SIPHONLESS LAYOUTS FACTSHEET SERIES #1

RESOURCES FOR COTTON GROWERS ON SIPHONLESS LAYOUT DESIGNS, IMPLEMENTATION AND AUTOMATED MANAGEMENT USING SMART IRRIGATION TECHNOLOGIES

IMAGE: GRANT OSWALD

CRDC COTTON RESEARCH AND DEVELOPMENT CORPORATION | CottonInfo

DEVELOPED BY SYNTIRO AGRICULTURAL SERVICES PTY LTD

Introducing Siphonless Systems

Siphonless irrigation systems have evolved as cotton growers adapt irrigation designs, layouts and management to improve productivity and resource efficiency. This factsheet introduces the key concepts, benefits, and limitations of siphonless systems to help growers assess whether conversion is right for their operation. It then outlines critical steps for the successful development of siphonless systems.

It also suggests ways growers can adapt or modify their existing system to improve irrigation performance without the significant outlay required for the development of a new siphonless layout.

This factsheet is part of the *Siphonless Irrigation Factsheet Series*.
Visit www.cottoninfo.com.au for all resources.

DEFINING SIPHONLESS SYSTEMS

Siphonless systems have been categorised by slope as it is the overarching defining characteristic between systems. **See Table 1 on page 2.**

The term *siphonless irrigation systems* refer to surface irrigation systems where manual hand siphons are not used. Siphonless systems do not have two-meter rotobucks which changes how water is delivered to the field. Water is delivered at a high flow rate from an inlet to a below field level area in which water is spread evenly, before entering all furrows simultaneously. Some designs also include tailwater back up which minimises the volume of water entering the recycling system.

BENEFITS AND LIMITATIONS OF SIPHONLESS SYSTEMS

The increase in the adoption of siphonless irrigation layouts has been driven primarily by labour savings and improved machinery efficiency. However, growers have reported a broader range of potential benefits depending on system design, soil characteristics and management. Overall, research and case studies suggest that irrigation performance is influenced more by seasonal conditions and management than by system choice alone. For more information about growers' experiences transitioning to siphonless systems, refer to case studies provided in the Appendix.

Machinery Efficiency

The removal of rotobucks in siphonless layouts eliminates three point turns at the head ditch end. In some configurations (such as GL Bays or Level Basin systems) tractors and spray rigs can pass through multiple fields or bays before turning. Timeliness of machinery passes is improved along with reduced fuel use and lower wear and tear. Reported operational improvements compared to a manual hand siphon system are between 20-30% [2,3].

Labour & lifestyle

Eliminating the manual setup and operation of siphons, along with formation and removal of rotobucks, significantly reduces labour inputs and physical work. Labour savings are particularly valuable in regions with limited workforce availability. Many growers report improved lifestyle, simplified management, and the ability to redeploy staff to other time-critical operations such as weed and pest spraying or fertiliser application[2].

> ***"Labour savings are particularly valuable in regions with limited workforce availability."***

Energy Efficiency

Siphonless systems that incorporate tailwater reuse between adjacent bays can halve the tailwater volume. Some growers estimating pumping fuel savings of up to 50% [5]. In some systems, the tailwater can be reduced to 5%, by designing a smaller last bay irrigated. However, where tailwater is not reused between bays, higher tailwater volumes are generated compared with siphon layouts.

Water use efficiency and crop performance

High flow rates and shorter irrigation durations improve the timeliness of irrigation events and can help match crop water demand. This is particularly beneficial on lighter soils with lower water-holding capacity. Many growers report more uniform water

<table>
<tr><th colspan="3">Layout Name</th><th>System type</th><th>Slope</th><th>Tailwater</th><th>Water enters furrow via</th><th>Irrigation Unit</th></tr>
<tr><td colspan="3">Traditional Overbank Siphons</td><td>Manual hand siphons</td><td rowspan="7">Down the slope</td><td rowspan="5">Recirculated tailwater</td><td rowspan="4">2m rotobucks</td><td rowspan="4">Single or dual furrow set</td></tr>
<tr><td rowspan="5">Pipe Through Bank (PTB)</td><td rowspan="3">Small PTB</td><td>Stepped Set small PTB</td><td rowspan="8">Siphonless</td></tr>
<tr><td>Double head ditch small PTB</td></tr>
<tr><td>Smart Siphons</td></tr>
<tr><td rowspan="2">PTB</td><td>PTB</td><td rowspan="2">Dispersion pond with >2m rotobuck</td><td>Multi furrows set</td></tr>
<tr><td>Pipes with Tailwater backup</td><td rowspan="4">Tailwater backup + recirculation</td><td rowspan="2">Bays</td></tr>
<tr><td colspan="3">GL Bays</td><td rowspan="2">Bankless channel</td></tr>
<tr><td colspan="3">Level Basin</td><td rowspan="2">Basin</td><td rowspan="2">Terraced Basin</td></tr>
<tr><td colspan="3">Rollover Basin</td><td>Bankless channel after side channel</td></tr>
</table>

Table 1: Characteristics of surface irrigation systems. Note – When we refer to 'PTB systems' in this document we are only referring to PTB and Pipes with tailwater backup (not small PTBs).

infiltration and crop growth [6], although results vary depending on soil type and system and maintenance.

Land forming for siphonless systems can expose subsoils with poor structure or low fertility. In such cases, infiltration, seedling establishment issues, and poor crop growth may occur (although careful design and soil management can mitigate these risks). The long-term trial 'Keytah System Comparison' indicates that seasonal conditions remain the dominant factor affecting gross production water use efficiency and yield rather than system type [7].

Economic considerations

Economic performance depends on development costs, labour savings, and water and energy efficiency improvements. Converting existing fields or developing new siphonless layouts requires significant earthworks and infrastructure investment, varying with field size, soil movement, and number of outlets. While comprehensive analyses are limited, growers have reported reduced input costs [6]. Land valuers are now also recognising the benefits of siphonless systems by assigning a premium to the valuation depending on the system installed. However, economic viability requires careful evaluation of site-specific development costs against anticipated operational savings.

High flow rate requirements

Siphonless systems deliver water simultaneously to all furrows in a bay. Uniformity of water advance depends on high flow rates to overcome variation in furrow depth and shape (noting that maintenance of furrow depth and shape and evenness of sill are also critical for uniformity). Required flow rates can exceed the capacity of a single bore or small irrigation scheme offtake structure. Where available flow cannot meet the design requirement, siphonless conversion may not be viable. Delivery entitlement can be a limiting factor in some regions during peak demand periods.

Slope and Soil Limitations

High flow rates increase erosion risk on steeper slopes, making siphonless layouts generally unsuitable for slopes exceeding 0.200% (1:500). Steeper or unstable soils require careful assessment to ensure there will not be erosion of the furrow or sides of the bed.


ANDREW MCKAY

Figure 1: Pipe through the bank is one example of a siphonless layout.

On soils with severe infiltration restrictions, the shorter irrigation runtime of siphonless systems may limit profile refill. Conversely, higher flow rates can improve infiltration by lifting the water level up the side of the furrow. Generally, level basin configurations are more suited to those soils that are very slow to refill the soil profile or where the soil has a poor ability to draw water up to the seed bed (sub up).

Reduction in green area

Green area is reduced by 5-10% with siphonless systems, however, some growers report the productivity benefits to outweigh the reduction [7].

ADAPTING SIPHON SYSTEMS TO IMPROVE IRRIGATION PERFORMANCE

Before investing in siphonless conversion, consider whether optimising your existing siphon system might deliver adequate improvements at lower cost.

Minor modifications and management changes can improve the performance of manual hand siphon systems without the need to invest in the conversion to siphonless irrigation. Flow rates from manual hand siphons are influenced by siphon placement, furrow entry conditions,

and supply head height. Flow through siphons increases as head increases. Some growers have found small changes *can deliver significant gains in water use efficiency and crop performance. Detailed guidance on optimising siphon irrigation performance, including assessment of application uniformity and irrigation scheduling, is provided in WATERpak Chapter 5.3.8 available on the CottonInfo website*.

In brief, practical improvements that can enhance the performance of existing siphon systems include the following below:

- Installation of water height sensors in channels, head ditches and tailwater pumps, to reduce time and travel associated with monitoring the irrigation – particularly beneficial during the night.
- Maintain head height to ensure consistent flow of manual hand siphons.
- Consistent placement of manual hand siphons.
- Adjusting siphon diameter based on available head height and furrow length to improve the uniformity of water advance across all furrows (E.g. use a smaller diameter siphon for wheel track furrows that run faster, or use two siphons in slow furrows)
- Changing to larger siphons to increase flow to minimise deep drainage losses through the increased speed of water advance.
- Widening tail drains, installing larger or additional tail drain outlets can improve drainage and reduce waterlogging at the tail drain end of field.

CRITICAL STEPS FOR SUCCESSFUL SIPHONLESS SYSTEM DEVELOPMENT

Follow these steps for successful siphonless system development. For detailed guidance on each step, refer to the *Siphonless Irrigation Factsheet Series.*

1. **Identify issues you're trying to solve**: Clearly define problems with your existing system. This helps determine whether siphonless conversion is the right solution.

2. **Optimise your siphon system first**: Before major investment, consider whether lower-cost modifications to your existing system might deliver adequate improvements (see WATERpak Chapter 5.3).

GRANT OSWALD

Figure 2: Water channel sensors are a pre-automation technology that can improve irrigation management of existing siphon systems. See the Smart Irrigation Factsheet series on key considerations of sensors.

Right: Cotton irrigation event.

ANDREW MCKAY

3. **Visit operating siphonless systems**: Spend time on farms with different system types during irrigation to understand practical management requirements and real-world performance.

4. **Engage experienced designer**: Select a qualified irrigation engineer or surveyor with demonstrated siphonless experience who will complete a thorough site assessment including:
   - Accurate RTK GPS topographic survey
   - Soil characteristics and infiltration rates
   - Available water flow rates and supply capacity
   - Existing infrastructure elevations and constraints
   - Discussions with crop consultant and manager to understand farm management principles

5. **Stage development with whole-farm planning**: Start by converting one or two fields to gain operational experience, but design with the ultimate whole farm system in mind and consider remote and automated irrigation technologies. Ensure supply channels, tailwater infrastructure, and pumping capacity are sized for future expansion.

6. **Apply sound design principles**:
   - Work with natural slopes to minimise earthworks
   - Size infrastructure for peak accumulated flows plus 10-20% margin
   - Match bay dimensions to available flow rates
   - Design drainage to prevent waterlogging

Siphonless systems can offer real productivity gains, but performance is site-specific and depends on system selection, design, and management

   - Ensure compatibility with existing machinery and cropping program

7. **Minimise earthworks and manage timing**: Designs that preserve topsoil prevent long-term yield losses. Deep cuts exposing poor subsoil compromise productivity for years. Avoid machinery traffic on wet or very dry soil to minimise compaction and structural damage.

8. **Verification and commissioning:** Survey completed earthworks to verify tolerances before installing infrastructure. Have your designer attend the first irrigation to assist with optimal operation.

Conclusion

Siphonless systems can offer real productivity gains, but performance is site-specific and depends on system selection, design, and management. Often improvements can be made to existing siphon systems at lower cost. This should be assessed before deciding to invest in the development of a siphonless system. For detailed guidance on system types, planning, and development, refer to the other Siphonless Irrigation Factsheet series.

Footnotes

[1] Small PTBs still require two-meter rotobucks. Whilst offering labour saving benefits, they retain most similarities to manual hand siphon systems and therefore are excluded from general siphonless system comparisons in this guide.

[2] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[3] Grower Case Study 'Norwood' Moree. CottonInfo, 2024.

[4] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[5] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[6] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[7] Irrigation systems, designs and scheduling options. GVIA. 2022.

[8] Grower Case Study 'Norwood' Moree. CottonInfo, 2024.

[9] Bankless channels- Bullamon Plains. More Profit Per Drop. 2011.

[10] WATERpak a guide for irrigation management in cotton and grain farming systems. CRDC. 2012.

APPENDIX: SIPHONLESS CONVERSION CASE STUDIES

Case studies on the conversion to a siphonless system.

Title	Year	Siphonless type	Location	QR code/link
Grower Case Study 'Lynbrae', Morago Irrigation Conversion	2025	Level Basins	Morago	
Southern Irrigation Development - An Irrigation Consultant's perspective Case Study	2025	Pipes with TWB	Coleambally	
Grower Case Study "Norwood' Moree Irrigation Conversion: Siphon to Bay and Rollover Bankless	2024	Level Basins	Moree	
Grower Case Study 'Bellevue' Narrabri Irrigation Conversion: Siphon to small PTB	2024	SPTB	Narrabri	
Bankless channel irrigation a good fit in the Gulf. A grower case study; Etta Plains Ag	2022	Level Basins	Julia Creek	
Irrigation profitability case studies in southern NSW - Murrumbidgee	2020	Level Basins	Murrumbidgee	
Siphonless irrigation guide: Deer Park	2019	Pipes with TWB	Unknown	
Siphonless irrigation guide: Woodvale Farming		GL Bays	Namoi Valley	
Siphonless irrigation guide: Avymore		Pipes with TWB	Border Rivers	
Siphonless irrigation guide: Anderson's block		Pipes with TWB	St George	
Siphonless irrigation guide: Thuraggi Overflow		Pipes with TWB	Unknown	
Siphonless irrigation guide: The Plantation		GL Bays	Unknown	Megan: All QR Codes to be updated
Siphonless irrigation guide: Bullamon Plains		GL Bays	St George	
Siphonless irrigation guide: Bullamon Plains		Pipes with TWB	St George	
Siphonless irrigation guide: Mundine		GL Bays	Unknown	
Siphonless irrigation guide: Wathagar		Level Basins	Unknown	
Siphonless irrigation guide: Bankless trial		Level Basins	N/A	
Bankless channels The Cook Family case study	2012	Level Basins	Boggabilla	
Bankless Channels – Bullamon Plains	2011	GL Bays	St George	

ACKNOWLEDGEMENTS:

This content is part of a series developed by Syntiro Ag with funding from the Cotton Research and Development Corporation.

The authors gratefully acknowledge the irrigation consultants, cotton growers, and industry representatives who shared their experience and insights on siphonless irrigation systems and smart irrigation technologies. Thanks to Michael Naylor, Darrell Fiddler, Lou Gall, Michael Scobie & Cathy Phelps for their contributions. Their practical knowledge has been invaluable in developing this resource.

Special thanks to the irrigation technology suppliers who participated in the self-assessment process and provided technical information about their systems and services.

CONTRIBUTORS:

Matt Champness led the project and developed the smart irrigation content, with review and editing of siphonless system design content. **Harriet Brickhill** developed the siphonless systems content and provided review and editing of smart irrigation technologies content. **Glenn Lyons** provided technical input and review of siphonless system content.

Syntiro Agricultural Services Pty Ltd

GLOSSARY

Naming conventions differ between regions and have changed as systems have evolved. Where multiple terms exist, bold text indicates terminology used within this document.

API (Application Programming Interface): A set of rules and protocols that allows different software applications to communicate with each other. In smart irrigation, APIs enable sensors from different manufacturers to share data with control platforms.

Automated Irrigation: Systems where the decisions about when to open/close inlets/ outlets or start/stop pumps are made automatically by the supervisory system based on sensor data and programmed rules, without requiring human intervention for each action.

Bay: A section of a down the slope field that is separated by banks running from supply end to tail drain.

Basin: A section of a field where there is no or minimal slope along the furrow, that is separated by banks running from end to end.

Bankless Channel/bankless head ditch: Used in GL Bays & Basin systems. A below field height levelled area that is filled prior to water entering furrows. It acts as the supply and drain. Drainage is through a check structure into the next stepped bay or basin.

Bankless Side Channel: Used in Rollover Bankless. A below field height channel that runs in the same direction as the furrow and supplies water to a bankless channel at each end of the furrow.

Bankless Check: Drop board, rubber door or gated pipe that controls the passage of supply water from bay to bay – or basin to basin.

Command: An instruction sent from the supervisory system or user interface to a controller, directing it to perform an action (e.g., open outlet, close valve, start pump).

Communication Network: The connectivity layer that transmits data and commands between field devices (controllers & sensors) and the supervisory system. May use cellular, LoRaWAN, radio, or Wi-Fi.

Controller: A device that opens and closes irrigation infrastructure (inlets, outlets, valves) based on commands from the supervisory system or direct user input. May include motor/actuator mechanisms and control electronics.

Cross Fall: lateral slope across the field (as opposed to down the slope of the furrow).

Dispersion Pond/ distribution basin / distribution bay/ dispersion basin/ pontoon area: Used in PTB systems. Below field height levelled area between head ditch and furrows that is filled prior to water entering furrows. This is only a supply and is at the upper end of the field.

Gateway: A device that receives data from field sensors or controllers using one communication protocol and translates it for transmission to the supervisory system using another protocol. Common in LoRaWAN and radio networks.

GL Bays: A siphonless system consisting of terraced bays stepping down the landscape with furrows running perpendicular to the natural slope. Water is supplied via bankless channels, with tailwater reused between adjacent bays.

Handshake: A communication protocol where the receiving device confirms it has received and executed a command. Provides verification that actions have been completed successfully.

Head Ditch: The main supply channel for the field, which enables supply via manual hand siphons, small pipe through bank or large pipe through bank. This controls water head height.

Level Basin/ flat bays, flat flat, beds in bays, bankless channel: A siphonless basin system with zero or minimal slope (typically flat or 0.01% down slope) along furrow length. Water enters and drains through bankless channels at each end of the furrows. Field is divided into terraced basins stepping down the landscape.

LoRaWAN (Long Range Wide Area Network): A low-power, long-range wireless communication protocol designed for IoT devices. Requires a LoRa gateway on the farm and is well-suited for large farms with many distributed sensors and controllers.

Offtake: Primary point of delivery from the irrigation scheme/river.

Outlet: An overarching term for a structure used in irrigation systems to control the flow of water. Includes inlets and check structures.

Pipe through Bank (PTB)/ Large PTB, Pontoon: A siphonless system where large diameter gated pipes (250-750mm) are installed through the head ditch bank to deliver water to a dispersion pond. Water then flows simultaneously into multiple furrows (typically 12-96 furrows per pipe). Field slopes down to taildrain.

Platform: The software system (web-based or app-based) that provides the user interface for monitoring and controlling smart irrigation equipment. May include data visualization, scheduling tools, and alert management.

Protocol: A set of rules defining how data is transmitted between devices in a communication network. Different protocols (e.g., LoRaWAN, Modbus, MQTT) have different characteristics for range, power consumption, and data capacity.

Radio (RF): Short-range wireless communication between nearby devices using radio frequency signals. Typically requires line-of-sight and may use mesh networks where devices relay signals to extend range.

Remote Irrigation Control: Irrigation systems where human operators make decisions about when to irrigate and manually trigger actions (open/close outlets, start/stop pumps) through a remote interface (app or web platform), without travelling to the field. Differs from automation where the system makes decisions.

Repeater: A device that receives and retransmits signals to extend the communication range of a wireless network, particularly important for large farms or areas with terrain obstacles.

Rollover / Rollover Bankless: A siphonless basin system where furrows follow the natural slope direction (allowing machinery to "rollover" from one basin to the next). Requires very flat terrain (<0.04% slope). Uses bankless side channel and bankless channels for water supply and drainage.

Sensor: A device that measures physical parameters (water height, soil moisture, weather conditions, flow rate) and transmits data to the supervisory system to inform irrigation decisions.

Sill: The point in the bay where the field slope changes to a negative slope.

Siphonless Irrigation: Surface irrigation systems that deliver water at high flow rates from an inlet to a below-field-level area where water spreads evenly before entering all furrows simultaneously, eliminating the need for hand-placed siphons and 2-meter rotobucks.

Smart Irrigation: An umbrella term for advanced irrigation technologies that use real-time data and automation to optimise irrigation management. Includes sensing/monitoring, remote control, and automated irrigation systems.

Small Pipe Through the Bank (Small PTB): A system using permanent 75-90mm pipes installed through the head ditch at consistent levels. Still requires 2m rotobucks. Variations include stepped set, double head ditch, and smart siphon configurations. See Chapter 1, Section 4 for detailed descriptions

Supervisory System: The central control or decision-making system that processes sensor data, interprets field conditions, and triggers controller actions (opening or closing infrastructure).

Supply Channel: A channel that carries water throughout the farm to supply the head ditch or fields.

Supply Inlet: a structure that allows water to enter the system, usually from the supply channel

Tail drain: Tail drains remove run-off from the field created by both irrigation and rainfall events.

Tail drain Checks: Drop board, rubber door or gated pipe that controls the passage of tailwater from bay to bay.

Tail drain Outlet: Drop structure and pipe that passes the tailwater to the recycling system.

Tailwater Backup (TWB): The slope at the tail drain end of the field is reduced to allow tailwater to back up slower furrows. This backed-up water is then drained and reused in the subsequent bay.

Terraced Basin: A basin system configuration where basins step down the landscape with minimum 15cm vertical drop between each basin level. Used in both Level Basin and Rollover systems.

Time-based Controller: A controller that operates on pre-programmed time schedules to open/close infrastructure or start/stop pumps. May lack sensor feedback beyond basic fail-safe protection.

User Interface: The platform (local buttons/screen, Bluetooth connection, mobile app, or web portal) where operators monitor system status, view data, and control irrigation equipment manually or remotely.