IRRIGATION INSIGHTS

Participant Manual

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Agricultural production and adoption

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1.1 WHAT IS IRRIGATION?

Water is an essential element for plant growth. Different plants need different amounts, but there is no known plant species that can exist without water.

Irrigation can be defined as the replacement of water storage in a plant root zone by means other than natural rainfall (or snowfall in some areas).

1.2 ANCIENT IRRIGATION

There is archeological evidence that irrigation has existed for 4,000 – 5,000 years. Unsurprisingly, it began in areas where there was not enough natural rainfall to support crops, but there was fresh water nearby that could be channelled into cropping areas. For example, farmers in Mesopotamia (modern day Iran and Iraq) built channels to take water into fields. The ancient Egyptians channelled water from the River Nile into fields surrounded by small walls.

Figure 1: Ancient Egyptian irrigators channelling water from the Nile River into fields (*Picture:* (International Commission on Irrigation and Drainage, 2016))

1.3 HISTORY OF IRRIGATION IN AUSTRALIA

Australia is a dry continent, and therefore irrigation is practiced widely. Even so, growing crops without irrigation is still widely practiced in some parts of Australia, for example, most grain production.

The first large scale irrigation schemes were introduced in Australia in the 1880s in response to drought, with an irrigated farm at Mildura being developed by Californians George and William Chaffey from 1886. In 1915 the River Murray Waters agreement was signed, which set out basic conditions for the use of water from that river, and was Australia's first major irrigation policy or agreement. Over 70% of irrigation in Australia occurs in the Murray-Darling river system.


Figure 2: Centre pivot irrigator in NSW using water from the River Murray (*Photo: Pinion Advisory*)

Water for irrigation in Australia either comes from rivers or on-farm dams, or from underground water storage called aquifers. The great artesian basin is an example of an aquifer and covers areas of Queensland, Northern Territory, South Australia and NSW and is the largest and deepest artesian basin in the world. The word "artesian" means that water will rise to the surface without pumping, because it is under pressure underground. Most of the other aquifers in Australia are smaller and more localised and may or may not be refilled every year by rainfall.

In 2021-2022 (the latest figures) Australia used 9,981 billion litres of water for agriculture, forestry and fishing. In comparison, the total consumption of water by households and other industries in Australia was 13,449 billion litres (Australian Bureau of Statistics, 2025).

Of the 9,981 billion litres used by agriculture, forestry and fishing, 7,336 billion litres of water were distributed from irrigation schemes, 1,046 billion litres were from self-extracted surface water (dams and rivers) and 1,509 billion litres was from self-extracted groundwater. Interestingly, 90 billion litres of water use for agriculture, forestry and fishing was reuse water.

1.4 HISTORY OF IRRIGATION IN TASMANIA

There were some irrigation systems set up along the Derwent, Macquarie and Clyde Rivers in Tasmania in the late 1800s, but it was not until the mid-20th Century that larger irrigation schemes began in the midlands and northern Tasmania. In 1974, the Cressy-Longford scheme began, the South East Districts scheme in 1986 and the Winnaleah scheme in 1987. Irrigation of vegetable and industrial crops began on the North West Coast in the 1960s, mainly out of creeks or on-farm dams, while perennial horticulture, primarily apples in the Tamar or Huon areas, began irrigation around this time, also out of creeks or farm dams.

Today, Tasmania has an enviable network of irrigation schemes. Tasmanian Irrigation Pty Ltd manages 19 schemes that deliver irrigation water to farmers. Figure 3 shows the area covered by these schemes.

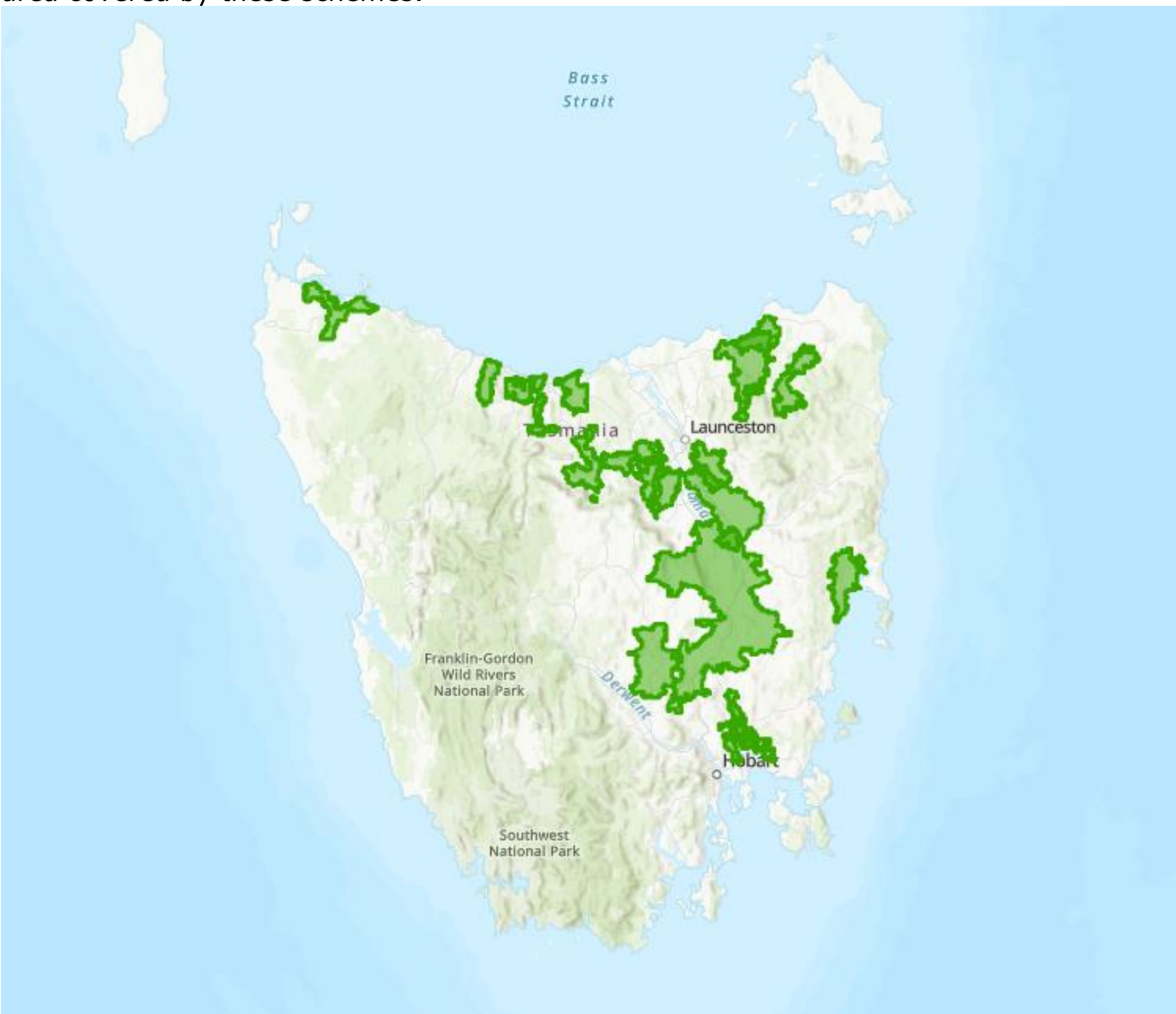

Figure 3: Area of Tasmania covered by irrigation schemes (*Source:* (Tasmanian Irrigation, 2025))

Early irrigators in Tasmania used flood irrigation, but in later years pressurised water systems using sprinklers or travelling irrigators became popular.

Today, Tasmania is one of the highest per-capita users of centre pivot irrigators in Australia. Drip and micro-irrigation systems are now used extensively in perennial horticulture and small fruit production. Irrigation is important to Tasmania's $2 billion dollar farm gate value agricultural industry (AgriGrowth Tasmania, 2022) with potatoes, vegetables, berries, fruit, wine and field crops relying primarily on irrigation, with a portion of beef, dairy and lamb / mutton production also relying on irrigated pasture production.

Figure 4: Prime lamb production under centre pivot irrigation in Northern Tasmania *(Photo: Pinion Advisory)*

Figure 5: Micro irrigation of raspberries in Southern Tasmania (*Photo: Pinion Advisory*)

Exercise

- What is the source of irrigation water where you work?

- Is it part of an official irrigation scheme? If so, do you know the name of it?

Types of irrigation systems

2.1 BASIC CLASSIFICATION OF IRRIGATION SYSTEMS

There are three basic types of irrigation systems. These are:

Surface irrigation
Surface irrigation, where water is channelled out onto a field and allowed to spread across the surface. It is still used worldwide, especially in the cultivation of rice, where the water also acts as weed control. In Tasmania, surface irrigation was used in the dairy industry for many years and is still used but has largely been superseded by methods that apply water more accurately. The advantage of surface irrigation is that it can be powered by gravity and therefore can be cheap to run. The disadvantage is that it can be difficult to control the distribution of water, and a lot of water can be lost to deep drainage or runoff. It is also restricted to relatively flat land. Figure 6 shows surface irrigation in Emerald, Queensland.

Figure 6: Surface irrigation of soybeans in Emerald, QLD. Notice that this land is particularly flat. Water is siphoned out of channels into the soybeans using the pipes shown (*Photo:* (Commercial real estate, 2025))

Spray irrigation
Spray irrigation simulates rain, in that water is sprinkled onto the soil surface. To do so requires water to be pushed under pressure through various types of nozzles. Common techniques using spray include travelling irrigators, centre pivots, lateral moves, solid set sprinklers and micro-jets. The advantages of spray irrigation are even water distribution,

even on land that is not flat. Spray irrigation can also be controlled and precise, so that water is used as efficiently as possible. It is more expensive than flood irrigation, however, and can lose significant amounts of water to evaporation in hot and windy conditions. Figures 7-13 show these different techniques.

Figure 7: Soft hose travelling irrigator, NW Coast Tasmania (*Photo: Pinion Advisory*)

Figure 8: Soft hose travelling irrigator in action (*Photo: Pinion Advisory*)

Figure 9: Hard hose gun irrigator (*Photo: Pinion Advisory*)

Figure 10: Centre pivot irrigator (*Photo: Pinion Advisory*)

Figure 11: Hose pull linear move irrigator (*Photo:* (Cadman Power, 2021))

Figure 12: Solid set irrigation system – (*Photo:* (Nelson, 2025))


Figure 13: Micro sprinkler in orchard (*Photo:* (Irrigear, 2025))

Micro irrigation
Micro irrigation is when water is released very slowly as drips to the surface of the soil or substrate. Sometimes, the water is released underground, and not on the surface. The pressure needed for these systems are much lower than sprinklers, because the water is not spread long distances from the point of release. Micro systems are good where plants can be targeted easily in rows or as individuals. Micro is particularly useful in hydroponic systems, for instance, in Tasmanian berry farms. Figure 14 shows a micro irrigation system.

Figure 14: Micro irrigated lettuce. The integrated dripline has emitter holes regularly along its length that release water onto the surface of the soil (*Photo:* (Kelemwork Trading, 2025))

Exercise

What irrigation system do you use on your farm or the farm where you work?

What are the advantages and disadvantages of that system?

Irrigation system components

3.1 INTRODUCTION

The main components of an irrigation system are:

- pumps and power units
- filters
- pipes and conveyance systems
- valves
- sprinklers, emitters and micro-irrigation components.

All these components are important for efficient running of an irrigation system.

3.1.1 Pumps and power units

For pressurised systems, the pump is the centre of the system, like the operation of the heart (pump) in the human body it critical for life (Figure 15). The pump, in turn, requires energy to move the water to the place where it is applied to the crop or pasture. The force in which water is delivered is called pressure. Pressure is measured many ways, but pounds per square inch (psi) or kiloPascals (kPa) are common measures of pressure.

Pumps are commonly powered by either electricity, or, where there is no electricity available, by fuel (commonly diesel). Supply of electricity or fuel is expensive, so pump design should supply water to the irrigator at the right pressure level and flow rate, while using as little energy as possible.

Figure 15: The pump is the critical energy centre of an irrigation system (*Photo: Pinion Advisory*)

Pumps have limited working ranges of pressure and flow rate, so it is critical that the right pump is selected for each system. Poor system performance is often due to a mis-match between the pump and the irrigation system.

There are many types of pumps, including centrifugal, turbine, piston and diaphragm. What is best will depend on system requirements. It is important to design a layout of the pump that is simple and safe (Figure 16).

Electronic pumps are preferable to diesel or fuel powered pumps, as they have fewer moving components, need less maintenance and should last for longer periods of time if installed correctly.

Figure 16: It is important to have a neat and simple design layout for pumping systems for ease of maintenance and safety (*Photo: Pinion Advisory*)

Other factors to consider when selecting a pump and power unit are:

- will it deliver the flow and pressure required?
- how efficient is it (energy per litre of water delivered)?
- suction performance
- cost of ownership (common brand vs unusual brand).

Exercise

What is the power source for pumps on your property?

Where are your pumps located? What do you think are the reasons they are put there?

What are the maximum and minimum flow rates and pressures for the pumps on your property?

3.1.2 Filters

Filters are installed in irrigation systems to remove particles in the water. This is especially important for micro sprinkler or drip systems that have very narrow nozzles that can be easily blocked.

Filters have various designs, depending on the requirements of the systems. Screen filters include a fine mesh that filters out particles as water moves through the mesh. Disc filters have a series of grooved rings, that form a cylindrical filter with each groove crossing the other in different directions. Media filters consist of sand, gravel or other media that cleans water as it flows through.

All filters need to be regularly cleaned to continue to have good operation. This can be done manually or automatically depending on the sophistication of the filter.

Figure 17: A bank of disc filters in a complex irrigation system (*Photo: Pinion Advisory*)

3.1.3 Pipes and conveyance systems

Pipes are used to transport water from the pump to the irrigator. Most pipes these days are made of plastic, such as polyethylene (Figure 18) or unplasticized poly-vinyl chloride (uPVC, Figure 19). Metal pipes are sometimes used but they are expensive and labour intensive to install.

Figure 18: These pipes are made of polyethylene (*Photo: Pinion Advisory*)

Plastic pipes have pressure ratings. Pipes must be able to carry water at working pressures needed to operate the irrigation system. Polyethylene and uPVC pipes are rated on the pressures that they can safely operate. Table 1 shows the classifications. In this instance, pressure is measured in "head" (metres).

Table 1: Pressure ratings for PVC and Polyethylene pipes

PVC		Polyethylene	
Head (metres)	Class	Head (metres)	Pressure Nominal (PN)
45	4.5	40	4
60	6	63	6.3
90	9	80	8
120	12	10	10
150	15	125	12.5
180	18	160	16

The classifications above are for water of 20°C or less, adjustments are needed for water at higher temperatures, as pipes can handle less pressure at higher temperatures. This might only be the case where warm or hot artesian water is used.

Polyethylene pipe is more flexible than uPVC, and it is sometimes more expensive. Joiners and other fittings are sometimes more expensive with polyethylene compared to uPVC.

Figure 19: The pipes in this photograph are made of uPVC. It comes in fixed lengths and joins are often made with solvent welds (*Photo: Pinion Advisory*)

Exercise

What material are your irrigation pipes made of?

Are there different diameter pipes made of different material?

Do you know the pressure rating of your pipes? Why is it important to get the pressure rating right?

3.1.4 Valves

Valves are devices that control the flow of water or air in an irrigation system. They are used to open and close pipes, regulate pressure or start / stop irrigation.

There are many types of valves in irrigation systems, and they are used for different purposes. These include:

Air release valves
These valves are located at high points in a pipeline to release air, but not water. Having less air in the pipeline means more water can be carried (Figure 20).

Figure 20: Air release valves (*Photo:* (Bermad Water Technologies, 2018))

Backflow prevention valves
These valves are used to stop backflow of irrigation water in systems connected to potable (drinkable) water supplies (Figure 21). This is so that any contaminants from the irrigation pipes and fittings or nutrients from a fertigation system are prevented from flowing back into the water that people use for drinking. These valves are mandatory in Australia for any system connected to a potable supply.

Figure 21: Backflow prevention valve (in light blue) (*Photo:* (Sydney Water, 2025))

Ball valves
These valves contain balls within them with holes. As they rotate, they open or close flow. They are simple, low maintenance and easy to use (Figure 22).

Figure 22: Ball valve (*Photo:* (Irrigation Express, 2025))

Butterfly valves
These contain a disc that rotates to provide an on/off function (Figure 23).

Figure 23: Butterfly valve (*Photo: Pinion* Advisory)

Check valves
These are one-way valves, that is, water can only flow through them in one direction (Figure 24). An example of when they are used is to stop water flowing back to the pump when the irrigation system is not operating. There are special check valves called **foot valves** which are placed at the end of a suction line to ensure that the suction pipe always remains full of water (i.e. remains primed).

Figure 24: Check valve (*Photo:* (Valve Warehouse Australia, 2024))

Float valves
Float valves are, like they sound, a valve connected to a float (Figure 25). When water levels decrease (for example in a tank as water is used), the angle of the float changes and water is released through the valve. As the tank fills, then the angle of the float flattens to the horizontal and the valve shuts off.

Figure 25: Float valve (*Photo:* (Land and Water Technology, 2025))

Pressure reducing valves
These valves create a constant water pressure downstream of the valve, by reducing the pressure from upstream of the valve (Figure 26).

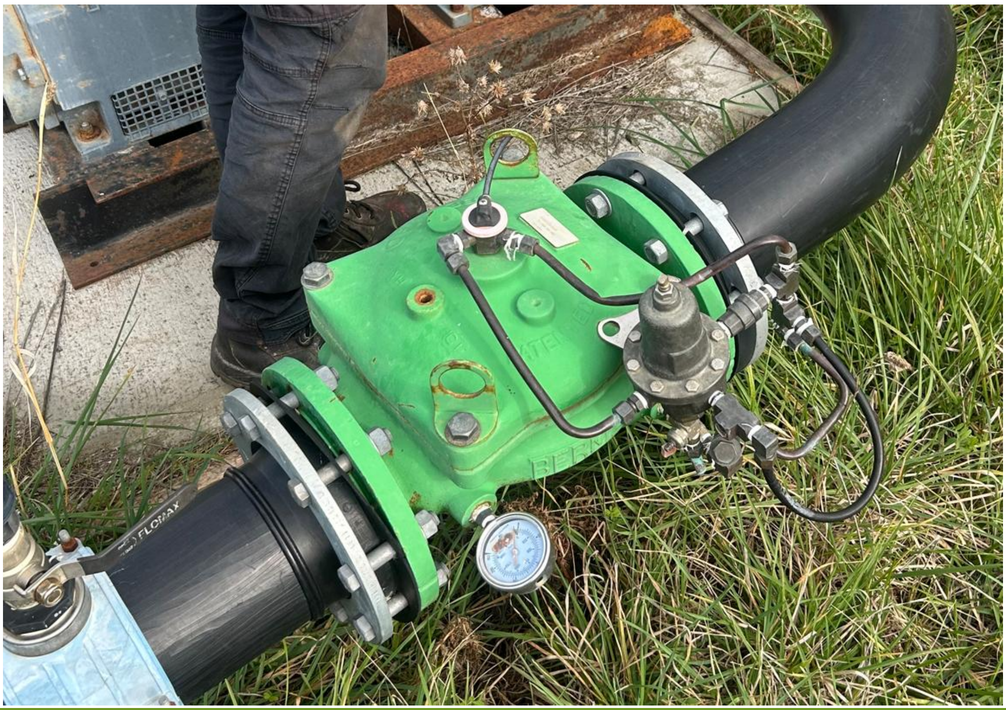

Figure 26: Pressure reducing valve (*Photo: Pinion Advisory*)

Gate valves
Gate valves control the flow of water by lifting a barrier (gate) out of the path of the water. When fully opened, there should be no restriction in flow (Figure 27).

Figure 27: Gate valve. These are often thrust blocked with steel and concrete, as shown here (*Photo: Pinion Advisory*)

Globe valves
Globe valves are a type of valve used for regulating the flow of fluids in a pipeline, that is, they can let more fluid through or cut off fluid flow. They consist of a movable plug within a spherical body (Figure 28).

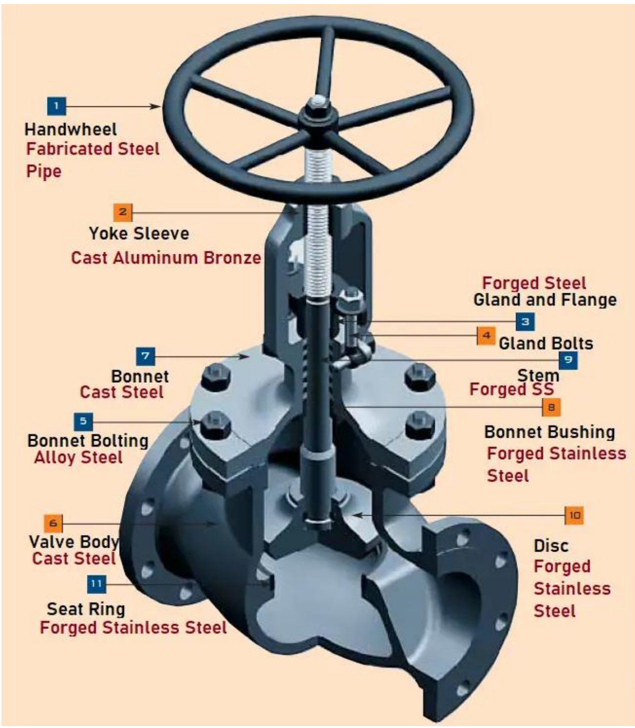

Figure 28: Typical globe valve (*Picture:* (Day, 2025))

Ratio valve
Like pressure regulating valves, they create a constant pressure downstream of the valve in a preset ratio to the upstream pressure (Figure 29). They are installed to make certain that pressures in the pipes in certain parts of an irrigation system remain below a set value.

Figure 29: Ratio valve (*Photo:* (Irrigation Box, 2025))

Pressure relief valve
These valves allow water to escape if pressure builds up in the system to a certain value. These valves are important if there is a blockage in the system which causes a pressure build up, and therefore the system is protected against breakage (Figure 30).

Figure 30: Pressure relief valve (*Photo:* (Indiamart, 2025))

Solenoid valve
These are diaphragm valves that can be controlled electronically (Figure 31). They are often used in domestic irrigation systems with automatic controllers that turn water on and off automatically.

Figure 31: Solenoid valve (*Photo:* (Baldivis Water, 2025))

Exercise

What valves have you encountered in your irrigation system?

What are they used for?

3.1.5 Flow meters

Flow meters are placed in pipes to measure the flow of water moving through that pipe (Figure 32). They are often used in situations where the volume of water used by a farmer is restricted through a licence.

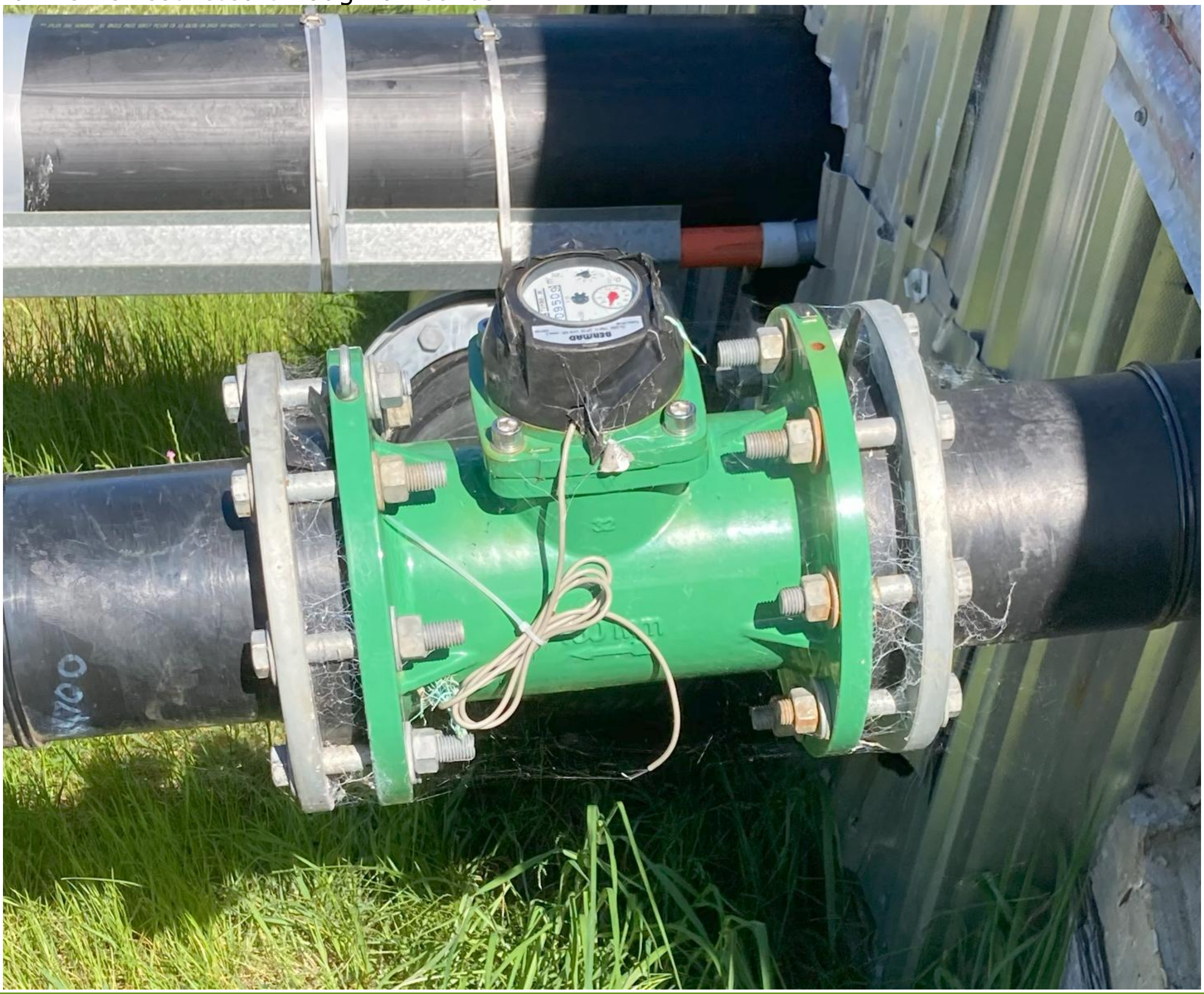

Figure 32: Flow meter (*Photo: Pinion Advisory*)

3.1.6 Sprinklers and emitters

Sprinklers, emitters and micro irrigation components are a small part (approximately 7%) of the capital cost of an irrigation system, but are responsible for up to 70% of performance, therefore it is important that quality is not compromised.

The goal of selection of these components is to be able to apply water uniformly. This depends on the:

- type of sprinkler or nozzle
- type and size of hole or orifice
- position and spacing of where the sprinkler is mounted
- operating pressure.

Figure 33: Sprinkler designed to work at high pressure (*Photo:* (Rain Bird, 2025))

Sprinklers

Sprinklers typically work at high pressures (around 50 psi or 350 kPa) (Figure 33) and throw water a large distance in a circular pattern. The diameter of the circle that a sprinkler wets is called the wetted diameter. To ensure uniformity, the distance between sprinklers is approximately half of the wetted diameter at the normal operating pressure.

Developments in sprinkler technology in the past few decades has improved sprinkler performance, meaning that they can work at lower pressure, and therefore use less energy. This is especially true of sprinklers that are attached to centre pivot irrigators. System pressures can be as low as 10 psi (145 kPa) and with a sprinkler component called a moving plate, similar wetted diameters can be achieved when compared to high pressure sprinklers.

Modern sprinklers typically have pressure regulating valves as a component, meaning uniformity of performance as pressure varies through the main system, and therefore the objective of uniformity of water application can be achieved (Figure 34).

Figure 34: Low pressure sprinkler with pressure regulator for centre pivot irrigator (*Photo: Pinion Advisory*)

Emitters or drippers
Emitters (or drippers) are devices that are attached to a small pipe that control the rate of water application to a crop in drip irrigation systems. It is important that emitters match the irrigation system. Emitters can be of varying quality, it is recommended reputable brands are used.

Drip irrigation systems operate at lower pressures than sprinkler systems, therefore are less costly to run and use less energy.

Emitters can be pressure compensating or non-pressure compensating. Pressure compensating drippers, like sprinklers with pressure regulators, have constant outputs over varying pressure. Non pressure compensating drippers have increased output as system pressure increases.

Aside from filters, emitters have design features like self-flushing diaphragms, and zig-zag water flow paths to cause turbulence and keep particles suspended, to ensure they do not become clogged by particulate matter.

Drip systems are typically used for perennial horticulture where the crop root zone is in distinct rows, with large spaces between the rows that do not require water. They are also useful in systems that use pots or containers, where root zones are very limited (Figure 30).

Figure 35: This raspberry crop uses drip irrigation (*Photo: Pinion Advisory*)

Exercise

What sprinklers or emitters / drippers does your irrigation system use?

What pressure do they operate at?

Maintenance and troubleshooting

4.1 INTRODUCTION

Even with well-designed systems, with time, there are bound to be problems that develop. These can often be avoided with good maintenance systems. If problems do occur, they can sometimes be easily fixed without contacting irrigation professionals if a simple troubleshooting process is followed.

4.2 MAINTENANCE

All irrigation systems need to be maintained regularly. Regular checks on operating parameters can be instructive, that is, if the numbers are not what they are meant to be, something is wrong that needs investigation. There should be an adequate system to check:

- operating pressure
- flow rate.

Simple checks of leaks and blockages should be done routinely, to make sure water is not wasted and system performance is optimal.

A simple maintenance checklist is given below. It covers:

- pump station and pump
- main line
- specific checks for a centre pivot
- specific checks for a dripper or micro-irrigation system.

4.2.1 Pump station

SAFETY TIP **Before completing any checks at the pump station ensure all electrical isolator switches are OFF (tagged/ locked) in the Switch Board**

Electrical

☐ Visually inspect all wiring for damage and condensation. This should include both wiring in cable trays and in cabinets

☐ Check for any sign of shorting, burnt cables, hot terminals

☐ Test starters / drives, ensure they are working

☐ Test priming system – reprime priming pump if applicable

☐ Test control systems i.e. pressure switches by shutting valves etc.

Mechanical

☐ Clean and inspect foot valve (if applicable)

Check adequate submergence of foot valve to ensure that vortexing/cavitation is not occurring

☐ Inspect suction and discharge piping for corrosion and leaks

☐ Fully close and open all valves to ensure they are still functioning

☐ Ensure air valve on discharge is functioning and sealing

☐ On systems drawing from a water source below the pump, ensure the suction assembly rises to the pump flange i.e. ensure there is no high point above the pump flange, this includes the fitting bolted to the pump flange

☐ Ensure system is primed / priming pump or system working if applicable

☐ Spin the pump by hand if possible to ensure it is free

☐ Grease pump and motor as per the manufacturer's guidelines (Important)

☐ Belt drive is tight (as applicable)

Run the pump

☐ General check over the pump and motor to detect any visible issue, leaks, cracks etc

☐ Check flow meter and pressure gauges are working and replace where necessary

☐ Check the pump runs up to pressure and note the pressure

☐ Check the water meter is functioning and check flow rate

☐ Healthy pumps and motors should be running cool and quiet, if there are strange mechanical noises and excess heat generation this warrants further investigation by a trained technician.

☐ Check pump rotation direction – phase switching might occur with work outside the property

4.2.2 Main line

☐ Drive the main line and check for leaks and damage (particularly after floods)

☐ Check air valves

- Ensure the isolation valve below the air valve is open
- Make sure the air valves are working – listen for air escaping while the line is filling
- Remove and clean the air valves if they are leaking

☐ Check for animals and nests in hoses and delivery pipes.

4.2.3 For centre pivots specifically

Centre pivot irrigation is the dominant irrigation system in Tasmania. Because of this, specific checks for centre pivots are detailed below:

Step 1 – When system is not running

☐ Inspect the power supply from the ground exit point to the pivot

☐ Inspect control cable for damage (if applicable)

☐ Check centre point hydraulic control valve & control tubing/wiring

☐ Check air valve at the centre point (if applicable)

☐ Inspect anchor bolts at centre point

☐ Grease Pivot point

☐ Inspect control panel – looking for obvious damage, insect nests, water and corrosion

☐ Walk the pivot and look for any obvious damage, loose wheel nuts, bent steel work, damaged drop tubes and sprinklers.

☐ Visually inspect span and motor cables for damage – chewed cables, cables pulled from glands etc.

☐ Inspection of gear boxes for correct oil level, and leaks.

☐ U-joints – check for worn u-joint inserts and ensure driveshaft shields are in place for safety.

☐ Check tyres for correct operating pressure and general condition. Correct pressures are:

Tyre Size	Suggested Running Pressure (PSI)*
16.9 x 24	11.5 to 14
11.2 x 38	17

*The suggested pressure does vary between manufacturers therefore it is best to check what is recommended for your brand of machine.

Step 2 – to be performed when system is on

SAFETY TIP **Walk the irrigator track before turning on the system to check for obstacles that the machine may collide with (fallen trees, machinery, damaged pivot bridges etc)**

☐ Start and run pivot
- Check forward and reverse operation
- Visual check of machine alignment
- Test safety circuit is working (out of alignment circuit)

☐ Test pump, start system from the pivot centre/
☐ Flush the pivot by running with the sand trap cap removed. Run until clear water is evident.
☐ Replace sand trap cap and run pivot up to pressure
☐ Inspect sprinklers and pressure regulators, ensure they are all working (look alive)
☐ Look for leaks, and repair as required.

4.2.4 For drip or micro irrigation systems specifically

Drip and micro irrigation systems are very popular in Tasmania for horticultural crops and protected cropping, for instance, cherries and berries. The biggest issue with drip and micro systems are blockages, because the emitters of water are so small. Systems that are flushed, cleaned and have adequate filtration should perform well.

Flushing
☐ Flush the mainline while the sub-main and lateral flush valves are closed for at least 2 minutes or the water runs clean
☐ Close the mainline flush valve and start flushing the submains for at least 2 minutes or until the water runs clean
☐ Close the flush valve of the sub-mains and flush the drip laterals patch by path for at least 2 minutes or until the water runs clean.
☐ Close the laterials in consecutive order and check that all drippers are working.

Disinfestation
Organic matter can block emitters. Chlorine (in the form of sodium or calcium hypochlorite) is used to clear out organic matter. The procedure is:
☐ Flush the system as per the instructions above
☐ Inject chlorine until it reaches the last dripper (divide the distance to the last dripper by 20 to give the time in minutes)
☐ Run the pump for another 10-15 minutes
☐ Shut the system down for 24 hours
☐ Flush the system again.

4.3 TROUBLESHOOTING

Table 3 below is a summary of common irrigation problems, possible causes and solutions.

Table 2: Troubleshooting

Problem	*Possible causes*	*Solutions*
Ponding and / or runoff of irrigation water	Irrigator left running too long at the end of the run	Turn off irrigator in time or install automatic cut offs
	Application rate greater than infiltration rate	Check sprinkler package and speed of irrigator
	Irrigation applied when soil is already wet or rain during irrigation	Check rain forecast and soil moisture before irrigation
	Irrigator is stuck on something	Remove obstacles from irrigator's path
Uneven crop or pasture growth	Blocked or broken nozzles	Unblock nozzles or replace if broken. Clean filters.
	Spacing between sprinklers or emitters is too high	Add more sprinklers or emitters and ensure overlap is adequate
	Poor pump performance	Conduct a system evaluation to ensure pressure and flows are adequate
Insufficient water flowing into the pump	Clogged screen or filters	Clean screen or filters

4.4 SAFETY

It is important to maintain a safe working environment while conducting irrigation activities. The key safety risks related to irrigation and ways to mitigate those risks are shown below in Table 4.

Table 3: Managing safety risks associated with irrigation

Safety risks in irrigation	Risk mitigation
Slips, trips and falls	Wear sturdy, waterproof footwear
Injuries due to water pressure	Keep your face as far away as possible from valves when adjusting a pressurised system Wear safety goggles
Splash when mixing fertilisers	Wear safety goggles and overalls / apron
Electrocution	Before completing any checks at the pump station ensure all electrical isolator switches are OFF (tagged/ locked) in the Switch Board Adhere to tag outs / out of service signage
Hearing damage from loud noises	Wear earmuffs

Principles of soil-plant-water relationships

5.1 PLANT WATER NEEDS

Water is an essential plant requirement. Plants need water to grow and survive. Water is essential for photosynthesis, nutrient transport, to keep cool, and to maintain structural support through turgor pressure.

Most plants that are important to agriculture take in most of their water through roots. There are some other plants, like orchids, ferns and moss, that can absorb water directly through their leaves or other above ground parts.

Different plant species have different water needs depending on a few different factors. These include:

- The root system: some plants have bigger or deeper root systems than others, and therefore can access more water from the soil.
- Leaf size: plants with bigger leaves generally need more water because there is a bigger leaf surface area for water loss.
- Leaf structure: plant water loss through leaves is affected by the number of pores (called stomata) on the leaf, and the thickness of layers of wax on the leaf surface (Figure 6). Also, some leaves can be curly in shape, which may restrict the loss of water from their surface.
- The way that some plants convert sunlight to energy: Some plants have special chemical pathways that use water more efficiently in the process of converting sunlight to energy (called photosynthesis). For example, some plants like cacti have a system called CAM (Crassulacean Acid Metabolism) that allows them to close their pores (stomata) during the day, therefore minimising the loss of water.

Figure 36: Onions are a common Tasmanian crop. Because of their waxy leaves, they use less water that other plant species (*Photo:* (Pixabay, 2025))

5.2 HOW DOES WATER MOVE THROUGH PLANTS?

Plants get water from the soil or other growing medium (in the case of hydroponic production) through their roots and this water moves through the plant and is lost from stems and leaves. This process is called *transpiration.*

Transpiration starts at the roots, where water is absorbed from the soil or growing medium. It is then pulled upwards by loss of water at the leaf surface through tiny pipes called *xylem*. At the surface of the leaf, if the tiny pores (stomata) in the leaf are open, water escapes to the atmosphere as a gas. For most plants, these stomata are only open during the day, and closed at night, therefore most plant water loss through transpiration is during daylight hours. The process is pictured as Figure 37.

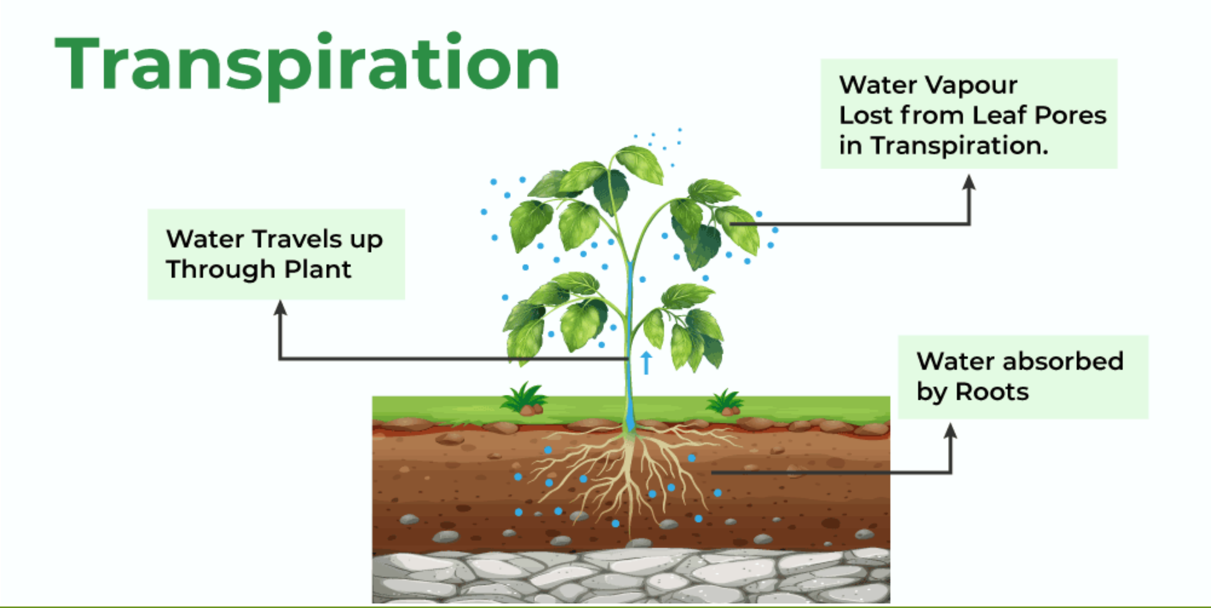

Figure 37: The process of transpiration in plants (*Image source:* (Geeks for Geeks, 2025))

As mentioned above, because of the differences between plants in the way they use water, their transpiration rates are different. For example, the water use of onions is approximately 60% of a perennial pasture over the same area due to differences in transpiration.

There is another process called *evaporation* where water is lost from any other surface other than the plant. The process of drying clothes on a clothesline is an example of evaporation. Evaporation can be measured using pans filled with water. In Australia, the Bureau of Meteorology uses a Class A evaporation pan, and measures the mm of water lost from the surface of these pans on a daily basis (Figure 38). This measure of evaporation can be used as an indication of the amount of water that plants are using. As can be seen from Figure 38, they are covered with mesh to minimise loss of water from consumption by birds or other animals.

To tell how much water is being lost from an area of land, transpiration and evaporation are added together. The result of this addition is called *evapotranspiration*.

Evapotranspiration can be measured by putting an area of land or potted plants on a set of scales called a lysimeter (Figure 39). As evapotranspiration occurs, the weight of land or pots decreases. This is impractical in most farming situations, but is used in intensive horticulture like berry production. To make things easier the Bureau of Meteorology calculates evapotranspiration using a formula that takes into account solar radiation, temperature and windspeed (Figure 40). Conveniently, evapotranspiration is measured in mm of water, therefore can be matched with mm of water applied through irrigation or rainfall.

Figure 38: Class A evaporation pan, used to measure daily evaporation in a standardised manner (*Photo: Pinion Advisory*)

Figure 39: Lysimeters are weighing scales that contain portions of land or pots that grow crops, and are used to directly measure evapotranspiration (*Photo: Pinion Advisory)*

The weather profoundly affects evaporation and transpiration. Both increase with:

- higher temperatures
- higher wind speed
- more sunlight
- lower humidity.

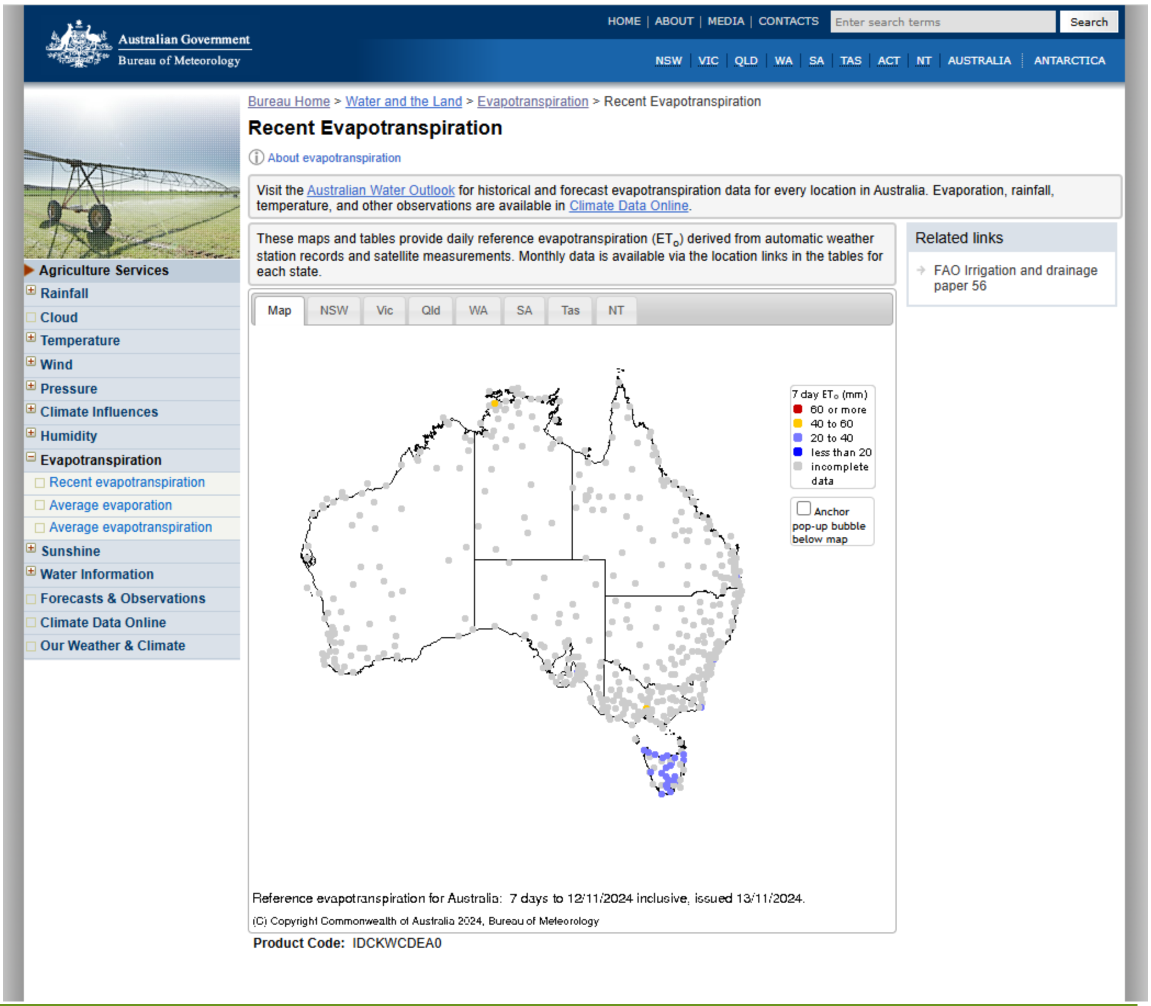

Figure 40: Evapotranspiration is reported by the Bureau of Meteorology (*Source:* (Bureau of Meteorology, 2025))

Exercise

- Go to the Bureau of Meteorology website and find the evapotranspiration in your area over the last seven days.

- From the website, can you find out what has the greatest influence over evapotranspiration?

Soil and irrigation

6.1 IMPORTANCE OF SOIL TO IRRIGATION

As mentioned in Section 5.1, most, if not all plants that are important agriculturally obtain their water through their roots, and these roots grow in either soil or other growing media (in the case of hydroponics). From now on, the word *soil* can be taken as meaning either soil or growing media, as they perform in very similar ways.

Once water enters soil through rain or irrigation, its availability to plants will depend on the characteristics of the soil. Furthermore, as the level of water changes in the soil from wet to dry, the availability to plants also changes. This means that some thought is necessary to determine when to irrigate so that the optimal amount of water is in the soil and therefore available to cropping plants.

6.2 SOIL TEXTURE

Not all soils are the same. They have different soil *texture*. Texture refers to the size of the particles that soil is made from. Particles of different dimensions have different names. These names are clay, silt and sand. The size range for these particles is in Table 4.

Table 4: Soil texture types and particle size

Soil texture type	Particle size
Clay	Smaller than 0.002 mm diameter
Silt	0.002 – 0.05 mm diameter
Sand	0.05 – 2 mm diameter

Soil is usually a mixture of these particle sizes, and these mixes have other more specific names, like loams, light clays, or loamy sands, for example.

The importance to irrigation is that different particle sizes cause soil to react in different ways towards water. For example:

- clays absorb and hold onto large amounts of water but can be slow to drain.
- sands allow water to enter soil more quickly that clays, and drain easily, but do not hold as much water as clays.
- silt is intermediate between clay and sand.

6.3 EFFECT OF SOIL TYPE ON WATER AVAILABILITY TO PLANTS

Soil acts like a sponge with regards to water. It can only soak up a certain amount, and after this it cannot hold any more. If there is more water applied than a soil can hold, then excess water will drain because of gravity. At the point when this drainage through gravity stops, the soil is said to be at *field capacity*.

As the soil dries out plants can use the water in soils between *field capacity* and another point of dryness called *permanent wilting point*. At this point, no more water can be extracted from the soil by the plant, even if there is water remaining in the soil. This is because the water left in the soil is held strongly between soil particles, and the force needed to extract this water is too much for plant roots.

The amount of water in soil between *field capacity* and *permanent wilting point* is called *available water*. Figure 41 shows the amount of *available water*, in mm of water per metre of soil depth, for various soil types. For example, for the column on the far right (self mulching clay), the amount of water that the soil holds is quite high (a little over 400 mm per m of soil at field capacity). As the soil dries out, water in the soil becomes impossible for plants to extract at about 200 mm / m soil (*permanent wilting point*). The *available water* is therefore around 210 mm / m soil.

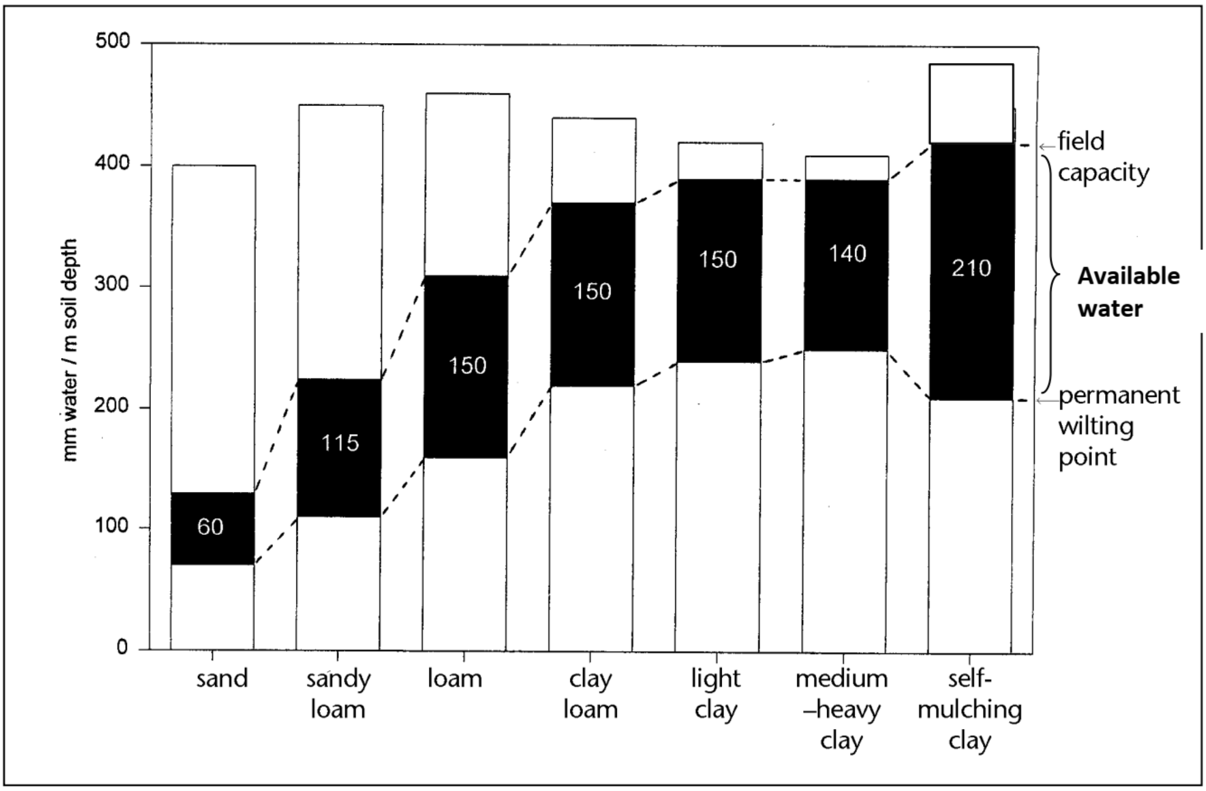

Figure 41: Effect of soil type on water storage (*Source:* (Cotching, 2011a))

Exercise

Using soil from your farm, or supplied, mix water and soil in a small handful into a lump about the size of a golf ball in your hand. Keep kneading the lump for a couple of minutes, ensuring the lump remains wet. Using your thumb and forefinger, press it out into a ribbon around 2 mm thick and 1 cm wide. Do this a few times and measure how long the ribbon gets before it breaks. Use the information in Figure 42 to determine your soil texture. This is the same method that soil scientists use in the field.

How long was your ribbon?

What is your soil texture?

Soil texture	Ribbon length	How the soil feels/behaves	Approx. clay content
Sand	nil	Coherence nil to very slight, cannot be moulded; sand grains adhere to fingers.	< 5%
Loamy sand	5 mm	Slight coherence; sand grains of medium size; can be sheared between thumb and forefinger.	5–10%
Clayey sand	5–15 mm	Slight coherence, sticky when wet, many sand grains stick to fingers, discolours fingers with clay.	5–10%
Sandy loam	15–25 mm	Coherent bolus but very sandy to the touch; dominant sand grains are of medium size and readily visible.	10–20%
Loam	about 25 mm	Loams can form a thick ribbon. Soil ball is easy to manipulate and has smooth spongy feel with no obvious sandiness. May be greasy to touch if much organic matter present.	about 25%
Silt loam	about 25 mm	Coherent bolus; very smooth to silky when manipulated.	About 25%
Sandy clay loam	25–40 mm	Strongly coherent bolus, sandy to touch; medium sand grains visible in a finer matrix.	20–30%
Clay loam	40–50 mm	Strongly coherent and plastic bolus, smooth to manipulate and slightly sticky.	30–35%
Silty clay loam	40-50 mm	Coherent smooth bolus; plastic and often silky to the touch.	30-35%
Sandy clay	50–75 mm	Plastic sticky bolus, fine to medium sand grains can be seen and felt.	35–40%
Light clay	50–75 mm	Plastic behaviour evident; smooth feel; easily worked, moulded and rolled into rod. Rod forms a ring without cracking.	35–40 %
Light medium clay	75–85 mm	Plastic bolus; smooth to touch; slight to moderate resistance to ribbon shearing.	40–45%
Medium clay	> 75 mm	Smooth plastic bolus; handles like plasticine; can be moulded into rods without cracking; resistant to shearing and sticks to thumb and forefinger.	45–55%
Heavy clay	> 75 mm	Smooth, very plastic bolus; firm resistance to shearing; will mould into rods. Handles like stiff plasticine. Very sticky and strongly coherent. Rods will form a ring without cracking.	over 50%

Figure 42: Field characteristics of different soil textures (*Source:* (Cotching, 2011b))

6.4 READILY AVAILABLE WATER

Figure 41 shows the *available water* for plant growth from various soil types. However, as the soil dries out, it becomes difficult for plants to extract water. Therefore, for practical purposes, there is another measure of soil water called *readily available water* or RAW for short. Only 25-60% of the total available water (the black section in Figure 41) is RAW. Once all the RAW is used in a soil, irrigation should be applied. If irrigation is applied at this point, the plants will then have a new source of water that they are easily able to extract from the soil, therefore their growth will not be hindered due to lack of water. Table 6 shows RAW for a range of soil textures. RAW is measured in mm of water per m of soil.

Table 5: Readily available water (RAW) for a range of soil textures (Cotching, 2011a)

Soil texture	Readily Available Water (RAW) mm/m
Sand	30
Loamy Sand	50
Sandy Loam	70
Loam	90
Clay	50
Clay Loam (Ferrosol)	80
Well structured clay	60

6.5 EFFECTIVE ROOT DEPTH

Different crops have different root depths in the soil from which they can effectively and easily extract water. This depth is typically around two thirds of the maximum root depth that will be found in these plants. Some effective root depths can be found in Table 6.

Table 6: Effective root depth for a range of crops (Cotching, 2011a)

Crop	Effective root depth (m)
Potatoes	0.6
Poppies	0.5
Peas	0.5
Green beans	0.5
Pyrethrum	0.8
Buckwheat	0.4
Carrots	0.5
Onions	0.3
Broccoli	0.5
Squash	0.5
Lucerne	1.2 – 1.8
Pasture	0.3 - 0.8
Stone / pip fruit	1.0
Vines	0.7
Barley	0.9 – 1.1
Rape	0.5 – 0.6
Kale	0.5 – 0.6
Fodder beet	0.5 – 0.6
Wheat	0.8 – 1.1
Maize	0.6 – 0.9
Oats	0.6 – 0.8

6.6 WHEN TO IRRIGATE

The above information can be pulled together to form a simple model of irrigation scheduling. The ingredients needed are:

1. Daily evapotranspiration
2. Soil texture, and therefore readily available water (from Table 5)
3. Effective rooting depth (from Table 6).

Example: Calculating RAW for a broccoli crop.

Broccoli is commonly grown on red soils on the North West Coast of Tasmania. These soils are called *Ferrosols* by soil scientists.

The effective rooting depth of broccoli is 0.5 m (from Table 6).
The RAW in a ferrosol is 80 mm / m.
Therefore the RAW for a broccoli crop is 40 mm for 0.5 m (RAW x effective rooting depth).

Therefore if a soil is at field capacity, there is 40 mm available for the broccoli before it experiences some level of water stress.

If evapotranspiration is 5 mm per day, and no precipitation occurs, the crop will need to be irrigated in around 8 days time (5 mm x 8 = 40 mm = RAW in the effective rooting depth for broccoli).

Exercise

Calculate the RAW for peas on a well-structured clay at field capacity.

If evapotranspiration is 4 mm a day, and the soil that is growing the peas is at field capacity, how many days will it be before the peas would need to be watered again?

6.7 SOIL MOISTURE MONITORING AND DECISIONS OF WHEN TO IRRIGATE

Few irrigators make irrigation decisions based on calculating the amount of water available in soil for plant growth and predictions of evapotranspiration for their crop. Some irrigators or their agronomists use soil moisture monitoring equipment to get an indication of the current soil moisture status and how it has been changing over time. This equipment might be a capacitance probe, tensiometer, or gypsum block. Whatever equipment is used, it should be calibrated for the soil type so that field capacity and the soil moisture level when readily available water runs out can be easily seen. Figure 43 shows the typical output from one of these tools.

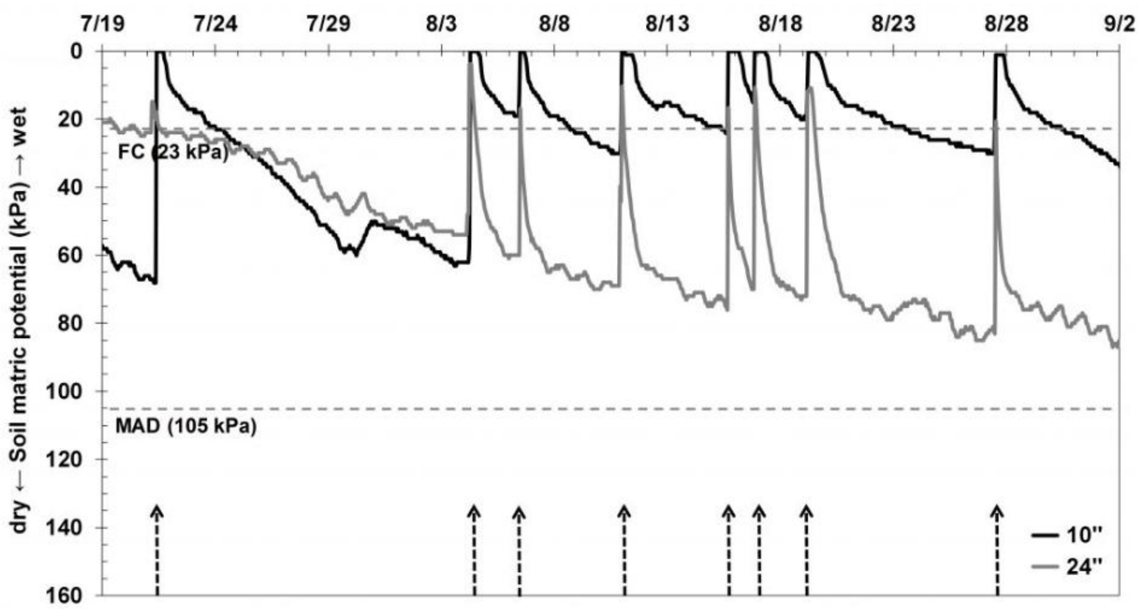

Figure 43: Typical output from a soil moisture monitoring probe (*Source:* (Oklahoma State University, 2018))

Using the output from these tools, patterns of water use can be seen and predictions made of when to water. There are now services in Tasmania that give indications of weather conditions predicted 7 days in advance that relate to irrigation decisions. For example, Table 8 shows the typical output from a service provided by Swan Systems for irrigators in the Central Highlands area of Tasmania. It shows evapotranspiration and rain predictions as well as other meteorological outputs relating to irrigation. With information on mm of water left in soil, and predicted mm of evapotranspiration, irrigators can easily calculate when to irrigate next. With rainfall predictions, irrigators can assess if they should wait for rain or commence irrigation.

Table 7: Typical output for an irrigation prediction service (*Source:* (Swan Systems, 2025))

	ETo*	Chance of Rain	Rain Range	Rain Estimate	Temp Range	Avg R. Humidity	Avg Wind Speed
	mm	%	mm	mm	°C	%	km/hr
Sat, 18-Jan	5.5	< 5	< 1	0	5-25	66	11
Sun, 19-Jan	5.5	< 5	< 1	0	7-27	65	10
Mon, 20-Jan	4.9	15	< 1	0	10-27	64	9
Tue, 21-Jan	5.2	15	< 1	0	10-28	66	9
Wed, 22-Jan	4.2	35	0-1	1	11-20	62	15
Thu, 23-Jan	3.1	60	1-6	5.3	5-19	67	11
Fri, 24-Jan	4.1	55	1-5	4.1	7-21	65	18
TOTAL	32.5			10.4			

6.8 INFILTRATION RATE

One of the most important characteristics of a soil is the speed at which it can absorb water. This speed is called the *infiltration rate*.

Infiltration rate is measured with an instrument called an *infiltrometer* (Figure 44).

Figure 44: Infiltrometer measuring speed of water absorption into soil (*Photo:* (Trade India, 2025))

Infiltration is measured in mm/hour.

The rate of infiltration into any soil changes depending on the initial moisture level in the soil, the number of cracks that water can move down, how compact the surface is and the soil texture. In some soils, infiltration rate can be changed dramatically by application of gypsum, for example, sodic soils (soils that contain clays that have a high proportion of sodium). To further complicate matters, soil texture may change throughout a soil profile with depth, therefore different layers of soil may have different infiltration rates.

Challenging soil types may include:

- water repellent sands – water runs off the surface of these sands
- heavy clay soils with very low infiltration rates
- cracking clays that have high infiltration when dry (due to cracks) and then become very impermeable when wet.

6.9 APPLICATION RATE

Infiltration rate is important to irrigation in tandem with *application rate*, which is the speed at which water is applied to the soil surface by irrigation. This, like infiltration, is measured in mm/hr.

The goal of irrigation is to match infiltration rate and application rate.

If application rate is greater than infiltration rate, then water runs off the surface of the soil, or if it is flat, will pond on the surface.

Table 8 shows maximum application rates for various soils in mm/hr.

Table 8: Estimated maximum water application rates in mm/hr (*Source:* (Dairy NZ, 2011))

Soil type	0-8^{o} slope (level to undulating)	9-12.5^{o} slope (Undulating to low hills)	>12.5^{o} slope (low – steep hills)
Sands and light sandy loams uniform in texture	31.8	25.4	20.3
Sandy loams overlying a heavier subsoil	20.3	16.5	12.7
Medium loams to sandy clays over a heavier subsoil	16.5	12.7	10.2
Clay loams over a clay subsoil	12.7	10.2	7.6
Silt loams and silt clays	10.2	7.6	5.1
Clays	6.4	5.1	3.8

Exercise

A sandy soil in Southeast Tasmania is growing pink eye potatoes. An infiltrometer has measured the soil infiltration rate as 25 mm/hour. Which of the following irrigation systems would be best for these potatoes?

- Drip irrigation (application rate 12 mm/hr)
- Sprinklers (application rate 24 mm/hr)

Why?

Do you know the application rate for the irrigators on your farm or the farm where you work?

Do you know the infiltration rate for the various soils on your farm or the farm where you work?

What do you notice from these numbers? Does the application rate match the soil types?

Why?

Further reading

For further information and resources, go to
https://www.tasfarmhub.com.au/water-use-efficiency-project/

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