Australian Government
Cotton Research and Development Corporation

Cotton Catchment Communities CRC

FINAL REPORT 2006

Due by 30th September 2006.

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: **5.1.12**
OR Cotton CRC Project Number:

Project Title: Siphon-less Irrigation

Project Commencement Date: Oct 05 **Project Completion Date:** May 06

CRDC Program: Farming Systems
OR CRC Program: The Farm

Part 2 – Contact Details

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Organisation:
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Ph: **Fax:** **E-mail:**

Signature of Research Provider Representative: _____

Part 3 – Final Report Guide (due 31 October 2006)

(The points below are to be used as a guideline when completing your final report.)

Background

Australian irrigated cotton growers are committed to improving their water use efficiency for economic, environmental, social and political reasons. The Australian cotton industry is predominantly irrigated by furrow irrigation with siphons. Increasing the performance of such systems generally requires an intensification of the existing labour requirements while the current labour force is dwindling. Various alternatives have and are being considered but there is a lack of data that exists about comparisons of alternatives to fully optimised furrow irrigated field and even more so a lack of data about the individual potential of each system to perform better. The siphon-less project was developed to address this knowledge gap by using the same methods to measure and the same water use efficiency indices to assess the performance of each alternative system and an adjacent furrow irrigated field. Four systems, located throughout the Border Rivers and Lower Balonne catchments, were assessed over the 2005/06 summer including: Overhead Irrigation (Lateral Move), Bank-less Channel, Bank-less Head Ditch and Pipes Through the Banks. The following water use efficiency indices were calculated: Gross production Water Use Efficiency Index, Application Efficiency and Distribution Uniformity. In addition final infiltration rates, gross margin including development, operational and input costs were generated for each field under investigation. Results have demonstrated that the siphon-less irrigation systems compared reasonably well and in one case exceeded the water use efficiency of the adjacent furrow irrigated field. The development of siphon-less systems is more costly while the operating costs vary between systems. All systems have shown that there is still room for improvement. While furrow irrigation with siphons remains the pre-dominant irrigation method of the Australian cotton industry efforts towards improving the performance of this system still remains of paramount importance.

Objectives

- Quantify and compare the amount of water used and lost (deep drainage) in-field in four siphon-less irrigation systems and corresponding furrow irrigated fields.
- Quantify and compare development costs, labour savings and yields of the four systems and corresponding furrow irrigated fields.
- Determine and promote the most water use efficient siphon-less irrigation system.
- Determine grower motivation for adopting one siphon-less irrigation method over another.
- Educate irrigators and stakeholders on and promote the adoption of water use efficient irrigation systems, deep drainage and any salinity management issues.

Methods

1. **Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research**.

The project was designed to measure the components required to assess the WUE of each system using several of the indices set out in WaterPAK (Table 1). These

indices are related to water use, along with the application efficiency and uniformity of the irrigation applications. The WUE indicators are defined in Table 1.

Table 1: WUE Indices Used to Assess the Performance of the Siphon-less Irrigation systems.

Water Use Efficiency Index	Acronym	Minimum Standard	Definition	Formulae	Relevant Sections in this Report	Relevant WaterPAK sections
Gross Production Water Use Index (bales/ML)	GPWUI	>1.1	Yield per total water infiltrating the paddock including irrigation and effective rainfall	= Yield÷ (Irrigation Water that Infiltrated the Field + Effective Rainfall)	4.4 Economic Returns 4.1.1 Irrigation Water Use 4.1.2 Rainfall	2.1 Assessing whole farm water use efficiency **NOTE Soil Moisture Used was not measured**
Application Efficiency (%)	E_a	>80	Percentage of water applied that is used by the crop.	= (Water used to refill the deficit) ÷ /(Water Delivered to the field – 85% of the tailwater volume)*100	4.2 Application Efficiency and Distribution Uniformity	As Above **NOTE 15% Tailwater losses are included to be consistent with all other industry data**
Distribution Uniformity (%)	DU	>90	Measure of how evenly the water is applied.	= (Average lowest 25% of infiltrated volumes) ÷ (Average of all infiltrated depths)	As Above	2.9

Water Use

Water use can be divided into two components: irrigation water use and rainfall.

Irrigation Water Use

Irrigation water use was measured two ways. Meters were installed in the head ditch and tail drain of every field under investigation to quantify the amount of water delivered to the paddock and returned as tailwater. The difference is the water used to irrigate the field. This volume includes the water infiltrated, evaporated and lost as seepage from the head ditch, tail drain and in field. Irrimate™ Irrigation Evaluations were conducted on every field except for the bank-less channel and the lateral move due to the limitations of the equipment on reverse slopes and overhead systems. The irrigation evaluations were used to quantify the amount of water delivered to the furrows through the siphons and leaving the

furrows as tail water. The difference is the water infiltrating the paddock alone. The two water use measures were used to cross check each other and to calculate the infiltrated irrigation water for each irrigation.

In the case of the bank-less channel system the meters in the supply and tail return pipes were used to generate the same data but were adjusted for evaporation and seepage using assumptions. For the lateral move the flow rate, speed and engine hours were used to calculate the amount of irrigation water that was delivered to the paddock.

Rainfall
Total rainfall was collected using on farm weather stations and on farm records in conjunction with SILO weather data. The proportion of rainfall that was infiltrated into the crop root zone, commonly referred to as Effective Rainfall, was estimated using HydroLOGIC. Grower observations were also used to validate these estimations.

Application Efficiency and Distribution Efficiency
During an Irrimate™ Irrigation Evaluation the inflow through siphon(s) and the total time of irrigation is measured with a flow meter and a data logger. To ensure representative measurements the monitored siphons are started and stopped at the same time as the rest of the siphons. The time it takes for water to advance down the field is measured at five, usually equi-distanced, points by advance sensors connected to data loggers. The advance and siphon flow data allow a volume balance to be generated which calculates how much water is moving into the soil profile over time. A flume with a flow meter and data logger is then inserted into furrow(s) at the tail drain end to measure the water leaving the paddock. This flume data can be used to validate the infiltration volume that has been determined using the flow meter and advance data. Once this data was collected and cross checked Application Efficiency (AE) and Distribution Uniformity (DU) was calculated using the Surface Irrigation Model (SIRMOD) computer program.

Continuously logging depth loggers were placed throughout each bay of the Bank-less Channel field to measure the time it took for water to advance up from the tail drain to the middle of the field and how long water was ponded for at each spot. The data was to be used to model the variation in infiltration throughout the bays and calculate AE and DU. Currently the method of interpretation is still being developed in collaboration with researchers at the National Centre for Engineering in Agriculture (NCEA) and The CRC for Irrigation Futures at the University of Southern Queensland.

A catch can evaluation of the lateral move would have provided the data to calculate AE and DU. Unfortunately an opportunity did not arise due to bubbler mode already in place prior to the trial.

Installation and Operational Costs
A gross margin was developed based on grower estimates of operation, maintenance and input costs for each system over the season. Costs of development for each siphon-less system were estimated for comparison with the adjacent furrow irrigated field.

Results:

Siphon-less vs Furrow	Yield Bales/Ha	Variety	GPWU Bales/Ml	Ae %	DU %	Deep Drainage	Labour %	Development Costs %	Gross Margin $/ML
Bank-less Channel	10.9	71	1.06	-	-		10	129	$274
Furrow	11.4	71	1.11	82	91		100	100	$340
Pipes through the Banks	10	289BR	0.88	87	93		40	320	$357
Furrow	8.6	71BR	0.78	79	91		100	100	$186
Bank-less Head Ditch	4	PIMA	0.45	84	88		-	-	-
Furrow	9.94	71BR	1.06	97	95		100	100	-
Lateral Move	8.12	289BR	1.3	-	-		70	218	$754
Furrow	8.1	DP611 BR	0.93	75	89		100	100	$281

2. Detail and discuss the results for each objective including the statistical analysis of results.

In review the siphon-less irrigation investigation is in a preliminary phase. None of the alternative systems have been fully optimised. Better measures of effective rainfall are required and the amount of soil moisture used needs to be measured to improve comparisons in the future.

The siphon-less and furrow systems evaluated have shown potential to benefit from optimisation and further investigation into "how far the systems can go" is needed to provide a greater understanding of what is achievable for each.

Although the field performance was similar the furrow out performed the bank-less channel system in all irrigation performance indices. Running costs were higher for the siphon-less system as a direct result of the tail water generated driven by the need for high head heights to maintain uniformity of advance.

The results of the comparison of furrow and bank-less head ditch system (although not conclusive due to varietals difference) highlighted the limits in the current design of the bank-less head ditch. This system is expected to mirror the performance of the bank-less channel system with an increase in costs associated with high rates of applied water and tailwater generated because of non-uniformity.

PTB performed on par with the furrow field. Both systems would benefit from further optimisation.

The lateral move significantly outperformed the furrow irrigated field in terms of WUE indicators, and gross margin. This was most likely a result of the ability of the lateral move to make better use of in crop rainfall and sub soil moisture but may also be determined by the fact that the furrow irrigation system has not been optimised. Optimisation is critical for a fair comparison.

The gross margin (based on growers estimates) of all the systems confirmed that a significant saving in labour can be achieved through the adoption of a siphon-less system at a higher cost of development. The operational costs for each system were influenced predominantly by the amount of water applied and tailwater generated by the system, having a greater effect on overall costs than either, repairs and maintenance or input costs. However, while furrow irrigation with siphons remains the dominant irrigation method in the Australian cotton industry efforts towards improving the performance and profit per megalitre of this system still remains of paramount importance.

Outcomes

3. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.

Outputs	Date for achievement	Description of milestone or deliverable.	Key Performance Indicator of Achievement
1.	31st October 2005	Identify Trial Sites.	Trial Sites (3 sites Qld, 1 site NSW).
2.	20th November 2005	Secure funding and in-kind support.	Stakeholder meeting Purchase Equipment
3.	Before 1st Irrigation (end of Nov) 2005	Set–up trial sites	Set up trial sites with equipment
4.	Nov 05 to March 06	Measure in-field irrigation events throughout season Farm walks	Data collected from each site
5.	February 2006	Collect and collate development costs, labour input and interview growers. Media release on project	Survey Results Gross Margin developed.
6.	March/April 2006	WUE of siphon-less irrigation systems quantified	Draft Report
7.	May 2006 (pending ginned yield results)	Final Report	Report -
8.	May 2006 post final report.	Extension Activities *Case Studies & Field day*	Published Case studies Field Days
9.	June 2006	Project review.	Meeting

Output 1. Three trial Sites at St George, and 1 trial site at Boggabilla:

Co-operators include:

"Bullamon Plains" Thallon, Ed Willis.
"Anchorage" St George,
"Iona" St George, John Knights.
"Parkdale" Boggabilla, Wally Taylor.

Output 4/8. Field Walks and Field Days:

WUE Information Day
Goondiwindi, 31st January 2006 and St George, 1st February 2006.

The WUE Information day covered a range of topics including presentations on: Water use of bollgard compared to conventional varieties by James Neilson and Dirk Richards; Infiltration under a Lateral Move and Web based tools for scheduling irrigations for overhead irrigation systems by David Wigginton DPI NSW, Overview of Siphon-less irrigation Project and preliminary results by Sarah Hood SIS and Emma Carrigan DPI&F, Deep Drainage Trial Results by Des McGarry NR&M.

15 people participated in the Goondiwindi Information day, including 9 growers, 1 consultant and 5 extension staff.

30 people participated in the St George Information Day, including 20 growers, 5 industry associated people and 5 extension staff.

Balonne Big Day Out
St George, 21st February 2006.

Two on -site visits of the Siphon-less Irrigation project were included in the Balonne Big Day Out, the field day had 50 participants initially, which increased to 80 participants at Bullamon Plains with two bus loads arriving from Dirranbandi and Mungindi.

At Anchorage the presentations were on the Development and Design of the system by Glen Lyon and Trial Review of Bank-less Head Ditch and the Siphon-less Irrigation Project by Sarah Hood and Emma Carrigan.

Bullamon Plains manager, Von Warner discussed the labour efficiency associated with the Bank-less channel system, Sarah Hood and Emma Carrigan presented a trial review of the bank-less channel system in comparison to the furrow irrigated field and the Siphon-less Irrigation project.

Output 5/8 Media Release/Case Studies

Siphon-less Irrigation Project Presentations

- The Siphon-less Irrigation Project results were presented at the Gwydir Valley Irrigators Association 22nd May 2006

- Siphon-less Irrigation Project Information discussions delivered by Sarah hood and Emma Carrigan as part of the Cotton CRC Water Team - Trade Display at the Moree Trade Show 23rd and 24th May 2006

- The Siphon-less Irrigation Project results presented at the Cotton Catchment Communities CRC Science Day Monday 7th August 2006 Broadbeach Conference Centre

- The Siphon-less Irrigation Project results presented at the Australian Cotton Conference Wednesday 9th August 2006, 5:00pm – 5:15pm in the Planary Area 1 Broadbeach Conference Centre

4. Please describe any:-

a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);

b) other information developed from research (eg discoveries in methodology, equipment design, etc.); and

c) required changes to the Intellectual Property register.

Conclusion

5. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. What are the take home messages?

The likely impact of the project is that irrigators can now make an informed decision when developing or implementing a system change in regards to the WUE, labour savings and the costs of development of each system. The project has also impacted on irrigators by highlighting the importance of system optimisation or the measure to manage, regardless of system type.

- Preliminary data

- The siphon-less systems have performed in the ball park of the traditional furrow irrigation systems in terms of WUE indices (except the LM)

- Some of the systems have been partially optimised

- Further investigation is required to draw a direct comparison between all systems (especially in regards to LM)

- All siphon-less systems investigated provide an advantage in Labour costs and ease of labour….over traditional furrow irrigated systems

- Operating costs associated with supply and return of water were limiting for the BHD and BC were high flow rates required to combat issues with uniformity of advance

Extension Opportunities

6. Detail a plan for the activities or other steps that may be taken:

(a) to further develop or to exploit the project technology.

A project is underway to develop a software program to evaluate DU and Ae on a traverse slope, Michael Grabham (NSW DPI) is doing his PhD to investigate this.

(b) for the future presentation and dissemination of the project outcomes.

RWUE3 will build on the project outcomes delivered through the siphon-less irrigation project and further demonstration sites this season will also provide more information to disseminate to the Cotton Industry as it becomes available.

(c) for future research.

The demonstration needs to be replicated over a number of seasons to further validate the seasons data. This season 06/07 the project will run again at both the PTB site and the Lateral move, the other two sites do not have any water to irrigate but there is an opportunity to do a whole farm water balance at Bullamon Plains and for Anchorage an opportunity to investigate the WUE of their new Lateral Move. To value add to the project there will also be an opportunity to include drip irrigation with the establishment of a 5th demonstration site.

8. **A. List the publications arising from the research project and/or a publication plan. (NB: Where possible, please provide a copy of any publication/s)**

1. Siphon-less Irrigation Project media release published Australian Cotton Outlook, January Edition.

2. Balonne Big Day out media release published Balonne Beacon March, 2nd 2006, Border News Monday March, 20th 2006.

3. Bank-less has labour benefits published Border News Monday March, 20th 2006.

4. Which Irrigation System? published Australian Cotton Grower April-May 2006 edition.

5. Siphon-less irrigation Systems: So how did they perform? published Australian Cotton Grower June- July 2006 edition.

6. An over view of the Siphon-less Irrigation paper Australian Cotton Outlook coverage of the Australian cotton Conference published 10th August 2006.

*Other associated media on the Siphon-less Irrigation Project includes***:**

Siphon-less Irrigation Project in the CRDC Spotlight on Cotton Research in the Autumn Edition.

Cotton Seed Distributors CSD Web on Wednesday featuring Bank-less channel irrigation on Bullamon Plains, Siphon-less Irrigation Project.

Have you developed any online resources and what is the website address?
No.

Part 4 – Final Report Executive Summary

Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

Siphon-less Irrigation Project

Sarah Hood Sustainable Irrigation Systems
Emma Carrigan Department of Primary Industries and Fisheries

Australian irrigated cotton growers are committed to improving their Water Use Efficiency (WUE) for economic, environmental, social and political reasons (Breen et al, 2006). Furrow irrigation is the dominant irrigation system and is used by over

90% of the Australian irrigated cotton industry (Foley et al, 2001). Increased precision during furrow irrigation with siphons typically involves higher flow rates using larger or multiple siphons over shorter times then that observed across the industry (Purcell, 2004). Consequently, irrigators aiming to improve their WUE require further intensification of an already labour intensive system at a time when there is a dwindling labour force. As a result there has been an increased interest in less labour intensive irrigation systems.

The current commercial irrigation systems that do not require siphons employed throughout the Australian cotton industry include:

- Overhead (Lateral Move and Centre Pivot)
- Drip
- Pipes Through the Bank (PTB)
- Bank-less Channel and Bank-less Head Ditch.

Overhead and drip irrigation have been used for some time in order to combat the issues of limited water and labour (Raine et al 2002 and Foley et al 2001). PTB's have also been used as a less labour intensive furrow irrigated system. Bay irrigation, although quite prevalent in other industries (rice and pasture), has been used more recently by cotton irrigators with some modifications (Grabham et al, 2005). These bay irrigation systems were installed because they were expected to be less labour intensive and perform on par with current furrow irrigation systems in regards to WUE.

There are various amounts of data about the WUE of the alternatives and how they compare to traditional furrow irrigation (Raine et al, 2002). Even more importantly there is a lack of data about how these alternatives compare to a WUE furrow irrigated system and the potential for optimisation of each system (Raine et al, 2002). The siphon-less irrigation project was designed to address these knowledge gaps by using the same measurement method and the same WUE indices to assess the performance of each alternative system and an adjacent furrow irrigated field.

The Performance Indicators Used to Assess the Siphon-less Systems

The project was designed to measure the components required to assess the WUE of each system using several of the indices set out in WaterPAK (Table 1). These indices are related to water use, along with the application efficiency and uniformity of the irrigation applications. The WUE indicators are defined in Table 1 along with the Gross Margin to determine the dollar returned per Megalitre of applied irrigation water.

Table 1: WUE Indices Used to Assess the Performance of the Siphon-less Irrigation systems.

Water Use Efficiency Index	Acronym	Minimum Standard	Definition	Formulae	Relevant Sections in this Report	Relevant WaterPAK sections
Gross	GPWUI	>1.1	Yield per	= Yield÷	4.4	2.1

Production Water Use Index (bales/ML)			total water infiltrating the paddock including irrigation and effective rainfall	(Irrigation Water that Infiltrated the Field + Effective Rainfall)	Economic Returns 4.1.1 Irrigation Water Use 4.1.2 Rainfall	Assessing whole farm water use efficiency **NOTE Soil Moisture Used was not measured**
Application Efficiency (%)	E_a	>80	Percentage of water applied that is used by the crop.	= (Water used to refill the deficit) ÷ /(Water Delivered to the field – 85% of the tailwater volume)*100	4.2 Application Efficiency and Distribution Uniformity	As Above **NOTE 15% Tailwater losses are included to be consistent with all other industry data**
Distribution Uniformity (%)	DU	>90	Measure of how evenly the water is applied.	= (Average lowest 25% of infiltrated volumes) ÷ (Average of all infiltrated depths)	As Above	2.9
Gross Margin ($/ML)			Dollar value returned per Ml of Water applied to the crop	= ((Bales/Ha* $440) – (Total costs))/ Irrigation Water Applied ML/Ha	-	-

How did the Siphon-less Systems Measure up?

Each siphon-less system was compared to a corresponding Furrow Irrigated field located on the same farm to minimise impacts of environment and management.

Siphon-less vs Furrow	Yield Bales/Ha	Variety	GPWU Bales/Ml	Ae %	DU %	Labour %	Development Costs %	Gross Margin $/ML
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