An Investigation into

Capacity Sharing for the Namoi Valley

A Study Conducted for the Cotton Research and Development Corporation, the New South Wales Irrigators Council, and the Namoi Valley Water Users Association

by

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Introduction

In early 1999 the Centre for Water Policy Research was approached by the Namoi Water Users Association, the NSW Irrigators Council, and the Cotton Research and Development Corporation (CRDC), to investigate the possibility of introducing Capacity Sharing for Namoi Valley irrigators. It was agreed that the Department of Land and Water Conservation, New South Wales (DLWC) would provide a copy of their Namoi river Integrated Quality and Quantity Model (IQQM), a hydrology model, to the Centre to enable the modelling of sharing scenarios. However, the DLWC advised the Centre that the Namoi IQQM was still being developed, and would not be available until October 1999 (This estimate later proved incorrect)[1]. The Centre then sought to use the DLWCs' monthly model for the Namoi that had been in use before the development of the IQQM. After discussions with the DLWC staff it was determined that the monthly model did not contain transmission loss elements, and would not therefore be suitable for the estimation of Capacity Shares. It was established that there were no other suitable existing models, and that the creation of a new model would be necessary for this project. Because of the project timetable the Centre researchers resolved to build a river hydrology model, with monthly time intervals, for the Namoi River to enable them to assess Capacity Sharing scenarios. This has been done, although it has consumed the financial resources made available for the project plus some of the Centre's own funds. This report describes the modelling approaches tested, some interim results, and discusses option for handling transmission losses.

[1] The current estimate for the completion of the model is March 2000.

Development of a Hydrology Model

The main objective of this project is to investigate the feasibility of changing volumetric allocations to Capacity Shares for Namoi water users. To do this the Centre developed a hydrology model for the Namoi, to simulate reservoir behaviour and flows into and out of each reach.

All available data on stream flow, storage volumes and diversions for the Namoi river were gathered for the development of the new model. Diversion data on the Namoi were available only in a monthly format, dating from October 1990. These data were the best available for estimating Capacity Shares (CS). Flow data to December 1996 were obtained from the "Pineena 5" CD-ROM published by the DLWC. "Pineena 6", a later CD-ROM version, was recently acquired by the Centre, which provided flow data up to April 1998. Further data, including major storage volume, and diversions that were not available on Pineena were sourced from regional DLWC offices.

Three modelling approaches were tried; one based on generating monthly loss ratios from streamflow data, one using regression analysis of streamflow data, and another using modifiable efficiency values for losses.

1. **Monthly Loss Ratio Model**

A monthly model was created, and monthly loss ratios were calculated from gauged river flow data and diversion information for each "reach" of the river. These ratios indicate monthly "delivery efficiencies". It is possible for ratios to exceed 1 (100%), where inflows in a reach exceed transmission losses. In such cases, however ratios were capped at 1 to eliminate potential distortions in data interpretation (for example a large inflow on a single day in a month may be sufficient to give an average delivery efficiency of greater than 1, even though there may have been net transmission losses on every other day). Unfortunately, there were some missing gauged data, which meant that it was not possible to calculate efficiencies for each month of the study. Ultimately, it was determined that modelling losses this way was not the optimum approach.

2. Regression Analysis

Pineena provided records of daily flow data throughout the valley. This allowed for the study of daily delivery efficiencies. Least square regressions were used to describe daily flows in terms of their upstream components (lagged through time where necessary). The regressions were applied to generate no constant, with the downstream flow capped to the level of the upstream flow. Initial evaluations of the regressions indicated very high correlations with R^2 values > 0.95. There was concern that large flows could dominate the sample, in most cases, however, the residuals observed were acceptable. Using this method flows were described as:

$$\text{Flow}_{\text{at point}} = \text{Constant}_1 * \text{Flow}_{\text{upstream}} + \text{Constant}_2 * \text{Flow}_{\text{upstream tributary}}$$

Where constant_1, and constant_2 are the relevant delivery efficiencies

However, further examination of the sample indicated that the coefficients estimated were not suitable for application in a model. Assuming that flows between the 20^{th} and 80^{th} percentile would contain most of the regulated flow, regressions were carried out on this sample. While reasonably high R^2 values were observed, the coefficients estimated were significantly different for those observed in the analysis of the whole population. It was not possible to fully investigate an appropriate loss co-efficient without access to daily diversion data, but the variability of the co-efficient estimated suggested that this was not a suitable approach for modelling CS.

3. Variable Efficiencies

It is possible, with the gauged data to calculate, with certainty, the change in storage levels, inclusive of evaporation, rainfall, and ungauged inflow by the formula;

$$\text{Net Inflow}_{\text{this period}} = \text{Volume}_{\text{current}} - \text{Volume}_{\text{Start this Period}} - \text{Releases}_{\text{this period}}$$

Monthly diversions are known, transmission losses may only be calculated with (unavailable) daily diversion data. Therefore a monthly model that takes as input variable transmission loss ratios, reach by reach, has been created, so that alternative assumptions may be investigated. The model is in a spreadsheet format, and calculates the volume, and inflow CS required (reach by reach) such that all historical diversions may be met. This is done by adjusting the inflow, and volume CS to a level such that all deliveries received may be met, and the minimum held by the user is zero megalitres. This is achieved using the "goal seek" function of Microsoft Excel. It would be possible to assign multiple inflow/volume share combinations that would allow this condition to be met, however to ensure an comparable translations for all users it is necessary to assign inflow and volume shares in the same proportion. The results obtained from the model would be immediately applicable if CS was to be implemented with pre-determined transmission losses, as was proposed for trials in Queensland.

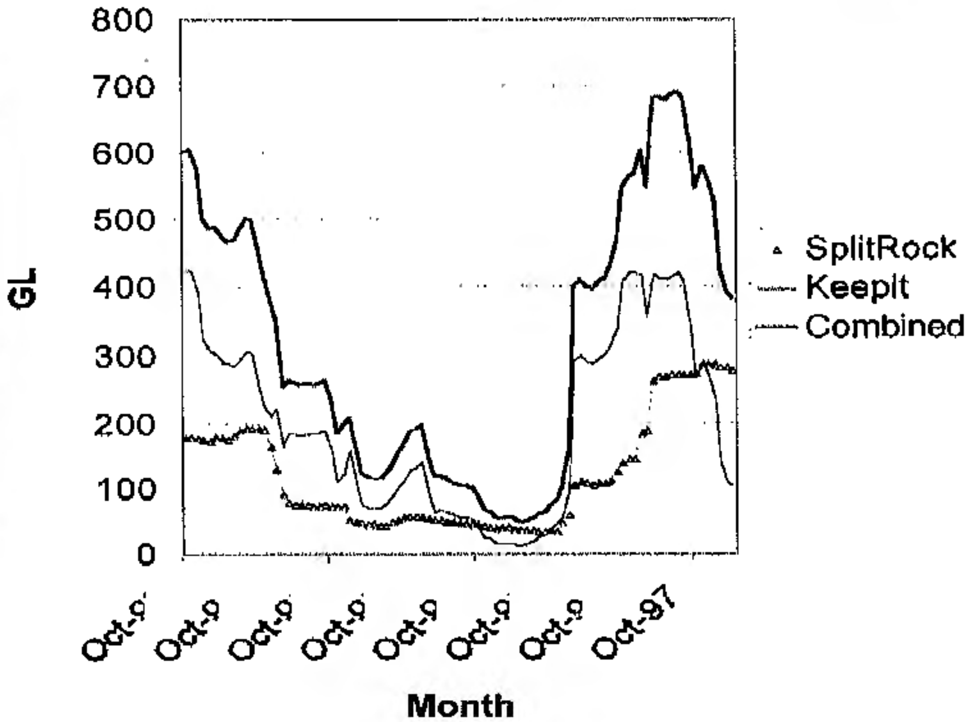

Figure 1. Volume held in Keepit and Split Rock.

The estimates obtained illustrate the use of resources for the period of study (October 1990 to January1999) for which the necessary data were available. A more complete picture of resource use is given by also considering volumes maintained in storage (Figure 1), these figures are the volumes observed on the first day of the respective month. The minimum combined quantity of water stored was 48.6 GL in May 1995. For the individual storages, the minimum quantity held in Keepit was 12.06 GL (May 1995). Split Rocks' minimum holding was 34.06 GL (November 1995).

It is not appropriate to consider scenarios where initial storage volumes for consumptive water users are altered when actual diversions are taken as an input to the model. Adjusted storage levels would lead to altered allocations, and consequently altered use.

The total high security usage across the period of study was 9.2GL, with a maximum usage of 2.4 GL in 1996/97. An inflow, and volume share of 0.803% would allow those demands to be met (exclusive of transmission loss requirements). A (similarly defined) 1.9% share of resources would result in a minimum holding in excess of 5GLs over the period, though would allow greatly increased water access, as the share regularly spills.

During the period under study (October 1990 to January 1999) water transfers were made from Split Rock to Keepit, the last being in 1992. The estimates obtained for Split Rock CS show the CS's required to enable the release of the users' share of the water assigned as inflow at Keepit. Note that an increased share in Split Rock would result in a lower share in Keepit's capacity, but the method employed reflects the actual use of resources over the period.

The DLWC has advised that no regulated water is supplied from the Peel to users downstream of Keepit. Internal spills have not been re-assigned to other users, and none occurred at times when other users had free capacity to benefit from them. Weirs have not been incorporated in to the model.

The model takes users recorded data for storage inflows, and diversions. As outlined above it was not possible to make robust estimates of transmission loss without access to daily flow and diversion data, consequently the model was designed to evaluate varying estimates of reach by reach transmission losses. The reaches employed were those used in the DLWC diversion data. The design will allow the application of the loss functions employed by the Namoi IQQM. When they are made available, single figure delivery efficiency may be calculated as a weighted average of the individual delivery efficiencies observed.

The effects of three simple transmission loss estimates on Keepit shares are displayed in the tables below, for illustration purposes only. The estimate with no transmission loss, however, is of value as it shows the amount of "deliverable" water that would have been required from a Capacity Share to allow users the access to water they actually experienced over the period of study. Note that the single figure delivery efficiency should be calculated as a weighted average of the individual delivery efficiencies observed.

Tables 1, 2, and 3 below, indicate the inflow shares (as percentages of the total inflow into Keepit Dam) and the Storage Capacity Shares Keepit Dam that would be assigned to the current Volumetric Allocation licence holders in each reach of the river. The percentage of inflows and storage volume for individual licences would be a proportion of the total licensed volume for the reach in which it is located.

	Keepit Dam Inflow Share (%)	Keepit Dam Volume Share (ML)	Efficiency this reach	Efficiency (from Keepit)
KEEPIT TO GUNNEDAH	0.70%	2968	100.00%	100.00%
GUNNEDAH TO BOGGABRI	1.09%	4625	100.00%	100.00%
BOGGABRI TO NARRABRI	1.78%	7546	100.00%	100.00%
NARRABRI TO MOLLEE WEIR	0.87%	3685	100.00%	100.00%
MOLLEE WEIR TO GUNIDGERA WEIR	28.75%	122192	100.00%	100.00%
GUNIDGER WEIR TO WEETA WEIR	7.23%	30734	100.00%	100.00%
WEETA WEIR TO DUNCAN GAUGE	2.31%	9803	100.00%	100.00%
DUNCAN GAUGE TO BUGILBONE GAUGE	4.52%	19194	100.00%	100.00%
BUGILBONE GAUGE TO GOANGRA GAUGE	2.51%	10683	100.00%	100.00%
GOANGRA GAUGE TO WALGETT	1.90%	8075	100.00%	100.00%
GUNIDGERA CREEK	8.60%	36539	100.00%	100.00%
PIAN CREEK	13.23%	56237	100.00%	100.00%
TOTAL	73.48%	73.48%		

Table 1. No Loss in Delivery (Case I)

	Keepit Dam Inflow Share (%)	Keepit Dam Volume Share (ML)	Efficiency this reach	Efficiency (from Keepit)
KEEPIT TO GUNNEDAH	0.71%	2998	99.00%	99.00%
GUNNEDAH TO BOGGABRI	1.11%	4719	99.00%	98.01%
BOGGABRI TO NARRABRI	1.83%	7777	99.00%	97.03%
NARRABRI TO MOLLEE WEIR	0.90%	3836	99.00%	96.06%
MOLLEE WEIR TO GUNIDGERA WEIR	30.23%	128490	99.00%	95.10%
GUNIDGER WEIR TO WEETA WEIR	7.68%	32645	99.00%	94.15%
WEETA WEIR TO DUNCAN GAUGE	2.47%	10517	99.00%	93.21%
DUNCAN GAUGE TO BUGILBONE GAUGE	4.89%	20801	99.00%	92.27%
BUGILBONE GAUGE TO GOANGRA GAUGE	2.75%	11694	99.00%	91.35%
GOANGRA GAUGE TO WALGETT	2.10%	8929	99.00%	90.44%
GUNIDGERA CREEK	9.13%	38810	99.00%	94.15%
PIAN CREEK	14.05%	59733	99.00%	94.15%
TOTAL	77.87%	77.87%		

Table 2. Delivery Loss of 1% per reach (Case II.)

	Keepit Dam Inflow Share (%)	Keepit Dam Volume Share (ML)	Efficiency this reach	Efficiency (from Keepit)
KEEPIT TO GUNNEDAH	0.72%	3060	97.00%	97.00%
GUNNEDAH TO BOGGABRI	1.16%	4915	97.00%	94.09%
BOGGABRI TO NARRABRI	1.95%	8268	97.00%	91.27%
NARRABRI TO MOLLEE WEIR	0.98%	4163	97.00%	88.53%
MOLLEE WEIR TO GUNIDGERA WEIR	33.48%	142294	97.00%	85.87%
GUNIDGER WEIR TO WEETA WEIR	8.68%	36897	97.00%	83.30%
WEETA WEIR TO DUNCAN GAUGE	2.85%	12133	97.00%	80.80%
DUNCAN GAUGE TO BUGILBONE GAUGE	5.76%	24490	97.00%	78.37%
BUGILBONE GAUGE TO GOANGRA GAUGE	3.31%	14052	97.00%	76.02%
GOANGRA GAUGE TO WALGETT	2.58%	10950	97.00%	73.74%
GUNIDGERA CREEK	10.32%	43865	97.00%	83.30%
PIAN CREEK	15.89%	67514	97.00%	83.30%
TOTAL	87.67%	87.67%		

Table 3. Delivery Loss of 3% per reach (Case III.)

	Keepit Dam Inflow Share (%)	Keepit Dam Volume Share (ML)	Efficiency this reach	Efficiency (from Keepit)
KEEPIT TO GUNNEDAH	0.74%	3125	95.00%	95.00%
GUNNEDAH TO BOGGABRI	1.21%	5124	95.00%	90.25%
BOGGABRI TO NARRABRI	2.07%	8802	95.00%	85.74%
NARRABRI TO MOLLEE WEIR	1.06%	4524	95.00%	81.45%
MOLLEE WEIR TO GUNIDGERA WEIR	37.16%	157916	95.00%	77.38%
GUNIDGER WEIR TO WEETA WEIR	9.84%	41810	95.00%	73.51%
WEETA WEIR TO DUNCAN GAUGE	3.30%	14038	95.00%	69.83%
DUNCAN GAUGE TO BUGILBONE GAUGE	6.81%	28932	95.00%	66.34%
BUGILBONE GAUGE TO GOANGRA GAUGE	3.99%	16950	95.00%	63.02%
GOANGRA GAUGE TO WALGETT	3.17%	13487	95.00%	59.87%
GUNIDGERA CREEK	11.70%	49706	95.00%	73.51%
PIAN CREEK	18.00%	76504	95.00%	73.51%
TOTAL	99.04%	99.04%		

Table 4. Delivery Loss of 5% per reach (Case IV)

The form of the model

The tables below are intended to illustrate the processes employed by the model; cells for user inputs are darkly shaded. Lightly shaded cells are referenced. All other cells are fixed inputs, or calculated.

Opening Balance at Keepit	424,000	ML
Capacity of Keepit	425,000	ML

	Efficiency this reach	Efficiency (from Keepit)
GUNNEDAH TO BOGGABRI	0.95	0.95
BOGGABRI TO NARRABRI	0.95	0.9025
NARRABRI TO MOLLEE WEIR	0.95	0.857375
MOLLEE WEIR TO GUNIDGERA WEIR	0.95	0.814506
GUNIDGER WEIR TO WEETA WEIR	0.95	0.773781
WEETA WEIR TO DUNCAN GAUGE	0.95	0.735092
DUNCAN GAUGE TO BUGILBONE GAUGE	0.95	0.698337
BUGILBONE GAUGE TO GOANGRA GAUGE	0.95	0.66342
GOANGRA GAUGE TO WALGETT	0.95	0.630249
GUNIDGERA CK	0.95	0.598737
PIAN CK	0.95	0.735092
	0.95	0.735092

Table 5. Global Inputs Sheet

Efficiency	0.99
Balance 1/10/90	424000
Full Volume	428000
Inflow Share	0.007055
Volume Share	0.007055
Volume ML	[redacted]
Volume Used	2998.324
Blanket CS	[redacted]

Maximum Held	2998.324
Minimum Held	-3.1E-13
Tot. Spills	1378.724
Date of min. vol	Dec-94

Net Inflow	Date	On Alloc Diversions	Required Release	Inflow Volume	Volume held at end of month	Spills
362.715						
33869.79						
3079.414						
31353.95						
20692.87						
43697.02						
134530.8						
183319.3						
78281.13					2991.269	
14987.13	01-Oct-90	16	16.16162	105.7324	2998.324	82.5
-1902.59	01-Nov-90	326	329.2929	-13.4225	2655.609	0
-3715.27	01-Dec-90	364	367.6768	-26.2108	2261.721	0
28017.42	01-Jan-91	68	68.68687	197.6595	2390.694	0
14544.41	01-Feb-91	6	6.060606	102.6091	2487.242	0
-2623.16	01-Mar-91	147	148.4848	-18.5061	2320.252	0
-2880.7	01-Apr-91	222.5	224.7475	-20.323	2075.181	0
4716.631	May-91	172.1	173.8384	33.27527	1934.618	0
6630.045	Jun-91	0	0	46.77418	1981.392	0
13069.55	Jul-91	0	0	92.20409	2073.596	0
2307.357	Aug-91	6.2	6.262626	16.27813	2083.612	0
-628.989	Sep-91	369.1	372.8283	-4.43744	1706.346	0
-2052.37	Oct-91	130	131.1395	-14.4792	1560.727	0
20209.82	Nov-91	78	78.74969	142.5779	1624.555	0
39859.99	Dec-91	35	35.35354	281.2075	1870.409	0
43193.79	Jan-92	223	224.9928	304.727	1950.144	0
37042.06	Feb-92	50	50.56277	261.3273	2160.908	0
842.508	Mar-92	108	109.3939	5.943794	2057.458	0
148.256	Apr-92	155	156.2626	1.045928	1902.241	0
2849.238	May-92	15	14.64646	20.10103	1907.696	0
1490.803	Jun-92	0	0	10.51744	1918.213	0
4621.789	Jul-92	15	15.15152	32.60617	1935.668	0
7272.63	Aug-92	25	25.06814	51.30754	1961.907	0
5217.596	Sep-92	27	26.82563	36.80952	1971.891	0
9449.155	Oct-92	528	533.3892	66.66266	1505.165	0
14260.42	Nov-92	16	16.51463	100.6056	1589.256	0
37976.8	Dec-92	57	57.17097	267.9218	1800.006	0
1973.648	Jan-93	307	310.1727	13.92385	1503.758	0
1250.132	Feb-93	179	181.0297	8.819532	1331.547	0
-384.357	Mar-93	159	160.507	-2.71159	1168.329	0
-167.531	Apr-93	85	85.89723	-1.18191	1081.25	0
1184.055	May-93	0	0.156016	8.353367	1089.447	0
6030.97	Jun-93	0	0	42.54777	1131.995	0
11369.8	Jul-93	0	0	80.21258	1212.207	0
13302.73	Aug-93	0	0	93.84918	1306.057	0
11201.84	Sep-93	0	0	79.02761	1385.084	0
14927.67	Oct-93	0	0.130336	105.3129	1490.267	0
6280.983	Nov-93	26	25.76989	44.31159	1508.809	0

Table 6. Example of a Capacity Share determination sheet, from the Hydrology model (for the Keepit - Gunnedah reach)

The "Inflow Share" cell takes the value from "Blanket CS". The "Volume Share" cell first references the volume ML cell, if this is empty the "Blanket CS" value is used. The "Volume Used" cell displays the volume currently being applied, in Megalitres. The CSs were determined using a component of the spreadsheet package, the "goal seek" function. The user is able to instruct the model to set "Minimum Held" to zero, by varying "Blanket CS".

The transfers from Split rock required 67.14% of resource (266537 ML) capacity. Therefore a Keepit share of x % would have an associated share in Split Rock of:

$$\frac{X * 67.14}{100} \%$$

The significant result above (Table 1) shows the Capacity Shares that would be required to harvest and store "deliverable" water, just as the allocation announcement under the current system relates to water supplied to the user. An associated CS is required to cover losses incurred in delivery. The purest application of CS would see every user with a share that includes their own loss component, and such losses would be debited from the individuals' account. A simpler (and more readily achievable) application of CS is to socialise losses within sectors (or valleys). While individuals will not directly benefit from their own efficiencies, as desired, their communities will.

Issues regarding water trade are discussed elsewhere in this report. The following tables illustrate the CSs required to deliver all water diverted to one reach (eg. the"end of system reach"), with the given transmission loss.

Efficiency	0.9	Maximum Held	345787.3
Balance 1/10/90	424000	Minimum Held	-1.1E-10
Full Volume	425,000	Tot. Spills	99984.78
Inflow Share	0.813617	Date of min. vol	Nov-94
Volume Share	0.813617		
Volume ML	[illegible]		
Volume Used	345787.3		
Blanket CS	[illegible]		

Table 7. All Diversions, Delivery Efficiency of 90%

Efficiency	0.85	Maximum Held	366127.7
Balance 1/10/90	424000	Minimum Held	9.21E-10
Full Volume	425,000	Tot. Spills	105866.2
Inflow Share	0.861477	Date of min. vol	Nov-94
Volume Share	0.861477		
Volume ML	[illegible]		
Volume Used	366127.7		
Blanket CS	[illegible]		

Table 8 All Diversions, Delivery Efficiency of 85%

Efficiency	0.8	Maximum Held	389010.7
Balance 1/10/90	424000	Minimum Held	-2E-10
Full Volume	425,000	Tot. Spills	112482.9
Inflow Share	0.915319	Date of min. vol	Nov-94
Volume Share	0.915319		
Volume ML	[illegible]		
Volume Used	389010.7		
Blanket CS	[illegible]		

Table 9 All Diversions, Delivery Efficiency of 80%

Assuming an average 10% transmission loss for all water deliveries in the system, a Capacity Share of 81.4 % of Keepit Dams' inflow and storage volume would be required to harvest and store the water required to meet all system diversions (and the losses incurred in their delivery), see Table 7. For losses of 15%, 86.1% of resources would be required, see Table 8. While an average loss of 20% could be met from a 91.5% share, see Table 9. Note that rain rejections have not been incorporated into the model; to maintain identical resource allocation a rain rejection share (that was not available on demand) would have to be incorporated. The dead storage volume of the reservoirs has not been taken into consideration, dead storage was not reached over the study period, all shares have been granted as a percentage of the total reservoir volume.

Options for Allocating Transmission Losses

Transmission losses are inevitable when delivering water from a reservoir. More losses must be incurred to deliver water to customers further downstream than others. For the purposes of modelling convenience, it is assumed that all customers in a particular reach of the river will incur a similar transmission loss. These losses can be significant, especially when one takes into account that they are cumulative as one moves downstream. Transmission losses must therefore be factored into any water allocation procedure (including the current release sharing mechanism). It is not clear, however, how the DLWC accounts for changes in transmission losses under the current allocation mechanism, when licences are traded upstream or downstream, as traders do not incur volumetric penalties or receive a credits. Such a practice of not accounting for trade-induced alterations to transmission losses is acceptable if there is no net change in the distribution of licences, because total transmission losses remain unchanged. Other situations that would enable trade without explicitly accounting for losses are;

when net reductions in transmission losses have resulted from trading (ie. where licences have traded from down-stream users to upstream users), and

where net increases in transmission losses could be accommodated from water held in reserve by the water agency.

A problem with the current practice of not attributing specific transmission losses to licences according to their location in the river system, is that it has meant that the market value of a similar sized water licence anywhere in the river system, at any given time has been the same. This presents a dilemma for introducing any more rigorous water allocation mechanism where transmission losses may be specifically assigned to licences in each reach of a river. If this were done, licences at upstream locations would immediately have less value than those located downstream, since the Capacity Shares needed to accommodate transmission losses would be smaller.

It is clear that transmission losses are important and need to be factored in for each licence to achieve a fair and sustainable mechanism for water accounting and trading. It is doubtful, however, that irrigators would tolerate the inequities in the value of entitlements that would arise by providing differential capacity shares according to users locations. This problem would arise for *any* more rigorous water accounting system - it is not unique to Capacity Sharing. In the Gwydir valley, irrigators have agreed to pool transmission losses. This is a simple and pragmatic approach which could work provided that there is enough water allocated to a 'loss pool' to cover potential rises in transmission losses associated with any future increase in these losses arising from water licences shifting downstream.

Getting reasonable estimates of transmission losses for each reach has, however, proved difficult. Values calculated the DLWC for the Namoi IQQM may eventually be available and acceptable. One approach that is under consideration is to elicit these estimates from the DLWC river operators. The rationale for this is that they are experienced in assessing river behaviour, and must use good judgement to ensure that sufficient volumes are released from storages to meet specific demands in various reaches. In many cases their job is made more complex as tributary inflows are used to supplement storage releases. A questionnaire has been sent (November 99) to the Namoi operators to assess the feasibility of collecting these kind of data. There was agreement to assist with the questionnaire, but no response has been received to date.

It is proposed that when reasonable estimates of transmission losses can be obtained, that they be used to assign water to an 'operating loss pool' and a 'trading loss pool' for each reach. The 'trading loss pool', which would be calculated, for each reach, as the additional transmission loss that would be needed if all the licences were transferred to the bottom of the system. While this is a highly unlikely scenario, it should be considered, as future trading may well alter the current distribution of licences in the valley and this represents the most extreme

These loss pools would be combined and shared between all users along the river. Unused water in this pool at the end of each accounting period would be credited to all users according to the size of their Capacity Share. If trading resulted in a net movement of licences downstream, then the size of the surplus in the pool would diminish. Conversely, a movement of licences upstream would result in an increased surplus of water for redistribution. The aim of this scheme would be to socialise the transmission loss costs and benefits associated with trading.

Conclusions

Capacity Sharing is feasible for implementation in the Namoi Valley using both Split Rock and Keepit Dams. It is recommended that a 'pool' be established within the storages to cater for transmission losses and possible redistribution of licence locations arising from trading. Unused water in the pool at the end of each accounting period would be allocated to Capacity Share holders in proportion to the size of their licences.

Estimates of transmission losses for each reach must be established and agreed to, in order to enable conversions of Volumetric Allocations into Capacity Shares.

A Summary of Progress with the Project; Developing a System of Water Management in the River Systems of NSW and QLD, Based on Capacity Sharing

11/10/99

The main objective of this project is to investigate the translation of volumetric allocations to Capacity Shares for Namoi water users. Initially it was hoped to use the Integrated Quality Quantity Model (IQQM) developed by the Department of Land and Water Conservation (DLWC) for this purpose. However, the DLWC advised that the Namoi IQQM would not be finished until late 1999, the current (October 1999) estimate for the completion of the model is March 2000. The Centre for Water Policy Research (CWPR) then sought to use the DLWCs' monthly model for the Namoi, that had been in use before the development of the IQQM. After discussions with the DLWC it was determined that the monthly model did not contain transmission loss elements and would not therefore be suitable for the estimation of Capacity Shares. It was established that there were no other suitable existing models and that the creation of a new model would be necessary for this project.

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Three modelling approaches were tried; one based on generating monthly loss ratios from streamflow data, one using regression analysis of streamflow data, and another using modifiable efficiency values for losses :

1 Monthly Loss Ratio Model

A monthly model was created, and monthly loss ratios were calculated from gauged river flow data and diversion information for each "reach" of the river. These ratios indicate monthly "delivery efficiencies". It is possible for ratios to exceed 1 (100%), where inflows in a reach exceed transmission losses. In such cases, however ratios were capped at 1 to eliminate potential distortions in data interpretation (for example a large inflow on a single day in a month may be sufficient to give an average delivery efficiency of greater than 1, even though there may have been net transmission losses on every other day). Unfortunately there were some missing gauged data, which meant that it was not possible to calculate efficiencies for each month of the study. Ultimately it was determined that modelling losses this way was not the optimum approach.

2 Regression Analysis Model

Pineena provided records of daily flow data throughout the valley. This allowed for the study of daily delivery efficiencies. Least square regressions were used to describe daily flows in terms of their upstream components (lagged through time where necessary). The regressions were applied to generate no Constant, with the downstream flow capped to the level of the upstream flow. Initial evaluations of the regressions indicated very high correlations with R^2 values > 0.95. There was concern that large flows could dominate the sample, in most cases. The residuals observed were acceptable, however, were acceptable. Using this method flows were described as:

$$Flow_{at\ point} = Constant_1 * Flow_{upstream} + Constant_2 * Flow_{upstream\ tributary}$$

Where $constant_1$, and $constant_2$ are the relevant delivery efficiencies.

Upon further examination of the sample, it was found that the co-efficients estimated were not suitable for application in the model.

Assuming that flows between the 20th and 80th percentile would contain most of the regulated flow, regressions were carried out on this sample. While reasonably high R^2 values were observed the coefficients estimated were significantly different for those observed in the analysis of the whole population. It was not possible to fully investigate an appropriate loss coefficient without access to daily diversion data, but the variability of the coefficient estimated suggested that this was not a suitable approach for modelling CS.

3 Modifiable Efficiency Values Model

It is possible, with the gauged data to calculate, with certainty, the change in storage levels, inclusive of evaporation, rainfall, and ungauged inflow by the formula;

$$Net\ Inflow_{this\ period} = Volume_{current} - Volume_{Start\ this\ Period} - Releases_{this\ period}$$

Monthly diversions are known, transmission losses may only be calculated with (unavailable) daily diversion data. Therefore a monthly model that takes as input variable transmission loss ratios, reach by reach, has been created, so that alternative assumptions may be investigated. The model is in a spreadsheet format, and automatically calculates the volume and inflow CS required (for a reach) such that all historical diversions may be met. If required the model may incorporate a stochastic element and generate a loss ratio for each month from a given distribution.

During the period under study (October 1990 to December 1998) Split Rock dam supplied little water to Keepit dam, and currently the model does not incorporate Split Rock dam. At present water supplied from Split Rock is simply included as inflow to Keepit dam. Split Rock dam now needs to be incorporated in the model, as well as non-irrigation supplies. The DLWC has advised that no regulated water is supplied from the Peel river to users downstream of Keepit. Internal spills have not been re-assigned to other users. Weirs have not been incorporated in to the model. CS on the Peel river should be estimated later using a similar but "stand alone" model.

Sample results that assume no transmission losses are presented the Appendix. These preliminary estimates indicate the shares required to harvest and store "deliverable" water only. The actual share allocations required, however, are sensitive to the efficiency values assigned to each reach. It is therefore very important that these values (or functions) be estimated in the best possible way. Work is currently progressing to estimate these values in two ways. First, daily stream flows recorded prior to 1962 (ie. before there were significant withdrawals of water for irrigation) are being used to estimate efficiencies associated with various flow volumes in each reach. Prior to 1962, however, daily streamflow data are only available for the upper reaches of the Namoi. A second, less accurate method is proposed to estimate efficiencies in the lower reaches. This involves using all available daily flow data and subtracting daily water ordering data. Unfortunately actual water diversion data are only available on a monthly basis, and only water ordering data is available for each day. Fortunately, estimates of efficiency values for the lower reaches are not as critical as for the upper reaches as they are not compounded so many times as water passes from higher to lower reaches.

It must be stressed that difficulties with data availability will always compromise the accuracy of modelled results. These difficulties need to be discussed with you to reach agreement on what is the best way to overcome them to produce a set of results in which that everyone can be confident are the best possible. The use of the third modelling approach is useful because provides ample opportunities to assess the impacts of different efficiency scenarios (including any data that may eventually become available from the DLWC's IQQM).

Timing of the Project

Once again, an attempt to use the DLWC Namoi IQQM model for estimating Capacity Shares has been thwarted because it is still not ready for release by the department. This time we have elected to resolve the problem ourselves by developing a monthly flow model to a standard that we feel can deliver a satisfactory answer for allocating Capacity Shares for Namoi water users. This has taken more time than was originally budgeted, and we would like to discuss with you the possibility of an extension of time and funding to bring this project a better conclusion.

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Appendix; Sample capacity Share results
(assuming 100% efficiency values)

Reach	Inflow Share	Volume Share (ML)
Not Assigned	27%	112,718
KEEPIT TO GUNNEDAH	1%	2,968
GUNNEDAH TO BOGGABRI	1%	4,625
BOGGABRI TO NARRABRI	2%	7,546
NARRABRI TO MOLLEE WEIR	1%	3,685
MOLLEE WEIR TO GUNIDGERA WEIR	29%	122,192
GUNIDGER WEIR TO WEETA WEIR	7%	30,734
WEETA WEIR TO DUNCAN GAUGE	2%	9,803
DUNCAN GAUGE TO BUGILBONE GAUGE	5%	19,194
BUGILBONE GAUGE TO GOANGRA GAUGE	3%	10,683
GOANGRA GAUGE TO WALGETT	2%	8,075
GUNIDGERA CREEK	9%	36,539
PIAN CREEK	13%	56,237
TOTAL	100%	425,000