ADOPTING IMPROVED USE OF CURRENT WATER MONITORING TECHNOLOGY TO MANAGE RECHARGE

Final report

August 1998

National Program *for*
Irrigation Research and Development

Adopting improved use of current water monitoring technology to manage recharge

Final Report

August 1998

Dr Liz Humphreys, Dr Geoff Syme
CSIRO Land & Water
James Butterworth, formerly CSIRO Land & Water
Tony Dunn, Charles Sturt University
Meredith Hope, formerly post graduate student, Charles Sturt University
Coleambally Irrigation

National Program for
Irrigation Research and Development

Contact details

	Postal address	Phone	Facs.	Email
Principal investigator				
Dr Liz Humphreys	CSIRO Land and Water PMB 3 GRIFFITH NSW 2680	02 6960 1500	02 6960 1600	liz.humphreys@grf.clw.csiro.au
Collaborators				
Tony Dunn	School of Agriculture Charles Sturt University PO Box 588 WAGGA WAGGA NSW 2678	02 6933 2385	02 6933 2812	adunn@csu.edu.au
Meredith Hope	Former post graduate student at CSU . Current address: NSW Agriculture Locked Bag 21 ORANGE NSW 2800	02 6391 3674	02 6391 3767	meredith.hope@agric.nsw.gov.au
James Butterworth	Formerly CSIRO Land and Water. Current address: Social Assessment Unit 197 St Georges Terrace Perth WA 6000	08 9222 9426	08 9222 9433	jbutterworth@mpc.wa.gov.au
Dr Geoff Syme	Australian Research Centre for Water in Society CSIRO Land and Water Private Bag PO WEMBLEY WA 6014	08 9333 6291	08 9387 0261	geoff.syme@per.clw.csiro.au
Coleambally Irrigation	PO Box 103 COLEAMBALLY NSW 2707	02 6950 2820	02 6954 4247	

10 members of the CIA farming community were substantial collaborators in either the RRA survey team or the paddock monitoring field trials

ACKNOWLEDGMENTS

We thank numerous Coleambally farm people for having us in their homes and participating in discussions.

We are grateful to the RRA team members for their hard work which ensured a very successful survey:

Don Ewan	Coleambally
Tom Graham	Coleambally
Margaret Sheppard	Coleambally
Helen Wild	Coleambally
Colleen Wray	Coleambally
John Madden	CSIRO
David Hope	University of South Australia
Don McCaffery	NSW Agriculture
Matthew Plunkett	NSW Agriculture

The success of the paddock monitoring was an outcome of the excellent collaboration with participating Coleambally farmers:

Keith Burge
Ben Goudie
Andrew Jackson
John Laurie
Ian Sutherland
Mike Witham

We thank Coleambally Irrigation for financial support and the use of facilities.

Finally, the implementation of this project would not have been possible without the initiative of LWRRDC in identifying the need to explore participatory research methodologies, and in providing funding support for this project.

CONTACT FOR FURTHER INFORMATION

Dr Liz Humphreys
CSIRO Land and Water
PMB 3 GRIFFITH NSW 2680
Ph. 02 6960 1500
Facs. 02 6960 1600
Email liz.humphreys@grf.clw.csiro.au

ABSTRACT

Rising watertables are a major threat to the sustainability of irrigated agriculture in the southern Murray-Darling Basin. Future sustainability will depend on the ability of each irrigation farmer to choose paddock-crop-irrigation management combinations that control impacts on watertables on their farm. There is a perception that the technology already exists to enable farmers to manage water sustainably, and that the problem is one of adoption rather than the development of new technology. However, farmers usually have good reasons for doing what they do, and the challenge for both farmers and researchers is to develop technologies that farmers want and can adopt, and which move towards more sustainable farming practices.

The goal of this project was to determine a process for successful technology transfer and adoption at a pilot scale, in relation to attempting to identify and evaluate technologies to enable farmers to make informed decisions that impact on net recharge and water use efficiency. Maximum emphasis was placed on the use of participative processes to try to ensure that the research and its outcomes were relevant, adoptable, wanted and owned by the farming community.

A range of approaches was used, including consultation with a large cross section of the farming community - to find out the things that were most important to them for their futures as irrigation farmers, to increase contact between researchers and community members, and to increase community awareness. Following this, a small group of farmers worked jointly with the researchers to evaluate methods for determining the fate of water applied to crops, at the paddock scale.

The project successfully demonstrated a process for involving the farming community in research. Tremendous support for and interest in the project were generated through the early activities involving a wide cross section of the farming community. People volunteered to participate in the paddock monitoring, and most participants maintained their interest and involvement, and wanted more. The process mobilised interest in and awareness of the importance of reliable paddock determinations of crop water use and recharge. The project lifted community awareness and understanding of the issues associated with net recharge management, and helped pave the way for Coleambally Irrigation to successfully introduce a comprehensive water use monitoring system.

The project also identified the inability of funding bodies to respond to initiatives generated through use of the participative process. It led to community-driven attempts to acquire funding and to expand the monitoring to include all major crops in the CIA for a range of conditions. However, numerous efforts to obtain funds to do this have not succeeded to date.

The project adapted and evaluated available technology to accurately measure water flows on and off paddocks, and identified monitoring procedures to enable accurate paddock water balance determination and to validate methods for estimating crop evapotranspiration. These methodologies have been adopted by a crop water use monitoring project about to commence in the Murray Valley, funded by Murray Irrigation Limited. The findings of the Coleambally project and the discussions it generated among the participants and the representatives of the three major irrigation areas of southern NSW were major factors in the development of the Murray project.

While the project generated much interest in increasing knowledge of the fate of water at the paddock scale, the farmers who participated in the paddock monitoring clearly preferred others to do the monitoring, to minimise demands on their time, and to ensure consistency of data across farms. Involving the farmers in the paddock monitoring greatly increased the quality of the data collected in terms of detail, and identification and explanation of anomalies, compared with what the researchers could have achieved on their own.

The project produced accurate water use benchmarks for 9 rice and 7 row crops for the 1996/97 season, a season in which evaporative demand was about 10% higher than the long term average. Rice paddock water use ranged from 11.9 to 18.4 ML/ha (mean 14.5 ML/ha), including four paddocks in high watertable (low recharge) situations with water use ranging from 11.9 to 12.6 ML/ha. Reference evapotranspiration over the rice season was 12.9 ML/ha, thus the crop factor of 1.0 currently used to estimate evapotranspiration from rice clearly led to this being overestimated. Assuming actual evapotranspiration of 12 ML/ha, recharge from the 9 rice crops ranged from 0-6 ML/ha.

Row crop water use ranged from 6.7 to 10.5 ML/ha (mean 8.3 ML/ha), and was 60% of rice crop water use on average. Estimates of crop evapotranspiration from locally derived monthly crop factors and reference evapotranspiration tended to be higher than net water use (irrigation plus rain minus surface drainage), leading to apparent water use efficiencies in excess of 100%. Upflow from shallow watertables may partly explain these findings for row crops in shallow watertable situations, but not in the deeper watertable situations.

The paddock water use findings highlighted the need for further research to validate or refine current methods for estimating crop evapotranspiration at the paddock scale. These methods range from single figure whole season crop factors to the algorithms used in irrigation scheduling programs and crop models, and in the whole farm water balance model SWAGMAN Farm. Accurately determined crop water use benchmarks and reliable crop evaporation estimates are critical to the development and implementation of soundly based land and water management strategies currently being introduced in the irrigation areas of the Murrumbidgee and Murray Valleys.

INTRODUCTION

At the time this project was proposed, two-thirds of the Coleambally Irrigation Area (CIA) and 90% of the Murrumbidgee Irrigation Area (MIA) had watertables within 2 m of the land surface. With current practices and no mitigation, it was predicted that 20-30% of the agricultural land could become salt-affected (Anon 1996). Future sustainability would depend on the ability of each irrigation farmer to choose paddock-crop-irrigation management combinations that control impacts on watertables on their farm. This project sought to identify and evaluate procedures to provide the means for farmers to make informed decisions that impact on net recharge and water use efficiency. Maximum emphasis was placed on the use of participative processes to try and ensure that the research and research outcomes were relevant, adoptable, wanted and owned by the farming community.

OBJECTIVES

The goal of this project was to determine a process for successful technology transfer and adoption at a pilot scale which could be a model for other crops and locations in the irrigation industry. Specific objectives for achieving this were designed around the issue of water use monitoring as follows:

1. To determine irrigator, community and agency perceptions of the advantages and disadvantages of water use monitoring (both self-monitoring and external monitoring, for supply and drainage water).
2. To determine perceptions of desirable scales and methods of water use monitoring.
3. To assess community acceptance of proposed scales and methods of water use monitoring and policy, both before and after demonstration and evaluation on selected farms.
4. To demonstrate and evaluate methods of water use monitoring on selected farms.
5. To determine irrigation efficiency and recharge for a range of soil x crop x irrigation management practices.
6. To determine the amount and type of assistance and equipment needed/desired by irrigators to help them monitor water use, and to help them use this information to improve irrigation efficiency.
7. Use the results to improve the water monitoring policy and refine the Net Recharge Management Models
8. To evaluate the effectiveness of the project by a telephone survey.

METHODS

1. Facilitating participation

A participatory research process, similar to the participative action management model (PAM – Cape *et al.* 1994), was used. It involved farmers and researchers in the following processes:

1. defining the broad issues of importance to irrigation farmers
2. identifying and prioritising research needs and determining the research approaches to be adopted
3. planning the research
4. carrying out the research

5. analysing and reviewing the results
6. making recommendations

A range of approaches was used to facilitate the above processes:

1. joint development of the initial proposal by the researchers and a couple of key Coleambally farming community representatives
2. formation of a steering committee, and then an advisory panel to further increase farmer representation
3. formation of a survey team including five farmer members
4. a Rapid Rural Appraisal (RRA) – 53 interviews involving over 100 members of the farming community
5. a public meeting, attended by 89 people, where preliminary results of the RRA were presented and feedback was sought both verbally and via a feedback sheet
6. mailing the summary report on the RRA, and a feedback sheet, to all farm businesses
7. collaboration in paddock monitoring, and frequent informal interaction, with six farmers over the irrigation season and beyond
8. a field day
9. a presentation by the researchers and lobbying by farmers at a LWMP public meeting
10. a group discussion with the five collaborating farmers

An overview of these approaches and their effectiveness is provided in the papers by Hope *et al.* (1997) and Dunn *et al.* (1997). The weakest link in the participatory process used was the development of the initial project proposal, which had relatively limited community input. This is a result of the fact that funds are generally only available for projects with clearly defined objectives and anticipated outcomes. The success of the whole process in producing adoptable outcomes may ultimately hinge on whether the proposals of the project initiators were really consistent with what is important to the end users, or to be flexible to be deal with priorities identified by them.

2. Paddock water use monitoring

Paddock water use was monitored for seven row crops and nine rice crops in the CIA during the 1996/7 irrigation season. The net amount of water applied was determined by measuring water on (irrigation supply and rain) and water off (surface drainage) using Dethridge wheels, propeller meters and ultrasonic flow meters. Crop growth and development were monitored at three representative locations within each paddock. The data collection was highly dependent on the farmers keeping good records of water movements and paddock activities, in collaboration with the researchers. The full details of the monitoring strategies are documented in the thesis by Hope (1998.

RESULTS AND DISCUSSION

Objectives 2-4: perceptions of water use monitoring

Findings of the RRA

The findings of the Rapid Rural Appraisal were the primary source of information regarding perceptions of water use monitoring. At the time of the interviews, the biggest issue for Coleambally farm people was chemicals for a range of reasons including weed resistance, herbicide drift, drainage water quality and risks to human and animal health. The next most important issues were watertables and salinity. Water policy was also high on people's minds, mostly in the context of crop policies that would help control watertables, and pricing. Only the findings relevant to objectives 2-4 are reported here. The full findings are reported by Hope (1998).

Water use policy

Many people said that the rice water use target should remain at 16 ML/ha, and nobody suggested changing it. While there was concern about the impact of high water use rice paddocks on watertables, there were few suggestions that regulation should be used to force people to stop using these paddocks for rice. In the words of one farmer *"It's hard to say you just can't grow rice"*.

Some people felt that rice shouldn't be singled out for target water use, however, others felt that crops other than rice weren't really a problem. Another suggestion was that the governing factor should be ML/ha/farm and not targets for individual crops.

Quite a few people were concerned about a possible increase in the price of water, however this concern was not unanimous. A couple of people said that water was too cheap, while a couple of others said that raising the price would lead to increased water use efficiency. This was one of the most contentious findings presented at the public meeting and in the summary reports, and there was feedback that the publicity given to minority views such as this could do a lot of harm in the wrong hands.

Research needs

The range of research needs mentioned during the survey included methods for identifying high rice water use areas and leaky soils, comparisons of recharge from rice and non-rice crops, and the use of crops to tap the watertable.

Attitudes to paddock water use monitoring

Quite a few people stated a need to know more about water use on a paddock basis. While many did not elaborate on how it would be useful, a few said it would help them become more efficient and optimise their use of water, especially in the light of increasing water prices and reduced allocation. There were also suggestions that monitoring would be useful in assisting decisions on crop suitability for different soil types, that it could be used to find the best ground for rice, that it would be useful for high water users, and that it was the *"underpinning of sustainability"*.

A few people said there was no need for paddock water use monitoring, and that it was *"a waste of time"*, while a couple of others didn't want to know about it if it involved extra work. One person suggested that it was useless as it didn't address irrigator behaviour, while another was concerned that individuals' details might be seen by regulatory authorities.

Several farmers said they were willing to participate in future paddock water use monitoring trials.

Paddock record keeping

Record keeping is critical to accurate paddock water use monitoring, therefore information on current record keeping practices was sought during the interviews.

Many people kept their paddock records *"in my head"*. About half the businesses interviewed kept some hard form of records - mostly in books or diaries, and a few on computer. The amount of detail ranged from a few fertilizer records, to diaries, to full paddock records including soil management, crops, varieties, sowing dates, fertilizers, chemicals, yields, water use and ET (from waterwatch). Few people recorded paddock water use, although many had rice water use figures in their heads. A couple also mentioned water use figures for other crops. Water use was always described in ML/ha - there was never any mention of tonnes/ML or other measures of irrigation efficiency.

Other findings

There was a strong sense among the farmer members of the Advisory Panel and survey team that, regardless of the findings of the RRA, the proposed paddock water use monitoring activity should proceed. Fortunately, the original project proposal was sufficiently relevant to the findings of the RRA to proceed with confidence, but in the knowledge that it was not an important issue for most of the people interviewed. The advisory panel members and co-operating farmers also felt very strongly about the need for accurate monitoring of water at individual paddock inlets and outlets, which led to the researchers requesting additional funds for flowmeters from LWRRDC, and which were granted at short notice.

Five of the six farmers participating in the paddock monitoring sustained their effort and interest throughout and beyond the irrigation season, reflecting the relevance of this process to them (Hope *et al.* 1997).

A landmark event for the researchers was the discovery, at the paddock monitoring field day in February 1997, that there was very strong belief among a range of farming community members that the paddock water use monitoring being undertaken was of fundamental importance to their future sustainability. They were concerned that there were only sufficient funds to do the monitoring for one season. This was again expressed on the following day in a motion passed unanimously at a public meeting to discuss the Coleambally Land and Water Management Plan. Following this, there were several efforts at lobbying funding agencies by the LWMP, Landcare and Coleambally Irrigation leaders. Consequently the researchers also felt compelled to renew efforts to obtain funding to further the monitoring (after having decided that they had already tried hard and long enough!).

Significantly, most interest appeared to be in the data itself – not in developing methods that farmers could use to get it themselves, which had been a major intention of the original project proposal. This also applied to the collaborating farmers. They wanted less direct involvement in the monitoring process. For example, they preferred ultrasonic water meters that they couldn't read (no display) over propeller meters with displays, but which required regular maintenance. They also wanted someone else to do the crop monitoring to get all the data needed and to ensure consistency and rigour.

Objectives 5-7: Demonstration and evaluation of paddock water use monitoring

Meter performance

The propeller meters required constant vigilance, screens and regular screen cleaning. They showed good agreement when checked against each other in well-maintained field installations The ultrasonic meters required no maintenance by the farmers and enabled data logging by the researchers, but the type used did not have a farmer friendly display. Flows were linearly related to those measured using Dethridge meter – at one site the Dethridge meter and the ultrasonic meter gave excellent agreement, but at another the Dethridge meter recorded significantly higher flows than the ultrasonic meter. Two ultrasonic meters tested against each other at this site gave similar results. Thus the portable meters used appeared to provide reliable flow measurements. Full details on meter performance and the paddock monitoring strategies and results are presented in Hope (1998). A summary of the results (more detailed than that presented here) is provided in the preliminary report by Humphreys and Hope (1997).

Crop water use

Row and rice crops were grown in adjacent paddocks on several farms (Table 1). Within individual farms, rice water use was always higher than row crop water use - by an average of 71%. Row crop net water use ranged from 6.7 to 10.5 ML/ha, while rice water use ranged from 11.9 to 18.4 ML/ha.

Table 1. Net crop water use (ML/ha of irrigation + rain - runoff): comparison of different crops in adjacent paddocks in the CIA - 1996/97 (crops in adjacent paddocks are in adjacent rows in the table)

Crop	**Farm**				
	A	**B**	**C**	**E**	**F**
maize					8.8
soybeans	10.5	6.8			7.5
rice	12.3	14.3			18.4
soybeans (A) sorghum (B)	10.1	6.7	7.8		
rice	12.6		12.3	14.6	18.4
rice			11.9	16.1	

The pattern of crop water use matched estimated evapotranspiration fairly closely for both row crops and rice. However, at the end of the season, crop evapotranspiration (ETc - calculated from reference evapotranspiration (ETo) and locally derived crop factors) always exceeded net water use (I+R-D) for rice, and sometimes exceeded it for row crops.

Using monthly crop factors to calculate ETc, apparent water use efficiency of the row crops ranged from 86% to 121% (Table 2). Apparent water use efficiencies in excess of 100% can occur with well-irrigated crops in shallow watertable situations due to upflow from the watertable. Myer *et al.* (1990) showed that net upflow accounted for 8% of ETc for well-irrigated soybeans grown on transitional red brown earth (Mundiwa clay loam) with a non-saline watertable at 1 m. Upflow increased to 20-25% of ETc on a more highly conducting Hanwood loam. Upflow is reduced by increasing depth to the watertable, by increasing salinity of the groundwater (Myer *et al.* 1996), and by reduced soil hydraulic conductivity. Net upflow and water use efficiencies in excess of 100% are unrealistic results for ponded rice where local water tables are below the rootzone (all paddocks in this study), and for well-irrigated row crops with deep watertables as at Farm F (>3 m). The results suggest that the methods for estimating ETc at the paddock scale overestimate actual ETc, or that we are at the limits of measurement accuracy, and recharge from all row crops monitored was less than the measurement error. These possibilities need to be further tested. Implementation of soundly-based net recharge management policies for the CIA, MIA and Murray Valley is highly dependent on good estimates of crop evapotranspiration at the paddock scale.

Therefore the technology we were evaluating with the farmers – calculation of paddock irrigation efficiency and recharge using a basic calculation of ETc (which could be provided to farmers in a lookup table) – was not yet sufficiently refined or explained to be useable by them.

Table 2. Row crop irrigation, rain, surface drainage and ET estimates (ML/ha) in the CIA - 1996/97

CROP (Farm) Variety	Sowing date	Maturity date	Irrigation I	Rain R	Drainage D	Net water use I + R - D	ETc calculated using monthly crop factors	Water use efficiency ETc*100/ (I+R-D)
SOYBEANS								
(F) Bowyer	20/11	22/3	8.1	0.5	1.1	**7.5**	9.1	121
(C) Bowyer	27/11	5/4	10.2	0.5	2.9	**7.8**	8.8	113
(B) Stephens	10/12	4/4	8.5	0.3	2.0	**6.8**	8.2	121
(A) Bowyer /Hooper	14/11	28/3	29.3	0.8	19.5	**10.5**	9.0	86
(A) Bowyer	21/11	1/ 4	17.5	0.8	8.2	**10.1**	9.1	90
MAIZE								
(F)	10/10	1/3	9.0	0.8	1.0	**8.8**	8.7	99
SORGHUM								
(B)	6/11	20/3	8.4	0.6	2.3	**6.7**	n/a	n/a

The results from four rice paddocks in high (1-2 m) watertable situations are summarised in Table 3. Recharge was probably relatively low from these paddocks because the watertables were high. Paddocks 1, 2 and 3 all grew rice in the previous season, and paddock 3 was too wet to cultivate until shortly before sowing. Thus the amount of water to fill the soil profile was probably also relatively small in these three paddocks. Net water use in the four paddocks ranged from 11.9 to 12.6 ML/ha. Evapotranspiration would have been somewhat less than this because soil wetting and recharge would account for a small part of the water use. Total reference evapotranspiration ETo from October to February was 12.9 ML/ha. The data suggest that the crop factor of 1.0 currently used for estimating total ET from rice is too high, and that a factor of 0.9 may be more realistic. This also needs further testing.

Assuming evapotranspiration was 12.0 ML/ha, and that soil water content increased by 0.5 ML/ha, recharge from the 10 rice paddocks monitored in the CIA ranged from 0 to 6.4 ML/ha, and averaged 2.3 ML/ha.

Table 3. Rice water use in high watertable situations in the CIA - 1996/97

Paddock number	**1**	**2**	**3**	**4**
Variety	Langi	Amaroo	Kyeema	"early" Millin
Area (ha)	29	13	24	24
Water started	2 Oct	8 Oct	27 Oct	24 Sep
Drained	5 Mar	11 Mar	19 Mar	16 Feb
Duration (days) start to drained	154	154	143	145
Irrigation water on (ML/ha)	12.1	11.5	11.4	11.3
Rain (ML/ha)	1.0	0.9	0.6	1.1
Total water on (ML/ha)	13.0	12.4.	12.0	12.4
Drainage (ML/ha)	0.5	0.09	0.10	0.07
Net water use I+R-D(ML/ha)	**12.6**	**12.3**	**11.9**	**12.3**
ETo Griffith (ML/ha) 1 Oct... 28 Feb	**12.9**	**12.9**	**12.9**	**12.9**
ETrice/ETo (ML/ha) 1 Oct....28 Feb	0.93	0.91	0.88	0.91

Objective 7: use the results to improve the water monitoring policy and refine the Net Recharge Management Models

Over the past two years the broad agenda of the LWRRDC project has been overtaken by the activities and policies of Coleambally Irrigation, and by the Land and Water Management Plan (LWMP), including the LWMP Education Program. In 1997 Coleambally Irrigation commenced compiling water use statistics for all irrigated enterprises on every farm in the CIA. It is now impossible to order water unless the farmer provides information on the type and area of each crop to be irrigated. Each time a farmer orders water, they must specify the amount of water to be supplied to each crop. The whole process is conducted via a computerised telephone water ordering system.

Over the same period, the SWAGMAN Farm model for optimising cropping options, at the paddock scale, to meet net recharge and economic objectives, has been developed. It is the intention of Coleambally Irrigation to run this model for every farm to identify potential excessive recharge, and to assist farmers in identifying cropping options to reduce recharge. The results of the LWRRDC project have highlighted the need to test this model against real data before it can have widespread application and acceptance, hence Coleambally Irrigation's desire for further paddock water balance studies as mentioned earlier.

Objective 8: telephone survey to evaluate the effectiveness of the project

A telephone survey was not conducted. It appeared clear that the project had had it's major impact in mobilising interest in the need for accurate knowledge of the fate of water applied to irrigated crops, rather than in the development of a readily adoptable technology.

Objective 1 (overall goal): determine a process for successful technology transfer and adoption at a pilot scale, which could be a model for other crops and locations in the irrigation industry

The project successfully demonstrated a process for involving the farming community in research. Tremendous support for and interest in the project were generated through the early activities involving a wide cross section of the farming community. People volunteered to participate in the paddock monitoring, and most participants maintained their interest and involvement, and wanted more. The process mobilised interest in and awareness of the importance of reliable paddock determinations of crop water use and recharge. It led to community-driven attempts to acquire funding and to expand the monitoring to include all major crops in the CIA for a range of conditions. Unfortunately, numerous efforts to obtain funds to do this have not succeeded to date, and this demonstrates the inability of funding bodies to quickly respond to strong community needs which emerge through the use of participative methodologies. However, there has been a flow on effect – Murray Irrigation has just commenced funding paddock water balance studies in the Murray Valley based on the methods developed in the Coleambally project. The findings of the Coleambally project and the discussions it generated among the researchers and the representatives of the three major irrigation areas of southern NSW were major factors in the development of the Murray project.

However, the project did not develop the paddock water monitoring technology to the stage where it could be readily used by farmers. The primary constraint was the unavailability of cheap, accurate, low maintenance and user friendly meters to measure supply and drainage flows. The participating farmers were eager to use meters supplied free of charge, and wanted to continue to use them after the formal project finished, but only one farmer has purchased a flow meter for his own use to date. The next major constraint appeared to be record keeping. The findings detailed by Hope (1997) suggest that a suitably designed pocket notebook may work, but this needs further development and evaluation. Thirdly, there is the technical problem of providing a credible estimate of crop evapotranspiration, if irrigation efficiency and recharge are to be calculated and compared by the farmer. Finally, there is the problem of data management, analysis and interpretation. In this project this was led by the researchers, with input from the farmers. A system to assist farmers to manage, analyse and interpret their own data is needed.

Although not directly related to the original project objectives, there were other valuable spin-offs from the participatory approach used in this project. The Rapid Rural Appraisal findings provided good baseline information on awareness of and attitudes to the CIA Land and Water Management Plan, in addition to the physical sustainability issues relevant to irrigated agriculture. Therefore, there is an excellent opportunity to evaluate changes in awareness and attitudes sometime after implementation of the LWMP commenced; for example, after completion of the first phase of the LWMP Education Program. The experience of the RRA also gave the LWRRDC project leader the background, interest, contacts and confidence to make a significant contribution to the development of the Education Program.

COMMUNICATION, TECHNOLOGY TRANSFER and ADOPTION ACTIVITIES

As described above, this project was built around participatory activities with the aim of enhancing the production of relevant and adoptable research outcomes. In addition to the major processes described above, the following communication activities were undertaken:

Date	Communication activity
Dec. '95	Information sheet distributed in Coleambally Irrigation mailout to all farm businesses
15 Jan. '96	Article in "The Southern Rural", "The Coly-Point Observer" and "The Area News" , local radio and TV news grabs
Feb. '96	Invitation to public meeting (on survey findings) posted to all CIA farm businesses
Feb. '96	Media release in local press advertising public meeting
16 Feb. '96	Public meeting
19 Feb. '96	Article in the local press on aspects of the survey findings
8 March '96	Media release in the local press summarising findings of RRA
15 Feb. '96	Pre-recorded radio interview (regional ABC) on findings of the RRA
20 Feb '96	Live radio interview (regional ABC) on findings of the RRA
12 March '96	Handout and short address at IREC irrigated farm competition
1 April '96	Survey summary report and feedback sheet posted to all CIA farm businesses
June '96	Article in the *Farmers' Newsletter* on the project in general, and on the findings of the RRA
18 June '96	Address at Landcare field day
June '96	Research needs document circulated to NRMS, RIRDC, MDBC
June '96	Seminar at CSIRO Griffith
20 June '96	Article in "The Land"
July '96	Article in Water Wheel Supplement – distributed to project participants
Occasional	Several contacts with advisory panel by fax/mail/phone over a range of issues
21 Aug. '96	Article in local media on progress with the paddock monitoring
Sep. '96	Media release in "The Coly-Point Observer"
Sep. '96	Short paper prepared for southern MBD Irrigated Cropping Forum
Oct. '96	Presentation at Charles Sturt University irrigation research workshop at Yanco
26 Feb. '97	Paddock monitoring field day
27 Feb. '97	Address (invited) at public CIA LWMP meeting
18-21 Nov. '97	Two presentations at the 2nd Australasia Pacific Extension Network Conference
Dec. '97	Preliminary report on water monitoring results sent to co-operating farmers and to Coleambally Irrigation

Over the past 12 months, communication of project outcomes has also been via advising and participation in discussion groups and steering committees concerned with determining whole farm and paddock water balance for irrigation farms in the Murray and Murrumbidgee Valleys. This has included:

‘97/98	Several discussions with representatives of Murrumbidgee, Coleambally and Murray Irrigation and MDBC on the need for paddock water use benchmarks and further testing of methods for estimating ET at the paddock scale
‘98	Providing advice for Murray Irrigation paddock water balance studies being conducted as a complementary activity to the CSIRO/MIL/LWRRDC project on determining optimal irrigation intensity
‘97/98	Steering committee member of Murrumbidgee Irrigation Water Use Efficiency Incentive Scheme (meetings every two months, commencing December ’97)
‘98	Input into development of monitoring strategies for the NSW Agriculture water use efficiency program

PUBLICATIONS

Anon. (1996). 'Coleambally Irrigation Area: What you told us about your Concerns, Opportunities and Needs for a Sustainable Future.' Summary of findings from a survey of Coleambally farm people carried out 7-13 February 1996. 15 pp.

Anon. (1997). Coleambally water use monitoring project. Farmers' Newsletter Large Area No. 147, pp. 54-56.

Dunn, A., Humphreys, E., Butterworth, J., Hope, M.A. and Syme, G. (1997). The Coleambally Rapid Rural Appraisal. 2nd Australasia Pacific Extension Conference. 18-21 November 1997, Albury, NSW. In press.

Hope, M. A. (1998). Using farmer skill and knowledge in agronomic research - a case study. Masters Thesis, Charles Sturt University (in preparation)

Hope, M.A., Humphreys, E. and Dunn, A. (1997). Using farmer skill and knowledge in agronomic research - a case study. 2nd Australasia Pacific Extension Conference. 18-21 November 1997, Albury, NSW. In press.

Humphreys, E. and Hope, M. A. (1997). Paddock Water Use Monitoring in the CIA and Murray Valley in 1996/97. Preliminary results. Unpublished report.

OTHER REFERENCES

Anon (1996) Coleambally Land and Water Management Plan.

Cape, J., Chamala, S. and Syme, G. 91994) National program for irrigation R&D: Technology transfer and adoption in irrigation. Occasional Paper No. 03/94. Land and Water Resources Research and Development Corporation, Canberra.

Meyer, W.S., Prathapar, S., and Barrs, H.D. (1990). Water flux to and from shallow water-tables on two irrigated soils. In "Management of Soil Salinity in South East Australia". Eds E. Humphreys, W.A. Muirhead and A. van der Lelij. Conference Proceedings, 18-20 September 1989, Albury, NSW. Australian Society of Soil Science, Riverina Branch. pp.79-87

Meyer, W.S., White, R.J. and Smith, D.,J. (1996) Water use of lucerne over shallow watertables in Australia. In "Evapotranspiration and Irrigation Scheduling". Proceedings of the International Conference, Nov. 2-6 1996, San Antonio, Texas. ASAE, IAA, ICID. pp. 1140-1145