Before the Hearings Commissioners
at Christchurch

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in the matter of: a submission on the proposed Hurunui and Waiau River Regional Plan and Plan Change 3 to the Natural Resources Regional Plan under the Resource Management Act 1991

to: **Environment Canterbury**

submitter: **Meridian Energy Limited**

Statement of evidence of Steven Woods

Dated: 12 October 2012

REFERENCE: JM Appleyard (jo.appleyard@chapmantripp.com)
TA Lowe (tania.lowe@chapmantripp.com)

Chapman Tripp
T: +64 3 353 4130
F: +64 3 365 4587

245 Blenheim Road
PO Box 2510, Christchurch 8140
New Zealand

www.chapmantripp.com
Auckland, Wellington, Christchurch

CHAPMAN TRIPP

1. QUALIFICATIONS AND EXPERIENCE

1.1 My name is Steven Woods. I am employed as a Civil Engineer in the Christchurch office of MWH New Zealand Limited, and have been engaged by Meridian Energy Limited ("Meridian") to provide Hydrology and Engineering evidence. I have approximately fourteen years of experience. I am a Chartered Professional Engineer in the Geotechnical and Civil practice areas, a Member of the Institute of Professional Engineers New Zealand and a Category A Recognised (Dam Safety) Engineer.

1.2 The evidence I will present today is within my area of expertise, except where I state that I am relying on information provided by another party. My expertise in hydrology includes assessment of available abstractions for irrigation and hydropower purposes on the Waiau, Hurunui, Rangitata and Rakaia Rivers, modelling of mine water management by routing of recorded flows through storage reservoirs and supervision of hydrological assessments of available flow and flood flows for dam design projects.

1.3 My involvement in the Balmoral Hydro Project has been to provide conceptual advice on the engineering of a potential hydro scheme (the Balmoral Hydro Project) and supervise an analysis of data provided by Pattle Delamore Partners (PDP) that models the effect of the proposed Hurunui Water Project and Balmoral Hydro Project on the river flows.

1.4 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted material facts known to me that might alter or detract from the opinions expressed.

2. SCOPE OF EVIDENCE

2.1 I have been asked by Meridian to prepare evidence in relation to:

- The natural hydrology of the Hurunui catchment and the impact of current takes for irrigation.
- The methodology adopted to estimate the impact that the proposed Balmoral Hydro Project (BHP) would have on the Hurunui River flows.
- The effects of the proposed BHP on the Hurunui River flow regime (from the scheme inlet to its outlet).
- To use the results of the analysis to illustrate the relative impact of water takes for irrigation and hydro purposes.

2.2 As modelled the BHP complies with the Environmental Flow and Allocation Regime in the Proposed Hurunui Waiau River Regional Plan ("the Proposed Plan") for the Hurunui River, except that it is assumed that the existence of a C Block is not dependent on the development of 20 million cubic metres (Mm^3) of storage as is required in the Proposed Plan.

I note that the modelling undertaken takes into account the effect of the proposed Hurunui Water Project takes and abstractions on the river regime and therefore accounts for all known abstractions and likely future irrigation abstractions.

3. SUMMARY OF EVIDENCE

3.1 The natural characteristics of the Hurunui River are for variable mean monthly flows throughout the year. The trend is for the lowest flows to occur during February, March and April with the highest flows in October and November.

3.2 Current river abstraction rules reflect the natural variability in flows by assigning variable minimum flows by month throughout the year. The river minimum monthly flows upon which most abstractions are currently based on are lowest in January to July (10 m^3/s) and highest in October (17 m^3/s).

3.3 The modelled BHP take utilises flow rules that are very close to the Environmental Flow and Allocation Regime in the Proposed Plan for the Hurunui River. The model accounts for the proposed Hurunui Water Project.

3.4 The proposed BHP increases the water taken from the river compared to existing and planned future irrigation, but relatively more water could be taken for future planned irrigation than for hydro.

3.5 The modelled BHP proposal has an effect on mid range flows by increasing the proportion of time that the river flow is at the monthly minimum level. Should all of the future proposed irrigation be developed then irrigation abstraction would be the dominant influence on reducing the mid range flows in the river, particularly in the summer months where there is frequently insufficient water in the river to allow water to be taken for hydro generation after irrigation abstraction.

3.6 The modelled proposal has limited effect on flood flows in the river as it has been assumed that the BHP would not operate for the first two days during floods in the Hurunui River flows above 130 m^3/s, as measured at the Mandamus Flow recorder.

4. HYDROLOGY OF THE HURUNUI RIVER

4.1 The Hurunui catchment is bounded to the north by the Waiau Catchment and to the south by the Waimakariri, Okuku and Waipara catchments.

4.2 The Hurunui River flows about 145 km from its source in the Crawford Range to the sea. The total catchment area is approximately 2,670 square kilometres.

4.3 There are a number of existing and historic water level and flow recording sites on the Hurunui River. Two sites are operated and flow rated by Environment Canterbury and NIWA; these provide a good basis for estimating mean river flows at potential hydropower sites on the river and assessing possible water allocation regimes. These are located at Mandamus (just upstream of the confluence with the Mandamus River) and at the State Highway 1 Bridge. The characteristics for both sites are summarised in Table 4.1.

Table 4.1 – Characteristics of Water Level and Flow Recording Sites[1]

Site Number	**Site Name**	**Catchment Area (km^2)**	**Period of Record**	**Mean River Flow (m^3/s)**	**Specific Mean Yield ($l/s/km^2$)**
65101	Hurunui at SH1	2,518	2/12/74 to on-going, Flood warning only from 18/06/99-July 2007	72.8	28.9
65104	Hurunui at Mandamus	1,060	26/10/1956 to on-going	52.7	49.7

[1] Catchment area and period of record "Index to Hydrological Recording Sites in New Zealand", NIWA Technical Report 73, 2000

Mean Flow - for Hurunui at Mandamus NIWA website EDENZ

http://edenz.niwa.co.nz/map/plot/archive?name=Hurunui%20at%20Mandamus%20(River%20Flow)# for data to 16/07/2012.

- for Hurunui at SH1 from "Draft: Hurunui River Management Regime" Environment Canterbury Report No. R06/40 May 2007

4.4 Table 4.2 presents the variation of the mean monthly flow in the Amuri Reach i.e. just downstream of the Mandamus. The trend is for the lowest flows to occur during February, March and April with the highest flows in October and November.

Table 4.2 – Hurunui River (Amuri Reach) – Mean Monthly Flows

Month	Mean Flow (m^3/s)
Jan	53
Feb	38
Mar	36
April	44
May	53
June	61
July	57
Aug	63
Sep	71
Oct	89
Nov	75
Dec	62

4.5 Currently abstraction on the Hurunui River is dominated by the Amuri Irrigation Company (AIC) Balmoral Irrigation Scheme which takes 5 m^3/s of the total 6.2 m^3/s allocated on the Amuri Reach of the river for abstraction. The minimum flow rules for the Balmoral Irrigation Scheme are:

- Jan to Jul – 12 m^3/s
- Aug – 13 m^3/s
- Sep- 15 m^3/s
- Oct – 19 m^3/s
- Nov – 18 m^3/s
- Dec – 13.5 m^3/s

The additional water not allocated to the Balmoral Irrigation Scheme, utilises minimum flow rules that are 2 m^3/s lower than applied to the AIC scheme on a monthly basis[2].

5. ASSESSMENT METHODOLOGY

5.1 The hydrology model was developed by Pattle Delamore Partners Ltd (PDP)[3] based on the Hurunui at Mandamus flow recorder site between 1 June 1972 and 31 May 2011. The location of the hydro scheme in relation to the recorder is shown on Figure. 5.1

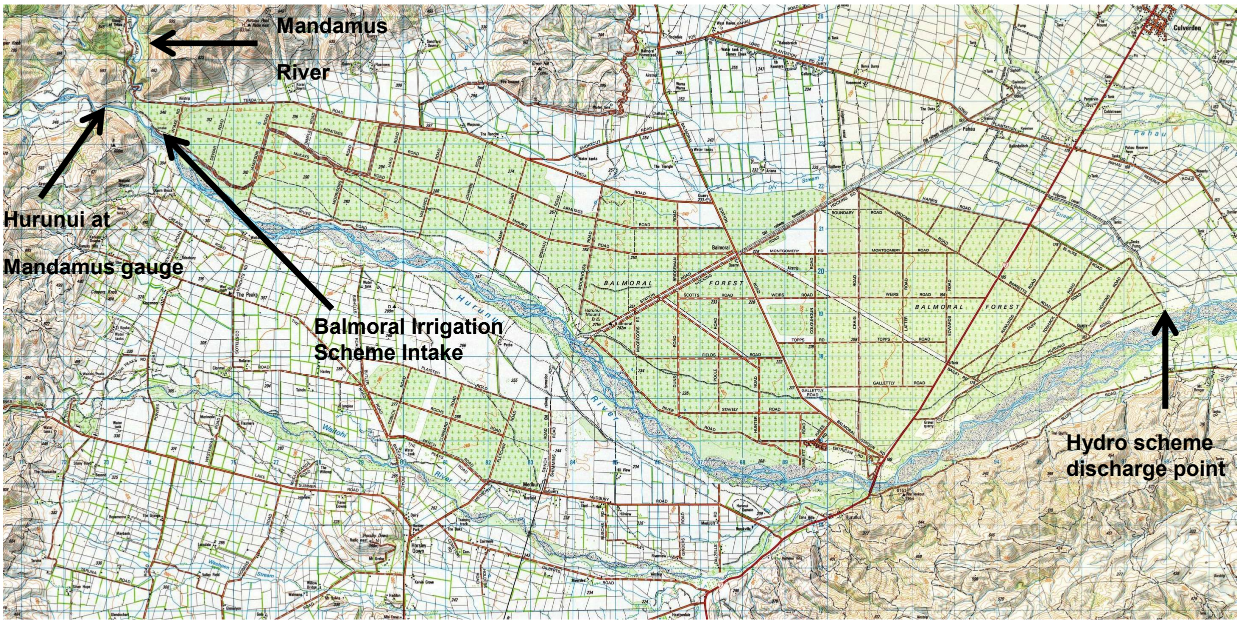

Figure 5.1 – Key Hurunui River Locations for Hydrology Assessments

5.2 Key assumptions made in the model are:

- Natural river flows are those provided by the flow recorder Hurunui at Mandamus plus the flow from the Mandamus River.
- The flow record 'Hurunui at Mandamus' is from 1 June 1972 to 31 May 2011 and is the mean daily flow in cubic metres per second (m^3/s). This

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[2] Balmoral Hydro project – Groundwater Levels and Abstractive Users Impact Assessment, CPG New Zealand Ltd, 16 August 2012

[3] Hydrological Outputs Balmoral Hydro Project (BHP), PDP, 22 May 2012

period of record was used because the extent of climate data used to estimate the irrigation demand was only available from this date.

- The flow record at Mandamus does not fully overlap with the Hurunui record. Based on the section of record that overlaps (approximately 5 years) PDP[4] have derived an average scaling factor of 8% i.e. the Mandamus flow is taken as 8% of the Hurunui at Mandamus flow on each day of the record.
- All modelled flows are calculated on a daily basis.
- The intake for the proposed BHP is at or about the existing intake structure for the Amuri Irrigation Company (AIC) Balmoral scheme.
- The outfall back into the Hurunui River for the proposed hydropower scheme is on the left bank and located just upstream of the confluence with Dry Stream.
- No losses or gains to groundwater have been included in the flow model within the reach.
- Tributary inflows have been included in the flow model for the Mandamus River, but not for the Waitohi River which enters the Hurunui just upstream of the SH7 Bridge.

5.3 The hydrology model was developed with the following assumptions regarding future water allocation on the Hurunui River[5].

- A minimum Hurunui River flow is applied. This is varied by month.
- An ‘A Block’ of up to 6.2 m^3/s is fully allocated to current irrigation. The ‘A’ Block is the highest priority water for river users.
- A ‘B Block’ of up to 10 m^3/s is for future irrigation demand. B Block water is only available once the full A Block allocation is available i.e. irrigators in the B Block cannot take water until the full allocation of the A Block is available for abstraction from the river.
- A gap (in m^3/s) is provided between the A and B Blocks i.e. water cannot be taken from the B allocation block until all of the A Block water is available and an additional number of m^3/s of flow in the river is

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[4] Pers comm. Richard Brunton, PDP

[5] From Proposed Hurunui and Waiau River Regional Plan, Environment Canterbury, Oct 2011

available. This gap is variable by month between 0 and 8 m^3/s in accordance with the provisions of the Proposed Plan.

- A ‘C Block’ of up to 33m^3/s is available for future abstraction if more than 20 Mm^3 of storage is constructed. C Block water is only available once the full A and B Block users flow requirements are satisfied.
- No flow gap is required between the B and C Blocks.
- Any available water from the ‘A’ or ‘B’ Blocks which is not taken (demanded) for irrigation is assumed available to be taken for hydro, i.e. irrigation usage has priority over hydropower.
- A maximum hydro generation take of 15 m^3/s has been used.
- The assessment is on a ‘run of river’ basis with no in scheme storage assumed i.e. the flow into the scheme for hydropower purposes is the flow discharged by the scheme.
- Hydro take is ceased for the first two days of a flood event greater than 130 m^3/s for sediment management purposes (which also has instream benefits).

5.4 Minimum monthly flows and gaps between the A and B block are summarised in the following Table 5.1. These are shown for:

- the existing takes;
- in the situation of the Proposed Plan rules before 20 Mm^3 of storage is reached, “pre storage”; and
- after 20 Mm^3 of storage is reached and the C Block allocation becomes available, “post storage”.

Table 5.1 – Existing and Proposed Hurunui River Allocation Rules[6]

Existing and future allocation regime minimum flows (m^3/s)				
Allocation Regime				
Month	Existing BIS Irrigation	Existing Other irrigation (1.2 m^3/s allocation)[1]	"Pre-storage"[2]	"Post-storage"[2]
Jan	12	10	15	15
Feb	12	10	12	15
Mar	12	10	12	15
Apr	12	10	12	15
May	12	10	12	12
Jun	12	10	12	12 (10)[3]
Jul	12	10	12	12 (10)[3]
Aug	13	11	13	12 (10)[3]
Sep	15	13	15	15
Oct	19	17	15	15
Nov	18	16	15	15
Dec	13.5	11.5	15	15
1. Minimum flow regime is subject to 1:1 flow sharing. 2. As per the 'Proposed Hurunui and Waiau River Regional Plan October 2011'. 3. Values in () are for non-consumptive takes provided the point of take and discharge are less than 250m apart.				

[6] Proposed Balmoral Hydro Scheme AEE, Table 1 (Environmental Flow and Allocation Regime Monthly Minimum Flows for Existing and Future Users in the Proposed Plan).

5.5 The model presents results for four different scenarios, namely:

- Scenario 1 (Natural Flow) – taken as the flow at the Hurunui at Mandamus recorder plus the synthesised flow record from the Mandamus recorder.
- Scenario 2 (Existing Irrigation Development) - uses the current Hurunui River minimum flow rules for irrigation abstraction and the current estimated irrigation demand along the Amuri Plains Reach ('A' Block only). For hydro takes the post storage minimum flow rules and block allocations are used.[7]
- Scenario 3 (Full Irrigation Development) – uses the 'post storage' flow regime and assumes that all existing irrigation takes are utilised and the Hurunui Water Project takes water from the A, B and C blocks to irrigate an area of about 58,500 Ha from a storage of about 220 Mm^3.
- Scenario 4 (Stage 1 Irrigation Scenario) – uses the 'pre storage' allocation regime and assumes that existing AIC takes are converted to spray irrigation and 8000 Ha of new irrigation is developed in conjunction with 11.2 Mm^3 of Waitohi storage.

5.6 Scenarios 2, 3 and 4 are further divided as follows:

5.6.1 Scenarios 2a, 3a and 4a assume irrigation water use only; while

5.6.2 scenarios 2b, 3b and 4b assume both irrigation and hydro water use.

For each of the combined irrigation and hydro scenarios it is assumed that the C Block allocation is available even if 20 Mm^3 of storage is not available. In all cases hydro flow is only taken once irrigation requirements are met.

5.7 A Scenario 5 was also considered with different assumptions regarding the staging of irrigation development but was found to be similar to Scenario 4 and was therefore not further developed.

6. MODELLING SUMMARY

6.1 MWH has taken the flow series produced by PDP and under my supervision produced the following flow statistics.

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[7] Pers. Comm. Richard Brunton, PDP

6.2 A summary of the results of the analysis are presented in Table 6.1 for each of the 7 scenarios. This table shows the effects of the different scenarios on a number of widely used flow statistics. As expected the effect of increasing takes from the river (Scenario 3 compared to the alternative lower abstraction scenarios) is to increase the percentage of time that the river is at lower flows as illustrated by the reducing mean, median, mean annual minimum, 25th and 75th percentile flows.

Table 6.1 – Summary of key river statistics from hydrology modelling (Waiau River)

Statistic	1	2a	2b	3a	3b	4a	4b
Minimum	9.9	9.9	9.9	9.9	9.9	9.9	9.9
Mean	58.6	56.5	45.5	46.7	39.9	55.5	44.9
Median	43.8	41.9	26.9	27.8	23.9	40.8	25.8
Maximum	805.5	805.5	805.5	801.9	801.9	805.5	805.5
MALF	17.0	13.9	13.0	14.2	13.6	14.1	13.3
7 day MALF	17.9	14.9	13.4	14.8	13.8	14.8	13.6
Mean Annual Maximum	427.0	425.7	421.2	414.1	410.0	425.0	420.5
75^{th} exceedance percentile	30.3	28.3	20.7	22.9	18.6	27.1	20.7
25^{th} exceedance percentile	68.4	66.6	51.6	54.4	40.6	65.4	50.4

With respect to Table 6.1, I make the following comments:

- The minimum flow is an average daily figure and reflects that the natural low flow in the river over the modelled period was 9.9 m^3/s. The river flow is not reduced below this level under any of the modelled scenarios.
- The mean and median flows in the river as expected show a reduction with increasing irrigation and hydro development. Scenario 3b which allows for full irrigation development and implementation of the hydro scheme has the lowest mean and median flow. Scenarios 2b and 4b have similar mean flows as Scenario 3b as, although there is less

irrigation abstraction, the hydro scheme would take the left over irrigation water and use it for generation (up to a maximum of 15 m^3/s).

- Under a fully developed irrigation and hydro scenario (Scenario 3) most of the abstraction is for irrigation purposes. Irrigation abstraction reduces the mean flow from a natural 58.6 m^3/s to 46.7 m^3/s while the effect of hydro abstraction is to further reduce the mean to 39.9 m^3/s. Under less fully developed irrigation scenarios (2 and 4) the relative reduction in flow for hydro abstraction is larger.

- The maximum flow over the modelled period is changed little by the modelled scenarios as the hydro take is restricted under flood conditions.

- The mean annual low flow or MALF (i.e. mean of the lowest flows in each year) reduces from the natural flow as expected under each of the take scenarios. The MALF's calculated under Scenario 2 (existing irrigation development) are the lowest as the minimum flows under the current minimum flow rules are lower than those proposed by the Proposed Plan that Scenarios 3 and 4 model.

- The mean annual maximum (also known as the mean annual flood) is the mean of the highest flow recorded each year. As noted above there is limited taking assumed under flood conditions, therefore limited change to the mean annual maximum.

- The 75th and 25th percentiles give an understanding of the percentage of time that the river exceeds certain flows. For example under the existing irrigation development the subject reach would have flows at or in excess of 28.3 m^3/s for 75% of the time. Under the scenario that abstracts the most water (3b) flows in the river would be at or in excess of 18.6 m^3/s for 75% of the time.

6.3 As shown by the small changes in maximum river flow in Table 6.1, the modelled scenarios have a more limited impact on high river flows than on mean and median flows. This is because water taken for hydro generation purposes is assumed to cease for the first 2 days of a flood in excess of 130 m^3/s to avoid excessive inflow of suspended sediment to the scheme. This effect is further illustrated in Table 6.2 which shows the impact on the modelled proposals on the occurrence of mean daily river flows at Mandamus in excess of 130 m^3/s. The mean number of days per annum reduces under the abstraction scenarios because of a small number of days when the natural flow would have been just over 130 m^3/s but the take reduces the flow to just under

130 m^3/s (this is more likely to be due to irrigation abstraction as this is assumed to continue once hydro takes stop). However these days were generally found to be part of a larger flood event such that the number of distinct events per annum (where consecutive days exceed 130 m^3/s they are included as one flood event) had only a small change.

Table 6.2 – Effect of Modelled Scenarios on River Flows over 130 m^3/s at Mandamus

Statistic	1	2a	2b	3a	3b	4a	4b
Mean number of days per annum flow is greater than 130 m^3/s	24	23	21	19	17	23	20
Mean number of distinct events per annum flow is greater than 130 m^3/*s	7	7	7	6	6	7	7
Mean number per annum that flow greater than 130 m^3/s is absent more than 6 weeks	3	3	3	2	2	3	3
Maximum number of days flow greater than 130 m^3/s is absent	514	514	514	536	536	514	514

*separate flood events where 130 m^3/s is exceeded (i.e. where consecutive days exceed 130 m^3/s they are included as one flood event).

6.4 In order to visually represent the data, flow verses time plots are presented in **Appendix A** for years considered to represent dry, average, and wet conditions. The representative years were selected by PDP and were based on a percentile assessment of mean annual flow[8]. From the percentile assessment on the Hurunui at Mandamus flows, a typical year within the 20th, 50th, and 80th percentile, without a major uncharacteristic event, were used for the typical dry, average, and wet years respectively. Flows in the selected years were also visually checked to make sure there was a reasonably even spread of flow across the year i.e. the overall annual average was not being skewed by a small number of isolated flow events e.g. one or two large floods.

6.5 Appended Figure A1 shows the effect of the proposed scenarios in a typical dry year. It can be seen from the blue natural flow line that the river had very limited flood or fresh activity between February and April. The effect of the existing irrigation takes is to further reduce the flows over this period while the

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[8] Pers. Comm. Richard Brunton, PDP

effect of the future modelled scenarios is less pronounced due to increases to the minimum flow under the proposed plan. Over the rest of the year there is a more regular series of floods and freshes every few weeks. The most pronounced impact of future proposed irrigation and hydro generation is over the October to January period where there are longer periods where the river remains at the minimum flow.

6.6 Compared to the flow series shown in Figure A1, Figure A2 showing a typical wet year illustrates similar behaviour in the February to April period but much more frequent floods and freshes through the rest of the year. Because of the more frequent flood activity there are less sustained periods of low flow under future modelled scenarios, which is particularly evident in the October to January period.

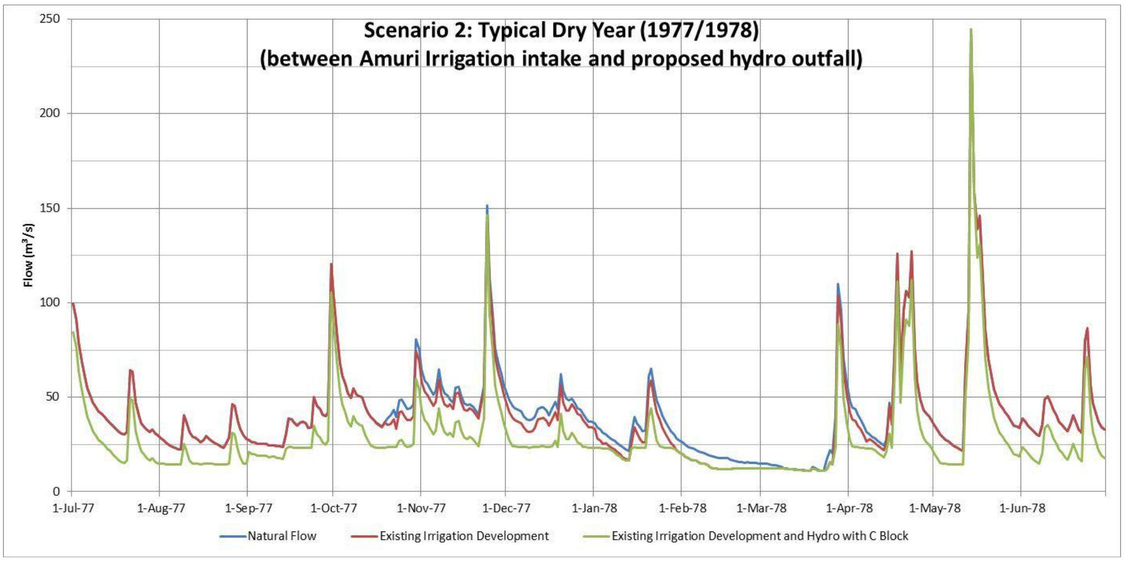
6.7 Figure A3 illustrates a typical average year. Compared to the two previous years there were elevated natural flows in February but a prolonged period of low natural flow until May. Over the February to May period the effect of the modelled future scenarios on the river flow is similar to the current irrigation abstraction. Over the remainder of the year there are few periods of sustained low flow in any of the modelled scenarios because of a regular series of floods and freshes.

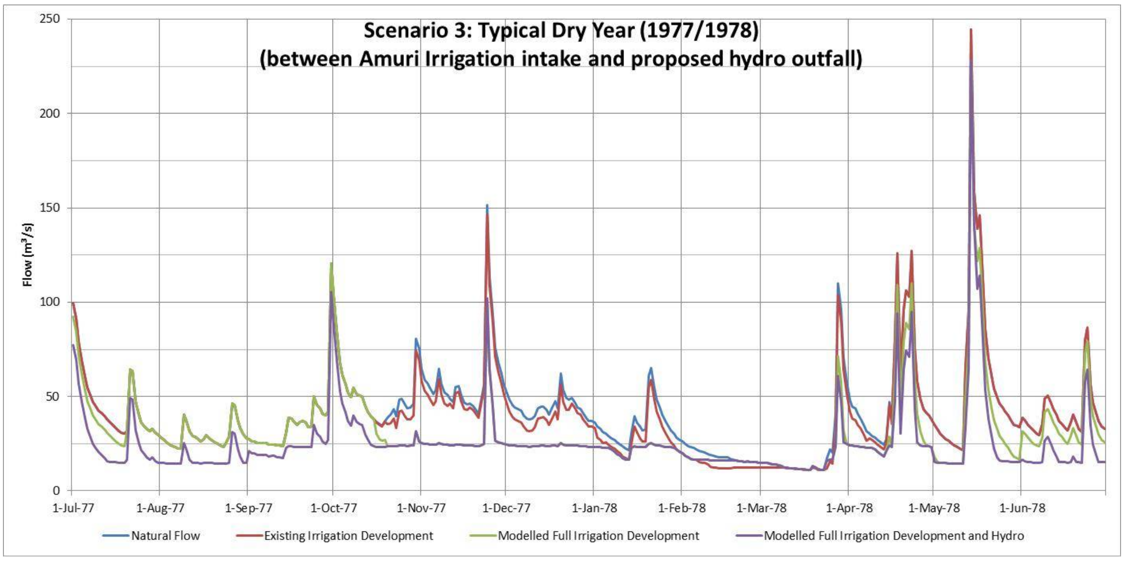
6.8 The relative effect of irrigation and hydro abstraction can be visualised by comparing the “irrigation” and “irrigation and hydro” lines on the appended plots. Under Scenario 3 (maximum irrigation development) there is limited separation of these lines over the summer months indicating that the water is being used for irrigation and is not available for hydro generation. In the winter months there is greater separation of the lines as water becomes available for generation use. Under Scenario 4 which has more limited irrigation development there is greater separation of the “irrigation” and “irrigation and hydro” lines as would be expected because of the greater relative impact of hydro generation.

Steven Woods

12 October 2012

Appendix A





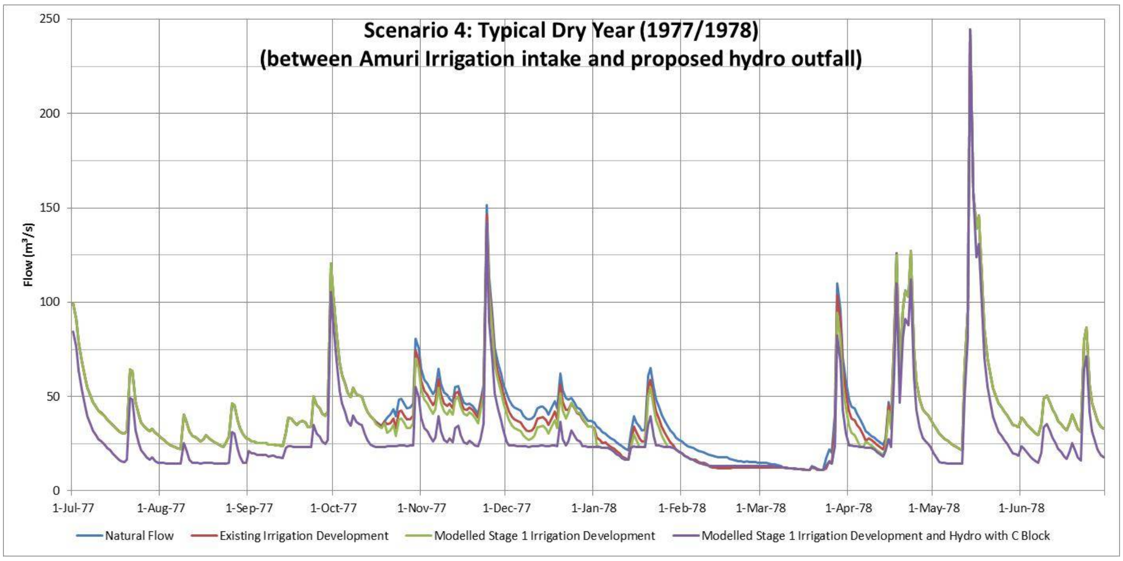
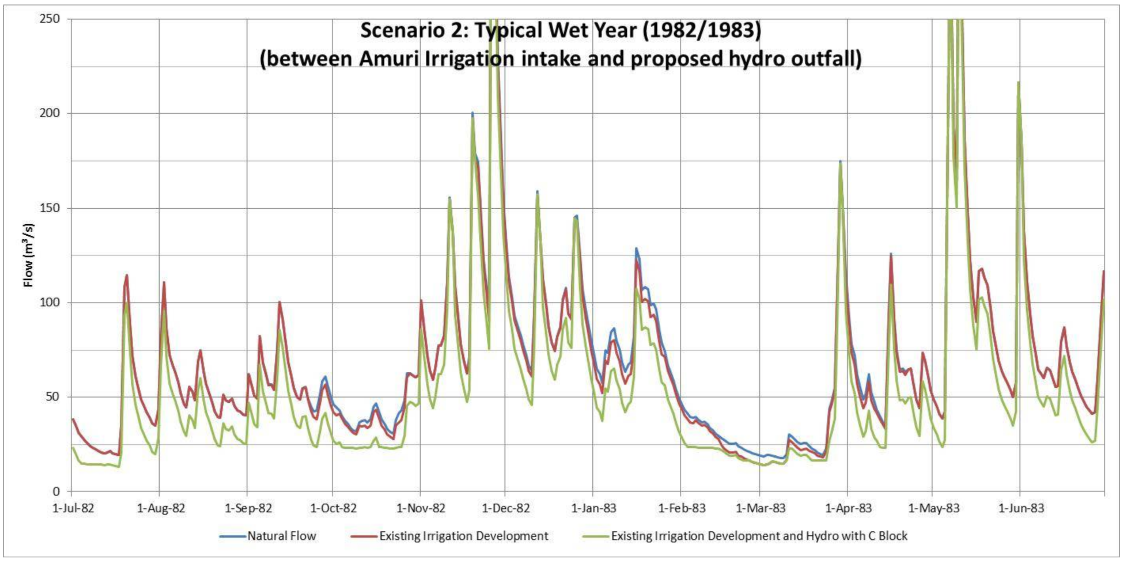
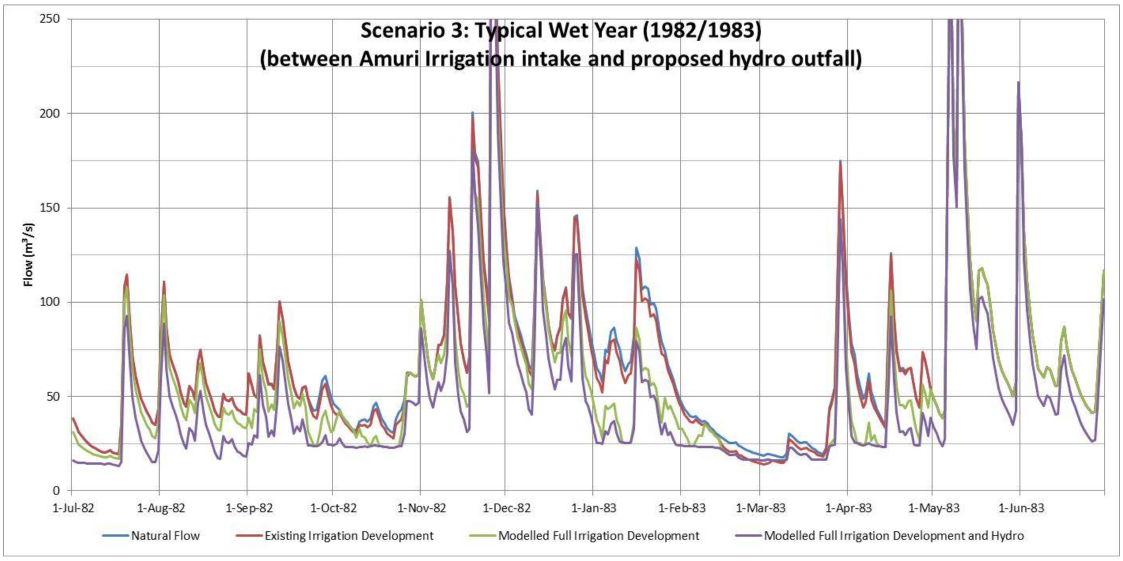


Figure A1 – Flow Series for Typical Dry Year





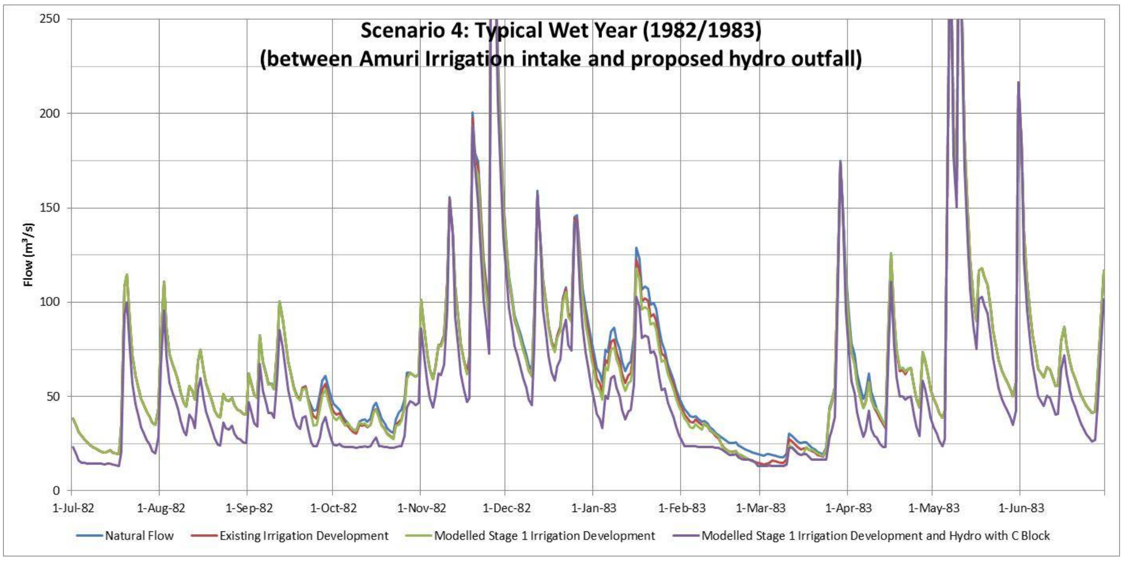
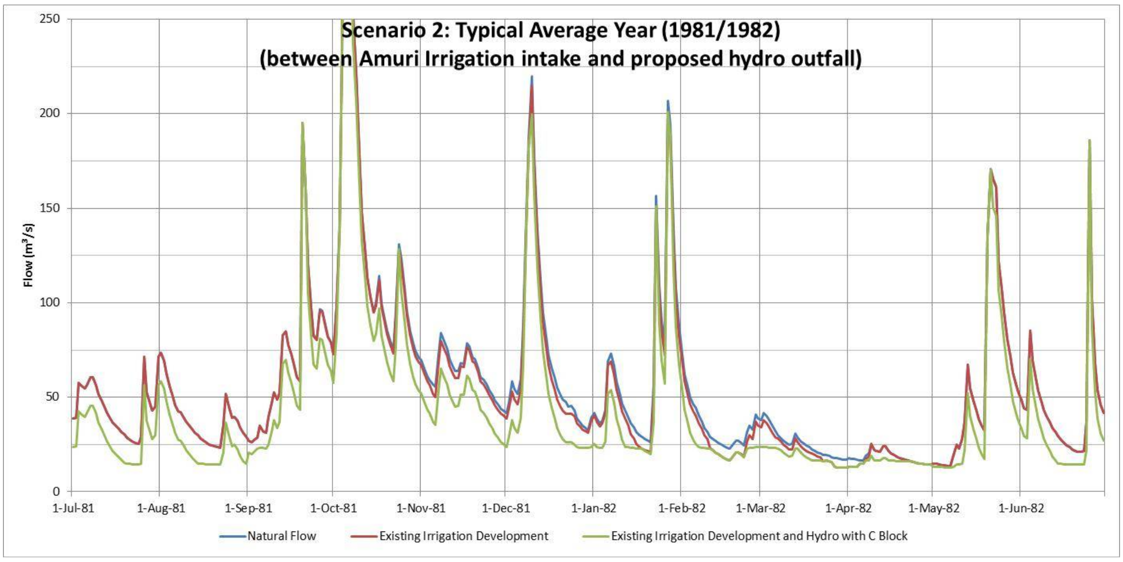
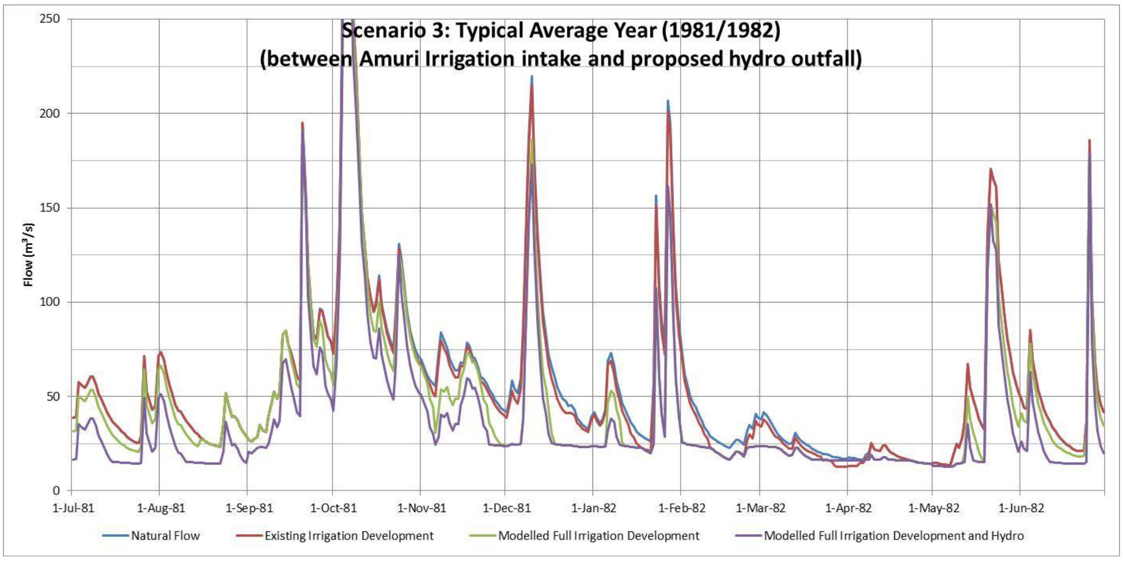


Figure A2 – Flow Series for Typical Wet Year





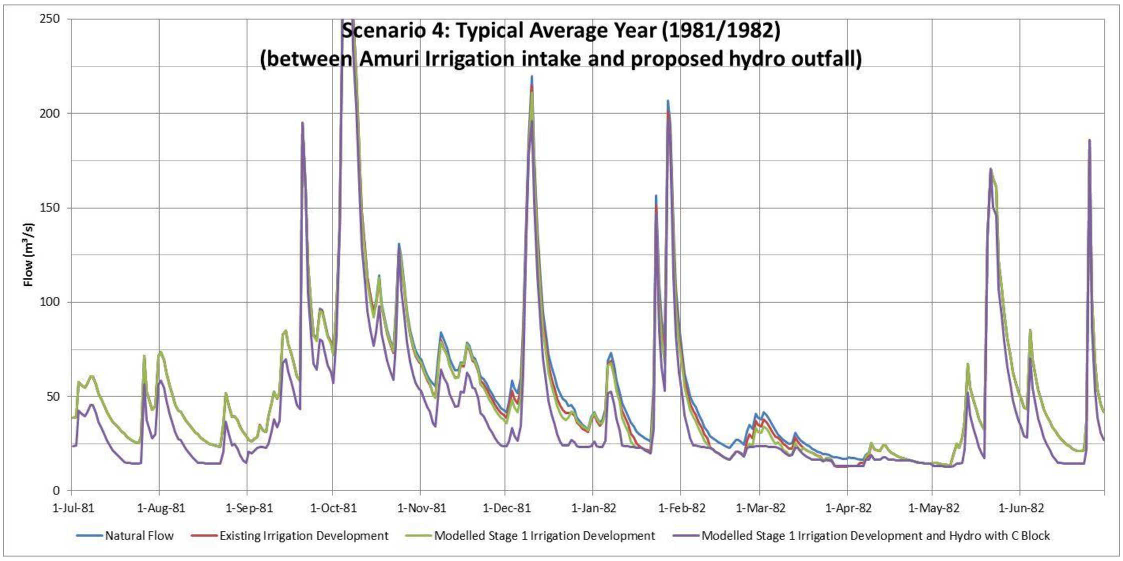


Figure A3 – Flow Series for Typical Average Year