

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



DEVELOPED BY SYNTIRO
AGRICULTURAL SERVICES PTY LTD

Introducing Smart Irrigation for Siphonless systems

Smart irrigation technologies are increasingly being adopted by cotton growers for labour and water efficiency gains and lifestyle benefits. This factsheet introduces the key concepts, components, and terminology of smart irrigation in the context of siphonless cotton systems, from sensing and monitoring through to remote control and automation. It also outlines the benefits and challenges to help growers assess whether smart irrigation is right for their operation.

This factsheet is part of the *Smart Irrigation for Siphonless Systems Series*. For guidance on selecting and implementing a system, see *Factsheet 2: Selecting and Implementing a Smart Irrigation System*. For a comparison of current suppliers, see *Factsheet 3: Smart Irrigation Supplier Self-Assessment*. To read about a practical example on farm, see the *Case study: Ashwood Farms' journey on driving water efficiency through siphonless smart irrigation systems*.

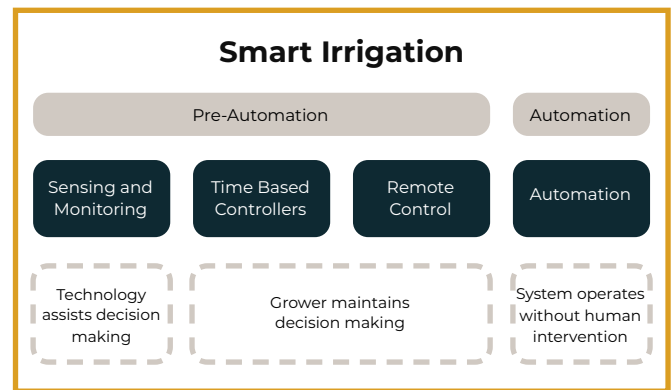


Figure 1: Smart irrigation encompasses a range of advanced technologies and is used as an umbrella term for pre automation and automation technologies.

Pre-automation technologies can be adopted as a phased step towards remote irrigation control or automation, or in lieu of automation, whilst still delivering enhanced farm productivity.

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The term ‘*Smart irrigation*’ encompasses a range of advanced technologies including use of real-time data to optimise irrigation management and improve irrigation performance. This guide uses ‘smart irrigation’ in the context of siphonless cotton layouts as an umbrella term for pre-automation and automation – as few cotton growers have adopted true automation.

COMPONENTS OF AUTOMATED IRRIGATION SYSTEMS

The minimum components of a fully automated irrigation system in a siphonless layout are:

1. Sensors

Devices that measure key parameters to inform irrigation decisions. Parameters may include soil moisture, crop (e.g. temperature), or weather data for irrigation scheduling; and water height (in channels or bays) and flow rate for monitoring and decision making during an irrigation event.

2. Actuators

Mechanical devices that execute control decisions by converting a command into physical movement (opening or closing inlet/outlet structures). In siphonless cotton systems, the most common actuator types are:

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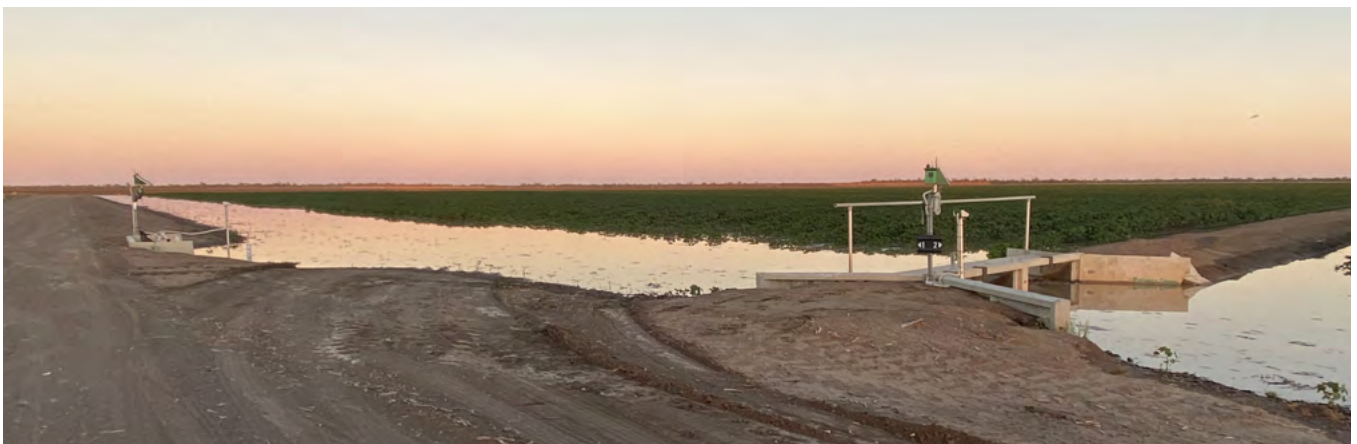
PRE-AUTOMATION IRRIGATION TECHNOLOGIES:

- » **Sensing and monitoring systems:** Individual technologies that improve irrigation monitoring to optimise irrigation performance and save labour.
- » **Remote irrigation management:** Systems where growers use technology to control irrigation remotely, but growers maintain decision-making authority.

Automated Irrigation

- » **Automation:** Fully integrated systems in which sensor data triggers irrigation decisions and actions with no human intervention. This is the most comprehensive form of smart irrigation and includes sensor data to initiate an irrigation, as is common in vineyards and greenhouse production.
- » In the context of this guide ‘*automation*’ refers to automated control after commencing irrigation (pump starting / farm supply inlet open), with subsequent actions controlled autonomously by the system. This is because the majority of siphonless systems do not have water on demand (unlike pressurised systems) and require starting a diesel pump, or other system limitations prevent remote start. A person is making the management decision to commence irrigation, with subsequent actions autonomous.

- i. **Valve actuators:** used on pipe-based outlets such as butterfly valves and ball valves in recycling systems and on-farm storage outlets;



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Figure 2: Remote and automated irrigation can offer substantial labour savings, when done well.

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Figure 3: LEFT: Water height sensors can be used for monitoring channel conditions. RIGHT: Weather stations can enhance irrigation decision making.

LOU GALL



Figure 4: Rotating elbow actuators — used in Smart Siphon systems, where a common cable rotates elbows simultaneously into or out of the water to start or stop flow.

RIC OTTON



Figure 5: Irrigation controllers such as this one can be used for many applications - driving motors, actuators, relays, valves, gates, pumps, doors and more.

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Figure 6: RIGHT: Automated winch driven controller. ABOVE: Direct drive removable controller.



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- ii. **Motorised gate actuators:** mounted on bay inlet/outlets; and
- iii. **Rotating elbow actuators:** used in Smart Siphon systems, where a common cable rotates elbows simultaneously into or out of the water to start or stop flow. The drive mechanism on the inlet/outlet (e.g. winch cable, linear actuator, rack and pinion, valve) determines compatibility with different controllers. In some commercial systems, the actuator and controller are

integrated into a single unit that can be removed.

3. Controllers

The electronics and logic layer that tells the actuator what to do and when. Controllers receive commands from the control system (or operate on pre-programmed schedules), trigger the actuator/s, and report status back. They may also include a local user interface — physical buttons, a screen, or Bluetooth — for manual operation when remote

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communication fails. Some controllers can be removed for manual over-ride.

4. Communication Network

The connectivity layer that transmits data and commands between field devices (controllers and sensors) and the control system. This may be via radio, cellular, Low Power WAN (i.e. LoRaWAN), Wi-Fi, or satellite links. Depending on the farm, additional equipment may be needed: repeaters (extend signal range across larger distances), gateways to translate between different protocols (different communication methods), and access points to create wireless connection hubs.

5. Control System

The central decision-making system that processes sensor data, interprets conditions, and triggers controller actions (opening or closing infrastructure). It may operate locally or in the cloud.

6. User Interface

Either local (on-controller via buttons/screen or Bluetooth) and/or remote platform (app or web portal) where the operator can monitor system performance, view data, and manually or automatically set irrigation schedules and rules.

PRE-AUTOMATION IRRIGATION TECHNOLOGIES

Pre-automation technologies incorporate one or more of the components described above. These technologies can be a stepping stone toward remote irrigation control, full automation or as standalone solutions to improve irrigation



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Figure 7: Communication gateway.

performance and reduce labour.

Sensing and monitoring

Sensors that measure soil moisture, water levels, crop conditions, or weather parameters provide valuable data to support irrigation decision-making

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Figure 8: FAR LEFT. Local user interface on portable controller.

LEFT: App used for monitoring sensor data and configuring irrigation commands.

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but may require human interpretation. Examples include:

- » **Water level sensors** in channels or basins that send text/app alerts when water reaches critical thresholds, notifying operators when changes are needed.
- » **Soil moisture, crop stress, or weather-based sensors** that inform irrigation scheduling decisions.

'Smart sensing' generally refers to sensors connected in-real time to a platform for user-viewing and decision making. Many sensing and monitoring technologies are described in detail in Irrigation Tools and Technologies ¹.

REMOTE IRRIGATION MANAGEMENT

Time-based controllers

Time based pump or mechanised controllers open and close irrigation infrastructure using pre-programmed time schedules but often lack sensor feedback (beyond fail-safe protection) and dynamic decision-making capabilities. They may have user interface on the device or web platform. Time-based controllers can be a cost-effective first step, reducing labour while maintaining operator control over irrigation timing and duration.

Remote irrigation control

This can include pump or mechanised controllers



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Figure 10: Example of a timer-based controller that can open and close based on pre-programmed commands.

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Figure 9: Water level and water advance sensors can help monitor irrigation progress or can be incorporated into remote and automated control.
LEFT: Storage water depth sensor.
THIS IMAGE: Water advance and height sensor.

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that use some of the components and capabilities of automated irrigation, but a grower retains control of decision making. For example, the control system is not making all the decisions, even though it may be designed to.

Remote irrigation control is how most growers with automation are using smart irrigation technology – they are making the decision on when to initiate an irrigation event (the control system is not). Thus, the systems are not truly automated. Instead, due to grower’s experience and complexity of their irrigation across farms, growers are using the following methods to schedule irrigation:

- » **Traditional:** Push probes or number of days
- » **Technology:** Soil water, crop or weather (inc. evapotranspiration) sensor-based parameters
- » **Forecasting:** Either by looking at weather forecasts, or sensor platforms incorporating forecasting models.

Once the irrigation event is underway, growers may allow irrigation to continue autonomously, whilst others use sensors and alerts to inform them whilst others use time based control, or sensors to trigger opening or closing. Alerts can inform growers on irrigation progress (which may be ground-truthed

Few, if any, cotton growers have adopted true ‘automated irrigation’ – most use ‘remote irrigation control’, and for many, this is sufficient.

by a visit to the field), then the grower decides when to open the next inlet/outlet.

BENEFITS AND CHALLENGES OF SMART IRRIGATION

By integrating smart irrigation technologies, irrigation can be managed based on real-time field conditions. This can enable substantial water, labour, and energy savings, while improving crop performance and farm management efficiency. Below are some of the benefits reported by early adopters of smart irrigation systems, however, these are site specific, and benefits depend on the number of irrigation events per season. Further, while the benefits of smart irrigation can be substantial, growers should be aware of potential challenges.

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Figure 11: Tail drain backing up tailwater before detachable controller opens based on time or water sensor.

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Figure 12: RIGHT: Pipe controller enables remote and automated control with manual over-ride buttons in event of communication failure.

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Labour efficiency and workforce management

Reducing on-farm labour demand is one of the most common drivers of smart irrigation adoption. Growers have reported reduced workload, labour costs and employee numbers - particularly casual or low-skilled seasonal labour. These benefits are often more pronounced in remote regions where labour shortages are enduring. Reduced travel for manual water changes further decreases vehicle wear, fuel use, and operating cost. Further, reduced workplace safety risks result from reduced travel to the field, particularly during the night.

Published examples:

- » 93% reduction in labour estimated for transition from manual siphon irrigation layout to automated PTB based on 11 irrigation events/season².
- » 85% reduction in labour estimated (baseline 0.4 hr/ha/season) with adoption of automation in Level Basin layouts^{3,4}.

Lifestyle, opportunity cost of time and other benefits

Remote and automated irrigation can ease disruption to family and personal time - reducing need for night-time, weekend, or festive season in-field irrigation management. Remote management of infrastructure reduces the need to travel to the field during a rain event – preventing road damage and reducing workplace safety risks, particularly during night conditions. While difficult to measure in economic terms, these wellbeing benefits are significant to grower health and quality of life, with some growers expressing increased farming longevity.

On many farms, irrigation often competes with

The opportunity cost of saved time is often the greatest benefit of smart irrigation

critical activities such as planting, spraying, or harvesting. Smart irrigation allows labour and management focus to shift to these higher-priority tasks, improving overall farm performance and productivity. Economic analyses consistently show that when the value of this redirected time is factored in, payback periods for smart irrigation systems are significantly reduced.

Published examples:

- » 82% measured labour saving during the flush-irrigation phase of rice (equivalent to standard cotton irrigation event) was achieved with automation of 4-bay Level Basin (20ha) when compared to manual irrigation of neighbouring identical field⁵. Factoring in a flat “cash” cost of labour and travel costs, automation saved \$73 (1st irrigation) and \$121 (subsequent irrigations) per irrigation. However, when accounting for opportunity cost of time and travel cost, automation saved \$406–450 per event, thus significantly reducing the payback period of automation. Extrapolation of this data for a cotton field receiving 10 irrigation events per season can be seen in **Table 1**.

Crop performance, water & energy efficiency

Improved timeliness of water changes through water height sensing and remote water management have been reported by growers to further reduce tailwater losses beyond the benefits gained in transitioning to siphonless and

Automation labour and travel cost savings		Cash cost (\$)	Opportunity cost (\$)
Measured	1st Irrigation	73	450
	Subsequent Irrigations	121	406
Extrapolation of 10 irrigations / season	\$/season saving	1,162	4,104
	\$ / ha saving	58	205

Table 1: Extrapolation (using 10 irrigations/season) of labour and travel savings associated with a 4 bay, 20 ha Level Basin field with automated irrigation, compared to neighbouring identical manually irrigated field. Note data is derived from flush irrigation events of a rice field, however, mirrors a cotton irrigation event.

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significantly reducing pumping costs.

Enhanced irrigation scheduling through use of soil, crop or weather parameters can ensure crops are irrigated when required. Coupled with improved timeliness of water changes which reduces over-irrigation (water logging, deep drainage), growers have reported improved crop and water productivity, albeit, challenging to quantify.

Published examples:

- » 11% energy productivity improvements have been reported through automation of a Level Basin field due to less tailwater pumping⁶.

Site and system limitations

Water distribution problems, inadequate slope, or undersized infrastructure will persist regardless of technology – automation will not solve fundamentally flawed layouts. Nevertheless, sensors can assist in monitoring irrigation advance in challenging layouts; however, inappropriate location or threshold setting can prove disastrous if left to automated decision making.

Supplier reliability

As an emerging technology in siphonless systems, supplier support varies. Service availability, technical backup, and long-term business viability should be carefully assessed. Further, proprietary systems or equipment may limit future flexibility to change suppliers or integrate with other technologies.

Technology and operational risks

Smart irrigation systems require time and patience to master. Managing multiple sensors, controllers, and platforms can add operational complexity compared to manual irrigation. Staff training and clear protocols for troubleshooting and refining

AVOIDING TROUBLE:

Reality check from early adopters

Budget extra time for learning in the first season, maintain manual backup options, and start with a small area to build confidence. The benefits are real, but they require persistence and patience to achieve.

These risks can be managed through proper planning, staged adoption of smart irrigation, thorough supplier evaluation, and realistic expectations—all addressed below.

settings, are important to build confidence in the system. Some early adopters have had equipment malfunctions, communication breakdowns/blackspots, and software glitches. These are often overcome as technologies mature, however, this experience highlights the advantage of having manual override capabilities and having a backup plan.

CONCLUSION

Smart irrigation in siphonless cotton systems covers a range of technologies, from simple sensors through to fully automated inlet and pump control. Few growers have adopted true automation; most use remote irrigation control, and for many, this is sufficient. Understanding the components, terminology, and realistic benefits and challenges outlined in this factsheet is the first step toward making an informed decision about adoption. For guidance on the next steps, see *Factsheet 2: Selecting and Implementing a Smart Irrigation System*.



Want more information on the benefits?

Watch this short video of grower and industry experience with remote irrigation control where they share their benefits and tips.

<https://smarterirrigation.com.au/irrigation-automation/>

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Footnotes

¹ Irrigation Tools and Technologies. Smarter Irrigation for Profit Phase II. 2018.

² “Consultant Case Study: Southern Irrigation Development” CottonInfo, 2023.

³ “New tech integrated smart sensing & automation for cotton: Application in bankless channel irrigation” SIP, 2021.

⁴ “GVIA Application of digital technologies for automated irrigation” SIP, 2021.

⁵ “Evaluating the Performance and Opportunity Cost of a Smart-Sensed Automated Irrigation System for Water-Saving Rice Cultivation in Temperate Australia” MDPI, 2023.

⁶ “Staged automation of irrigation in cotton systems” SIP, 2023.

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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.

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REPORT LIMITATIONS

This guide is an educational resource that has collated current information on siphonless irrigation systems and smart irrigation technologies. It provides general layout designs and description of terms to guide discussions between industry and best practice principles for planning and developing new layouts. However, this information is not prescriptive. Performance outcomes and benefits are site-specific and will vary based on individual farm conditions, management capacity, and technology choices. Growers should adapt this information to their specific circumstances.

Smart irrigation technologies are rapidly evolving. Inclusion of specific products, features, photos and suppliers does not constitute endorsement. Growers should conduct their own due diligence before making investment decisions.

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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.

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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 runoff 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.

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