

TOTAL CHANNEL CONTROL™ AN IMPORTANT ROLE IN IDENTIFYING LOSSES

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ABSTRACT

Total Channel Control™ (TCC™), a system of automated structures and advanced control and modeling software, has been operating for the last two irrigation seasons in South Eastern Australia. Two large systems have been implemented involving more than 500 gates. It is now established that the system can provide better control, more responsive customer service and effectively eliminate system outfalls. The system has also shown considerable potential to identify areas of high system losses primarily attributed to leakage and seepage. The extent and benefit of the water savings realised has been the subject of some debate both in a policy and technical sense. The policy debate revolves around the merit of environmental benefits associated with uncontrolled outfalls from channels that may accrue a downstream benefit. The technical debate centres around the comparison of the before and after positions and necessarily focuses on the accuracy and timing of flow measurement under both regimes. The paper provides a high level overview of TCC™ and a detailed analysis of components of the overall water balance.

INTRODUCTION

Total Channel Control™ (TCC™) has been developed by Rubicon Systems Australia Pty Ltd (Rubicon) and involves a number of integrated technologies centred around major breakthroughs in system modelling and control theory. The improved monitoring and control associated with TCC™ accrues benefits in the following areas

- **Improved customer service**
 - Close to “on-demand” supply to customers
 - Supply of flows as ordered.
 - Automated opening and closing of outlet.
 - Orders are confirmed at the time lodgement.
 - Ability to interface to on farm automation equipment
- **Water Savings**
 - Channel system outfalls are effectively eliminated whilst delivering significantly improved customer service except in shutdown events.

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- The “on demand” service combined with assured flow rates onto farm facilitate on-farm savings and improvements
- **Productivity Savings**
 - The TCCTM system operates automatically without a traditional field operator
 - The Planner’s role changes from routine scheduling to supervision, exception handling and emergency response.
- **Occupational Health and Safety**
 - The TCCTM system eliminates the manual lifting of drop bars and meter outlet doors.
 - The TCCTM system eliminates the OH&S risks associated with lifting of the Dethridge Outlet door and the rotating wheel.

Key theoretical and practical aspects of this work have been published in refereed journals and conference papers locally and internationally. For further information on the control and modelling aspect of TCCTM refer to Oii 2001 and Mareels 2003. Luscombe 2002 and Luscombe and Oakes 2003 detail expectations and preliminary outcomes for the TCCTM pilot on the No. 2 channel in the Central Goulburn Irrigation Area. Goulburn-Murray Water (2004) provides a comprehensive report on the outcomes of the pilot and G-MW have recently taken a decision to significantly expand TCCTM in the Central Goulburn Irrigation Area during the 2005 calendar year.

The primary focus of this paper is on the water savings aspects of TCCTM and more particularly an analysis of unaccounted water and how previous understanding may be extended.

BACKGROUND

There are many definitions of irrigation efficiency but in the context of irrigation distribution systems this is generally regarded as the ratio of water delivered to customers versus the volume of water taken into the system. Sinclair Knight Merz (SKM 2000) undertook a major study of the efficiency of the Northern Victorian Irrigation systems. This report showed that the average weighted distribution efficiency for the 10 years from 1989/90 to 1998/99 was 71% for the gravity irrigation areas. The report also indicated that the 10 year average diversion volume was on the order of 3380 GL, deliveries approximately 2400 GL with losses of the order of 980 GL. The 980 GL loss component was reported as shown in Table 1.

Table 1. GMID 10 year average unaccounted for water – 1989/90 to 1998/99 (SKM2000)

| Mechanism | Volume (GL) | Percentage | Volume (GL) without unaccounted component |
|------------------------|--------------------|-------------------|--|
| Outfalls | 298 | 30 | 387 |
| Meter Error | 110 | 11 | 143 |
| Evaporation | 101 | 10 | 131 |
| Leakage | 85 | 9 | 110 |
| System Filling | 64 | 7 | 83 |
| Seepage | 55 | 6 | 71 |
| Unmetered D&S Supplies | 38 | 4 | 49 |
| Theft | 5.5 | 0.6 | 7 |
| Unaccounted | 225 | 23 | 0 |
| Total | 981.5 | 100.6 | 981 |

A significant conclusion from this work was that 225 GL could not be assigned with confidence to any of the eight physical components shown in the table. Clearly 225 GL is a very substantial quantity of water and the fourth column of the table simply apportions this volume to the other categories.

Luscombe and Oakes (2003) reported the following 5 year average annual statistics for the Central Goulburn No 2 Channel (CG2) prior to the commencement of the CG2 pilot in 2002/2003 as:

Table 2. CG2 efficiencies - 5 years 1996-2001

| | |
|------------|-----------|
| Inflows | 13,100 ML |
| Deliveries | 10,800 ML |
| Outfalls | 1,500 ML |
| Efficiency | 82 % |

The data reported in Table 2 and substantial amounts of the data reported in Table 1 are based on once a day measurement, typically taken at 8:00am.

An analysis of the continuous flow measurements acquired from the TCC™ system on the CG2 channel for the 2003/2004 season shows the following quantities:

Table 3. CG2 efficiency - 2003/2004

| | |
|------------|----------|
| Inflows | 14011 ML |
| Deliveries | 11064 ML |
| Outfalls | 10 ML |
| Efficiency | 79 % |

Despite outfalls effectively being eliminated and a slight increase in the volume of water delivered the comparison of the data from Table 2 Table 3 and Table 3 shows the overall efficiency has declined by the order of 3%. This is a non intuitive outcome. However, G-MW continue to collect once a day measurements of the inflow to the CG2 system and the sum of these figures for the same period represents a total volume of 11,263 ML which equates to an overall efficiency of 98%. On the basis of these data a reasonable conclusion would be that the historic methods of data recording significantly under estimate system inflows. Experience with the introduction of continuous measurement within other authorities, particularly on outfalls has shown substantial variation with traditional manual measurement and in an extreme case last season this was under recording by 500% i.e. manual measurements showed 1/5th of the volume recorded by continuous measurement.

SEASON ANALYSIS

Necessary prerequisites to delivering the control outcomes associated with TCC™ are

- Accurate and continuous water level measurements
- Accurate Flow Measurement
- Accurate and timely representation of demand
- An accurate network model
- Control and actuation equipment capable of supporting a high duty cycle

Accurate and continuous flow measurements together with the network model also enable real time water balances to be undertaken on a pool by pool basis. Furthermore the ability of the TCC™ system to maintain constant flows on to farm ensures that the ordered flow rate (demand) equates very closely to metered usage.

Figure 1 shows a plot of the inflow to the CG2 system less the demand, using average daily quantities. Given that demand is an excellent indicator of metered usage this is effectively a plot of system loss computed on a daily basis, although these daily values are underpinned by continuous records. Apart from one small order on 18 September 2003 the system was not completely filled until the first significant demand that occurred on 28 September 2003. The volume of water taken into the system from the filling start date of 10 Sept. until 28 Sept. was 292 ML and as a percentage of the total inflow for the year (from Table 3) this represents a value of approximately 2%. This is substantially smaller figure than that quoted by SKM as shown in Table 1, although it is reasonable to expect this for a small channel when comparing to system wide data.

Note that the loss was highest for the initial filling period, when there was no demand and fluctuated between 0 and 20 ML/day with an average of 9.1 ML/day over the period of the season when orders were being delivered.

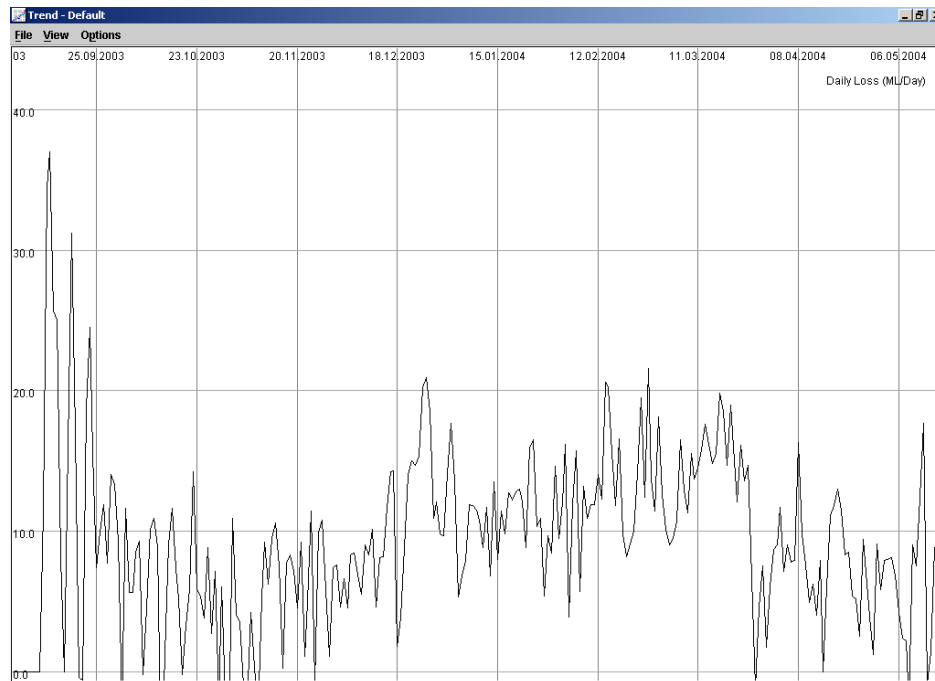


Figure 1. Plot of Inflow - Demand (loss) - CG2 System 2003/2004 Season.

Figure 2 shows the demand (represented as a step function plot) and inflow (represented as a continuous line generally above the demand) during a major shutdown event.

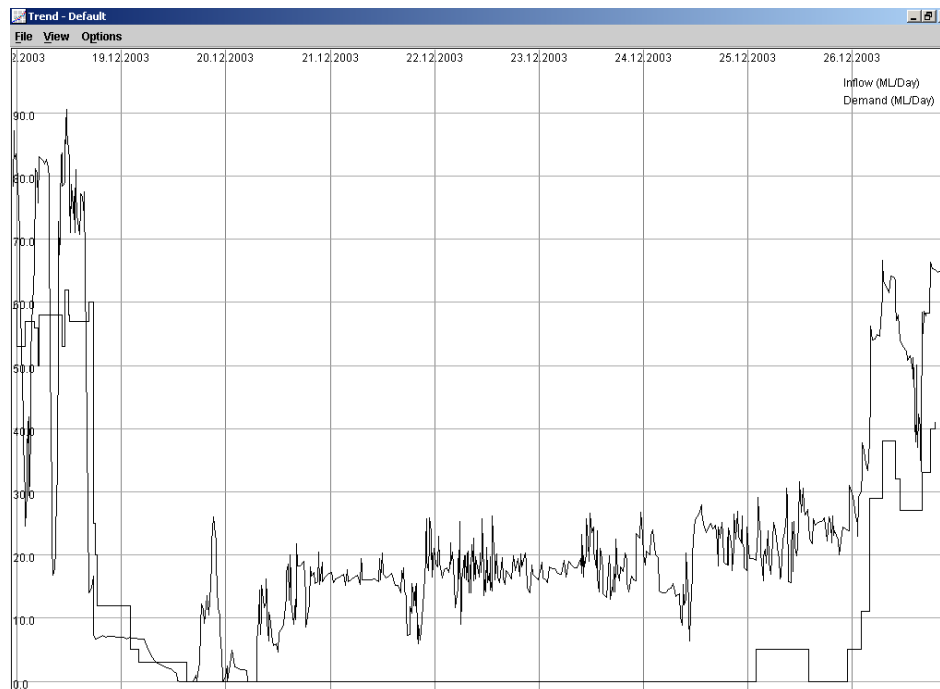


Figure 2. Plot of Inflow and demand – December Shutdown.

This shutdown occurred after a major rainfall event (of the order of 125 mm) on 18 December 2003. There was no demand from midway through 19 December until Boxing Day but significant inflows were required to maintain the channel system at supply level. Clearly this water was consumed by the mechanisms shown in Table 1 and a total volume of 86 ML was brought into the system over this six day period, which represents an average value of 14.3 ML/day. This event was the catalyst for increased scrutiny of losses and subsequent to this period a number of significant channel leaks were identified and repaired. The fact that the average daily loss of 9.1 ML/day for the entire season was less than this figure would imply a reduction in the leakage from the system. Of course since leakage is not directly measured we cannot assert with 100% confidence that this reduction is due entirely to leakage.

Given that TCC™ had effectively eliminated outfalls (Table 3) but system efficiency had marginally decreased, the estimates of loss shown in Table 1 must not be representative of the loss distribution for CG2. There is a strong argument that TCC™ has reduced meter error and Evaporation was one of the components that SKM had most confidence in estimating. On this basis it is concluded that Leakage, Seepage or Theft must represent a much larger proportion of the loss than reported by SKM.

END OF SEASON MEASUREMENT

In light of the mid season shutdown event and the insight gained throughout the balance of the season it was decided to continue to operate the system after the season concluded. The last order finished at 10:00 am on 16 May 2004 and the system continued to operate in TCC™ mode (i.e. system maintained water levels at set point) until 10:00 am on 28 May 2004. The system was then allowed to “drain” for 1 week before being turned on again at 10:00 am on 4 June to fill before being finally turned off on 7 June 2004.

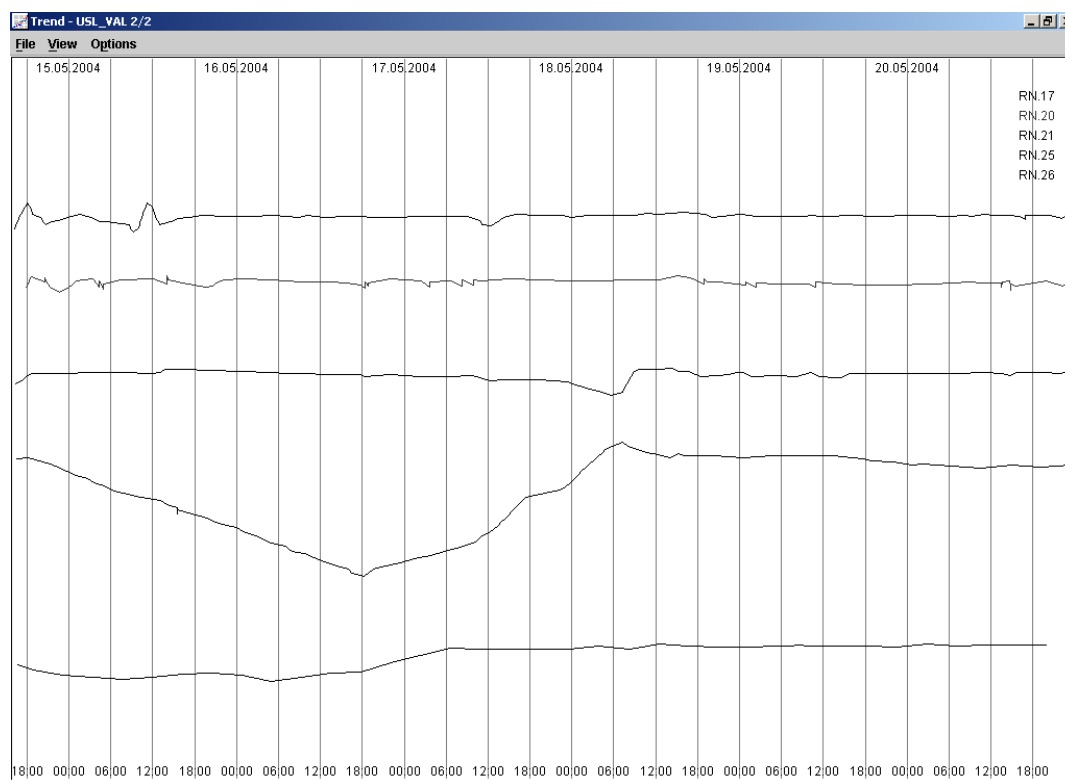


Figure 3. Water level reduction with no demand.

It was expected that the inflow to the system would reduce after the conclusion of the last order however the converse situation was observed. Figure 3 shows the rapid reduction in the water level in one pool and given that no leaks or channels breaks were reported it is concluded that some unauthorised access took place at the season end and due to the configuration of the control system at time this time it took nearly two days to replenish. The average inflow to the system over this 10 day period was 8.2 ML/day although this reduced to 7.5 ML/day over the last week.

A quantity of 37 ML was required to replenish the system after the 1 week drain period which equates to an average daily loss rate for the week of 5.3 ML/Day.

POOL LOSS ANALYSIS

At the conclusion of the irrigation season an audit of the water level and gate position instrumentation was undertaken on the “in-line” FlumeGate™ devices to verify measurement accuracy. For the period from 17 May 2004 to 28 May 2004 an analysis of the pool by pool losses showed that 49% of the losses from the entire system were contributed by four of the 38 pools in the system. 81% of the losses were contributed by 11 of the pools. If these statistics are representative of

the entire system then targeted leakage recovery is an attractive water savings option.

OUTFALLS AND SAVINGS

There are two key issues to be addressed when considering the benefits of reduced outfalls

- What is the magnitude of the saving
- What is the value

Both questions have stimulated considerable discussion within the industry in recent times. In the case of the CG2 system after two seasons of operation there seems to be little debate that outfalls can be effectively eliminated. The key issue is just how accurate was the before estimate and how representative is this amount for other systems. Anecdotal evidence from Southern Rural Water in the Gippsland region of Victoria, Australia is that continuous measurement on 6 outfalls has shown previous estimates to be in error by 100%. In targeting systems for water savings manual once a day measurement can at best be used as only a guide and that ongoing continuous measurement is necessary to verify and audit the quantity of savings.

There are policy makers that consider if an outfall can be reduced and the source of water retained in storage then this is a legitimate water saving. However, some advocate that uncontrolled outfalls are consumed further down river and therefore there is no value to be gained by their reduction. Clearly this is not a black and white issue and available capacity and timing are key factors in determining the value of the overall reduction. Clearly those advocating the maintenance of outfalls are at odds with the general water saving principles and advertisements used in the major urban locations.

CONCLUSIONS

Whilst the initial drivers for the development of TCC™ were based primarily on the benefits accruing from improved control, accurate and continuous measurements of flow on an intense basis have shed new light on the distribution of losses within open channel systems. Outfalls from the CG2 channel system were effectively eliminated for the 2003/2004 irrigation season and yet the computed efficiency was marginally lower than that previously reported. It is the author's view that point source leakage is a more significant component of water loss than previously thought and this should become more apparent as more focus is placed on water recovery.

ACKNOWLEDGMENT

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