Smarter Irrigation for Profit
PHASE II EVENT

St George Irrigation Field day
Tuesday 8th March 2022
Thuraggi Overflow

Optimisation and automation of surface irrigation focused on the siphon-less tailwater backup designs

Australian Government
Department of Agriculture, Water and the Environment

This project is supported by funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program.

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PHASE II EVENT

Part 2 of St George Cotton Management Field Day
Thuraggi Overflow
Tuesday 8th March 2022

Time	Topic	Presenters
9:45	Morning tea	
10:00	**Welcome to Siphon-less trial site**	Lou Gall (GVIA)
10:10	**Water Productivity**	Ben Crawley (NSW DPI)
10:25	**Overview of Thuraggi Overflow** • Why Saunders farming involved with on-farm research • Expectations and Learnings from Project	Craig Saunders (Saunders Farming)

10:35	**Panel Session**
	• Adoption of Tailwater backup systems
	• Automated irrigation and optimisation of surface irrigation
	  • Overview of tailwater backup systems
	  • Overview of siphon-less trial
	  • Automation of surface irrigation
	  • Optimisation of surface irrigation
		Facilitator: Lou Gall (GVIA)
		Panel Members:
		Lucas Wuersching (Saunders Farming)
		Glenn Lyon (GL Water Services)
		Andrew McKay (CottonInfo)
		Grant Oswald (Padman Stops)
		Malcolm Gillies (USQ CAE)

11:30	Trial site inspection	
12:00	St George irrigation tour	Glenn Lyon and Andrew Mckay
14:00	Travel home	

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Smarter Irrigation for Profit Phase 2 (SIP2) is a partnership between the irrigation industries of sugar, cotton, grains, dairy and rice, research organisations and farmer groups. It is supporting research into new technology, system designs, automation and water use efficiency.

Smarter Irrigation for Profit has demonstrated that improved water productivity hinged on 'Getting the Basics Right'. Improvements of 10-20 percent in farm profitability can be achieved through adoption of best practice and precision irrigation technologies.

SIP2 has 14 sub-projects covering three main components:

- Development of new irrigation technologies including new sensors, advanced analytics to improve irrigation scheduling and strategies to reduce water storage evaporation.
- Cost effective, practical automated irrigation systems for cotton, rice, sugar and dairy.
- Closing the irrigation productivity yield gap for cotton, rice, dairy, sugar and grains irrigators through a network of 46 farmer led optimised irrigation sites and key learning sites located on commercial farms across Australia.

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Trends and Drivers of Irrigated Cotton

NSW DPI, in partnership with the Cotton Research and Development Corporation, have been monitoring water productivity in irrigated cotton over the last decade and a half.

The objective of this work has been to facilitate continuous improvement in cotton water productivity and to identify the drivers of water productivity. The benchmark can also indicate how the industry is improving its performance and its sustainable use of the scarce water resource, nationally and internationally.

The research has previously shown an increase of 40% over a decade. Recent studies by the DPI team have shown a near 100% improvement over the last 25 years up to 2018 - a doubling of water productivity which is a fantastic result for the industry. This is presented in Figure 1.

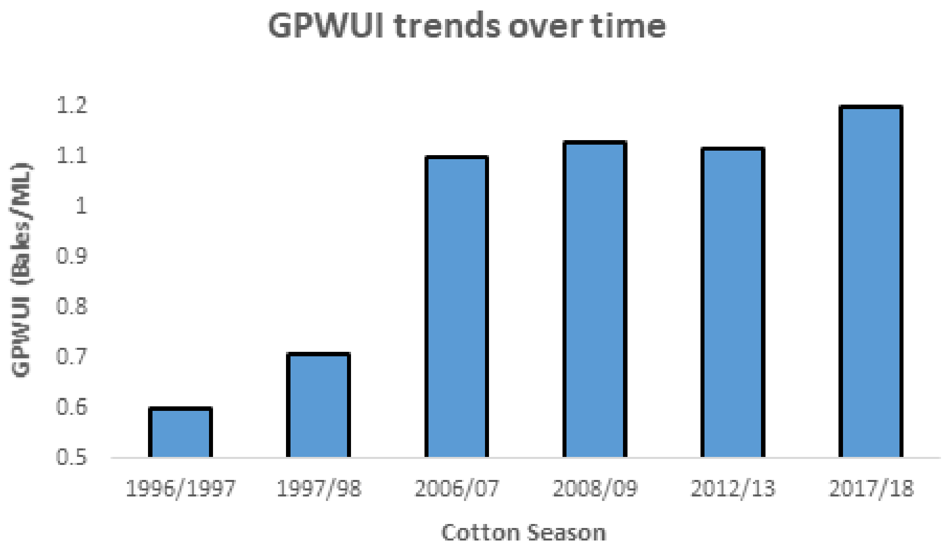

Figure 1 – Yield, irrigation water and rainfall

To calculate the water productivity a survey is used to collect data and is then input in the WaterTrack™ software developed by Jim Purcell from AquaTech consulting Narrabri. The total water used over the season is calculated by adding water metered on from bores/rivers, harvested water from runoff, effective rainfall, soil moisture and any water in storages before the start of the season. Any water left in the storages at the end of the season is then excluded. Effective rainfall is calculated using daily rainfall, soil type and irrigation dates to portion the amount of water that made into the root zone. The total yield is then divided by the total water to give the water productivity or the gross production water use index (GWPUI).

The project also involves breaking down where this total water went to look at efficiencies on farm. Firstly the, crop water use is estimated by using satellite technology to obtain growth factors for each field which is then modelled by the WaterTrack software which uses these growth factors and reference crop evapotranspiration to obtain the crop water use.

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Total Water = Water held in storages pre-season + Effective rain & rainfall on storage + Water harvested (rainfall run-off etc) + Metered Water (river & bore) + Soil moisture − Water left in storages − Water used on other crops

Next, the storage losses are calculated by again using satelites to estimate the wet surface area over the season which is then multiplied by daily evaporation and seepage rate to get a volumetric water loss over the season. Figure 2 outlines the wet surface area of a storage and fields traced to obtain growth factors. Losses from channels and drains are also estimated using a similar process. Finally, losses in the field are calculated by subtracting crop water use, storage and channel and drain losses from the total water.

Figure 2 – Screen shot of IrriSat displaying fields and storages (grey)

Results from our study showed crop water use was approximately 80% of the total water, with storage losses making up an average of 9%. Other previous studies have also shown average losses of 20 and 18%. The next biggest loss was in the field which was also 9%. Losses in the channel and drain made up approximately 2%.

Data from the 20-21 is now being processed with results expected in March-April for an updated estimate on water productivity.

For more Information Please contact:
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Optimised application in tailwater backup systems

1. What is the project about?

In recent years the industry has increased their adoption of bankless channel or siphon-less irrigation systems. This is driven by a need to address labour, energy, management and water use efficiency.

In most bankless channel or siphon-less designs, the field is split into bays and watered at a high flow rate. All furrows in a bay are irrigated at once without siphons or rotobucks.

The continuous reuse of tail water in adjacent bays can potentially reduce water loss from channels, reduce pumping costs and enhance efficiency of cultivation. Additionally, transitioning to a siphon-less design can enable higher flow rates through the field, this can minimise non uniformity and reduce deep drainage, but irrigations may be more frequent.

There has been limited research into the irrigation performance of these designs, but the irrigators who are utilising some of them have found improved irrigation water use efficiency, significant labour saving and management benefits.

Figure 1: Installing water advance sensors

Scan the QR code to listen to a short podcast on the trial

Scan the QR code to watch a short video on the trial

This short animation illustrates a bankless channel / tailwater backup irrigation system at work at the St George property Thuraggi Overflow. Over the 21/22 growing season, the CottonInfo team is running a trial at the property to assess the system, in partnership with the Gwydir Valley Irrigators Association (GVIA), NSW DPI, University of Southern Queensland, Padman Stops and Glenn Lyons.

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3. What are the benefits to Irrigators?

The collection of robust water measurements, will provide an indication of irrigation performance and water productivity for siphon-less irrigation systems. Growers will be able to use this to make more informed decisions around implementing siphon-less designs.

The project will demonstrate the use of sensors to automate irrigation systems and showcase technologies such as water meters, level sensors and water advance sensors available for growers to adopt.

The project will demonstrate the potential to save water and improved irrigation efficiencies through the optimisation of irrigation events.

2. What do you hope to achieve?

- Measure irrigation water use efficiency (IWUE) and Gross production water use efficiency (GPWUI) of a tailwater backup system. Strong, robust measurement will provide quantitative evidence.
- Demonstrate the fit and benefits of automation of a tailwater backup design.
- Measure water infiltration rate from head ditch to tail train in the tailwater backup siphon-less design and estimate the irrigation performance of the system.

Figure 2: Padman gates fitted with rubber inserts and autowinch sense.

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Overview of different siphon-less designs

Small PTB's – Permanent 75-90mm horizontal pipes are placed in the head ditch. The head ditch is split into sections, with each section filled from the supply channel behind by a gate fitted with automation. Rotobucks are still needed.

Large PTB's – Hand siphons are replaced by a large diameter gated pipe. The rotobuck area is excavated to create a distribution basin for the water to level out and enter all furrows. A 250mm diameter pipe will supply 12 furrows, while a 750mm pipe can supply 100 furrows. A large rotobuck is placed between each pipe outlet.

GL Bays – The existing siphon furrow direction is rotated 90 degrees. The new head ditch is below ground level and looking exactly like a tail drain. The head ditch fills and water enters the furrows. A check bank runs through the field to the tail drain, with the tail water backed up by closed off bay outlets. There is a 200mm drop between each section, allowing head ditch water and tail water to cascade from bay to bay.

Rollover Bays (Flat Bays with rollover banks or Furrows across bays with rollover banks) – The existing field or series of fields are cut up into level bays. Each level bay has a furrow length of 400m and width of 500m. This 20ha pond is filled with water from each end until the water meets in the middle. The tail water and new supply water is then drained into the next bay which is 150mm lower.

Siphon-less with Tailwater Backup – Hand siphons are replaced with a large PTB or single rubber door type bay outlet. The rotobuck area is excavated to create a distribution basin for the water to level out and enter all furrows. The rotobuck/check bank continues through the field to the module pad. A rubber door type bay outlet holds tail water in the section so it backs up the dry furrows.

Considerations for System Choice are?

Slope – If your field is steeper than 0.300%, (1:333) a siphon system must be used.

Flowrate – A supply rate of at least 24 ML/day is required for siphon-less systems.

Soil Characteristics – Soil with a very slow infiltration rate will limit your choices.

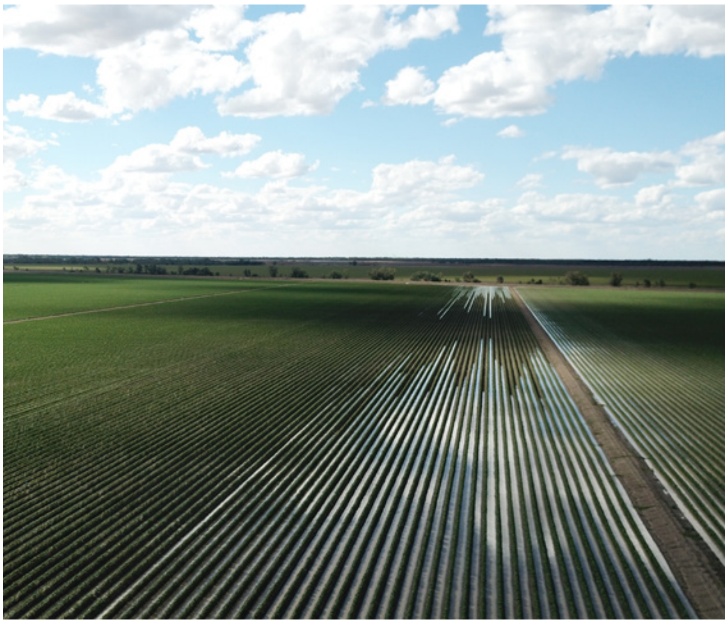
Topsoil – Minimise topsoil movement.

Cost – Rollover systems are more expensive to build.

Every field has unique features.

Tick as many boxes as possible in your 'Wish List', while not letting costs get out of control.

Talk with your designer about your 'Wish List' and your specific field and soil characteristics.



GL Water Services

Padman Stops infrastructure and automation

Infrastructure Field 5

- Padman Stops pipe end combo structure with:
- Pipe Ends (PE1000-1000) W2000mm x D1000mm Door
- 3 x MaxiFlow 1800 culverts
- 1000 Bubbler – Structure passing 90-110 ML/D flow
- D6 Multi Doors for Tail Water management and transfer. 2 Linked Doors W1800mm x D650mm (Total Door Width 3600mm)
- PE1000 tail water return structures. W2000mm x D750mm door
- Also at T/O you will see the new D10 Door with w3000mm door. Along with new door opening technology to replace cables on Bay 8 called the Geardrive. This Tech offers a positive displacement of the Door and isn't affected by trash.

Farm Automation and Sensing

Aims for Automation of an Irrigation System

- Soil moisture and scheduling data provides triggers on when to irrigate.
- In irrigation event triggering of water change over via both water advance and water depth sensors.

Automation at T/O

- Head Ditch control via Autowinch Seasonal attached to the PE1000-1000. Provides options of control via App, by time schedule, by triggering from the external independent sensor at preset thresholds.
- Tail Water Backup structures via the Autowinch Sense attached to the D6 multi structures. With attached water level sensors provide constant farmer feedback on the progress of Irrigation.
- Sensor Pro monitors head ditch water height and alerts to unexpected water heights
- The Irrigation manager uses an IPAD to monitor and control the status of devices via the Padman Webapp portal and receives critical alerts via the Padman Mobile App.
- Field 5 total capital cost of $180 HA for farm irrigation automation.
- $15/ha ongoing per year cost for connectivity, apps and maintenance of devices.

Padman STOPS
The FARMERS Friend

Drivers for return on investment (ROI) for automation

1. Water use efficiency (WUE). Automation enables the irrigation manager the opportunity to execute critical events with timeliness for optimised precision irrigation with the following potential benefits:

- Lower deep drainage losses, which research has shown to average 12% water loss. Which could be the equivalent of an extra irrigation = Less whole of system water used per hectare.
- Reduce leaching of nutrients from soils – More nutrient available to plants = more yield per hectare and more yield per ML.
- Roots underwater for less time means more growing time = more yield per hectare and more yield from less water.

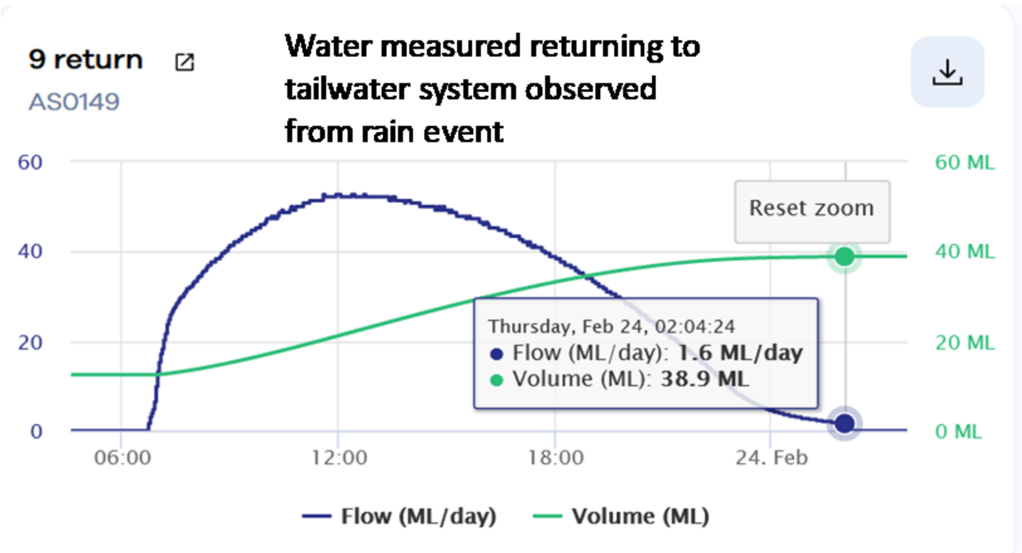
2. Labour and Human Resources gains.

- Reduction in required labour in paddock of approx. 85% - Live examples of irrigators spending 20 hours in travel and labour to perform changeovers per irrigation event and reducing that to three hours. Saving 17 hours work per irrigation event
- Automation allows smart irrigation managers to be making more of the critical decisions that leverage's smart labour on farms better.
- Critical farm staff not being distracted by checking irrigation at times when other time-critical farm operations are in progress. (Spraying / harvesting etc)
- Reduction in human resource risk and overheads.
- Reduction in safety risk with less staff hours being performed during the night and during rain events.

Irrigation Trial Automation and Sensing

As part of collating information for analysis, Padman Automation provided Sensing and logging devices.

- 25x infield water advance sensors
- 3x waterflow loggers to measure flow through the head ditch structures
- 1x Logger to Siemans Water Meter
- 1x tailwater return water flow solution
- 2x infield soil moisture measurements via watermark soil tension sensors

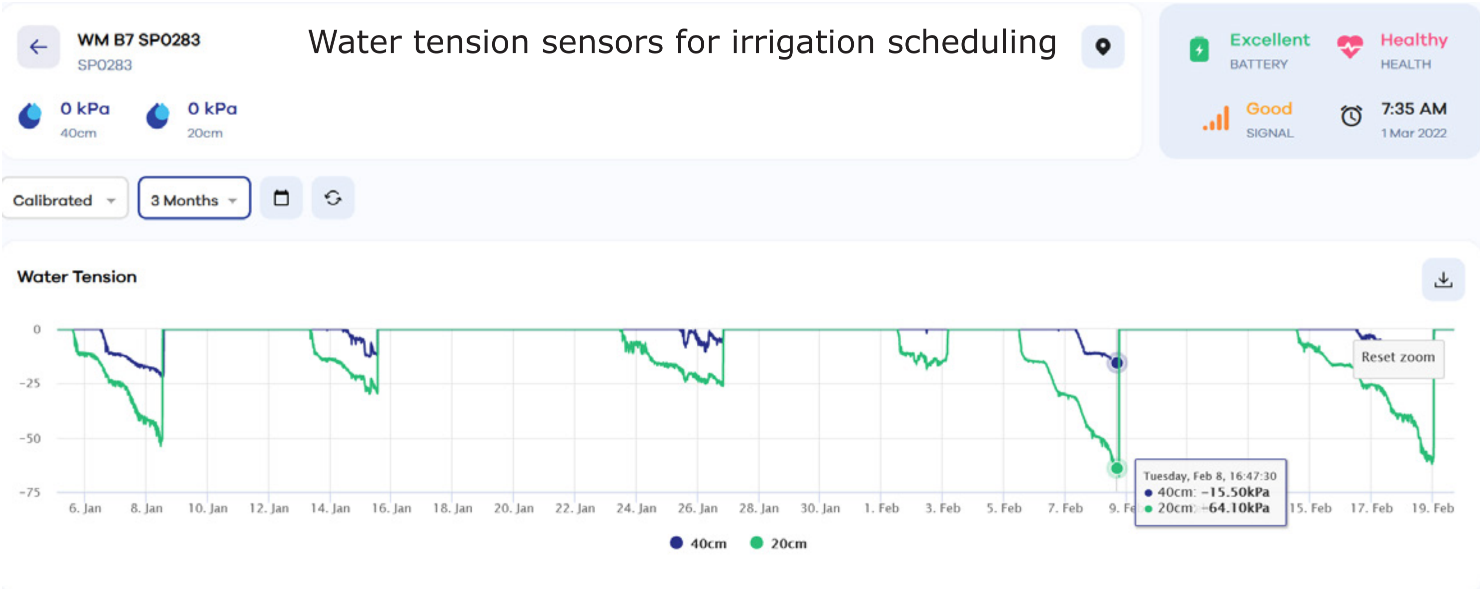


All of this information is displayed via a customized dashboard that enables the download of data in CSV format for further analysis.

Water tension sensors were installed to see how they compare to capacitance probes. The advantages of these sensors include

- Low cost to install and maintain
- No calibration is required
- Readings do not drift from year to year

The readings below show that irrigation events all happened before cotton reached moisture stress points



Key Questions

1. How much is your water worth per ML?
2. How many ML would your farm need to save per hectare to achieve a high ROI from a $180/ha capital investment in automation?

Key points to consider when looking at automation

- Be wary about installing/designing full blown automation in new bankless layouts before doing a manual irrigation. Economical portable time-based automation available to assist initial irrigation are available whilst assessing full automation design.
- Understand what optimised irrigation is for your layout, soil types etc when considering designing a new automation system.
- Ensure thorough consultation with automation company in design process when considering full autonomous automation systems.
- Assess the automation companies' ability to understand the design requirements for your system, flexibility to implement system and then provide support and back up for the system ongoing.

Smarter Irrigation for Profit
PHASE II EVENT

SISCO optimisation of surface irrigation

1: What is optimised surface irrigation?

Optimised surface irrigation is controlled surface irrigation in which active irrigation management aims to replace the target soil water deficit measured prior to the irrigation.

This involves setting a target irrigation application depth based on water used by crop evapotranspiration or other objective measurements systems that deliver information about the soil water deficit.

Scan the QR code to watch the SISCO videos.

Optimised surface irrigation can occur where-ever an understanding of irrigation inflow rates into furrows or bays can be measured, and the corresponding irrigation water advance times down the field can be captured during the irrigation event.

The SISCOweb processes available today determine the infiltration curve for the field during the irrigation event, and then optimise for the best time to cut-off the irrigation water supply into the field. This can be delivered as a scheduled closure time on an automation gate, or via an SMS to growers managing the irrigation.

2: Is it only for siphons/SPTB or can we fit it to siphon-less designs?

This process has been successful in siphon fields and sPTB layouts, and is being trialled in siphon-less systems such as bankless designs.

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3: How do we collect information to develop infiltration characteristics for the field?

Irrigation water advance rates are captured by simple advance sensors, and inflows through sPTB and siphon systems are calculated from the head of water operating on the siphon.

4: How can farmers use this information to improve Water Use Efficiency in the field?

When the applied depth of water matches the measured soil water deficit, excessive tail water pumping is reduced and deep drainage through the bottom of the root zone is minimised to maximise field application efficiency.

5: Key results to date

Siphon and sPTB (75mm straight pipes) trials have been successful across multiple farms using SISCOweb processes and advance sensors to understand irrigation performance, and optimise events and actuate remote controlled gates to manage irrigation events. Trials on the bankless irrigation site are on-going, and capturing furrow flowrate for use in the analysis and optimisation of bankless irrigation continue to be challenging.

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CASE STUDY: THURAGGI OVERFLOW

Thuraggi Overflow

Owner:	Craig Saunders
Farms:	Thuraggi Overflow
Irrigation Area:	520ha (210ha PTB, 310ha Siphon-less)
Water Source:	Balonne River

Siphon-less with tail water backup

The siphon-less flood irrigation systems have been designed around the inherent features of the fields. Thuraggi Overflow Field 5 is a siphon-less system which has been fitted to a field with minimal cross fall. Water is delivered to each of the nine bays via Padman Bubbler outlets with one per bay. It incorporates tail drain structures enabling the backup of tail water from the bottom of each bay. Tail water is about 10%.

Key Questions:

How did you determine what design to install?

The design was determined in conjunction with an irrigation designer. The farm irrigation systems have evolved from conventional siphons, through-the-bank pipes and overhead (pivot) irrigation. Bankless and or siphon-less designs were determined to be next step to improve water efficiency.

Thuraggi Overflow Field 5 was a new development where we had bankless in mind when we started the development process. Four design variants were considered before settling on this one. The development was worked to an earthwork budget.

System at a glance:

SITE	SIPHON-LESS SYSTEM WITH TAIL WATER RE-USE
Soil type	Self mulching clay with areas of sand
System type	Siphon-less with Tail water backup
Field size (ha)	270ha
Row length (m)	1,200m
Number of bays	9
Bay width	240m
Field slope	Bulk of field in range 0.019 to 0.050%. (1:5263 to 1:2000) Two bays are 0.115 and 0.12% (1:870 and 1:833) at the top flattening to 0.02% (1:5000) at bottom.
Bay slope	Not significant
Cut/Fill	370m^3/ha for in-field earthworks
Supply flow rate (ML/day)	90ML/day (up to 110ML/day)
Structures installed	1 x Padman 1000 bubbler with 1800 maxiflow pipe/bay on supply, 2 x 1.8m Padman Stops/bay in tail drain. 1 x 0.9m Padman stop between head ditch bays.
Steps between bays (mm)	Various – minimal
Time to irrigate bay (Hrs)	6 – 8 hours
Previous field set up	NA – new development
Sensors installed	C-probe
Cost ($/Ha)	$2,000/ha
Automation	Nil at present – timers for winches planned
Average yield bales/Ha	Not yet harvested (1st crop)
Average water use ML/ha	Less than PTB's

CASE STUDY: THURAGGI OVERFLOW

Did you use a consultant or a design engineer? What role did they perform?

Glenn Lyons designed the systems to fit targeted field whilst using existing parameters such as pump capacities, flow rates and desired watering times. Glenn surveyed the field to collect elevation data, then developed the design to fit to a budget that minimised the amount of topsoil moved while still focusing on achieving the desired outcome.

Why did you move away from siphon irrigation and what have you found following the change?

Labour / Lifestyle: Labour was not a motivation, but the changes are expected to achieve a 50% labour saving from pipe through bank (PTB) systems. This is the first crop this season, so we are not clear yet what the saving will be. However, following the implementation of automation we estimate that labour savings could be as high as 70%.

Energy: There was expected to be a 50% saving in fuel due to less tail water, but this could be even higher. During the December watering, the recirculation pump only ran for half a day at the end of watering to drain the field and empty the tail water drain.

Water: Improving water use efficiency was the main driver for installing a siphon-less design.

“There is far more to the hybrid system (Siphon-less with tail water backup) than you think, so many spin-offs from improved efficiencies and water management – it’s a game changer.”

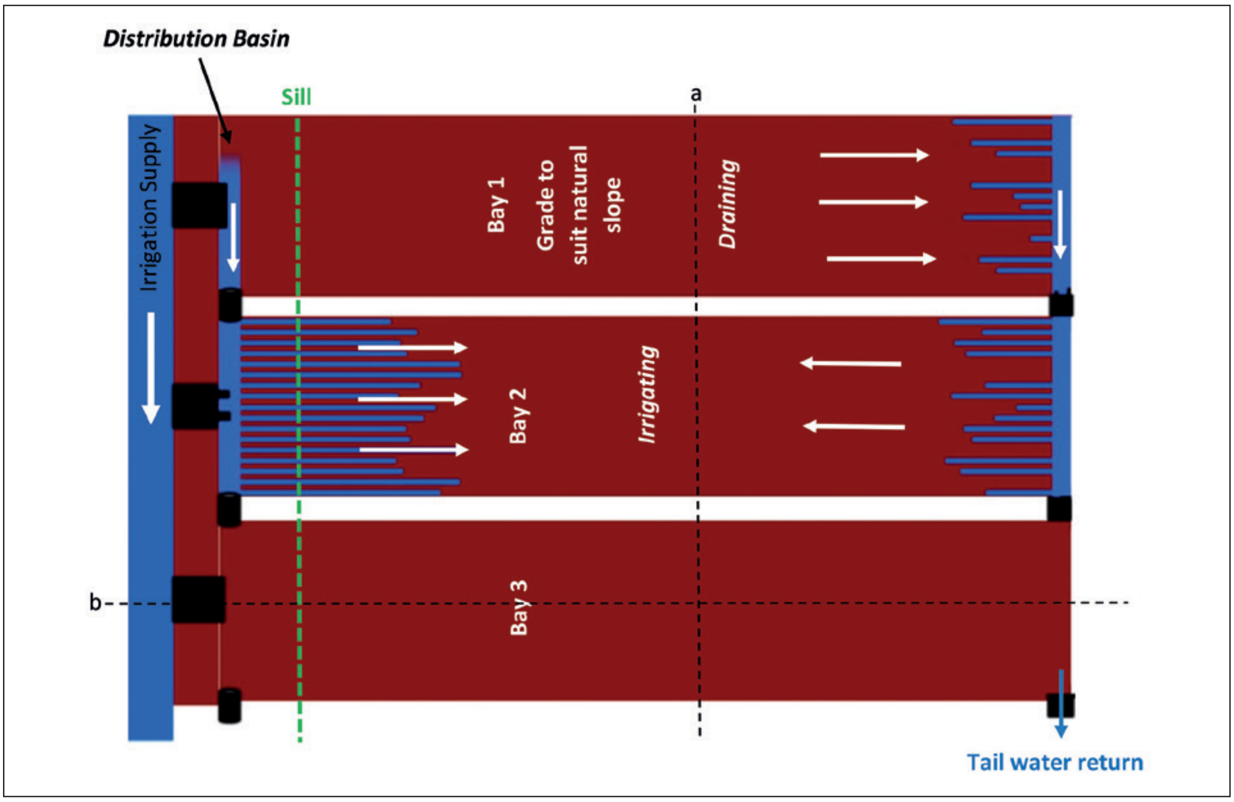
Productivity: Productivity gains are expected to be linked to labour saving, about 50%, these staff are now available for other operations. There are no siphons to deal with, no rotobucks to put in and plough out between field operations and irrigations.

What worked well?

Water savings: High flow capacity has led to reduced water run time and has saved water.

What didn’t work well or was difficult to implement?

The head ditch water drain time is slow. Having 1.8m wide doors between the distribution bays would result in even more water being re-used in the field rather than



Plan View.

going to the recycling system. Structures in tail drain need to operate in both directions which they are not designed to (but can) do – not clear how they can automate this process at reasonable cost. Structure suppliers need to manufacture two-way doors.

What would you do differently from a design or infrastructure perspective?

Install wider Padman stops between head ditch distribution bays.

Have you seen any issues with tail water management or drainage?

The structures in tail drain allow tail water to be backed up furrows in bay to meet water coming from head ditch. This ability has improved irrigation times. As we gain experience with the system, improved timing of the irrigation shut off will reduce the irrigation time even more and further reduce tail water.

What might you consider going forward?

Automation: Winch timers are being installed.
Additional sensors: Trip doors on tail drain structures.
Other: Dispersion vanes have been fitted on Padman bubbler outlets to eliminate swirling of water and resultant erosion.

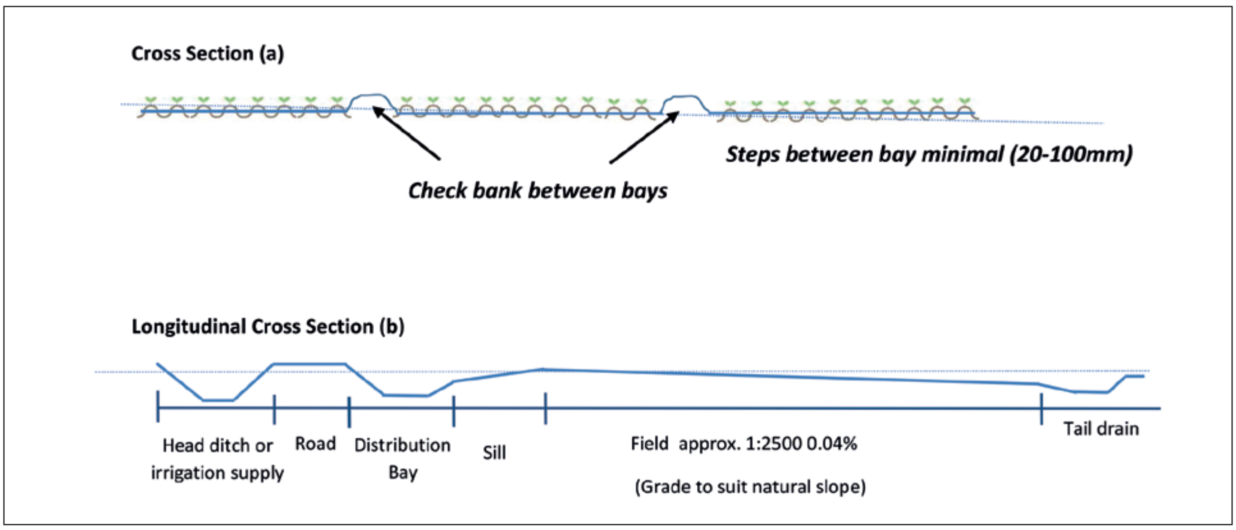
Description of watering Thuraggi Overflow F5

This 270ha siphon-less development consists of 9 bays. The gates have a flow capacity of 90ML/day (upto 110ML/day) which will water 216 furrows per bay. Field length is 1200m. Steps between bays are minimal.

Referring to the plan view, water moves from the head ditch into the distribution basin through a Padman Bay Outlet which have been fitted with dispersion vanes

Figure 1: Padman Bay Outlet fitted with dispersion vanes.

to eliminate swirling of water and resultant erosion. The distribution basin fills and overflows into the furrows where the water flows up a short (30m) reverse grade to a sill to help even flow, then flows down the furrows to the end of the field (field slope around 0.04% or 1:2500, natural grade of the field). Padman Bay Outlets are installed in the tail drain to enable the tail water to back up into the field. Once the field is watered, the gates in the tail drain are opened and water moves into the next bay, fills the tail drain at the end of bay 2, then backs up into the field. At the head ditch end, the next the gate is also opened into the next bay and water flows into bay 2. Therefore bay 2 is watered from both ends. Similarly, once bay 2 is watered, the bay outlets are opened and the next bay is irrigated.



CASE STUDY: ANDERSONS BLOCK, ST GEORGE

Andersons Block, St George

Owner: Rob Jakins

Irrigation Area: 122ha siphon-less irrigation, 500ha siphon irrigation

Water Source: Balonne river

Siphon-less with Tail water Backup

A siphon-less flood irrigation system designed to re-use and minimise tail water. Developed to replace three siphon irrigation fields. In the new development, two fields are at right angles to the original field, the third one runs the same direction as the original field.

Key Questions:

How did you determine what design to install?

Worked with design consultant to convert three fields to one with the aim to improve ease of watering, working and tail water management.

Did you use a consultant or a design engineer? What role did they perform?

Our consultant collected survey data and designed the field with minimal movement of soil required. It was important to work to fit the design into existing field levels as best as possible.

Why did you move away from siphon irrigation and what have you found following the change?

We were looking to achieve faster irrigation times and to reduce tail water pumping

Labour/lifestyle: There have not been any labour savings directly as new system has time requirements elsewhere. The lifestyle of our irrigators has improved.

System at a glance:

SITE	FIELD 1 – ANDERSONS
Soil type	Self-mulching grey clay with areas of red loam
System type	Siphon-less with Tail water Backup
Field size (ha)	105ha
Row length (m)	450m to 800m
Number of bays	10
Bay width	144m (Bay 2 168m to get to corner) – 144m divisible by machine widths (4, 6, 8 & 12m)
Field slope	Mostly 0.035-0.04% (1:3850 or 1:2500)
Bay slope	Minor
Cut/Fill	approx. 20,000m^3 moved. 208m^3/ha
Supply flow rate (ML/day)	Designed for 40-50ML/day
Structures installed	Head ditch – Padman E8 & D6L bay outlets Tail drain – Padman outlets
Steps between bays (mm)	Variable but minor 30 to 70mm
Time to irrigate bay (Hrs)	Up to 9 hrs
Previous field set up	3 fields – 2 perpendicular and one parallel, siphon over bank
Sensors installed	Nil at present. Moisture probe to go in
Cost ($/Ha)	$1,200
Automation	None
Average yield bales/Ha	First crop
Average water use ML/ha	

CASE STUDY: ANDERSONS BLOCK, ST GEORGE

Energy: The main saving has been associated with fuel saving from pumping less tail water.

Water: The siphon-less has been faster to irrigate, so there have been time and water efficiency gains. Under the old system it took 60 hrs to irrigated the area, now we do it in 36 hrs.

Productivity: There may be some productivity gains

What worked well?

The Design worked out well with accurate levels and the volume of dirt we had to move was acceptable (20,000m^3).

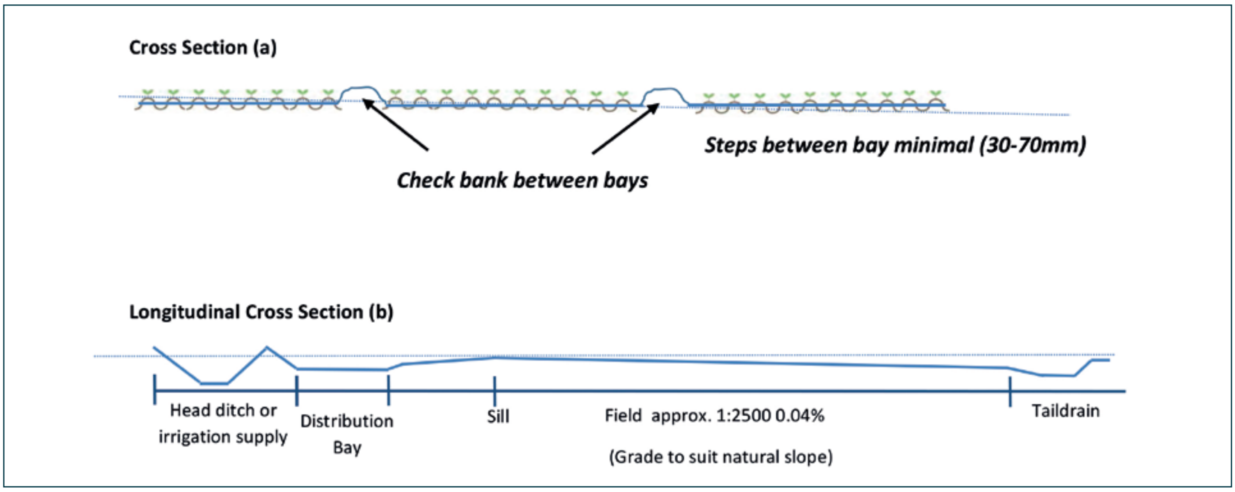
What didn't work well or was difficult to implement?

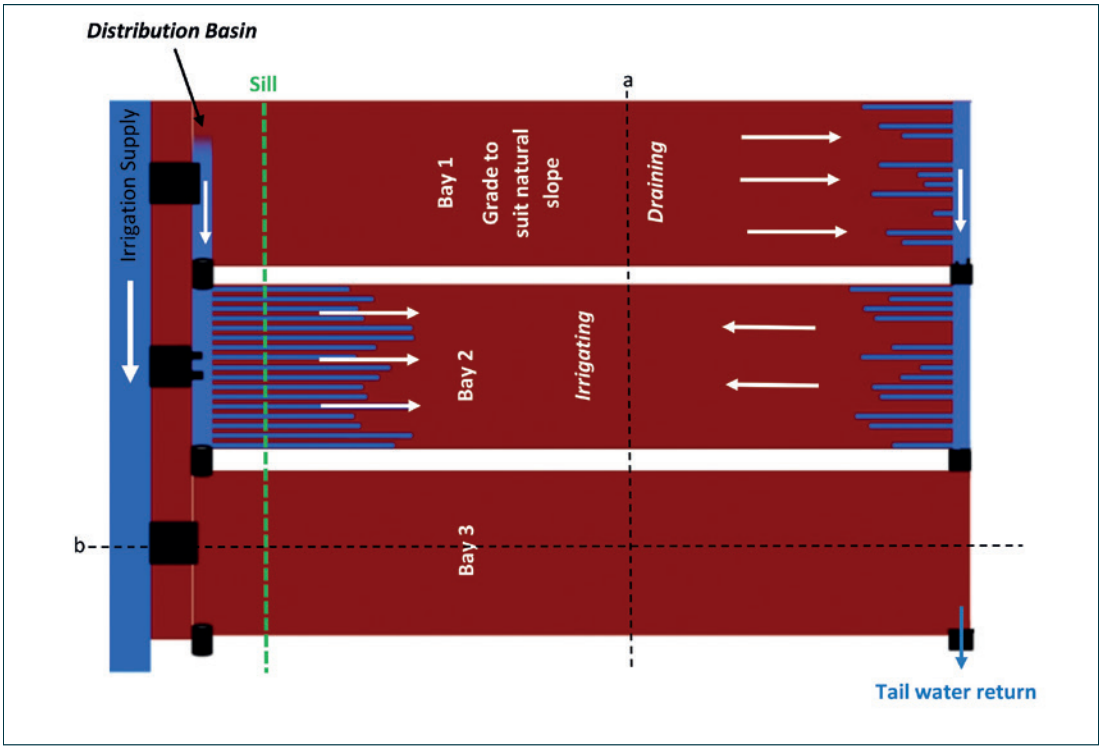
Initially there was some wash out of beds in front of bay outlets, caused by soft beds (not stabilised) and too great a water volume. The head ditch (rotobuck) area has since been widened.

What would you do differently from a design or infrastructure perspective?

Adjust the channel base height so it is a maximum of 150mm above base of head ditch, this would help to avoid water momentum build up that we have seen when releasing water into the bays, could maybe use a deeper outlet position, say 800mm instead of 600mm.

Would increase diameter of pipe between head ditch





ABOVE: Cross section.

LEFT: Plan View.

CASE STUDY: ANDERSONS BLOCK, ST GEORGE

bays to 300mmm, so that drainage is faster.

Have you seen any issues with tail water management or drainage?

No issues have been seen with tail water, to avoid water backing up the field too quickly, the height of the tail drain outlet is being set lower, at about 100mm below top of hill at tail drain end.

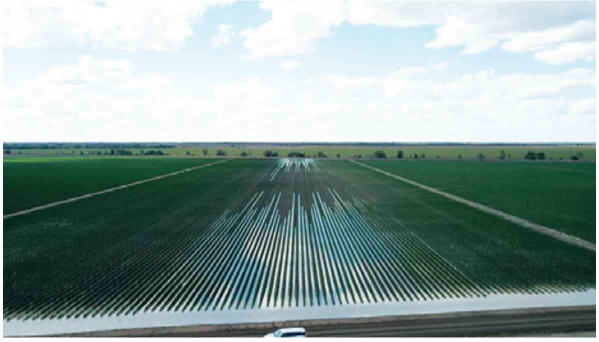
What might you consider going forward?

Automation: Yes
Additional sensors: Yes

Description of watering F1 Andersons

This 105ha siphon-less development consists of 10 bays. The gates have a flow capacity of 40-50ML/day which will water 144 furrows per bay. Bay length varies but maximum length in this field is 800m.

Referring to the plan view, water moves from the head ditch into the distribution basin through a Padman Bay Outlet (Figure 1). The distribution basin fills and overflows into the furrows where the water flows up a short (30m) reverse grade to a sill to help even flow, then flows down the furrows to the end of the field (field slope around 0.04% or 1:2500, natural grade of the field). Padman Bay Outlets are installed in the tail drain to enable the tail water to back up into the field. Once the field is watered, the gates in the tail drain are opened and water moves into the next bay, fills the tail drain at the end of bay 2, then backs up into the field. At the head ditch end, the next the gate is also opened into the next bay and water flows into bay 2. Therefore bay 2 is watered from both ends. Similarly, once bay 2 is watered, the bay outlets are opened and the next bay is irrigated.



Tail drain view of water advance from both ends.

"This modified bankless design ticks a number of boxes – minimal cut/fill, minimal tail waters, decreased pumping and faster irrigation times"

Figure 1: Padman Bay Outlet.

Automated broad-acre irrigation with small Pipe Through Bank (sPTB)

KEY MESSAGES

- Compared to manual siphon irrigation systems, automated small pipe through bank (sPTB) reduces labour inputs and costs.
- **Investment in automated sPTB was found to generate a NPV of $364/ha when compared to manual siphon irrigation.**
- Up-front investment costs can be heavily influenced by individual farm characteristics and could range from $500/ha to $1000/ha.
- The seasonal net benefits of $153/ha were driven by irrigation labour savings of up to 85%.
- In years of low water allocation there may be insufficient irrigation water to fully use the sPTB area, leading to reduced return on investment.

ABOUT THE RESEARCH

As part of the ***Smarter Irrigation for Profit Phase 1*** (SIP1) project the National Centre for Engineering in Agriculture at the University of Southern Queensland (USQ) completed successful trials of a blind head-ditch and small pipe through bank (sPTB) irrigation system at “Red Mill” near Moree, NSW, and supported early adoption of the technology at “Waverley” near Wee Waa, NSW.

The trials highlighted the potential benefits related to commercially available sPTB systems, including:

- Reduced labour requirements in starting and stopping siphons and monitoring water levels.
- Remote control of furrow irrigations from an office computer, smartphone or tablet.
- Remote monitoring of water levels in channels and ditches, with alerts based on level.

ANALYSIS OF FARM LEVEL COSTS AND BENEFITS

Drawing on the USQ SIP1 outputs and other cotton industry research and data, this case study presents an economic analysis of converting a 1m spaced manual siphon irrigation system to automated sPTB. Solid configuration cotton is produced in a two-year rotation with dryland winter crops. The analysis applied discounted cashflows to compare the costs and benefits of the investment using a 5% discount rate[1] over 25 years. The results are summarised in Figure 1 and Table 1.

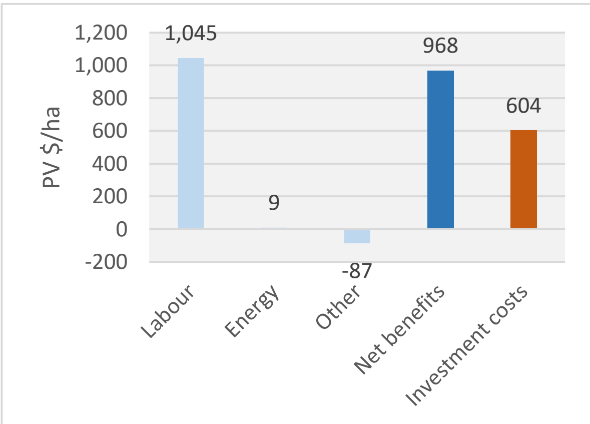


Figure 1. sPTB present value of benefits and costs.

With an upfront cost of $604/ha and net benefits of $968/ha over 25 years, investment in automated sPTB with a blind head-ditch was found to generate a net present value (NPV) of $364/ha.

[1] Discounted cashflows reflects the time value of money, where $1 today is worth more than $1 in the future. To make all figures comparable, future cashflows are discounted to “present values” using a “discount rate” (here 5%) reflecting the business cost of capital.

Table 1. Summary of results. Total change is in present value (PV) terms using a 5% discount rate and 90% investment use efficiency over 25 years.

	Manual siphon	Blind head-ditch sPTB	Seasonal benefit ($/ha)	Total change ($/ha)
Irrigation labour costs ($/ha)	$192	$27	+$165	+$1,045
Irrigation energy (vehicle fuel) costs ($/ha)	$2	$0	+$1	+$9
Other operational costs ($/ha)		$14	-$14	-$87
A. Net Benefits ($/ha)			+$153	+$968
B. Investment cost ($/ha)		$604		-$604
Net Present Value (A-B)				**+$364**
Internal rate of return				**10%**
Payback period				**12 years**

Investment costs. The up-front cost of $604/ha included the following items[2]:

- Head-ditch re-design with blind-head ditch.
- sPTB every 2nd furrow.
- Box culvert sealed rubber lay-flat gates.
- Remote gate actuators.
- Water level sensors in channels & head-ditches.

Cost per hectare can be influenced by field dimensions and total area developed. In addition, individual farm characteristics may negate the need for a blind head-ditch, and gate actuators and water sensors can be moved each season, reducing the whole farm sPTB cost.

Depending on the farm, the up-front cost may vary from $500/ha to $1000/ha.

In this analysis, a cost below $945/ha is required to generate an NPV greater than zero. Of note, individual investor hurdle rates will likely require an NPV above zero.

Labour use changes. As the main driver of the economic benefits, changes in the achieved labour savings have a large impact on the results. Avoided labour includes throwing and collecting siphons, starting and stopping siphons, and monitoring channel water levels.

By allowing the remote control of irrigations, automated sPTB can reduce labour requirements by up to 85% compared to manual siphon systems[3].

Irrigation labour costs in a manual siphon system vary depending on the farm characteristics, with estimations varying from $134/ha/season[4] to $250/ha/season[5]. This analysis used a mid-point of $192/ha/season with 85% labour savings therefore equal to $165/ha/season. Seasonal labour savings of at least $107/ha/season are required to generate a positive return in this analysis. While not included in the results, other labour and lifestyle factors such as reduced reliance on casual staff, reduced human error, and improved work-life-balance have also been identified as drivers for adoption of automated irrigation systems such as sPTB.

Water availability. The ability to derive a return from the investment is tied to water availability.

In years of low availability there may be insufficient irrigation water to fully use the land developed to sPTB, leading to reduced return on investment.

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[2] Foley, J., 2018, *Smarter Irrigation for Profit Phase 1—Autonomous Furrow Irrigation with small Pipe Through Bank (sPTB)*. Modified in discussion with J. Foley Nov-Dec 2020.

[3] Roth, G. et al, 2018, *Smarter Irrigation for Profit Phase 1—Final Report combined.*

[4] Gall, L, 2016, *Grower Led Irrigation System Comparison in The Gwydir Valley, CRDC1606 Technical Research Report*.

[5] Roth, G. et al, 2018, op cit; and Farquharson R., Welsh J., 2017, *The Economics and Perspectives of Site Specific Irrigation Management*.

The analysis used a baseline figure of 90% investment use, equivalent to 1 year in 10 of zero water availability. In comparison, the 10 year average general security allocation in NSW cotton growing regions was 73%, ranging from 64% to 90%[6]. Where available, bore water use may offset a low river water allocation. For this analysis, an average investment use of 57% over the life of investment is required to generate an NPV greater than zero.

Energy and other operational costs. Energy costs related to irrigation vehicle use, including starting and stopping siphons, and checking water levels. Other operational costs associated with sPTB include maintenance costs and foregone profits from the part of the field converted to a blind head-ditch. Maintenance costs were estimated at 1% of capital costs per year[7], equal to $6/ha/yr. Foregone profits were valued at the gross margin per hectare of the rotation crops (cotton and dryland wheat)[8], with an average loss of $8/yr for every ha developed to sPTB.

Smart automation. While not included in this case study, research of automated sPTB has identified the potential for system optimisation by integrating in-field sensors and advanced crop and irrigation modelling such as VARIwise and IrriMATE to work synchronously with the sPTB system. By leveraging the benefits of an automated system, optimisation or "smart automation" can autonomously control irrigation changes in line with plant water requirements. Smart automation has the potential yield increases of 10% and water savings of 15% in fully irrigated cotton[9]. Improved water application efficiency can also reduce fertilizer loss from leaching and denitrification, and thereby support reduced fertilizer application rates and greenhouse gas emissions.

CONCLUSIONS

While converting manual siphon irrigation to sPTB can represent a large upfront investment, this analysis has shown that the costs can be outweighed by operational savings particularly relating to irrigation labour. Drawing on the USQ SIP1 research and other industry research and data, this analysis has identified an NPV of $364/ha over 25 years, equal to an internal rate of return of 10%. When considering investment in sPTB, producers should undertake individual farm analysis and consider specific farm and market dynamics.

Smarter Irrigation for Profit Phases I (SIP1) was led by the Cotton Research and Development Corporation (CRDC) in conjunction with Dairy Australia, Agrifutures, Sugar Research Australia. SIP1 was supported by funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program. For information on the SIP1 research, including the USQ project underlying this analysis, visit https://www.crdc.com.au/smarter-irrigation-phase-1.

For more information on the SIP2 visit https://smarterirrigation.com.au/.

For more information on this economic analysis, please contact George Revell, Principal Economist at Ag Econ, through george@agecon.com.au.

[6] NSW Gov, *Water allocations Dashboard*
[7] Farquharson R., Wesh J., 2017, op cit.
[8] Powell J. et al, 2019, *Furrow Irrigated Cotton Gross Margin*; and NSW DPI, 2012, *Winter crop gross margin budgets, Dryland north-west*
[9] Gall, L, 2020, *Benchmark Manual vs Automated Siphon Efficiencies, Smarter Irrigation for Profit Phase 2.*

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This project is supported by funding from the Australian Government Department of Agriculture, Water and the Environment as part of its Rural R&D for Profit program.

Notes

References and Links

Smarter Irrigation for Profit:
- https://smarterirrigation.com.au/
- https://smarterirrigation.com.au/malcolm-gillies-and-joseph-foley-from-usq-talk-about-sisco-at-the-gvia-field-day/
-
- https://smarterirrigation.com.au/st-george-bankless-channel-podcast/
- https://smarterirrigation.com.au/ial-icid-webinar-addressing-the-global-water-challenge-through-autonomous-irrigation/
- https://smarterirrigation.com.au/andrew-greste-talks-about-precise-real-time-automated-cotton-and-dairy-irrigation-for-improved-water-productivity/
- https://smarterirrigation.com.au/joseph-foley-talks-about-automation-of-large-scale-irrigation/

CRDC:
- https://www.crdc.com.au/smarter-irrigation-phase-2

CottonInfo:
- Bankless Optimisation Trial: https://youtu.be/D5GCtCcj304
- Optimising Furrow Irrigation with SISCO: https://youtu.be/-saHo7ZdQhY
- https://cottoninfo.com.au/water-management

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