



129. 08/10/2013 04:00:00

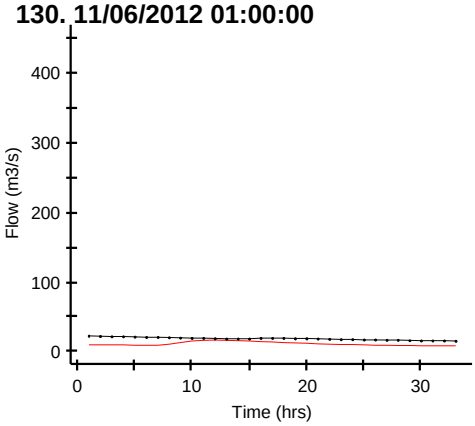


Key

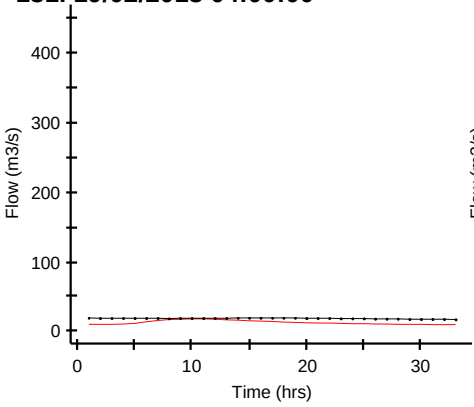
Modelled

Observed

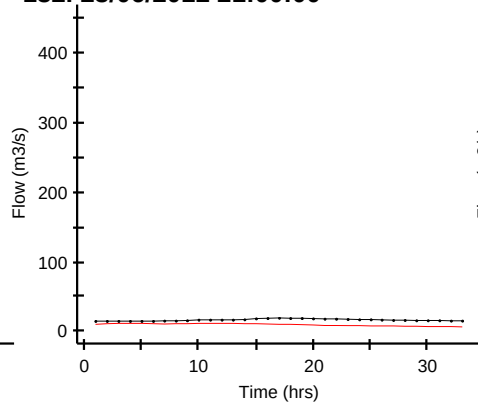
130. 11/06/2012 01:00:00



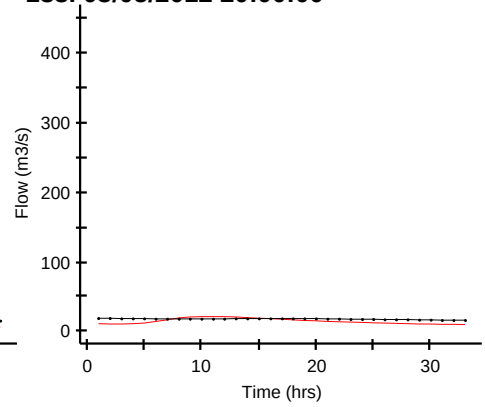
131. 19/02/2013 04:00:00



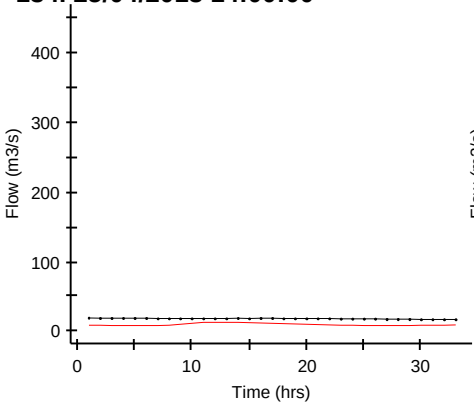
132. 23/06/2012 21:00:00



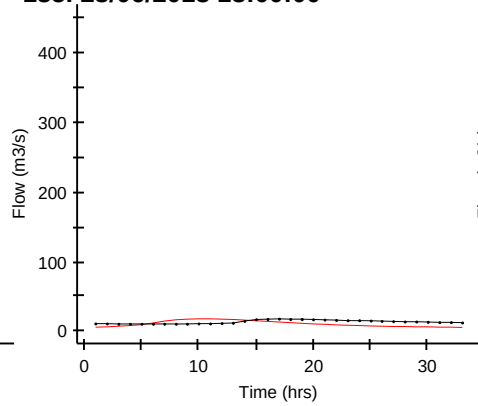
133. 03/05/2012 20:00:00



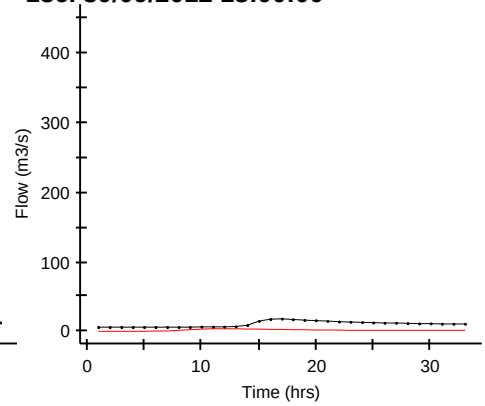
134. 25/04/2013 14:00:00



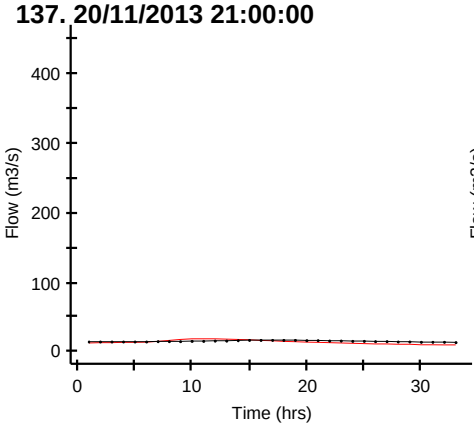
135. 23/06/2013 13:00:00



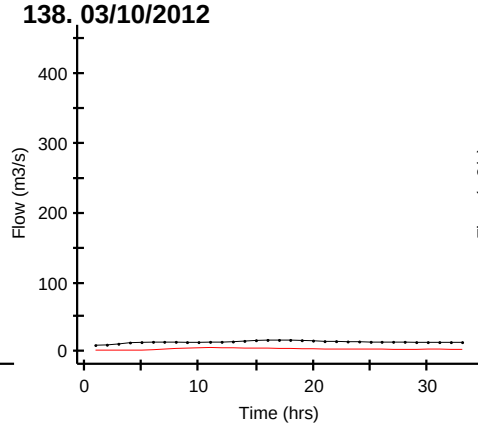
136. 30/09/2012 18:00:00



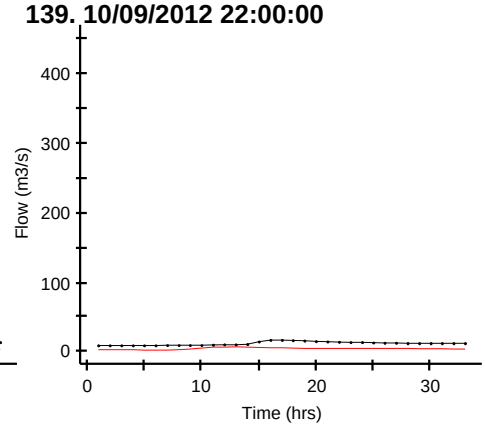
137. 20/11/2013 21:00:00



138. 03/10/2012



139. 10/09/2012 22:00:00

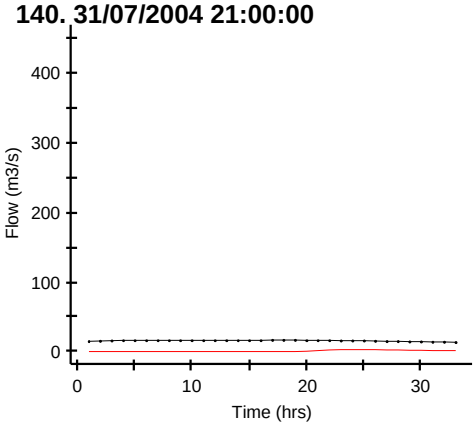


Key

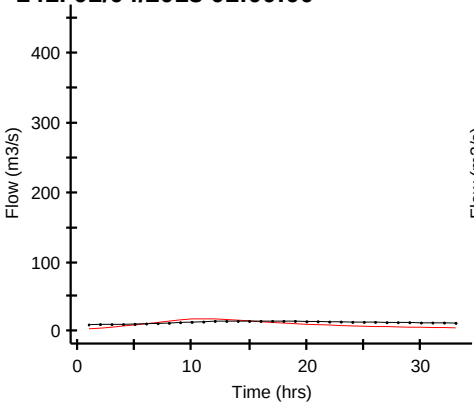
Modelled

Observed

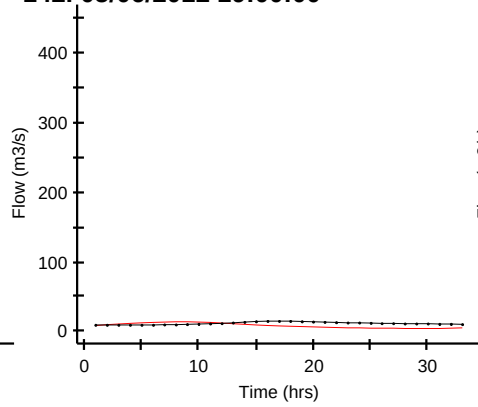
140. 31/07/2004 21:00:00



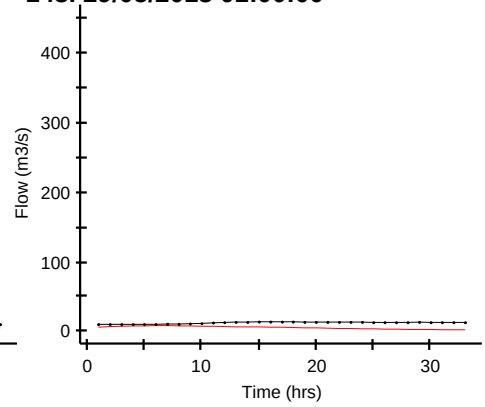
141. 01/04/2013 01:00:00



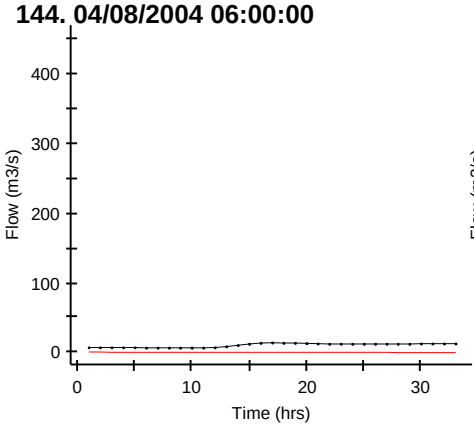
142. 05/06/2012 19:00:00



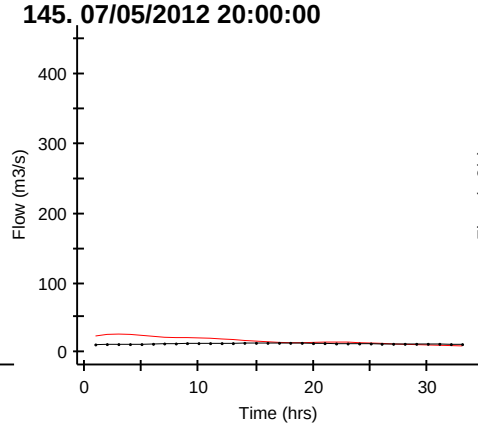
143. 29/05/2013 01:00:00



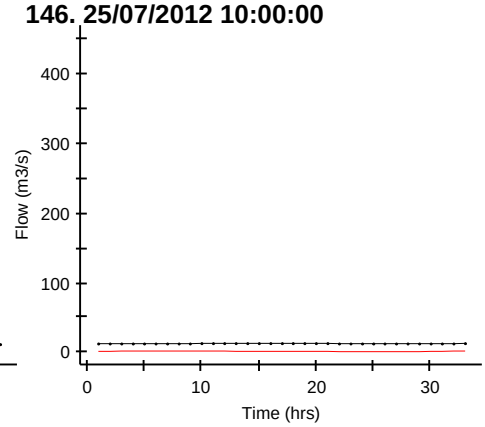
144. 04/08/2004 06:00:00



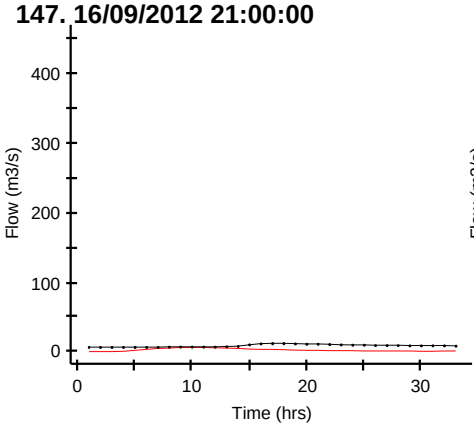
145. 07/05/2012 20:00:00



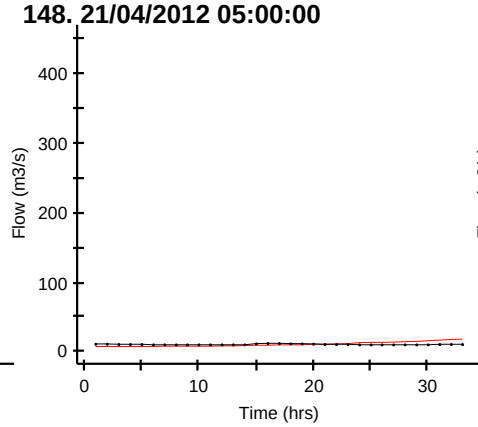
146. 25/07/2012 10:00:00



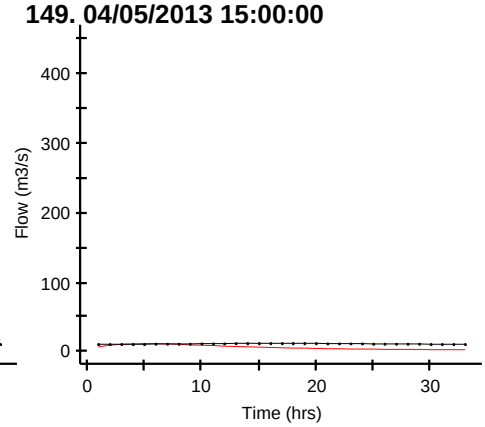
147. 16/09/2012 21:00:00



148. 21/04/2012 05:00:00



149. 04/05/2013 15:00:00

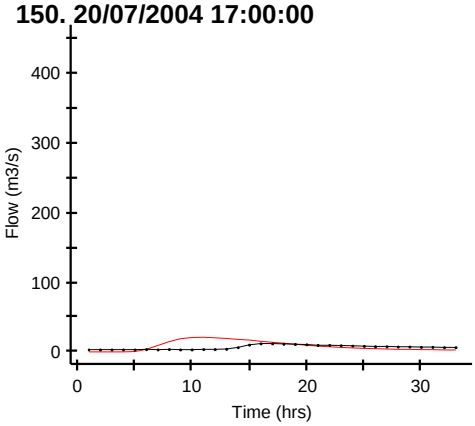


Key

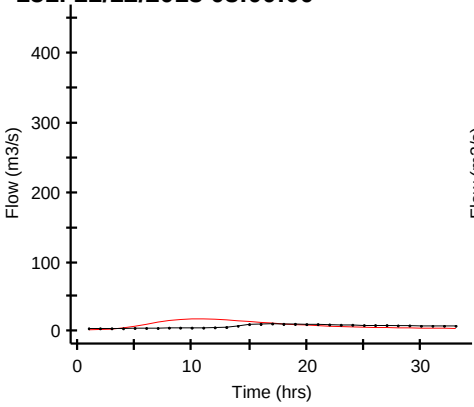
Modelled

Observed

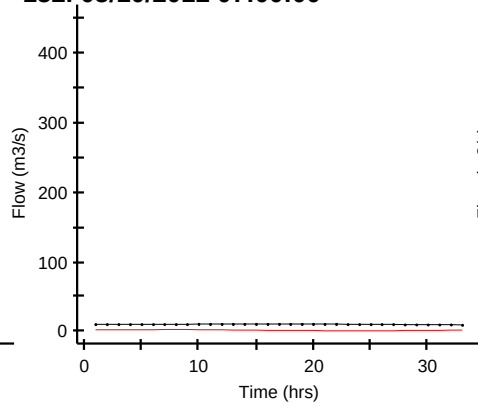
150. 20/07/2004 17:00:00



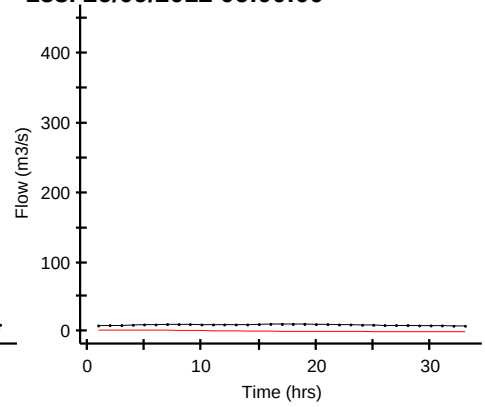
151. 11/12/2013 03:00:00



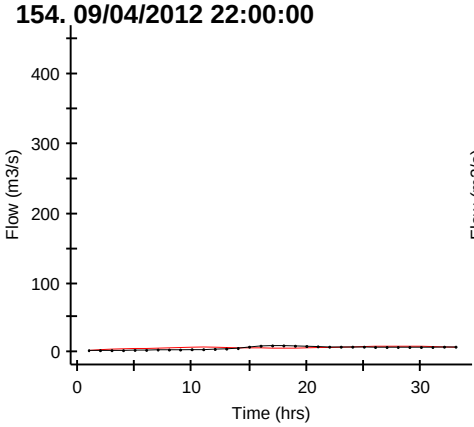
152. 05/10/2012 07:00:00



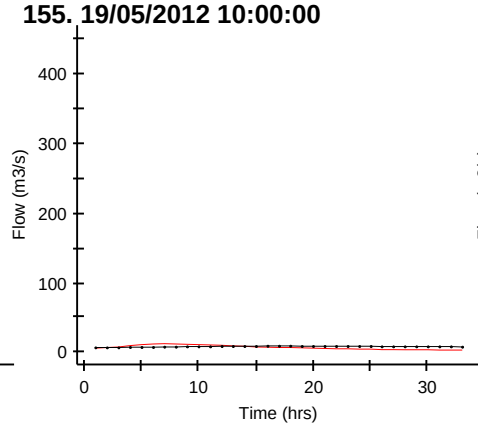
153. 26/09/2012 06:00:00



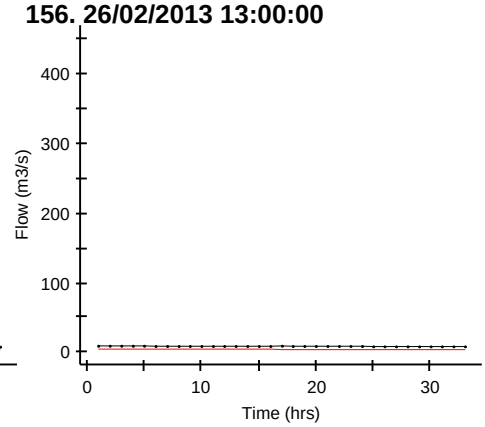
154. 09/04/2012 22:00:00



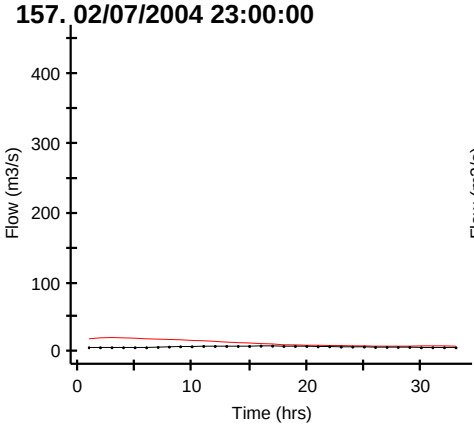
155. 19/05/2012 10:00:00



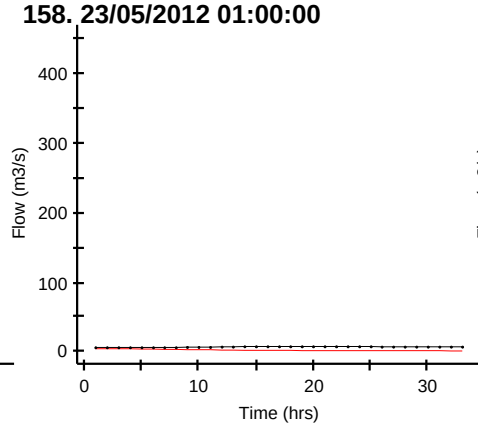
156. 26/02/2013 13:00:00



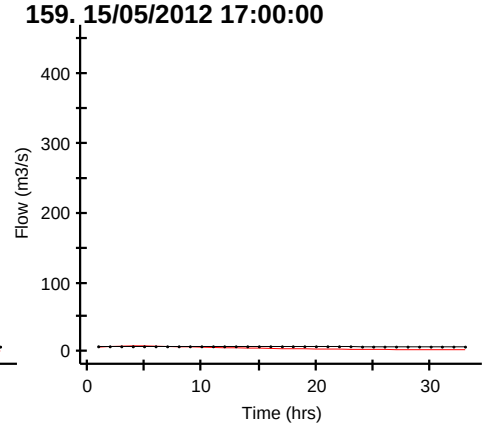
157. 02/07/2004 23:00:00



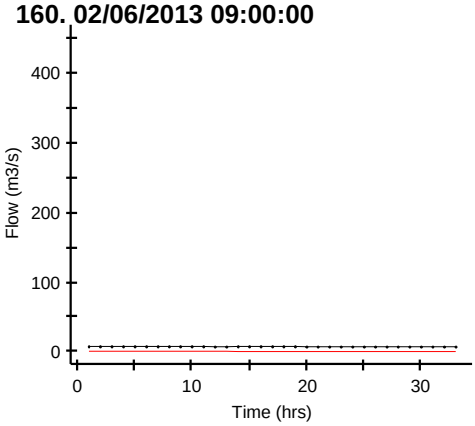
158. 23/05/2012 01:00:00

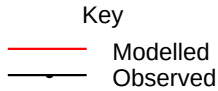


159. 15/05/2012 17:00:00



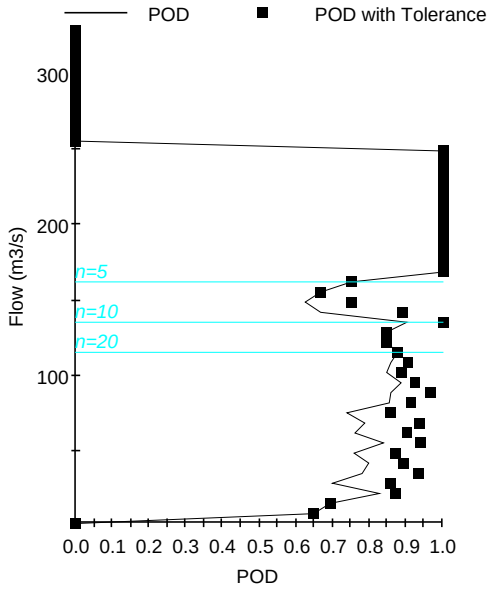
160. 02/06/2013 09:00:00

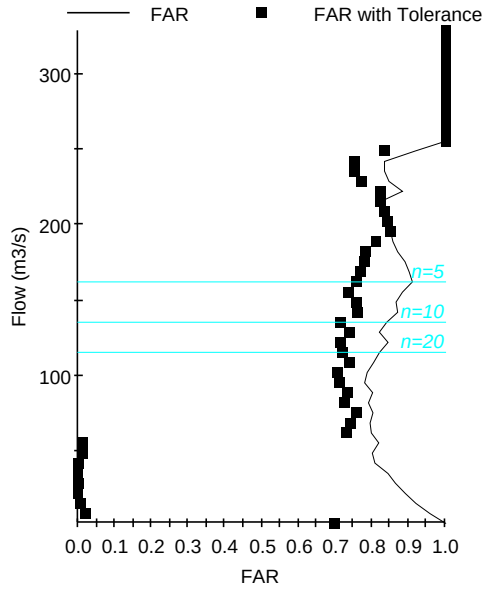


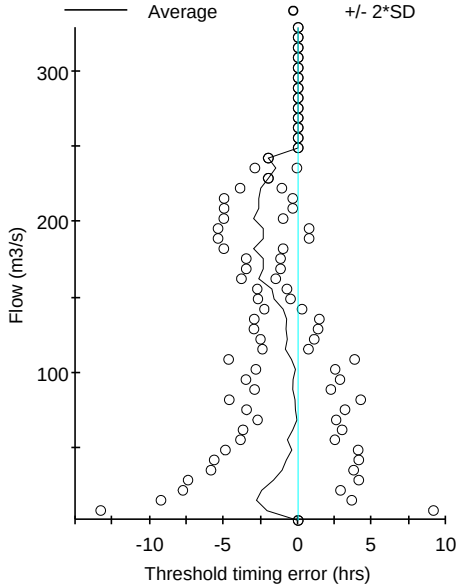


Model Evaluation Sheet : CarrigInput (Q.simulated)

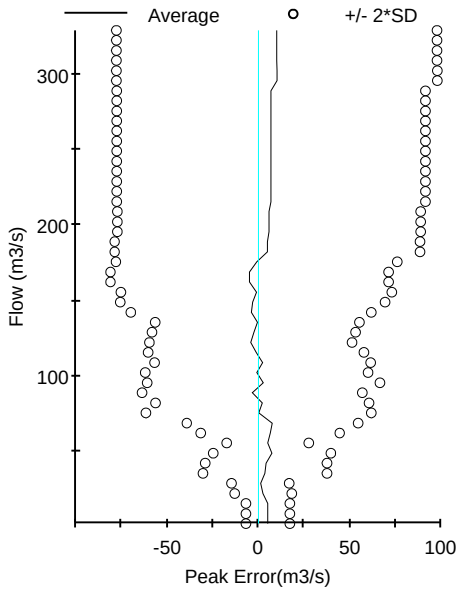
POD, FAR and peak matching statistics over full range of observations

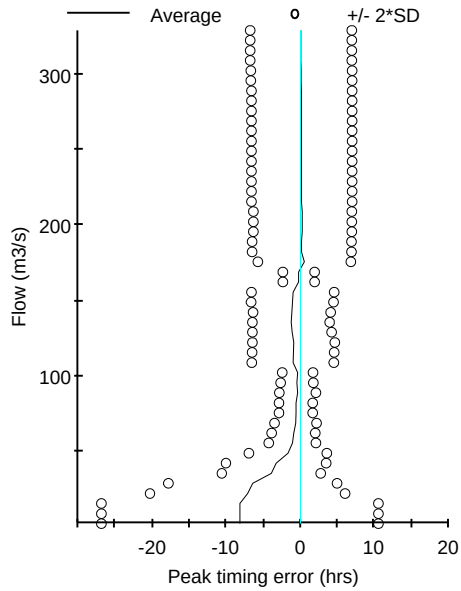


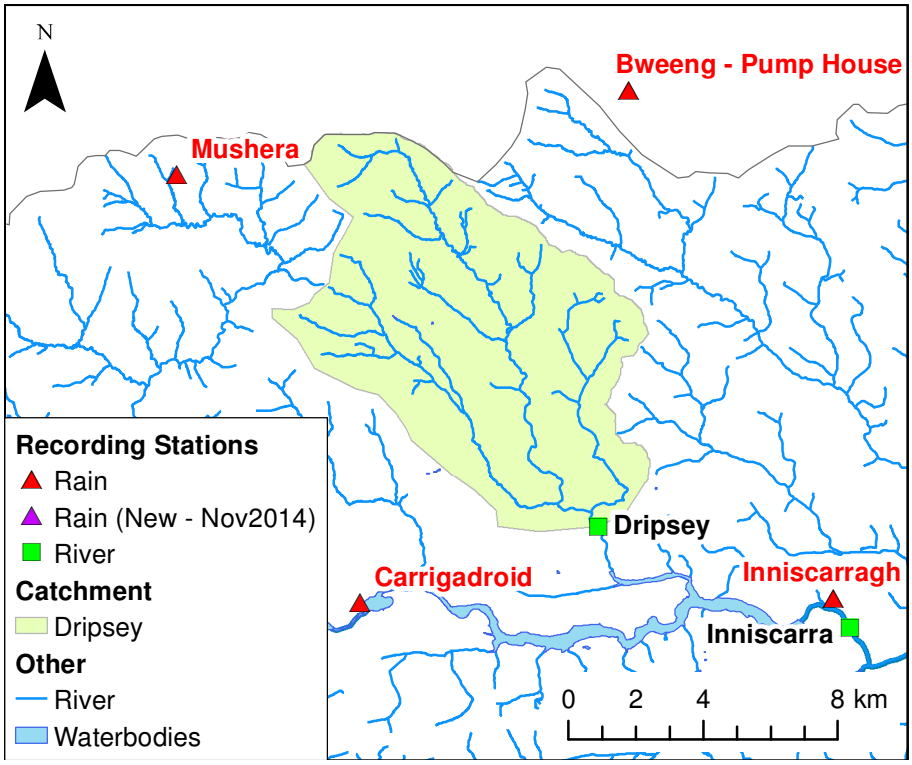




Notes: Moving average of 20 peaks used in peak calculation. Tolerance of 5% (14.7) used in POD and FAR. Threshold crossing window is 10 to 10 hrs







Raingauges used

TBR Ref	Name	Weight
Mushera_irIREev	Mushera	0.05
Carrig_irIREev	Carrigadrohid	0.6
Inniscarra_irIREev	Inniscarra	0.05
BweengPHREev	Bweeng Pump House	0.3

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	23 Oct 2002 00:00	To	06 Sep 2014 00:00

Flow gauge : (19028_irISG)

No.	Limb	Description	K	a	p	Max stage	Start-End
367	a	ESB	20.212	-0.100	1.830	1.15	01 Jan 1753-31 Dec 3999

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
76.6	0.95	10	100	1	3	6000	2	0	2	n/a	36.8	0	2

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	3.03	0.52	0.50	1.29	2.10	1.27	2.01	1.80				

Calibration Notes

1 Dripsey PDM

1.1 Catchment description

Dripsey PDM is situated on the main River Dripsey at Dripsey gauging station. The River Dripsey is one of two main tributaries to Inniscarra Reservoir. The catchment covers an area of approximately 76km^2 and comprises undulating uplands used primarily for pastoral grazing. Geology is largely impermeable consisting of mudstone, siltstone and sandstone.

1.2 Rainfall and evaporation inputs

The Dripsey catchment receives an annual average precipitation of 1360mm. There are no rain gauges situated within the catchment; the nearest is Mushera to the west of the catchment. Rainfall inputs to the PDM are taken from Mushera, Carrigadrohid, Bweeng Pump House and Inniscarra. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Inniscarra has been included for this purpose and as such has very little weight assigned to it initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 3.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 100mm and a Cmin of 10mm, with the exponent of the soil store capacity, b (1) allowing an even distribution of soil stores between Cmax and Cmin.

Both linear stores have surface routing constants (K_1) of 2 hours. Drainage parameters are Kg = 6000 and Bg = 2. This combination means drainage to the baseflow store is relatively quick and is fairly sensitive to soil moisture state.

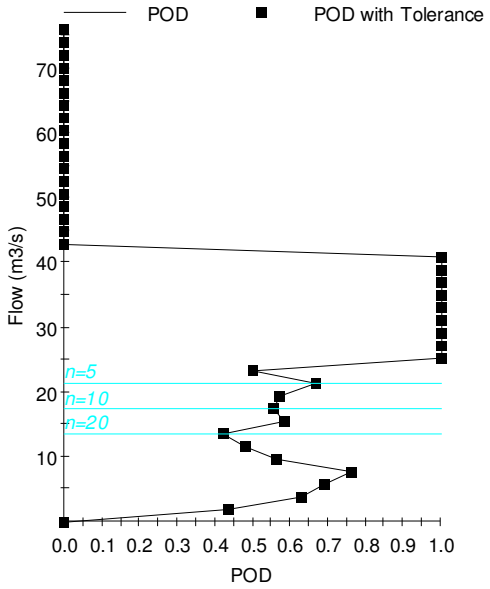
The baseflow routing time constant (Kb) is 38.6hmm^2. The depth of water retained by soil under tension (St) was set at 0mm. A time delay of 2 hours was also assigned to bring timing of peaks more into line.

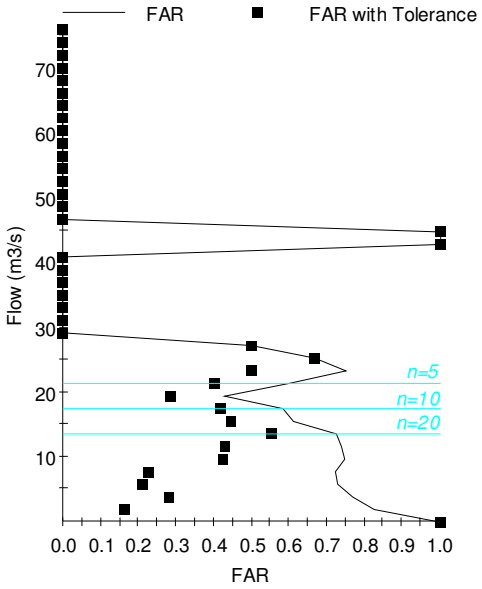
1.4 Overall performance

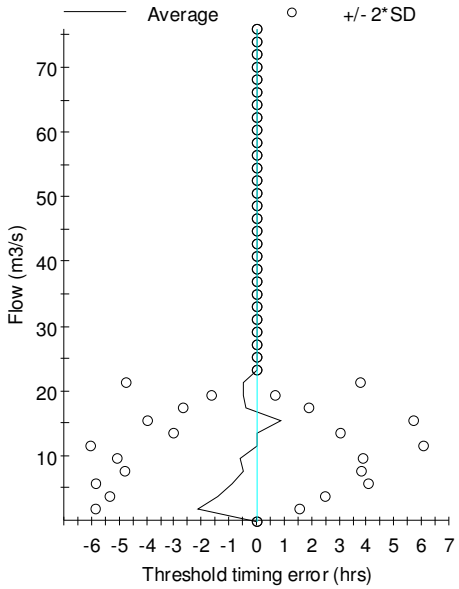
The PDM performance was compared to observed flow data from Dripsey gauging station. Overall performance of the Dripsey PDM is reasonable with both hydrograph shape and timing well represented, although magnitude of the two largest peaks is underestimated. The nature of rainfall inputs will also result in some under performance.

PDM Model Sheet for : Dripsey_v1

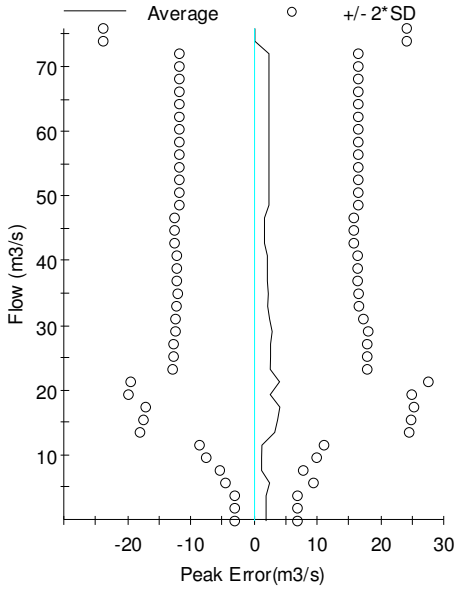
POD, FAR and peak matching statistics over full range of observations

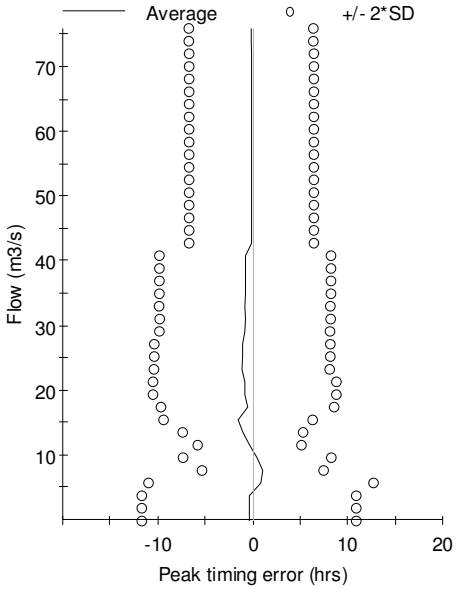






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -7 to +7 hrs



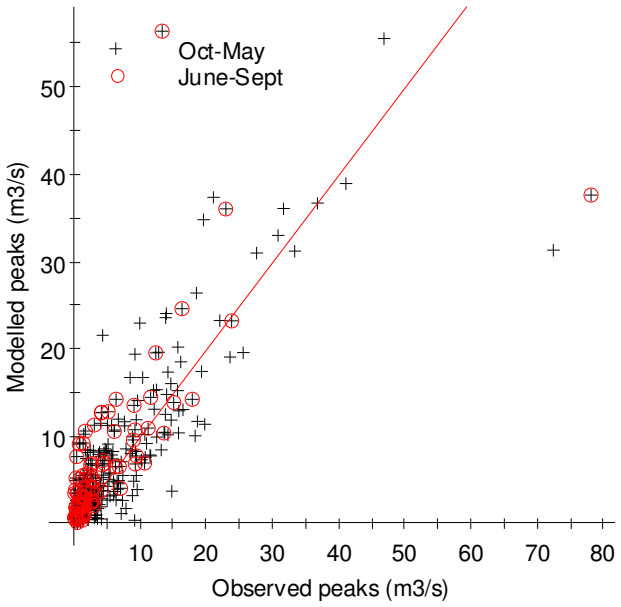


PDM Model Sheet for : Dripsey_v1

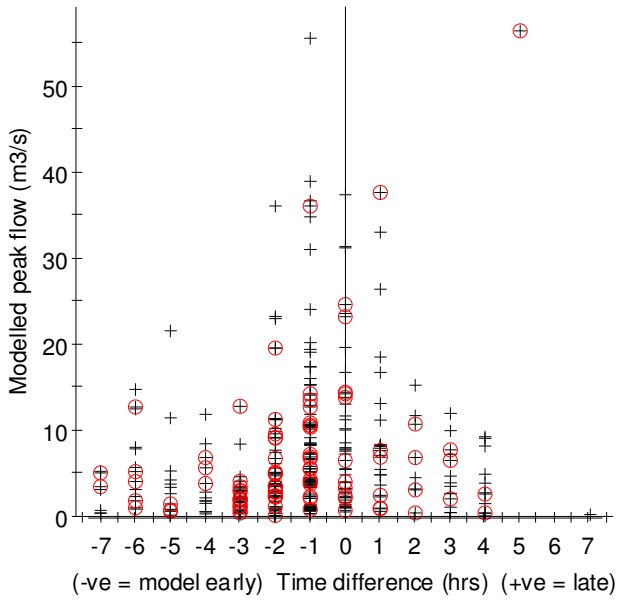
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	28/06/2012 06:00	77.9	28/06/2012 07:00	37.7	-52%	1.0	0.574	12.766	0.791
2	10/01/2008 09:00	72.3	10/01/2008 09:00	31.4	-57%	0.0	0.416	12.185	0.922
3	19/11/2009 17:00	46.7	19/11/2009 16:00	55.5	19%	-1.0	0.770	5.390	0.948
4	03/12/2006 04:00	41.0	03/12/2006 03:00	39.0	-5%	-1.0	0.876	3.615	0.915
5	21/11/2009 15:00	36.7	21/11/2009 14:00	36.8	0%	-1.0	0.018	5.614	0.846
6	17/11/2010 03:00	33.3	17/11/2010 03:00	31.3	-6%	0.0	0.965	1.645	0.974
7	16/11/2009 09:00	31.6	16/11/2009 07:00	36.1	14%	-2.0	-0.574	6.105	0.839
8	12/01/2010 17:00	30.8	12/01/2010 18:00	33.1	7%	1.0	0.933	2.403	0.951
9	30/11/2006 21:00	27.5	30/11/2006 20:00	31.1	13%	-1.0	0.883	2.522	0.918
10	03/11/2005 02:00	25.5	03/11/2005 00:00	19.7	-23%	-2.0	-0.254	5.316	0.731

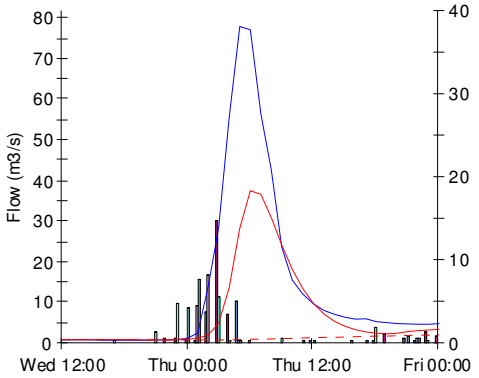
Modelled and observed peak flows, r2=0.640



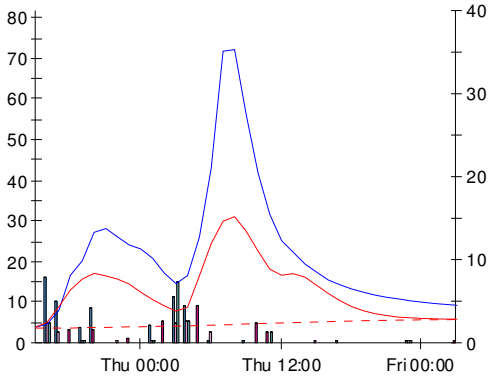
Modelled and observed peak timing



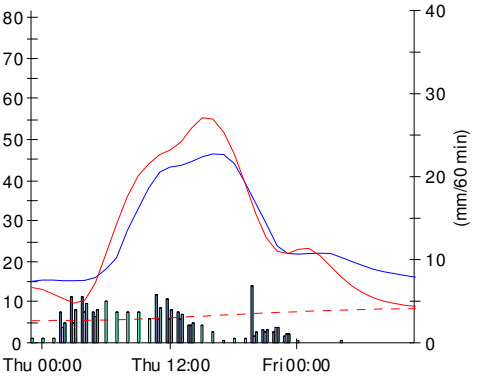
1. 28 Jun 2012 06:00 (30-49-50mm)



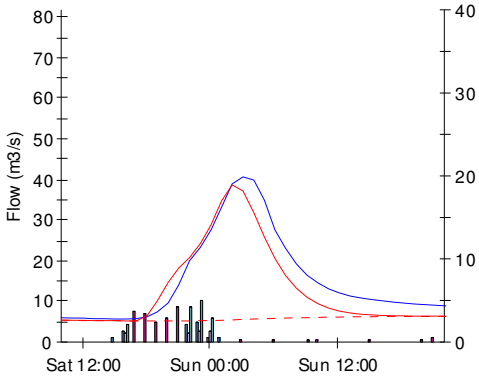
2. 10 Jan 2008 09:00 (31-36-56mm)



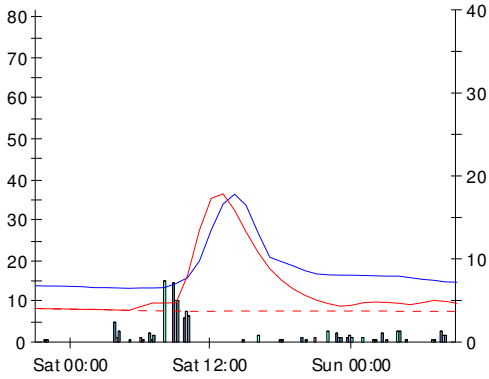
3. 19 Nov 2009 17:00 (45-60-75mm)



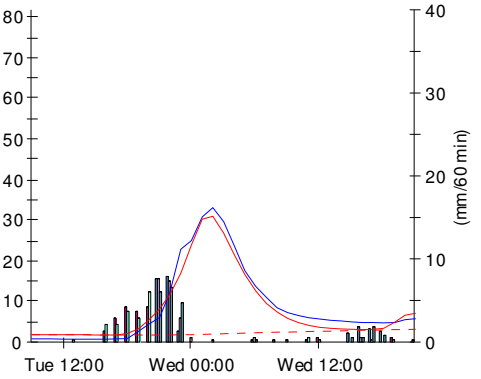
4. 03 Dec 2006 04:00 (11-31-34mm)



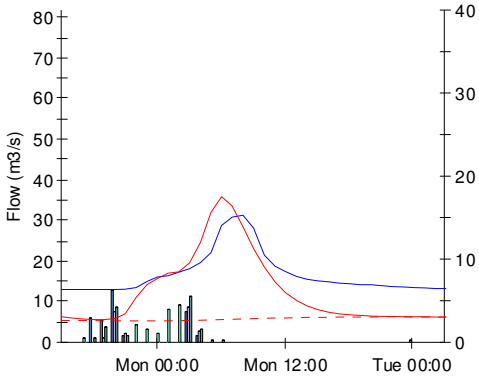
5. 21 Nov 2009 15:00 (19-25-34mm)



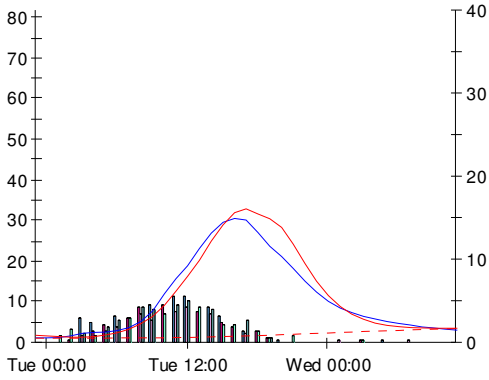
6. 17 Nov 2010 03:00 (36-40-46mm)



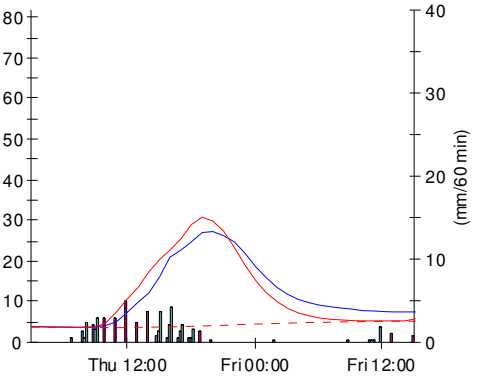
7. 16 Nov 2009 09:00 (22-28-34mm)



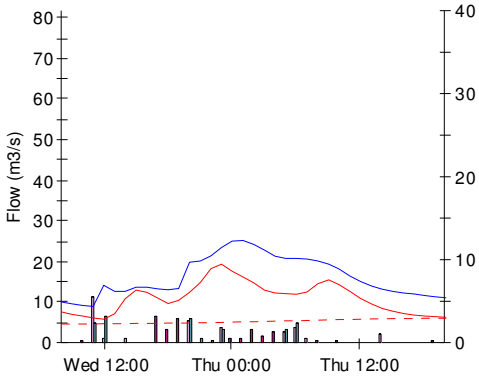
8. 12 Jan 2010 17:00 (36-49-59mm)



9. 30 Nov 2006 21:00 (14-35-38mm)



10. 03 Nov 2005 02:00 (0-27-30mm)



Key

- 19028_irlSG - Flow : Dripsey
- Modelled Q
- Modelled Qg
- Mushera_irlREev - Recording Rain : Mushera
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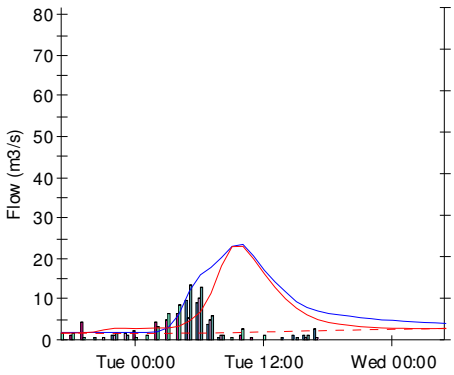
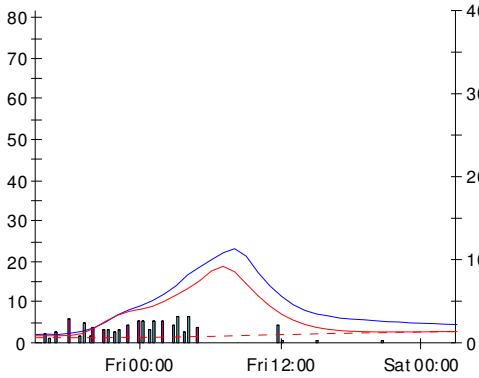
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

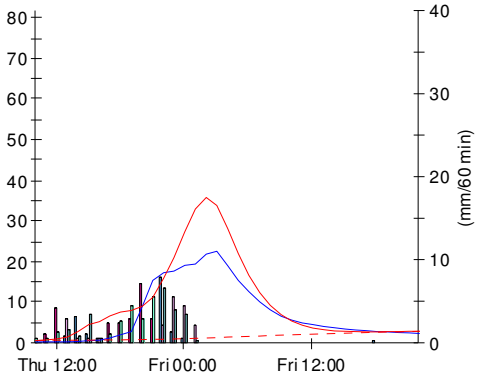
11. 09 Sep 2008 11:00 (21-32-33mm)



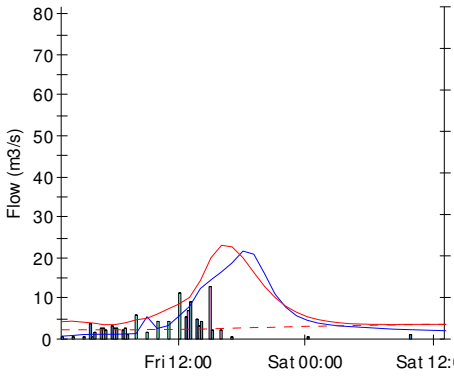
12. 13 Jan 2006 09:00 (20-31-31mm)



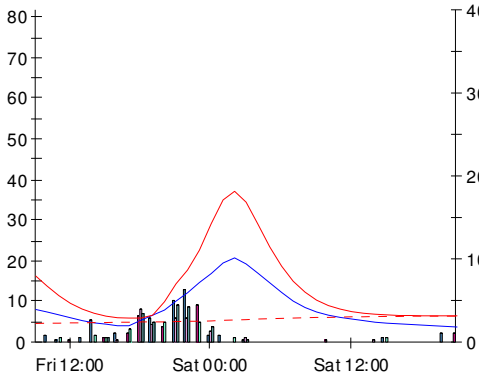
13. 01 Aug 2008 04:00 (33-43-49mm)



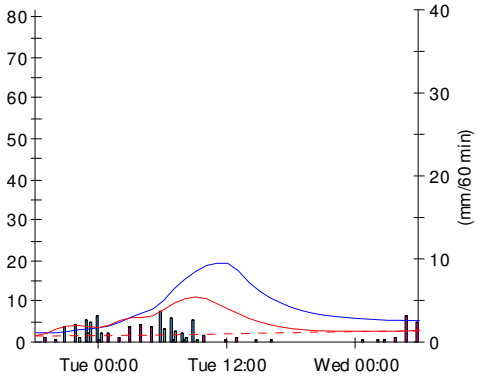
14. 30 Oct 2009 19:00 (25-27-31mm)



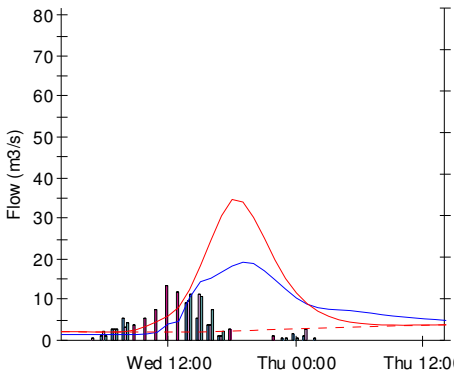
15. 16 Jan 2010 03:00 (23-26-39mm)



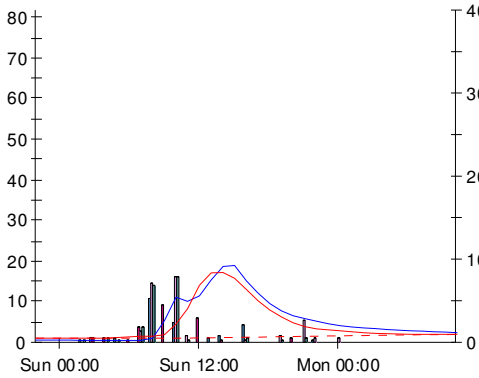
16. 03 Feb 2004 12:00 (6-25-64mm)



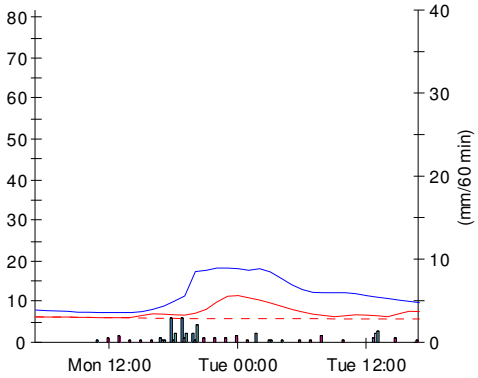
17. 25 Oct 2006 20:00 (30-41-43mm)



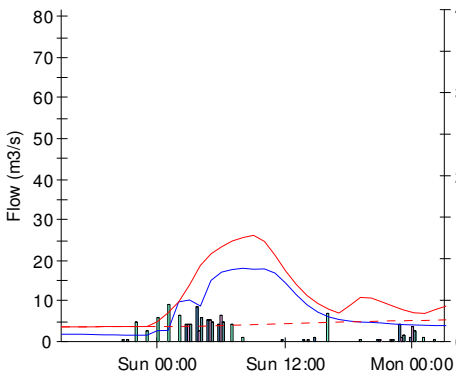
18. 21 May 2006 16:00 (20-28-30mm)



19. 04 Dec 2006 23:00 (7-13-24mm)



20. 01 Nov 2009 09:00 (30-35-45mm)



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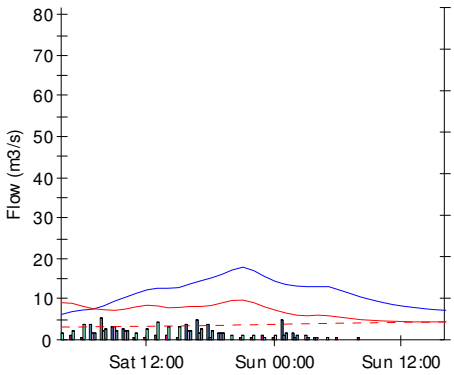
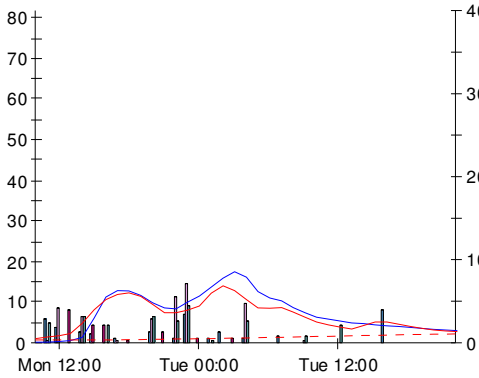
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

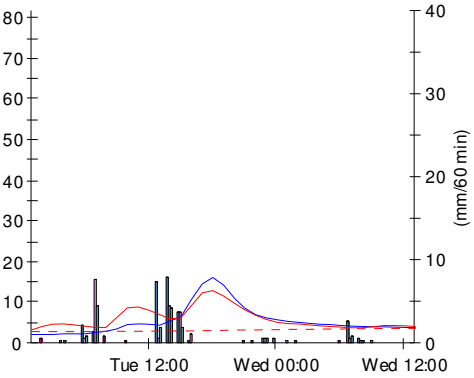
21. 15 Jan 2011 22:00 (11-18-41mm)



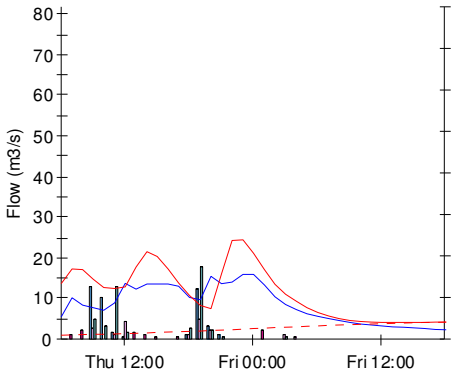
22. 10 Jun 2003 04:00 (29-43-44mm)



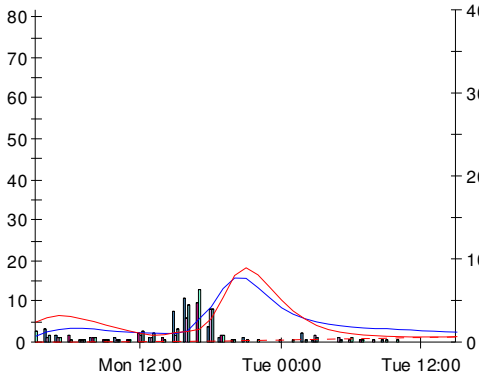
23. 08 Jan 2008 19:00 (17-19-36mm)



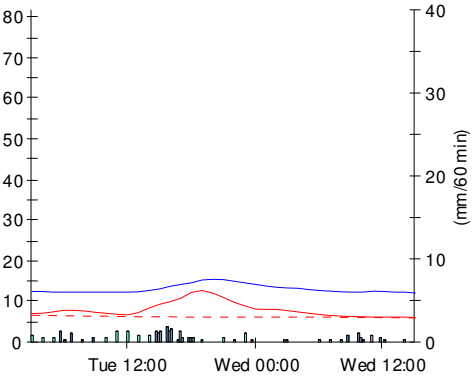
24. 22 Sep 2006 00:00 (25-30-36mm)



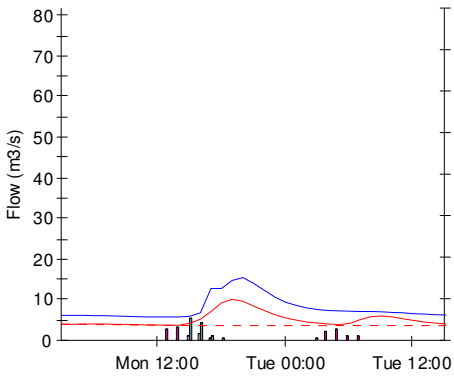
25. 27 Dec 2010 21:00 (23-28-37mm)



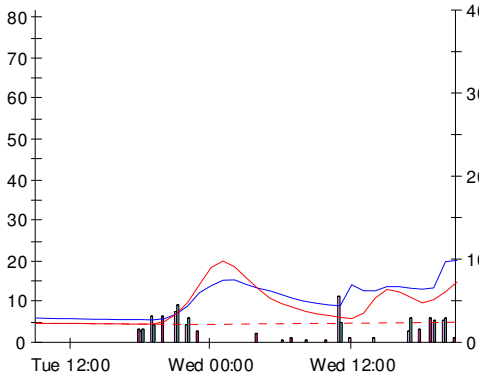
26. 24 Nov 2009 21:00 (0-13-21mm)



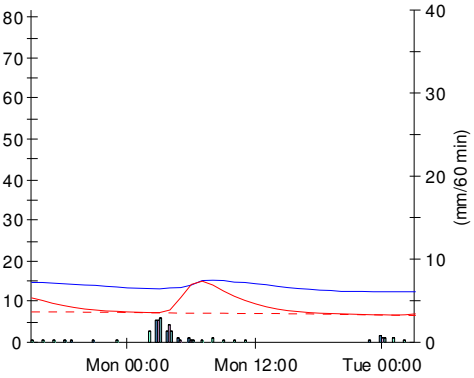
27. 07 Nov 2005 21:00 (0-12-13mm)



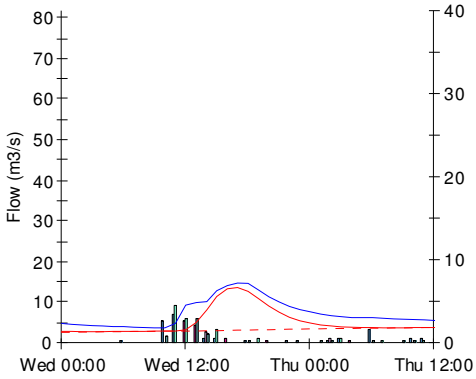
28. 02 Nov 2005 03:00 (0-33-36mm)



29. 23 Nov 2009 09:00 (7-9-14mm)



30. 10 Sep 2008 18:00 (11-15-22mm)



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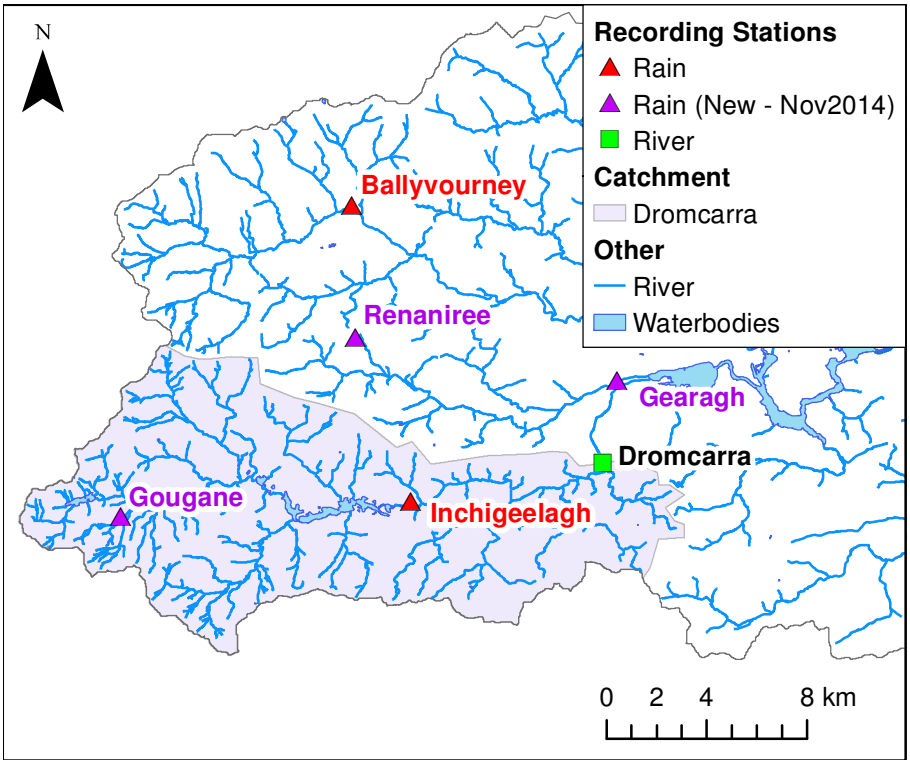
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

PDM Model Sheet for : Dromcarra_v3



Raingauges used

TBR Ref	Name	Weight
Inchigeelagh_irlREev	Inchigeelagh	0.421
Gearagh_irlREev	Gearagh	0.053
Renanir_irlREev	Renanirree	0.105
Gougaune_irlREev	Gougaune	0.421
Ballvourney_irlREev	Ballvourney	0.05

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	01 Jul 2004 00:00	To	27 Feb 2015 00:00

Flow gauge : (19014_irlSG)

No.	Limb	Description	K	a	p	Max stage	Start-End
450	a	LeeCFRAM	38.214	-0.250	1.901	1.15	01 Jan 1970-31 Dec 3999
450	b	LeeCFRAM	36.160	-0.249	1.560	1.78	01 Jan 1970-31 Dec 3999
450	c	LeeCFRAM	34.223	-0.255	1.690	3.00	01 Jan 1970-31 Dec 3999

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
169.5	1.05	10	130	1	3	8000	1.7	0	8	n/a	4.6	0	0

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	1.75	1.71	1.07	1.40	1.87	0.83	0.30	1.27				

Calibration Notes

1 Dromcarra PDM

1.1 Catchment description

Dromcarra PDM is situated on the River Lee at Dromcarra gauging station upstream of Carrigadrohid Reservoir. The River Lee is the main river running through the Upper and Lower Lee catchments originating in the headwaters of the Dromcarra catchment, draining into Carrigadrohid then Inniscarra Reservoirs and through the city of Cork before discharging to Cork Harbour. The catchment covers an area of approximately 170km^2 and comprises undulating uplands with exposed rock and peaty topsoil. Geology is largely impermeable consisting sandstone and siltstone.

1.2 Rainfall and evaporation inputs

The Lee catchment to Dromcarra receives an annual average precipitation of 2070mm. The only rain gauge situated within the catchment is Inchigeelagh. Rainfall inputs to the PDM are taken from Inchigeelagh, Renaniree and Balvourney. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Renaniree and Balvourney have been included for this purpose and as such have very little weight assigned to them initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 3.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 130mm and a Cmin of 10mm, with the exponent of the soil store capacity, b (1) allowing even distribution of soil stores between Cmax and Cmin.

Both linear stores have surface routing constants (K_1) of 8 hours. Drainage parameters are Kg = 8000 and Bg = 1.7. This combination means drainage to the baseflow store is relatively quick and is slightly sensitive to soil moisture state.

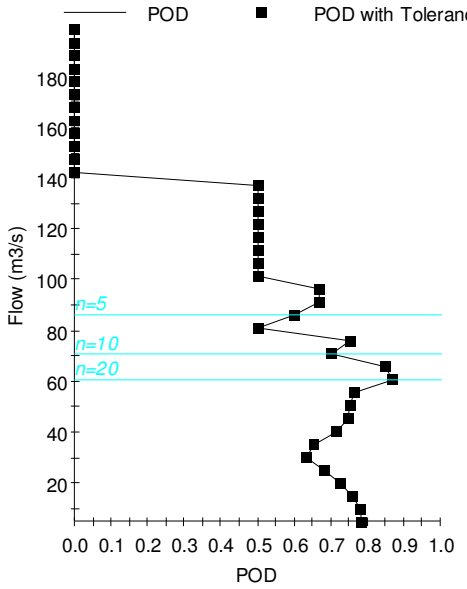
The baseflow routing time constant (Kb) is 4.6hmm^2. The depth of water retained by soil under tension (St) was set at 0mm.

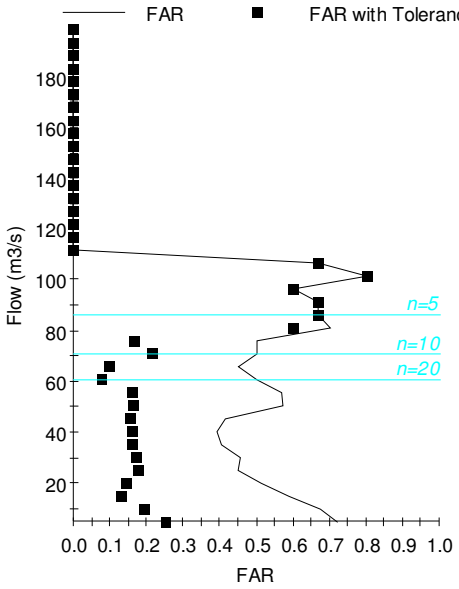
1.4 Overall performance

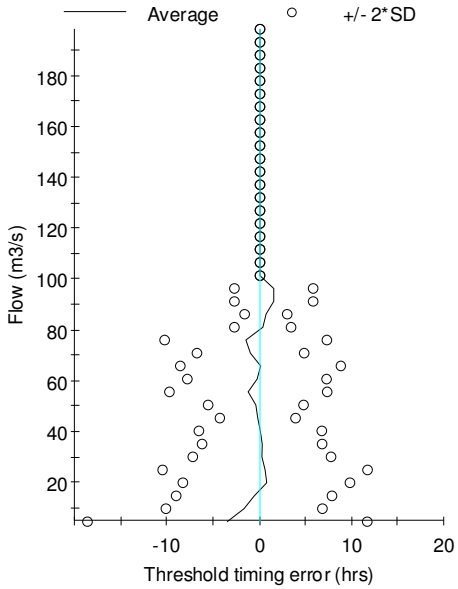
The PDM performance was compared to flow data from Dromcarra gauging station. Overall performance of the Dromcarra PDM is reasonable with both hydrograph shape and timing well represented in the majority of events, however the nature of rainfall inputs will result in some under performance.

PDM Model Sheet for : Dromcarra_v3

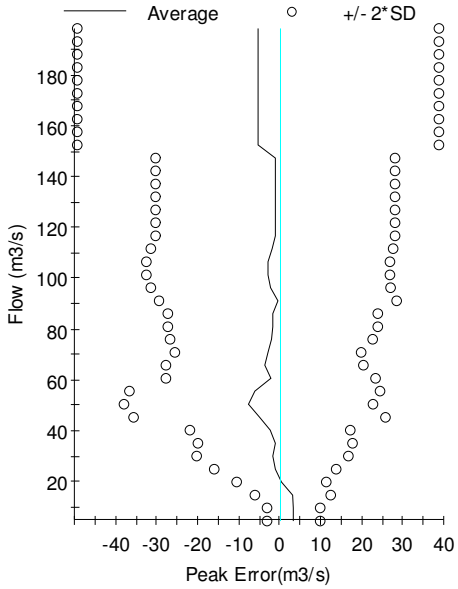
POD, FAR and peak matching statistics over full range of observations

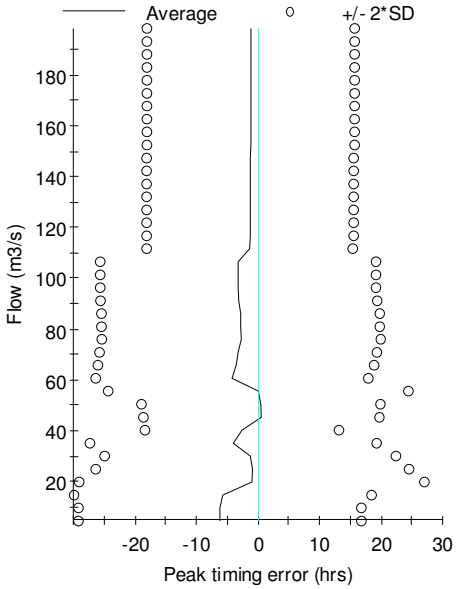






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -24 to +24 hrs



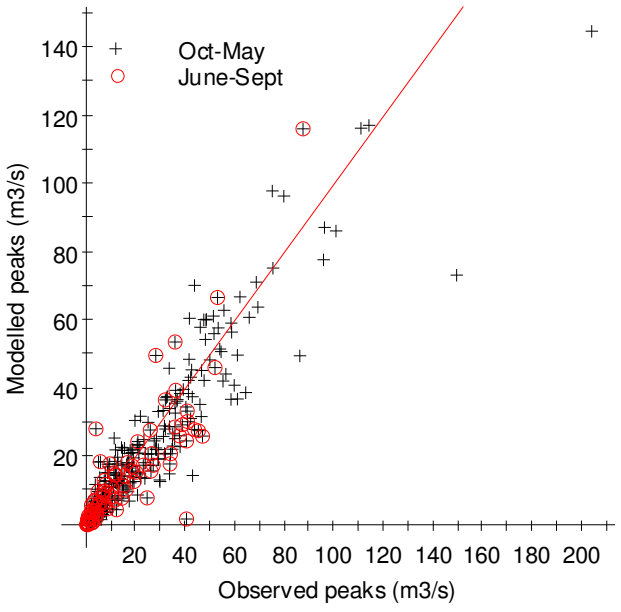


PDM Model Sheet for : Dromcarra_v3

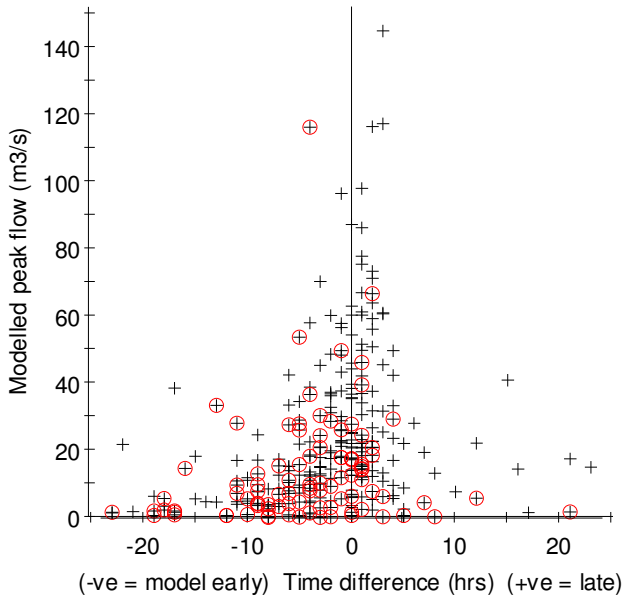
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	19/11/2009 15:00	203.4	19/11/2009 18:00	144.6	-29%	3.0	0.634	31.643	0.921
2	16/01/2011 03:00	149.1	16/01/2011 05:00	73.2	-51%	2.0	0.462	30.360	0.924
3	10/01/2008 09:00	113.9	10/01/2008 12:00	117.1	3%	3.0	0.820	10.174	0.890
4	03/12/2006 04:00	110.7	03/12/2006 06:00	116.2	5%	2.0	0.514	14.101	0.822
5	19/11/2012 09:00	100.5	19/11/2012 10:00	86.2	-14%	1.0	0.840	10.579	0.923
6	13/01/2006 09:00	96.0	13/01/2006 09:00	87.1	-9%	0.0	0.744	9.042	0.907
7	16/01/2010 03:00	95.6	16/01/2010 04:00	77.7	-19%	1.0	0.492	13.510	0.896
8	22/09/2006 03:00	87.4	21/09/2006 23:00	116.0	33%	-4.0	0.547	15.416	0.801
9	12/01/2010 16:00	86.1	12/01/2010 20:00	49.7	-42%	4.0	0.624	15.207	0.891
10	25/10/2013 08:00	79.5	25/10/2013 07:00	96.4	21%	-1.0	0.701	8.096	0.912

Modelled and observed peak flows, r2=0.837

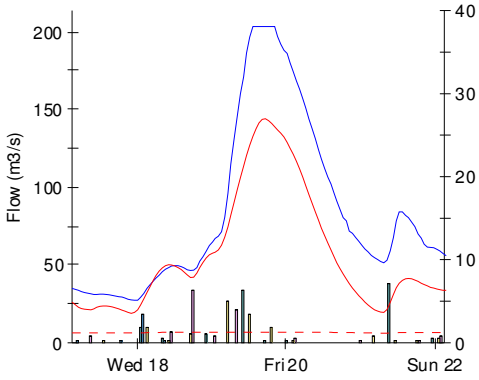


Modelled and observed peak timing

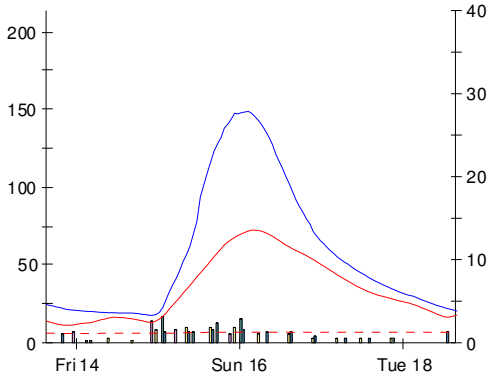


PDM Model Sheet for : Dromcarra_v3

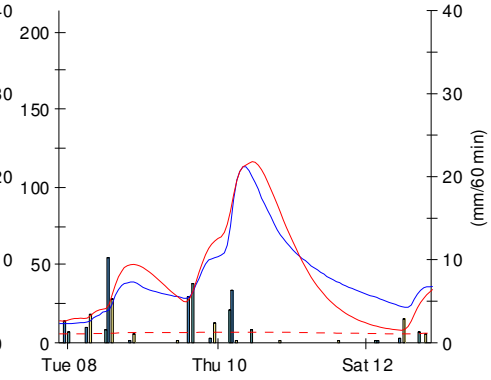
1. 19 Nov 2009 15:00 (32-148-158mm)



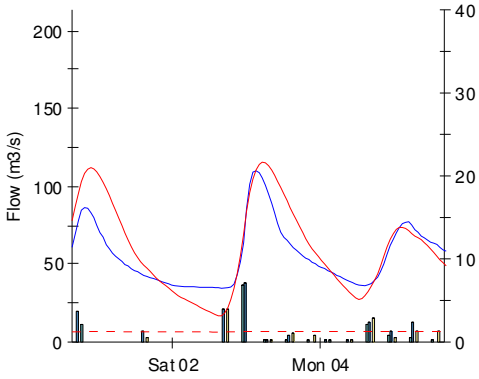
2. 16 Jan 2011 03:00 (68-93-97mm)



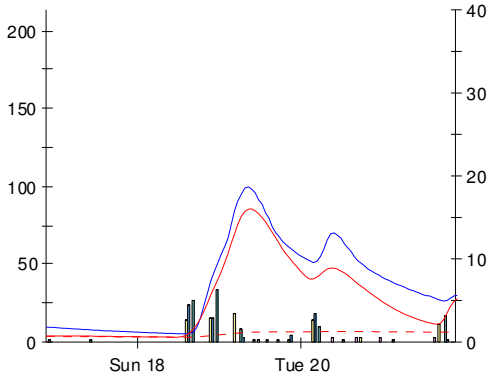
3. 10 Jan 2008 09:00 (101-117-119mm)



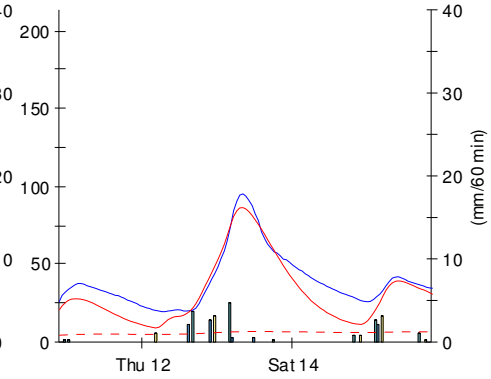
4. 03 Dec 2006 04:00 (134-134-138mm)



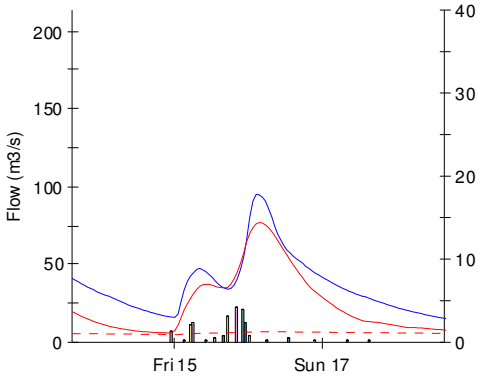
5. 19 Nov 2012 09:00 (21-97-114mm)



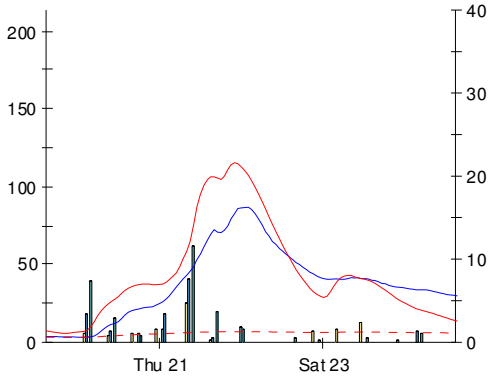
6. 13 Jan 2006 09:00 (91-92-101mm)



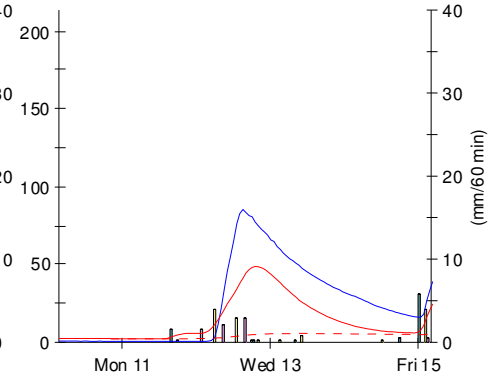
7. 16 Jan 2010 03:00 (48-62-65mm)



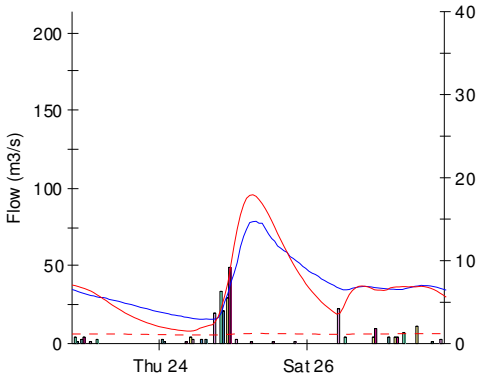
8. 22 Sep 2006 03:00 (132-135-162mm)



9. 12 Jan 2010 16:00 (22-67-81mm)



10. 25 Oct 2013 08:00 (62-89-114mm)

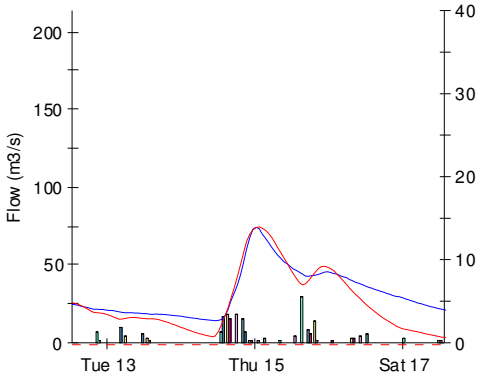


Key

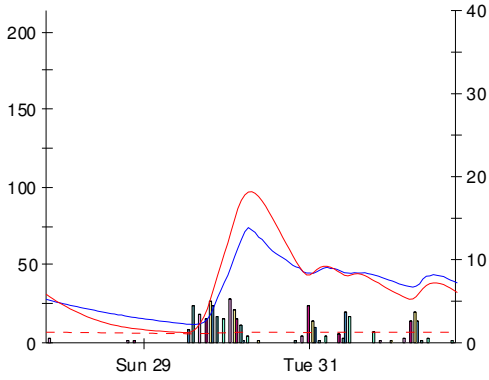
- 19014_irlSG - Flow : Dromcarra
- Modelled Q
- Modelled Qg
- Inchigeelagh_irlREev - Recording Rain : Inchigeelagh
- Gearagh_irlREev - Recording Rain : Gearagh
- Renanir_irlREev - Recording Rain : Renanirree
- Gougaune_irlREev - Recording Rain : Gougaune
- Ballvourney_irlREev - Recording Rain : Ballvourney
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

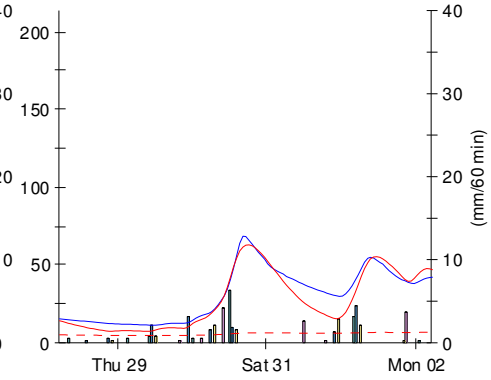
11. 15 Jan 2015 01:00 (60-76-82mm)



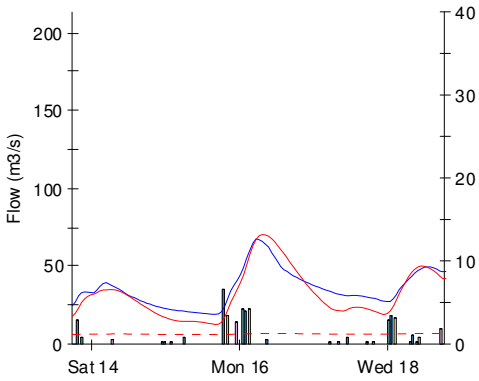
12. 30 Dec 2013 07:00 (65-91-101mm)



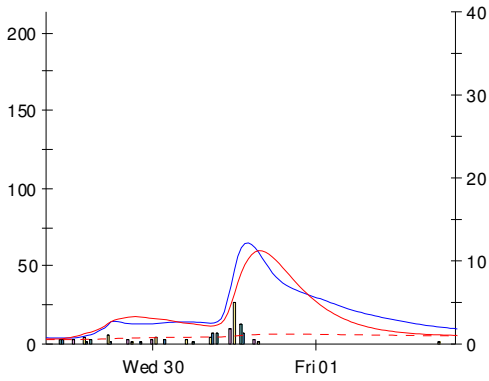
13. 30 Oct 2009 17:00 (76-91-93mm)



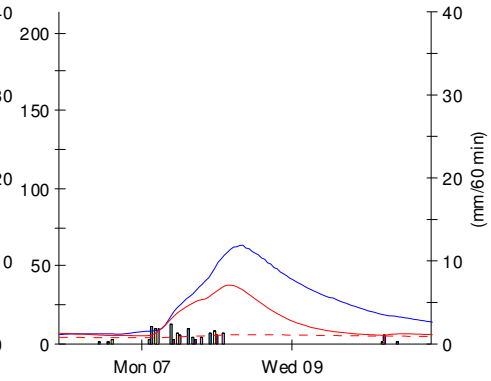
14. 16 Nov 2009 06:00 (84-93-92mm)



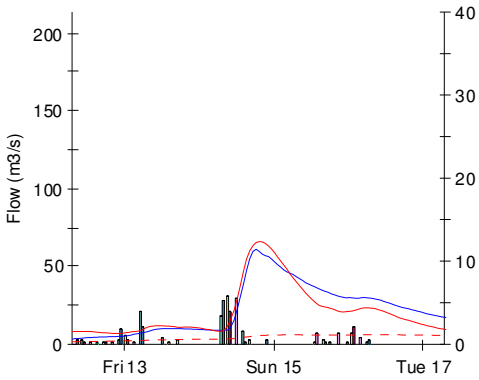
15. 31 Dec 2009 05:00 (46-62-67mm)



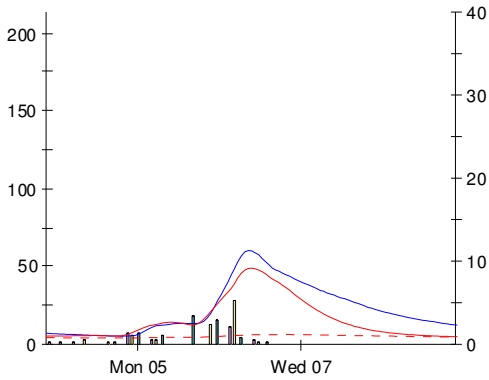
16. 08 Jan 2013 09:00 (0-39-53mm)



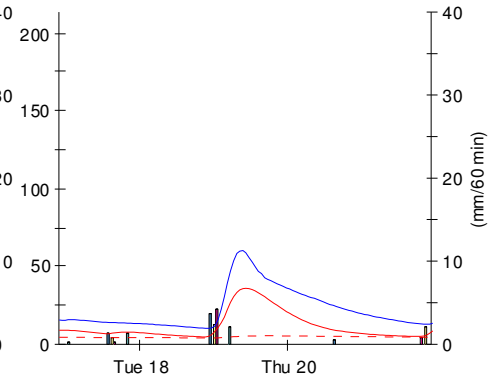
17. 14 Dec 2013 19:00 (56-74-84mm)



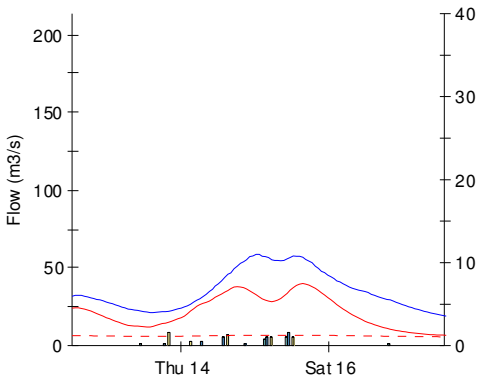
18. 06 Apr 2010 09:00 (2-51-67mm)



19. 19 Dec 2012 10:00 (0-35-52mm)



20. 15 Dec 2006 01:00 (24-46-48mm)



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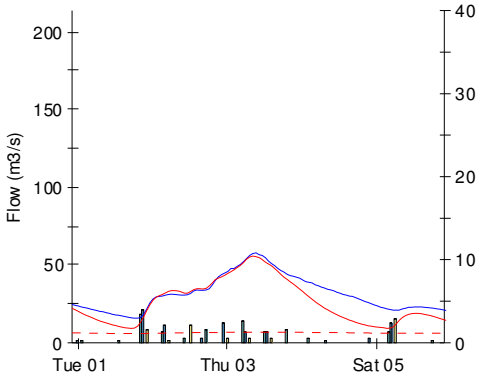
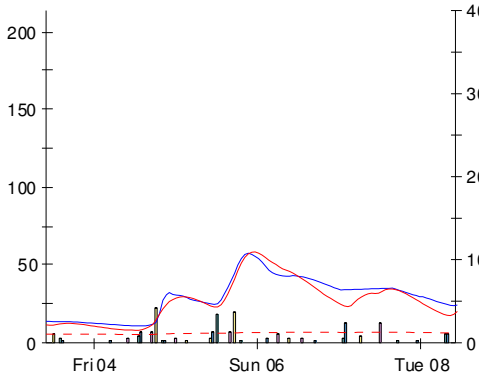
- Ballvourney_irlREev - Recording Rain : Ballvourney
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

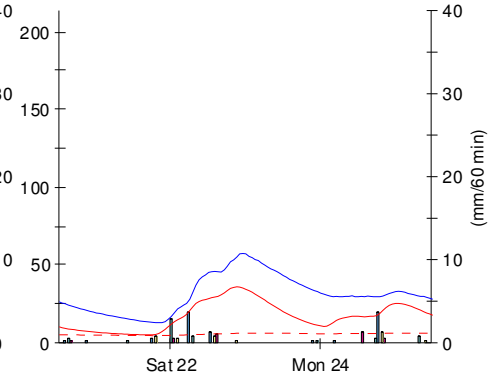
21. 03 Nov 2005 10:00 (64-66-78mm)



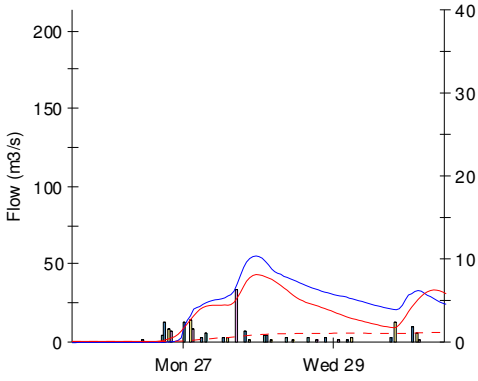
22. 05 Dec 2009 22:00 (63-77-87mm)



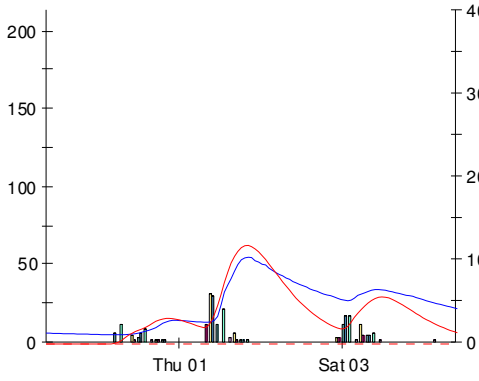
23. 23 Dec 2012 00:00 (0-52-64mm)



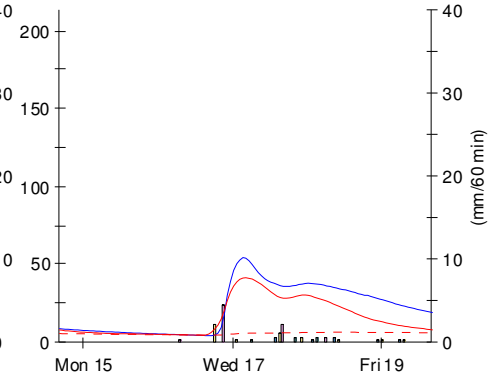
24. 28 Dec 2010 00:00 (72-90-96mm)



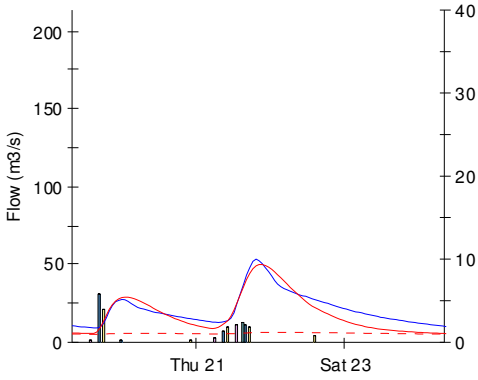
25. 01 Jan 2015 21:00 (43-75-97mm)



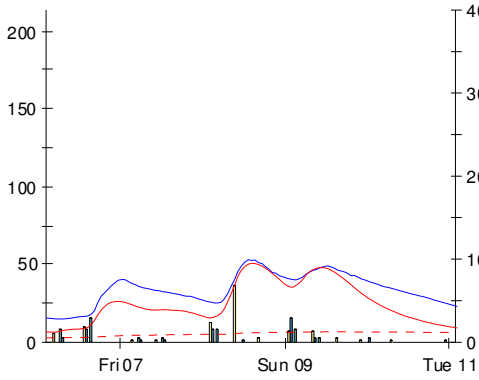
26. 17 Nov 2010 04:00 (16-45-57mm)



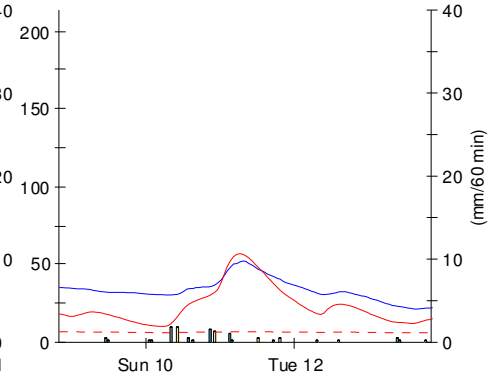
27. 21 Jan 2010 20:00 (26-48-52mm)



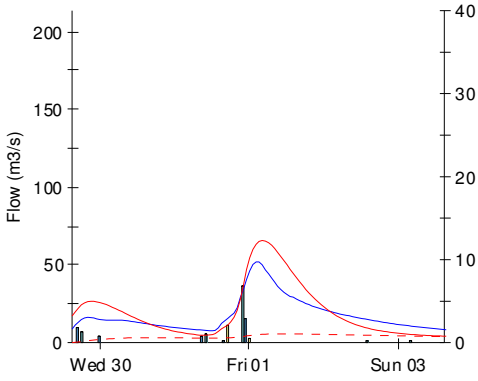
28. 08 Dec 2007 14:00 (56-84-87mm)



29. 11 Dec 2006 08:00 (38-58-60mm)



30. 01 Aug 2008 03:00 (64-64-72mm)



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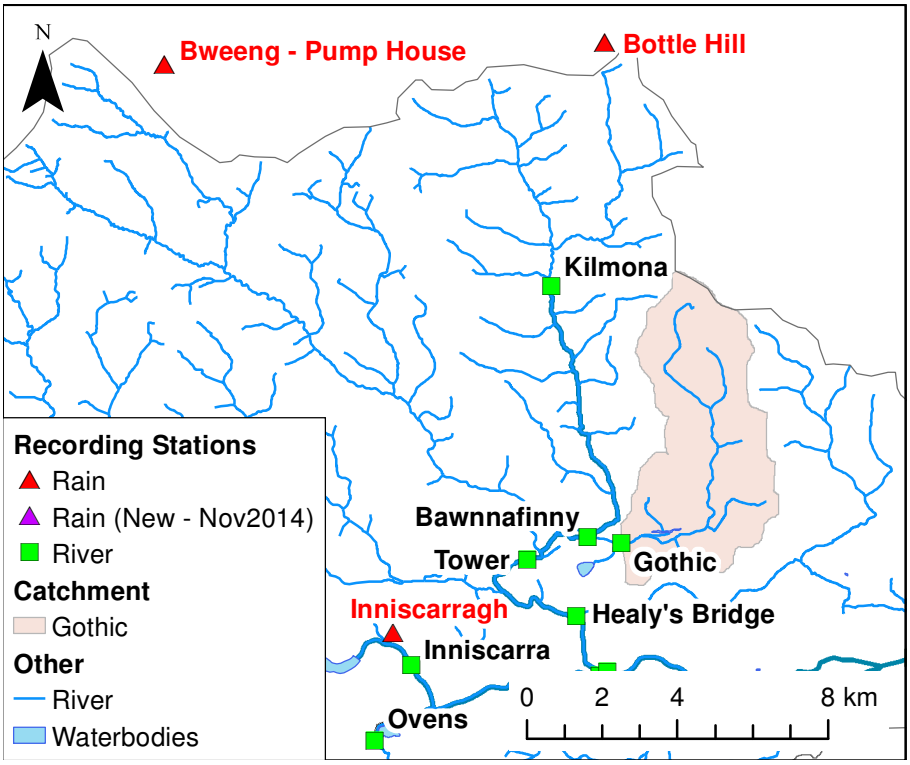
Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected



Raingauges used

TBR Ref	Name	Weight
Inniscarra_irlREev	Inniscarra	0.481
BottleHillPHREev	Bottle Hill Pump House	0.297
BweengPHREev	Bweeng Pump House	0.222

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	17 Jan 2003 00:00	To	11 Feb 2015 00:00

Flow gauge : (19045_irlSG)

No.	Limb	Description	K	a	p	Max stage	Start-End
1	a	JBa Arbitray	6.000	-0.100	1.500	0.10	01 Jan 1753-31 Dec 3999

PDM parameters

Surface		Linear cascade		Base	Cubic store			Drainage		Gravity		
Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
22.5	1.05	0	60	1	2.5	1000	1.7	0	4	20	21.5	0	1

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	2.72	2.79	2.25	1.40	2.52	3.60	3.06	2.54				

Calibration Notes

1 Gothic PDM

1.1 Catchment description

Gothic PDM is situated on the River Blarney at Gothic Bridge gauging station. The River Blarney is one of two main tributaries to the River Shournagh. The catchment covers an area of approximately 22km^2 and comprises steep-sloping valleys used mainly for pastoral grazing. Geology is largely impermeable consisting primarily of sandstone with some mudstone and siltstone.

1.2 Rainfall and evaporation inputs

The Blarney catchment to Gothic Bridge receives an annual average precipitation of 1140mm. There are no rain gauges situated within the catchment; the nearest is Inniscarra to the west of the catchment. Rainfall inputs to the PDM are taken from Inniscarra, Bottle Hill Pump House and Bweeng Pump House. Due to the patchy nature of rainfall records in the Lee catchment, three rain gauges have been included to allow weight to be re-allocated to more gauges during periods of missing data.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 2.5.

1.3 PDM parameters

The PDM is structured with a cascade of linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 60mm and a Cmin of 0mm, with the exponent of the soil store capacity, b (1) allowing even distribution of soil stores between Cmax and Cmin.

Linear stores have surface routing constants (K_1 and K_2) of 4 hours and 20 hours respectively. This results in quicker and slower response components to the peak hydrograph thereby accounting for varying attenuation. Drainage parameters are Kg = 1000 and Bg = 1.7. This combination means drainage to the baseflow store is relatively quick and is fairly sensitive to soil moisture state.

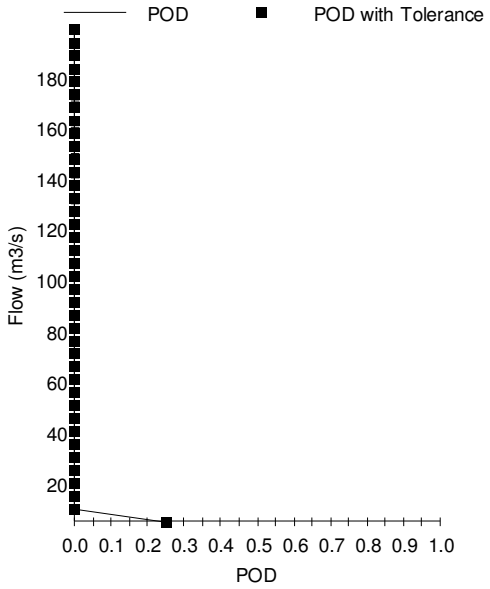
The baseflow routing time constant (Kb) is 21.5hmm^2. The depth of water retained by soil under tension (St) was set at 0mm. A time delay of 1 hour was also assigned to bring timing of peaks more into line.

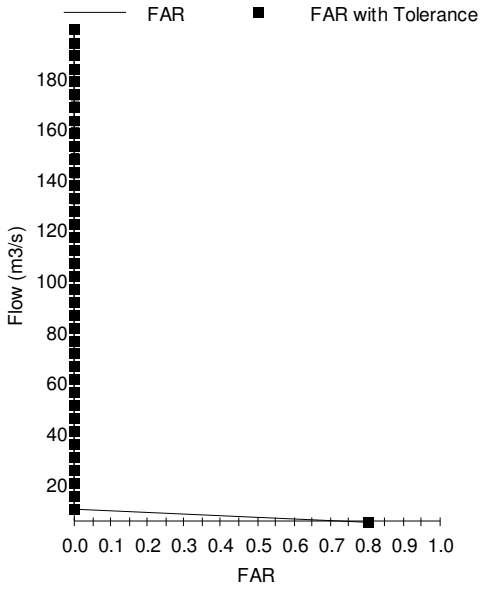
1.4 Overall performance

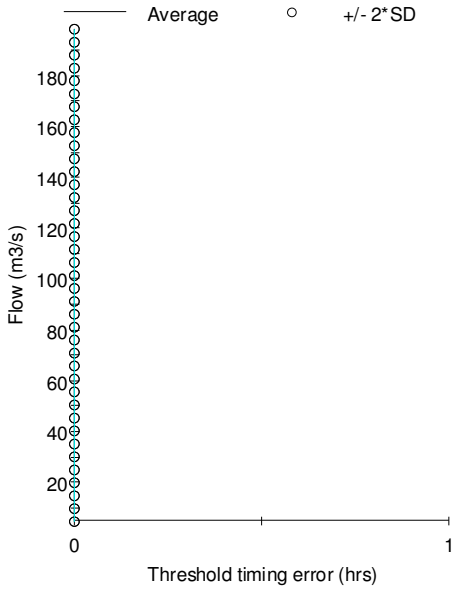
The PDM performance was compared to observed flow data from Gothic Bridge gauging station. Overall performance of the Gothic PDM is reasonable with both hydrograph shape and timing well represented, however the rising limb is better represented than the falling limb. The nature of rainfall inputs will also result in some under performance.

PDM Model Sheet for : Gothic_v1

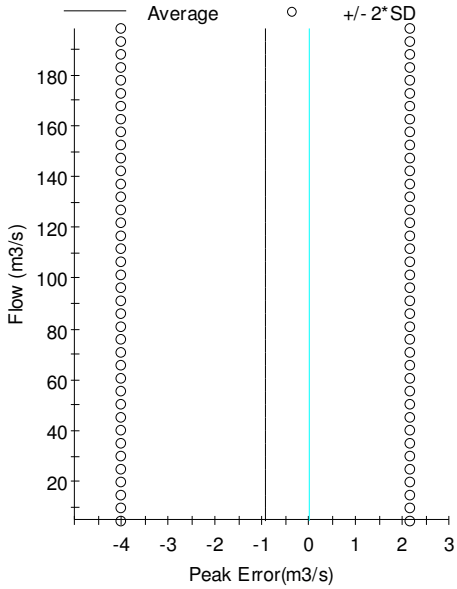
POD, FAR and peak matching statistics over full range of observations

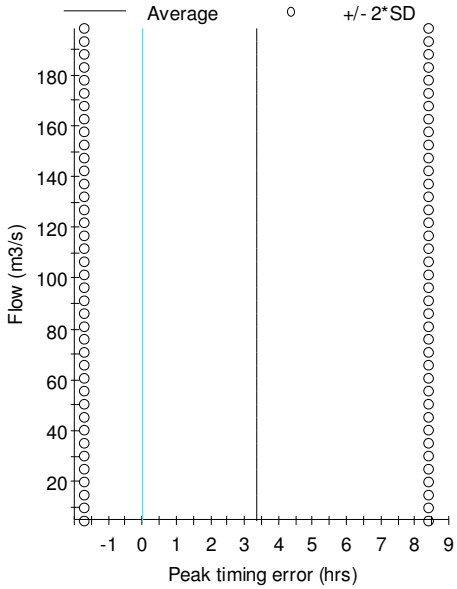






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -7 to +7 hrs



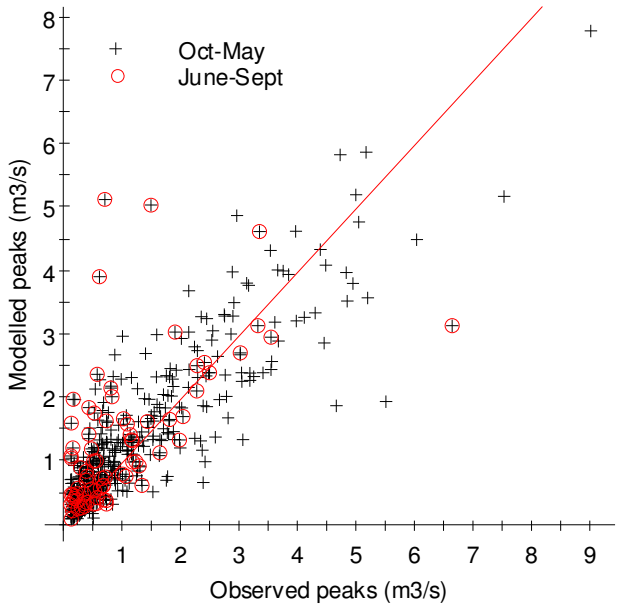


PDM Model Sheet for : Gothic_v1

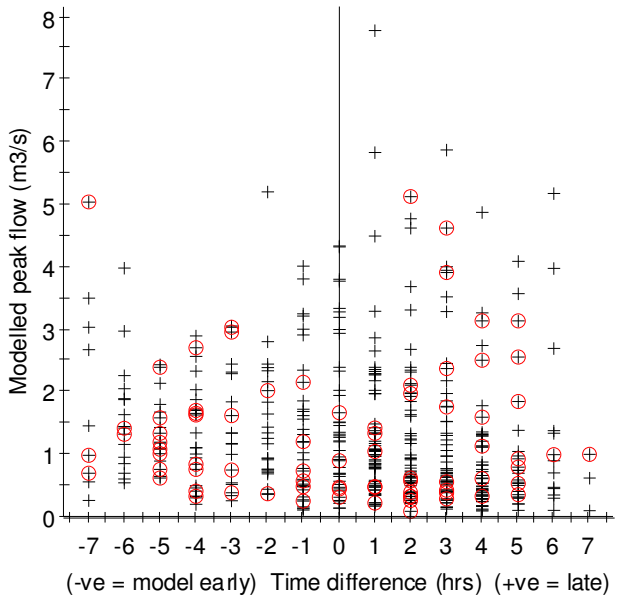
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	19/11/2009 19:00	9.0	19/11/2009 20:00	7.8	-13%	1.0	0.839	0.850	0.980
2	12/01/2010 18:00	7.5	13/01/2010 00:00	5.2	-31%	6.0	0.647	1.595	0.879
3	28/06/2012 08:00	6.6	28/06/2012 12:00	3.1	-52%	4.0	0.387	1.600	0.849
4	21/11/2009 16:00	6.0	21/11/2009 17:00	4.5	-25%	1.0	-11.458	1.522	0.696
5	31/01/2009 04:00	5.5	31/01/2009 04:00	2.0	-64%	0.0	-36.755	3.217	0.982
6	14/02/2014 16:00	5.2	14/02/2014 21:00	3.6	-31%	5.0	-4.871	1.571	0.931
7	10/01/2008 11:00	5.1	10/01/2008 14:00	5.9	14%	3.0	-0.078	1.002	0.589
8	16/11/2009 09:00	5.0	16/11/2009 11:00	4.8	-5%	2.0	0.055	0.610	0.970
9	05/02/2014 10:00	5.0	05/02/2014 08:00	5.2	5%	-2.0	0.814	0.317	0.946
10	12/02/2014 18:00	4.9	12/02/2014 18:00	3.8	-23%	0.0	-1.730	1.151	0.882

Modelled and observed peak flows, r2=0.692

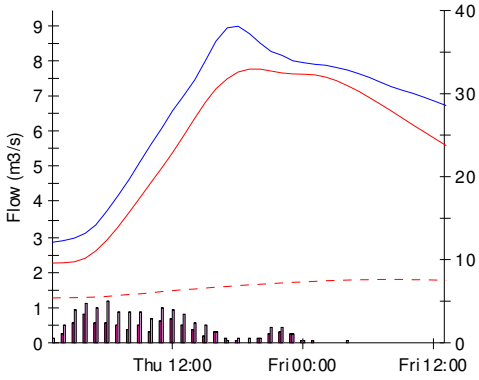


Modelled and observed peak timing

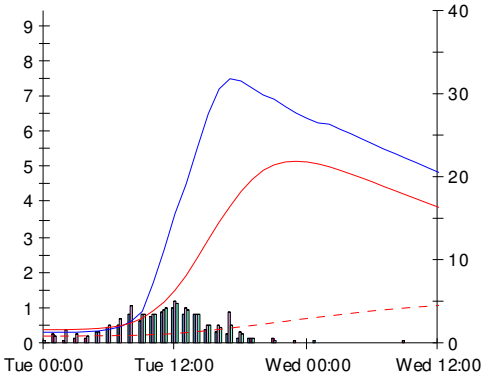


PDM Model Sheet for : Gothic_v1

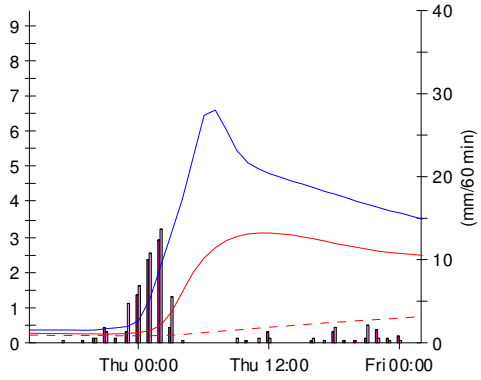
1. 19 Nov 2009 19:00 (36-45-59mm)



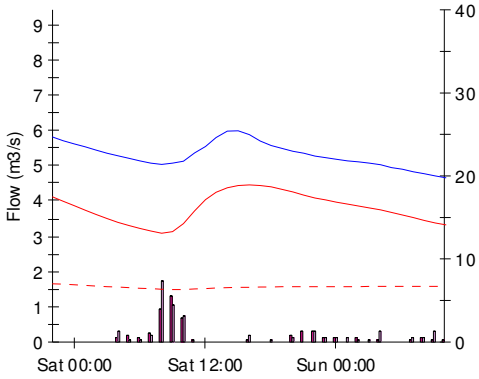
2. 12 Jan 2010 18:00 (36-44-52mm)



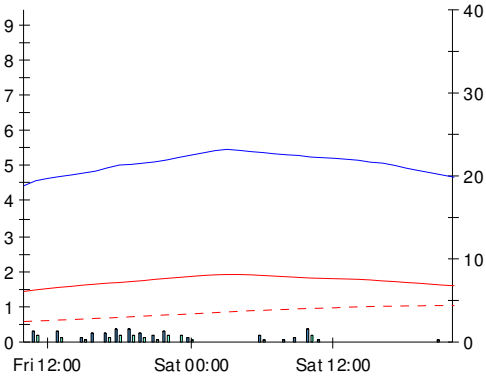
3. 28 Jun 2012 08:00 (30-38-51mm)



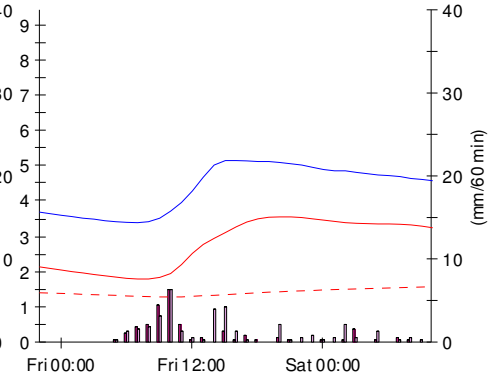
4. 21 Nov 2009 16:00 (19-21-26mm)



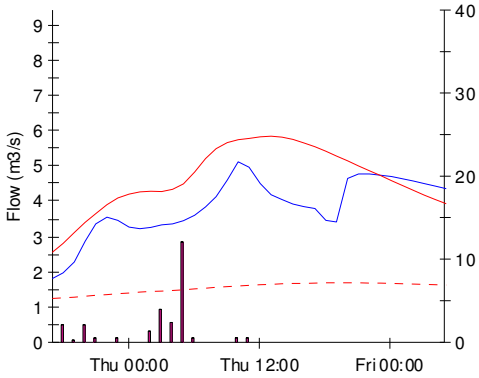
5. 31 Jan 2009 04:00 (0-11-23mm)



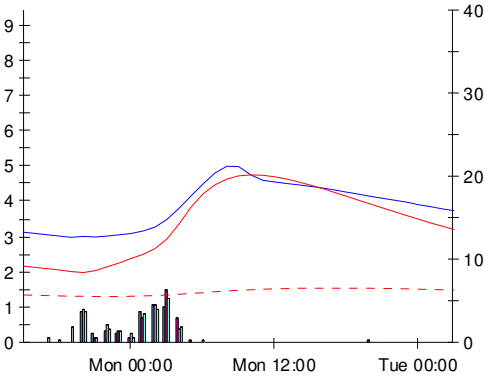
6. 14 Feb 2014 16:00 (18-24-35mm)



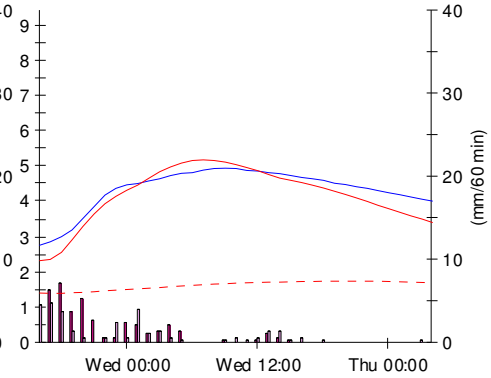
7. 10 Jan 2008 11:00 (24-28-33mm)



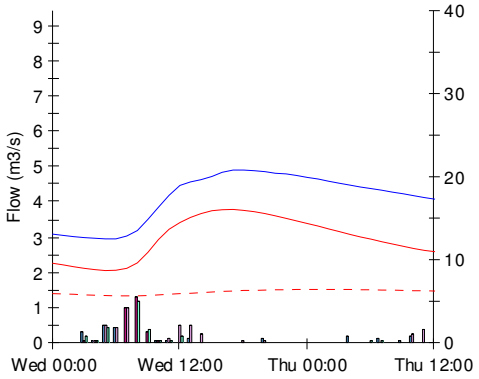
8. 16 Nov 2009 09:00 (22-23-28mm)



9. 05 Feb 2014 10:00 (21-30-43mm)



10. 12 Feb 2014 18:00 (17-20-26mm)

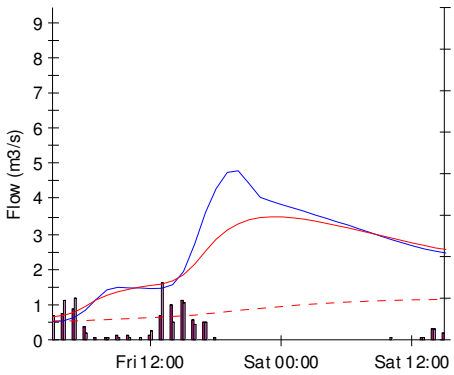


Key

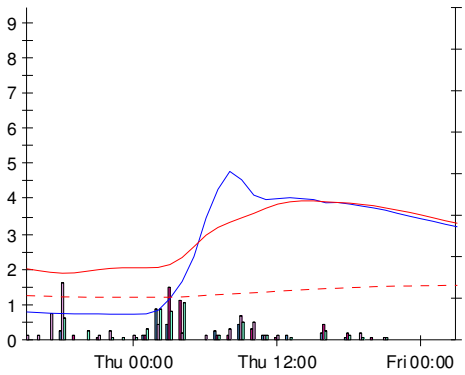
- 19045_irlSG - Flow : Gothic Bridge
- Modelled Q
- Modelled Qg
- Inniscarra_irlREev - Recording Rain : Inniscarra
- BottleHillPHREev - Recording Rain : Bottle Hill Pump House
- BweengPHREev - Recording Rain : Bweeng Pump House
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

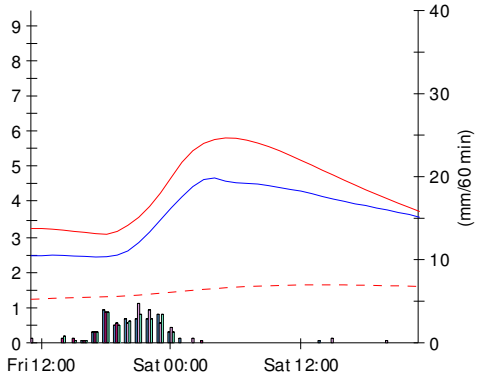
11. 25 Jan 2013 21:00 (26-30-36mm)



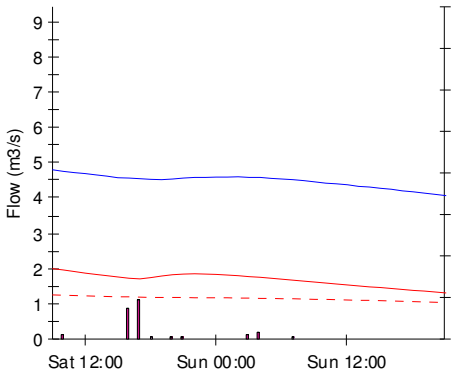
12. 22 Nov 2012 09:00 (20-26-34mm)



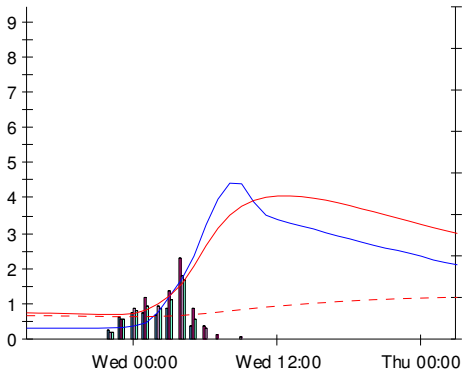
13. 16 Jan 2010 05:00 (23-24-25mm)



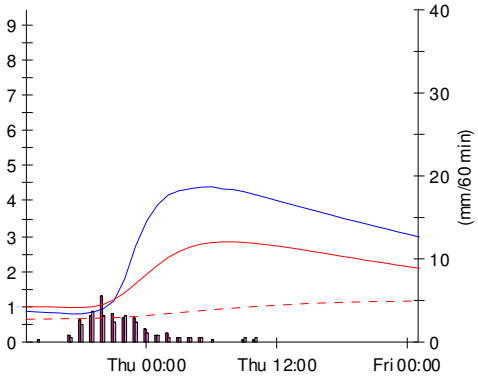
14. 16 Nov 2014 03:00 (0-5-11mm)



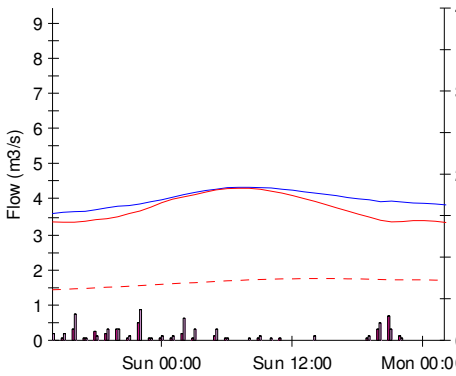
15. 19 Dec 2012 09:00 (24-30-37mm)



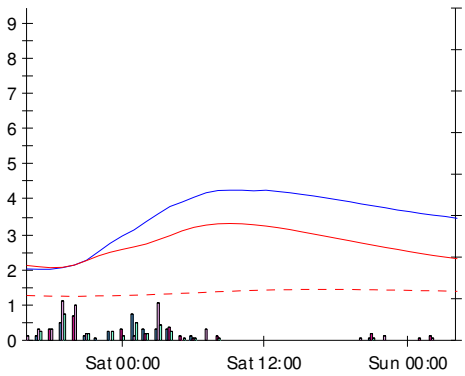
16. 31 Dec 2009 07:00 (13-19-27mm)



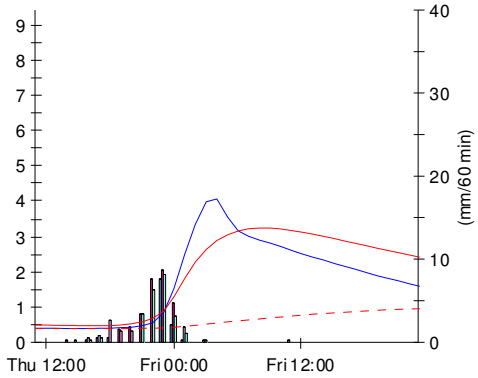
17. 09 Feb 2014 08:00 (15-20-26mm)



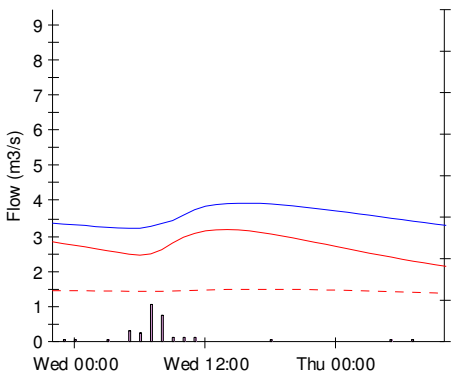
18. 14 Nov 2009 10:00 (14-18-22mm)



19. 18 Jan 2013 05:00 (23-28-34mm)



20. 01 Jan 2014 16:00 (10-10-12mm)



Key

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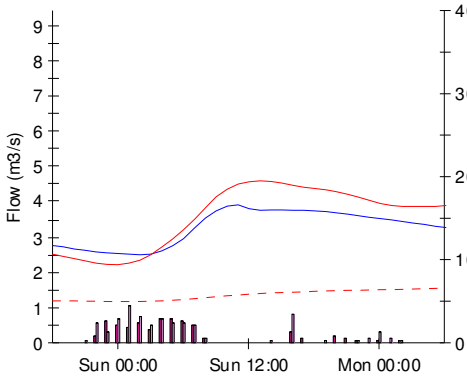
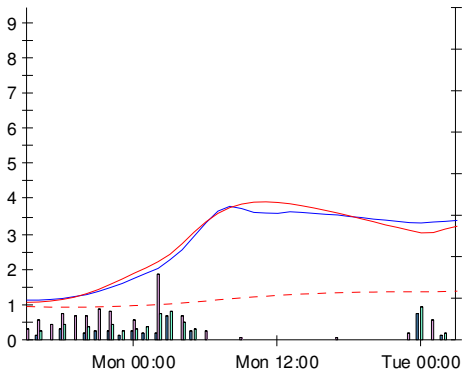
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

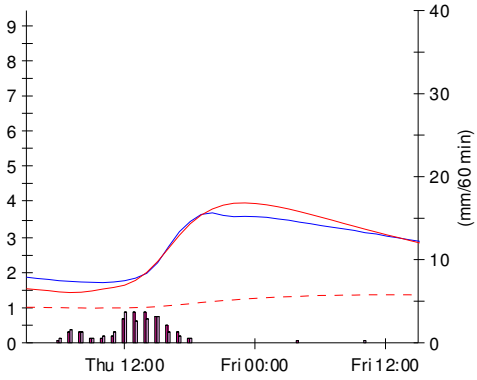
21. 01 Nov 2009 12:00 (26-33-36mm)



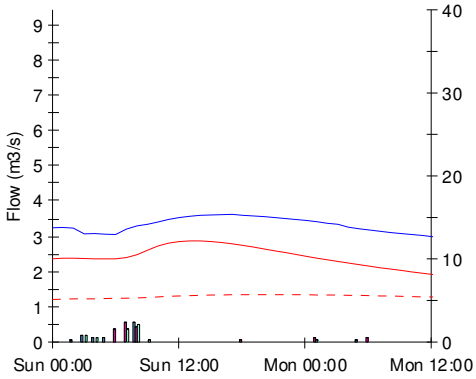
22. 30 Dec 2013 09:00 (21-33-59mm)



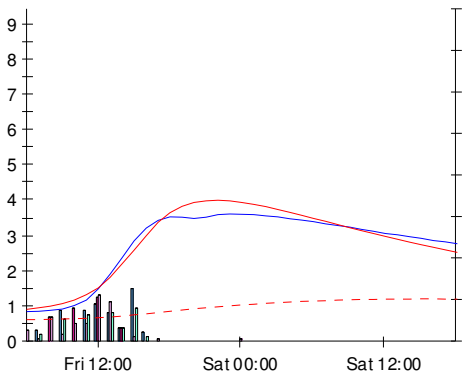
23. 21 Jan 2010 21:00 (21-24-26mm)



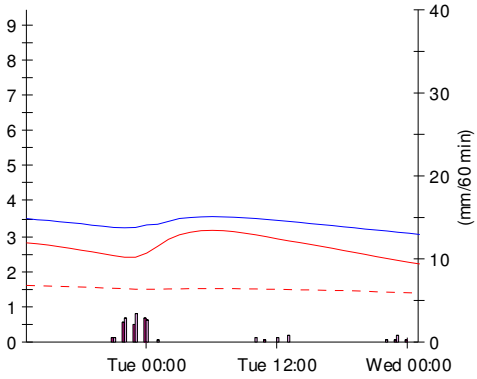
24. 13 Jan 2008 18:00 (9-10-11mm)



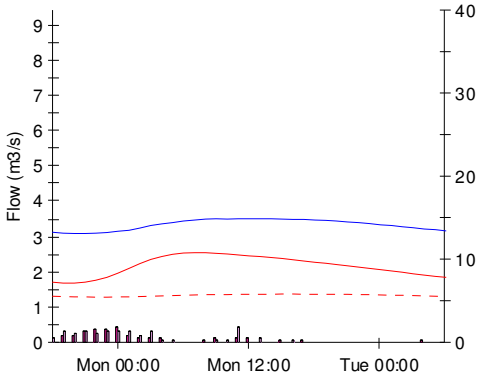
25. 31 Oct 2009 00:00 (23-27-30mm)



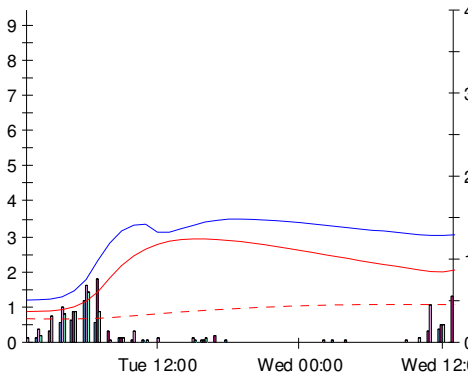
26. 11 Feb 2014 07:00 (9-11-12mm)



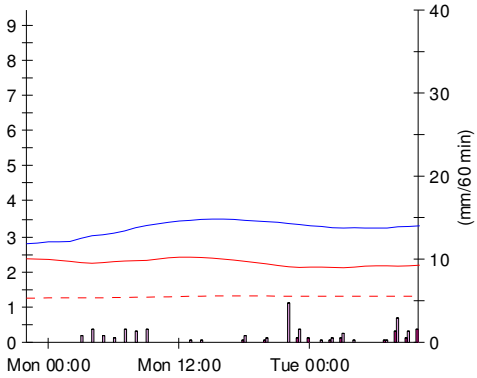
27. 17 Feb 2014 12:00 (13-13-14mm)



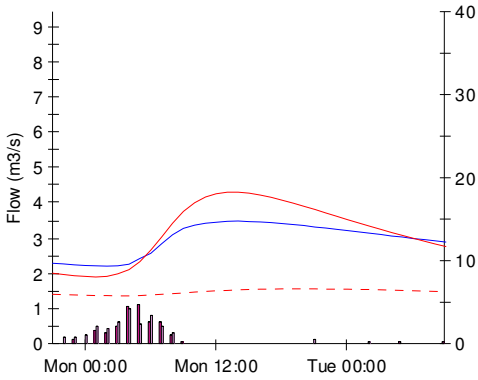
28. 09 Sep 2008 19:00 (20-28-38mm)



29. 06 Jan 2014 16:00 (4-12-23mm)



30. 03 Feb 2014 15:00 (20-21-23mm)



Key

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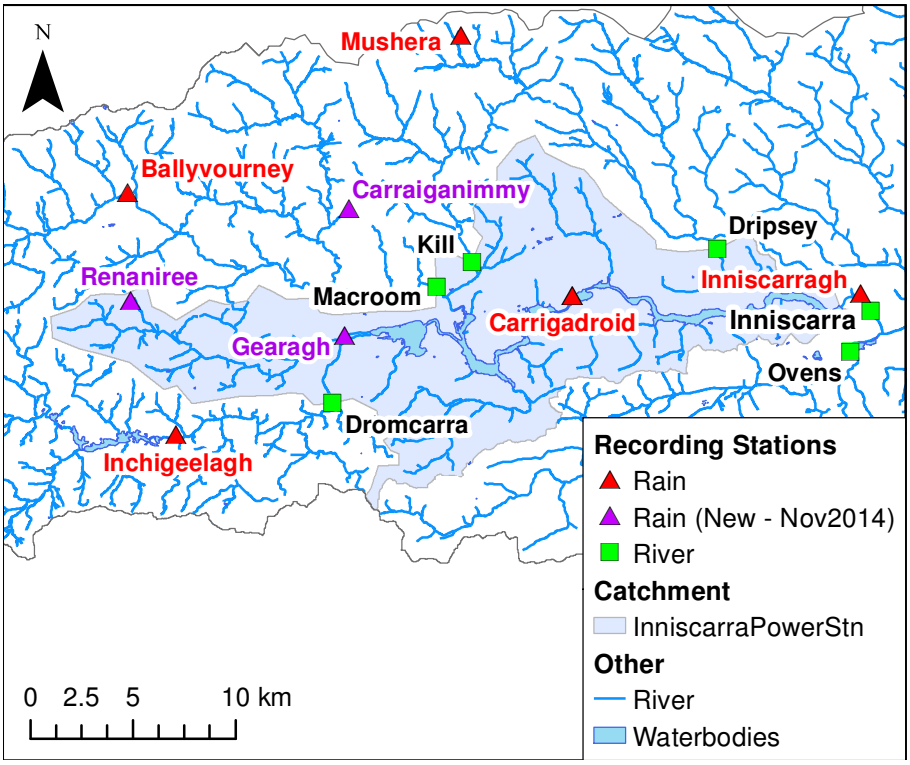
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

PDM Model Sheet for : InniscarraPowerStn_v3



Raingauges used

TBR Ref	Name	Weight
Inniscarra_irlREev	Inniscarra	0.583
Inchigeelagh_irlREev	Inchigeelagh	0.019
Carrig_irlREev	Carrigadrohid	0.388
Mushera_irlREev	Mushera	0.01
Renanir_irlREev	Renanirree	0
Ballvourney_irlREev	Ballvourney	0

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
240.8	1	10	90	1	3	700	1.7	0	4	n/a	36.8	0	0

Calibration Notes

1 InniscarraPowerStn PDM

1.1 Catchment description

InniscarraPowerStn PDM is situated at the downstream boundary of Inniscarra Reservoir and accounts for all lateral inflows to Carrigadrohid and Inniscarra Reservoirs not accounted for by other PDMs. The catchment covers an area of approximately 240km^2 and comprises lower terrain of the Upper Lee valley. Geology is largely impermeable consisting sandstone and siltstone.

1.2 Rainfall and evaporation inputs

The Lee catchment to Inniscarra Power Station receives an annual average precipitation of 1660mm. The only rain gauge situated within the part of catchment represented by lateral inflows is Carrigadrohid. Rainfall inputs to the PDM are taken from Carrigadrohid, Inchigeelagh, Inniscarra, Mushera, Ballyvourney, Renaniree. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Mushera, Ballyvourney, Renaniree have been included for this purpose and as such have very little weight assigned to them initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 3.

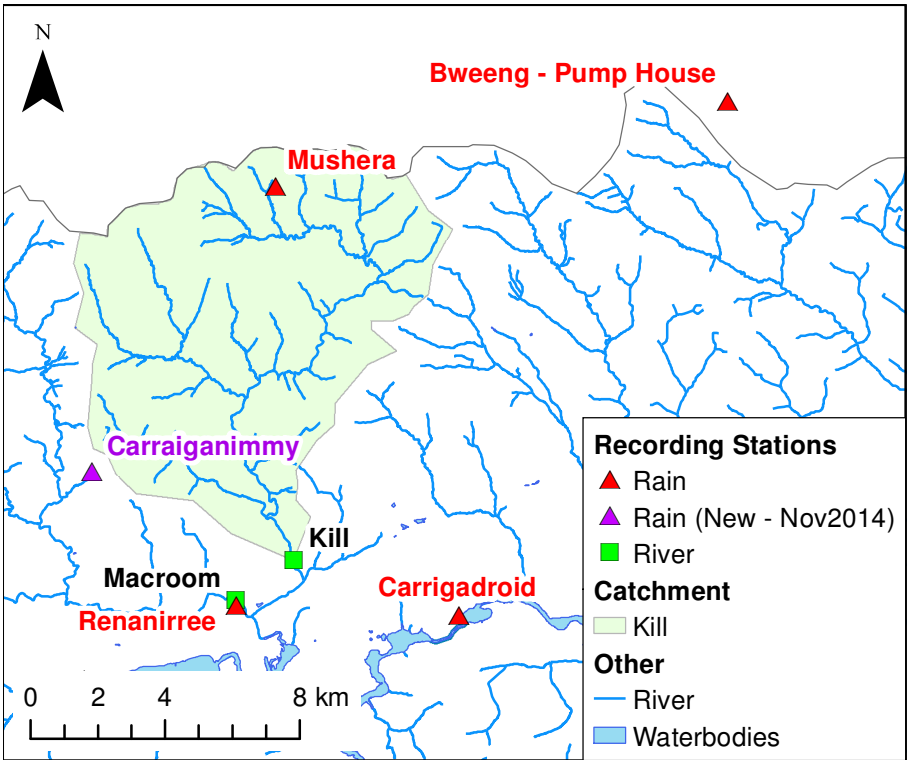
1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the ‘gravity’ method is used for soil drainage.

Soil stores are represented using a Cmax of 90mm and a Cmin of 10mm, with the exponent of the soil store capacity, b (1) allowing even distribution of soil stores between Cmax and Cmin.

Both linear stores have surface routing constants (K_1) of 4 hours. Drainage parameters are Kg = 700 and Bg = 1.7. This combination means drainage to the baseflow store is very quick and is slightly sensitive to soil moisture state.

The baseflow routing time constant (Kb) is 36.8hmm^2. The depth of water retained by soil under tension (St) was set at 0mm.



Raingauges used

TBR Ref	Name	Weight
Mushera_irlREev	Mushera	0.55
Carriganimma_irlREev	Carriganimma	0.45
Carrig_irlREev	Carrigadrohid	0.05
BweengPHREev	Bweeng Pump House	0.05

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	19 Feb 2002 00:00	To	27 Feb 2015 00:00

Flow gauge : (19027_irlSG)

No.	Limb	Description	K	a	p	Max stage	Start-End
368	a	ESB	13.579	-0.150	2.088	1.99	01 Jan 1753-24 Aug 3999

PDM parameters

Surface		Linear cascade		Base	Cubic store			Drainage		Gravity		
Area	**Fc**	**Cmin**	**Cmax**	**b**	**Be**	**Kg**	**Bg**	**St**	**K1**	**K2**	**Kb**	**QConst**	**Tdly**
Km^2		**mm**	**mm**					**mm**	**hrs**	**hrs**	**hmm^2**	**m^3/s**	**hrs**
86.1	1	0	80	1	3	5000	1.8	0	2	6	36.8	0	1

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	2.66	0.13	0.14	1.43	1.14	0.73	1.56	1.45				

Calibration Notes

1 Kill PDM

1.1 Catchment description

Kill PDM is situated on the River Laney at Kill gauging station. The River Laney is a main tributary to the River Sullane which drains into Carrigadrohid Reservoir. The catchment covers an area of approximately 86km^2 and comprises undulating uplands used primarily for hill grazing and forestry. Geology is largely impermeable consisting sandstone and siltstone.

1.2 Rainfall and evaporation inputs

The Laney catchment to Kill receives an annual average precipitation of 1600mm. The only rain gauge situated within the catchment is Mushera. Rainfall inputs to the PDM are taken from Mushera, Carrigadrohid, Renaniree and Bweeng Pump House. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Renaniree and Bweeng Pump House have been included for this purpose and as such have very little weight assigned to them initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 3.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 80mm and a Cmin of 0mm, with the exponent of the soil store capacity, b (1) allowing even distribution of soil stores between Cmax and Cmin.

Both linear stores have surface routing constants (K_1) of 4 hours and a time delay (Tdly) of 1 hour is applied. Drainage parameters are Kg = 5000 and Bg = 1.8. This combination means drainage to the baseflow store is relatively quick and is slightly sensitive to soil moisture state.

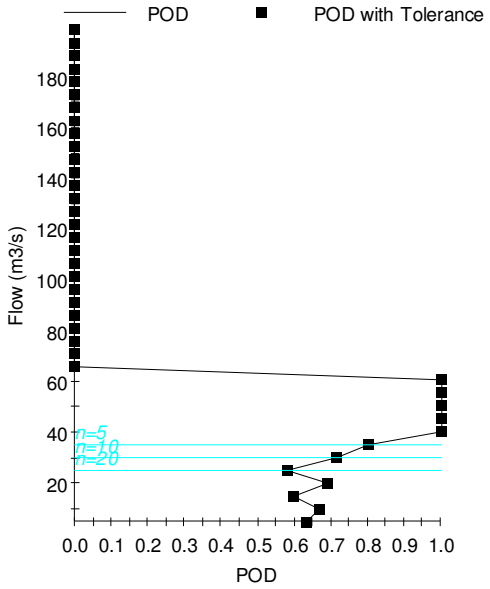
The baseflow routing time constant (Kb) is 36.8hmm^2. The depth of water retained by soil under tension (St) was set at 0mm.

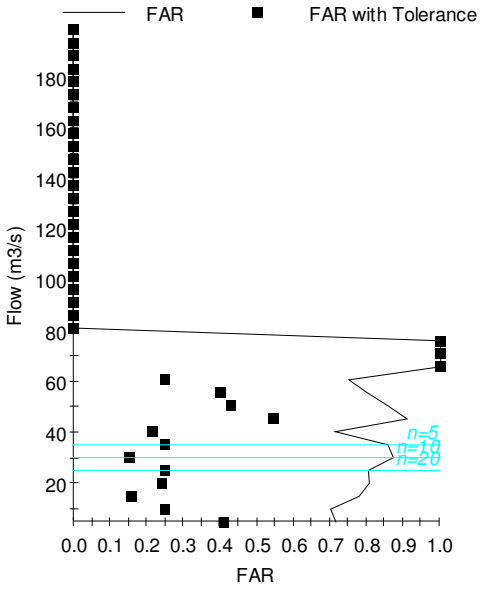
1.4 Overall performance

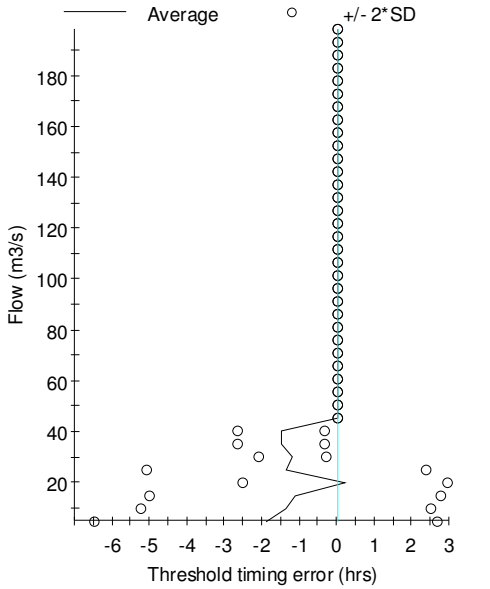
The PDM performance was compared to flow data from Kill gauging station. Overall performance of the Kill PDM is reasonable with both hydrograph shape and timing well represented in the majority of events, although magnitude of peaks is a little variable. The nature of rainfall inputs will also result in some under performance.

PDM Model Sheet for : Kill_v3

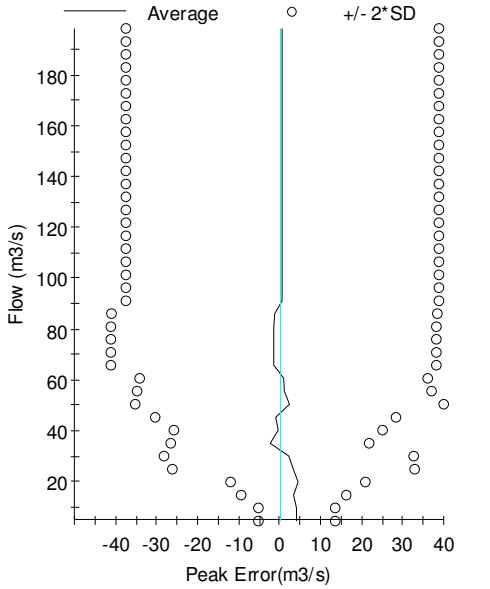
POD, FAR and peak matching statistics over full range of observations

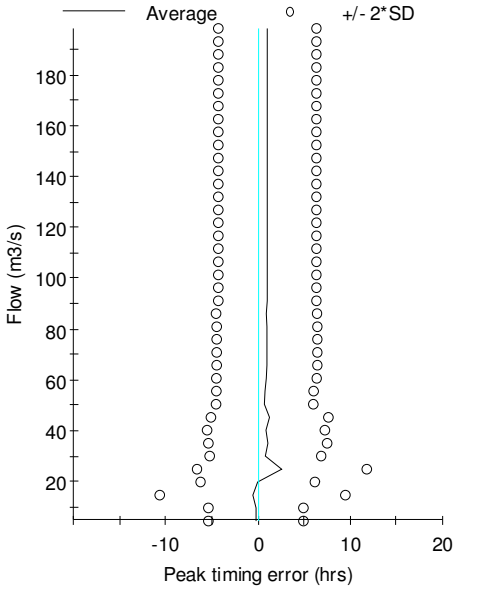






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -7 to +7 hrs



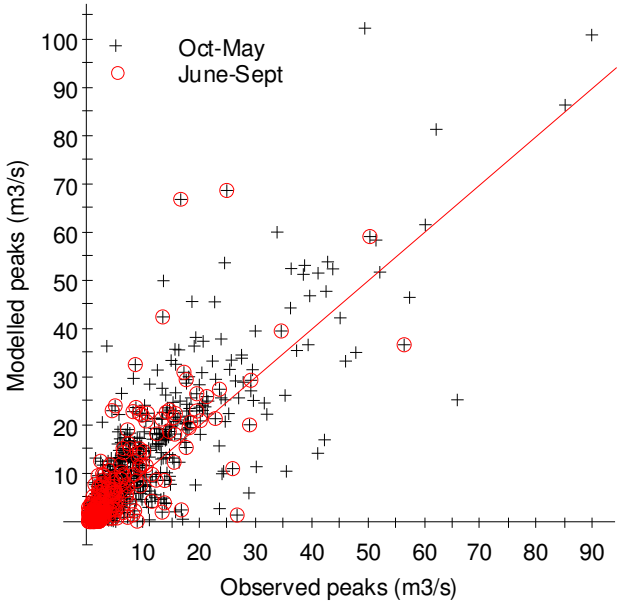


PDM Model Sheet for : Kill_v3

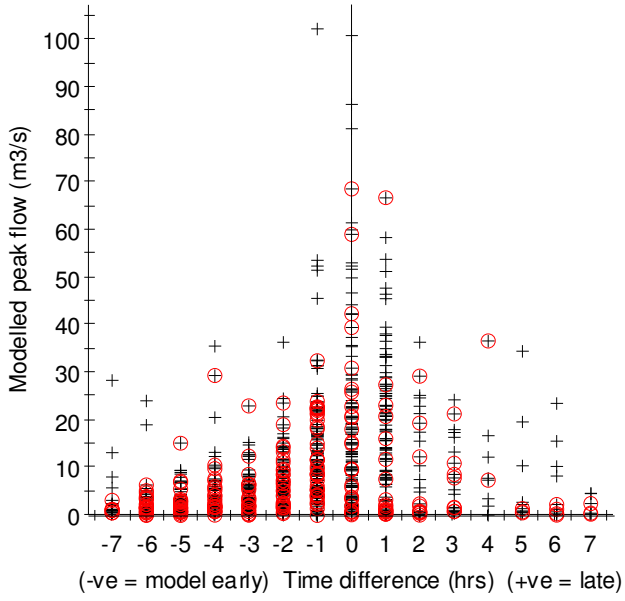
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	25/10/2013 04:00	89.6	25/10/2013 04:00	100.8	13%	0.0	0.573	16.320	0.889
2	19/11/2009 16:00	84.8	19/11/2009 16:00	86.3	2%	0.0	0.871	7.401	0.933
3	03/12/2006 03:00	65.7	03/12/2006 05:00	25.3	-61%	2.0	-0.329	16.600	0.899
4	30/12/2013 06:00	62.0	30/12/2013 06:00	81.3	31%	0.0	0.330	15.006	0.904
5	10/01/2008 08:00	60.0	10/01/2008 08:00	61.5	2%	0.0	0.505	9.156	0.824
6	18/01/2013 03:00	57.3	18/01/2013 04:00	46.5	-19%	1.0	0.744	7.258	0.774
7	28/06/2012 05:00	56.3	28/06/2012 09:00	36.7	-35%	4.0	0.137	14.373	0.212
8	19/12/2012 08:00	52.0	19/12/2012 08:00	51.7	0%	0.0	0.651	8.120	0.800
9	14/01/2015 22:00	51.3	14/01/2015 23:00	58.4	14%	1.0	0.645	8.508	0.889
10	01/08/2008 02:00	50.2	01/08/2008 02:00	59.0	18%	0.0	0.820	5.717	0.956

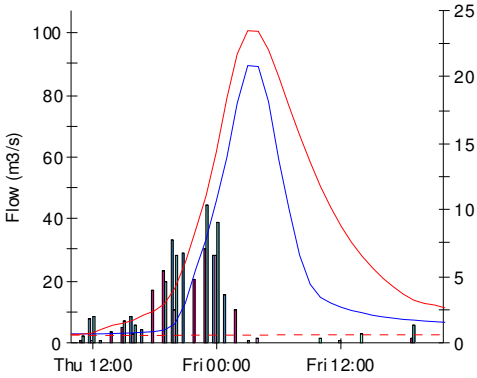
Modelled and observed peak flows, r2=0.701



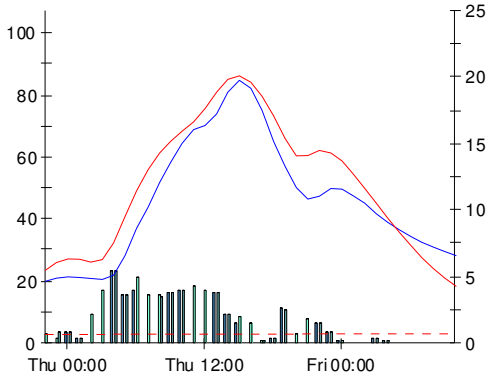
Modelled and observed peak timing



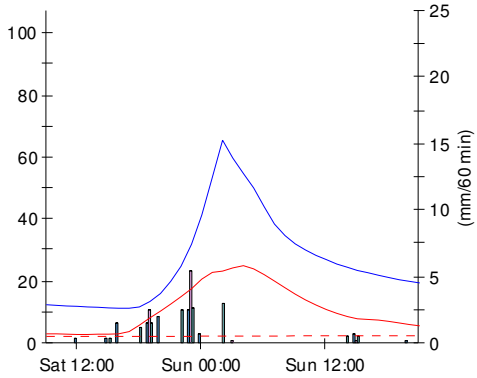
1. 25 Oct 2013 04:00 (2-63-69mm)



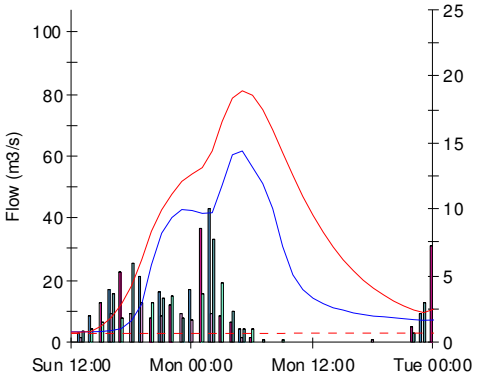
2. 19 Nov 2009 16:00 (61-76-77mm)



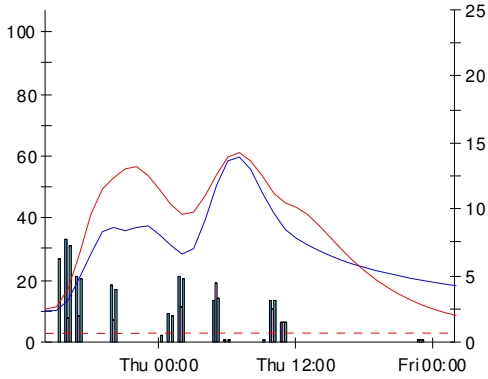
3. 03 Dec 2006 03:00 (21-22-33mm)



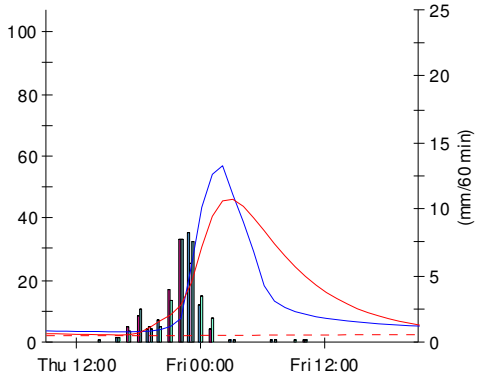
4. 30 Dec 2013 06:00 (33-61-64mm)



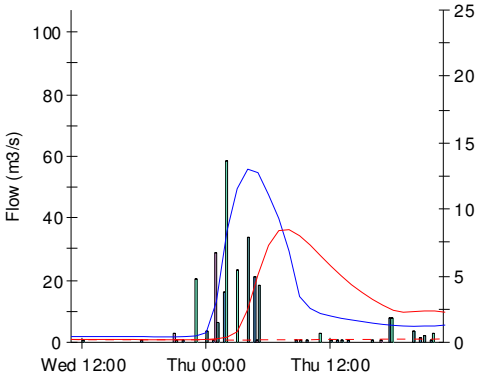
5. 10 Jan 2008 08:00 (35-55-56mm)



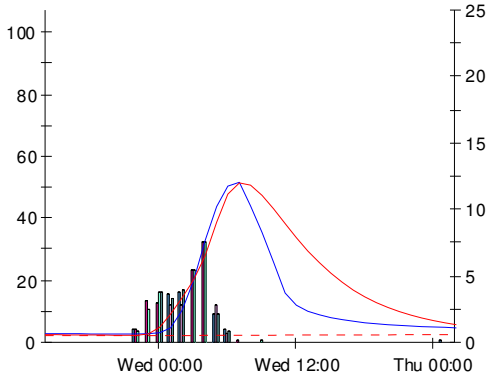
6. 18 Jan 2013 03:00 (20-30-32mm)



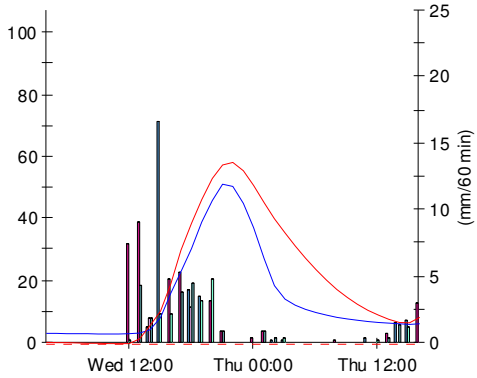
7. 28 Jun 2012 05:00 (41-42-50mm)



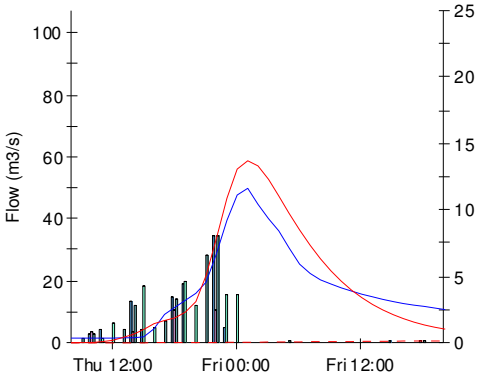
8. 19 Dec 2012 08:00 (22-32-34mm)



9. 14 Jan 2015 22:00 (21-45-55mm)



10. 01 Aug 2008 02:00 (41-47-49mm)



Key

- 19027_irlSG - Flow : Kill
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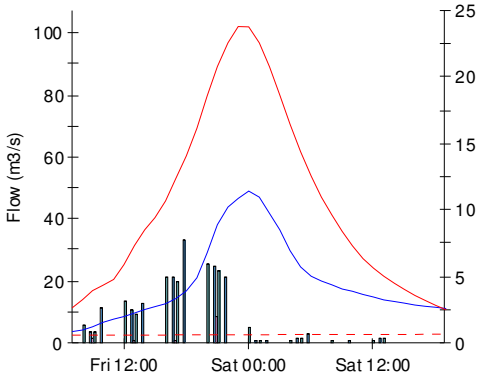
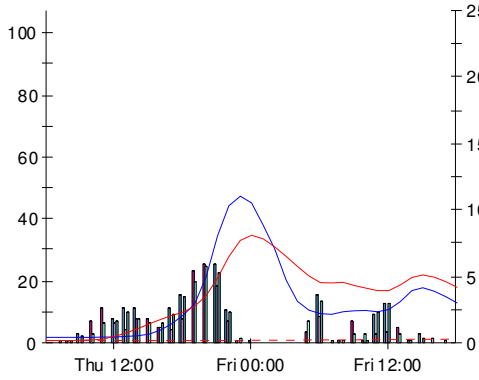
Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

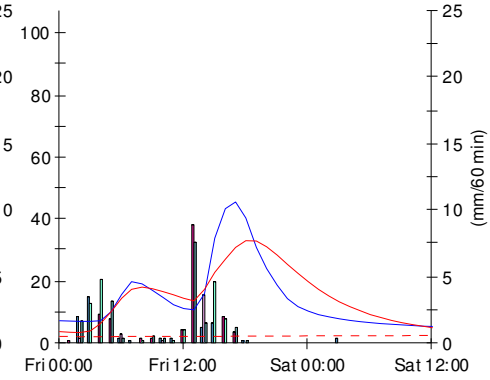
11. 08 Jan 2005 01:00 (15-71-76mm)



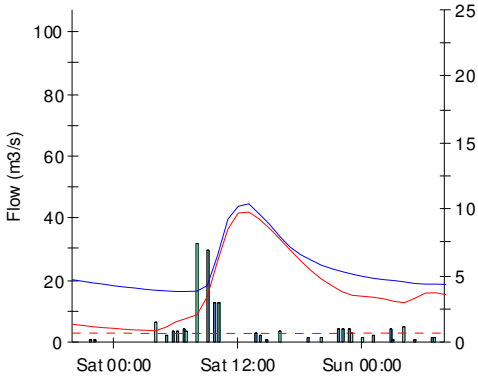
12. 22 Mar 2013 00:00 (26-53-59mm)



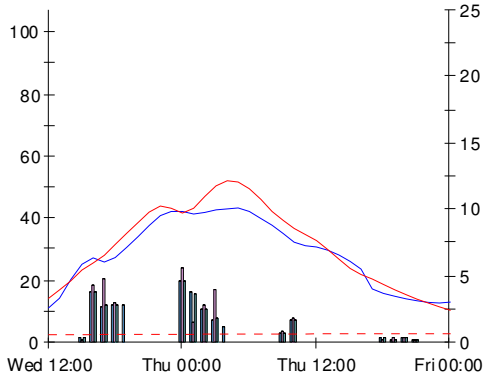
13. 25 Jan 2013 18:00 (23-30-34mm)



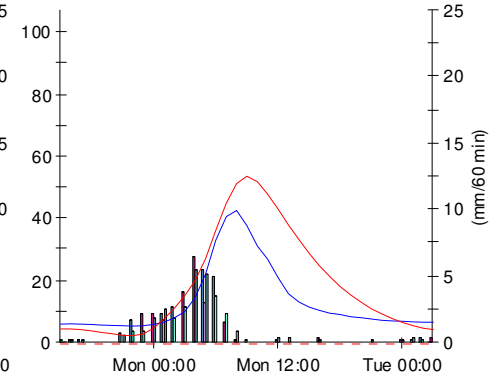
14. 21 Nov 2009 14:00 (24-32-32mm)



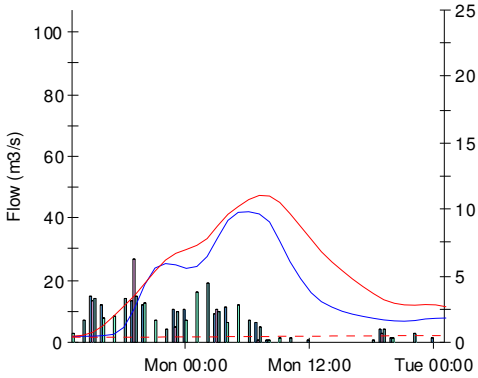
15. 28 Oct 2004 06:00 (51-51-55mm)



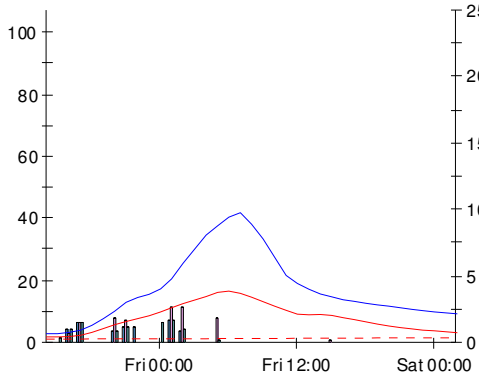
16. 03 Feb 2014 09:00 (23-35-37mm)



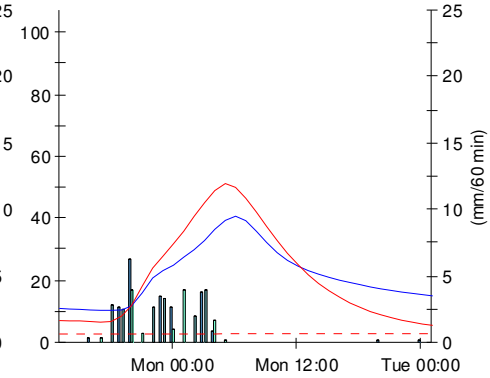
17. 19 Nov 2012 07:00 (43-53-55mm)



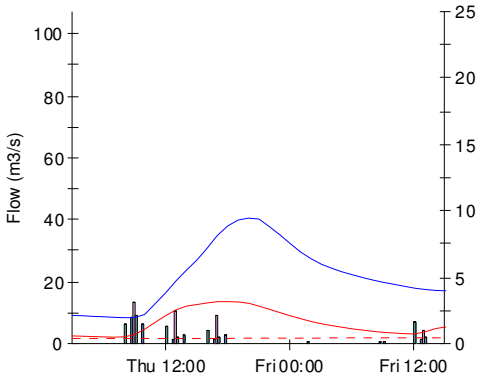
18. 13 Jan 2006 08:00 (20-21-32mm)



19. 16 Nov 2009 07:00 (28-34-35mm)



20. 30 Nov 2006 21:00 (14-16-38mm)



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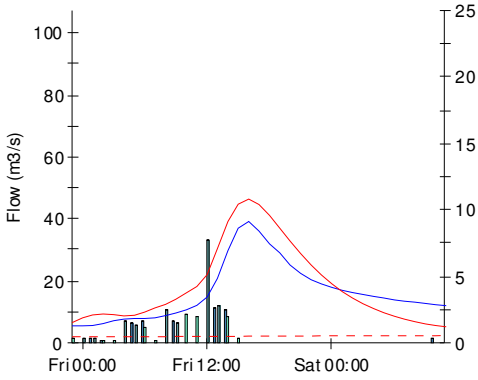
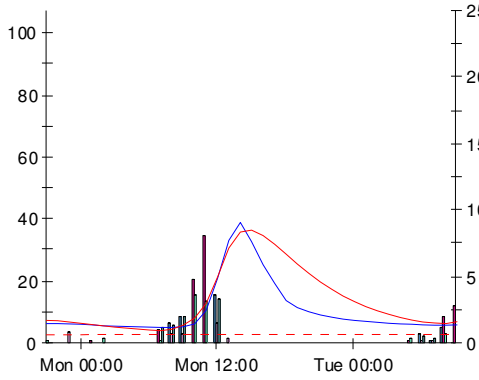
Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

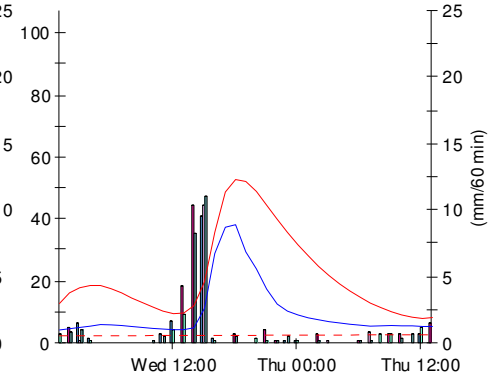
21. 30 Oct 2009 17:00 (27-34-32mm)



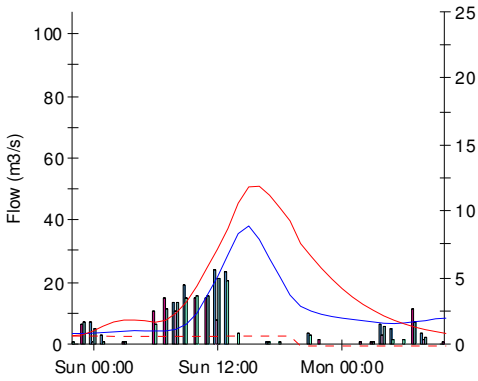
22. 28 Jan 2013 15:00 (11-21-24mm)



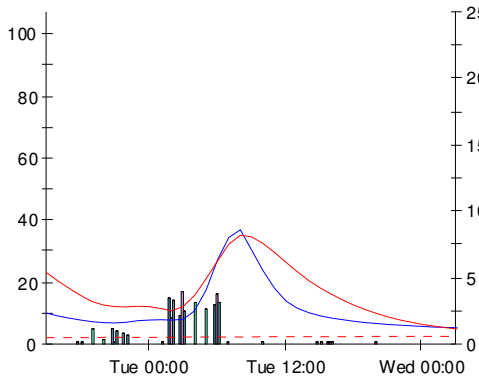
23. 18 Dec 2013 19:00 (24-35-44mm)



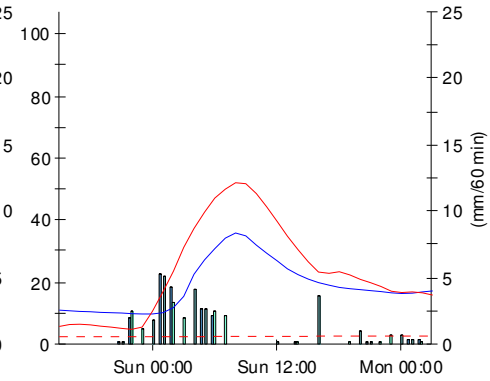
24. 12 Jan 2014 16:00 (27-42-45mm)



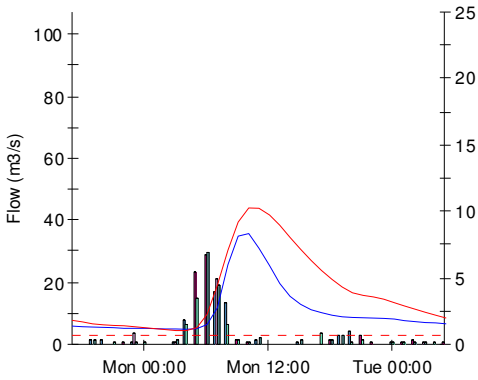
25. 20 Nov 2012 09:00 (16-20-21mm)



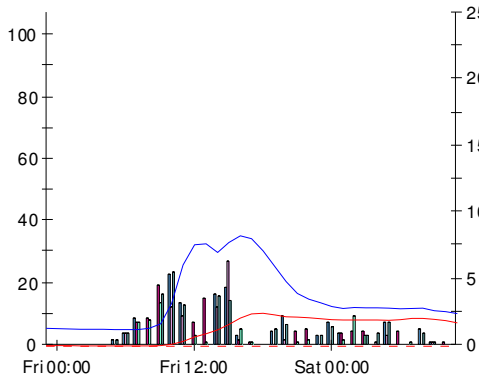
26. 01 Nov 2009 09:00 (34-44-45mm)



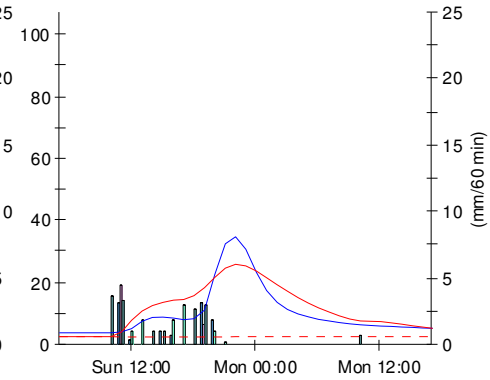
27. 23 Dec 2013 11:00 (19-27-30mm)



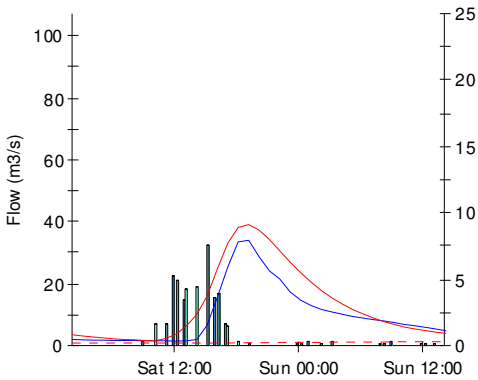
28. 14 Feb 2014 17:00 (26-42-44mm)



29. 25 Nov 2012 23:00 (17-23-24mm)



30. 11 Jul 2009 20:00 (32-36-36mm)



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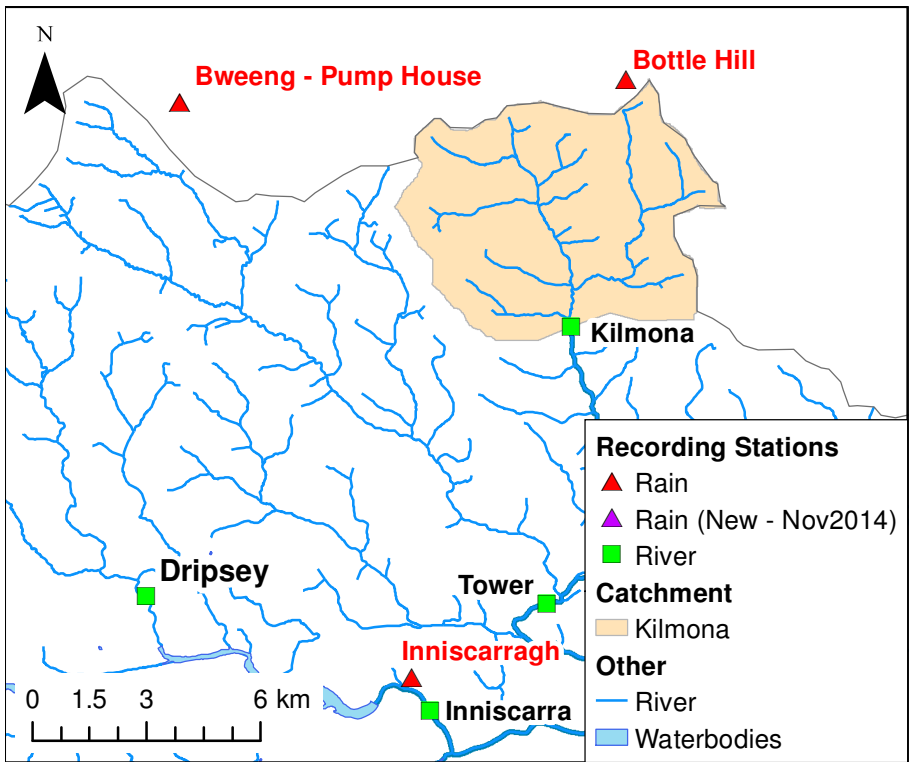


Raingauges used

TBR Ref	Name	Weight
BottleHillPHREev	Bottle Hill Pump House	0.6
BweengPHREev	Bweeng Pump House	0.3
Inniscarra_irlREev	Inniscarra	0.015
Renanir_irlREev	Renanirree	0.015

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	17 Jan 2003 00:00	To	11 Feb 2015 00:00

Flow gauge : (19044_irlFQ)

No.	Limb	Description	K	a	p	Max stage	Start-End
1	a	2013s7330Lee	4.010	0.000	1.503	0.10	01 Jan 1753-31 Dec 3999
1	b	2013s7330Lee	4.397	0.005	1.576	0.30	01 Jan 1753-31 Dec 3999

PDM parameters

Surface	Linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
39.6	1	0	60	0.75	2.5	200	1.5	0	1	1.5	79.4	0	1.75

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	3.13	2.16	1.87	1.10	1.33	0.31	2.87	2.03				

Calibration Notes

1 Kilmona PDM

1.1 Catchment description

Kilmona PDM is situated on the River Martin at Kilmona gauging station. The River Martin is a tributary of the River Blarney which in turn is one of two main tributaries to the River Shournagh. The catchment covers an area of approximately 40km^2 and comprises steep-sloping valleys with the Boggeragh Mountains to the northwest of the catchment. Geology is largely impermeable consisting of mudstone, siltstone and sandstone which is overlain by well-drained acid brown earths.

1.2 Rainfall and evaporation inputs

The Martin catchment to Kilmona receives an annual average precipitation of 1210mm. There are no rain gauges situated within the catchment; the nearest is Bottle Hill Pump House to the north of the catchment. Rainfall inputs to the PDM are taken from Bottle Hill Pump House, Bweeng Pump House, Renanirree and Inniscarra. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Inniscarra and Renanirree have been included for this purpose and as such have very little weight assigned to them initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 2.5.

1.3 PDM parameters

The PDM is structured with a cascade of linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 60mm and a Cmin of 0mm, with the exponent of the soil store capacity, b (0.75) favouring deeper soil stores. This allows runoff to vary as the soil wets up.

Linear stores have surface routing constants (K_1 and K_2) of 1 hour and 1.5 hours respectively. This results in quicker and slower response components to the peak hydrograph thereby accounting for varying attenuation. Drainage parameters are Kg = 200 and Bg = 1.5. This combination means drainage to the baseflow store is very quick and is fairly sensitive to soil moisture state.

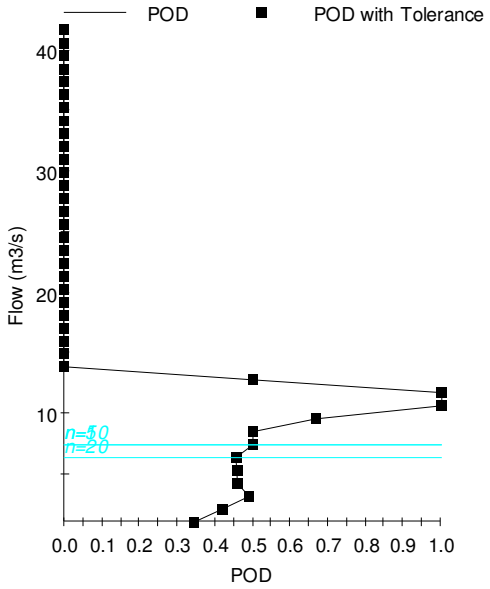
The baseflow routing time constant (Kb) is 79.4hmm^2. The depth of water retained by soil under tension (St) was set at 0mm. A time delay of 1.75 hours was also assigned to bring timing of peaks more into line.

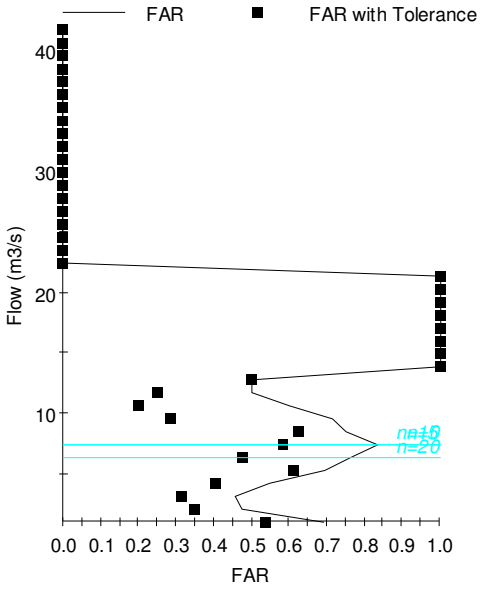
1.4 Overall performance

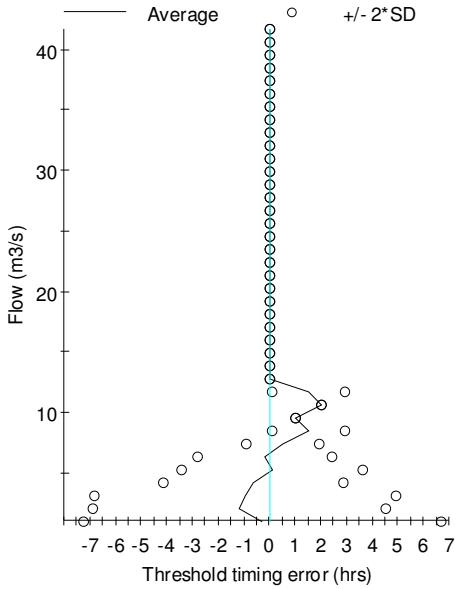
The PDM performance was compared to observed flow data from Kilmona gauging station. Overall performance of the Kilmona PDM is reasonable with both hydrograph shape and timing well represented, although estimation larger peaks is a little variable. The nature of rainfall inputs will also result in some under performance.

PDM Model Sheet for : Kilmona_v1

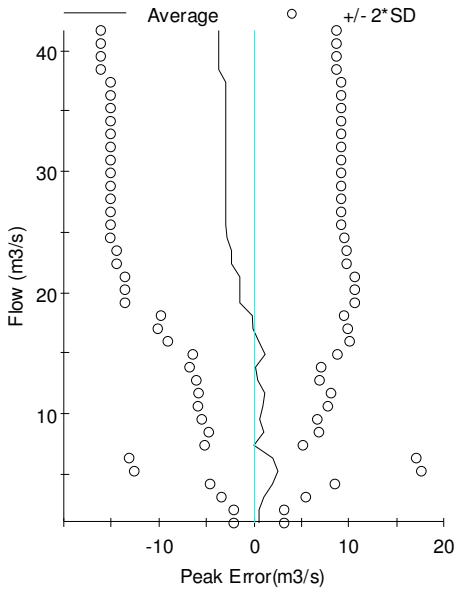
POD, FAR and peak matching statistics over full range of observations

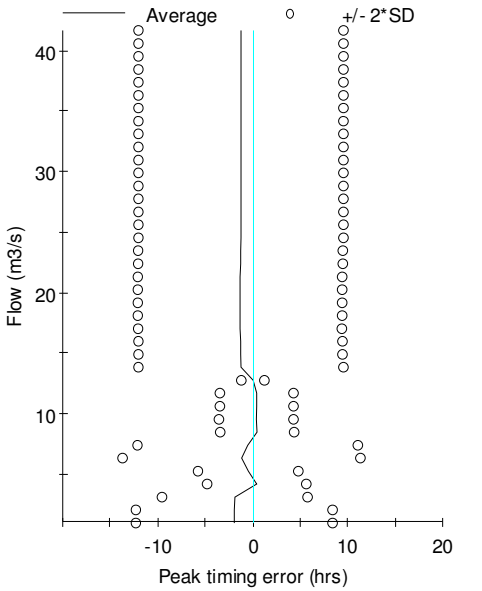






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -12 to +12 hrs

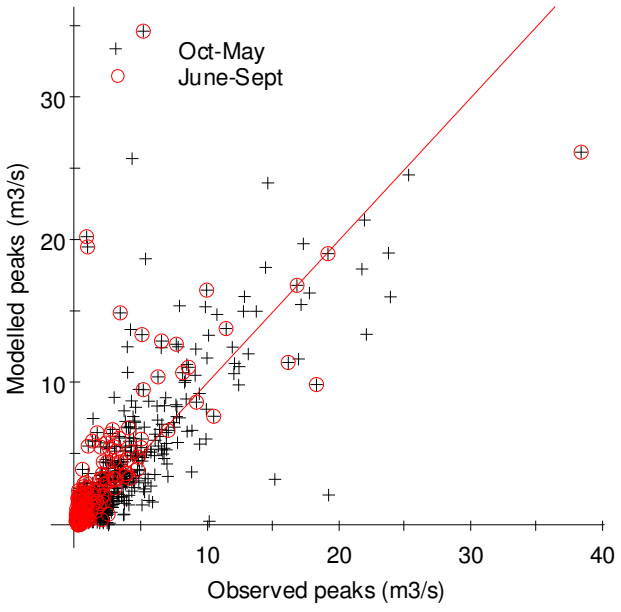




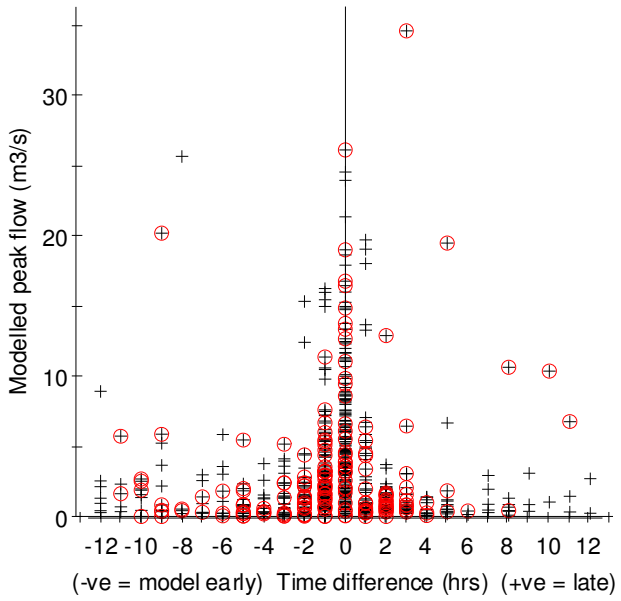
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	28/06/2012 05:00	38.3	28/06/2012 05:00	26.1	-32%	0.0	0.878	2.415	0.971
2	10/01/2008 08:00	25.2	10/01/2008 08:00	24.6	-3%	0.0	0.844	1.769	0.858
3	19/11/2009 16:00	23.8	19/11/2009 15:00	16.0	-33%	-1.0	0.739	2.669	0.948
4	12/01/2010 15:00	23.7	12/01/2010 16:00	19.1	-19%	1.0	0.885	1.879	0.944
5	22/11/2012 06:00	22.1	22/11/2012 06:00	13.4	-39%	0.0	0.616	2.380	0.892
6	19/12/2012 07:00	21.9	19/12/2012 07:00	21.4	-2%	0.0	0.932	1.024	0.975
7	18/01/2013 02:00	21.7	18/01/2013 02:00	18.0	-17%	0.0	0.950	0.861	0.980
8	11/10/2012 06:00	19.2	11/10/2012 06:00	2.2	-89%	0.0	0.132	3.200	0.866
9	15/08/2012 11:00	19.1	15/08/2012 11:00	19.0	0%	0.0	0.444	2.790	0.886
10	29/08/2012 00:00	18.3	29/08/2012 00:00	9.9	-46%	0.0	0.707	1.588	0.853

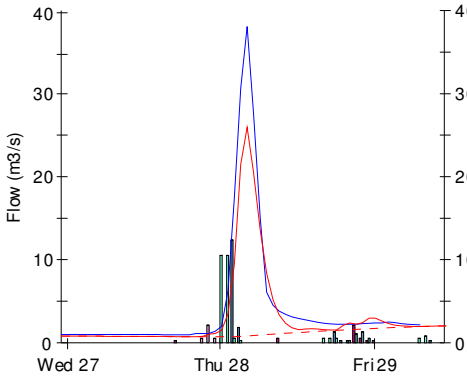
Modelled and observed peak flows, r2=0.603



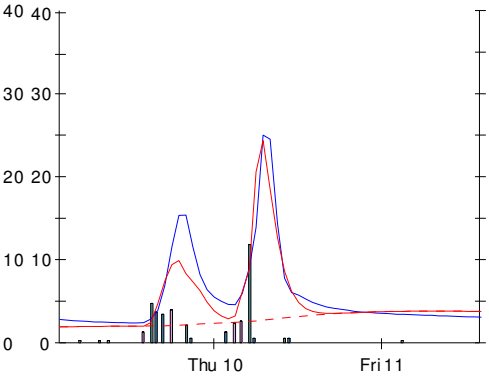
Modelled and observed peak timing



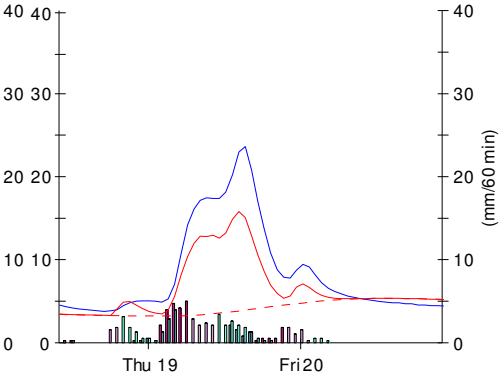
1. 28 Jun 2012 05:00 (30-44-52mm)



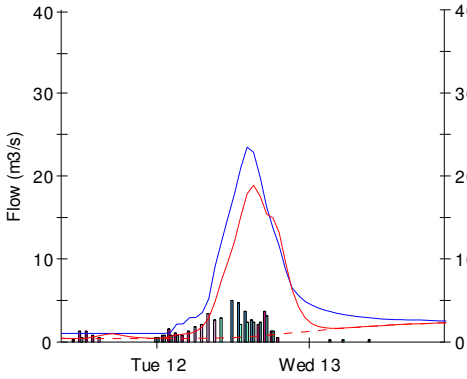
2. 10 Jan 2008 08:00 (33-39-39mm)



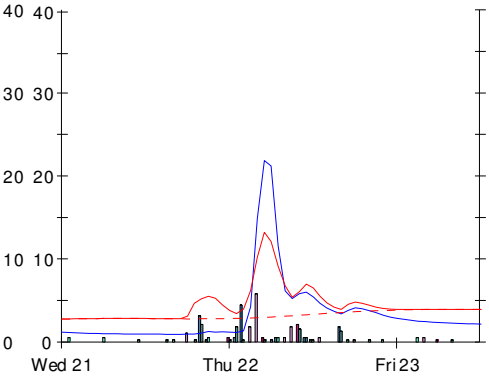
3. 19 Nov 2009 16:00 (39-50-91mm)



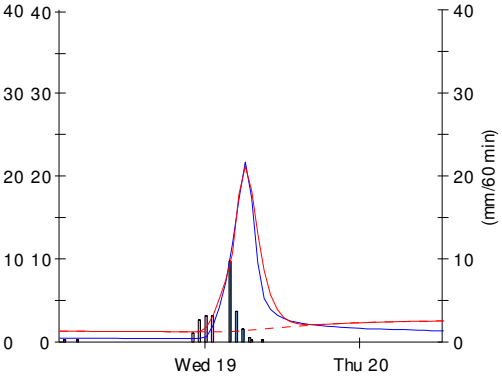
4. 12 Jan 2010 15:00 (42-56-57mm)



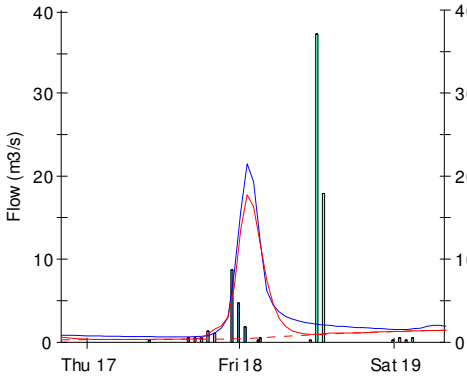
5. 22 Nov 2012 06:00 (20-31-35mm)



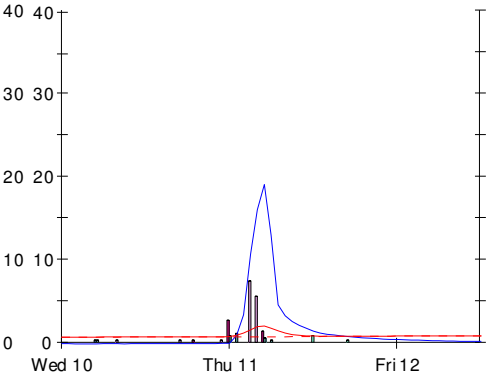
6. 19 Dec 2012 07:00 (0-35-37mm)



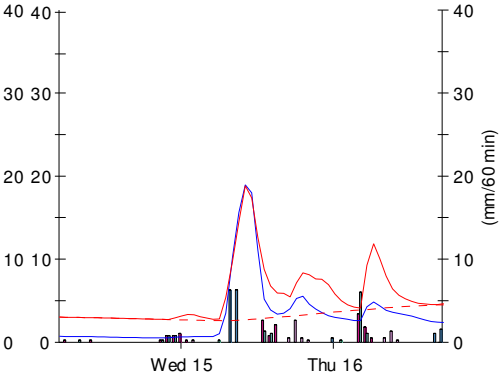
7. 18 Jan 2013 02:00 (25-33-57mm)



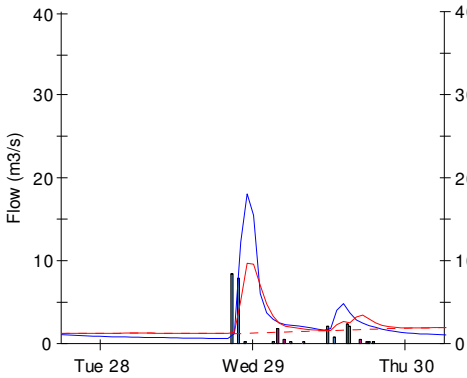
8. 11 Oct 2012 06:00 (0-8-25mm)



9. 15 Aug 2012 11:00 (2-53-60mm)



10. 29 Aug 2012 00:00 (0-25-27mm)



Key

- 19044_irlFQ - Flow : Kilmona Bridge
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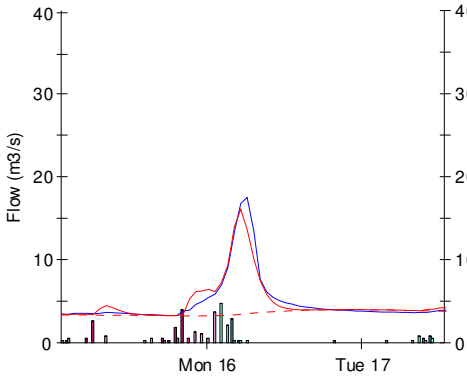
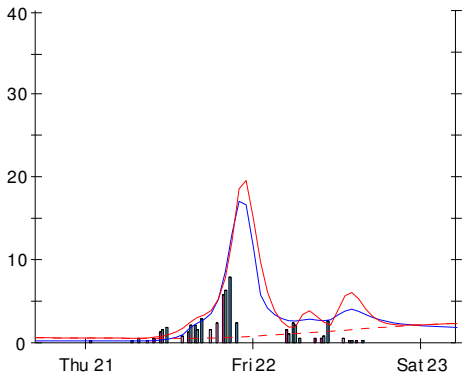
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

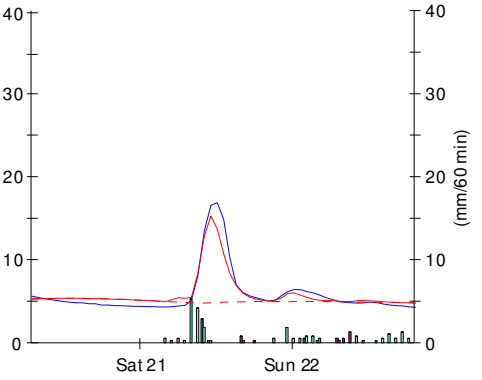
11. 16 Nov 2009 07:00 (28-30-41mm)



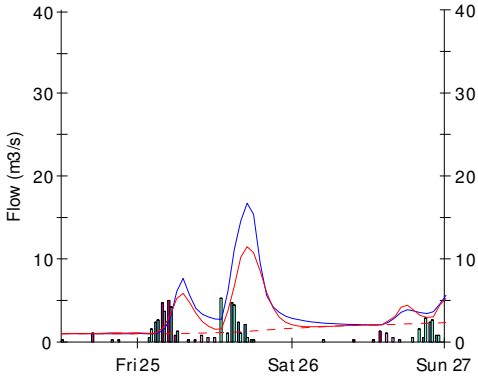
12. 21 Mar 2013 23:00 (0-53-58mm)



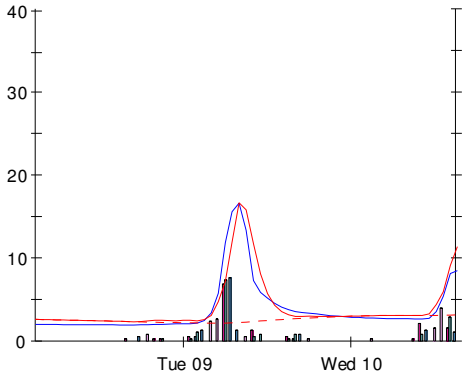
13. 21 Nov 2009 13:00 (21-24-32mm)



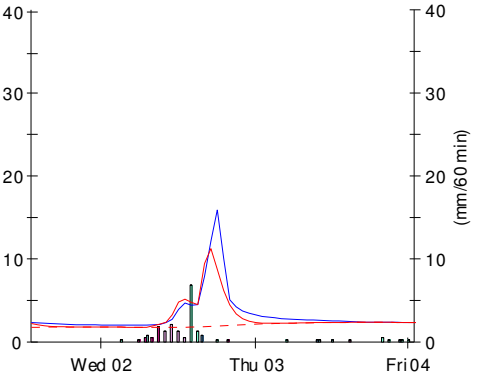
14. 25 Jan 2013 18:00 (30-43-49mm)



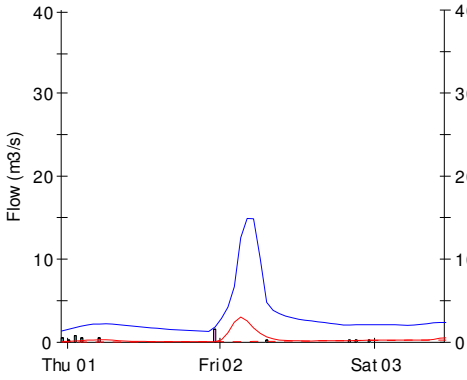
15. 09 Sep 2008 09:00 (29-45-49mm)



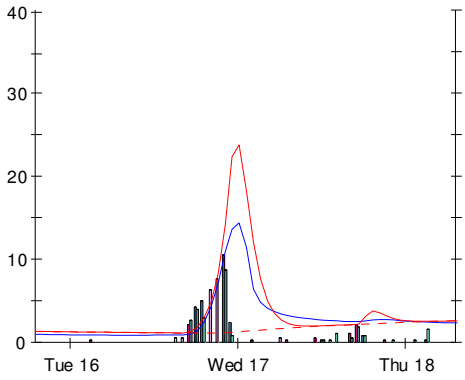
16. 02 Sep 2009 19:00 (10-23-26mm)



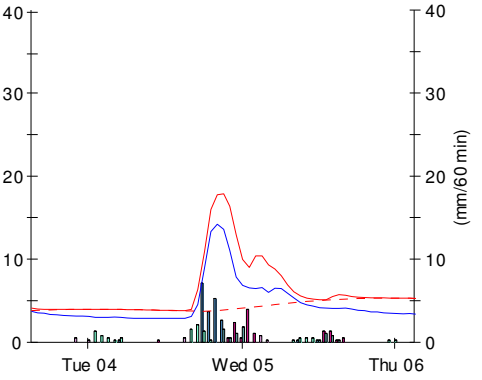
17. 02 Dec 2005 05:00 (16mm)



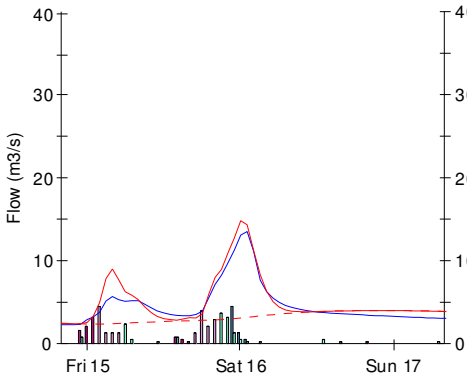
18. 17 Nov 2010 01:00 (36-43-44mm)



19. 04 Feb 2014 21:00 (22-40-44mm)



20. 16 Jan 2010 02:00 (37-40-47mm)



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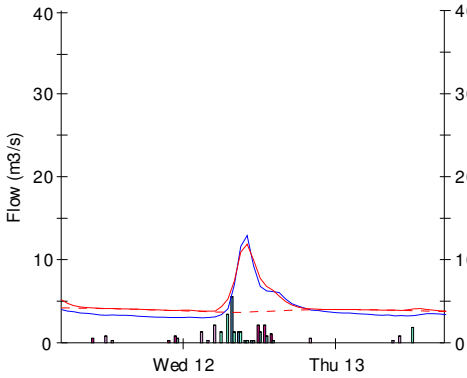
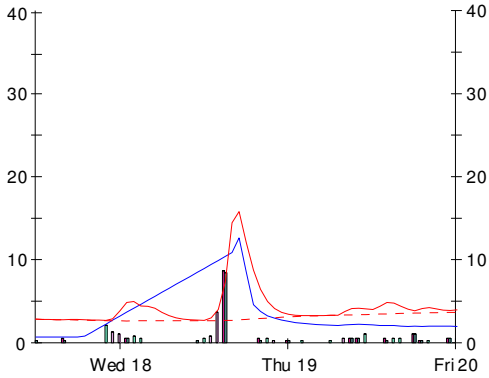
Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

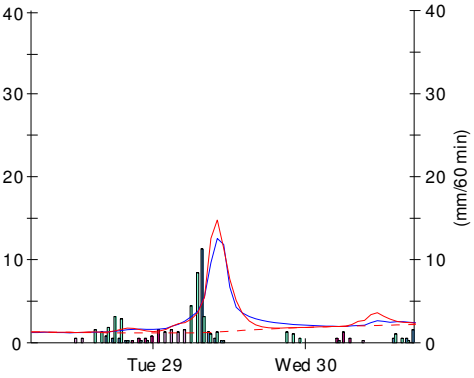
21. 12 Feb 2014 11:00 (17-21-29mm)



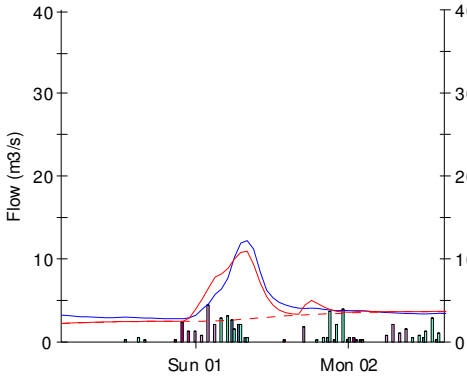
22. 18 Dec 2013 18:00 (19-38-38mm)



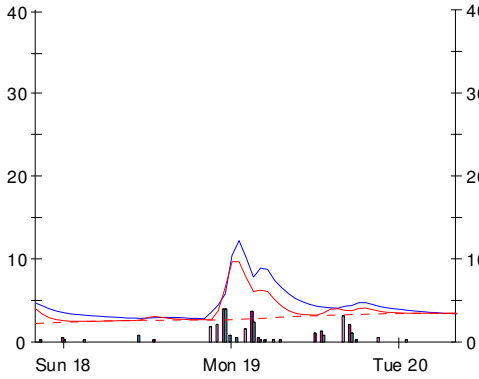
23. 29 Nov 2011 11:00 (23-35-65mm)



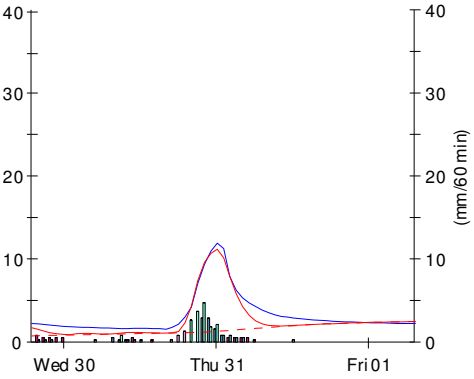
24. 01 Nov 2009 09:00 (27-30-46mm)



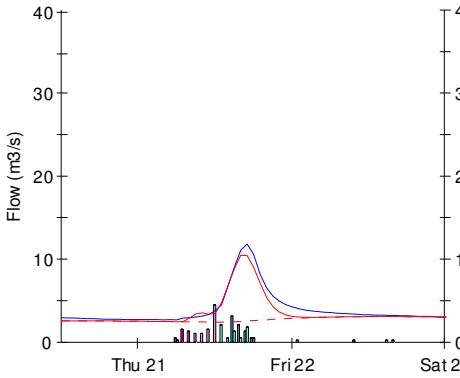
25. 19 Jan 2009 02:00 (18-23-33mm)



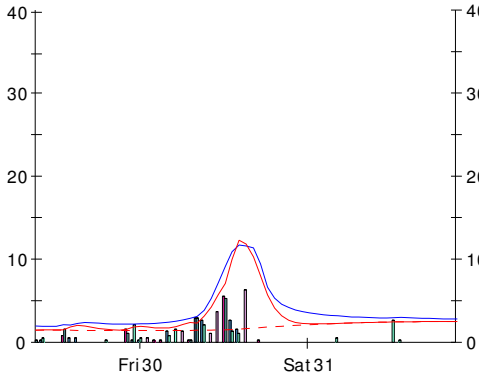
26. 31 Dec 2009 01:00 (13-30-32mm)



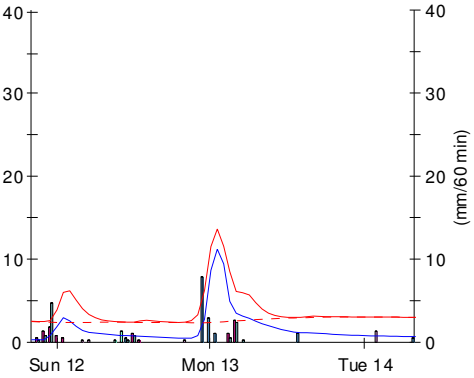
27. 21 Jan 2010 18:00 (15-22-27mm)



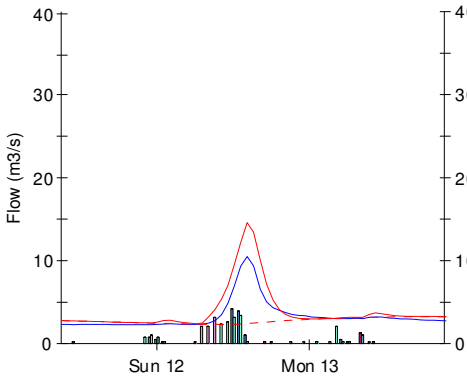
28. 30 Oct 2009 15:00 (31-33-38mm)



29. 13 Aug 2012 02:00 (2-36-40mm)



30. 12 Jan 2014 15:00 (25-31-35mm)



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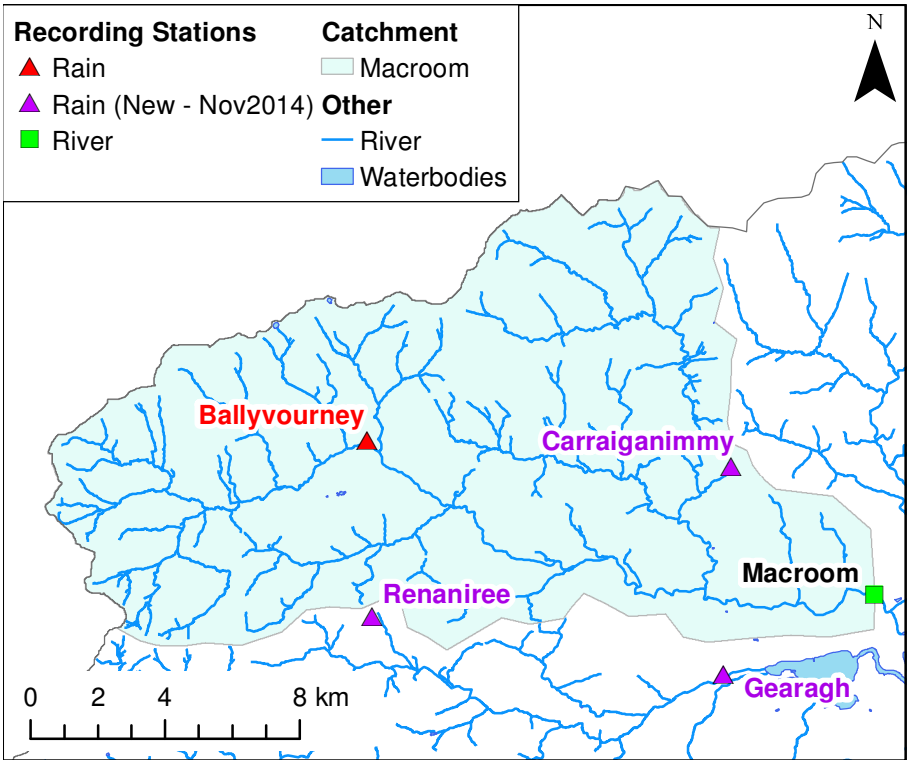
PDM Model Sheet for : Macroom_v3



Raingauges used

TBR Ref	Name	Weight
Ballvourney_irlREev	Ballvourney	0.592
Renanir_irlREev	Renanirree	0.194
Carriganimma_irlREev	Carriganimma	0.107
Gearagh_irlREev	Gearagh	0.107

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	01 Jul 2004 02:00	To	14 Nov 2014 08:00

Flow gauge : (19031_irlSG)

No.	Limb	Description	K	a	p	Max stage	Start-End
999	a	JBA rating (April 2015)	33.976	-0.050	1.911	0.74	01 Jan 1980-31 Dec 3999
999	b	JBA rating (April 2015)	10.706	0.479	2.265	999.0	01 Jan 1980-31 Dec 3999

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
213	1	10	100	1	2	8000	1.7	0	4	n/a	4.6	0	2

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	1.52	0.27	0.14	1.24	2.84	2.59	2.08	1.52				

Calibration Notes

1 Macroom PDM

1.1 Catchment description

Macroom PDM is situated on the River Sullane at Macroom gauging station. The River Sullane is a main tributary to Carrigadrohid Reservoir. The catchment covers an area of approximately 213km^2 and comprises undulating uplands with exposed rock and peaty topsoil. Geology is largely impermeable consisting sandstone and siltstone.

1.2 Rainfall and evaporation inputs

The Sullane catchment to Macroom receives an annual average precipitation of 1770mm. The only rain gauge situated within the catchment is Ballyvourney. Rainfall inputs to the PDM are taken from Ballyvourney, Renaniree, Inchigeelagh and Mushera. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Inchigeelagh and Mushera have been included for this purpose and as such have very little weight assigned to them initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 2.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 100mm and a Cmin of 10mm, with the exponent of the soil store capacity, b (1) allowing even distribution of soil stores between Cmax and Cmin.

Both linear stores have surface routing constants (K_1) of 4 hours. Drainage parameters are Kg = 8000 and Bg = 1.7. This combination means drainage to the baseflow store is relatively quick and is slightly sensitive to soil moisture state.

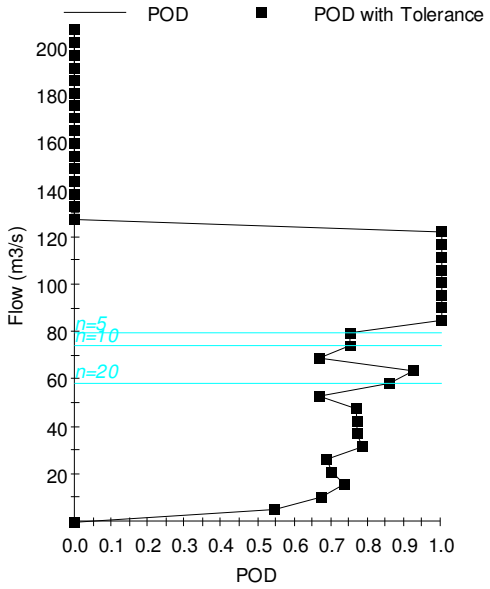
The baseflow routing time constant (Kb) is 4.6hmm^2. The depth of water retained by soil under tension (St) was set at 0mm. A time delay of 2 hours was also included to bring the modelled peaks more into line with the observed.

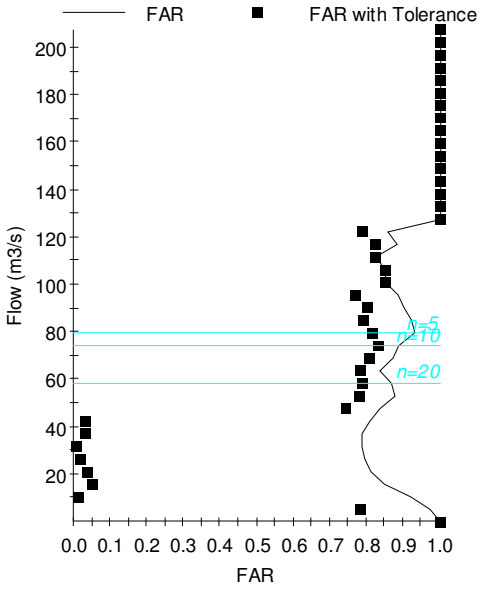
1.4 Overall performance

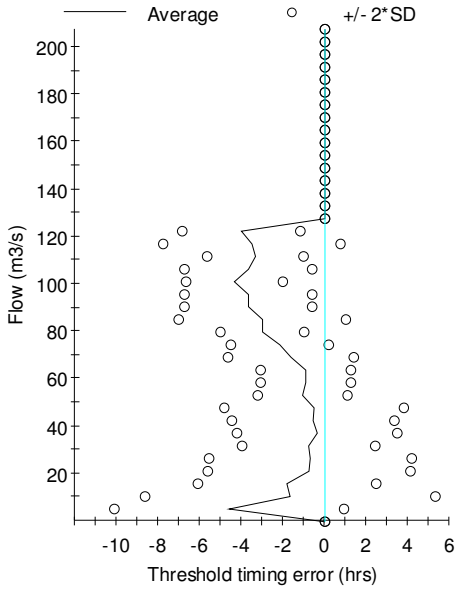
The PDM performance was compared to flow data from Macroom gauging station. The records here are particularly patchy which presents significant uncertainty in the model results. Overall performance of the Macroom PDM is reasonable with both hydrograph shape and timing well represented in the majority of available events, however the nature of rainfall inputs will result in some under performance.

PDM Model Sheet for : Macroom_v3

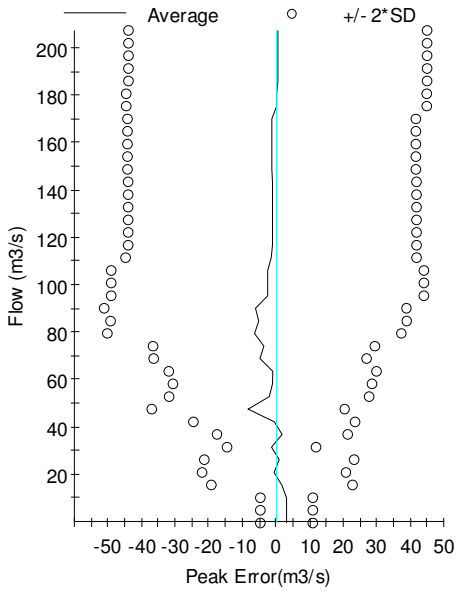
POD, FAR and peak matching statistics over full range of observations

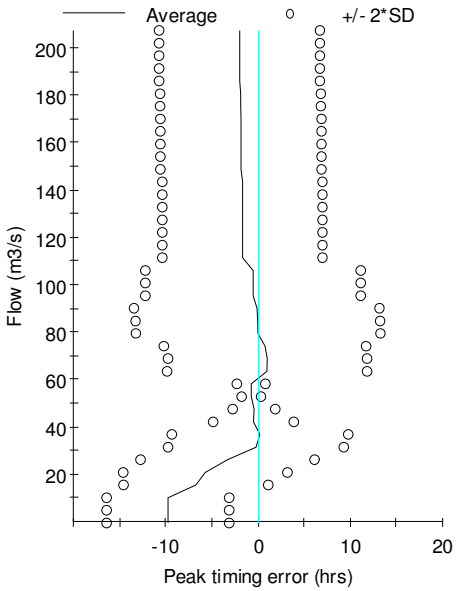






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -9 to +9 hrs



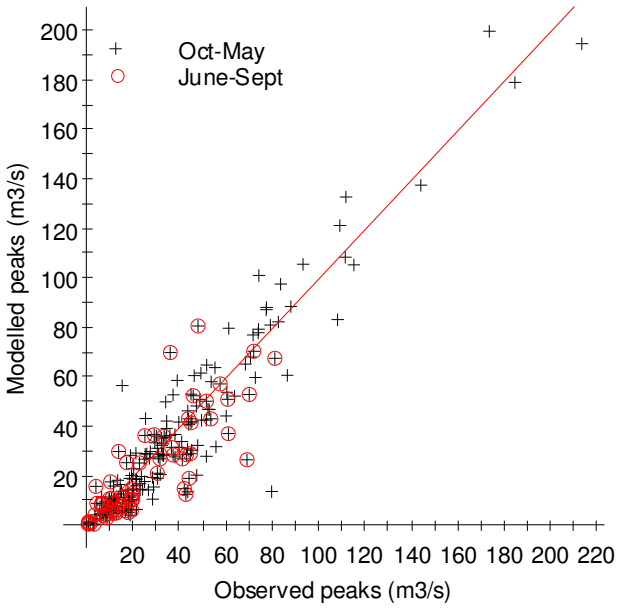


PDM Model Sheet for : Macroom_v3

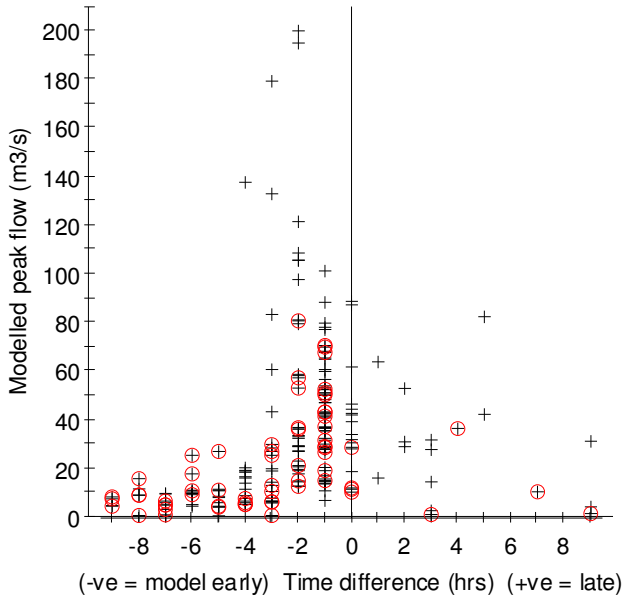
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	25/10/2013 08:00	212.6	25/10/2013 06:00	194.7	-8%	-2.0	0.817	24.078	0.834
2	30/12/2013 10:00	184.1	30/12/2013 07:00	179.0	-3%	-3.0	0.795	20.347	0.864
3	19/11/2012 10:00	173.1	19/11/2012 08:00	199.6	15%	-2.0	0.684	27.035	0.867
4	14/12/2013 22:00	143.6	14/12/2013 18:00	137.7	-4%	-4.0	0.680	18.526	0.774
5	19/12/2012 12:00	114.8	19/12/2012 10:00	105.5	-8%	-2.0	0.843	10.779	0.901
6	12/01/2014 21:00	111.4	12/01/2014 18:00	132.9	19%	-3.0	0.756	13.299	0.924
7	18/12/2013 23:00	111.1	18/12/2013 21:00	108.6	-2%	-2.0	0.781	11.062	0.839
8	03/02/2014 13:00	108.7	03/02/2014 11:00	121.4	12%	-2.0	0.720	12.661	0.935
9	23/02/2014 13:00	107.9	23/02/2014 10:00	83.4	-23%	-3.0	0.542	17.503	0.947
10	23/12/2013 15:00	93.0	23/12/2013 13:00	105.7	14%	-2.0	0.677	11.094	0.935

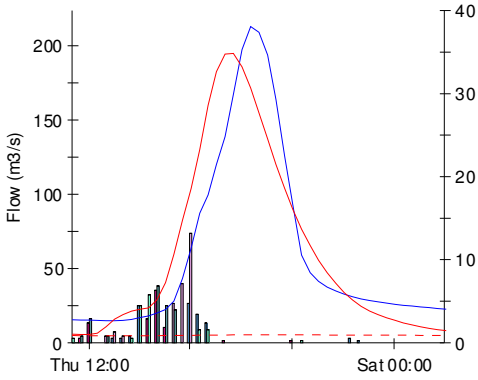
Modelled and observed peak flows, r2=0.873



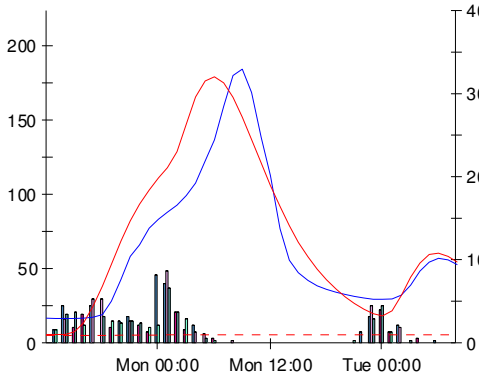
Modelled and observed peak timing



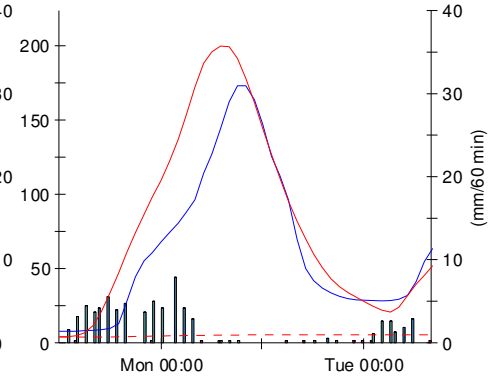
1. 25 Oct 2013 08:00 (36-50-64mm)



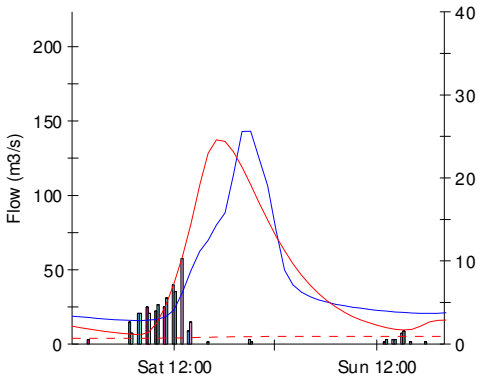
2. 30 Dec 2013 10:00 (45-64-72mm)



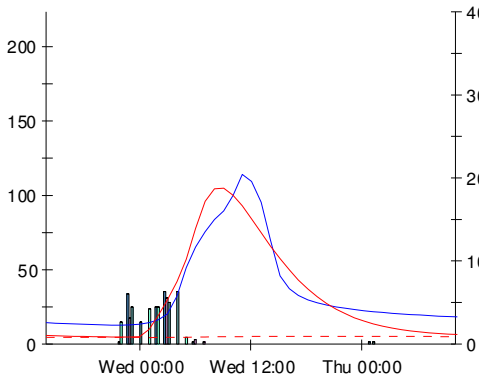
3. 19 Nov 2012 10:00 (5-79-103mm)



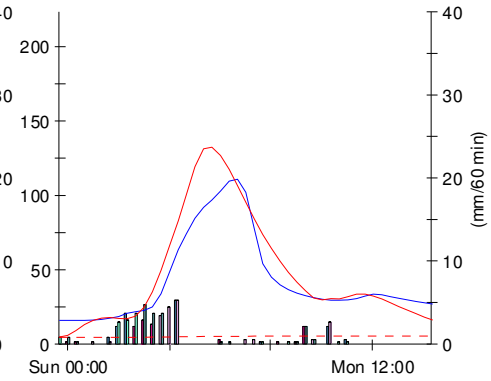
4. 14 Dec 2013 22:00 (35-39-47mm)



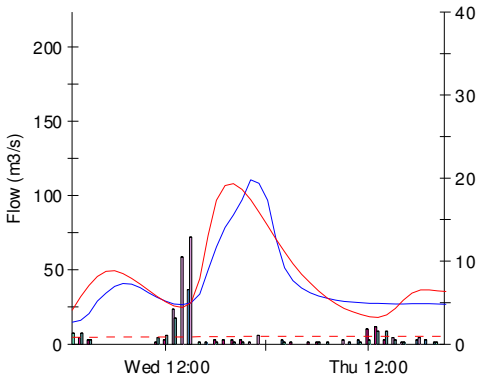
5. 19 Dec 2012 12:00 (0-27-34mm)



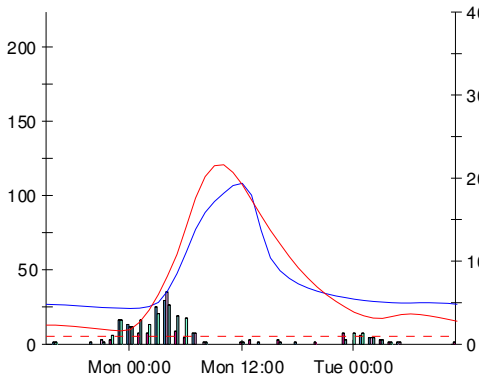
6. 12 Jan 2014 21:00 (29-42-47mm)



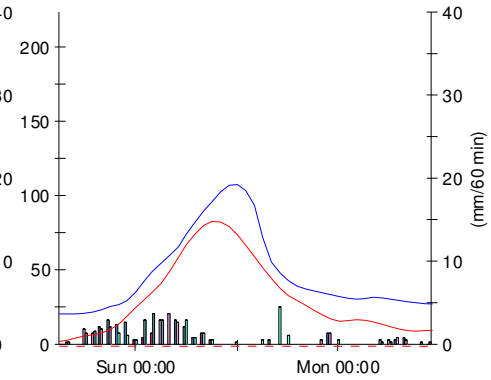
7. 18 Dec 2013 23:00 (31-37-51mm)



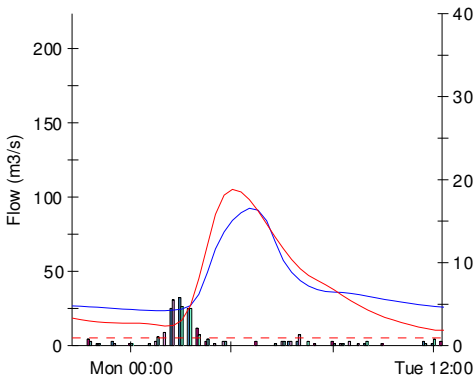
8. 03 Feb 2014 13:00 (21-32-35mm)



9. 23 Feb 2014 13:00 (22-40-47mm)



10. 23 Dec 2013 15:00 (25-29-32mm)

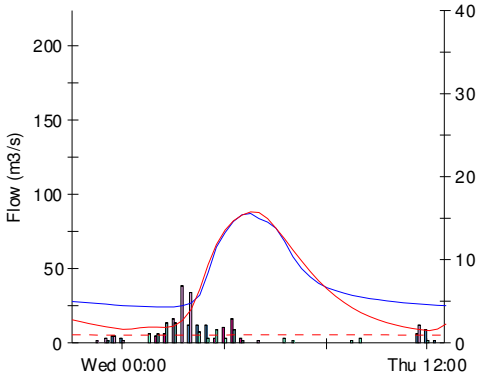


Key

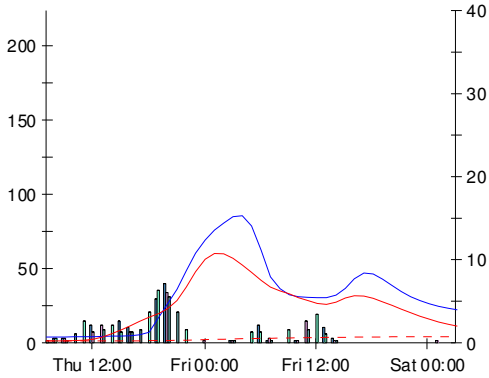
- 19031_irlSG - Flow : Macroom
- Modelled Q
- Modelled Qg
- Ballvourney_irlREev - Recording Rain : Ballvourney
- Renanir_irlREev - Recording Rain : Renanirree
- Carriganimma_irlREev - Recording Rain : Carriganimma
- Gearagh_irlREev - Recording Rain : Gearagh
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

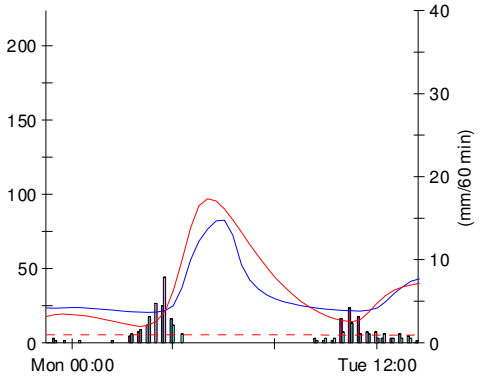
11. 12 Feb 2014 16:00 (21-27-35mm)



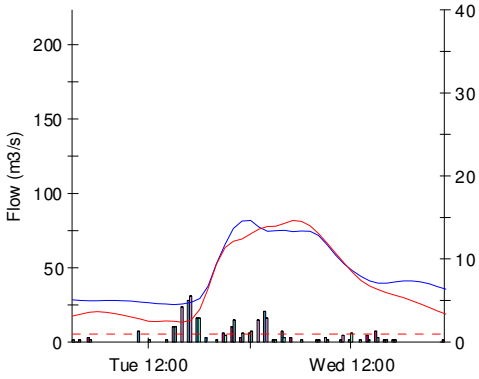
12. 22 Mar 2013 05:00 (0-41-52mm)



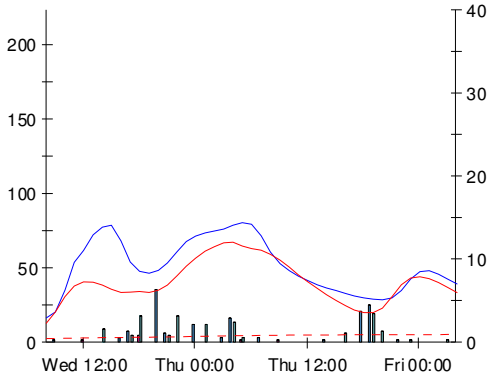
13. 28 Jan 2013 19:00 (25-32-45mm)



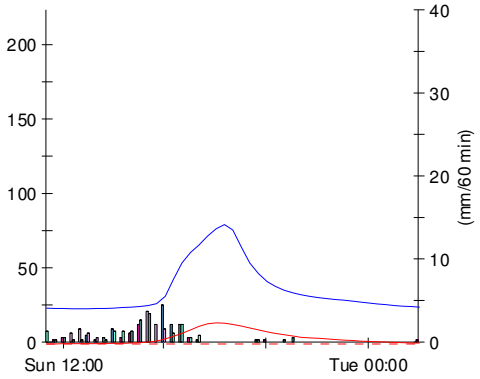
14. 05 Feb 2014 01:00 (23-31-42mm)



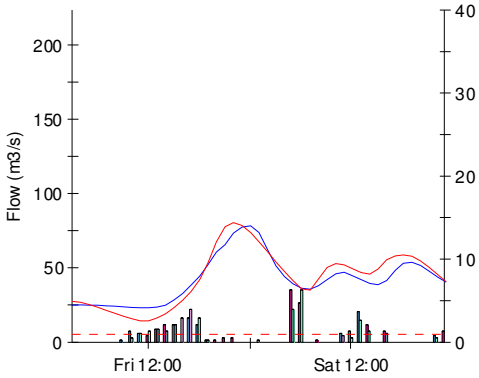
15. 16 Aug 2012 06:00 (2-48-63mm)



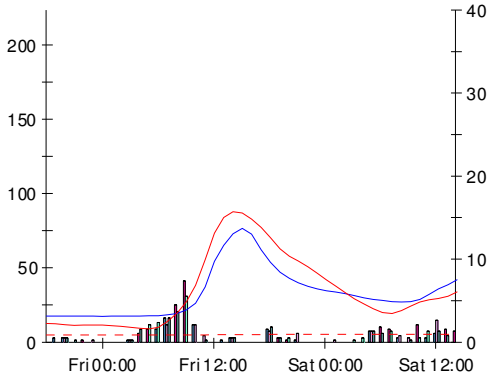
16. 17 Feb 2014 08:00 (17-24-29mm)



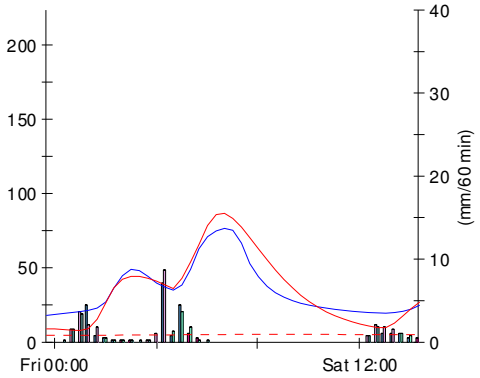
17. 21 Dec 2013 01:00 (28-34-50mm)



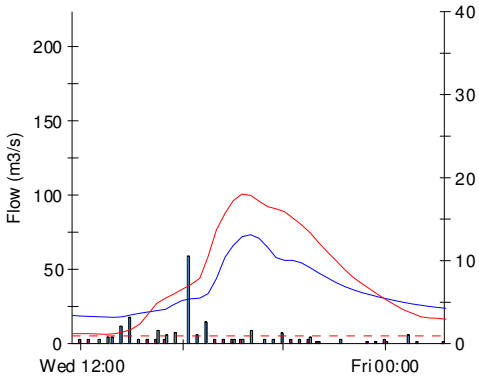
18. 31 Jan 2014 16:00 (29-34-46mm)



19. 25 Jan 2013 21:00 (26-34-38mm)



20. 22 Nov 2012 09:00 (15-36-43mm)

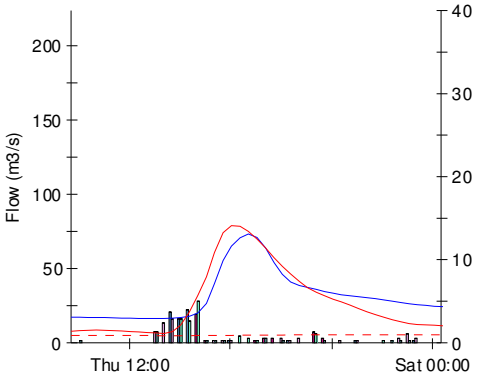


Key

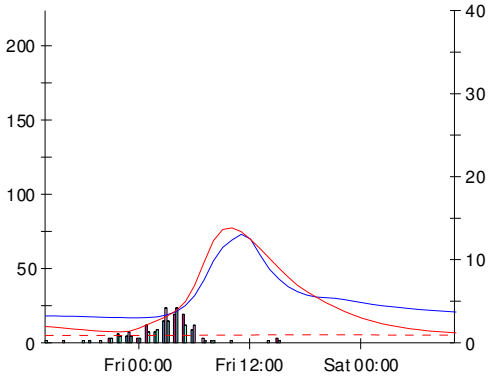
- 19031_irlSG - Flow : Macroom
- Modelled Q
- Modelled Qg
- Ballvourney_irlREev - Recording Rain : Ballvourney
- Renanir_irlREev - Recording Rain : Renanirree
- Carriganimma_irlREev - Recording Rain : Carriganimma
- Gearagh_irlREev - Recording Rain : Gearagh
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

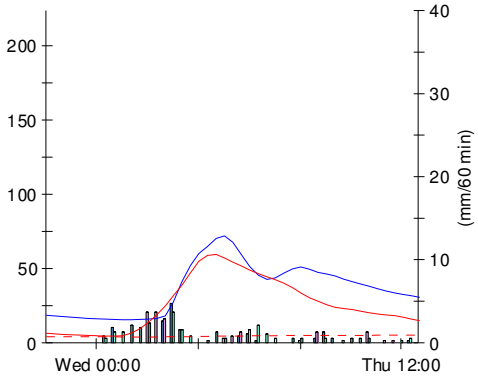
21. 27 Dec 2013 03:00 (22-25-33mm)



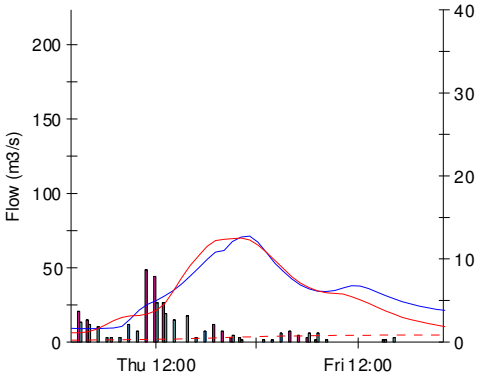
22. 24 Jan 2014 12:00 (15-20-29mm)



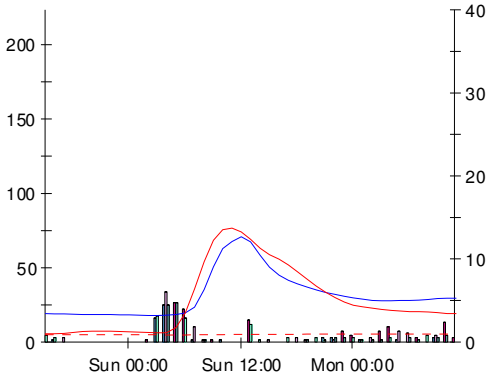
23. 17 Apr 2013 16:00 (0-30-41mm)



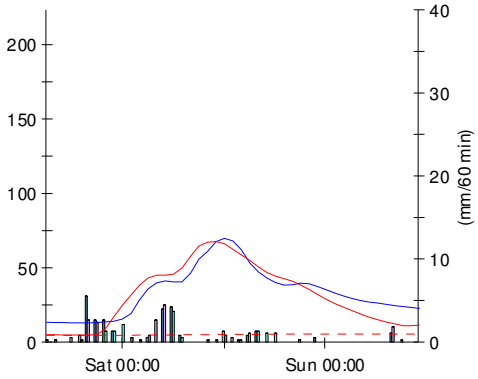
24. 08 Jun 2012 00:00 (43-48-64mm)



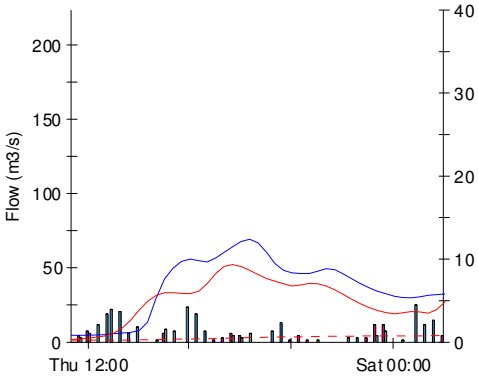
25. 26 Jan 2014 13:00 (21-28-41mm)



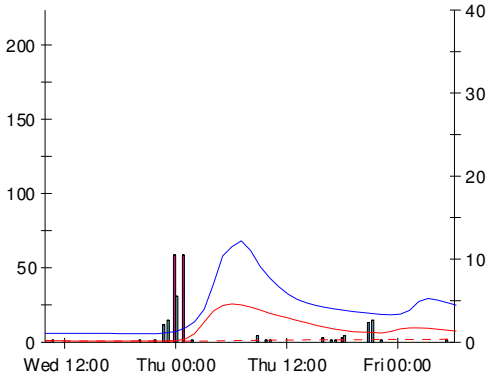
26. 22 Dec 2012 13:00 (0-29-41mm)



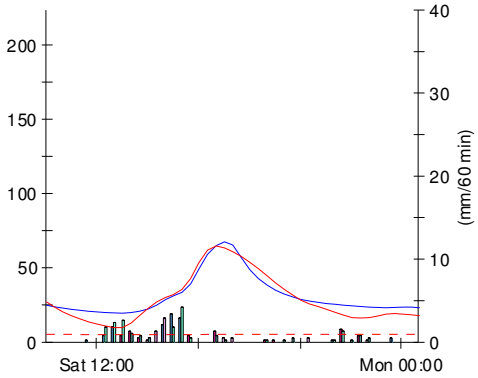
27. 15 Jun 2012 08:00 (47-55-57mm)



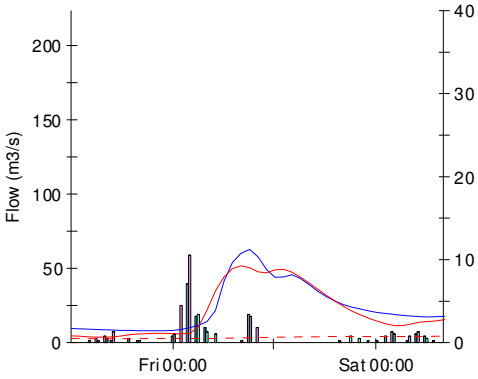
28. 28 Jun 2012 08:00 (19-23-33mm)



29. 27 Jan 2013 04:00 (22-23-26mm)



30. 14 Dec 2012 10:00 (0-28-37mm)



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- Modelled Qg
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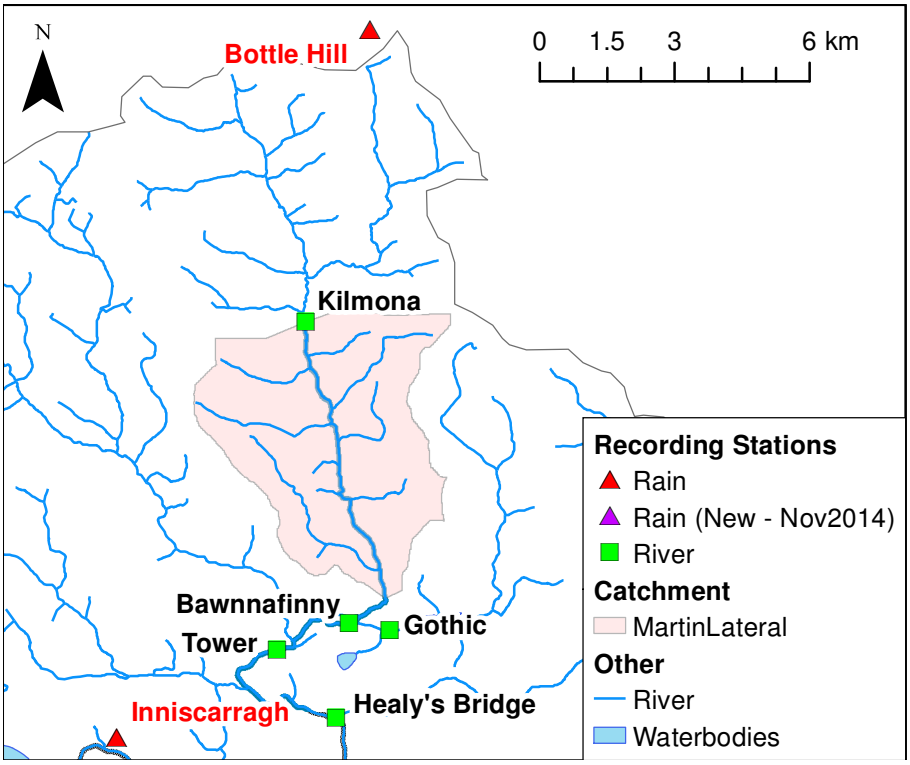
- Gearagh_irlREev - Recording Rain : Gearagh
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

PDM Model Sheet for : MartinLateral_v1



Raingauges used

TBR Ref	Name	Weight
BottleHillPHREev	Bottle Hill Pump House	0.6
Inniscarra_irlREev	Inniscarra	0.015

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

PDM parameters

Surface		Linear cascade			Base	Cubic store			Drainage		Gravity		
Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
23.6	1	0	60	0.75	2.5	200	1.5	0	2	1.5	79.4	0	0

Calibration Notes

1 MartinLateral PDM

1.1 Catchment description

MartinLateral PDM is situated on the River Martin between Kilmona gauging station and the River Martin confluence with the River Blarney; the PDM accounts for lateral inflows to the River Martin between these two points. The River Blarney is in turn one of two main tributaries to the River Shournagh. The catchment covers an area of approximately 23km^2 and comprises steep-sloping valleys with the Boggeragh Mountains to the northwest of the catchment. Geology is largely impermeable consisting of mudstone, siltstone and sandstone which is overlain by well-drained acid brown earths.

1.2 Rainfall and evaporation inputs

The Martin catchment between Kilmona and the Martin confluence with the River Blarney receives an annual average precipitation of 1190mm. There are no rain gauges situated within the catchment; the nearest is Bottle Hill Pump House to the north of the catchment. Rainfall inputs to the PDM are taken from Bottle Hill Pump House and Inniscarra. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Inniscarra has been included for this purpose and as such has very little weight assigned to it initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 2.5.

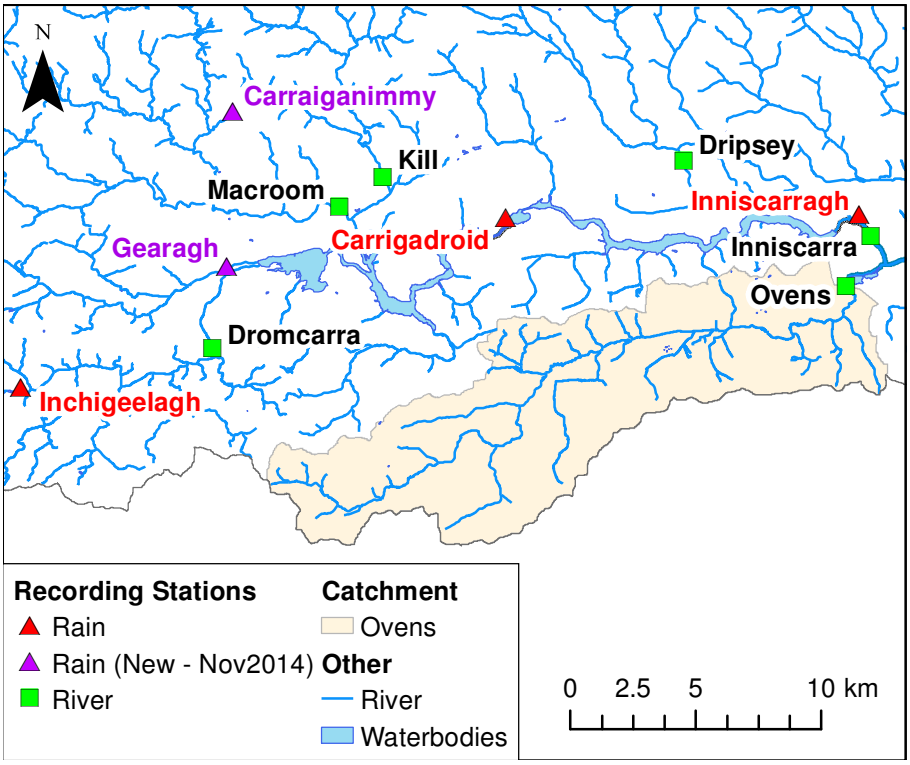
1.3 PDM parameters

The PDM is structured with a cascade of linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 60mm and a Cmin of 0mm, with the exponent of the soil store capacity, b (0.75) favouring deeper soil stores. This allows runoff to vary as the soil wets up.

Linear stores have surface routing constants (K_1 and K_2) of 2 hours and 1.5 hours respectively. This results in quicker and slower response components to the peak hydrograph thereby accounting for varying attenuation. Drainage parameters are Kg = 200 and Bg = 1.5. This combination means drainage to the baseflow store is very quick and is fairly sensitive to soil moisture state.

The baseflow routing time constant (Kb) is 79.4hmm^2. The depth of water retained by soil under tension (St) was set at 0mm.



Raingauges used

TBR Ref	Name	Weight
Inchigeelagh_irlREev	Inchigeelagh	0.054
Carrig_irlREev	Carrigadrohid	0.521
Inniscarra_irlREev	Inniscarra	0.277
Renanir_irlREev	Renanirree	0.148

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

From	23 Oct 2002 00:00	To	27 Feb 2015 00:00

Flow gauge : (19016_irlSG)

No.	Limb	Description	K	a	p	Max stage	Start-End
450	a	LeeCFRAM	11.721	-0.050	1.811	0.27	22 Oct 1949-31 Dec 3999
450	b	LeeCFRAM	43.602	-0.050	2.679	0.60	22 Oct 1949-31 Dec 3999
450	c	LeeCFRAM	30.000	-0.050	1.980	2.00	22 Oct 1949-31 Dec 3999

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
121.6	1	0	60	2	2	500	1.7	0	8.5	n/a	36.8	0	0

Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score				
This PDM	3.12	2.41	2.15	1.70	2.63	3.74	4.00	2.85				

Calibration Notes

1 Ovens PDM

1.1 Catchment description

Ovens PDM is situated on the Southern Bride at Ovens gauging station. The Southern Bride is a main tributary to the the River Lee downstream of the outflow from Inniscarra Reservoir. The catchment is long and narrow in nature covering an area of approximately 121km^2 and comprises undulating uplands used primarily for pastoral grazing and arable farming. Geology is largely impermeable consisting sandstone and siltstone.

1.2 Rainfall and evaporation inputs

The Southern Bride catchment to Ovens receives an annual average precipitation of 1260mm. There are no rain gauges situated within the catchment; the nearest is Inniscarra to the north of the catchment. Rainfall inputs to the PDM are taken from Carrigadrohid, Inniscarra, Renaniree and Inchigeelagh. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Inchigeelagh has been included for this purpose and as such has very little weight assigned to it initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 2.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 60mm and a Cmin of 0mm, with the exponent of the soil store capacity, b (2) favouring shallower soils.

Both linear stores have surface routing constants (K_1) of 8.5 hours. Drainage parameters are Kg = 500 and Bg = 1.7. This combination means drainage to the baseflow store is very quick and is slightly sensitive to soil moisture state.

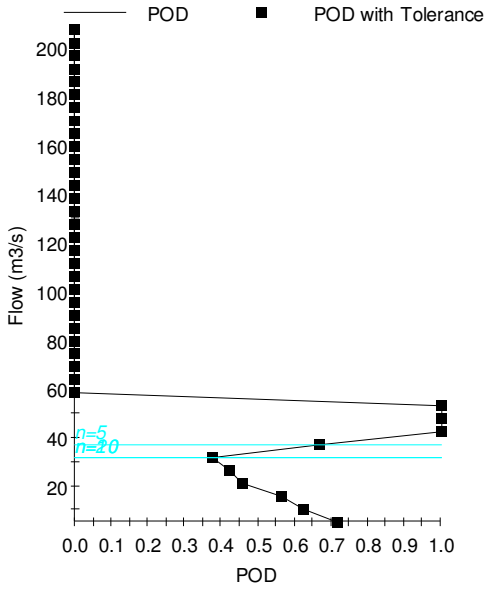
The baseflow routing time constant (Kb) is 36.8hmm^2. The depth of water retained by soil under tension (St) was set at 0mm.

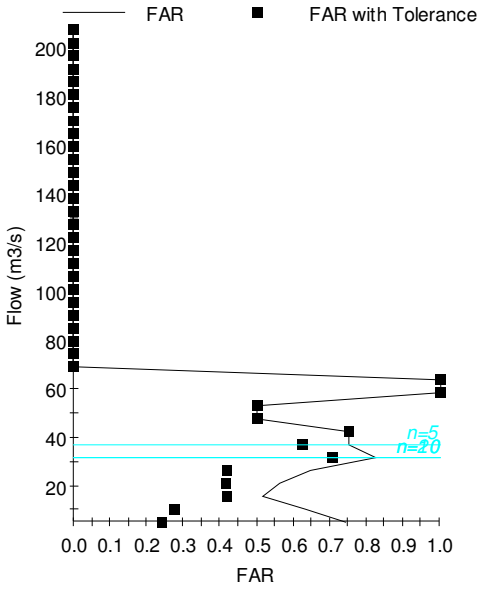
1.4 Overall performance

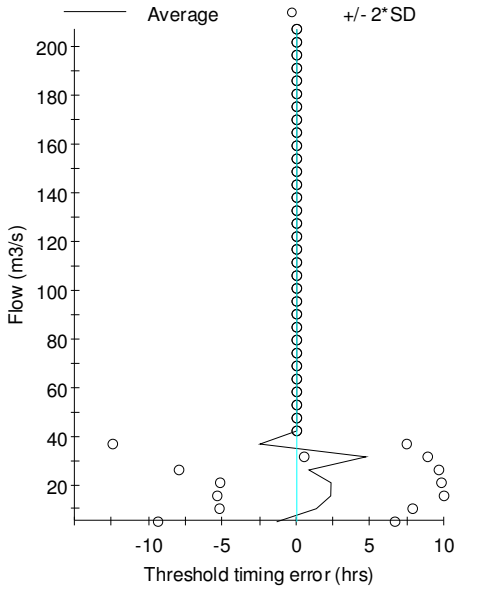
The PDM performance was compared to flow data from Ovens gauging station. Overall performance of the Ovens PDM is reasonable with hydrograph shape well represented in the majority of events, although magnitude and timing of peaks is a little variable due to the long and narrow nature of the catchment. The representation of rainfall inputs will also result in some under performance.

PDM Model Sheet for : Ovens_v1

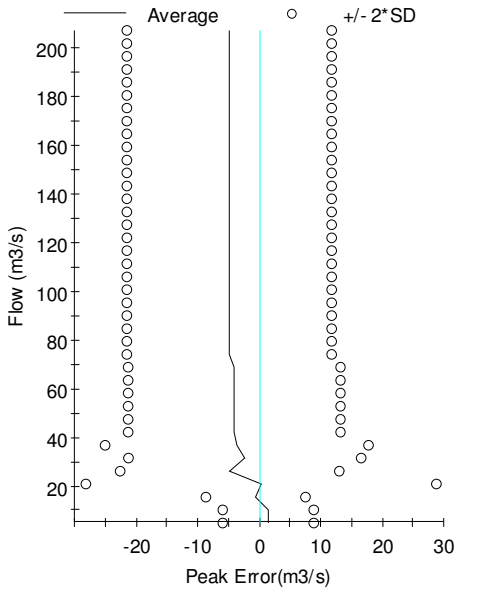
POD, FAR and peak matching statistics over full range of observations

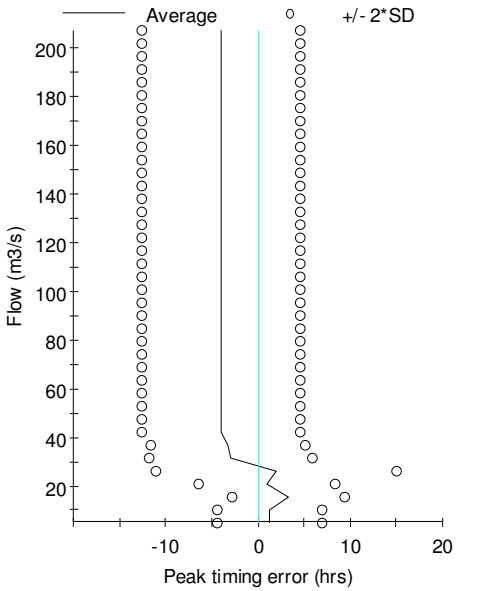






Notes: Peak statistics based on a moving average of 20 peaks. Tolerance of 0 used for POD and FAR. Threshold crossing window is -14 to +14 hrs

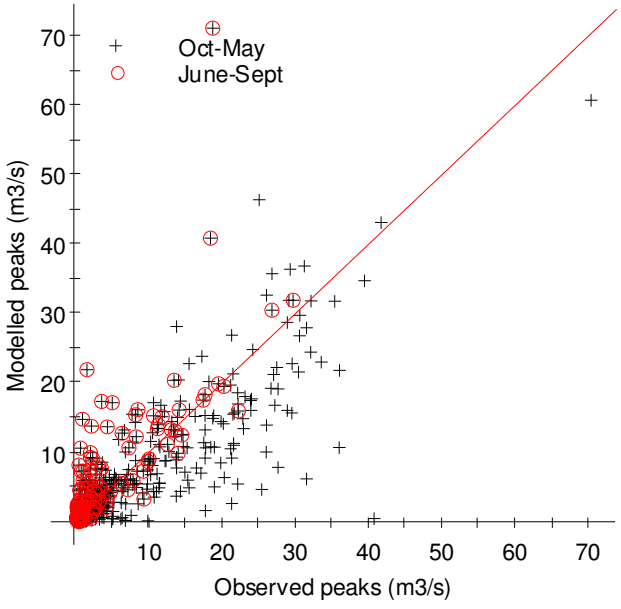




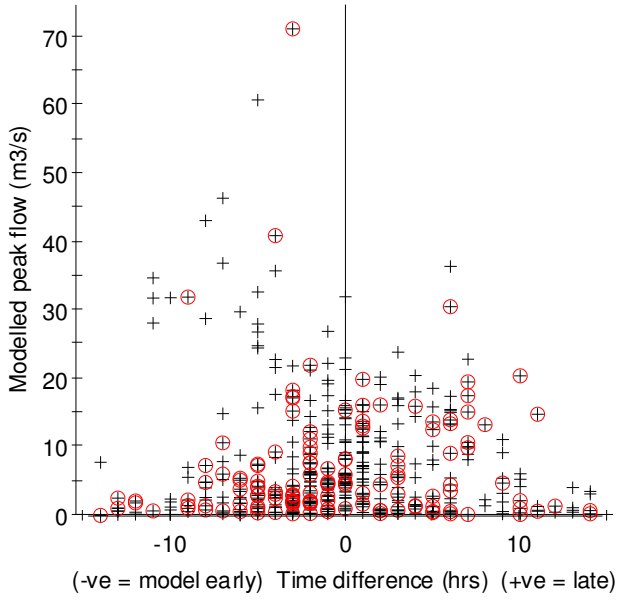
Peak magnitude and timing for the top ten observed events

	Observed		Modelled		Difference		Event statistics		
	Date	Flow (m3/s)	Date	Flow (m3/s)	Q (%)	T (hrs)	NSE	RMSE	r^2
1	19/11/2009 23:00	70.2	19/11/2009 18:00	60.6	-14%	-5.0	0.473	10.038	0.832
2	13/01/2010 06:00	41.6	12/01/2010 22:00	43.1	3%	-8.0	0.844	5.711	0.876
3	15/02/2014 02:00	40.7	15/02/2014 14:00	0.6	-99%	12.0	-9.436	23.803	0.000
4	31/12/2009 19:00	39.4	31/12/2009 08:00	34.7	-12%	-11.0	0.696	7.145	0.832
5	12/02/2014 19:00	36.0	12/02/2014 16:00	21.9	-39%	-3.0	-3.915	13.140	0.348
6	25/02/2014 04:00	35.9	25/02/2014 01:00	10.8	-70%	-3.0	-11.115	19.390	0.846
7	03/12/2006 18:00	35.3	03/12/2006 07:00	31.8	-10%	-11.0	-1.588	11.193	0.466
8	21/11/2009 17:00	33.5	21/11/2009 17:00	23.1	-31%	0.0	0.511	9.835	0.930
9	01/12/2006 10:00	32.1	01/12/2006 00:00	31.8	-1%	-10.0	0.597	5.544	0.845
10	22/01/2010 04:00	32.1	21/01/2010 23:00	24.5	-24%	-5.0	0.570	4.598	0.908

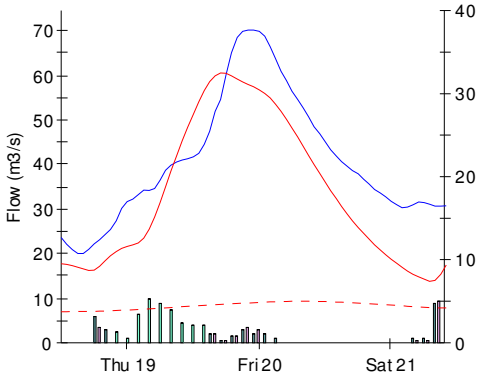
Modelled and observed peak flows, r2=0.607



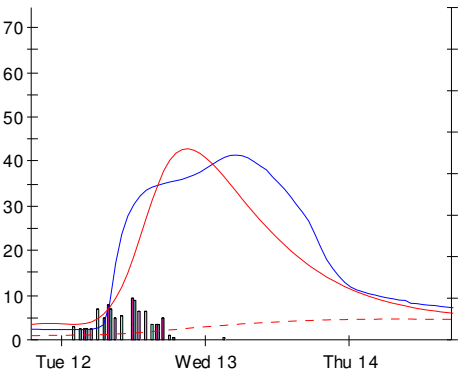
Modelled and observed peak timing



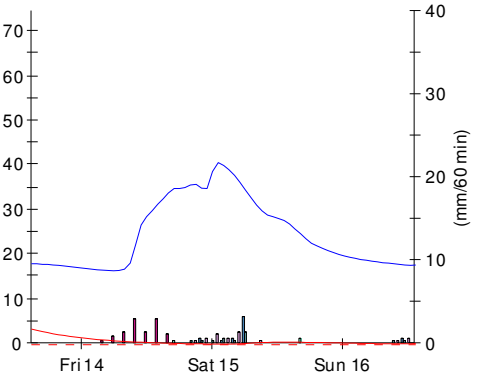
1. 19 Nov 2009 23:00 (1-76-101mm)



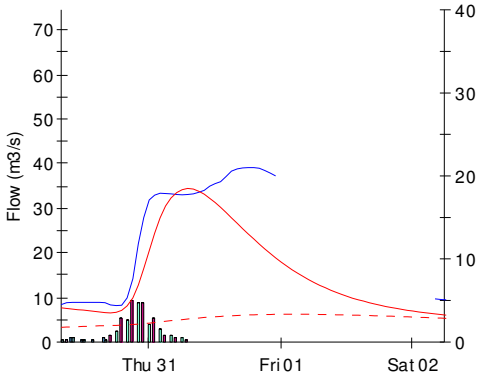
2. 13 Jan 2010 06:00 (5-46-50mm)



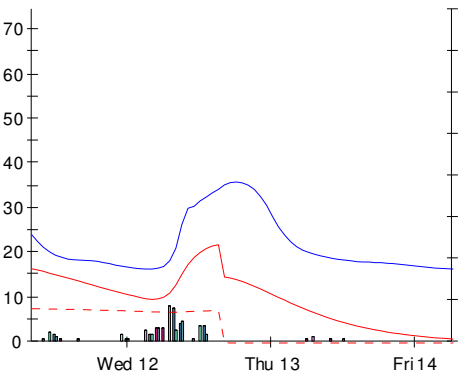
3. 15 Feb 2014 02:00 (13-6-27mm)



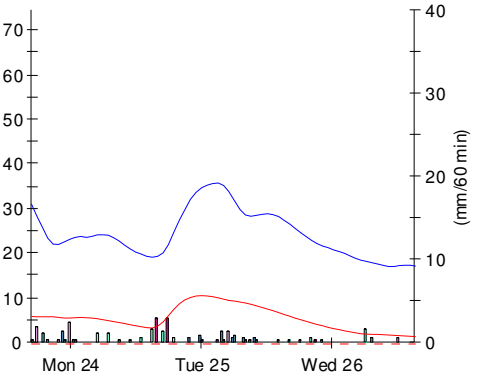
4. 31 Dec 2009 19:00 (13-31-42mm)



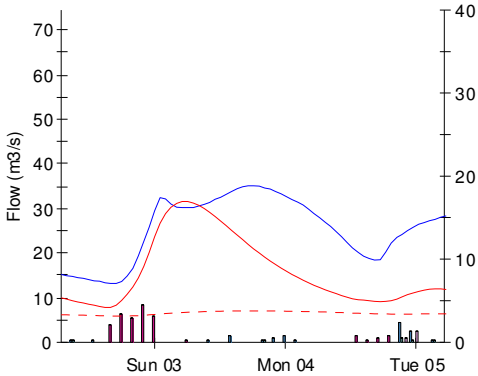
5. 12 Feb 2014 19:00 (19-19-26mm)



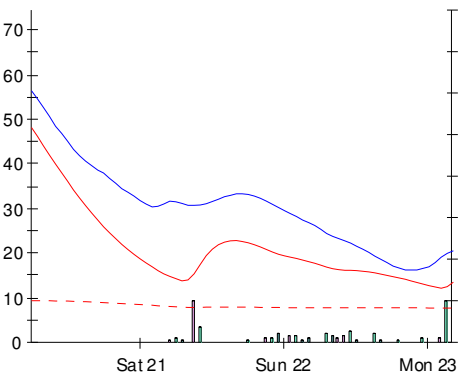
6. 25 Feb 2014 04:00 (22-24-37mm)



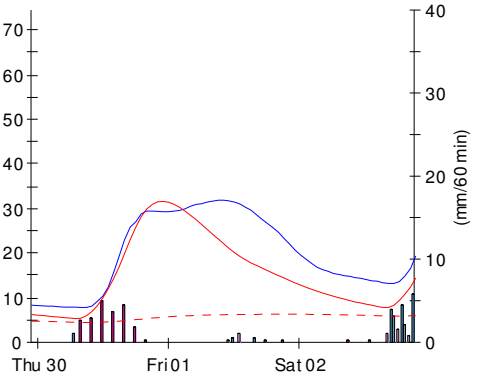
7. 03 Dec 2006 18:00 (15-37-98mm)



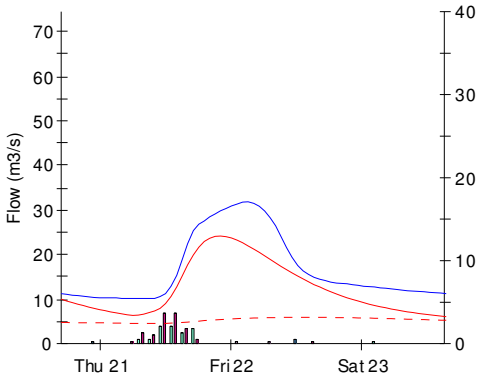
8. 21 Nov 2009 17:00 (24-30-42mm)



9. 01 Dec 2006 10:00 (22-47-90mm)



10. 22 Jan 2010 04:00 (15-24-35mm)



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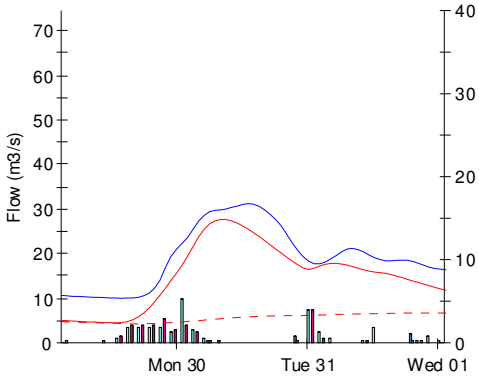
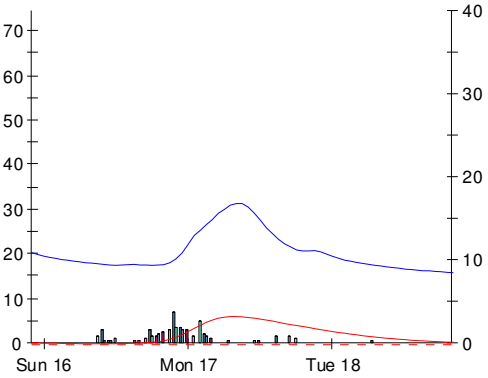
- Average Rain

Rainfall accumulations shown as minimum-average-maximum for the plot period, using the rain gauges selected

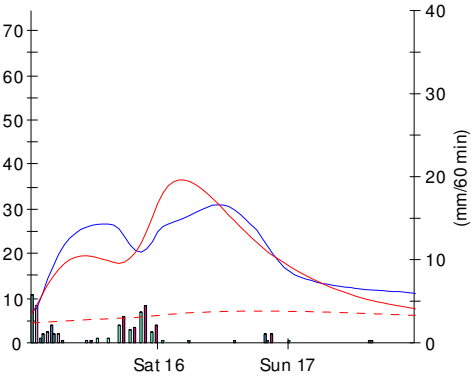
11. 30 Dec 2013 14:00 (24-41-77mm)



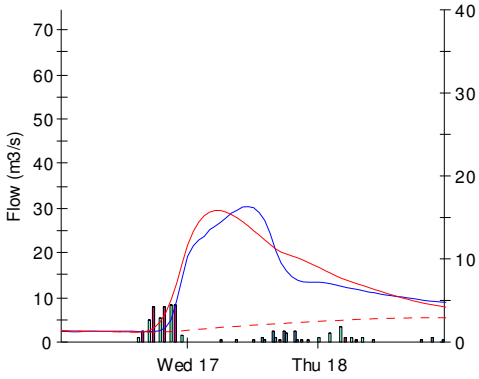
12. 17 Feb 2014 09:00 (15-17-27mm)



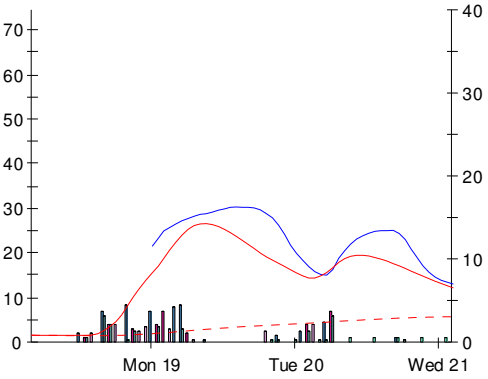
13. 16 Jan 2010 12:00 (41-44-61mm)



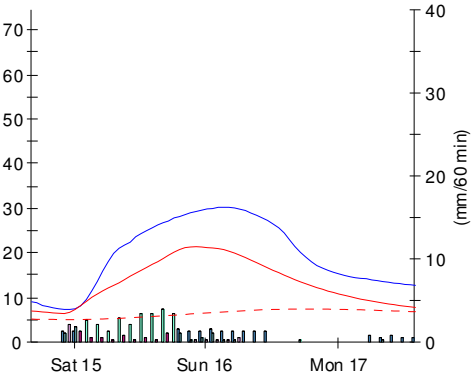
14. 17 Nov 2010 12:00 (14-41-40mm)



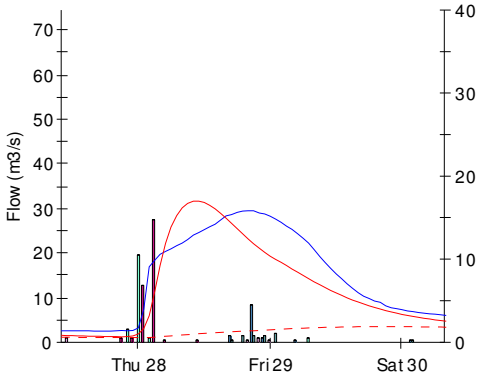
15. 19 Nov 2012 15:00 (13-50-97mm)



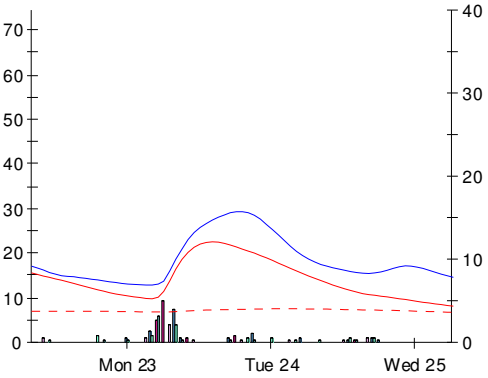
16. 16 Jan 2011 03:00 (17-31-77mm)



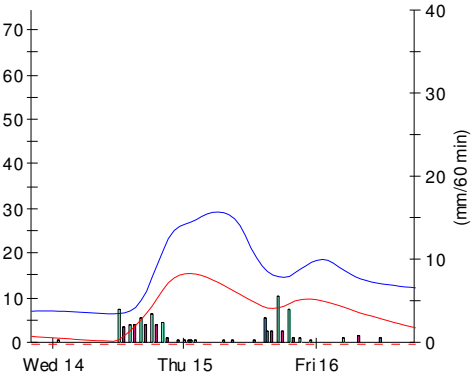
17. 28 Jun 2012 21:00 (31-44-53mm)



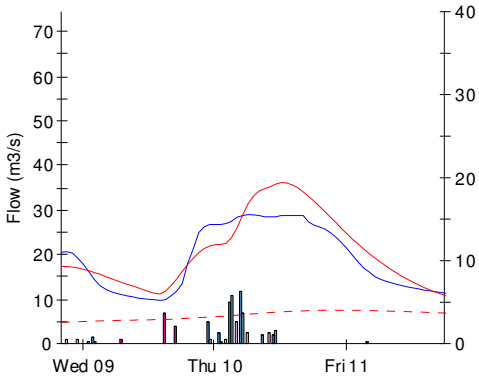
18. 23 Dec 2013 19:00 (19-23-44mm)



19. 15 Jan 2015 07:00 (24-33-63mm)



20. 10 Jan 2008 07:00 (34-38-71mm)



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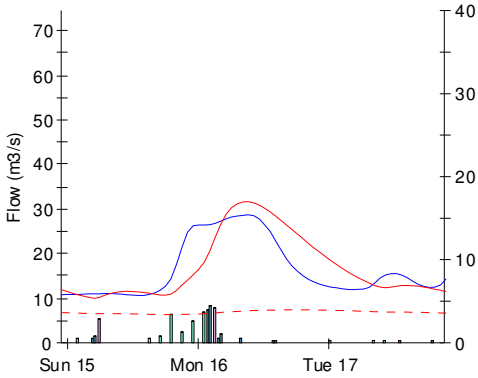
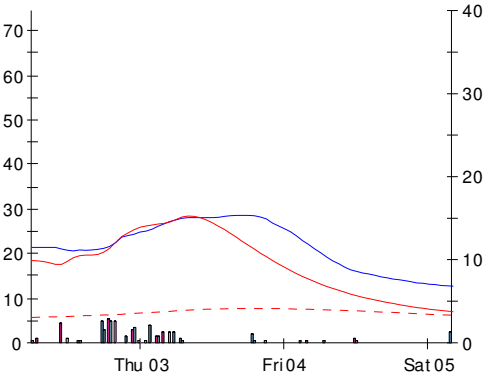
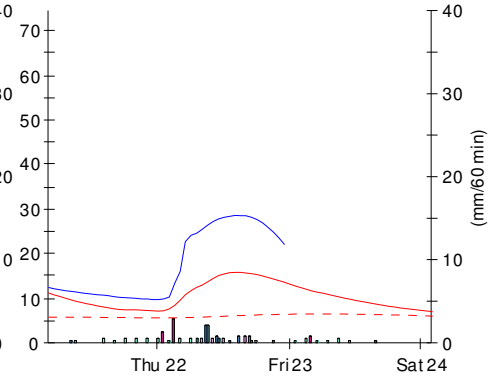
21. 16 Nov 2009 10:00 (31-37-52mm)



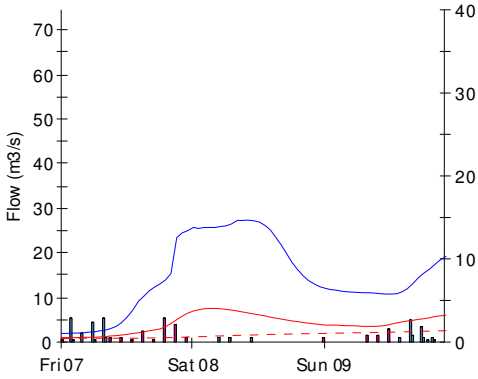
22. 03 Nov 2005 17:00 (24-29-37mm)



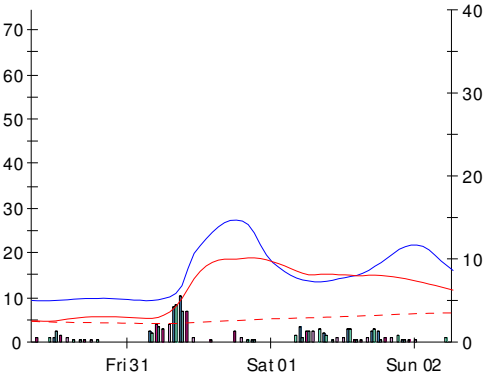
23. 22 Nov 2012 15:00 (16-20-47mm)



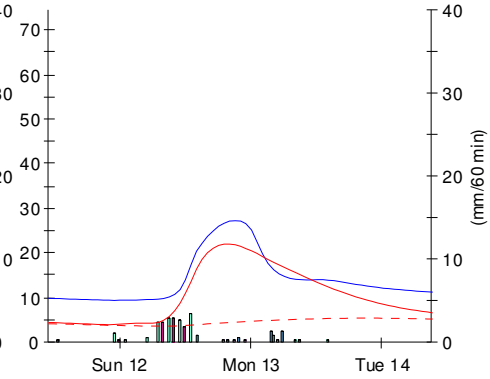
24. 08 Jan 2005 11:00 (3-23-100mm)



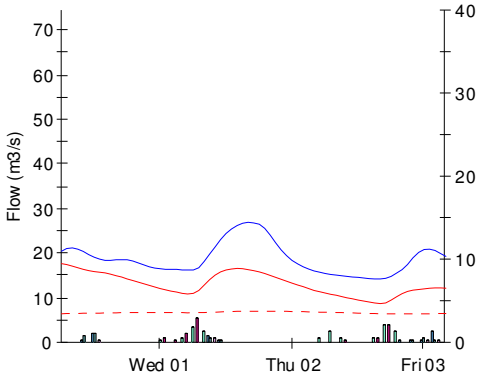
25. 31 Jan 2014 19:00 (30-37-61mm)



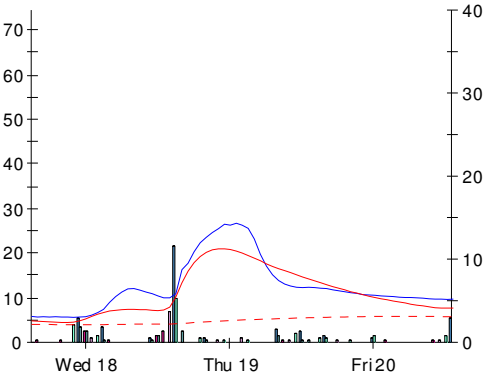
26. 12 Jan 2014 22:00 (25-27-33mm)



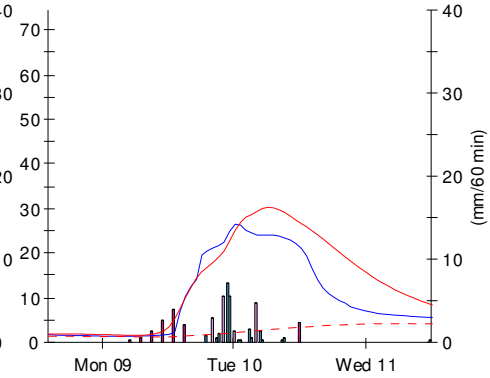
27. 01 Jan 2014 17:00 (19-24-37mm)



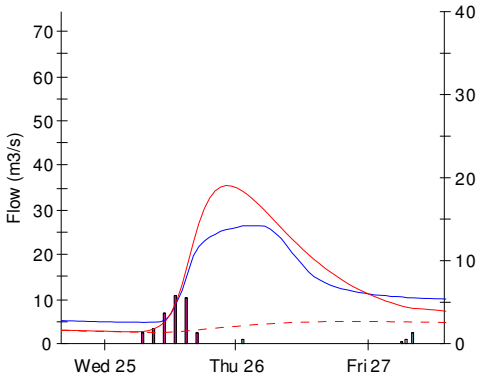
28. 19 Dec 2013 02:00 (20-30-52mm)



29. 10 Jun 2003 01:00 (46-47-55mm)



30. 26 Oct 2006 03:00 (35-41-45mm)



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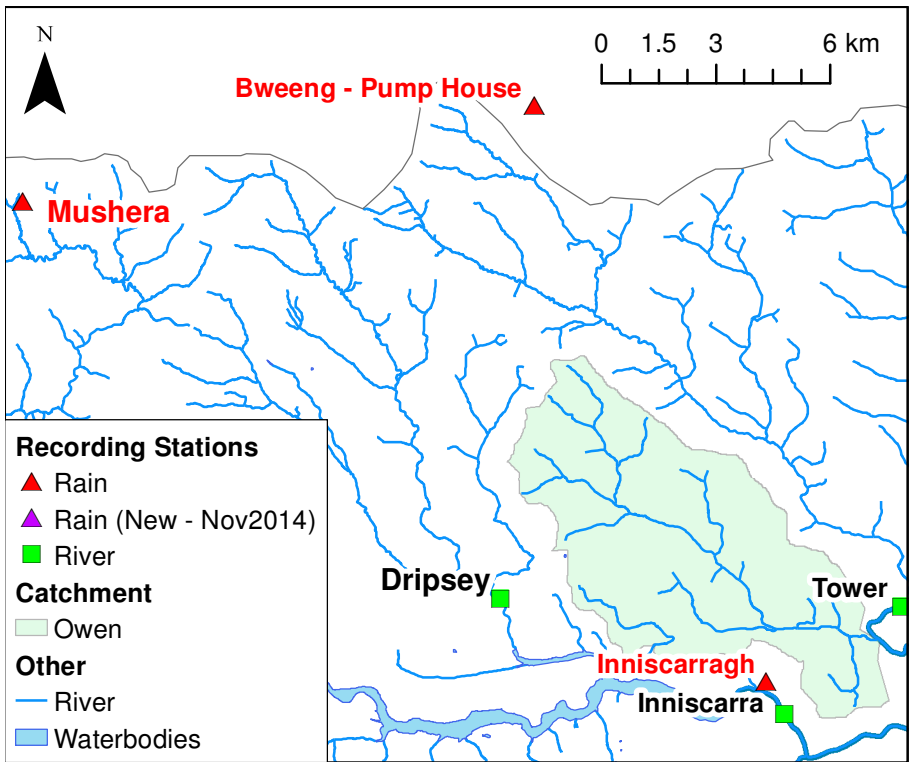


Raingauges used

TBR Ref	Name	Weight
Inniscarra_irlREev	Inniscarra	0.3
BweengPHREev	Bweeng Pump House	0.7
Mushera_irlREev	Mushera	0.01
Renanir_irlREev	Renanirree	0.01

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
45	1	10	60	1	1	2800	1.7	0	2	n/a	36.8	0	2

Calibration Notes

1 Owen PDM

1.1 Catchment description

Owen PDM is situated at the downstream boundary of the Owennagearagh catchment where the Owennagearagh River is a tributary to the River Shaunagh. The catchment covers an area of approximately 45km^2 and comprises steep-sloping valleys with the Boggeragh Mountains situated to the north of the catchment. Geology is largely impermeable consisting of mudstone, siltstone and sandstone.

1.2 Rainfall and evaporation inputs

Owennagearagh receives an annual average precipitation of 1150mm. There are no rain gauges situated within the catchment; the nearest is Inniscarra to the south of the catchment. Rainfall inputs to the PDM are taken from Bweeng Pump House, Inniscarra, Mushera and Renanirree. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Mushera and Renanirree have been included for this purpose and as such have very little weight assigned to them initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 1.

1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 60mm and a Cmin of 10mm, with the exponent of the soil store capacity, b (1) allowing an even distribution of soil stores between Cmax and Cmin.

Both linear stores have surface routing constants (K_1) of 2 hours. Drainage parameters are Kg = 2,800 and Bg = 1.7. This combination means drainage to the baseflow store is relatively quick and is slightly sensitive to soil moisture state.

The baseflow routing time constant (Kb) is 36.8hmm^2. The depth of water retained by soil under tension (St) was set at 0mm. A time delay of 2 hours was also assigned to bring timing of peaks more into line.

Shaunagh ISIS Results

Data summary

39 peaks analysed at SHOUR_01810 between 16.5m3/s and 151.5m3/s, for period 18 Oct 2005 to 25 Feb 2014 from :

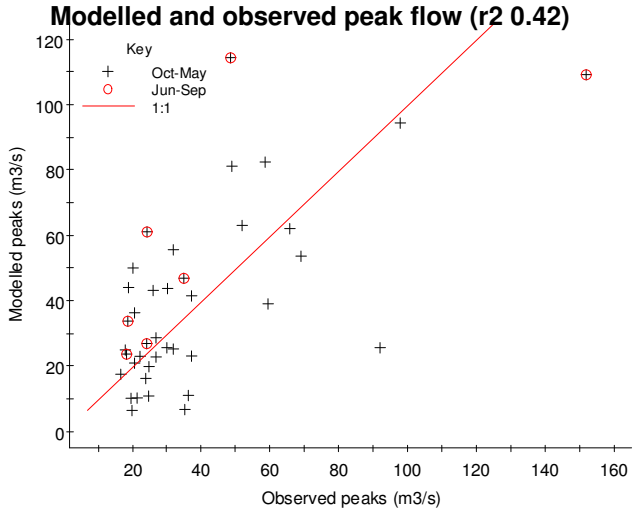
N:\2013\Projects\2013s7330 - JBA Consulting - Lower Lee Scheme\Calculations\02 Routing Model\10 ShaunaghValidation\01 Events

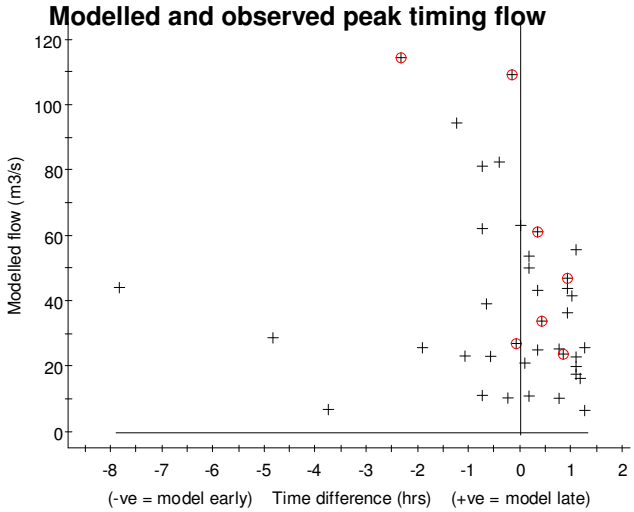
Peak magnitude and timing for the top ten observed events (01 Events)

	Observed		Modelled and differences				Event statistics		
	Date	Obs. (m3/s)	Mod. (m3/s)	Diff. (m3/s)	Diff (%)	Time Diff. (hrs)	NSE	r^2	RMSE
1	28 Jun 2012 07:15	151.47	109.29	-42.2	-28%	-0.2	0.856	0.961	14.47
2	10 Jan 2008 11:15	97.55	94.56	-3.0	-3%	-1.3	0.772	0.880	10.31
3	03 Dec 2006 05:15	91.71	26.05	-65.7	-72%	-1.9	-0.34	0.800	25.80
4	30 Dec 2013 13:15	68.80	53.96	-14.8	-22%	0.2	0.787	0.899	6.72
5	05 Feb 2014 02:15	65.60	62.29	-3.3	-5%	-0.8	0.829	0.955	5.58
6	03 Nov 2005 01:15	59.24	39.41	-19.8	-33%	-0.7	0.059	0.728	11.01
7	12 Jan 2014 20:15	58.42	82.58	24.2	41%	-0.4	0.515	0.960	8.60
8	31 Jan 2014 17:15	51.75	63.32	11.6	22%	0.0	0.706	0.926	5.49
9	25 Oct 2006 20:15	48.78	81.36	32.6	67%	-0.8	0.394	0.950	10.07
10	01 Aug 2008 05:15	48.43	114.42	66.0	136%	-2.3	-2.91	0.931	25.21

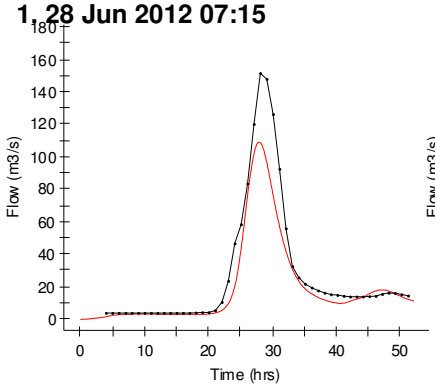
Model scores

	Variability	bias -absolute	bias -significance	shape	Timing bias - abs.	Timing bias - sign.	Seasonality	Overall Score
This model	3.65	0.30	0.25	1.40	0.64	0.37	3.50	1.97

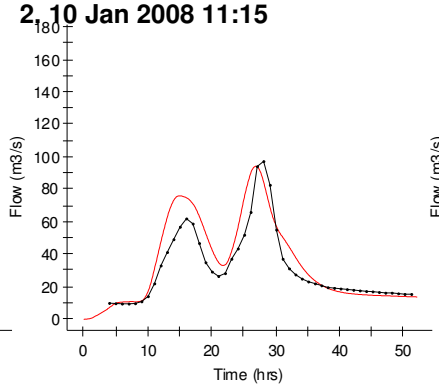




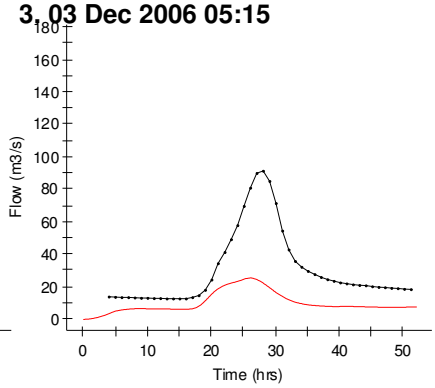
1, 28 Jun 2012 07:15



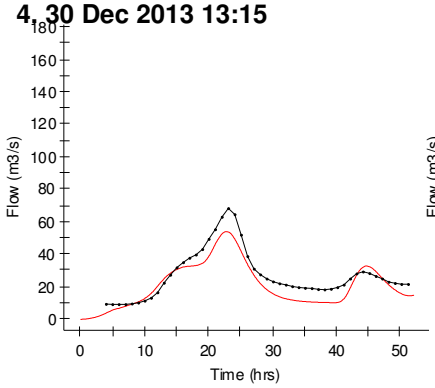
2, 10 Jan 2008 11:15



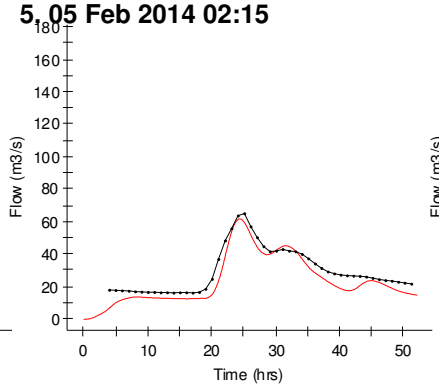
3, 03 Dec 2006 05:15



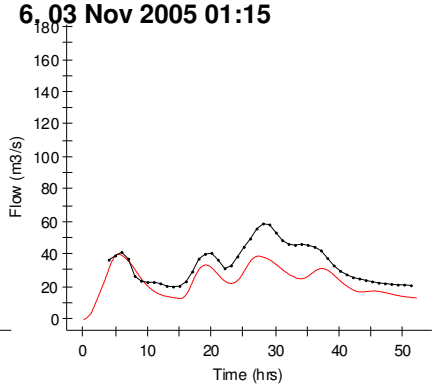
4, 30 Dec 2013 13:15



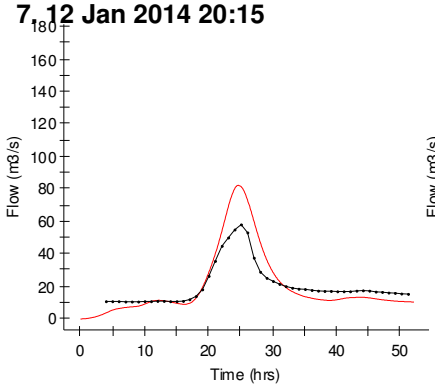
5, 05 Feb 2014 02:15



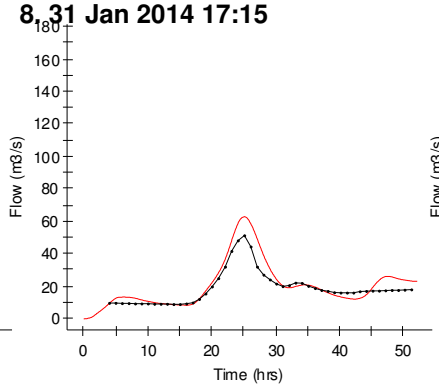
6, 03 Nov 2005 01:15



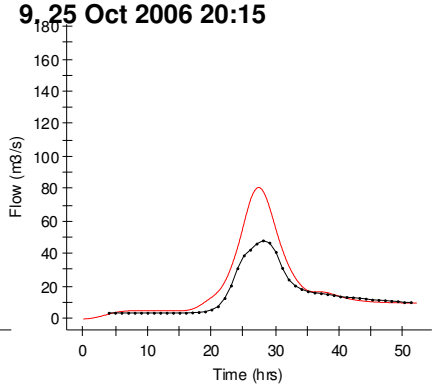
7, 12 Jan 2014 20:15

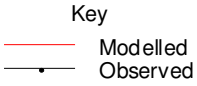


8, 31 Jan 2014 17:15

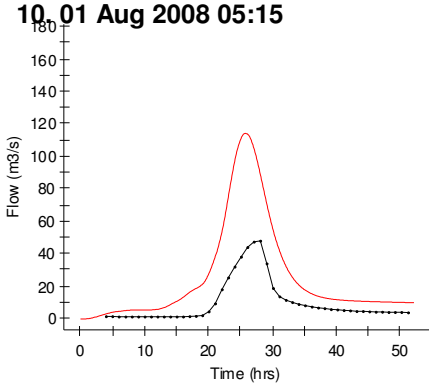


9, 25 Oct 2006 20:15

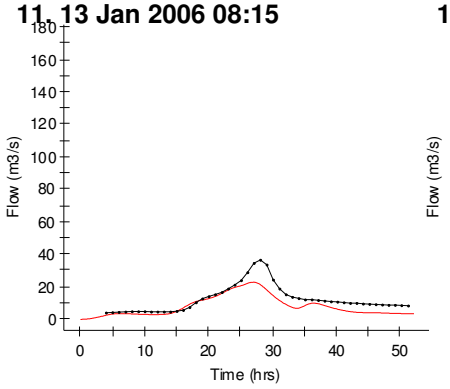




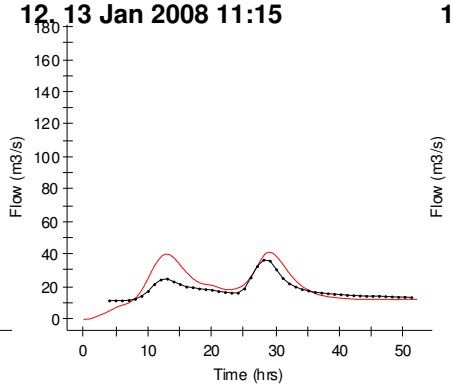
10, 01 Aug 2008 05:15



11, 13 Jan 2006 08:15



12, 13 Jan 2008 11:15



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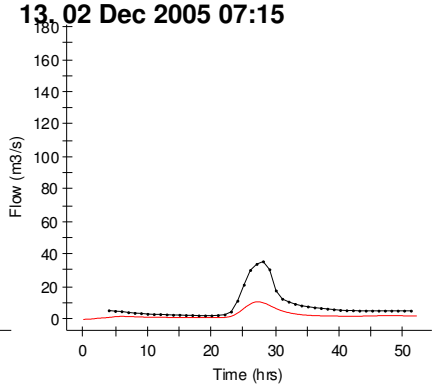

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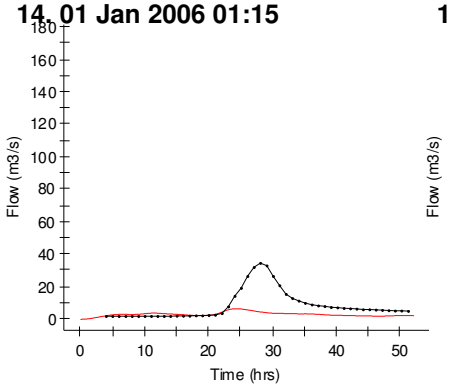

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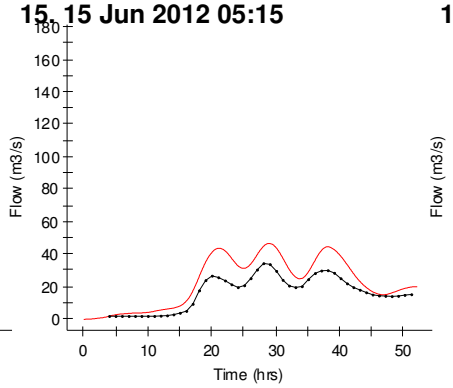

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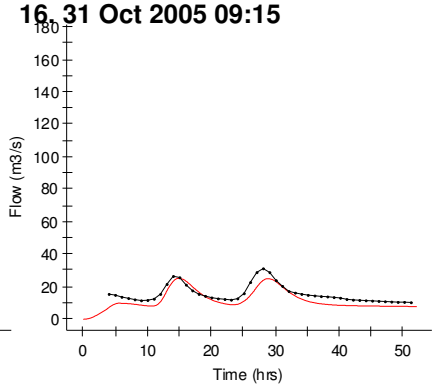

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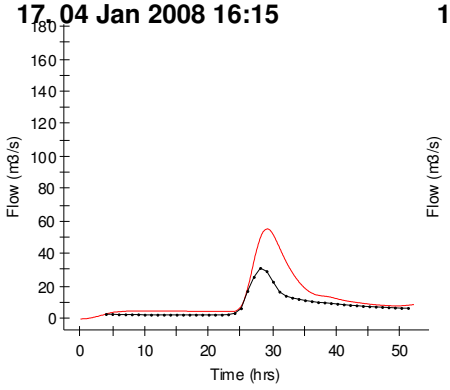

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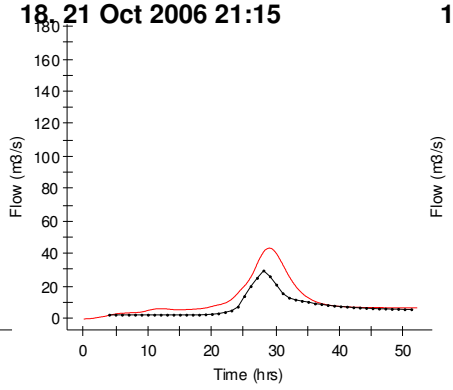

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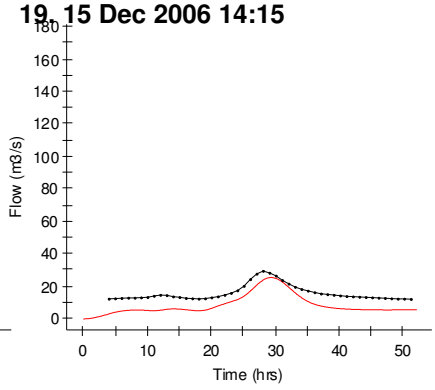

Key

Modelled

Observed

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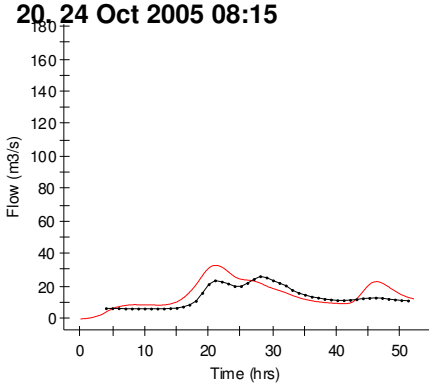

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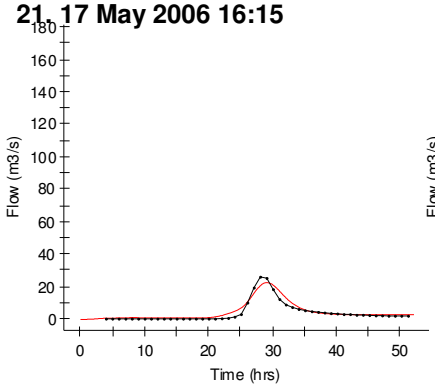
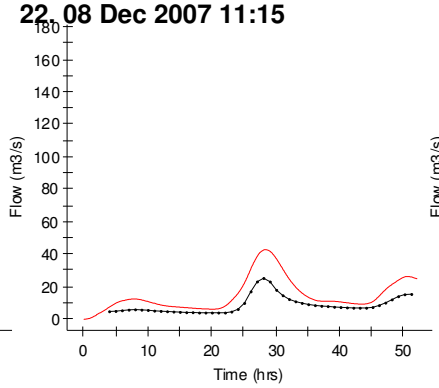


22. 08 Dec 2007 11:15



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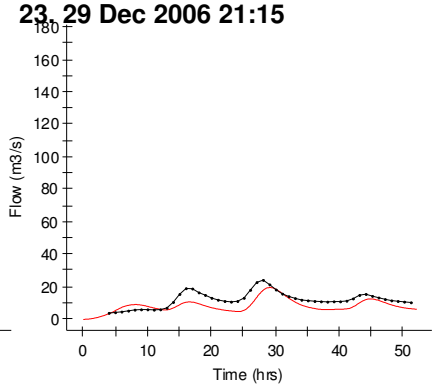

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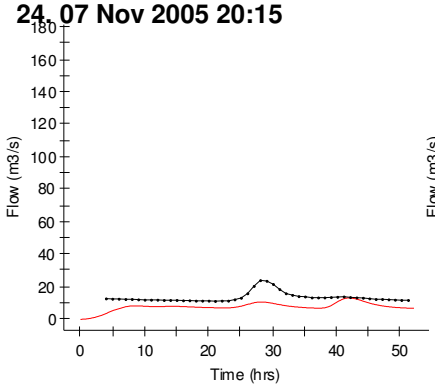
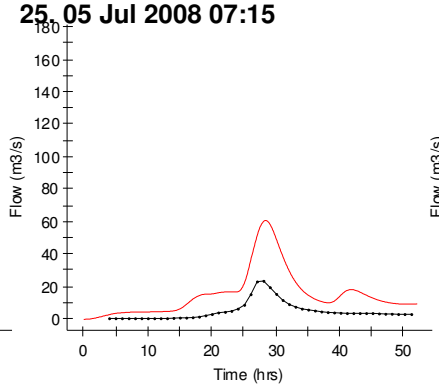


25. 05 Jul 2008 07:15



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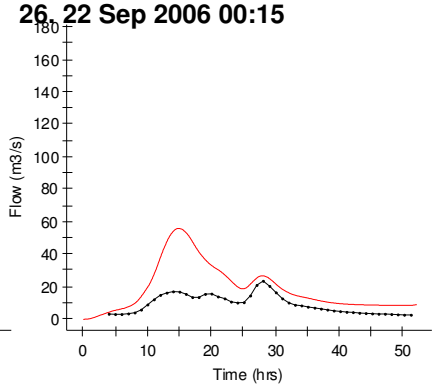

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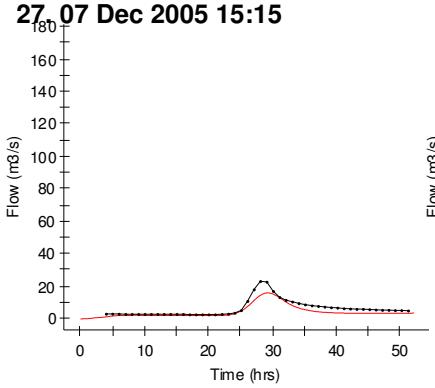
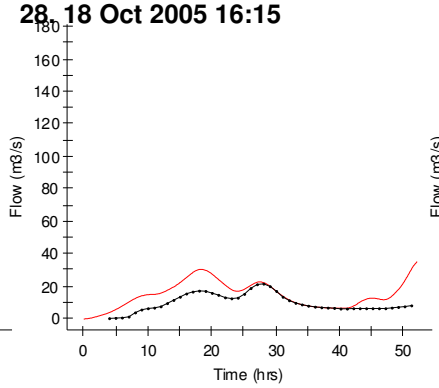


28. 18 Oct 2005 16:15



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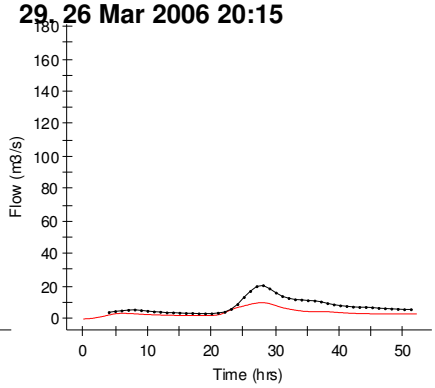

Key

Modelled

Observed

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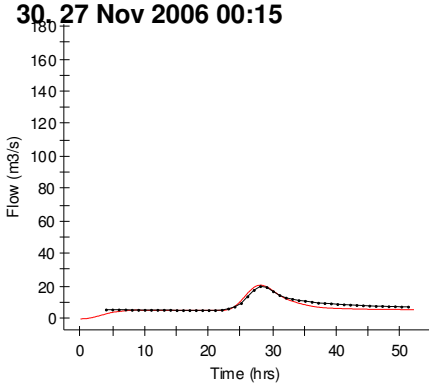

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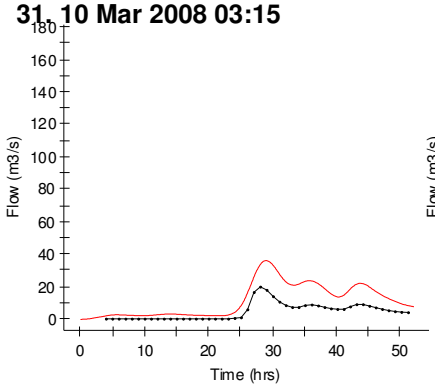

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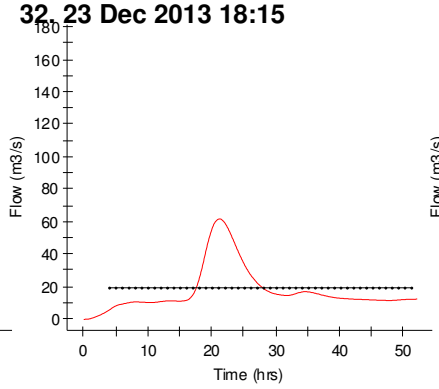

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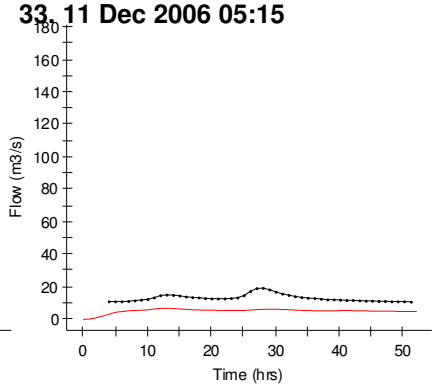
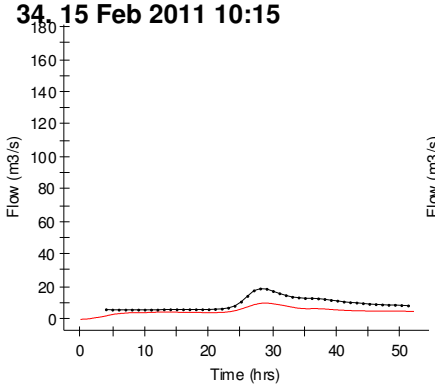


34. 15 Feb 2011 10:15



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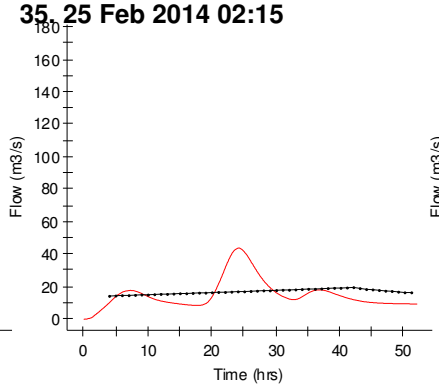
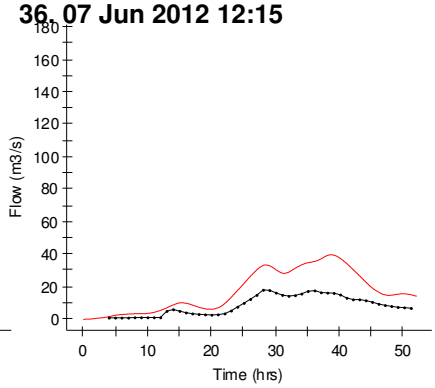
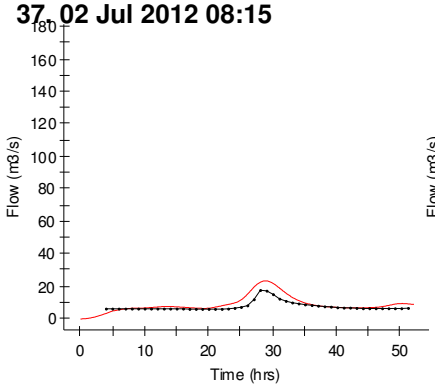


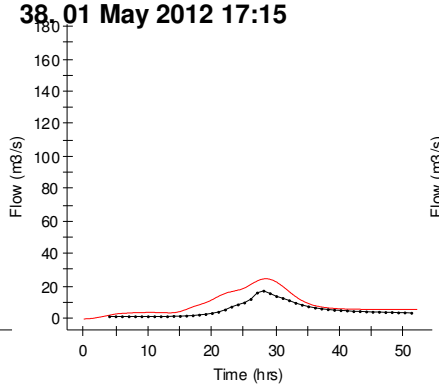
36. 07 Jun 2012 12:15



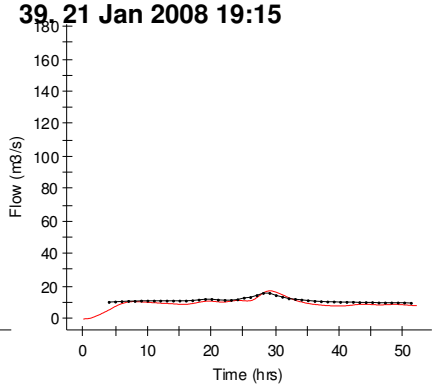
37. 02 Jul 2012 08:15

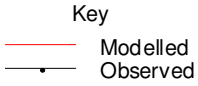


38. 01 May 2012 17:15

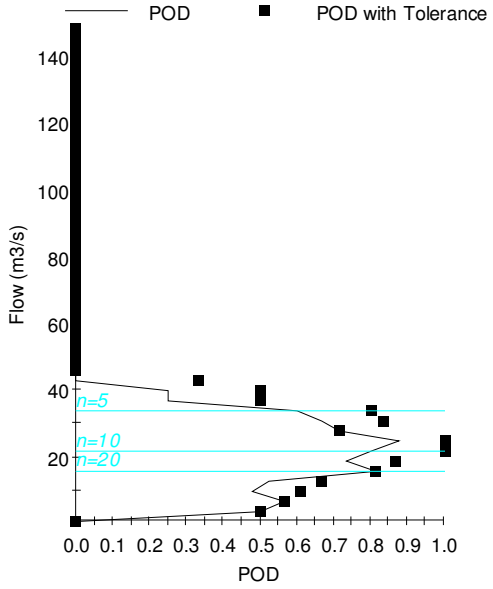


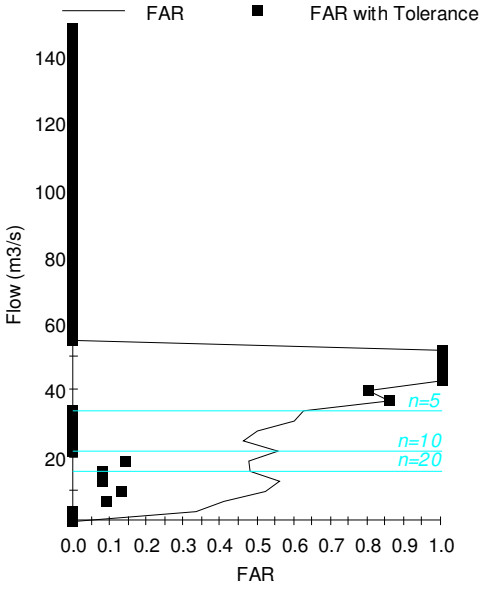
39. 21 Jan 2008 19:15

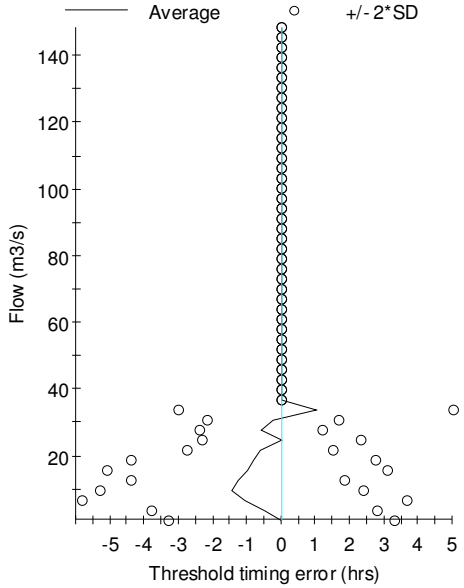




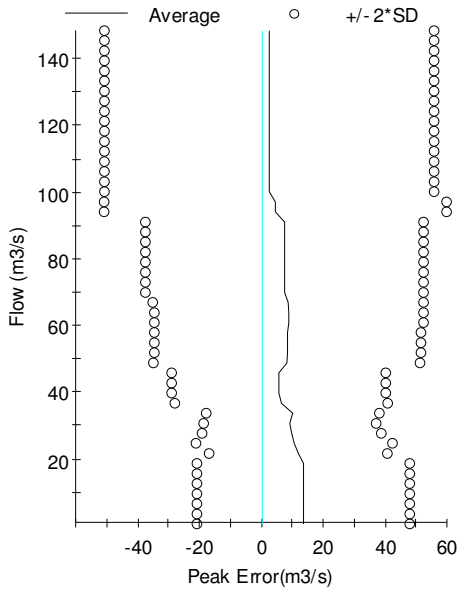
POD, FAR and peak matching statistics over full range of observations

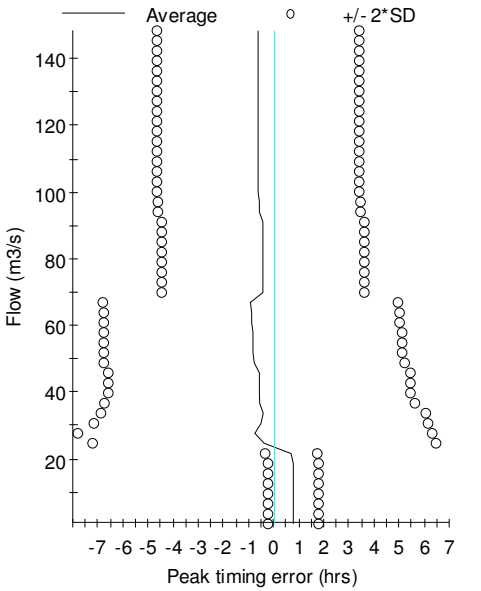


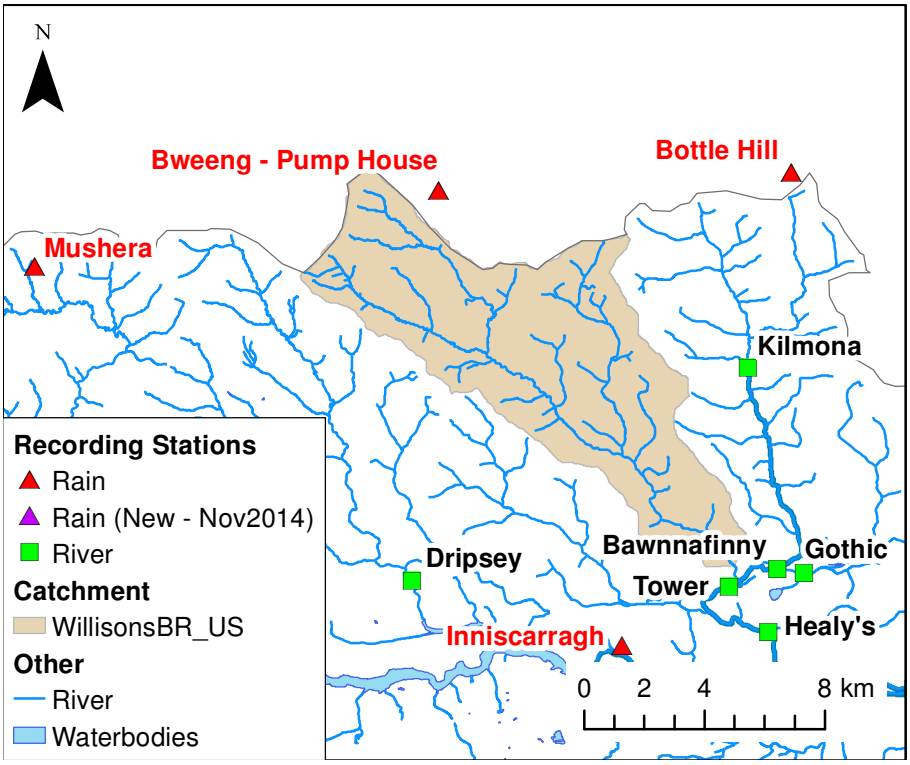




Notes: Moving average of 20 peaks used in peak calculation. Tolerance of 5% (6.6) used in POD and FAR. Threshold crossing window is 5 to 5 hrs







Raingauges used

TBR Ref	Name	Weight
Mushera_irlREev	Mushera	0.05
Inniscarra_irlREev	Inniscarra	0.2
BweengPHREev	Bweeng Pump House	0.7
BottleHillPHREev	Bottle Hill Pump House	0.15

Potential evaporation data from SINE curve

Min	0 mm/day	Max	3 mm/day	Month	Jul

Period of calibration

PDM parameters

Surface	Identical linear cascade	Base	Cubic store	Drainage	Gravity

Area	Fc	Cmin	Cmax	b	Be	Kg	Bg	St	K1	K2	Kb	QConst	Tdly
Km^2		mm	mm					mm	hrs	hrs	hmm^2	m^3/s	hrs
71	1	20	100	0.75	1	8000	1.7	0	2	n/a	3.7	0	2.5

Calibration Notes

1 WillisonsBridge U/S PDM

1.1 Catchment description

WillisonsBridge U/S PDM is situated on the River Shournagh at Willisons Bridge Upstream gauging station. The River Shaunagh is a main tributary to the River Lee. The catchment covers an area of approximately 71km^2 and comprises steep-sloping valleys forming part of the Boggeragh Mountains. Geology is largely impermeable consisting of mudstone, siltstone and sandstone.

1.2 Rainfall and evaporation inputs

The Shournagh catchment to the Willisons Bridge receives an annual average precipitation of 1260mm. There are no rain gauges situated within the catchment; the nearest is Bweeng Pump House to the north of the catchment. Rainfall inputs to the PDM are taken from Bweeng Pump House, Inniscarra, Bottle Hill Pump House and Mushera. Due to the patchy nature of rainfall records in the Lee catchment, more rain gauges have been included to allow weight to be re-allocated to other gauges during periods of missing data. Mushera has been included for this purpose and as such have very little weight assigned to it initially.

Potential evaporation inputs are represented using a sine curve profile with a maximum of 3mm/day at the end of June and the evaporation exponent (Be) was set at 1.

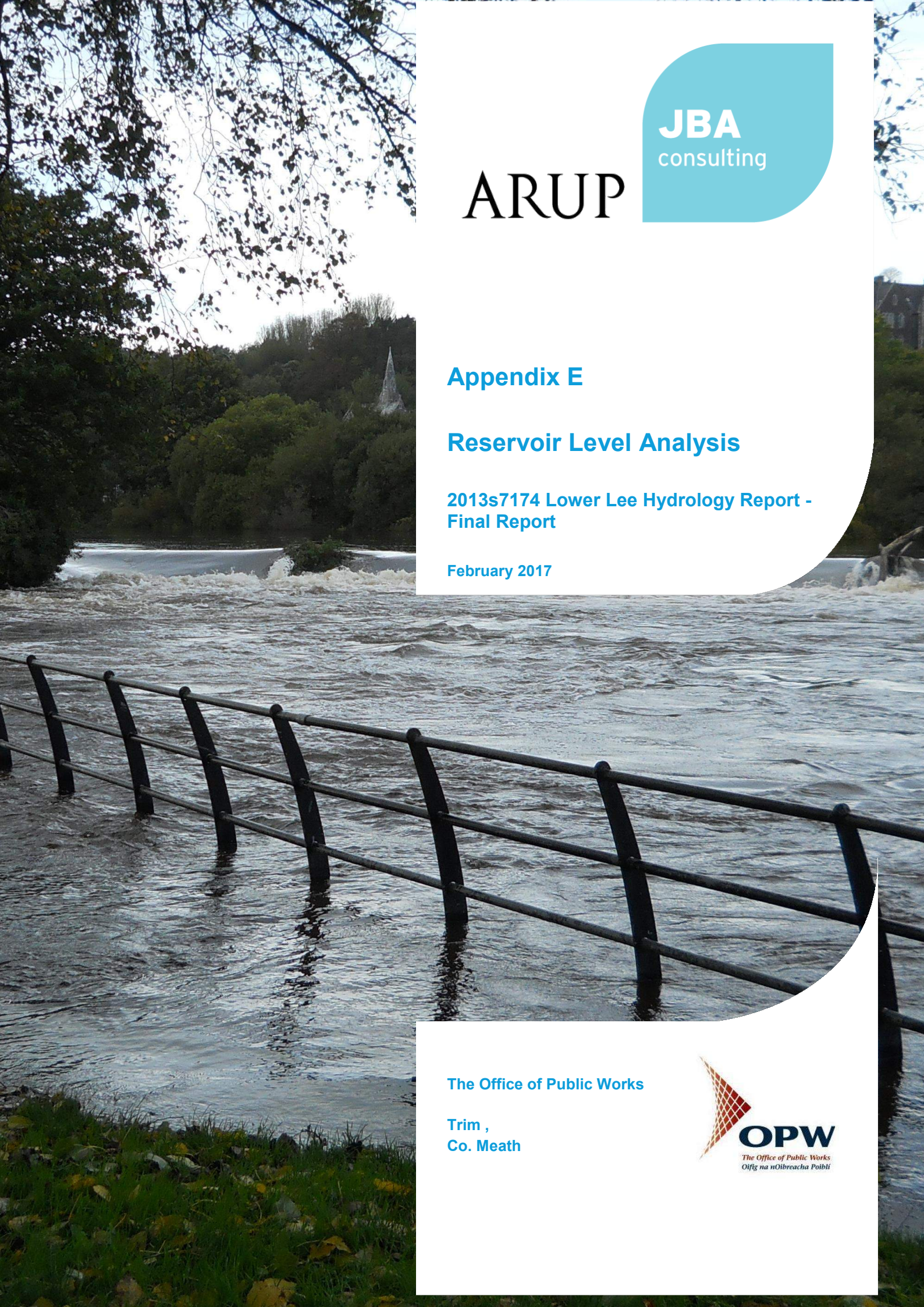
1.3 PDM parameters

The PDM is structured with a cascade of identical linear stores for surface routing and a cubic store for baseflow routing. A Pareto distribution describes the soil stores and the 'gravity' method is used for soil drainage.

Soil stores are represented using a Cmax of 100mm and a Cmin of 20mm, with the exponent of the soil store capacity, b (0.75) favouring larger soil stores. This allow runoff to vary as the soil wets up.

Both linear stores have surface routing constants (K_1) of 2 hours. Drainage parameters are Kg = 8000 and Bg = 1.7. This combination means drainage to the baseflow store is relatively quick and is slightly sensitive to soil moisture state.

The baseflow routing time constant (Kb) is 3.7hmm^2. The depth of water retained by soil under tension (St) was set at 0mm. A time delay of 2.5 hours was also assigned to bring timing of peaks more into line.



ARUP

JBA consulting

Appendix E

Reservoir Level Analysis

2013s7174 Lower Lee Hydrology Report - Final Report

February 2017

The Office of Public Works

Trim ,
Co. Meath

OPW
The Office of Public Works
Oifig na nOibreacha Poibli

E - Reservoir Level Analysis

Figure E-1: Carrigadrohid simulated and observed reservoir level and total flow out (November 2009)

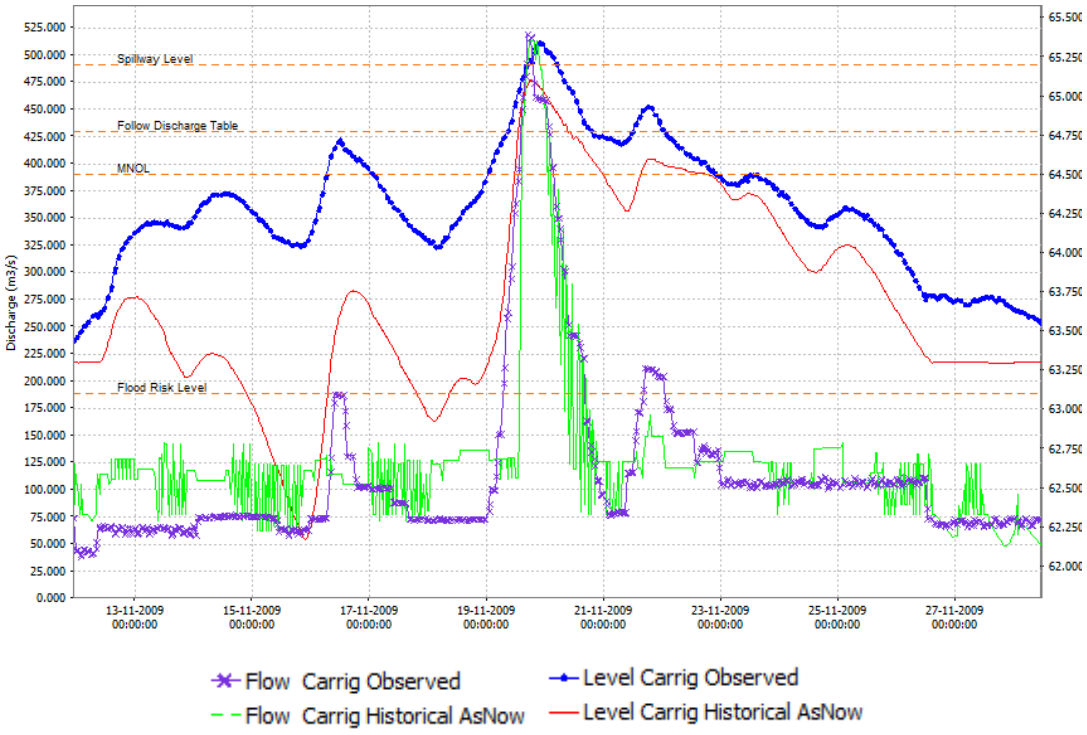


Figure E-2: Inniscarra simulated and observed reservoir level and total flow out (November 2009)

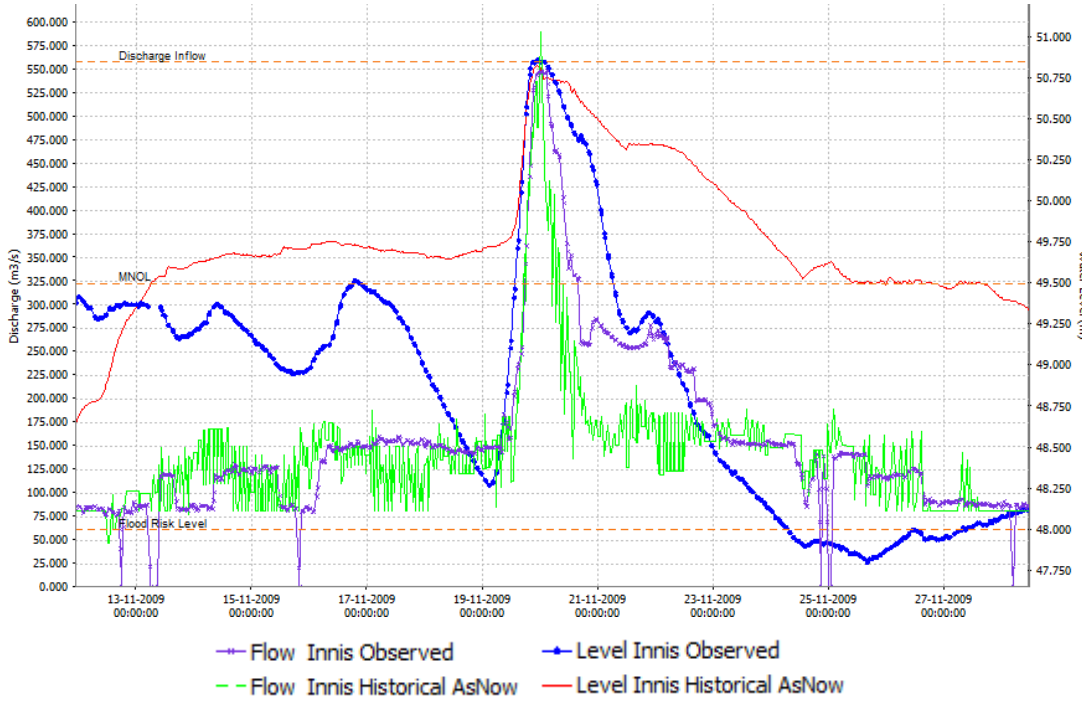


Figure E-3: Carrigadrohid simulated and observed reservoir level and total flow out (January 2008)

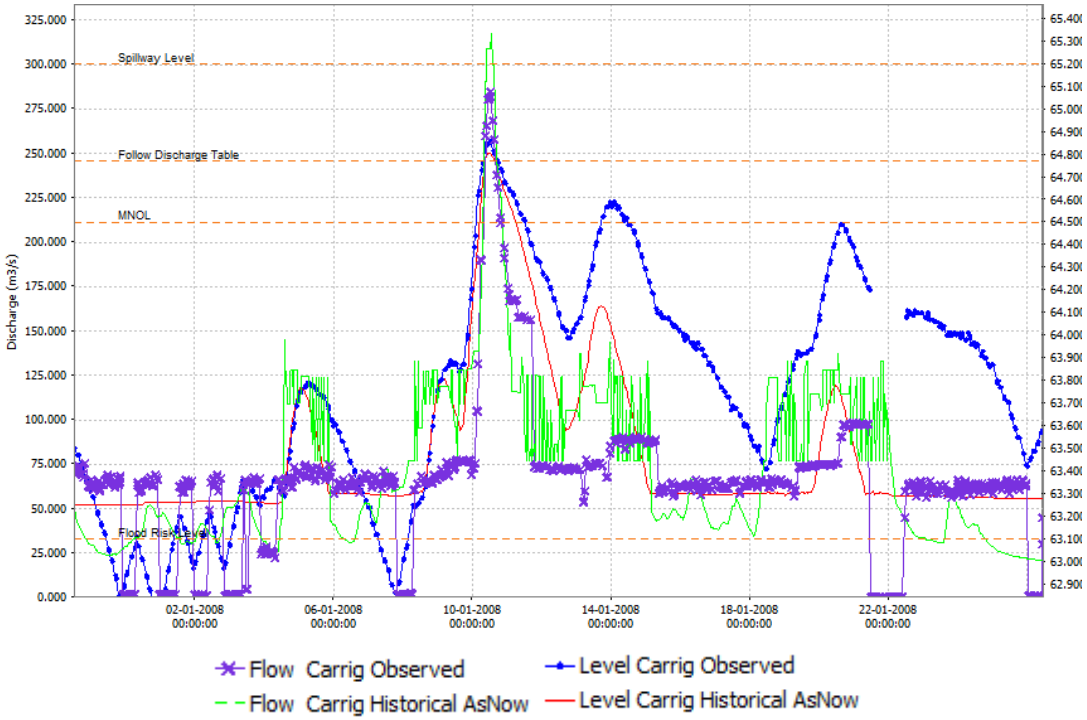


Figure E-4: Inniscarra simulated and observed reservoir level and total flow out (January 2008)

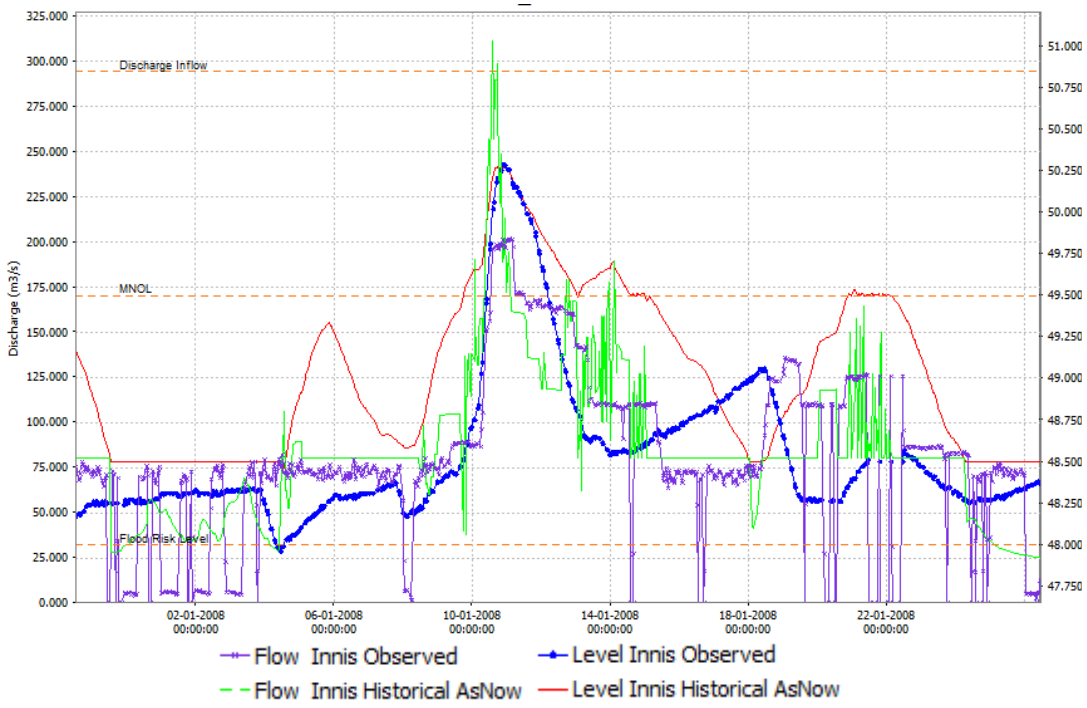


Figure E-5: Carrigadrohid simulated and observed reservoir level and total flow out (October 2013)

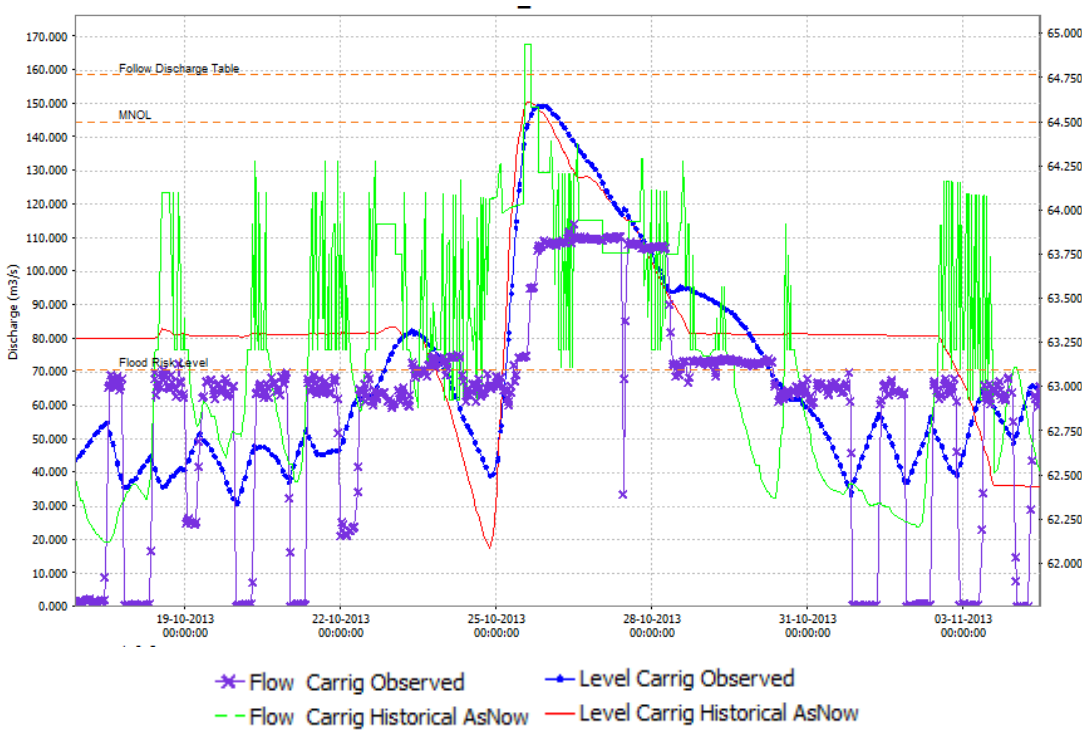


Figure E-6: Inniscarra simulated and observed reservoir level and total flow out (October 2013)