SOUTHERN IRRIGATION DEVELOPMENT

An irrigation consultant's perspective

AgEcon RESEARCH, DEVELOPMENT & EXTENSION SERVICES

CASE STUDY JANUARY 2025

BACKGROUND

Michael Naylor is an irrigation consultant based in the Murrumbidgee. In this case study, Mike steps through the process for considering irrigation design and provides an example for changing from siphons and rotabucks to an automated "Pontoon" Large Pipe Through the Bank (LPTB).

- Mike Naylor: Irrigation consultant (30 years)
- Case study: Bore Block on western edge of Coleambally Irrigation Area
- Irrigation area in this analysis: 580 ha
- Irrigation conversion: 24 ha siphon / furrow to pontoon LPTB / furrow (down the slope, zero sidefall)
- Water Source: Murrumbidgee (via CICL and private channel) and bore.
- Average annual rainfall: 350mm / year evenly spread (~30mm/month) Rain events usually 10-20mm, summer storms <100mm (unusual).
- ETo 1800 mm ~2 mm/day winter, 6-8 mm/day spring, 12+ (19) mm/d summer peak
- Summer hot 36-42 C and dry (rain ineffective), winter -4 C (frosts, rain effective)

INFORMATION REQUIRED & CONSIDERATIONS OF DESIGN

Any irrigation design requires consideration of several key factors (listed below) and potentially other farm specific factors that may come up during the design process.

- Soil types
- Climate
- Annual average available water
- Available flowrate
- Surface elevations
- Typical cropping rotations and water budgets
- Cash flow / available finance

Elevation, flow rates, available water, crop choice and labour can all be manipulated (at cost). Many of these factors impact each other as well as influence the "best" irrigation system design choice (linear move, centre pivot, drip {other pressurised systems), or a version of surface or flood irrigation).

In the case of southern areas, permanent flooding may be required for potential rice production. Consideration may also be given for stock grazing.

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Soil type and climate are generally beyond the farm managers control and may result in ruling out some irrigation designs, or irrigation simply not being a viable option.

"Not proceeding with irrigation development has been my recommendation on occasions. It is just better to be upfront and realistic rather that spend a lot of money on a system that just doesn't work." - Mike Naylor

A single soil type makes irrigation design simpler. Sandy soil with deep percolation rates may mean that flood irrigation is unsuitable. Soils with low intake rates may be less suitable to pressurised systems.

Water access, availability and potential flow rates on farm are all considerations for irrigation design. For example, if daily water supply is limited, this may exclude large bays and sets or long pressurised systems.

Labour availability may not keep up with a crops demand for water. This factor has driven interest in remote monitoring as well as irrigation designs that reduce labour requirements and allow for irrigation automation.

DEVELOPMENT EXAMPLE: SIPHON TO PONTOON LPTB

The recently purchased property located on the western edge of the Coleambally Irrigation Area has access to bore water as well as Murrumbidgee water via CICL (Coleambally Irrigation Co-operative Ltd) and private channels. The property is focused on irrigation and had been previously partially developed for row cropping and border ditch irrigation.

The new owners also have an adjoining property, with a range of irrigation designs including; pontoon, level bays as roll over and furrows along the bay, siphons and medium pipe through the bank, border check (cattle) and previously rice in contours.

They are motivated to redevelop the new farm with the aim of gaining improvements in both water use and labour efficiencies such as those experienced from recent irrigation redevelopment and implementation of automation on their home property.

AVAILABLE FLOW RATE

The preferred irrigation design for the new property requires 30 ML/d pontoon inflow. This is achievable from either bore or CICL capacity. To suit the summer and winter cropping rotations and poor subbing soil 1.8 m beds with a "camel hump" or shallow centre furrow are used. Sets of 72 m allows easy conversion from 1.8 m beds to 1 m beds if required.

Pontoons are 80 1.8 m beds (144 m). 1.8 m beds have about 45% less furrows than 1 m hills. At 30 ML/d changing from 1.8m beds to 1m spacing reduces the furrow inflow from 0.375 ML/d/furrow to 0.208 ML/d/furrow which would increase the flow variability within each pontoon. At most times 40 ML/d is available to each pontoon.

"If the flowrate was restricted to 30 ML/d inflow and 1 m furrows I would suggest pre-storing and releasing water to get the flow rate up. Always have a fallback position!" - Mike Naylor

DESIGN CONSIDERATIONS

"We are aiming for a design suitable for potential automated machinery in the future."

- A new design should minimise the area of supply, drain and roads and lost area without compromising supply, drainage or access.
- Each downslope area should incorporate a backup area at the bottom of the field that returns water from fast rows to the slow ones in the same set.
- The backup area should probably be the same for the siphons as the proposed Pontoons supplied by LPTB.
- The field tail is the same batter and tail drain and road for pontoons and siphons (see Figures 2 & 3).

"For this design 2 to 3 Pontoons back up together (1 drain per 2 or 3 pontoon widths). I believe this should be 1 per pontoon but it costs $$$$$ to extend the main drain, extra structures and automation of those.

As a result, the first pontoon watered backs up all 3 and the drainage is released. The other 2 pontoons come through quickly because the backup area is already irrigated."
- Mike Naylor

SOUTHERN IRRIGATION DEVELOPMENT

An irrigation consultant's perspective

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THE COMPARISON

This comparison considers an existing 900m long field, 288m wide to step through the process to convert from a functioning syphon irrigation to a pontoon LPTB and automate irrigation. With a 900m long field, one 50mm siphon per furrow takes too long. This example assumes one 65mm syphon per 1.8m furrow (160 beds total).

Siphon Plan

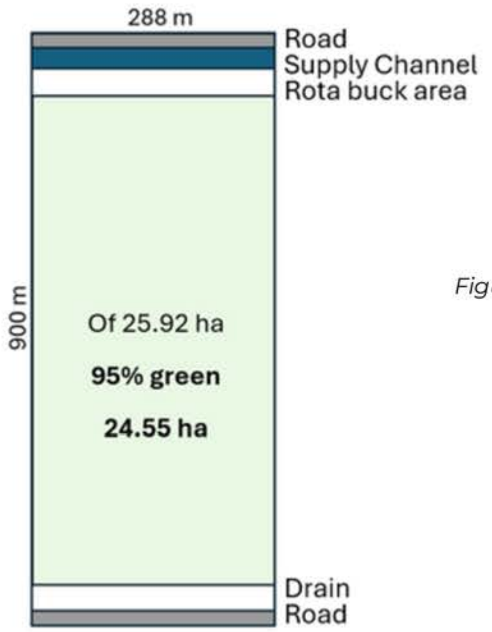
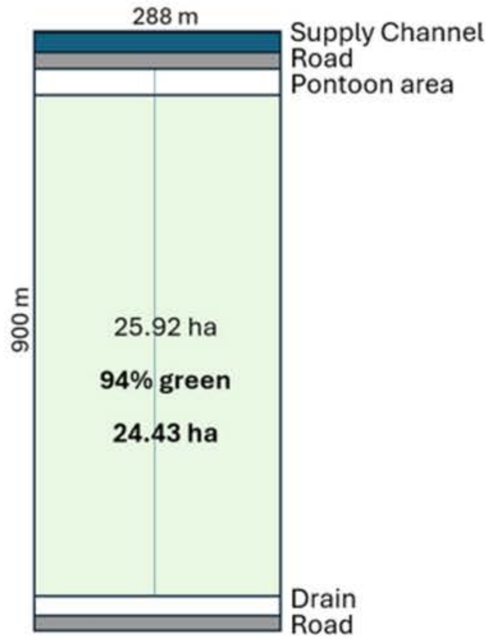


Figure 1. Field plans

LPTB Pontoon Plan



- 2 x 144m sets with 1.8m hills (80 beds)
- One 65mm ID syphon each furrow, 80 syphons per set 12.28ha
- 30 ML/d applied= 0.375ML/d/furrow
- Refill 60mm requires a run time of between 8 and 10 hours

The refill is different between the two systems because siphons give lower head in the furrows and so must run longer to try to sub up and are not irrigated as frequently as the automated pontoons due to labour constraints.

- 2 x 144m pontoons separated by stub banks
- Each pontoon = 80 x 1.8m beds
- To maintain relatively even distribution 80 furrows (144m) have 30ML/d applied 0.375ML/d/furrow or at 40ML/d. 0.50ML/d/furrow
- Refill 60mm takes 6-8 hours per 144m but at 40ML/d refill 60mm 4.5hours

LONGITUDINAL CROSS SECTIONS

Figure 2. Longitudinal cross section - Siphons

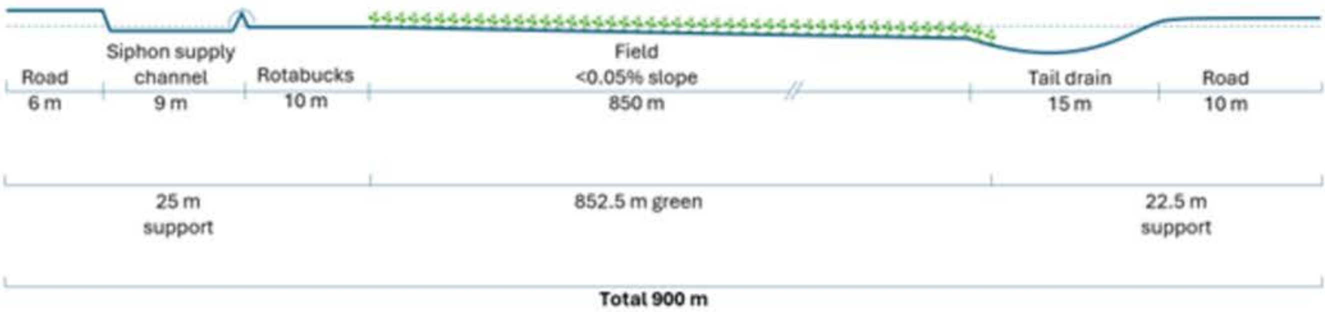
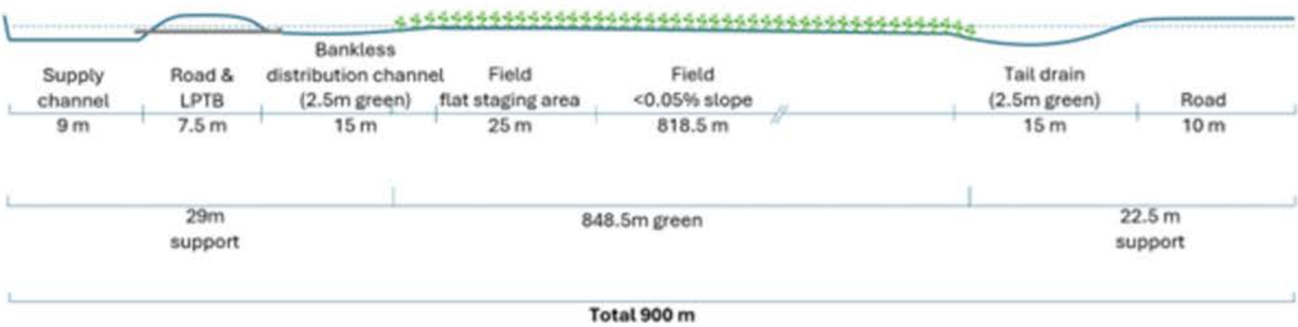


Figure 3. Longitudinal cross section - Pontoon and large pipe through bank



SYSTEM COMPARISON

Table 1. System comparison siphon v pontoon

	SIPHON	PONTOON
Flow rates (supply)	30 ML/day	30-40 ML/day#
Area irrigated	12.28 ha	12.22ha
	80 1.8m beds	80 1.8m beds
	80 65mm ID siphons	750mm ID LPTB
Flow rates per furrow	0.375 ML /day	0.375-0.50 ML /day
Water – Summer crop		
Water up or pre-irrigate	1.5 ML/ha	1.2 ML/ha
In crop irrigation @ 1 ML/ha	2	
In crop irrigation @ 0.6 ML/ha	8	14
Total water use per hectare	8.3 ML /ha	9.6 ML /ha*
Labour – Summer crop		
Time required per siphon change (45 mins per change^ x 2 sets x 11 irrigations) = 16.5hrs	16.5 hrs per season 40 mins /ha	0
Checking pumps, channels**	18.3 hrs 44.7 mins/ha	4.5 hrs 11 mins/ha
Pick up siphons, lay out siphons (1 x year)	3 hours 7.5 mins /ha	
Build / Knock down rota bucks (45 mins, 3 x year) = 2.25hrs	2.25 hrs 6 mins/ha	0
Total irrigation labour	66.30 hrs /year 162 mins /ha /year	4.5 hrs /year 11 mins /ha /year =93% reduction in labour

#This Pontoon system is designed for a minimum of 30ML with the option of increasing flow rates via additional (supply) inflow via stored water or recirculation (drainage / tail water). The siphon system would not accommodate the additional inflow without doubling up siphons and reducing sets sizes.

**On this farm under irrigating has occurred due to labour limitations, the automated pontoon system removes labour restraints creating the ability to water the crop as required - resulting in higher water use corresponding to a higher targeted yield.*

^Time taken to stop / start 80 syphons = 25 mins, plus 20 mins driving / monitoring etc

Remote monitoring (bay and channel sensors) reduces the time spent checking water levels for either level basins or pontoons to near zero (4.5hrs allocated to monitoring). Without remote monitoring estimated time driving / monitoring channel levels etc is 50 mins per change x 2 sets x 11 irrigations = 18.3hrs. Gains from remote monitoring can be made without irrigation redevelopment.* ***NOTE: *Per hectare labour inputs are highly influenced by row length. This example uses relatively long row lengths of 900 m. The shorter the row length the higher the labour input per hectare.*

CONVERSION COSTS

Earthworks

This example assumes the drainage, recirculation system, supply to field and roads are in place for furrows and are suitable for pontoon. In this example the field and tail drains remain untouched, with earthworks restricted to the range of the top boundary to the staging area (50 m). The earth works are estimated to cost a total of $10,000 (ex GST) based on the current costs 09/2024 (see Table 2).

This is a very basic conversion cost, most conversions will also include some change to field layout, requiring more dirt to be moved (at additional cost). When new areas or old structures are included within a new field soil damage reduces yield, and the cost of a field regrade needs to be included. A field regrade is not included within this simple conversion comparison. It is also assumed that normal ground prep is carried out on the field.

In the case where there is side fall and or a step between pontoons allow for a dividing bank. In this case there is only a stub bank across the Pontoon feed for each inlet and one per drain outlet and it is sown. It may be necessary to provide a drainable field supply so the whole supply system does not have to drain.

Infrastructure

This example assumes the water supply and recirculation system are in place for furrows and are suitable for pontoon. For this system Mike would recommend Padman PE pipe ends with rubber flaps (750 dia pipes and a 900 Padman bubbler). Experience has found that the PE with rubber flaps is almost waterproof. It is essential the door must be held down after irrigation to drain the distributer back to supply, and they rarely leak ensuring the distributor dries for machinery access between irrigations. These ends are also automation ready.

In contrast, Mike has found the Milcast headwall with aluminium door in rubber ACTDC often leak, less so with automation pressure down on the floor seal and they are a lot cheaper to purchase and install. This option will allow drain back of distributor to supply by opening the door. This design does not allow for overflow, and for automation it needs a special fitting on the door for the actuator.

"Ensure all structures are located beyond or beneath the length of cropping toolbars and boom and are at the end of the toolbar not in the middle of the tractor to avoid damage." - Mike Naylor

For this project 750 dia pipes were chosen to allow increased flow at low head loss. Field inlets are 3 socket/spigot and 1 spigot/spigot pipe long. Both Padman and Milcast structures rubber ring join so remember to order the extra rubber for the spigot/spigot.

CONVERSION COSTS CONT'D

Automation

Padman timers are transportable, have no feedback and are reasonable to program. You just need to move them and get the timing settings right. Some of them were used on this job initially and are still at the home farm.

This project will be automated using a Bidgee Automation system. It has a solar panel, battery, control box and pole to pole radio connected to a linear actuator at each structure, pump etc. It is linked back to a home base computer and SMS messaging to a mobile telephone. Using the internet the operator can mobile phone link back to the computer to interrogate and change any settings.

Remote monitoring works similarly and also connects to the home base. There are bay depth sensors, flow sensors, motor / pump controls etc. Each sensor is linked back to the base antenna and computer which has alarms and can be interrogated by mobile phone.

"With narrow roads, if using the channels for equipment overhang, placement of automation poles is important!" - Mike Naylor

Labour savings from the installation of remote monitoring apply to both systems (time saved from driving to check channel heights etc), the pontoon automation relies on these sensors to change bays, so the cost of automation is included in the conversion costs and the benefits for reduced irrigation time are also included.

Total costs

The total cost of converting the existing siphon irrigated field to a pontoon LPTB (288 m wide paddock) is $42,480 (see table 2) or $1,739 per green hectare. These costs include earthworks to the irrigation supply end of the field only, infrastructure and automation.

The size of the field highly influences the per hectare costs. The longer the field length, the more cost effective per green hectare conversion is. For example, if these same costs were applied to a field 500m long (instead of 852.5 green row length), the costs change from $1,739 /ha to $2,950 / ha.

Similarly, the infrastructure and automation costs listed in this example could service a wider field length (increasing the hectares serviced and decreasing the per hectare costs).

The primary consideration is: do the benefits outweigh the costs?

CONVERSION COSTS CONT'D

Table 2. Cost of conversion siphon to pontoon

		COST^
	EARTH WORKS	
	Site establishment & design	$1000
	Remove the siphon road and supply channel and grade the channel as a pad (Grader 2hrs @ $240/hr, Laser Bucket 2hrs @ $290/hr)	$1260
	Rip from top boundary to edge of staging area (25-50m plus supply and distribution) (Laser bucket 5 hrs @$290/hr)	$1950
	Rebuild supply deep enough to drain pontoon feed. 1.00m rather than 0.90m (Grader 4 hrs @ $240/hr)	$960
	Cut the distribution channel and build road (Laser bucket 5hrs @ $290/hr)	$1950
	Level staging area (Laser bucket 3hrs @ $290/hr)	$1170
	Install two outlets (Excavator 6hrs @ $220/hr, Labour 6hrs @ $40/hr)	$1560
	Build two stub banks (Pontoon distribution bays & tail drain banks) (Excavator 1 hr @ $220)	$220
		$10,070
	INFRASTRUCTURE (2 pontoons)	
Drainage	Pipes (2.4m concrete 600dia) (5 pipes per two pontoons) installed $4900	$4900
	Automate discharge structure (1 per two pontoons @ $1000 ea)	$1000
Supply	Control headwall (1 per pontoon @ $1400)	$2800
	Nib (3 per pontoon @$30)	$180
	Pipes (750 dia) with PE900 pipe ends & rubber flaps (1 per pontoon @ $1100 ea)	$2200
	Bubbler (1 per pontoon @ $1300)	$2600
	Install cost including excavator, labour (3hrs per pontoon of excavator @$220/hr & labour @ $40/hr per pontoon)	$1560
	Foam & sundries	$120
Automation	Padman timer (portable, $2000 ea)	$2000
	Inlet and drainage nodes (2 inlets and 1 drain for the two pontoons @ $3250ea)	$9750
	Base node and laptop	$4000
	Water level sensors supply, pontoon distribution, tail drain	$800
	Install cost	$500
		$32,410
	TOTAL	**$42,480**

^Indicative pricing, freight inclusive, ex GST. September 2024

BENEFITS

Water Use Efficiency

This property has soils with a low water holding capacity. The lower plant available water in the soil is used quickly and increases the frequency in which irrigation is required. Labour restraints meant in the past, irrigation scheduling didn't meet the crops requirements. The quicker irrigation time and automation within the pontoon system allows the number of irrigations to be increased without labour availability concerns.

Depending on soil type, pontoons quicker irrigation time could potentially reduce deep drainage and waterlogging, thereby improving yield. Another potential benefit not valued in this analysis is system efficiencies by getting the whole farm irrigated faster.

Labour savings

In this example the irrigation conversion from siphons to LPTB pontoon, including (automation and remote monitoring) results in an estimated 93% reduction in labour costs (see Table 1). These labour savings include:

- Avoided time requirement for starting / stopping syphons. This benefit is a product of seasonal conditions and crop rotations, on average summer crop is irrigated 11 times (due to poor water holding soils).
- Avoided rota buck knockdown and reconstruction (3 per summer). (There are usually 1 cultivation pass and at least 2 ground rig spray passes plus harvest requiring rota buck knock down and reconstruction)

Reduction in labour time is related directly to the number times there is an irrigation on a field within a year. In this example we assume a cotton crop grown 2 out of 3 years. There would also probably be a winter crop and potentially other summer crops in the rotation, however a simple and conservative approach has been taken (11 annual irrigations, 3 avoided rotabuck knockdowns and reconstructions). For soils with higher water holding capacity or crops with a lower frequency irrigation schedule, the benefits would be reduced. An irrigator in Cecil Plains (for example), who may only irrigate summer crops 3 times would experience reduced benefits in terms of water and labour savings.

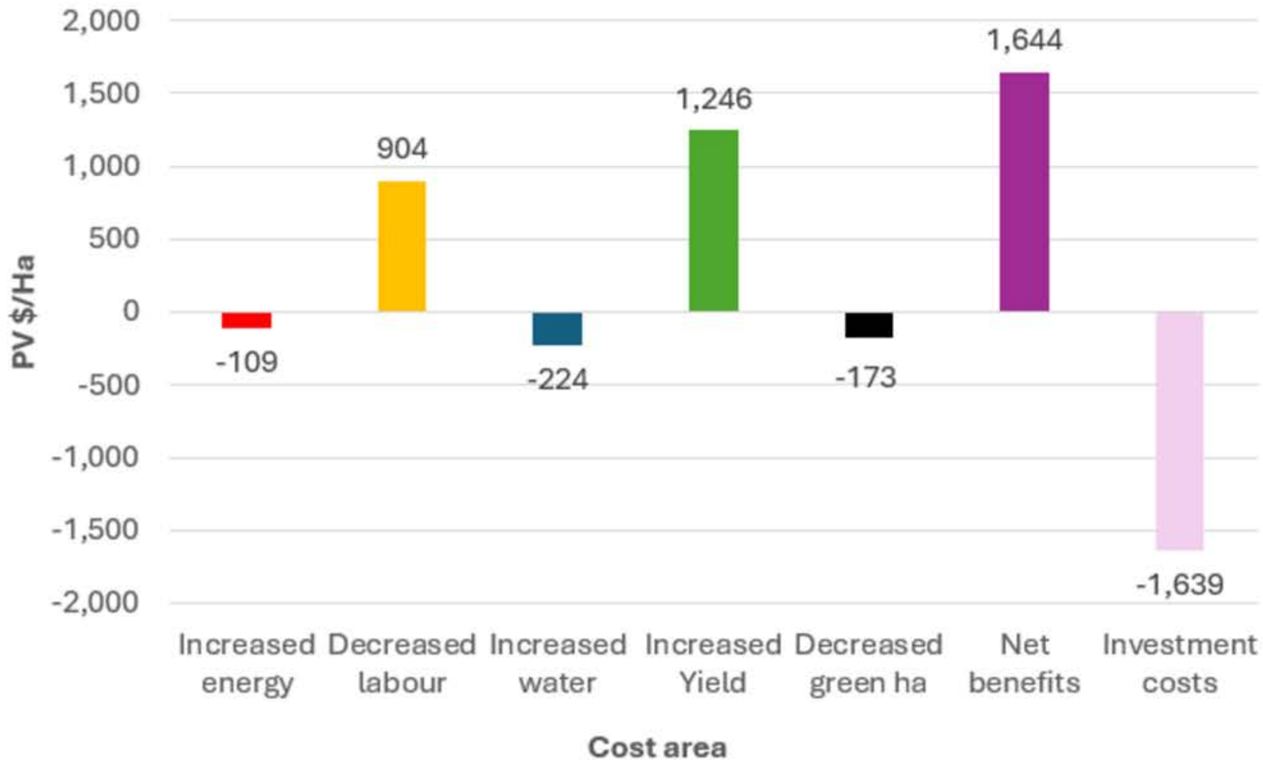
Yield change due to optimal watering

The increased irrigation budget assumes an associated increased yield. Seasonal yield variability makes it very challenging to compare system yields. The cotton yields in the example field have ranged from 7 to 12.5 bales/ha over the past 5 years, similar to top district yields.

This range on a seasonal basis makes it almost impossible to compare system yields unless there is still some siphon country on the same soil, slope etc. In this analysis we consider what average yield increase is required to break even on the investment.

RESULTS

Figure 4. Net present value benefits and costs



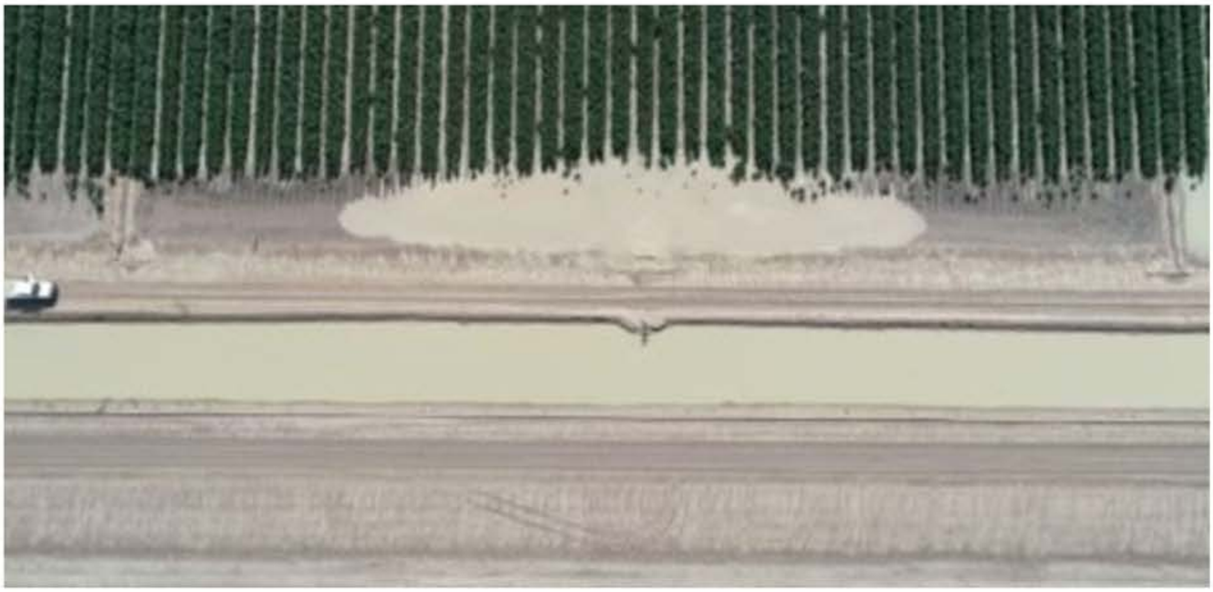
Discounting to present values allows comparison of an investment today with projected future cash flows. The benefits of this proposed project were calculated over a 25-year period.

The total investment cost of $1639 /ha was not offset by the single benefit of decreased labour ($904 /ha, NPV cumulative benefit over 25 years). Additional benefits are required for the investment to break even. In this example the owner plans on increasing the number of irrigations to maximise yield. This results in an increase in both water and energy usage and costs (NPV $224 /ha and $109 /ha) and requires an increase in yield of 2.6% (0.27 bale/ha increase on a 10.5 bales/ha/yr yield average) returning a NPV cumulative benefit of $1246/ha to ensure the project breaks even.

Discussions with an agronomist are helpful in estimating realistic yield responses due to changes in irrigation management practices. The size of the labour savings (benefit) is most sensitive to the number of irrigation requirements within a cropping rotation.

Calculating estimated per hectare costs and benefits of a development or redevelopment can be challenging, however it is a process that will highlight if the project is economically viable.

Photos supplied by Ben Watson as an example of LPTB pontoon.



For further information:

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