Siphon-less Irrigation
Field Day February 2019

Irrigation Australia Membership

Irrigation Australia Ltd (IAL) was founded in 2007, following the merger of ANCID and Irrigation Association Australia. It is Australia's peak national organisation representing the Australian irrigation industry in all sectors from water users, consultants, designers and installers through to educational institutions, government, manufacturers and retailers. Irrigation Australia is a Registered Training Organisation – RTO 91313. IAL is also the Australian representative body of the International Commission on Irrigation and Drainage (ICID)

Membership is categorised by 'market sector', which allows you to select the category that best describes your business. For further information follow the link: www.irrigationaustralia.com.au

Base membership includes:

- Four copies of the Irrigation Journal.
- Copy of a new Irrigation Directory providing a list of our member Irrigation Dealers, Certified Irrigation Designers, Certified Irrigation Professionals and Consultants and their contact details
- Discounts for you and your staff to attend Irrigation Training provided by Irrigation Australia.
- Discounts on the cost of Certification Programs provided by Irrigation Australia
- Discounts on attending (delegate) or exhibiting at Irrigation Australia conferences and tradeshows
- Access to member-only portal on the Irrigation Australia website and our library of documents including Irrigation System Design Guidelines
- New eKnowledge area on our website providing members with access to our vast range of technical, research and conference papers in our electronic library and FAQ's – just type in a keyword or author in the search field to display topics.
- Discounts on publications and merchandise

The siphon-less irrigation field day is supported by:

IRRIGATION AUSTRALIA
GVIA
NSW SUSTAINING THE BASIN Irrigated farm modernisation
CRDC
CottonInfo
NSW Local Land Services
NSW Department of Primary Industries
AQUA Smart Water
University of Southern Queensland

The Australian Government is providing more than $13 billion for implementation of the Murray-Darling Basin Plan and associated activities, with the vast majority (more than $8 billion) being made available for modernising infrastructure and water efficiency improvements. The Sustaining the Basin Irrigated Farm Modernisation Program is funded through the Australian Government's Sustainable Rural Water Use and Infrastructure Program.

PROGRAM

6th February 2019

Bankless Field Day

COMPONENT	PRESENTER
Welcome	George Truman, NWIAL
Background ■ What we know and what we don't know about bankless and its performance? ■ What research has occurred?	Malcolm Gillies, USQ Sam North, NSW DPI
Experience of Growers and Designers ■ Design ■ Drivers for change and costs involved ■ What worked well and what did not work ■ How has it performed	Harry Cush "Deer Park" Tom Cush "Avymore" Designer Bernie Martin Richard Wright "Woodvale" Rob Jakins "Anderson's Block" Designer Glenn Lyons Brett Corish "Mundine" Designer Peter Leeson
Morning Tea	
Investment Decisions	Phil Alchin, Jono Hart, Boyce Chartered Accountants, Moree
Developing design recommendations for basin (bankless) irrigation systems	Sam North, NSW DPI
Panel Session Q&A ■ Capture research gaps ■ Key messages from Growers, Finance, designers ■ Grants/funding options	Jim Purcell, Aquatec Consulting
Lunch	
Bus Returns to Moree Racecourse by 2pm	

Siphon-less Irrigation Systems

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 (Bankless Head Ditch) – The furrow direction is rotated 90 degrees. The new head ditch is below ground 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 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 Tail water 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.
Soil Characteristics – Soil with a very slow infiltration rate will limit your choices.
Topsoil – Minimise topsoil movement.
Cost – GL Bay and 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.

Thanks to Glenn Lyons, GL Water Services, St George for providing this information

Deer Park

Owner:	Pechelba Farming
Managers:	Jim Cush, Harry Cush and Phil Fuller
Irrigation Area:	2,500ha
Water Source:	Moomin Creek

Top to Bottom Siphon-less

The farm was originally developed for siphon irrigation in the 1980's and 1990's. It is an aggregation of a number of adjoining farms. This initial move towards siphon-less irrigation on Deer Park started in the 2017-2018 season and is expected to continue for the next five to ten years. The Deer Park development follows previous development on Woodvale in the Namoi and Avymore in the Border Rivers. Deer Park is quite steep compared to neighbouring farms, which presented different challenges to the other farms. The developments have been designed to manage this slope, whilst still minimising the amount of dirt that had to be moved and the cost associated with the transition.

Key Questions:

How did you determine what design to install?

Knew from experience on other farms that we wanted to eliminate siphons. The top to bottom design had worked well and we knew that it could be implemented at a practical price point.

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

The design was developed in consultation with engineer Bernie Martin. Final design was strongly influenced by practicality, limiting the amount of dirt moved and minimising cost. Fields are surveyed with a green star tractor; the data is sent to Bernie who then developes a proposal. This is adjusted through consultation as required

System at a glance:

SITE	FIELD 57 (1)	FIELD 57 (2)
Soil type	Heavy grey vertisol	
System type	Top to bottom siphon-less	
Field size (ha)	64ha	61ha
Row length (m)	Approx. 1,400m	
Number of bays	2	2
Bay width	Bay 1A = 300m Bay 1B = 298m	Bay 2A = 352m Bay 2B = 323m
Field slope	Anywhere from 1:278 (0.36%) to 1:833 (0.12%)	
Bay slope	Bay 1A and 1B maximum 1:1205 or 0.083%	Bay 2A and 2B maximum 1:1370 or 0.073%
Cut/Fill	Total cut 400 m^3/ha Total fill 320 m^3/ha	Total cut 305 m^3/ha Total fill 244 m^3/ha
Supply flow rate (ML/day)		
Structures installed	900mm supply pipe 300mm drainage pipes (at head ditch) and 1200mm drainage pipe (at tail drain) head ditch and tail drain weirs	
Steps between bays (mm)	Vary from 150mm to 450mm size influenced by land slope, adjusted to minimise earth movement	
Time to irrigate bay (Hrs)	8 to 9 hours	
Previous field set up	Siphons (running same direction)	
Sensors installed	C-probes at head ditch and tail drain	
Cost ($/ha)		
Automation	Not presently	

to minimise dirt movement, while still maintaining focus on delivering a practical workable design.

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

Labour and Lifestyle: We were looking for a way to reduce the human error associated with irrigation. It is really difficult to find staff who like irrigating and who are committed to doing it properly. Too often we were relying of back packers, who needed constant supervision or training. Siphon-less is a means to reduce the reliance on casual staff and lead to more sustainable employment for our permanent local staff. The change has seen better irrigation management, improved lifestyle through faster irrigation and more security for our permanent staff. The farm will have a combination of siphon and siphon-less for the next five to 10 years so the transition will be gradual.

Energy: Still pumping water in the tail drain, but we have joined smaller fields so have fewer tail drains to manage. With further development we may be able to move tail water through to the next field with minimal pumping. We have seen improvements with tractor passes.

Water: We have not yet measured any differences in water use by the crop and are not expecting much change. We have however removed head ditches and tail drains so there are fewer channels for water losses.

We are irrigating faster and wetting the profile more evenly than we were with siphons. We believe we are getting a more even distribution of irrigation water, although there are still some issues with wheel tracks. We are looking at some means to minimise compaction and the number of passes in the field. Possibly increasing the number of track tractors in our fleet to replace wheel tractors as we will not have turning issues in the rotobucks.

Productivity: There has been some improvement in tractor efficiency, there are longer runs in most fields (1 to 1.6Km compared to 5-600m in some siphon fields) and hence fewer turns. We also have double ended tail drains which are much easier to manage that rotobucks in the head ditch of siphon fields. Potentially up to 30% saving in tractor efficiency.

Other: We were looking for possible ways to improve some difficult fields, changing field size and adjusting

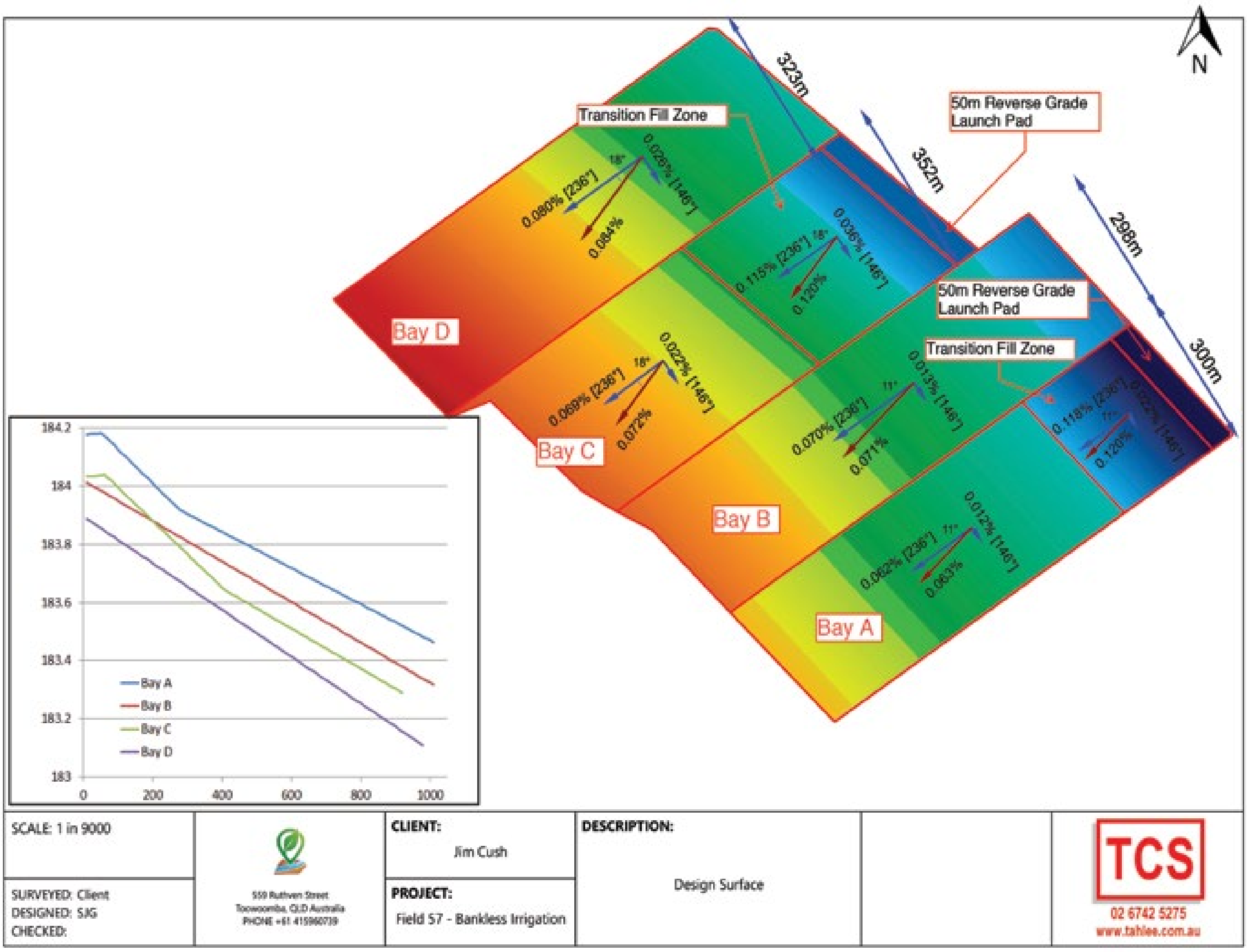


Figure 1: Design view.

furrow directions with the intention to make irrigation more efficient is a key driver in these fields.

What worked well?

The process we used is to move the bulk dirt with laser buckets, to chisel plough the field and then cross with a grader board. Once this has settled, we then move to the final plough, grader board and then the final grade with laser buckets to five mm. The launch pad is lasered two to three times on zero percent grade to make sure its absolutely perfect. This is followed by gypsum, gin trash and hilling up.

The weirs were designed and built on-farm; they are a steel fabrication on a cement base with 50cm rat walls to prevent undermining.

We have found that it is easier to irrigate; one person compared to three or four people and that the field is irrigating more uniformly. We have longer rows which has improved tractor productivity and there are fewer gates and channels, which has reduced the maintenance of infrastructures.

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

One of the challenges was to have time to develop fields properly. Ideally, we would like to be able to do the initial stages of bulk earth works, then allow it to settle for a few months, preferably with some rain before moving to the final grade.

Doing the work in-house can lead to some potential for misunderstanding. We found it was important to check that slopes are all as they should be (for example the slope of the head ditch is correct). It is important to check and address issues as soon as they are found.

The launch pad or top 100m of the field must be as close to perfect as possible, this is critical to get the uniform distribution across the field.

Deer Park has some quite steep slopes which have influenced design and mean that we cannot effectively back water up the tail drain end of the field.

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

There has been some wash on the weirs. We don't move the bottom board generally and have had to install tyres to prevent too much erosion at the weirs.

Figure 2: Head ditch weir.

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

No. Once the water moves out of the launch pad it essentially irrigates the same way a siphon field irrigates. We do not see an increase in tail water.

What might you consider going forward?

Automation: Our primary driver is to convert to the siphon-less designs to increase the practical efficiency of the farm. Automation may be beneficial in the future

Additional sensors: Can see the benefit of water advance sensors to trigger weir opening in field, but it must be cost effective and reliable so that irrigators have confidence in it.

Other: There is minimal technology on farm, but we have moved to trash elevators and hydraulic gates, which can be remotely operated in the future.

"Deer Park has some quite steep slopes which have influenced design and mean that we cannot effectively back water up the tail drain end of the field."

Woodvale Farming

Owner:	Richard Wright
Irrigation Area:	Bankless 710ha
Water Source:	Namoi Regulated

GL Bay

The bankless system consists of two blocks of fields. The southern block has six bankless fields whilst the second one to the north consists of 10. All fields are a ‘GL Bay’ configuration and are fed from one dam that is to the south. When water is released from the dam it travels to the northern end of each block and enters the basin of the first field by opening a boarded gate. Water is then pushed along up the sill by the gravity head in the basin and is forced along the furrows. Water is then collected in a tail drain and backs up furrows that are not fully irrigated. Once the field is irrigated, the boarded gate to the next field is opened and water drains from the first field to irrigate the next. The step between each field is approximately 15-20cm. Once the irrigation is complete, water is recycled back to the dams.

Key Questions:

How did you determine what design to install?

This was a greenfield site that was relatively flat so was ideal for the zero slope design.

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

Bernie Martin helped run a number of scenarios before we settled on a particular layout

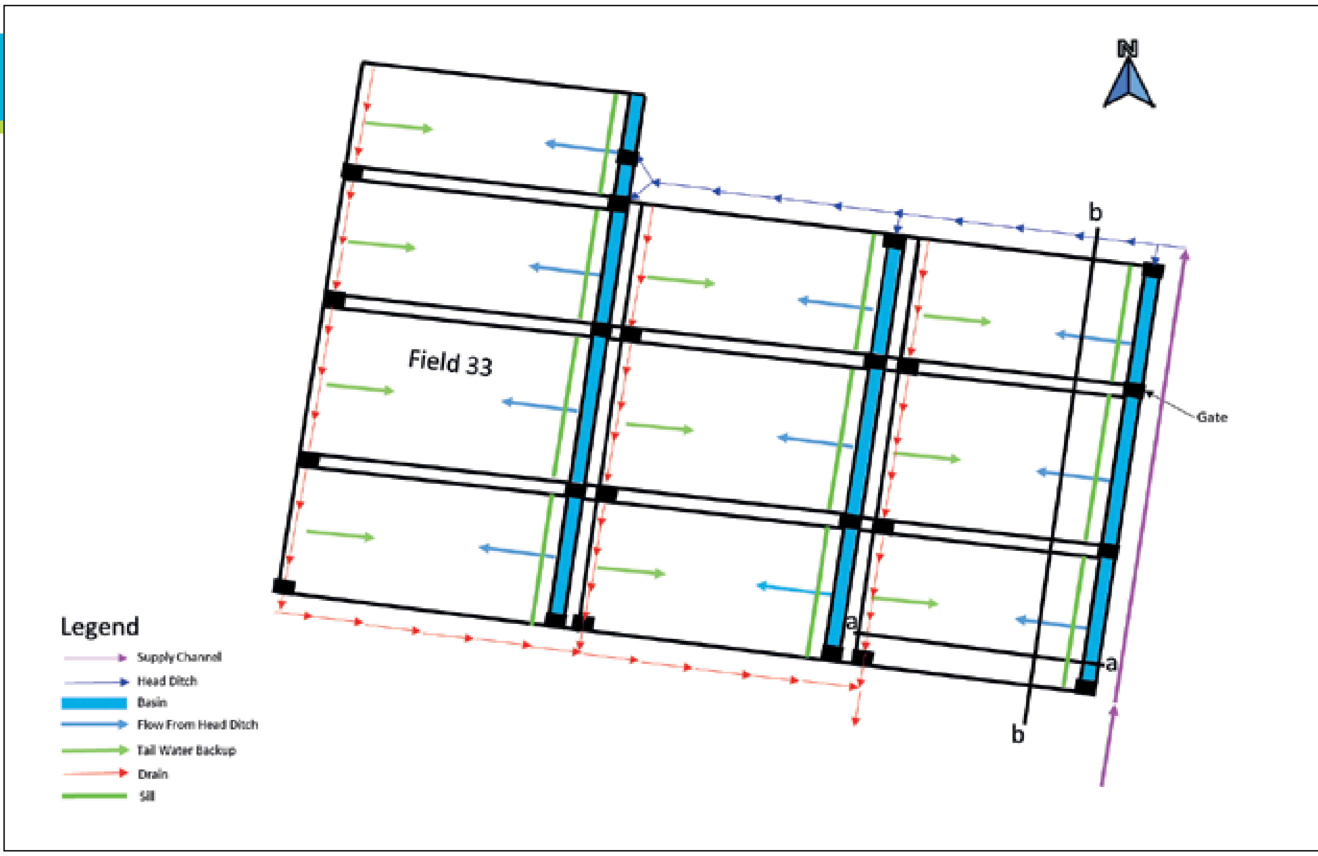
Why did you move away from Siphon irrigation and what have you found following the change?

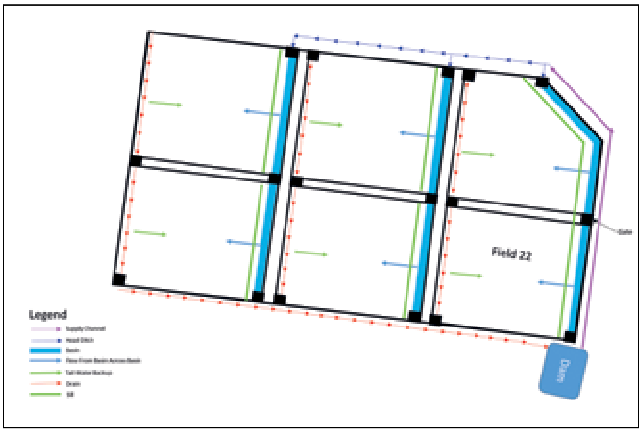
Labour/Lifestyle:

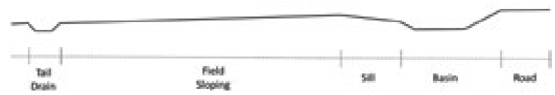
Noticeable labour saving, now one man can water 700 ha in 3.5 days. The improvements to lifestyle are obvious.

System at a glance:

SITE	FIELD 22	FIELD 33
Soil type	Grey Self mulching Clay	Grey Self Mulching Clay
System type	Bankless GL Design	Bankless GL design
Field size (ha)	45ha	30ha
Row length (m)	770	770
Number of bays	2 per field	3 per field
Bay width	600m	400m
Field slope	0.05% (1:2000)	0.03% (1:3000)
Bay slope	0% cross slope	0% cross slope
Cut/Fill	425 m^3/ha cut	350 m^3/ha
Supply flow rate (ML/day)	120	100 – 120
Structures installed	Weirs and boards	Weirs and boards
Steps between bays (mm)	200	150 – 200
Time to irrigate bay (Hrs)	10	8 – 10
Previous field set up	New development	New development
Sensors installed	Soil Moisture only	Soil Moisture only
Cost ($/ha)	$600	$600
Automation	None	None
Average yield bales/ha	12.7	2 seasons only (14.5 and hail affected)
Average water use ML/ha	9.1	9.5







Energy: There is a bit of excessive tail water that has to be recirculated.

Water: We have not noticed any difference in water use.

Productivity: The new designs have performed well, producing good results. There are certainly no penalties.

Other: It does require a bit more maintenance of cross field slope to get it watering evenly, particularly early after development as fill areas settle and cut areas rise.

“This was a greenfield site that was relatively flat so was ideal for the zero slope design.”

What worked well?

The field slope from 0.03 to 0.05% (1:3000 to 1:2000) have worked well for us.

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

We would utilise all steel structures because they are much simpler to manufacture and can be pre-fabricated in the workshop beforehand.

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

Can get a lot of washout as the tail water is released into the tail water return.

Avymore

Owner:	Pechelba Farming
Managers:	Tom Cush, Jim Cush
Irrigation Area:	1,425ha irrigation (495ha Bankless), 700ha dryland
Water Source:	Macintyre River general security and Overland Flow

Top to bottom siphon-less

New siphon-less development, the second of three farms to initiate the transition. The first crop was grown in the 2016-2017 season. All siphon-less fields on Avymore have produced two crops. Ideally the management team want to move as much of the farm to siphon-less operations as is possible/practical. The actual design for each field is dependent on the slope and where possible fields have been combined.

To date, the focus has been on fully developing the farm for irrigation. We are now moving to redeveloping siphon fields to simplify management.

For Field 21, formerly a dryland cultivation field, siphon-less just made sense, the field had a natural downfall of 70cm / km, (0.07% or 1:1428) and some slight side fall, there was also a large ridge in the SE corner which assisted in getting the 150mm drop between first and second bay. Water is supplied to the head ditch via two 900mm gates, the target was 30ML per 100m of head ditch (per day).

Key Questions:

How did you determine what design to install?

We decided that any new development should be done without siphons if possible. Pechelba Farming had established bankless setups on Woodvale in the Namoi and had had good results so decided to install at other farms.

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

System at a glance:

SITE	FIELD 21
Soil type	Belah/box, mixed predominantly grey with red ridges
System type	Top to bottom siphon-less
Field size (ha)	195ha
Row length (m)	1,500m
Number of bays	3 (150mm/6inch drop)
Bay width	408m
Field slope	1:3000 or 0.03% at top
Bay slope	South: 0.03%, 0.035%, 0.03% (1:3000 to 1:3850) Centre: 0.03% (1:3000) North: 0.03%, 0.04%, 0.03% (1:3000 to 1:2500)
Cut/Fill	350-500m^3/ha. All best fit.
Supply flow rate (ML/day)	130ML/ha
Structures installed	Metal weirs with boards
Steps between bays (mm)	150
Time to irrigate bay (Hrs)	12-24 hours depending on soil moisture levels
Previous field set up	Dryland cultivation
Sensors installed	nil
Cost ($/ha)	Approx. $2,000/ha
Automation	nil

Worked in consultation with Bernie Martin. Provided Bernie with existing field details (surveyed with GPS) and a basic idea of what we wanted to achieve. Bernie then developed options designed to fit the development with minimal dirt movement. Moved between 350 and 500 cubic metres of soil per hectare.

Terra-Cutta was used to calculate how much soil to move. The main part of the field was laser finished to within five millimetres, then grader boarded. The top 100m of field (launch pad) was laser finished to 0mm, (critical to get this part as perfect as possible) it was final trimmed three times and chisel ploughed between each trim. This may seem excessive but if it sinks/rises the first time it gets wet there's nothing you can do, you can't leave one row running or double up a few rows. The field was then cross checked with a GPS on a tractor.

Head ditches (bankless channels) were developed to 500mm deep to give capacity and enable even flow. The head ditch and launch pad are the most critical part of the field, the launch pad should be developed to be a minimum of 100m down the field.

There are 150mm steps between each bay.

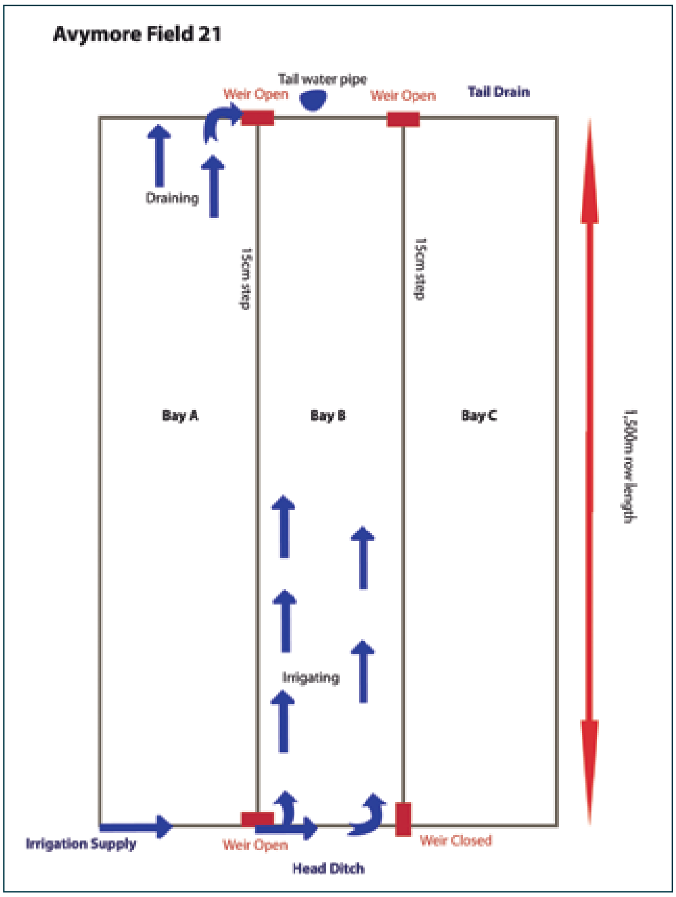


Figure 2: Aerial View and Irrigation.

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

Labour/Lifestyle: Labour is more efficient. Siphon-less are run with one man compared to most siphon fields which need at least two and normally three men. There is also less potential for human error with siphon-less.

Lifestyle – Irrigation is much easier to run in that particular field. Start two pumps, set them to 1300rpm. Open both gates, ensure boards are in structures. I don't have to touch anything now, just monitor tail water level. The first two irrigations took around 24 hours per bay but mid season they're only taking 11-12 hours. There is less potential for human error.

Progress from each Bay is a simple straight forward action of pulling boards. Adjustments for slow or fast run times is much easier and is a one man job as opposed to needing a number of people, this is really beneficial at 3am and prevents over watering the field.

It's a noticeable improvement to fatigue levels, if the whole farm was siphons, we would be changing 2,000 to 3,000 siphons per day, but when you have some siphon-less in the mix it cuts back on the physical side of irrigating. Having one third of our area siphon-less we have been able to cut back to changing 1,200 to 2,000 siphons per day.

Doing a change takes one man five minutes compared to a siphon change which can take two or three men 20-40 minutes depending on the size of the change. And if you

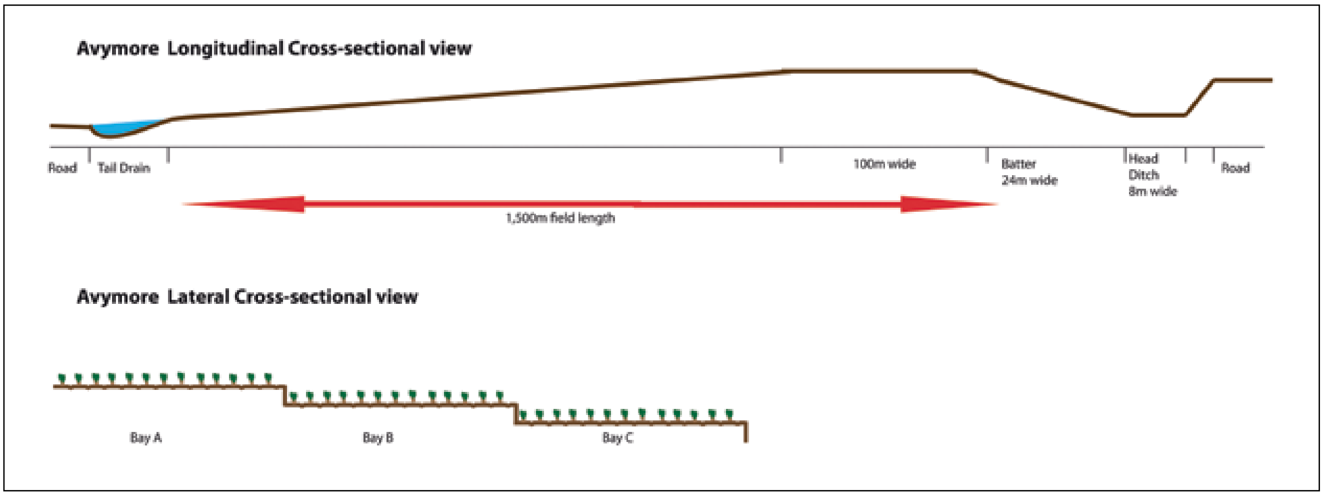


Figure 1: Cross Sectional view.

have multiple fields running you can have the changes done in less than an hour compared to two to four hours to do all the siphon changes.

You do end a shift feeling a lot less worn out, even having one less field of siphons to change makes a difference.

Energy: Still pumping tail water and supply water. Have been able to improve efficiency of tractor use in most fields. Tractor efficiency has gone from 100ha per day to 130ha per day, as a result of not having to stop and back up at the head ditch.

Water: Not seeing any significant change in total water use per hectare, however you do have a lot more water in the system at any one time compared to siphons. For example, 200 x 2.5" siphons might require half (1/2) a gate on a 900mm head ditch pipe to keep the head ditch full whereas the same number of rows being watered in a siphon-less setup you would be running a full gate.

Because we are running a full furrow every furrow, it is possible to totally wet the field in a much shorter time compared to siphons. It is like running two 3" siphons down every furrow. So, we are able to get more water onto a field in less time, with reduced risk of waterlogging.

Probes suggest that the soil profile is wetting more evenly, especially at the top of the field.

Productivity: We have been able to improve efficiency of tractor use in most fields. Tractor efficiency has gone from 90-100ha per day to 120-130ha per day, chiefly as a result of not having to stop and back up to turn at the head ditch, as well as longer rows (1,500m row length instead of 500 to 750m).

Spray application has been improved, generally able to spray at about 75ha per hour, (36m spray rig) and it's quite achievable to do 600 to 700ha in a day.

What worked well?

Siphon-less just made sense, field had a natural fall of 70cm per km (0.07% or 1:1428) and some slight side fall, also a ridge in SE corner which assisted in getting the 150mm drop between first and second bay.

Working in partnership with engineer was important. Engaged quality staff to do the final trim and levelling.

Able to develop the whole 1,200m x 1500m square into one field, maximising green area and efficiency by not having to split it into two or more siphon fields.

> *"We have been experimenting with siphon-less for a number of years now in a number of soil types and field sizes, and we have been able to make it work well for us."*

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

Soil Variation: We do have issues around soil types, the redder/lighter areas dry out faster than the black areas, but there is not a great deal you can do about it as the red spots tend to be 5-20ha patches surrounded by black soil.

Compaction: We have had some problems with compaction on a grade break in one field. The buckets were turning on the grade break, and it ended up being quite compacted, and it was not picked up or fixed. The first irrigation worked well, but on the second irrigation of that field when we had a 60m x 1200m dry spot. The first irrigation was the first time that field had been wet and the first chance that compaction had to rise.

Guess rows are normally slow, but we have had some success running some traffic (spreaders) down the guess rows instead of the wheel tracks to even out the compaction. Also, a three row cultivator that can deepen rows could prove useful.

Steps between bays: The steps are 150mm, but a step of 170-180mm would be better, as 150mm seems barely enough. If the step is not large enough, when the boards are pulled to move into the next bay, the level won't drop enough in the first bay to stop water running down the furrows. You end up where the whole bay keeps trickling instead of stopping.

Bay width: 408m wide bays are too big. Narrower bays, approximately 300m would have given more even flow rates, but would have resulted in four rather than three bays and doubling the amount of dirt we would have had to move. Optimal bay size seems to be 1,000-1,200m row length and 300m bay width.

Supply pipe diameter: Installed two 900mm gates, when it would have been better to install one 1,200mm gate.

Have had to monitor and manage some erosion in the head ditch between bays. But this is quite manageable.

You can have big issues at the head ditch with machinery if the batter is too steep, and track tractors are worse. What happens is when a tractor is approaching and drives off the field grade and onto the head ditch batter, the front of the tractor drops, the rear of the tractor kicks up, and whatever rig is on the back also kicks up. If it is ground engaging it ends up leaving 13 piles of dirt in the start of that set of furrows which will block water from running down. It is manageable by having a flatter transition from head ditch batter to launching pad, and also by pushing the hitch down as the tractor tips into the head ditch, thus keeping the rig down at the bottom of the furrow.

If you have a dry row there isn't much you can do

Figure 3: Weir.

about it. You can't just double up that row like you can with siphons.

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

Take soil types into account and try and work that into the design if possible.

Going forward limit bay width to 350m maximum Ideally make row length in the 800 to 1,200m range. Any redevelopment that is done should aim to keep within these parameters by joining fields together or changing row direction.

Make a three row cultivator so we can go up and down any dry rows and pull them deeper. We need to get better at keeping the furrow depth uniform across the full 12m. Don't let the wheel track rows get deeper than the outside rows.

Keep refining our weir design. There is potential to move away from boards and move to a flip down door or winched door design.

The very first fields we developed had 4m roads for check banks, this was partly due to some bad advice and partly due to having extra dirt in the bays. You only need a large windrow of dirt for a check, similar in size to a small siphon bank. There is no great amount of water being restrained by the check bank as all the water should be in the furrows.

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

When we started irrigating, we were blocking the tail drains and backing water up to try and speed up the irrigation, which may have caused some minor water logging. We have now adjusted so that the tail drain runs out like it would in a normal siphon field, and we can back it up to wet up dry rows if necessary. However, when the field is 1,500m long it is impossible to push the water very far back up the hill into the field. Some fields here are 450m row length so in those fields it is possible to back water a long way back up the field.

What might you consider going forward?

Automation: No, it only takes five minutes to change weir, so not on the immediate list. We are working on a flip down door instead of boards. Labour $25-30 per hour and you need a man there anyway running pump levels, trash elevators etc.

Sensors also not on the list. You have to remember that you have a man on farm anyway running the pumps, supply channel levels, gates etc who can look at the field with his own eyes and make judgement on when to do a change. There is also challenges with connectivity, we do not have 3G signal here, so data transmission is difficult. In the future there may be benefit in looking into water advance sensors, but they have to provide a value that the man on site cannot deliver.

Other: Currently using boards but could potentially change from boards to a bottom pivoting door.

Another way to potentially even the irrigation out is to change from 1m hills to 2m beds. Halving the number of furrows should lead to a more even flow.

May look at putting a zero or even reverse grade on the first 50-100m of field to improve even flow.

Description of watering F21

Water supplied from main supply into head ditch which is 500mm below field level, via two pipes. Water fills the Southern Bay A head ditch then flows over lip onto the launching pad (100m), and down the field.

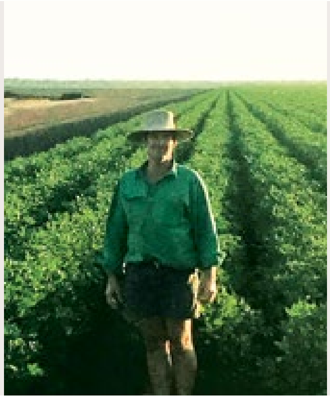
Once all rows are through the head ditch structures are opened into centre Bay B. The tail drain is generally run in the same way a normal siphon field would be run, the tail drain outlet is in the centre of the field, Bay B. there may be some back-up into rows in Bay B and Bay B may be a little quicker to irrigate. The structures at the tail drain can be closed and tail water can then back up into the field if there are rows which have not wet up properly.

This is repeated into the northern Bay C. The tail water is pumped from the field.

The tail water runs out of the field into the tail water channel and is then pumped back into a supply channel or back into a dam.

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	

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 (20,000m³).

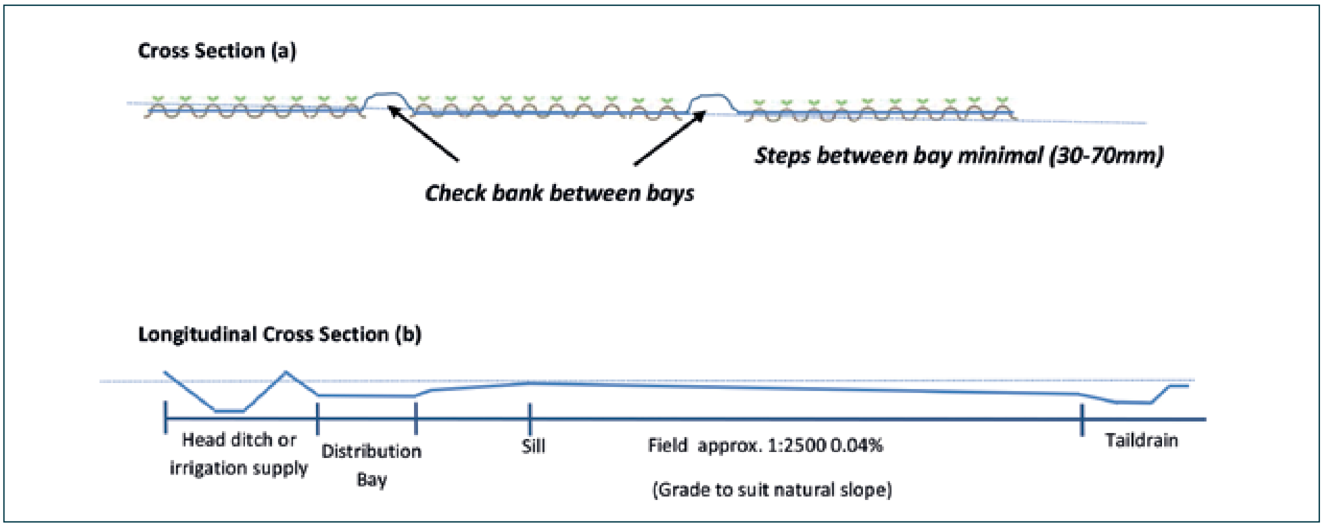
What didn't work well or was difficult to implement?

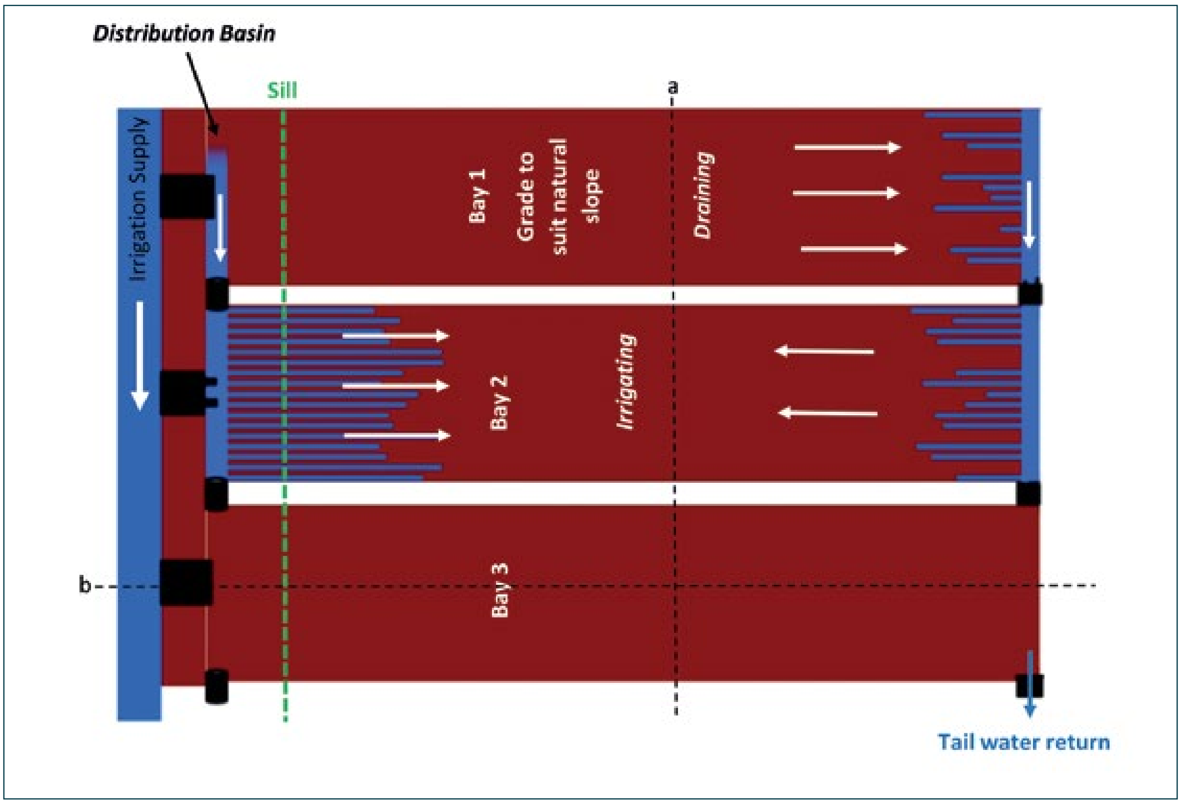
Initially there was some wash out of beds in front of bay outlets, caused by soft beds (not stabilised) and too great a water volume. The head ditch (rotobuck) area has since been widened.

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.

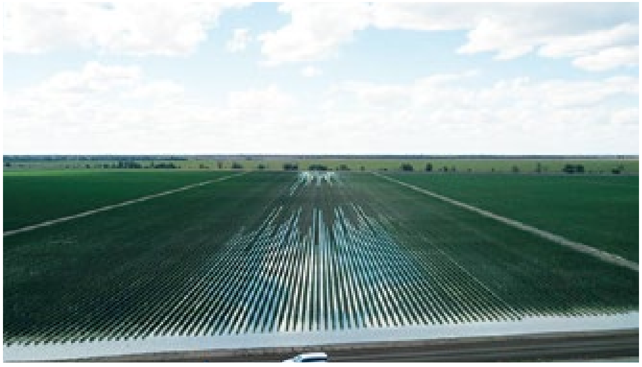
bays to 300mmm, so that drainage is faster.

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



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"

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.

Figure 1: Padman Bay Outlet.

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

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."

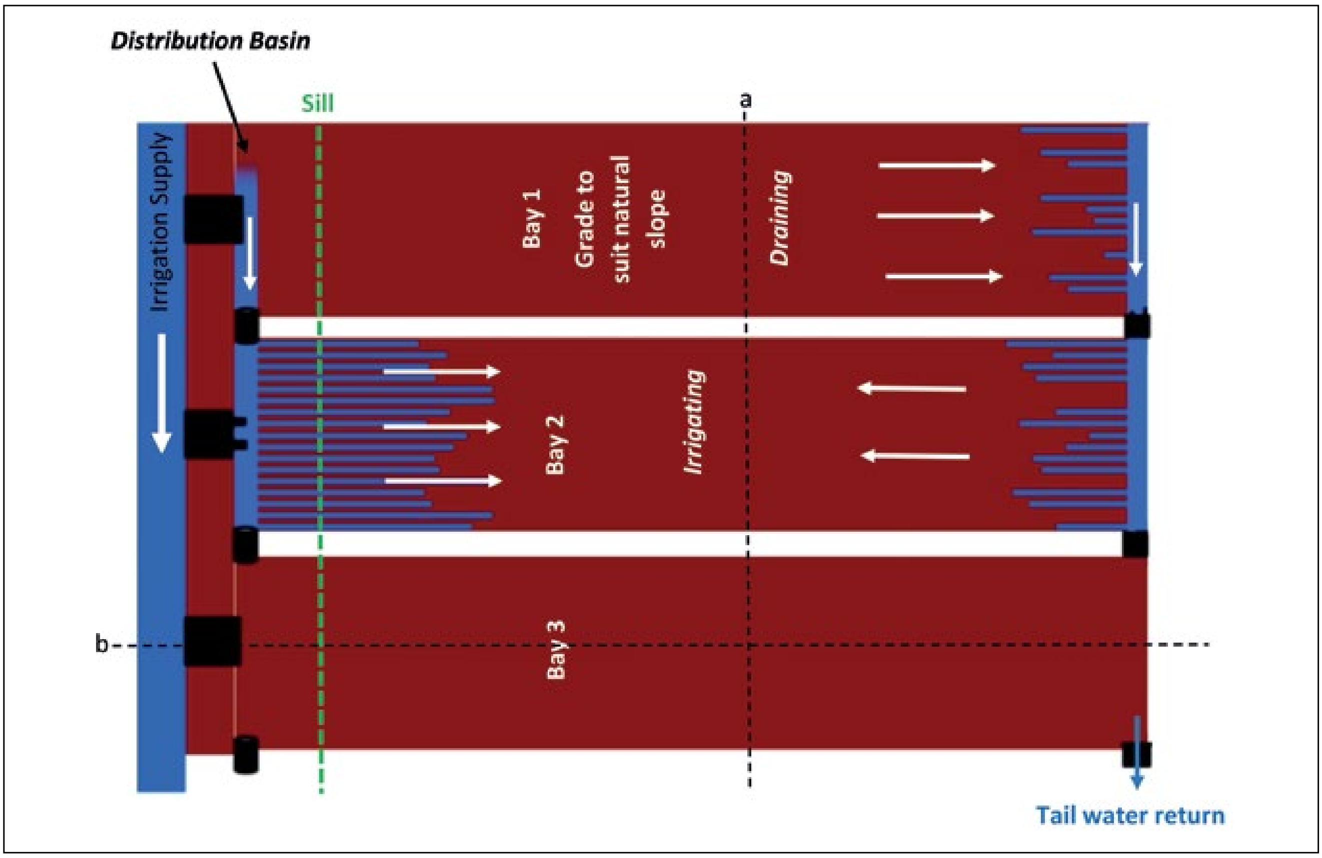
Productivity: Productivity gains are expected to be linked to labour saving, about 50%, these staff are now available for other operations. There are no siphons to deal with, no rotobucks to put in and plough out between field operations and irrigations.

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.

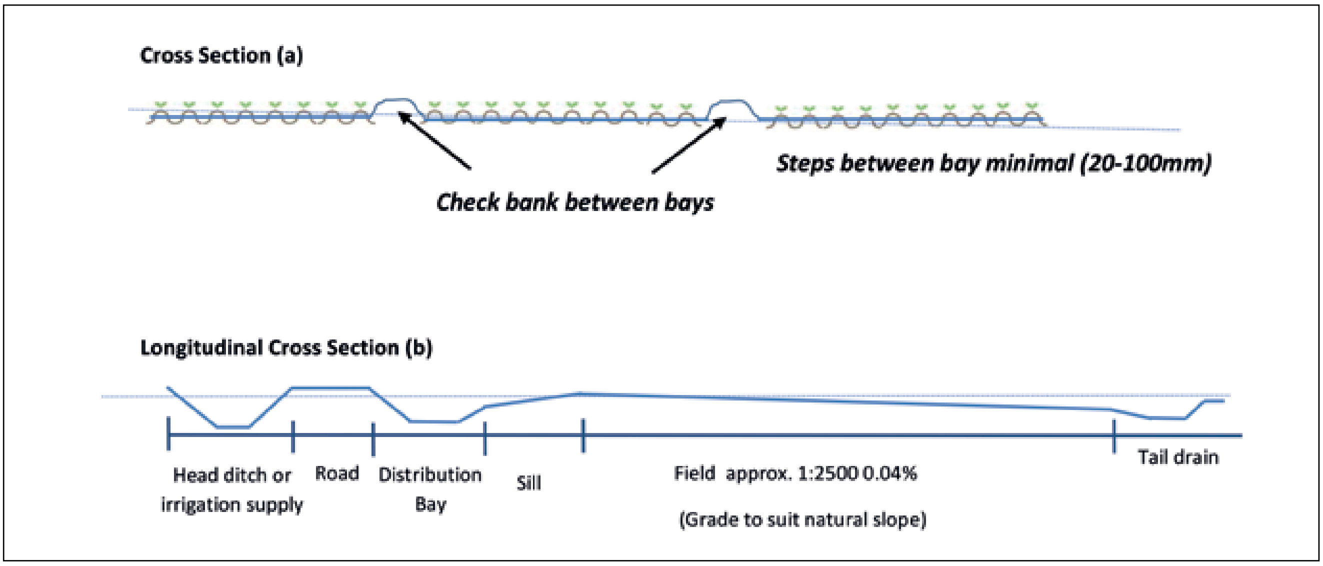
Other: Dispersion vanes have been fitted on Padman bubbler outlets to eliminate swirling of water and resultant erosion.

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 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.

Figure 1: Padman Bay Outlet fitted with dispersion vanes.



The Plantation

Owner:	Craig Saunders
Farms:	The Plantation
Irrigation Area:	250ha (65ha is GL Bay)
Water Source:	Balonne River

GL Bay:

The siphon-less flood irrigation systems have been designed around the inherent features of the fields. Plantation Field 2 is a bankless channel ‘GL Bay’ system fitted to the cross fall of the field and comprising five bays. Water is delivered via a single inlet at the high end of the head ditch and is cascaded through regulatory structures into lower bays. The design 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. Over the years the farm irrigation systems have evolved from conventional siphons, through-the-bank pipes and overhead (pivot) irrigation. At the time bankless was thought to be the next step to improve water efficiency. One consideration was that the system chosen could effectively irrigate very long runs with minimal earth movement. Plantation field 2 was due for laser work and a full renovation, triggering investigation of options.

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

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

System at a glance:

SITE	PLANTATION 2 (P2)
Soil type	Self mulching grey clay
System type	Bankless Head Ditch ‘GL Bays’
Field size (ha)	65ha
Row length (m)	1,100 – 1,700m
Number of bays	5
Bay width	107m
Field slope	0.04 to 0.055% (1:2500 to 1:1818)
Bay slope	0.01 to 0.03% side fall (1:10000 to 1:3333)
Cut/Fill	178m^3/ha
Supply flow rate (ML/day)	25-30ML/day
Structures installed	Padman Stops 2 x 1.8m at head ditch,
Steps between bays (mm)	150mm
Time to irrigate bay (Hrs)	8 – 12 hours
Previous field set up	Flood – 250mm through the bank pipes
Sensors installed	C-probe
Cost ($/Ha)	$3,000/ha plus structures
Automation	Testing automatic winch timers
Average yield bales/Ha	Highest farm yield
Average water use ML/ha	Less than PTB’s

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. Following the implementation of automation estimates of labour saving are expected to be closer to 70%.

The major improvement in lifestyle was ease of water changes and capacity to automate.

Energy: There was expected to be a 50% saving in fuel due to less tail water, but the estimate to date suggests savings are closer to 65%.

Water: Improving water efficiency was the main driver for change. The existing attributes of the field suited a terrace design of bankless channel (GL bay) system.

Productivity: Productivity gains are linked to labour saving, as these staff are now available for other operations. The expectation was for a 50% improvement, but it is now estimated to be slightly better than this. There are no siphons to deal with, no rotobucks to put in and plough out between field operations and irrigations.

Other: There has been improved evenness of crop growth and yield.

What worked well?

There has been 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?

Two metre check banks were used between bays. We would go to four metres in future developments. The highpoint or sill in each bay is parallel to the head ditch in an irregular shaped field, this means that the sill is not square to sides of the bay, and tractors and implements crossing the sill are not running square to the sill. This will be changed to right angles when the field is next brushed.

Figure 1: Head ditch structure – Padman Stops 2 x 1.5m.

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

We would lift head ditch structures by 100mm. In this design, we took a conservative approach to ensure that the bays would drain but have found it was not needed.

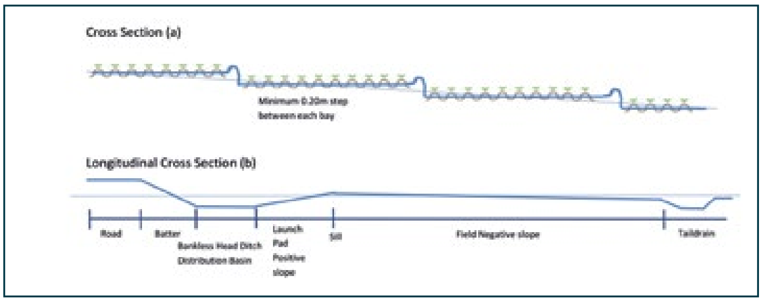
Have you seen any issues with tail water management or drainage?

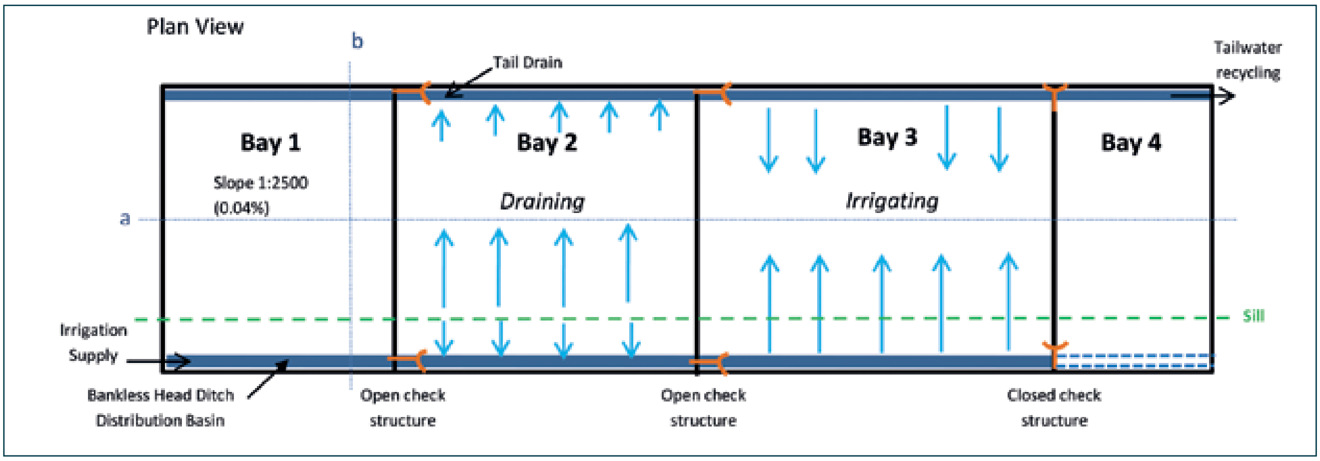
No. The structures in tail drain allow tail water to be backed up furrows in bay to meet water coming from head ditch. This ability has improved irrigation times. As we gain experience with the system, improved timing of the irrigation shut off will reduce the irrigation time even more and further reduce tail water.

What might you consider going forward?

Automation: Further automation includes winch timers installed on the head ditch structures.

Additional sensors: Trip doors on tail drain structures.





Plan View.

Bullamon Plains

Owner:	Ed Willis
Location:	Thallon
Water Source:	Moonie River

GL Bays and Siphon-less with Tail water Backup

"Bullamon Plains" is a farm using flood irrigation to grow crops. Three systems are used;

Irrigation Type	Percentage of Area	Year Built
Siphons	34%	pre 2002
GL Bays (Bankless Head Ditch)	60%	2002-17
Siphon less with Tail water Backup	6%	2018

Commencing in 2002, new developments were built in the 'Roof Top' type of bankless irrigation where water was pushed out into the field from a tail drain at each end.

From 2009 to 2017, all new development was done in the 'GL Bay' style to reduce earthworks and to achieve a more consistent inundation time for all plants along each row. All existing 'Roof Top' fields were converted to 'GL Bays'.

In 2018 a siphon field was converted to 'Siphon-less with Tail water Backup'. In 2019, another three siphon fields will be converted to 'Siphon-less with Tail water Backup'.

Key Questions:

How did you determine what design to install?

Initially built 'Roof Top' system because the very flat landscape was not easily developed to siphons. Moved on to 'GL Bays' because 'Roof top' required too much earthwork, and water inundation was less than ideal. I am now converting the remainder of the siphon fields to

System at a glance:

SITE	GL BAYS	'SIPHON-LESS WITH TAIL WATER BACKUP'
Soil type	Self-mulching grey clay with areas of red loam	Self-mulching grey clay with areas of red loam
System type	GL Bays	'Siphon-less with Tail water Backup'
Field size (ha)	1000 ha	80 ha
Row length (m)	800m	960m
Number of bays	Varies	5 Bays
Bay width	360-528m	216m
Field slope	Ranging from 0.010-0.120% (1:10000 to 1:833)	Ranging from 0.020-0.050% (1:5000 to 1:2000)
Bay Cross fall	Nil	Nil
Cut/Fill	400 m^3/ha in the field	120 m^3/ha in the field
Supply flow rate (ML/day)	Designed for 120 ML/day	70 ML/day
Structures installed	Head ditch – drop-board structures Tail drain – drop-board structures	Head ditch – Padman cotton inserts Tail drain – Padman cotton inserts
Steps between bays (mm)	Minimum of 150mm	Minimal
Time to irrigate bay (Hrs)	6 hrs	6 hrs
Previous field set up	New development	Siphons
Sensors installed	Moisture probes	Moisture probes
Cost ($/Ha)	$3,000/ha	$1,200/ha
Automation	None	None
Average yield bales/Ha	Equal to or more than siphon fields	
Average water use ML/ha	Less than siphons	Less than siphons

'Siphon-less with Tail water Backup' rather than to 'GL Bays' because the earthworks is minimal, while still getting all of the benefits of 'GL Bays' except the ability to drive through consecutive fields before turning.

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

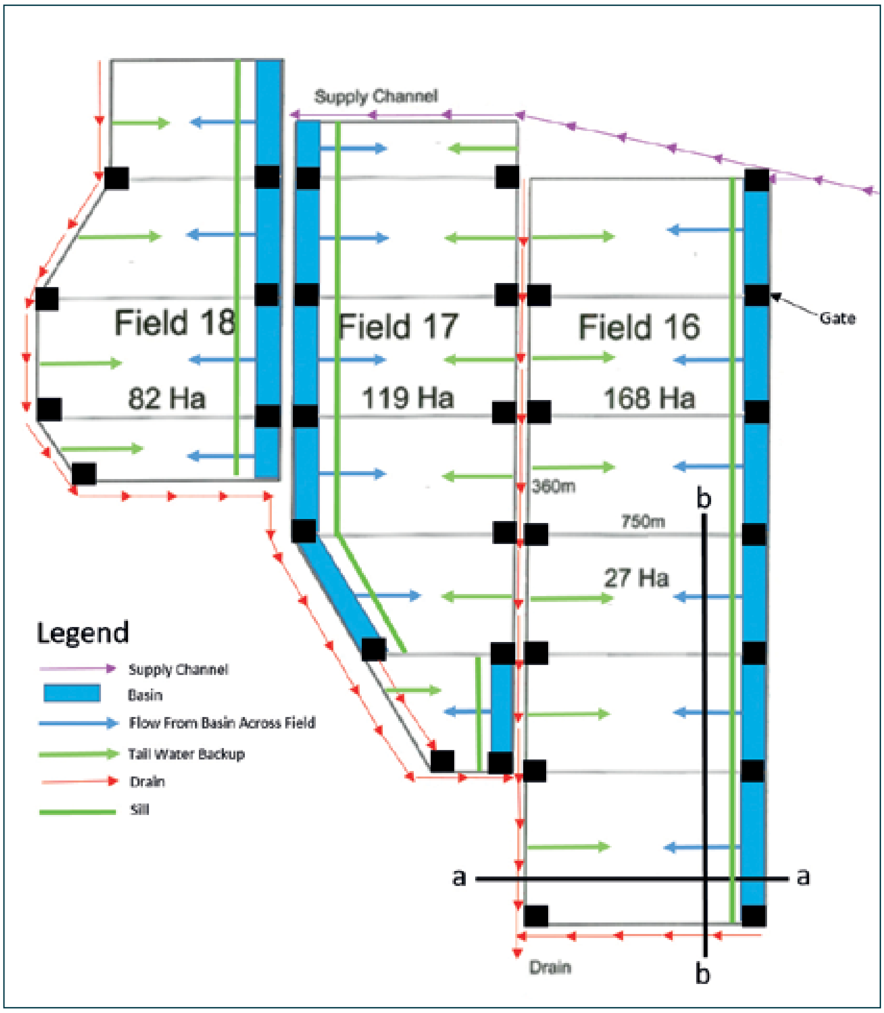
We used a consultant, Glenn Lyons to assist with the designs. They collected survey data and developed field design with minimal movement of soil. Good design and laser control are critical to get even distribution of water into each row.

Why did you move to a siphon-less systems and what have you found following the change?

Labour/Lifestyle: These systems save approximately 20% of labour compared to siphons and there is much less stress associated with irrigation. There is the opportunity for time off for staff between irrigations. The whole of siphon-less farm can be irrigated by one person on day shift and one on night shift (manager and leading hand). With siphons we would have had needed an additional four irrigators plus a tractor and operator preparing rotobucks. The system has turned a hectic seven days into five calm days.

Water flowing from head ditch into distribution basin through twin outlets in Field 3.

Energy: The main saving is associated with fuel savings as a result of pumping less tail water. Tail water is 10% rather than the 30% from 'high flow siphon' and 'Siphon-less' systems that don't have tail water backup.



Water: The reduced tail water means more hectares are irrigated in a day with the water supply rate available. The farm is irrigated in five days rather than seven days with the same supply rate. Run times for siphon-less are four to six hours compared to eight or 12 hours for 75mm siphons. The reduction in tail water and minimisation of deep percolation lead to clear water savings.

Productivity: The fields produce yields which at equal or better than siphons.

What worked well?

Tail water backup reduces the run time substantially. There is no silt.

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

The steps in the 'GL Bays' were set at 150mm but would have worked better at 200mm. The depth of the head ditch was set at 300mm but would have worked better at 400mm.

What would you do differently from a design or infrastructure perspective?
'Siphon-less with tail water backup' is working well.

Have you seen any issues with tail water management or drainage?
We have not had any issues, there is less tail water and trash, and no silt

What might you consider going forward?
We will be converting all 'siphons' to 'Siphon-less with Tail water Backup'.
Automation will help with irrigation changes during the night.

Tail drain structure of Field 3 with cement impregnated.

Description of Irrigation

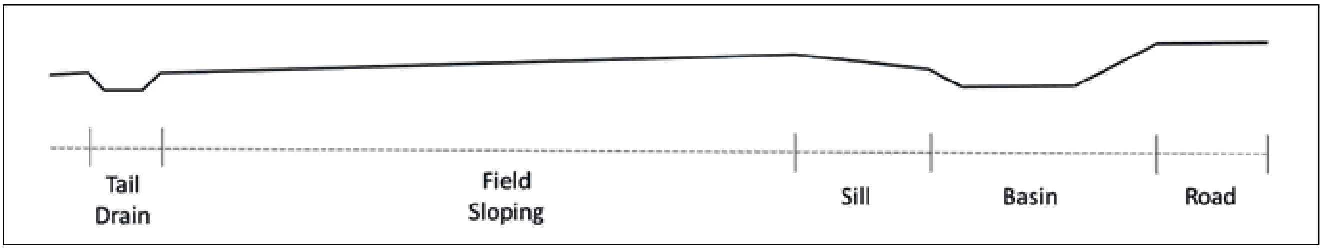
GL Bays:

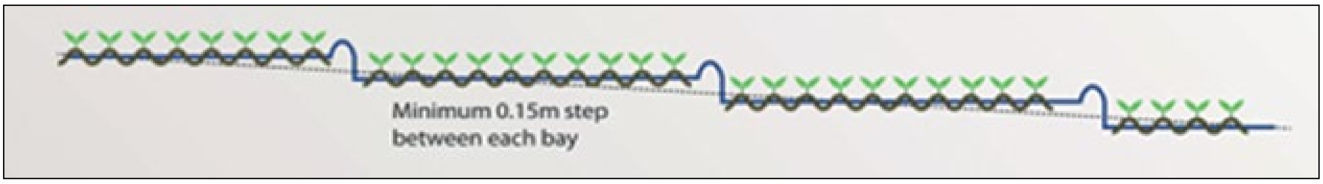
The 'GL Bay' system operates by filling a below ground level head ditch called a 'Distribution Basin' with an inlet pipe from the supply channel. This basin looks exactly like a deep tail drain, and as the water level rises in it, the water pushes out into the furrows. About 30 metres along the furrow is the high point (Sill) that the water will flow over before moving down the general slope of the field. The last 150-200 metres of the furrow before the tail drain is flattened off. With the installation of a check structure in the tail drain, tail water is held in the bay and forced back up the dry rows. The field is divided up into bays of a particular width depending on the flowrate available. The drop in elevation from bay to bay is 20 cm so that the below ground head ditch 'Distribution Basin' can supply the next bay without any water running out into the furrows of the previous one. Tail water is dropped from each bay to the next and used to backup.

Normally to convert a siphon field to 'GL Bays', the furrow direction needs to be turned 90 degrees to create the 20cm step from bay to bay. The downside is the more substantial earthworks and the reduced downfall slope. However, where fields are very steep, rotating the furrow direction by 90 degrees can work well to achieve a more ideal down field slope.

Siphon-less with tail water backup:

When converting a siphon field to 'Siphon-less with Tail water Backup' the furrow direction stays the same. Water is supplied to the 'Distribution Basin' of each bay from the conventional head ditch with a large pipe or Padman weir type outlet located midway across the bay. A 20cm step from bay to bay isn't needed for this system to work. Tail water is again held up in the tail drain and backs up the non-complete furrows. Once the bay is complete, the tail drain check structure between this bay and the next is opened. This tail water will fill the tail drain of the next bay and start to back up the field. The first bay to be irrigated is the lowest in the system. Therefore, not all the tail water from the first bay will drain into the next bay. The small amount left in the tail drain is allowed to go to the recycling system to ensure the crop isn't inundated for too long. Backing up the tail water and then re-using a large percentage of it in the next bay has reduced recycling water dramatically. Earthworks is reasonable, and good slope can be maintained.





Cross section.

Mundine

Owner:	Corish Farms
Managers:	Brett Corish
Irrigation Area:	1000ha GL Bay, 900ha Siphon irrigation, 70ha sub surface drip.
Water Source:	Macintyre River (NW NSW)

GL Bay

Corish Farms have been on Mundine for over 30 years and had a good understanding of the original irrigation set-up, the soil, climate and farm as a whole. The whole farm was in need of a re-brush, regrade and review of the siphon fields. Following an evaluation of irrigation systems being used on other farms, Corish Farms made the decision to progress to Bankless Channel. There was support from the sustaining the basin program (STBIFM) which helped fast track the implementation.

There have been seven fields converted to Bankless Channel on Mundine, the conversions were made in sections that could be adapted with acceptable earth works. They were used for the first time in the 2017-2018

System at a glance:

SITE	FIELD 1 – B1	FIELD 2 – B2
Soil type	Belah/box	Belah Box
System type	GL bay with flat launch pad 48m,	GL bay with flat launch pad 48m,
Field size (ha)	182	183
Row length (m)	1140	1140
Number of bays	4 200mm back-up because on old siphon field	4
Bay width	400m	400m
Field slope	Varies 1 :500 (0.2%) to 1:1500 (0.066%) (average 1:1100 (0.096%)	Varies 1:1800 (0.055%) to 1 in 1100 (0.096%)
Bay slope	50m Launch zero- field varies mostly zero	50m Launch zero- field varies mostly zero
Cut/Fill	Av. 495 cu.m /ha	Av 750 cu.m /ha
Supply flow rate (ML/day)	100 ML/day plus	100 ML/day plus
Structures installed	2 supply, 3 Tail water checks + drop box	Supply plus 3 checks 2 x drop box modifications, 3 checks
Steps between bays (mm)	Install additional supply because sufficient step could not be generated	Varies 150-250mm
Time to irrigate bay (Hrs)	Field 1 takes approximately 10-12 hours to get water on and off. The first bay takes about 12 hours and each bay after that gets quicker and quicker as you build up water, with the last bay taking about 8 hours.	
Previous field set up	Siphons	Siphons
Sensors installed	Soil probes	Soil Probes
Cost ($/ha)	Contractors	
Automation	Not at this stage	Not at this stage
Yield (b/ha)	13.1 b/ha (2017/18)	
Water use ML/ha	10 ML/ha (compared to 11.5ML/ha siphon fields)	

season. The engineer was Peter Leeson, who provided options based on the levels of the existing fields. The design we have used is a GL Bay design.
Yattlewondi on the Weir River also owned by Corish Farms had some of their field converted three years ago.

Key Questions:

How did you determine what design to install?
We were looking to make changes that were cost effective but were targeted to the best outcome we could achieve. Each segment will have different management because of what changes were implemented.

Did you use a consultant or a design engineer? What role did they perform?
We collated survey data and levels across the existing field and provided them to engineers Peter Leeson and Russell McKeowen. They provided options and helped guide progress to the final design.

Why did you move away from siphon irrigation and what have you found following the change?
Labour/Lifestyle: Labour resourcing is a driver for change as we strive to provide a work life balance for employees. The change has meant that there is less reliance on casual staff, and there has been improvements for permanent staff. Staff management is important; the changes will help to provide security for permanent employees.

Energy: Fuel and tractor hours are important. The changes have seen a reduction in the time to complete cultivation (potential for 50% time reduction). Additionally, there is no need to put in rotobucks, further reducing tractor hours.

Water: We had been looking into the variability of flow rate caused by variation in the placement of manual siphons. Flow rates vary noticeably based on placement, even if the channel head height is consistent. This had the potential to result in poor irrigation uniformity and distribution over the field.

"Labour resourcing is a driver for change as we strive to provide a work life balance for employees. The change has meant that there is less reliance on casual staff, and there has been improvements for permanent staff."

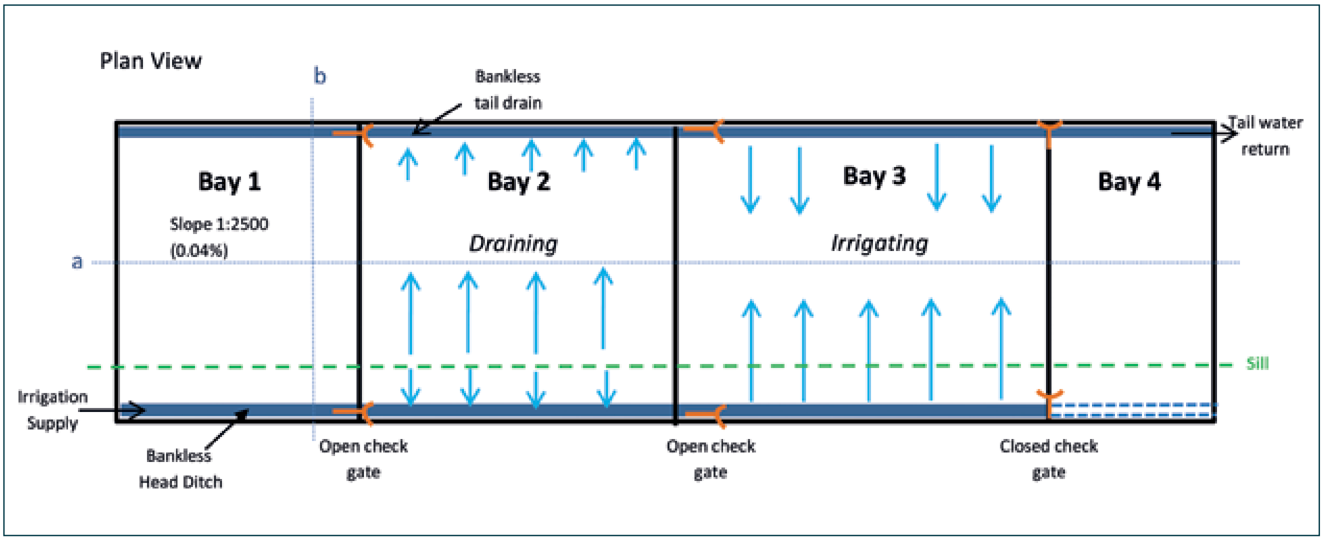
We hope that we get a more even application uniformity with the bankless design and may reduce water losses by reusing tail water. We are measuring water on and off using a Davie-Shepherd flow meter, flow meters on the inlet pipe and on gates between bays.

Productivity: Operational efficiency is our primary driver and includes measures such as water efficiency and tractor/machinery efficiency. With only one year of irrigation, we are still learning how the system works, and how we can maximise the efficiency of it. We are targeting a 30% improvement in operational efficiency. The change to Bankless Channel has improved our application uniformity across the field. Going forward we are hoping to measure water flow and measure each bay to develop a better understanding of the efficiency and history of use.

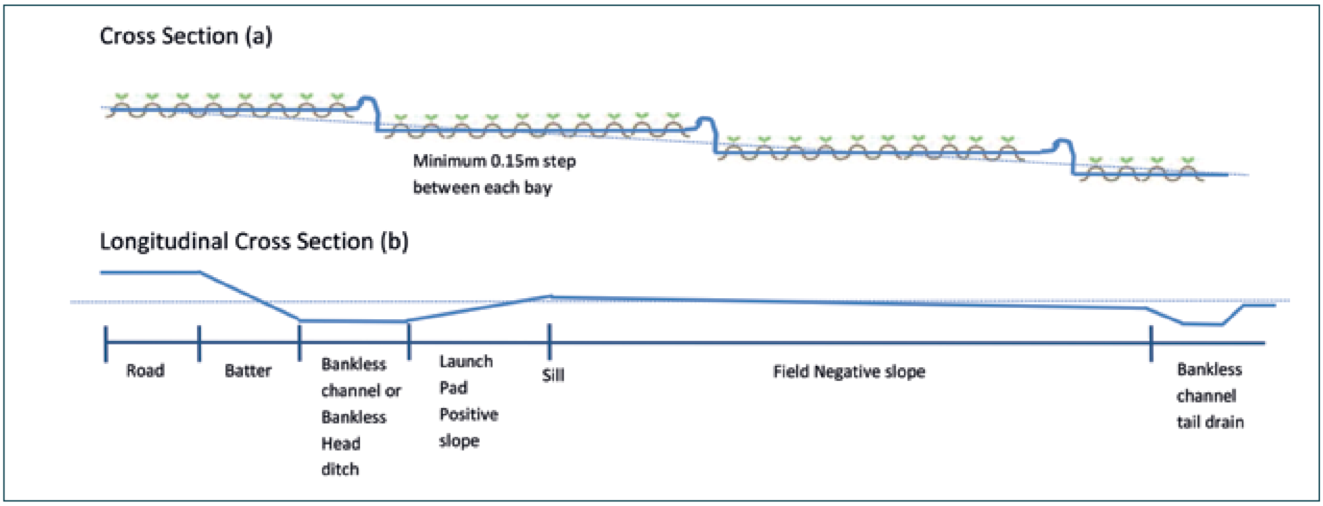
What worked well?
We worked with our engineers to try to minimise the amount of earth work necessary, this ensured the approach was as cost effective as possible. The result is that there are different slopes, bay widths and management requirements with different segments of the system.

Have you seen any issues with tail water management or drainage?
We are running more tail water, but it is backing up the field in each bay.

What might you consider going forward?
Automation: Currently using boards, not specifically looking to automate as yet. Have utilised Padman pneumatic weirs at Yattlewondi.



Plan View.



Additional sensors: We will continue to utilise C-probes. We are interested in getting a better understanding of water movement at various spots in the fields and are trialling some water advance sensors.
Other: We have not had a wet season or any heavy storms as yet, so we have not seen how the systems will manage flood conditions.

Description of watering Mundine Field 1:

This 182 ha GL Bay development consists of four bays. Flow capacity of 100 ML/day watering bays that are 400m wide and 1140m in length.

Referring to the plan view, the 'GL Bay' system operates by filling a below ground level head ditch called a 'Distribution Basin' with water flowing through an inlet pipe from the supply channel. This distribution basin looks exactly like a deep tail drain, and as the water level rises in it, the water pushes out into the furrows. About 50 metres along the furrow is the high point (Sill) that the water will flow over before moving down the general slope of the field. With the installation of a check structure in the tail drain between the bays, tail water is held in the bay and forced to back up the dry rows. When the water flowing down from the head ditch has joined up with the tail water backup, the check structure in the 'Distribution Basin' between bay 1 and bay 2 is opened. The drop in elevation from bay 1 to bay 2 of 20 cm draws the supply water into bay 2. This lowering of the water level in the 'Distribution Basin' of bay 1 pulls the water back away from the sill.

Then the check structure in the tail drain between bay 1 and bay 2 is opened so that tail water from bay 1 can flow into bay 2 and be used to backup. This process continues, with the only tail water going to the recycling system coming from the last bay.

Wathagar

Owner:	Sundown Pastoral Company	
Managers:	**General Manager:**	Nick Gillingham
	Irrigation Manager:	Nathanial Phillis
Irrigation Area:	10,000Ha	
Water Source:	Gwydir and Mehi Rivers	

Bankless Flat Flat design

Sundown Pastoral Company operations were developed for standard siphon irrigation. In recent years the operations have initiated the transition to a bankless channel design in areas where suitable. In 2008-2009 the first design was installed a small roof top design of 32ha in field K29 featured in the Keytah System Comparison Trial. In 2012-2013 a small investigation of the launch pad design was initiated, and in 2016-2017 the operation initiated the current installation of the flat flat design over a much larger area. The current designs incorporate components learned from on farm experience and from investigation of systems on other farms. Field W19, W20 and W21 grew their first crops in 2017-2018, W17 and W18 have been completed but are yet to grow a crop and the case study fields W5, W6 and W7 are currently in development. The developments have involved turning the furrow direction 90 degrees.

Key Questions:

How did you determine what design to install?

Significant time was spend considering how we could progress to a bankless design with minimal cut and fill. Experience was gained from small on-farm bankless fields and from discussions with other farmers. Our experience with both roof top and launch pad demonstrated that it did not suit our needs. The designs chosen needed to provide benefits in a number of areas including management of both tail water and labour and energy efficiency.

System at a glance:

SITE	FIELD W5	FIELD W6	FIELD W7
Soil type	Grey Vertisol		
System type	Flat		
Field size (ha)	190ha	190ha	190ha
Row length (m)	850m	850m	850m
Number of bays	5	5	5
Bay width	1* 200m 4*432m	1* 200m 4*432m	1* 200m 4*432m
Field slope	Nil		
Bay slope	Nil		
Cut/Fill (refer to map)	$600m^3$ – $872m^3$	$763m^3$ – $943m^3$	$809m^3$ – $1208m^3$
Supply flow rate (ML/day)	60ML/day at both sides of field	60ML/day at both sides of field	60ML/day at both sides of field
Structures installed	2 weirs between each bay	2 weirs between each bay	2 weirs between each bay
Steps between bays (mm)	250-340	330-480	310-550
Time to irrigate bay (Hrs)	8	8	8
Previous field set up	Standard siphon (90° change in direction)		
Sensors installed	Soil probes		
Cost ($/ha)	≈$2,000/ha earth works $1,000/ha structures		
Automation	Not currently		

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

Used Jay Carrol from PCTAg, we worked in consultation with Jay to discuss the layout and design. The designs and planning documents were developed through this consultation. We made adjustments to some of the specifications following our experiences with W19-21 in 2017-2018.

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

Labour/Lifestyle: The developments will see a change in staff management, with more permanent skilled labour and less reliance on casual labour. This removes the need to train new casual labour each season. In addition, it provides increased security for permanent staff. Changes between bays and fields runs more smoothly and is less labour intensive which is beneficial for permanent staff.

Energy: To date we have seen improvements in fuel consumption due to reduced tail water pumping. Pumping times have reduced by approximately 85%, which is saving an estimated 1,250L of fuel.

Water: Don't think that there has been any saving of water in field but believe that there is potentially 5-10% saving from cycling water from one tail drain to the next; for example, in W5, W6 and W7 the tail water is reused in five bays before being put back into the main tail water return.

Productivity: There are improvements with ground passes such as cultivation, spraying and the installation of rotobucks. Savings are in the vicinity of 30%. Additionally, there is no need to put siphons out at the start of the season, nor collect them at the end.

"The flat flat system is ideally suited to our soils, or in situations where infiltration can be difficult. We have found that the bays wet up more evenly than other systems, i.e. more consistently filling the whole bay to the desired depth."

Other: Provides flexibility to use fallow fields to help manage heavy rainfall events.

What worked well?

The flat flat system is ideally suited to our soils, or in situations where infiltration can be difficult. We have found that the bays wet up more evenly than other systems, i.e. more consistently filling the whole bay to the desired depth (actually filling the bay up rather than running water through the bay). We have found that they drain well, this has also been seen by other growers who have seen less damage from water logging because the water spreads more evenly and then drains evenly. The fields can be irrigated faster/

more efficiently because every ML of water supplied to the field is usable, none is returned until all five bays have been watered.

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

Field edge Batters: We had to ensure that the field edge batters were not too steep. Initially ours were five metres, which was too short for tract machinery. These have now been extended to 10m. The most important aspect is the hinge point between the field and the batter, this needs to be designed to enable smooth transition of machinery across the hinge.

Weir Choices: The height of the weirs must not be too close to the field height. It is important to have good design parametres which will enable you the flexibility to use the weirs as you need; for example, to be able to back the water up into the field if required, without topping the weir.

Check Banks: These need to be higher and more secure so that they do not become a weak point in the design. The W5, W6 and W7 design have check roads, these are designed so a vehicle can travel on them. The check roads are approximately four metres wide with an eight metre footprint compared to a more typical three metre configuration. They were installed because it was easier to build and maintain, and they are more secure. They are also beneficial for improved access to the crop for irrigation or agronomy assessments. This design did mean that all the weirs had to be drive over as they were fitted in through the check roads on the floor of the drains.

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

The batters, weirs and check roads were all design changes which we have implemented following our experiences in the two previous flat flat design developments.

This current design is implementing some very large bays of 40ha.

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

We are running less tail water than with siphons, it is all re-used in each of the consecutive bay. We would have liked to have been able to use the tail water from the last bay in the adjacent field, but this would have introduced a number of challenges in timing irrigation in adjacent fields. To avoid introducing too much complexity this has not been done.

What might you consider going forward?

Automation: The system has been set up to enable automation of weirs between bays. This has the potential to further streamline irrigation and help improve energy utilisation.

Additional sensors: There is also potential to install automation of supply channels, and to use channel level sensors and water advance sensors. Importantly all of these aspects must be reliable and provide benefits from a management or efficiency perspective.

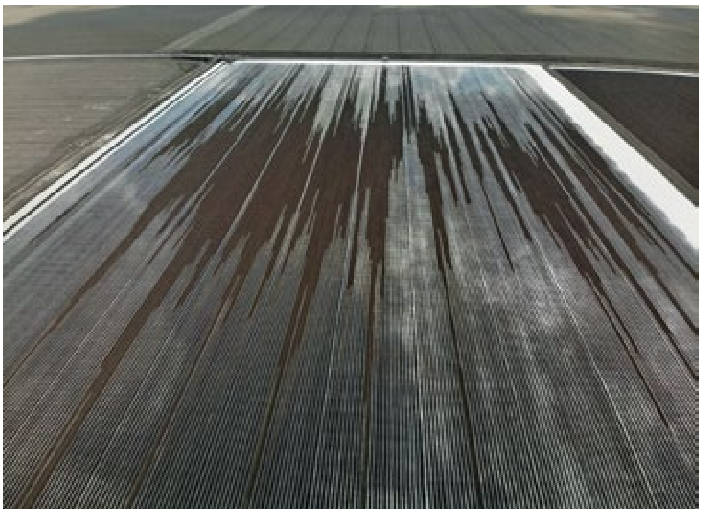
Bankless Irrigation

Bankless channel irrigation must consider many factors to ensure irrigation works effectively and full coverage is provided. Some of these factors include soil type (texture, structure, sodicity and susceptibility to erosion), slope, run length, the flow rate and gravity head required to move water along the field and the flow rate available to the field. If these factors are not carefully taken into consideration, the bankless system may fail to properly irrigate the field.

Background

A grower had a field converted from siphons over to a bankless layout and was pre irrigating for the first time to gain an understanding of the system. The siphon field was spilt into two fields each with a bankless head ditch at either end. The fields are therefore irrigated simultaneously from both ends.

After almost 24 hours of irrigation, the system had failed to fully irrigate the whole field (This was also exacerbated due to dry profile from minimal rainfall and heavy cut and fills in the redevelopment). As displayed in the image below, water had failed to advance to the middle of one of the fields and the furrows had been blocked up by sediment.



The Problem

Given this was the first season with the new system, the grower was not aware of the issues the system would pose and has identified the problems as:

Insufficient flowrate through the head ditch supply pipe. The inlet from the supply channel could not provide the flowrate required to water the field. An insufficient flowrate into the head ditch meant that a suitable gravity head could not be provided to move the water across the field. An inverse inlet to provide more head was therefore installed to increase the flow rate.

A 10:1 head ditch batter made it difficult for tillage equipment to enter and leave the field. When tractor wheels dropped into the batter the rig lifted and dropped dirt causing some furrows to be blocked resulting in preferential flow down unblocked furrows.

Additionally, the soil seemed to have a high susceptibility to erosion causing soil in the head ditch to be eroded and deposited in the furrows as water enters.

The grower was able to rectify these issues and subsequent irrigations were able to provide full coverage of the field. Given this is the first season, teething issues were expected by the grower.

The grower also noted that the following two bankless fields were created from cutting and therefore have nutrient depleted soils; something that growers should be aware of when implementing a system.

Future options

The grower will most likely change to two metre beds next season instead of the standard one metre bed configuration. The smaller number of furrows with two metre beds will significantly reduce the required flowrate, helping to provide faster coverage.

Conclusion

Bankless systems can offer the grower a whole range of benefits such as reduced labour, water usage and time to irrigate when done correctly. Growers must carefully consider their site's different characteristics to ensure the bankless system is designed appropriately to provide an even application of irrigation across the entire bay, fill the soil profile while minimising deep drainage and tail water losses.

As seen in this example, issues arose given the conveyance system could not provide a suitable flowrate to the head ditch and the furrows were blocked off from the tillage equipment leaving the field and the soil possibly being highly susceptible to erosion. Despite working with an irrigation designer, problems still arose due to the differences of a paper design and what happened in practice.

Smarter Irrigation for Profit –

Maximising on-farm irrigation profitability: southern connected system.

Sam North[1]; Nima Zoriasateyn[2]; Lloyd Chua[2]; Alex Schulz[1]; Don Griffin[1]

1. NSW DPI, Deniliquin, NSW, 2710 samuel.north@dpi.nsw.goc.au (03) 5881 9926
2. School of Engineering, Deakin University, Warun Ponds, Vic, 3216

The research

Research under the "Maximising on-farm irrigation profitability" project aimed to develop design criteria for optimising basin surface irrigation systems used in the rice and cotton industry.

Design criteria have been developed to assist in determining an optimal bay size given a soil type (moderate; low and very low final infiltration rate), bay configuration (contour, v-bay, beds-in-bays), and flow rate (1 L/s per m bay width; 2 L/s per m bay width; 3 L/s per m bay width).

Work is on-going to determine a minimum step, given bay size, bay configuration, soil type, and supply flow rate.

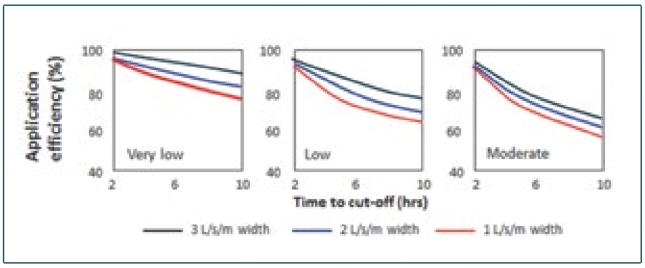
Characterisitcs of basin systems

Basin systems are surface irrigation systems that are characterised by:

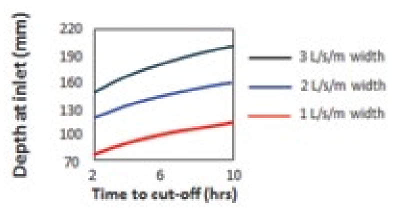
- A bund on all four sides of each bay
- NO SLOPE in the direction of water advance

(Compare to border check and furrow systems which are only bunded on the long axes, are open ended with supply and drainage at opposite ends, and water flows down a slope.)

Because basins are "filled", rather than irrigated by a "wave", there is potential for excessive deep drainage losses if basins are located on permeable soils. Consequently, they are best suited to soils with low final infiltration rates. This is illustrated in the following Figure, which shows how application efficiency decreases markedly as soil final infiltration rate drops (very low infiltration = sodic soils; low infiltration = red-brown earths; moderate infiltration = self-mulching clays) and bay size increases (i.e. longer time to cut-off)



Because there is no slope in the direction of advance, the head of water at the inlet end of the bay needs to rise throughout the irrigation advance phase in order to maintain an energy grade and "push" water to the end of the bay. This head is greater for rougher surfaces (e.g. crop or pasture compared to bare earth), higher flow rates, and longer bays. This is seen in the following Figure, which shows the relationship between water depth at the inlet end of the bay, flow rate (greater water depth with higher flows) and bay length (i.e. greater water depth with longer time to cut-off).



Characteristics of bankless channel supply/drain

When thinking about these systems, it is best to think about the bay surface configuration (i.e. furrows down the slope OR flat basins) and the delivery and drainage infrastructure separately. Bankless channel systems are peculiar because the stop/pipe between bays, firstly, acts as both supply and drainage and, secondly, hydraulically connects adjacent bays.

In bankless channel systems, the head of water in the filling bay rises and the head in the draining bay falls. This reduces the driving head through the structure between bays and supply /drainage flow rates fall. If the head difference between bays decreases to zero, then drainage will cease in the upstream bay and it will start to re-fill. The effect of this is to decreases application efficiency, markedly prolong irrigation opportunity times, and potentially lead to waterlogging.

This is why a sufficiently large step is needed between bays. If there is insufficient step between bays, then supplying and draining bays individually should be considered.

Key messages to irrigators

Basin systems are best suited to:

- slowly permeable soils – irrigation efficiency will be low in permeable soils
- soils that do not sub – water levels can be raised to over-top beds/hills

Bankless channel, basin systems are best suited to:

- highly dissected country or broken slopes where long runs will require large earthworks
- steeper slopes that are generally too steep for furrow

Furrow systems are best suited to:

- more permeable soils
- soils which sub
- long even grades
- flatter slopes

Use the irrigation system that best suits your soil and paddock slope.

Poor irrigation performance is inevitable if you design layouts only for labour saving. It should be noted that furrow systems can be cost effectively automated with Pipe-through-the-bank systems. Seek advice from your irrigation advisor. Further information contact your local CottonInfo REO.

NSW GOVERNMENT | Department of Primary Industries

Sustaining The Basin Irrigated Farm Modernisation (STBIFM) 2012-2019

$99 MILLION invested in **IRRIGATION INFRASTRUCTURE** on farm

$22 MILLION invested by > 80 **IRRIGATOR PARTNERS**

$77 MILLION invested through **COMMONWEALTH GOVERNMENT**

"Strong farms mean strong towns. The STBIFM program has helped to keep farmers and rural communities viable."
Richard Schwager, Wee Waa farmer and STBIFM partner.

10.6 GL kept on farm to enhance rural production

33.9 GL of WATER SAVINGS

23.3 GL water entitlement returned to environment

$655,000 invested in **PLANNING** for more efficient water use **ON FARM**

147 plans **COMPLETED**

$208,000 invested by **IRRIGATORS**

$447,000 funded by the **COMMONWEALTH**

IRRIGATED FARM MODERNISATION

- Overhead irrigation
- Reconfiguration of water storages
- Laser levelling of fields
- Bankless channels
- Automated systems

ENVIRONMENTAL GAINS

PRODUCTIVE GAINS

SOCIAL GAINS

On-farm improvements
Helps upgrade irrigation systems to save identified water losses

Planning support
Helps irrigators work out where and how much water is being lost on-farm

Training& development
To help operate irrigation systems as efficiently as possible

ENGAGEMENT

548 irrigators have taken part in **64** STBIFM field days and training & development events

NSW SUSTAINING THE BASIN
Irrigated farm modernisation

The Australian Government is providing more than $13 billion for implementation of the Murray-Darling Basin Plan and associated activities, with the vast majority (more than $8 billion) being made available for modernising infrastructure and water efficiency improvements. The Sustaining the Basin: Irrigated Farm Modernisation Program is funded through the Sustainable Rural Water Use and Infrastructure Program and implemented by NSW DPI across the Northern Murray Darling Basin.

Making Effective On-Farm Investment Decisions

Executive Summary

- The Rogers Adoption Curve shows how an average market place will adopt new technology.

- According to this theory the average market place can be split into 5 main categories:
  - *Innovators* – quick to take up new ideas and less risk averse. Will face many pitfalls but will have an intimate knowledge of the process
  - *Early Adopters and Early Majority* – learn lessons from Innovators and implement at reduced cost by avoiding pitfalls
  - *Late Majority* – adopt later than the average for reasons of economic necessity. More risk averse
  - *Laggards* – Last in so get less benefit from the new idea. Idea could be obsolete by time of adoption.

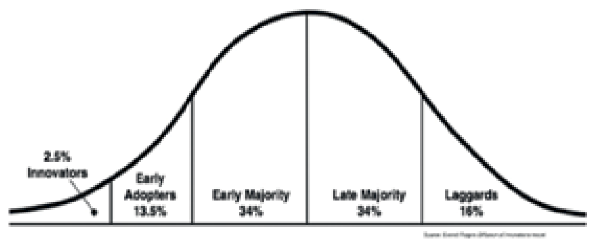
- When is the most profitable time to adopt an innovation? No one size fits all.

- We can analyse the return from the investment in innovation using different methods:
  - Return on Investment (ROI)
  - Payback Period
  - Average Annual Return.

- Key steps in calculating the Average Annual Return on an investment in a "Siphonless" irrigation system:
  - **Estimated Cost of the Investment** – Fully costed
  - **Expected Average Annual Net Financial Gain**
    - ♦ Expected cost savings
      - ◊ Labour/contract irrigation savings
      - ◊ Energy cost savings
      - ◊ Fertiliser savings
      - ◊ Other
    - ♦ Less: additional annual costs (before interest)
      - ◊ Depreciation
      - ◊ Other
    - ♦ Add: additional income
      - ◊ Potential yield increases? – Lack of research currently to support
      - ◊ Increase in area grown from water savings.
      - ◊ Expected Average Annual Return
  - (Expected Average Annual Net Financial Gain/ Expected Investment Cost) = x% p.a.
  - **Hurdle Rate** – What return is acceptable? Key factors:
    - ♦ Cost of bank debt
    - ♦ Inflation
    - ♦ Comparable returns – e.g. Australian farmers - average annual return 10%
    - ♦ Other factors when setting hurdle rate could include:
    - ♦ Lower hurdle rate
      - ◊ Reduced labour availability
      - ◊ Reduction in risk profile
      - ◊ Improved quality of operation
      - ◊ Greater potential for automation
      - ◊ Improved efficiency of plant operation
      - ◊ Improved work life balance
      - ◊ Improved sustainability?
    - ♦ Higher hurdle rate
      - ◊ Impact on management of disease and herbicide resistance?
      - ◊ Is the technology fully tested - Lack of trial results to date?

When is the Best Time to Adopt New Technology?

The diagram below is called the Rogers Adoption Innovation Curve. It shows the percentage of an average market place and how quickly they adopt new technologies. It is a key component of the Diffusion of Innovation theory developed by Everett M Rogers which was a leading theory post World War II in agricultural extension (and is still used today). Based on this theory 2.5% of a market will be the Innovators, at the cutting edge, whereas around 16% will be Laggards almost having to be dragged across the line.



Source: http://blog.leanmonitor.com/early-adopters-allies-launching-product/

Innovators take a "venturesome" approach, are quick to take up new ideas and can cope with uncertainty and failure. They play an extremely important role in introducing new innovations and in the flow of information about these innovations. While Innovators will face many pitfalls they will have a more intimate knowledge of a process than later adopters. There is no positive correlation between being an Innovator and being profitable.

Early Adopters / Early Majority are able to learn lessons from Innovators and therefore can avoid pitfalls and as a result can implement at a reduced cost as compared to the Innovators. They help trigger the critical mass when they adopt an innovation by providing their "stamp of approval".

The Late Majority adopt new ideas later than the average, often for reasons of economic necessity rather than through motivation for change. Most of the uncertainty needs to be removed before the Late Majority will adopt an innovation.

Laggards will have the maximum amount of information on an innovation from lessons learnt by others, but by definition will have less time to participate in the benefits of adoption, in fact the innovation could be obsolete by the time Laggards adopt it.

We feel that the understanding of innovation adoption is important. If profit is the goal (and we understand there could be many other goals in a farming business) then we need to understand when is the most profitable time to adopt an innovation.

There is no one size fits all.

To analyse this, we need to look at / agree on a way to analyse the profitability or return of adoption of innovation.

Evaluating Investment Decisions

Two relatively simple financial metrics for evaluating investment decisions that are often discussed are *Return On Investment (ROI)* and *Payback Period.* ROI is the total net financial gain of an investment divided by the total cost of that investment. For example, if I invest $100,000 and that investment generates a financial gain of $50,000 over the life of the investment, the ROI for the investment is 50%. While a simple calculation, the main limitation with looking at a simple ROI is that it tells you nothing about the time it took to earn that return on investment. 2 years? 10 years?

Payback Period is the length of time that it takes for the cumulative gains from an investment to equal the cumulative cost of that investment. In other words, how long will it take for an investment to pay for itself? For example, if I invested $100,000 and that investment generates a financial gain of $50,000 per year, the Payback Period for that investment is 2 years. Investments with lower payback periods are considered to have lower risk than those with longer payback periods. While Payback Period can be a useful tool for selecting from a number of mutually exclusive investment options it has limitations when evaluating a single investment decision, (what is an acceptable Payback Period?), and it doesn't consider the financial performance of the investment after the investment has paid for itself.

Perhaps a starting point for evaluating an investment in a "Siphon-less Irrigation" system is Average Annual Return, which is the expected average annual net financial gain from the investment divided by the cost of that investment, excluding funding costs. While this methodology has limitations, in that, in its simplest form, it won't take into account the compounding of returns or the impact of inflation, it is relatively easy to calculate for a "Siphon-less Irrigation" investment, easy to understand and readily comparable to an acceptable hurdle rate. The hurdle rate being the Average Annual Return rate required to proceed with the investment in "Siphon-less Irrigation". We expect that this hurdle rate will vary from grower to grower based on a number of factors mentioned below. (See Point 4).

Evaluating an Investment in Siphon-less Irrigation Using Average Annual Return as a Measure

In calculating the expected Average Annual Return on an investment in a "Siphon-less Irrigation" system the key steps in our mind are:

1. **Calculate the estimated cost of the investment.** Obviously the investment cost will vary from farm to farm based on topography (how much dirt do you need to move) and the constraints of the foot print of the existing irrigation support infrastructure.

   It is important if you intend to do part or all of the earthworks using owned plant and existing employed labour that you fully cost things like plant repairs and maintenance, plant depreciation and labour including on-costs into your calculations of the estimated cost of the investment.

   While, as stated above, the cost of converting fields under siphon irrigation to bankless channel configurations will vary greatly from farm to farm, we see often quoted a rule of thumb for these costs of around $1,500 per hectare. In recent times feedback received has been that the rule of thumb cost for conversion to bankless could start at $2,000 per hectare.

2. **Calculate the expected average annual financial gain from the investment.** The expected annual financial gain will be the sum of:

a) Expected cost savings, which will include:

i) Expected annual labour/contract irrigation savings – Based on say 9 waters, a contact irrigation cost for siphon irrigation of $20/ha per water plus $5/ha for putting the siphons out and $5/ha for picking them up, contract siphon irrigation would be $190/ha p.a. The ability to utilise existing labour for irrigating as a result of the reduced time required for irrigation with a "Siphon-less" system obviously provides significant savings. The numbers from the Keytah Irrigation System Comparison Trial published by the GVIA in 2016 suggest that the labour cost for irrigating cotton with a bankless channel system using existing employees could be as low as $11.20/ha p.a.

ii) Expected annual saving in energy costs largely as a result of reduced tailwater. The GVIA numbers from the Keytah Irrigation System Comparison Trial suggest of a saving of around $17/ha p.a. in energy costs between siphon irrigation and bankless channel growing cotton.

iii) Potential expected annual saving in fertiliser costs as a result of reduced leaching and reduced tailwater. At this stage it seems it is generally agreed that reduced tailwater can result in reduced fertiliser costs as there is less fertiliser lost from the field in surface runoff.

It is more difficult to accurately quantify any potential savings per hectare from reduced leaching.

iv) Other?

b) Less: Expected additional costs, which could include:

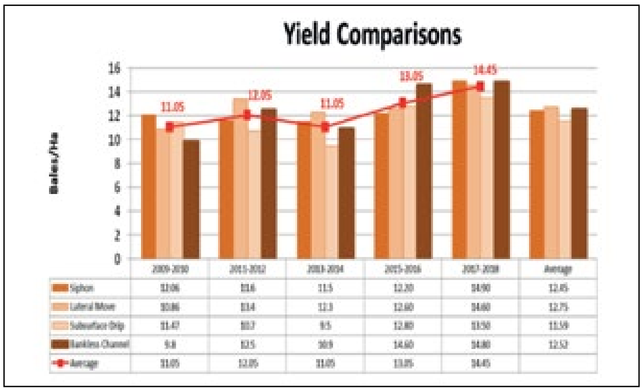
i) Depreciation. What is the average annual decline in value of the "Siphon-less Irrigation" system? Are there future system refurbishment costs which should be amortised in your calculations?

ii) Other?

c) Add: Expected increased net income, from:

i) potential increases in yield/ha. While anecdotally it has been suggested that greater precision in the timing and application of irrigations in "Siphon-less" systems could be leading to higher yields, it has also been suggested that potential average yield increases could be negated in the early years as a result of the removal of top soil from the "cut area" in developments. At this stage it seems that the research to verify the impact on yield is limited given that "Siphon-less" systems are continually being adapted and fine-tuned, research has been conducted for a relatively limited time and it seems that these systems may yet to be fully tested over a range of different seasonal conditions.

The below graph/table shows the average cotton yields achieved over 5 seasons by the 4 irrigation systems being trialled in the Keytah irrigation System Comparison trial. While this indicates only a small difference in yields achieved on average by the 3 highest yielding systems, our understanding is that in the first year there were delays in developing the bankless channel system resulting in sub-optimal planting and growing conditions.



Annual cotton yields from four irrigation systems (2009/10 – 2017/18) – Source Gwydir Valley irrigators Assoc.

ii) expected increased area grown annually as a result of water savings.

3. Calculate the Expected Average Annual Return for your investment in "Siphon-less" (Expected Average Annual Net Financial Gain/ Expected Investment Cost) = x% p.a.

4. Determine your hurdle rate – What is an acceptable Average Annual Rate of Return for the Investment? While hurdle rates will vary from enterprise to enterprise, we feel that key considerations will include:

a) What is your current cost of capital (what interest rate are you paying on your bank debt) and is this expected to change over the life of the investment? 4 – 5% currently?

b) Current and expected inflation rates.

c) Comparable returns:

i) Average annual returns for Australian

Farmers, 10% (3% operating return, 7% capital appreciation in farm assets)

ii) Australian Share Market – Average Annual Return of 9.96% p.a. from 1900 to 2016.

d) Factors that are difficult to quantify currently but could support a lower hurdle rate for a "Siphonless irrigation" investment decision:

i) Reduced labour availability – The financial impact of reduced labour availability could be significant given the importance of timing and detail in irrigated agriculture. If you live in an area impacted by reduced labour availability can you afford to be a "Laggard"?

ii) Reducing the risk profile of your enterprise through having lower numbers of employees/ contractors on your farm and as a result reduced potential WH&S risk

iii) The potential for improved timing and precision of irrigation operation resulting in improved yields through having permanent staff conducting operations rather than casuals/ contractors

iv) Greater potential for further automation in the future – Technology is continuing to improve and will become cheaper and connectivity is improving rapidly in rural areas

v) Subject to layout, improved efficiency of plant operation through being able to continue operations through fields without the constraint of head ditches

vi) The possibility for improvements in deep drainage, water-logging and soil health over the longer term

vii) Improved work/life balance for employees and business owners.

e) Factors that are difficult to quantify currently but could support a higher hurdle rate for a "Siphonless irrigation" investment decision:

i) Lack of trial results to date on a commercial scale over a long enough period to encounter a range of seasonal conditions

ii) Unknown impact at this stage on longer term issues such as management of disease and herbicide resistant weeds.

1. In relation to the suggested methodology for calculation of estimated the cost of the investment in a "Siphon-less" system and expected annual financial gains we note:

2. While it would be technically correct to do so, we haven't suggested using after tax amounts for the calculation of net investment cost and expected annual net gains. As capital expenditure on water facilities by primary producers are fully tax deductible in the year of expenditure the Average Annual Return will be the same under both pre-tax and post-tax calculations. In our suggested calculation methodology above we are assuming that any capital appreciation in farm values as a result of adopting a "Siphon-less" system is negated by the likely reduction in green area resulting from the increased foot print of support infrastructure for "Siphon-less" systems. As such we have not allowed for capital appreciation/depreciation in land and water values in the calculation of expected net annual gain.

3. We have not allowed for a reduction in grown area (in fact we have suggested that there could be an increase in grown area due to potential water savings) in our calculation of expected net annual gain as it seems that in most years water, not land, is the limiting factor when deciding the total area to be planted.

4. We feel that there is no need to consider the cost of current infrastructure in your calculations. What you have spent is a sunk cost and is not relevant to your decision.

5. We feel that it is important that following the implementation of an on-farm investment decision that the actual results being achieved are regularly calculated and reviewed and compared to the assumptions used to evaluate the investment decision. This not only allows returns to be maximised through fine-tuning of new systems but also will promote improved decision making for future investment decisions.

In conclusion, no one investment is right for all, but the blanket adoption of new technology, at least from a short term profit viewpoint, is always worth reviewing. We feel that by having a framework for analysing investments in new technology, and consistently reviewing and fine-tuning this framework and decision making process over time, you will more consistently make more optimal decisions on the timing of adoption of new technology in your business.

Phil Alchin & Jono Hart
Boyce Chartered Accountants – Moree

BOYCE CHARTERED ACCOUNTANTS
Knowledge. Insight. Experience.

More Information:

CottonInfo:

www.cottoninfo.com.au

GVIA:

www.gvia.org.au/community-and-industry-initiatives/industry-partnerships/siphon-less-irrigation

NSW DPI:

www.dpi.nsw.gov.au/agriculture/irrigation

IAL:

www.irrigationaustralia.com.au

NW LLS:

www.northwest.lls.nsw.gov.au

STBIFM:

www.dpi.nsw.gov.au/agriculture/irrigation/sustaining-the-basin