# Guide to Good Irrigation

## Part 1: good irrigation practices on-farm

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DairyNZ

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# *Part 1: good irrigation practices on-farm*

## *About this booklet*

The DairyNZ *Guide to Good Irrigation – parts 1 and 2* were developed to help dairy farmers fine-tune their farms irrigation and help with daily operation.

*Part 1* is for farm staff and managers operating irrigation systems on a daily basis. It deals with how soil and plant types, climate, various system capabilities, timing and volume of water application influence the farm's irrigation needs.

*Part 2* is about making irrigation managers aware of their responsibilities as irrigators, including conditions of water supply, protecting water quality, efficient water use, teaching staff good irrigation practices and improving the system's performance. It also covers soil moisture monitoring, upgrading an old system and considerations when designing and installing a new system.

## *Contents*

## *Being a good irrigator*

Increased competition for water means the whole community is looking at how irrigators use water. Good irrigation not only has benefits for the wider community, but for individual farms too.

**This is because:**

- Pastures grow better, providing more feed which is easier to manage
- Fewer breakdowns occur and systems are simpler to operate.

Running irrigation well comprises three main components:

## *To irrigate well, you should:*

**Apply the right amount of water at the right time to get maximum growth from pasture.**

Put on too much water and it drains away below the pasture and leaches out some of your expensive nutrients; leave it too late and the plants may stress, which reduces growth rates.

**Maintain and manage the irrigation system to minimise wastage and leaks.**

There is little point in using expensive energy to pump water and then let it go to waste because of leaks in the system. Leaks may reduce the operating pressure so much that the system doesn't apply water evenly, leading to patchy growth of pasture. Watering tracks and other non-productive areas wastes water.

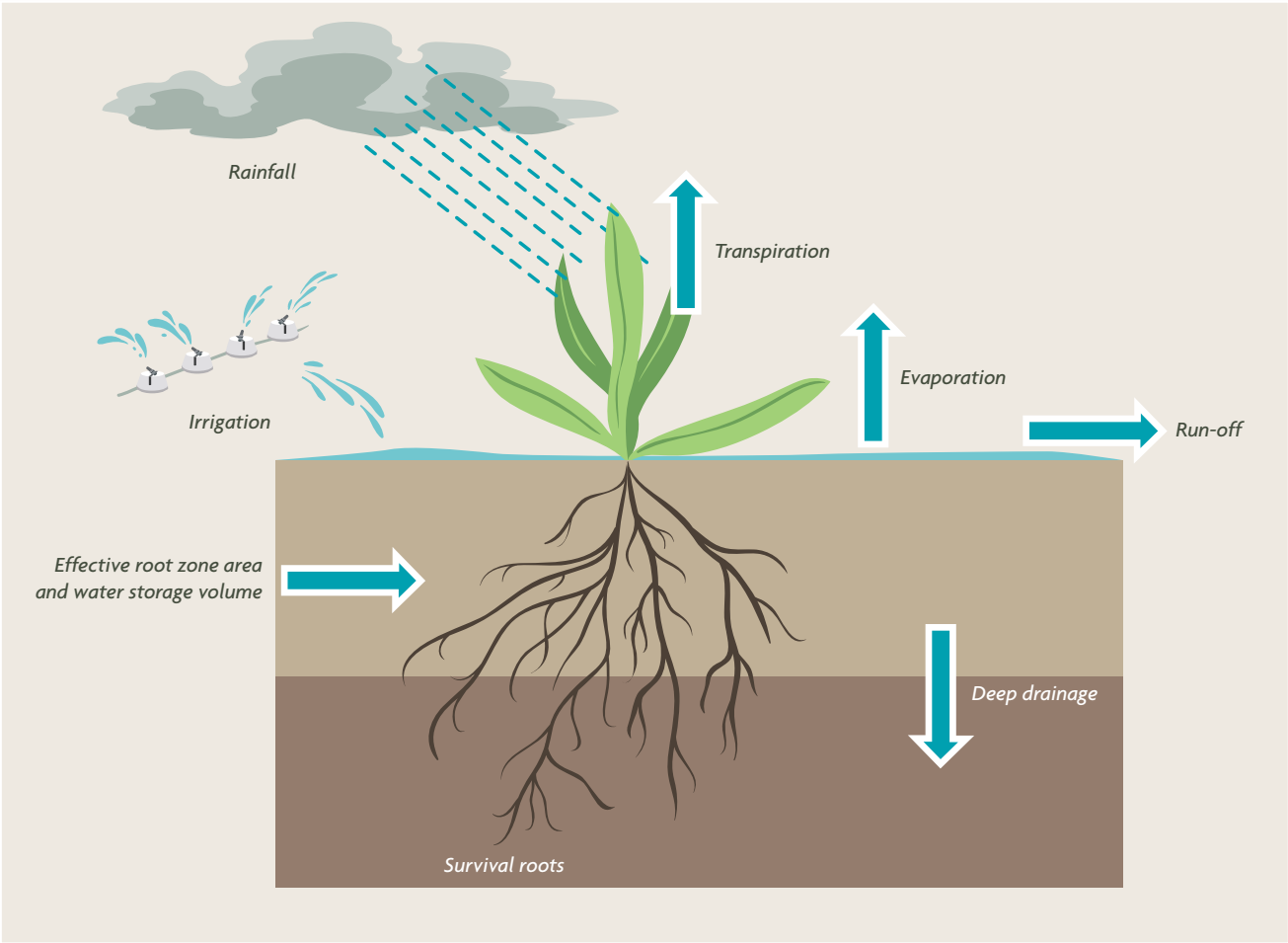
**Plan ahead for possible restrictions to water.**

If you depend on irrigation, decide on irrigation priorities (for example, crops vs pastures, good pastures vs poor pastures, or shallow soils vs deeper soils) and develop a plan to best minimise the impacts of water restrictions.

## *What influences irrigation needs?*

1. Soil type
2. Plant type
3. Climate
4. Irrigation system capability.

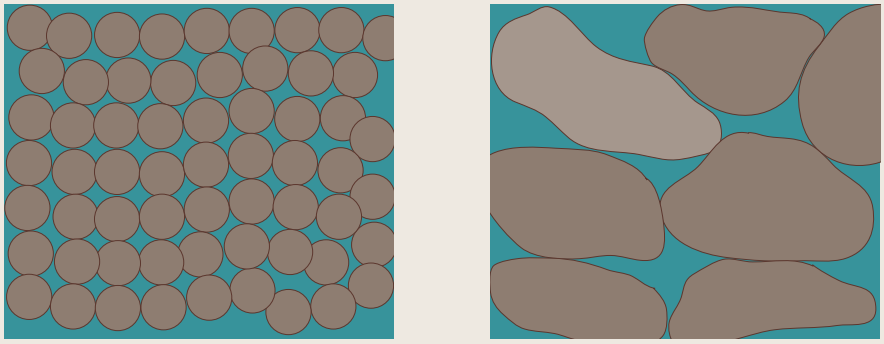
The diagram below illustrates the inputs and outputs of water in an irrigation system.



### 1. Soil type

Soil is a natural storage tank, holding water for pasture plants to absorb through their roots.

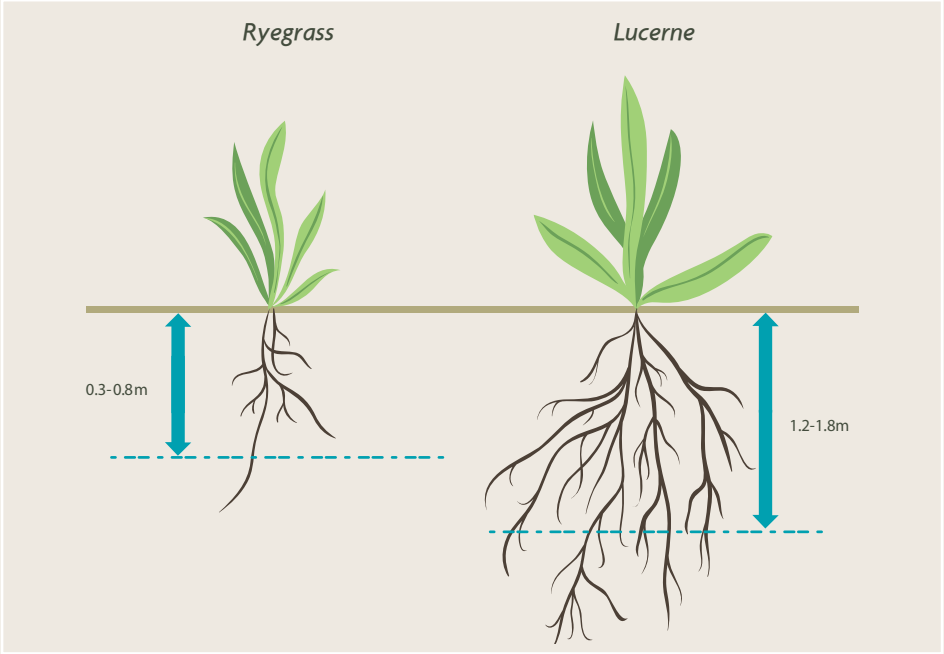
Soils vary greatly in the amount of water they can hold onto. Clay soils have smaller pores and can hold more water, but hold onto the water tighter. Sandy soils have bigger pores and hold less water but make it easier for plant roots to extract the water. The amount of water a soil can hold is expressed in millimetres of water per metre depth of soil (mm/m) and is called water holding capacity (WHC). It varies from 175-190 mm/m for clay loam to 45-55 mm/m for sand.



*Clay Soils* *Sandy Soils*

### 2. Plant type

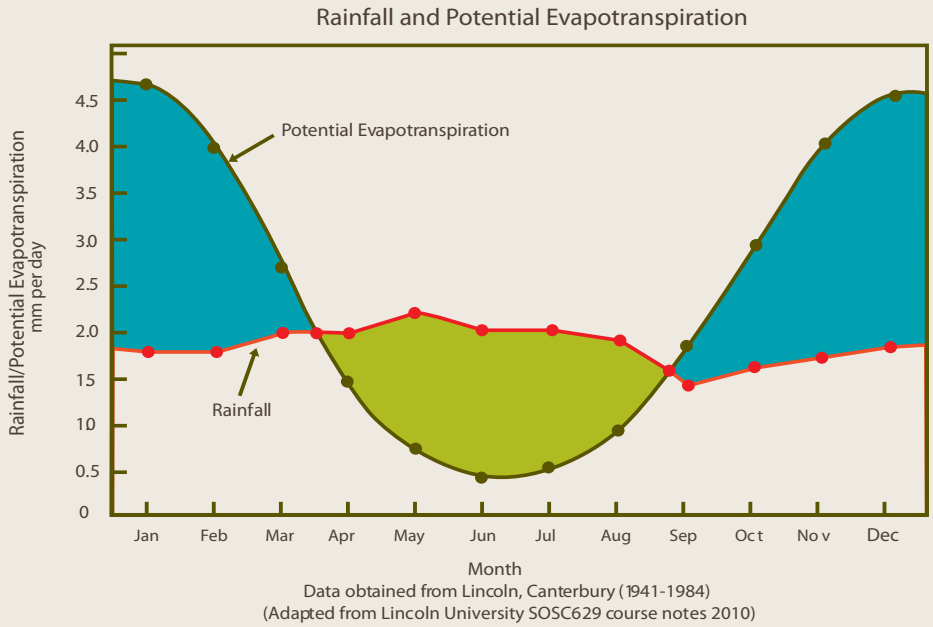
Pastures receive the majority of the water they require through their roots. Therefore, the depth of the plant's roots affect the amount of water a plant can uptake. A shallow rooting plant will have less water available through its root system than a deep-rooted plant. Annual and perennial pasture has a rooting depth between 0.3-0.8m, compared to lucerne's 1.2-1.8m. The root zone will also be affected by the plant growth stage, so a seedling will have a smaller root area than an established plant.



### 3. Climate

Plants use the majority of the water they require to keep themselves cool, pumping water from the roots to be transpired by the leaves.

The rate at which they extract water from the soil is based on the evapotranspiration rate (ET). ET rates are affected by climatic conditions such as temperature, wind, humidity and growth stage of the plant. A hot windy day in the middle of summer will have a high ET rate because the plant needs more water to keep cool.




KEY:

Potential evapotranspiration exceeds rainfall.

Rainfall exceeds potential evapotranspiration.

In Canterbury, ET is high during the summer period and irrigation generally needs to proceed uninterrupted (until a significant rain). The "shoulders" of the season are generally where much of the water savings can be made:

#### Spring

In spring, soils are generally near field capacity (full of water) and temperatures are still low. There is good potential to save water by delaying the start of irrigation until it is actually needed, i.e. when a soil moisture deficit occurs and temperatures increase. Saving water in the spring, when ET is low (risk to crops is minimal) also means there will be more water left for the peak season. But care must be taken not to let the soil get too dry, as it may be hard to catch up, especially with irrigators that have a long return period (e.g. when it takes longer than 10 days to return back to a paddock).

#### Autumn

ET rates can decrease rapidly in the autumn. This means irrigation water does not need to be applied as regularly. Minimising unnecessary irrigation in the autumn also helps minimise cooling of the soil, helping to keep plants growing longer.

Rainfall is the best form of irrigation as it does not cost anything. Where possible, leave enough room in the soil to absorb any rain so it can be utilised to naturally increase soil moisture, saving on irrigation. If soil is fully saturated and it rains, the water has nowhere to go except run-off or drain out the bottom of the soil, so it is not utilised and may take important nutrients along with it.

**4. Irrigation system capability**

Not all irrigation systems can apply the same amount of water. The amount of water that can be applied varies depending on the type of irrigation system (border dyke, centre pivot, rotary boom etc).

Other influences include:

- The amount of water available for use
- How soon an irrigator can return to a paddock
- How much water the irrigator can apply.

The overall capability of a system is referred to as system capacity and describes the maximum amount of water able to be applied in a given timeframe (e.g. mm/day, l/s/ha or mm/wk).

Because the main aim of irrigation is to keep up with ET rates (plants demand for water), system capacity should try to match ET levels. As it can be impractical or uneconomic to have an irrigation system which is able to match ET rates at their peak, decisions have to be made on how to manage this limitation.

During the season, options may include reducing the area of land irrigated, feeding supplements, or reducing stock numbers.

Long-term options include reviewing the irrigation system and making changes to improve the efficiency of the existing irrigation, increasing irrigators or installing more efficient irrigation types. To improve the reliability of water supply, development of seasonal storage or applying for additional water allocation may be required.

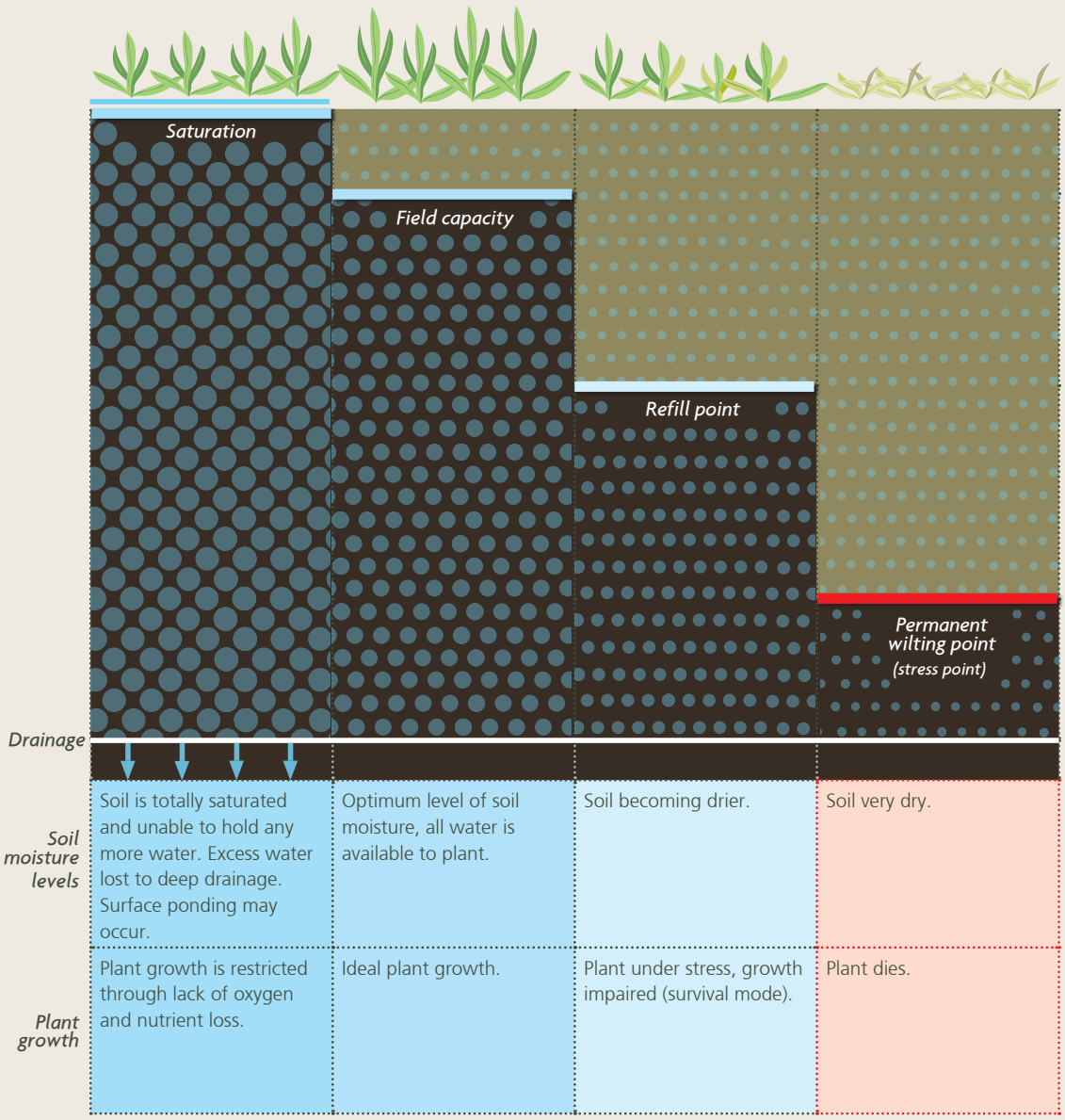
## *When is the best time to irrigate?*

When irrigating, the objective is to:

- Apply water when the plant needs it, to maximise plant growth
- Not overfill soil, which wastes water.

There is no value (only cost) in applying more water than the soil can store, but if water isn't applied before critical soil water deficit is reached, pasture growth will slow down. If the irrigation system and water supply arrangements allow, irrigation should happen when the soil moisture level reduces to refill point. Up until this point, moisture levels will not limit pasture growth and no visual signs of plant stress will be occurring.

The diagram below illustrates how plant growth is affected at each level of soil moisture.



Refill point for your farm needs to be customised, as it is dependent on soil and crop type. However, a simple rule of thumb is 50% of plant available water. In the early and later months (the 'shoulders' of the irrigation season) soil moisture levels can be kept closer to refill point because ET rates are lower, and irrigation and rainfall are able to keep up with plant demand for water.

When soil moisture levels fall below refill point, plant roots have to work harder to find water, slowing down plant growth. To demonstrate how soil releases water for plant growth, it can be compared to a sponge. The sponge is the soil and the hand represents the energy required by the plant to extract water from the soil.

| | Hold a kitchen sponge under a tap until totally saturated | Hold sponge over a bowl, water drips out bottom | Lightly squeeze sponge | Squeeze sponge harder | Sponge nearly dry, but still squeezing |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| *Moisture levels of soils* | Irrigation event | Saturation | Field capacity | Refill point | Stress point |
| *Roots* | | No energy required to extract water | Small amount of energy required to extract water | More energy is required to extract water | A lot of energy required to extract a small amount of water |

**Soil moisture monitoring** is an accurate way to measure and monitor soil moisture and temperature levels during the irrigation season, to ensure irrigation is scheduled appropriately.

Monitoring tells you when the soil is at field capacity to stop watering and when it is at the refill point to start irrigating.

By combining soil moisture information with soil temperature data, the greatest benefit is usually achieved at the start and end of the irrigation season, when the aim is to ensure soil moisture levels are sufficient without reducing soil temperature to a level which will reduce plant growth. This is because soil is easier to heat than water, meaning drier soils heat faster and maintain heat for longer.

Irrigation management in spring should focus on not irrigating too early, so soil temperature can increase faster; and in autumn not over-watering and dropping soil temperature at a quicker rate, slowing down pasture growth rates.

Irrigating too early in the season can waste water, as plants use less water when temperatures and evaporation are low, but letting the soil get too dry before starting to irrigate may make it hard to catch up, depending on soil and irrigation type.

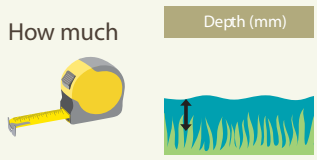
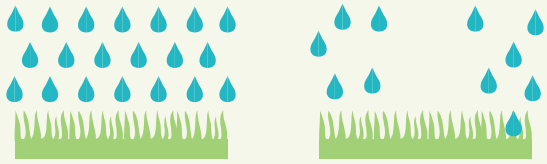
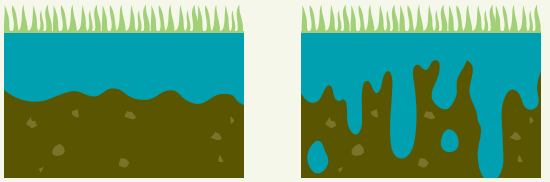
Although soil moisture can be monitored manually, the most common way is by a handheld meter such as a neutron probe or a permanently installed strip. Data can be collected by a consultant or the farmer, or sent direct to a personal computer.

## *How to decide when to start/stop irrigating*

It is important to know who has the responsibility of deciding when to start and stop irrigation, and how that decision is made. Copying the neighbours is not good practice. Below is the process to follow before starting to irrigate.

- **Soil temperature –** Check soil temperature before irrigating. Grass growth is slow below 10°C at 10cm depth. Drier soils warm more quickly than wet soils. Also, applying water can cool the soil further
- **Soil moisture status –** Check soil moisture status is between refill point and field capacity (with room for irrigation and rainfall)
- **Weather forecast –** Check weather forecast for rain
- **Water restrictions –** Check for water supply restrictions, annual volume allocation limits or water delivery roster
- **Effluent –** In areas where effluent is applied, ensure irrigation does not result in ponding
- **Stock –** Preferably graze in advance of the irrigator. This means the soil is at its driest and minimises soil compaction and pugging.

## *How much water is being put on?*

| | |
|---|---|
| **Application depth =** how much water is applied<br><br>To apply 1 mm (depth) you need 1 litre/m² or 10 m³/ha |  |
| **Application rate (or application intensity) =** how fast the water goes on. It is measured by the depth of water applied in a fixed time. It is usually measured in mm/hr. |  |
| **Distribution uniformity (Du) =** the evenness with which the soil receives water across the irrigated area. The higher the distribution uniformity, the better the system is performing. A Du of 85-90% should be readily achievable under a centre pivot. |  |
| **Infiltration =** the movement of water from the soil surface into the soil. Infiltration rate of soil indicates the speed water can be applied and soaks into the soil without causing run-off or ponding. Infiltration rate varies according to soil type, crops and slope. |  |

*The 'bucket test' helps determine correct application of water.*

Carrying out a 'bucket test' will help determine the application depth, rate and how uniformly water is being applied during an irrigation event. The 'bucket test' method is based on collecting irrigation water in strategically placed buckets and measuring what water is collected over a certain period of time. The 'IRRIG8Quick' system checks provide instructions on how to carry out this test and others for pivot, linear, traveller and sprayline irrigators. Go to **pagebloomer.co.nz/resources/tools**.

## *Irrigation system and application depth*

The amount of water an irrigator applies (application depth) varies hugely and depends on how the irrigation system has been designed.

If a farm's irrigation system has been designed to return to a paddock frequently (every 3 to 4 days) then a lower application depth can be used, because it is only a short period of time before water will be applied again. Conversely if an irrigation system is designed to only return to the paddock every 15 days, then a higher application depth is required to keep the soil moisture levels above refill point and limit plant stress over the longer period of time.

Below is an example of two different irrigation systems which deliver 4 mm of water per day but at different application depths.

| | Irrigation type | Return period | Application depth per irrigation pass | mm/day |
|---|---|---|---|---|
| **System A** | Centre pivot | 3 days | 12 mm | 4 mm (12 mm/3 days) |
| **System B** | Rotary boom | 15 days | 60 mm | 4 mm (60 mm/15 days) |

## *Centre pivot length and application rate*

With a centre pivot, the outside span needs to travel faster than the inside span in order to keep in line. Because the outer span covers greater distances, the application rate varies along the length of the pivot to achieve the same application depth.

At the centre it will be a low application rate (light drizzle) and at the end span, a higher application rate (heavy downpour). The longer the pivot, the greater the application rate will be at the end span.

This can cause problems, especially on rolling country, if the application rate is too high and the water is being applied faster than the soil can absorb it, increasing the risk of puddles and run-off. Because of uneven infiltration into the plant root zone, grass production can also be reduced. Any steps that reduce very high application rates will be beneficial. For example:

- Installing sprinklers with greater coverage and which spread water over a larger area
- Decreasing the application depth for each watering and returning more frequently.

## *Minimising the pump's energy use*

For spray irrigators the pump is the centre of the irrigation system, much like the human heart is to the body. If the irrigation pump is not working properly, the whole irrigation system will suffer.

A pump requires energy to move the water to the irrigator. The force at which the water is delivered is pressure (m, kPa, bar, psi), the amount of water sent to the irrigator is the volume ($m^3$) and the speed at which the water is moving through the pipe is the flow rate (l/sec, $m^3$/hr, gpm).

The pump's role is to supply the irrigator with the correct volume of water at the right pressure level and flow rate, using as little energy as possible. It should run smoothly and perform efficiently.

By having a healthy pump:

- Fewer breakdowns will occur
- Less energy will be used
- The correct amount of water will be delivered to the irrigator.

If a leak occurs in the system, the pump will have to work harder (using more energy) to achieve the same amount of pressure.

## *How to maintain the irrigation system*

Catastrophic failures of pumps and irrigation equipment during the season can waste a lot of time, restrict pasture growth and create stress. Regular equipment checks and ongoing maintenance is vital in preventing breakdowns and reducing the chance of serious damage. Having a weekly or monthly and annual task list for irrigation maintenance, where you can check tasks off easily, ensures maintenance is kept up-to-date.

Below is a summary of some essential maintenance procedures for most irrigation systems. For more detail specific to your system, contact the service provider. If you install a new pump, ensure the supplier provides the specifications and a pump commissioning report. These will serve as benchmarks for future checks.

## *Maintenance throughout the season*

### *Before the irrigation season starts*

**At the pump:**

- Record water meter reading and pump hours
- Protect pump shed from birds and vermin, if possible
- Grease pump and motor
- Ensure frost drain plugs are reinstated.

**At the irrigator:**

- Grease all moving parts – follow manufacturer's instructions
- Ensure frost drain plugs are reinstated
- Check hoses and ropes for damage
- Check for animals and nests in hoses and delivery pipes
- Check tyre pressure, wheel nuts and wheel shims for pivots
- Check drive shaft covers and safety stickers
- Check oil levels in gear boxes
- Check electronic controls which may need a new battery or re-charging
- Border dyke system – clear headraces of weeds by spraying or grazing with sheep
- Check and repair damage to sills, gates etc.

## *First irrigation*

**At the pump:**

- Surface pumps are primed
- Fill mainline slowly
- Take initial flow readings, operating pressures and amp meter readings – these will serve as benchmarks for the rest of the season
- Listen for any unusual noise
- Check all pressure and/or flow switches which could have been damaged over the winter
- Check any leaking seals, joints or glands
- Check suction screens and surface water takes. If auto clean, ensure it works.

**At the irrigator:**

- Grease pump and motor
- Check operating pressure to compare with initial readings or specifications
- Check sprinklers for condition, rotation, blockage, wear and tear
- Check hoses and pipes for damage or leaks.

## *During irrigation season*

**At the pump:**

- Grease pump and motor
- Check flow readings, operating pressures and amp meter readings to compare with initial readings or specifications.

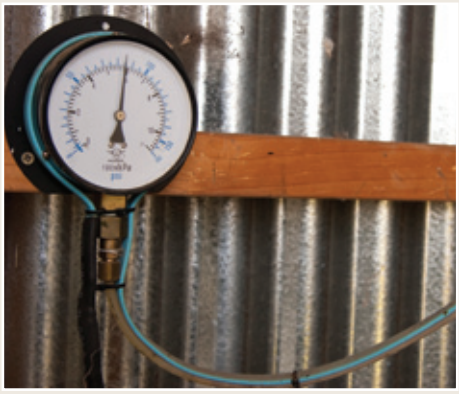
**At the irrigator:**

- Check sprinklers for condition, rotation, blockage, nozzles not hooked up, wear and tear
- Check irrigation speed and operating pressure
- Check application depth and compare against design specifications
- Check hoses and pipes for damage or leaks
- Follow maintenance schedule for regular greasing of travelling irrigators
- Have a plan to manage travelling irrigators in high winds. This may include turning water off, but keeping the irrigator filled with water; parking the irrigator behind shelter; or in the same direction as the wind to minimise the contact area. Tie down rotary booms.

## *At the end of the irrigation season*

**At the pump:**

- Repair or replace broken meters and gauges
- If the pump is operating more than 5% below specifications, consider taking action to repair.



**At the irrigator:**

- Remove frost drain plugs
- Remove any plug-in cords and store them in a covered area off the ground
- Tie boom irrigators so they can't rotate; store against a shelter belt
- Park the pivot in the same direction as the prevailing wind to reduce the contact area of wind on the machine
- Do not park the pivot in the wheel tracks or down a steep incline
- Pull K-line alongside a permanent fence, not under trees
- Do not store irrigators near trees which may break or fall over under the weight of snow
- Arrange an annual maintenance check by the supplier, for travelling irrigators
- Check major overhaul needs: usually every 10,000-20,000 hours of operation
- With border dyke irrigation, review performance and the need to redevelop border strips and levels.

## *Troubleshooting*

Problems which occur with irrigation can range from minor issues which take time to fix, through to major problems which cost time, money and loss of pasture production (from delayed irrigation) or loss of nutrients (through over watering). It is important that any problem is fixed quickly and the cause identified to stop it happening again.

Below is a summary of common irrigation problems, likely causes and possible options to deal with the problems.

**In the paddock**

| *Problem: Ponding and/or run-off of irrigation water* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Uneven application depth resulting in uneven pasture growth. | Irrigator malfunction. | Call service provider. |
| | Irrigator left running at the end of the run for too long. | Install automatic cut-offs or manually turn off irrigator sooner to reduce irrigation time, saving water and electricity. |
| | Too much water being applied over the wrong space of time, so the soil cannot absorb all the water (may occur with long centre pivots)<br>Incorrect sprinkler package fitted to irrigator. | Check soil moisture status and rain forecast before irrigating<br>Check sprinkler package and speed of irrigator. |
| Drainage or run-off causing soil erosion and loss of nutrients. | Irrigator travelling too slow or incorrect sprinkler nozzles. | Check nozzles and speed of irrigator. |
| | Irrigator is stuck on something or the hose is incorrectly laid out. | Remove obstacles from the irrigator's path and check layout of hoses is correct. |

| *Problem: Uneven pasture growth* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Grass growth is restricted because of insufficient water. | Blocked or broken nozzles. | Unblock nozzles or replace if broken. Clean screens and filters and check water quality. |
| | Spacing between irrigation runs is too wide. | Mark run locations on map and/or fences. |
| | Spacing between irrigation sprinklers is too wide. | Contact irrigation company to replace or add more sprinklers. |
| | Poor pump performance. This could mean a worn pump or pushing the system too hard. For example, by adding new sprinklers without upgrading mainline or pumps. | Investigate your irrigation system further by doing a system evaluation or calling a service provider. |

| *Problem: Water is being applied on roads, lane-ways or boundaries* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Water is wasted and not being utilised by plants. | Irrigator runs are in the wrong place. | Stop irrigation and move irrigator. Contact irrigation company to address irrigation layout design<br>Mark run locations on map and/or fences<br>Consider installing automatic cut-offs. |

**At the irrigator**

| *Problem: Irrigator stops* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Irrigator falls behind in the irrigation round. If unable to catch up, soil moisture will go below refill point and cause plant stress, limiting growth. | Irrigator or pump malfunction. | Call service provider. |
| | Irrigator is stuck on something or hose is laid out incorrectly. | Remove obstacles from the irrigator's path and check layout of hoses is correct. |

| *Problem: Leaks in pipes or hydrants* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Leaks waste water and energy, reducing the system's operating efficiency. | Bad connection or a cracked pipe. | Fix leaks in pipes and hydrants. |

| *Problem: Water is not spraying out of the irrigator properly* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Poor distribution uniformity. | Sediment blocking nozzles or a damaged nozzle. | Unblock nozzles or replace if broken. |
| | Sediment in water supply. | Clean screens and filters and check water quality. |
| Not enough water being applied, resulting in uneven growth. | Nozzle sizes are not correct, reducing pressure. | Replace nozzles. |
| | Not enough pressure to operate irrigator properly. | Call pump service provider. |

### At the pump

| *Problem: Measurement devices are not working (flow rate, pressure, energy)* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Unable to see how the system is performing, carry out monitoring or testing. | Meter is worn out. | Replace meter. |
| | Damaged in extreme weather conditions or by animals. | For spray systems, working pressure gauges should be installed on all pump delivery pipes, pump inlet pipes and irrigator inlets<br>Take measures to protect the system from weather and animals. |

| *Problem: Pump is making strange noises* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| If pumps wear or corrode, more power is used and less water is delivered at lower pressure. The irrigation system no longer does what it is designed to do. | Pump is incorrectly adjusted, worn out or broken. | Contact service provider. |

| *Problem: No power* | | |
|---|---|---|
| **Result** | **Possible Causes** | **Fixes** |
| Complete breakdown of a pump during the season can cause significant loss of production. | Power cut or pump malfunction. | Contact service provider. |

### At the water source

| *Problem: Build-up of debris* | |
|---|---|
| **Result** | **Fixes** |
| Insufficient water flowing to the irrigator. | Clean screen and/or filters. Protect from future build-up. |

## *Your farm's irrigation information*

### Emergency contacts

| | Name/company | Phone number |
|---|---|---|
| Pump repairs and services | | |
| Nozzle and hose repairs | | |
| Water supply restrictions (irrigation scheme or regional council) | | |
| Electrician | | |
| Irrigation service technician | | |
| Other | | |

### Soils

| | | | |
|---|---|---|---|
| Location | | | |
| Soil type | | | |
| Refill point | | | |
| Field capacity | | | |

### Irrigator

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Irrigator name | | | | | | | |
| Irrigation type | | | | | | | |
| Area (ha) | | | | | | | |
| Return period (days) | Max | | | | | | |
| | Min | | | | | | |
| Application depth (mm) | Max | | | | | | |
| | Min | | | | | | |
| Application rate (mm/hour) | Max | | | | | | |
| | Min | | | | | | |

## *References*

| | | |
|---|---|---|
| **The Irrigation Guide** (Farmer Irrigation Management Group, South Canterbury) | A must-read for farmers thinking about irrigation development. It will guide them through the decision-making process. | **irrigationefficiency.co.nz** |
| **The New Zealand Irrigation Manual** (Malvern Landcare Group, Central Canterbury) | A practical guide to irrigation. Covers management and maintenance as well as design, installation and regulations. | **irrigationnz.co.nz**<br>Hard copy available from Irrigation NZ<br>Ph: 03 341 2225 |
| **Irrigation NZ Knowledge Centre** | An evolving web-based information resource for all things irrigation in New Zealand. It contains fact sheets, articles, presentations, reports, current research projects, practical irrigation tools, links to other websites, field days and workshops. | **irrigationefficiency.co.nz**<br>Irrigation NZ<br>Ph: 03 341 2225 |
| **DIY Performance Evaluation** | Find out how well your system is performing by completing your own system evaluation. | **myirrigation.info**<br>Aqualinc Research Ltd<br>Ph: 03 964 6521 |
| **Irrigation calibrations and efficiency tests** | Guidelines and worksheets for a series of do-it-yourself, in-field irrigation system calibrations e.g. 'the bucket test'. | **pagebloomer.co.nz**<br>Page Bloomer Associates Ltd<br>Ph: 06 876 6630 |
| **Efficient irrigation** | DairyNZ Farmfact 8-5 – efficient irrigation | **dairynz.co.nz/farmfacts (water)** |