THE FIRST STAGE OF THE COLEAMBALLY WATER SMART AUSTRALIA PROJECT: BUILDING ON CICL'S ADOPTION OF TOTAL CHANNEL CONTROL® (TCC) TECHNOLOGIES

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ABSTRACT

This paper provides an overview of the first stage of the Coleambally Water Smart Australia Project. The Coleambally Irrigation Co-operative Limited (CICL) is providing its customers with the tools and systems to improve on-farm water use efficiency building on CICL's achievements through the adoption of TCC technologies. Through the implementation of channel automation (and a range of other initiatives) CICL has lifted conveyance efficiency from 75% in 2002/03 to 90% in the 05/06 irrigation season, saving approximately 60,000 megalitres of water per year. Whilst still recognising the capacity for incremental improvements in water delivery efficiency CICL acknowledges that the greatest opportunity to further lift efficiency and productivity in the Coleambally Irrigation District (CID) is on-farm. This paper focuses on CICL initiatives, with assistance from the Australian Government Water Smart Australia Programme, to provide its irrigation customers with the decision support systems and tools that will allow them to increase water use efficiency, productivity and profitability whilst reducing the environmental footprint of their irrigation activities.

BACKGROUND

CICL is a private co-operative that is responsible for providing irrigation water delivery and associated services to 320 irrigation customers in the CID as well as stock water customers in the West Coleambally Channel area. CICL's focus is the day-to-day operation of the irrigation scheme and the provision of water at the most affordable price to its member customers, consistent with its regulatory obligations and long-term business sustainability objectives.

The CID is located 650 km south-west of Sydney in the Riverina region in the southern Murray Darling Basin of south-eastern Australia (see Figure 1). Water is diverted to the area from the Murrumbidgee River at Gogelderie Weir and is supplied to customers through the 47km Coleambally Main Canal and 469km of supply channels. Surface drainage for 97,000ha is provided via 711km of drainage channels. CICL holds a bulk water licence of approximately 620 GL.

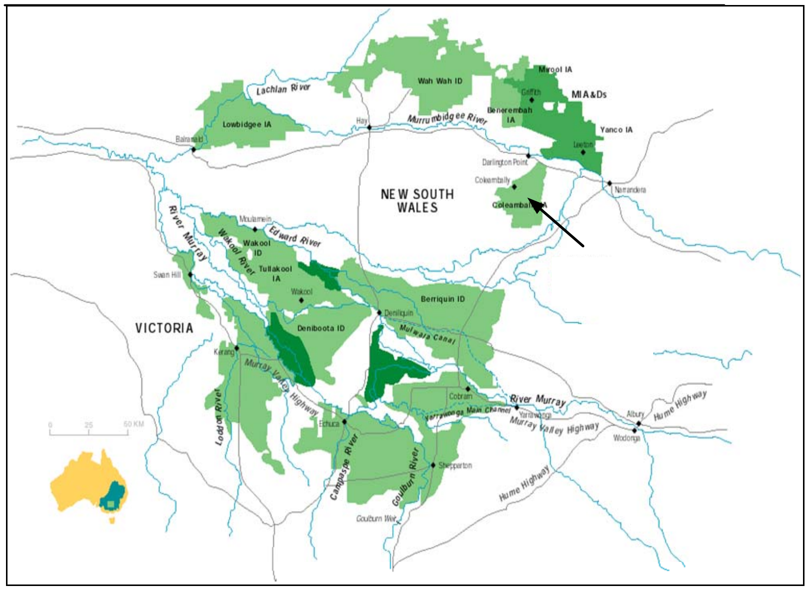

Figure 1. Location of the Coleambally Irrigation District within the southern Murray-Darling Basin

Approximately 320 irrigation farms are supplied through the CID delivery system. Some 79,000 hectares has been developed for intensive irrigation, and a further 42,000 hectares is used for a mix of irrigation and dryland farming. Landholders irrigate a range of crops including rice, row crops, winter cereals, grapes, plums and pastures. Traditionally rice has been the predominant crop grown in the district followed by a winter cereal crop utilising the soil moisture left over from the rice crop.

Historically irrigators in the CID have received on average a volume of 440 GL per year since 1994. In recent years, water deliveries have been negatively impacted by changing State Government water allocation policy and drought. In 2006/07 the volume of irrigation deliveries fell to an all time low of 179 GL (See Figure 2).

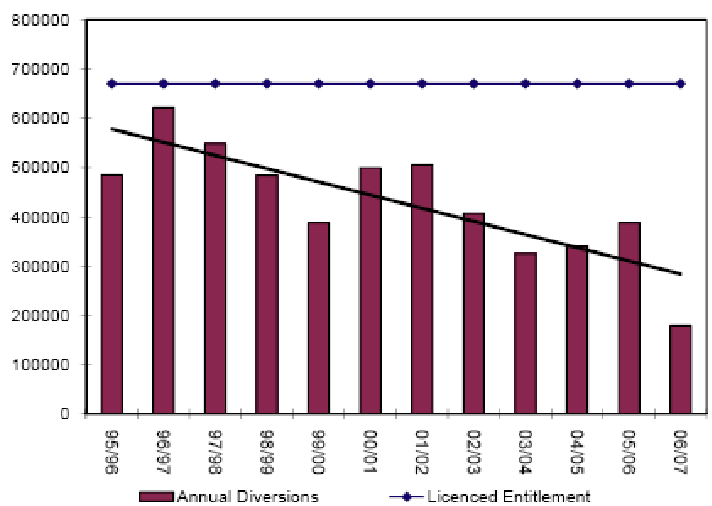

Figure 2. Annual Diversions 1995/96 to 2006/07 Coleambally Irrigation District

The precipitous decline in water availability and shifts in commodity prices has seen irrigators start to shift from the traditional higher water using rice crops to row crops, winter cereals and pastures (see Figure 3.). In the period between 1997/98 and 2001/02 an average of 70 percent of irrigation deliveries were used for rice growing and 5.8 percent for irrigating wheat. In comparison between

2002/03 and 2006/07 an average of 52 percent of water deliveries were used for rice and water deliveries for wheat increased to 16 percent.

	Rice		Soybeans		Corn		Wheat		Pastures		Canola	
	Area (ha)	Proportion of delivery (%)	Area (ha)	Proportion of delivery (%)	Area (ha)	Proportion of delivery (%)	Area (ha)	Proportion of delivery (%)	Area (ha)	Proportion of delivery (%)	Area (ha)	Proportion of delivery (%)
2006/07	8518	54.3	478	0.8	1863	7.6	12509	15.9	9958	7.8	1602	1
2005/06	18025	62.8	2106	2.9	3306	7.0	13610	8.4	15440	8.7	1748	0.9
2004/05	8142	44.0	1495	2.2	3671	7.2	20287	18.8	12865	10.8	2681	1.3
2003/04	12597	55.8	1938	3.5	3545	5.7	21192	14.98	12131	7.5	1763	0.7
2002/03	11395	46	1788	1	4788	9.3	21346	20.4	10183	7.4	2095	1.7
2001/02	27493	67.5	3297	3.4	3808	4.2	21103	9.2	11581	6.1	2191	0.6
2000/01	30440	73.9	4551	5.9	4074	5.7	14276	4.6	11998	4.7	2153	0.4
1999/00	24138	77.7	2185	3.9	1178	3.1	12649	6.1	7485	4.4	2152	0.7
1998/99	24491	73.8	4339	5.7	1059	1.3	13963	1.7	13879	8.1	2184	1.7
1997/98	24624	70.4	4998	7.5	1678	2.4	14943	7.4	9964	6.1	2053	0.4

Figure 3. Irrigated Crop Area 1997/98 to 2006/07 Coleambally Irrigation District

COLEAMBALLY CHANNEL AUTOMATION PROJECT

In response to declining water availability, in 2002, CICL made the decision to install Total Channel Control (TCC) automation technologies to improve the efficiency of the channel delivery system. TCC is a turnkey solution for taking existing manually operated channel systems and converting them to fully automated operation with the objective of supplying water near-on-demand, maintaining tight water level control and with zero outfalls or escape flows.

TCC involves the replacement of manually operated gates and drop logs in channel regulators with automatic control gates (FlumeGates™). The automation of the channel structures required the installation of a robust radio communications network and the implementation of specialist control, demand management and Supervisory Control and Data Acquisition (SCADA) software. The success Rubicon has achieved in becoming a world leader in this field is largely as a result of the accurate flow measurement of the FlumeGate and the specialist TCC control technology.

Prior to the implementation of TCC technologies, CICL operated a traditional gravity channel supply system where water officers, through manual operation of drop logs and doors, attempted to balance supply and demand and minimise water losses through escapes to the drainage system. To ensure an expected level of customer service, the tendency was to run channels at slightly above ordered flows to ensure customers were delivered in line with their expectations. As a consequence the system escapes tended to run continuously throughout the irrigation season leading to large volumes of escape flows lost to the channel system. The operating policy also led to land being commanded above initial design.

As of September 2007 CICL's entire channel system (incorporating 326 channel regulating and control structures) controlling 514 km of channel with flow capacities ranging from 15 ML/day to 6,000 ML/day is remotely operated. The Coleambally Irrigation District is the first open channel system in the world to largely automate regulators in its entire channel delivery system.

To date CICL has invested $10 million dollars in the automation of channel regulating structures and the implementation of the associated SCADA and telemetry systems. The primary benefits of the automation project have been:

- Water savings: Automation has effectively eliminated unplanned outfall losses. The stable operating environment has reduced uncontrolled escape flows to almost zero compared to a baseline of 30,000 ML/year prior to TCC implementation (see Figure 4). The TCC system is also effective in regulating outfalls from rainfall rejection events. As a result primarily, of the

TCC investment the 2005/06 irrigation year saw CICL set a new world benchmark of 90% distribution efficiency for an open channel system (water delivered on-farm/water diverted).

- Operating cost savings: A significant reduction in kilometres driven by the water officers to regulate channels has occurred resulting in reduced vehicle operating costs and channel access track maintenance costs. The solar powered, semi-autonomous FlumeGates have reduced the need for daily visits to sites by water officers. The savings in fuel usage has also reduced green house gas emissions. Reductions in labour costs associated with channel regulation are being progressively implemented. However this has been offset to some degree by the requirement to retain staff with additional skill sets to support the TCC system.
- Improving customer services: Automation has enabled CICL to implement two-hour water ordering compared to 24 hour ordering prior to automation.
- More Effective Scheme Operations: Real time monitoring and control of the gate network and water levels across the irrigation scheme allows more effective utilisation of channel storage capacity and improved control over water levels in channels.

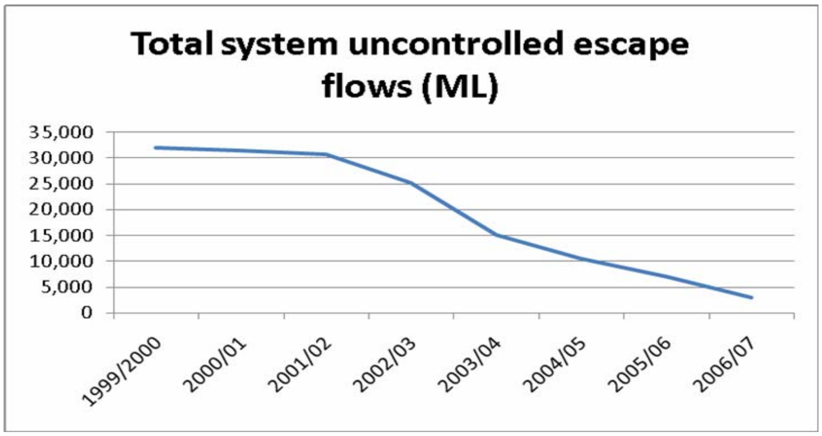

Figure 4. Annual Volume of Outfalls from the CID - 1999/2000 to 2006/2007

COLEAMBALLY WATER SMART AUSTRALIA PROJECT

After significantly improving the efficiency of the district's delivery system, CICL took the strategic decision to focus on assisting its irrigation customers to achieve similar levels of efficiency gains on-farm. In 2007 CICL successfully bid for federal funding under the National Water Commission's *Water Smart Australia Program*. The project, known as the *Coleambally Water Smart Australia (CWSA)* project will implement a range of initiatives designed to assist irrigators to better manage irrigation scheduling and applications. The project also aims to provide CICL with better information about the district water balance and aggregate water demands enabling more effective operations of the CICL retail and Murrumbidgee bulk water systems.

The CWSA project comprises 12 separate investment activities that will be rolled out over a 3 year project period from 2007 to 2010. This paper will focus on those elements of the project which commenced in phase one of the project, the current irrigation season (2007/08):

1. Farm meter outlet modernisation
2. Soil sensors
3. Data integration

These current elements of the project are examined in more detail next.

FARM OUTLET METERS

In common with other irrigation districts in Australia, CICL had employed Dethridge Wheels to meter water use onto farms. Prior to embarking on the CWSA project CICL had rationalised and replaced approximately 35% of existing Dethridge Wheels with a variety of modern accurate meters including Doppler ultrasonic meters, electromagnetic meters and FlumeGates. These were developed as an outcome of the industry based ANCID "Know the Flow Project" undertaken in 1995 and adapted to rural water supply specifications.

This transition to accurate meters was initially problematic as a range of technology and equity issues needed to be resolved. An average under measurement of the volume of water received by irrigators through the Dethridge Wheels created issues with "big megalitres" versus "real megalitres" when accurate meters where installed. Given that the inaccurate measurement had persisted over 40 years it was very difficult for some customers to accept accurate measurement. This has been offset by compensating irrigators for the loss in water access by increasing their annual water allocation and by the reduced head loss through the new meters. This was facilitated by the regulatory control CICL has, as the owner of the district conveyance loss entitlement, and its capacity to distribute water savings to its customers.

In the initial stages of the meter replacement program, CICL encountered a range of technical issues arising with the various meters employed, particularly as the cooperative was an early adopter of these technologies in the context of open channel irrigation metering. These problems included water quality affecting the ability of the Doppler meter to accurately measure flow rates under gravity supply situations, electrical problems in the electromagnetic meters and sensor drift issues with the FlumeGates. To the credit of the suppliers of this equipment, all the major technological problems have now largely been resolved.

As an essential component of efficient on-farm operations, a contribution of 50% of the capital cost of future meter replacement was obtained through the CWSA Project.

While all three types of metering technologies trialled by CICL generally performed effectively, the cooperative has elected to fit Rubicon FlumeGates to the remaining 310 Dethridge Wheels to be replaced under the CWSA project.

The key reasons for choosing the FlumeGate over other metering technologies were:

- Economies of scale: the FlumeGate meter outlet is almost identical to the gate used in the channel regulators. There are considerable benefits in terms of operations, servicing and maintenance costs in having essentially the same device and telemetry system on both the regulators and meter outlets.
- The proven automated flow rate control feature of the gate. The gate can maintain the flow rate ordered by the irrigator to within 0.2 ML/day. In addition the flow rate through the gate can be monitored and altered by the irrigator at any time over the internet prior or during the ordered irrigation event. These remote automation features are critical aspects of achieving more efficient water application and minimising deep leakage and drainage losses on-farm.
- Low head loss: The very low water head loss through gate compensated for the lowered (design level) operating levels in the channel system that was introduced with channel automation.
- Integration: The FlumeGate meter outlet is also fully integrated with the TCC channel automation system and the CICL SCADA system. It has identical set up, monitoring and alarming features to the channel gate. In comparison the full integration of other vendors' meters while technically possible proved to be problematic particularly in relation to commercial and intellectual property concerns.

- Competitive price and cost savings: The capital cost of the FlumeGate is about 25% greater than an equivalently accurate electromagnetic meter. The on-going costs will also be higher because of the number of sensors in the gate and motorised moving parts. The additional cost is at least partly offset by elimination of manual operations, monitoring and meter reading of the meter outlet by CICL channel operators.
- Capacity to build on features: The FlumeGate also has a spare communications port which allows other farm captured data to be communicated back to CICL's hub for real-time remote presentation to its customers e.g. soil moisture data.

The rationalisation of farm supply points is also an integral part of the CWSA project. It is expected that at least 20% of the existing Dethridge Wheel meter outlets will be removed without replacement. This is expected to provide ongoing business efficiencies.

SOIL MOISTURE SENSORS

While the application of soil moisture sensors to irrigation scheduling is not new, the rate of uptake of this technology has been very low in the Coleambally area. CICL estimate that less than 1 per cent of irrigators in the project area currently use soil moisture sensors to monitor irrigation applications. The primary barrier to their use in the management of annual crops is that irrigators only get one chance to get it right, miss an irrigation and the crop could be lost. Thus relying solely on soil moisture sensors is considered too great a risk in the view of many CICL irrigators. For the full benefits of soil moisture sensors to be realized there is a need to be able to deliver water near 'on demand'- TCC provides this crucial first step.

Nevertheless the experience of progressive irrigators throughout the world clearly demonstrates that there are significant water savings and crop yield benefits from the use of soil moisture sensors that provide direct and reliable measurement of soil moisture. Thus a key element of the Water Smart Project is to provide incentives to increase the rate of uptake of soil moisture sensing technologies and demonstrating their benefits as a first step. Funding for the acquisition of some 300 soil moisture sensors and low cost radios has been made available through the Water Smart Project.

Perhaps the most unique element of the soil moisture component of the Water Smart Project is the deployment model. CICL purchases, installs and maintains the soil sensor and associated telemetry system. It is anticipated that CICL will charge irrigators an annual fee for the service over time as the technology proves itself in the field. The irrigator elects where to install the sensor in the field, usually on advice from an agronomist. The soil moisture sensor data is made available in real time to the irrigator and/or the agronomist through CICL's existing radio network and computing infrastructure.

The infrastructure to support the soil moisture sensors comprises short range radios that use the farm meter outlet FlumeGate as a communications node. A number of short range radios have been evaluated for this purpose including innovative ZigBee protocol based mesh networking radios developed by the Australian Government NICTA organization. However, the NICTOR radios while showing some considerable technical promise were judged not to be commercially mature at this time. CICL therefore elected to use conventional point to point radios for the soil moisture deployment, although it is continuing to closely monitoring developments in this area.

Given the severe lack of irrigation supplies in the current season CICL has elected to initially trial multi depth capacitance soils sensors (from vendors Aquaspy and Sentek) on a dozen farms to evaluate their performance over an extended period. This will provide guidance as to which technologies are preferred to roll out more extensively across the irrigation district. The trial has been supported by a local irrigation agronomics service provider (Cropsol). The support package includes installation of the sensors, training of irrigators and the on-going analysis and interpretation of the soil moisture trends.

The trial over the current summer (2007-08) has shown that soil moisture sensors do offer a significant benefit over the well accepted 'shovel technique'. Take for example the graph below (Figure 5.) which shows soil moisture reading from a sensor in a maize crop where the irrigator has been encouraged to continue to use his accepted method of shovel scheduling. Rainfall events are also evident. The blue zone (upper band) effectively identifies water logging, while red (lower band) indicates the refill point and the green zone (middle band) flags the optimal growing condition for the crop. The soil type is a black cracking clay.

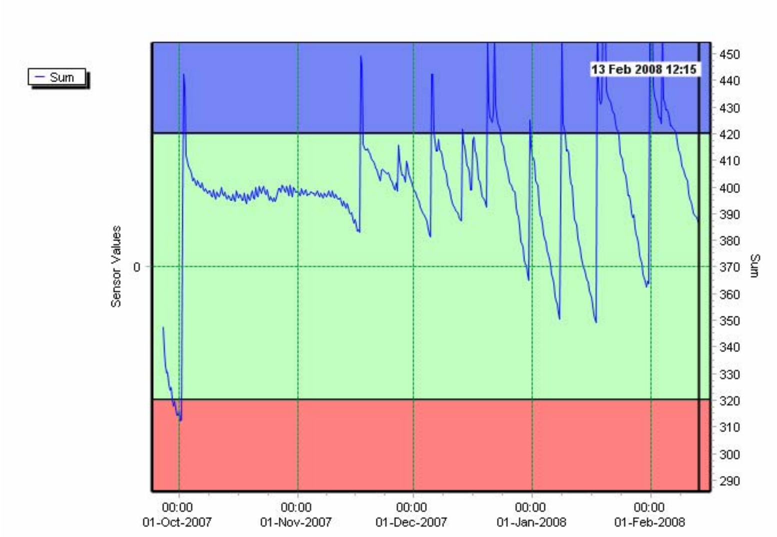

Figure 5. Soil Moisture Trends over a Number of Irrigation Events

From this trend it is apparent is that this irrigator is watering too soon with the shovel technique, not providing an adequate indication of what was happening at depth within the root zone of the crop. This crop will continue to be monitored for the entire crop cycle to allow comparison between scheduling techniques; but it would be fair to say that even up to early January the crop could have used one less irrigation event if optimally scheduled.

One of the key lessons learnt to date is the critical importance of on-going agronomic support to the successful application of soil moisture sensors. The data produced by the soil moisture sensors requires careful analysis to determine the refill point as the crop develops. It is evident that even with some initial training irrigators were not confident in interpreting the soil moisture trends for their crops without the assistance of the irrigation agronomist.

DATA INTEGRATION AND WEB INTERFACE

A key objective of the WaterSmart Project is to use the existing CICL SCADA and telemetry system to support the collection, storage and dissemination of on-farm sensor data such as the soil moisture sensors discussed above. Rubicon has committed to developing a robust and flexible commercial solution for this purpose. Development of this new package known as FarmConnect is underway and comprises the following elements:

- Irrigator/Agronomist internet page interface: This will provide the farmer with the facility to view and manipulate soil sensor data in real time and to configure fill and capacity points for each sensor through the WEB. The "alarm" limits will be capable of being changed over time and the system will record and present historic values or these alarm limits. The system will provide the farmer with the facility to use the "alarm" limits to generate SMS or Email messages when these conditions are encountered and optionally enable these messages to be directed to their nominated agronomist/adviser. A facility will be provided to allow the agronomist to access one or more farmer's sensor data through the use of a single login. The establishment and maintenance of this grouping facility will be managed by CICL staff on the basis of farmer approved 3rd parties. For example this facility will provide the capability for the agronomist to login and navigate to individual farmers' properties and review sensor data and system configurations. The application will be integrated with spatial visualization tools such as ESRI or Google Earth (see Figure 6 below).

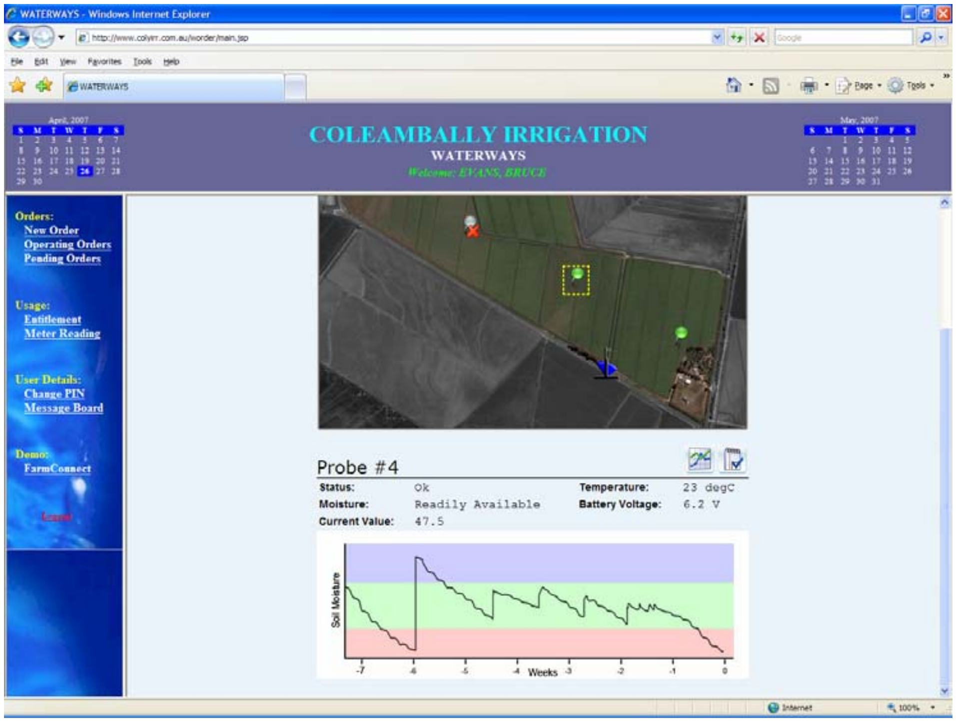

Figure 6. Prototype Irrigator Internet Page Interface

- Telemetry and SCADA Tools: This involves the development of software tools to enable CICL staff to add/remove/maintain on-farm sensors in the CICL SCADA system. This will result in a standalone application that will transparently build all the existing underlying SCADA data structures (traditionally considered to be SCADA engineering), that are required to support the addition, modification and removal of sensors. Software drivers to integrate the FlumeGate MOSCAD RTU with the low cost radio network for the on-farm soil sensors are also under development.

This aspect of the project is very much in a developmental phase. CICL also expects to make available to its customers a wide range of additional irrigation decision support tools including real time weather data from a number of automatic weather stations from around its irrigation district; forecast crop evapotranspiration and weather developed through other elements of the project. It is also anticipated that soil moisture monitoring and automation elements will also be integrated with, for example, the soil moisture status triggering the opening and closing of gates.

CONCLUSION

CICL is committed to raising the water use efficiency of irrigation within its areas of operations. To this end the cooperative has invested in Total Channel Control automation to improve the efficiency of the channel delivery system with considerable success. The focus of attention has now turned to achieving similar gains on-farm. With assistance from the Australian Government Water Smart Australia Fund, CICL is implementing the CWSA project to provide irrigators with information and tools to improve on farm water efficiency. This paper has described the activities being undertaken in the first stage of the project.

Whilst many of the elements of the CWSA project are not new and have been shown to operate efficiently in their own right, it is the integration and broad scale application of technologies within an irrigation scheme that is the major innovation of this project. Indeed it is this innovation and its potential application to other irrigation schemes across Australia that provides the rationale for the public investment in the project.