ECONOMIC IMPACTS OF ENVIRONMENTAL FLOWS

IN THE

ADELONG CREEK CATCHMENT, NSW

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Abstract

Efficient management of water in unregulated river systems is essential in meeting current and future needs of water users and the environment. As an integral part of the new water management process, volumetric conversions convert current area based licences into volume based licences. Hydrology modelling determines the Daily Extraction Limits for different flow conditions in each management rule proposed for meeting environmental objectives in the catchment. The case study is the Adelong Creek Catchment, an unregulated river catchment in southeastern New South Wales. Economic and hydrological modelling assesses the impacts of proposed extraction rules, designed to meet environmental flow objectives, on water availability in the catchment. A spreadsheet based optimisation model was developed to assess the impacts of different flow management rules on the regional agricultural economy. The suitability of this approach will be assessed for application to other unregulated stream catchments.

Key words: economic modelling, unregulated streams, Adelong Creek catchment

Note: The views expressed in the paper are those of the authors and do not necessarily reflect the views of the NSW Department of Land and Water Conservation.

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INTRODUCTION

Adelong Creek rises on the northern slopes of the Great Dividing Range in southeast New South Wales, at an elevation of about 950 metres. It flows in a generally northerly direction for about 68 km to join the Murrumbidgee River 7 km downstream of Gundagai. The Adelong Creek subcatchment is long and narrow, with most tributaries flowing only a short distance from the hillslopes to the valley floor. The total catchment area is approximately 360 square kilometres.

Adelong Creek is a tributary of the Murrumbidgee River and is classified as an unregulated river subcatchment. Unregulated rivers are those that do not have major rural dams, and water users rely on natural flows for their water. Town water supply and irrigation dams or weirs can affect these flows. Unregulated streams can vary from low gradient inland tributaries to streams and rivers of the coast. Flows fluctuate – some have no flows for 2-10 percent of the time (particularly west of the Great Dividing Range), and some cease for longer than 20 percent of the time. Coastal streams rarely cease to flow although water volumes can be low at times (DLWC 1997).

Most of the subcatchment has been cleared for grazing of sheep and cattle, but extensive radiata pine forests and scattered orchards occupy much of the south. The main urban area is the township of Adelong in the middle of the catchment with a population close to 900. Adelong was the centre of intensive alluvial gold mining during the 19th century, and numerous old workings are evident along the creek.

Until the embargo on the issue of new licences in the mid 1990s, little consideration was given to the impact of area-based licences on the flow behaviour of the subcatchment. This has often resulted in little incentive to implement on farm water conservation strategies and a lack of information as to how much water has been used and when.

Recent government initiatives have led to a review of the management of unregulated rivers and their classification according to the level of hydrological and environmental stress. The stressed river classification was based on a subcatchment analysis, enabling the rivers in each subcatchment to be assessed independently.

The stressed river classification influences reviews of current licence embargoes, priorities in river management plans and volumes available for extractions in any subcatchment. Environmental stress was based on a range of indicators, such as bank and bed erosion, riparian vegetation, landuse, fish barriers, water quality, macro-invertebrates, and algal blooms. The outcome of the classification is information for water users and local communities for river management.

The Adelong Creek catchment was classified as having a relatively high extraction rate and judged as being subjected to a medium level of environmental stress. It is already subject to high extraction with current pressure to further expand the horticultural industry. This catchment was one of 12 unregulated subcatchments in the Murrumbidgee Catchment to receive high priority status and was chosen as the first for water management plan development.

The realisation that water is becoming a serious limiting resource in many catchments, and evident environmental degradation, has prompted the Commonwealth and State Governments to engage the community in the reform of water management. A central part of reform in NSW is the establishment of river management committees to prepare water management plans to achieve environmental, economic and social objectives. The Murrumbidgee Unregulated Streams Management Committee (MUSMC) is required to consider the economic effects of their water management recommendations in the process of developing their water management plan (MUSMC 2001). The Socio-economic Services Unit in DLWC was requested to undertake a preliminary assessment of the economic impacts of the proposed access conditions on the irrigation industry in the Adelong subcatchment.

HYDROLOGICAL MODELLING

Hydrological modelling of the Adelong Creek subcatchment provided input data for the economic modelling. A "lumped" IQQM (Integrated Quantity Quality Model) was used to model the subcatchment over a range of climatic conditions (1890 –1995). All individual irrigators were combined to form one "irrigator unit" which represented the entire catchment. As there was limited hydrological, extraction and cropping information available, this was considered to be the most accurate and efficient way to model the catchment.

The area based licences were converted to a volumetric basis according to the agreed conversion rate (*Volumetric Conversion – the next stage*, DLWC, 2000). This rate is based on crop types, average water use and climatic zones.

Flow

When observed information was not available, average daily flows were modelled from 1890-1995. In the following table, the number of days Adelong Creek flowed at certain rates is compared under three scenarios. One is the pseudo-natural flow regime, (pseudo because it is limited to irrigation use), the next under the base case (current access conditions) and the third under scenario 1 (proposed access conditions - see Table 2). This provides an indication as to the impact of proposed diversions compared with the base case. Including the pseudo-natural inflow data provides an indication of the impact of base case diversions on the natural flow regime. Table 1 shows that while irrigation development has an impact on the flow regime, there is little difference between the base case and scenario 1. This provides an indication of the impact of proposed diversions from the base case.

Including the natural inflow data illustrates the impact of base case diversions on the natural flow regime, which is clearly greater than the change in proposed rules compared to the base case. The greatest impact of scenario 1 is in the 11-20 megalitres per day range where the implementation of proposed rules will reduce availability by 23 days over a 106 year period. However, there is an increase of 14 days over that period for average daily flows of 21-30 megalitres.

TABLE 1 IMPACT OF PROPOSED RULES: NUMBER OF DAYS BY FLOW RANGES (MODELLED 1890-1995)

average daily flows (ML/day)	natural inflow (days)	flows in base case (days)	flows in scenario 1 (days)	difference between scenario 1 and base case (days)
<10	764	764	764	0
11-20	1515	2684	2661	-23
21-30	3149	3048	3062	14
31-40	3498	3391	3396	5
41-50	3207	2883	2882	-1
51-100	11495	10971	10977	6
101-300	12083	11970	11969	-1
301-500	1548	1548	1548	0
501-1000	983	983	983	0
1001-3000	419	419	419	0
3001-5000	38	38	38	0
>5000	16	16	16	0
total days	38715	38715	38715	

The following options for low-flow management are put forward by the MUSMC to protect access and reduce environmental impacts. These measures are regarded as interim whilst data collection continues on actual water use, flow extraction capacity and environmental flow requirements.

TABLE 2 PROPOSED ACCESS RULES

threshold / flow range	flow (ML / day)	arrangement	implications
less than cease-to-pump	0 – 11	restricted access for life supporting uses only	water may only be extracted for essential uses
cease-to-pump	12	level at which general extraction ceases	
Flow Range A	13 – 22	14 ML / day (60% of 80th percentile) available for extraction	a high level of water conservation measures should be implemented such as rostering of high rate extractors to reduce pressure on any given day
80th percentile	23	level at which Flow Range A begins	
Flow Range B	24 – 37	11 ML / day (30% of 50th percentile) available for extraction	a moderate level of water conservation should be observed
50th percentile	38	level at which Flow Range B begins	
Flow Range C	39 and above	16 ML / day (30% of 30th percentile) available for extraction	period of relatively high water availability which could be used to top up off-stream storages

Note: These levels apply to flow rates measured at the end of the majority of irrigators (downstream of Adelong Township) and extrapolated to the Adelong Creek at Batlow Road Gauging Station (upstream of Adelong).

Percentile flow is the flow value that is exceeded x% of the time based on the driest month of the year. For example the 80th percentile is the flow that is exceeded 80% of the time in the driest month (February). This protects flows in the driest month, which is usually when demand is highest and by default minimises impacts throughout the year.

Diversions

Descriptive statistics of total annual diversions under the base case and proposed access rules are shown in table 3.

TABLE 3 TOTAL ANNUAL DIVERSIONS (WATER YEARS 1890-1995)

	base case (ML/pa)	scenario 1 (ML/pa)
average	565	560
median	580	580
maximum	952	952
minimum	227	185

The average change in water diversions under the base case and scenario 1 and also the maximum change in diversions over the 106-year period of modelling are shown in table 4. Over the 106 years of simulation modelling, the average change in water diversions was 5 megalitres/year while the maximum potential change or impact of scenario 1 over that time was 110 megalitres.

TABLE 4 CHANGE IN ANNUAL DIVERSIONS (WATER YEARS 1890-1995)

	scenario 1 less base case (ML)
average	-5
maximum	-110

ECONOMICS METHODOLOGY

The aim of the economic evaluation was to develop an approach that provided adequate information regarding the impact of access rules, but also took into account the restrictions on time and resources of the researchers given the large number of economic assessments required throughout the State. Two approaches were developed to assess the impacts of the access rules on irrigation in the Adelong subcatchment

The first approach was the development of a model utilising "Solver' in Excel. 'Solver' enables linear and nonlinear optimisation problems to be solved. The Unregulated Streams Economic Model (USEM) optimised gross margins for the catchment under a given scenario of water availability. The USEM quantified the average impact on irrigation over time. In this model, water availability was assumed to be the only constraint in the production process. Area was not considered a constraint, as area expansion was unlikely to occur given the reduction of water availability being modelled. Note that in the model construction, water availability is directly linked to irrigation area.

The second approach developed a Detailed Economic Assessment Model (DEAM) which applied the same input data and identified the annual maximum impact of access rules over the period of hydrology data.

The models assumed that two landuse activities, orcharding and pastures, were undertaken in the Adelong subcatchment. Because orchards return a higher dollar value per megalitre of water and are permanent plantings, the model assumed that in a situation of water shortage, irrigated pastures would decline in area.
In the extreme situation where there is insufficient water for orchards, farmers could either

- Reduce orchard area being irrigated, or
- Reduce application of water.

The modelling assumed that this impact would result in the irrigated area of orchards being reduced.

The base case scenario was the current water availability under the volumetric conversion policy and access rules. Scenario 1 was the impact of the proposed access rules on the base case.

Data

The crop/pasture mix and other data used in both models are shown in table 5. All data used were supplied/accepted by the Committee. Gross margin data were obtained from the Horticultural Gross Margins for Loddon Murray Region (DNRE 2000) in the absence of local data.

TABLE 5. AGRICULTURAL INPUT DATA USED IN THE ECONOMIC MODELLING

	area (ha)	area (%)	crop water usage (ML/ha)	total water usage (ML)	total water usage (%)	gross margin ($/ML)
perennial pasture	16	10%	3	48	4%	44
orchards (apple)	144	90%	8	1,152	96%	2,714
total	160	100%		1,200	100%	

TABLE 6 IMPACT OF PROPOSED RULES ASSUMING ONLY PASTURES AFFECTED

	scenario 1 less base case (ML)	gross margin ($/ML)	total gross margins ($)
annual average	-5	44	-221
maximum in one year	-110	44	-4,865

The USEM calculated the annual average impact on gross margins of the proposed access rules over 106 years (being the period of hydrology data availability). The impact was $221 per year only, based on the annual average decrease in water availability of 5 megalitres.

Under the assumptions of the modelling, the total number of years where yield or production of pastures and/or orchards could be affected under scenario 1 was 14 years of the 106 years of hydrology data. The greatest shortfall was 110 megalitres which, if only affecting pasture production, amounted to a maximum loss in gross margins of $4,900 in that year. The DEAM quantified the more realistic impacts where orchards could be affected. Under the proposed access rules in only 3 of the 106 years would the yields of orchards be affected.

The following table indicates the possible magnitude of annual losses in these three years.

TABLE 7 LOSSES INCURRED WHERE ORCHARD PRODUCTION IS AFFECTED OVER 106 YEARS

	orchards		**pasture**		**total**	
water year	water volume shortfall (ML)	gross margin losses ($)	water volume shortfall (ML)	gross margin losses ($)	water volume shortfall (ML)	gross margin losses ($)
1902/03	2	5,699	48	2112	50	7,811
1944/45	62	168,268	48	2112	110	170,380
1968/69	28	75,178	48	2112	76	77,290
total		**249,145**		**6,336**		**255,481**

SUMMARY AND DISCUSSION

The economic modelling provided indications of the scale of impacts on irrigators of proposed access rules. These results will be utilised by the Murrumbidgee Unregulated Stream Management Committee in assessing the impact of access rules in the Adelong subcatchment. Modelling will be applied in other catchments that are also identified as stressed river catchments

The Unregulated Streams Economic Model (USEM) provided a conservative indication of the annual average impact of the proposed access rules on gross margins in the irrigation industries in the Adelong Creek catchment. With an annual average impact of $221 on gross margins, based on the last 106 years of hydrology data, the access rules would appear to have little impact.

The Detailed Economic Assessment Model (DEAM) showed that over that period a maximum annual loss in terms of gross margins of $170,380 could be incurred. The sum of losses in the three years where both pastures and orchards could be affected was $255,481.

The modelling was developed to enable the rapid assessment of the impacts of proposed access rules for a large number of catchments and committees. Given the scope of the project, timeframes and resources, the modelling is regional in scale, straightforward in its assumptions and presents the worst case scenarios where there is *no further action to mitigate the impacts of insufficient irrigation water.* Clearly the scale of impact is evident from the hydrology data.

At this stage it is anticipated that these models will continue to be used to assess the impacts of changed access rules on irrigation in other catchments. It is expected that where there are significant hydrological impacts, more detailed economic analysis will be requested by the Committees.

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APPENDIX 1

The following is a brief summary of the assumptions underlying the hydrology modelling.

- Only irrigators who use the river have been included. This excludes those who do not pump directly from the river (that is, have storages filled naturally from drainage lines or other creeks)
- No pumping into storages for use later
- Perfect water sharing amongst all users. In the model there was only one irrigator who was an aggregate of all those who used the creek for irrigation.
- Perfect rostering between irrigators – this effectively reduces the impact of streamflow shortages.
- All water is extracted at one outlet– this maximises streamflow compared to the true situation were some of the irrigation demand occurs upstream where stream flows are less reliable.
- Crop water demand is based on the FAO theoretical upper bound crop factors – this maximises crop production and is almost certainly significantly above the production rates which are achieved in practice.
- The soil moisture holding capacity is set at 200mm/metre.
- 30% loss occurs in the delivery of water from the river to the crop
- Pumps operate at unlimited pump capacity
- No risk taking is assumed ie. water users plant the same crop area each year regardless of climatic conditions or the produce market
- The annual volume entitlements resulting from the volumetric conversions are not included in the model and therefore have no influence on the estimated diversions.

A number of these assumptions have the potential to cause an overestimation of the volume of water extracted. For example, locating the "lumped irrigator" at one point in the catchment where water supply will be the greatest does not allow for the variability in water supply upstream of this point. By using FAO crop factors, no consideration is give to possible underwatering of crops by the individual irrigator.

Underestimation of water used is a result of other assumptions. For example, perfect rostering will not occur in reality and possibly more water will be used. However, experience indicates that these final model results provide good approximations of water usage in Adelong Creek under all three scenarios.