New Zealand Irrigation Overview
## Contents

### Irrigation in New Zealand

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution of irrigation</td>
<td>1</td>
</tr>
<tr>
<td>The economic value of irrigation</td>
<td>6</td>
</tr>
<tr>
<td>How irrigation adds value</td>
<td>7</td>
</tr>
<tr>
<td>Irrigation schemes</td>
<td>8</td>
</tr>
</tbody>
</table>

### Irrigation system types

<table>
<thead>
<tr>
<th>Type</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface irrigation</td>
<td>12</td>
</tr>
<tr>
<td>Pressurised irrigation</td>
<td>12</td>
</tr>
<tr>
<td>Solid set</td>
<td>12</td>
</tr>
<tr>
<td>Micro-irrigation (drip and sprinkler)</td>
<td>13</td>
</tr>
<tr>
<td>Spraylines</td>
<td>14</td>
</tr>
<tr>
<td>Travelling irrigators</td>
<td>16</td>
</tr>
<tr>
<td>Linear and centre pivots</td>
<td>18</td>
</tr>
<tr>
<td>Comparison of irrigation system types</td>
<td>20</td>
</tr>
</tbody>
</table>

### Componentry guide

<table>
<thead>
<tr>
<th>Component</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply</td>
<td>21</td>
</tr>
<tr>
<td>Water meters</td>
<td>24</td>
</tr>
<tr>
<td>Backflow preventers</td>
<td>27</td>
</tr>
<tr>
<td>Pressure gauges</td>
<td>31</td>
</tr>
<tr>
<td>Chemical injectors</td>
<td>31</td>
</tr>
<tr>
<td>Filters</td>
<td>32</td>
</tr>
<tr>
<td>Valves</td>
<td>34</td>
</tr>
<tr>
<td>Reticulation</td>
<td>38</td>
</tr>
<tr>
<td>Sensors</td>
<td>39</td>
</tr>
<tr>
<td>Emitters</td>
<td>39</td>
</tr>
</tbody>
</table>

### References

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41</td>
</tr>
</tbody>
</table>
Irrigation in New Zealand

Distribution of irrigation

New Zealand stretches almost 1,500 km from end to end. It is a long, narrow and mountainous island ridge situated between the Tasman Sea and Pacific Ocean.

New Zealand’s topography, coupled with its latitude and the prevailing westerly wind flow, determines the climate experienced in different regions.

Due to the mountains effects on climate, western regions of New Zealand tend to be wetter and eastern regions drier. The eastern dryness is especially so in summer, when drought is relatively common.

Fortunately, many of the eastern areas have surface water supplies from rivers originating in the mountains where rainfall is high, and ground water from extensive aquifer systems.

As well as causing wet and dry variation, the mountain effects cause higher temperatures in the east.

Wet air loses temperature relatively slowly as it is lifted over the ranges. With water gone, the dry air warms faster as it drops again on the other side.

RAINFALL AND TEMPERATURE CHANGES

Figure 1. Mountains cause an increase in rainfall on windward side.

Figure 2. Once the moisture is removed from the air, it heats up as it travels down the leeward side.

FURTHER INFORMATION
Read the article ‘Irrigation and Drainage’ by Terry Heiler at: www.teara.govt.nz/en/irrigation-and-drainage
IRRIGATION BY REGION

Figure 3 showing the irrigable land per region demonstrates the dominance of Canterbury and Otago which together account for almost 80% of allocated water for irrigation. Canterbury and Otago together have made the biggest investment in spray irrigation systems. However there are still areas of flood and borderdyke irrigation with flood being almost half the irrigated area of Otago.

There are no new flood or borderdyke irrigation being established in New Zealand. Conversion to spray irrigation increases farm business opportunities and improves water use efficiency. Spray systems such as centre pivot and linear (lateral move) irrigators are used by the majority of pastoral irrigation systems.

By contrast the majority of the irrigated area in Marlborough and about one third in Hawke’s Bay is drip or micro-irrigation. This is a reflection of the importance of the wine industry. Vineyards located on shallow and gravelly soils require little and frequent irrigation. Orchard production also utilises micro-irrigation with significant areas in Tasman and Hawke’s Bay. Spray irrigation in these regions is mainly used for vegetable cropping and pastoral farming.

The strategic value of irrigation has been increasingly demonstrated in western areas to provide certainty of yield and quality. In the Waikato the majority of irrigation is for dairy production including application of dairy effluent to land.

Figure 3. New Zealand’s existing irrigated area and future potential.

FARMING ENTERPRISES USING IRRIGATION

The range of crops and activities for which irrigation is used is shown in Figure 4.

New Zealand irrigates 800,000 hectares:

- **47% Dairy**
- **23% Sheep & Beef**
- **16% Arable**
- **5% Vegetable**
- **4% Grapes**
- **4% Fruit**
- **<1% Amenity**
- Less than 0.1% Other

Figure 4. Irrigated land use in New Zealand

New Zealand Irrigation Overview

Northland's major irrigated areas:
- **57% Dairy**
- **27% Fruit**
- **9% Sheep & Beef**

Waikato's major irrigated areas:
- **75% Dairy**
- **15% Vegetable**
- **6% Sheep & Beef**

Taranaki's major irrigated areas:
- **94% Dairy**
- **4% Sheep & Beef**
- **2% Arable**

Manawatu's major irrigated areas:
- **80% Dairy**
- **12% Sheep & Beef**
- **6% Vegetable**

Auckland's major irrigated areas:
- **53% Vegetable**
- **27% Dairy**
- **12% Fruit**

Bay of Plenty's major irrigated areas:
- **63% Dairy**
- **33% Fruit**
- **3% Sheep & Beef**

Gisborne's major irrigated areas:
- **63% Vegetable**
- **18% Fruit**
- **16% Sheep & Beef**

Hawke's Bay's major irrigated areas:
- **26% Sheep & Beef**
- **23% Fruit**
- **17% Vegetable**

Wellington's major irrigated areas:
- **77% Dairy**
- **10% Sheep & Beef**
- **5% Grapes**

Figure 5. Irrigated land use by regions – North Island.
Tasman’s major irrigated areas:

- **35%** Fruit
- **35%** Dairy
- **14%** Sheep & Beef

Malborough’s major irrigated areas:

- **72%** Grapes
- **11%** Sheep & Beef
- **7%** Dairy

West Coast’s major irrigated areas:

- **78%** Dairy
- **22%** Sheep & Beef

Canterbury’s major irrigated areas:

- **52%** Dairy
- **22%** Sheep & Beef
- **20%** Arable

Southland’s major irrigated areas:

- **75%** Dairy
- **21%** Sheep & Beef
- **3%** Arable

Otago’s major irrigated areas:

- **55%** Sheep & Beef
- **34%** Dairy
- **6%** Arable

Figure 6. Irrigated land use by regions – South Island.
The economic value of irrigation

In 2002–03 based on 425,000 hectares of irrigation nationally, irrigation contributed $0.92 billion or 11% of farm gate GDP\(^1\). Since then the irrigated area has increased by almost 50%. In 2011–12 the study was repeated for the then 720,000 hectares and estimated to contribute $2.17 billion\(^2\). These figures are farm gate based and do not take account of the considerable flow-on community socio-economic benefits (processing and related service industries).

Looking at the future potential, based on the NZIER report of 2010\(^3\), increasing irrigable area by 350,000 hectares increases national GDP by 0.8%.

A 2012 report by AERU, based on 500,000 hectares of existing irrigation in Canterbury with a further 250,000 hectares of new irrigation, reinforces this. It demonstrates the Canterbury economy receives an additional $2 billion in revenue, and just under 8,000 FTE’s, from the increased irrigation. For New Zealand wide impacts these numbers rise to $3 billion in revenue and just under 8,400 FTE’s.

There are considerable flow-on economic benefits to the community from irrigation. The Opuha Dam and the North Otago Irrigation Company ex-post studies show that farm expenditure, gross farm revenue and farm employment opportunities typically increase threefold when converting from dryland to irrigated agriculture.

There are also large social benefits, including a higher household and personal incomes and a higher proportion of the population in full-time employment.

** BENEFITS OF IRRIGATION **

- More certain and higher production levels.
- Increased land use opportunities for farm business.
- Increased profitability and improved return on investment.
- A more consistent income from year to year.
- Improved opportunity for family succession.

** OTHER CONSIDERATIONS **

A decision to invest in irrigation involves many considerations. The benefits of irrigation invariably exceed costs over time but there are other factors and associated risks.

- High investment in plant and equipment.
- Increased debt loading.
- Additional farm staff and infrastructure (buildings, grain storage, etc) required.
- Need to up skill in a range of areas.
- Substantial seasonal finance is often required.
- Changes in workload patterns.

The decision to irrigate or not is primarily an economic one but the personal, family and business implications also need to be factored in.
How irrigation adds value

The way irrigation adds value is illustrated in Figure 8. The natural summer dry weather pattern (from spring to autumn) leads to reduced plant growth. Irrigation makes up the water deficit and enables production to be maximised throughout the season.

The general trend shown in Figure 8 is typical of a pastoral farming system. The actual impact varies by region, season, farm system and enterprise. The effect on farm profit is further influenced by the farm management system and practices adopted.

Irrigation increases the efficiency of other inputs such as labour, energy, agrichemicals and fertiliser. Most of these inputs are required at the same level regardless of final yield. Irrigation effectively increases the benefit per litre of diesel, application of herbicide, and hour of work used in establishing crops.

Some farm systems can cope with periods of water deficit. Arable crops do not need water when drying off ready for harvest and grape crops are sometimes deliberately put under moisture stress to alter quality characteristics.

Avoiding water stress induced production losses has flow on benefits. Processers require certainty from primary producers so their production and market commitments can be met. Irrigation gives them confidence to contract purchase and maximises their processing and marketing efficiencies.

Sources of Irrigation Water

There are three water source categories:

1. Surface – rivers, streams and drains
2. Groundwater – bores accessing aquifers
3. Stored – dams, lakes and ponds. Storage can be within natural lakes or man-made reservoirs.

Irrigation systems may use one or a combination of these to meet demand. The different sources are discussed in more detail in Book 6: Developing Irrigation.
Irrigation schemes

ENHANCING IRRIGATION WATER SUPPLIES

Irrigation requires large volumes of water. In New Zealand a typical full cover crop or pasture will use about 30mm per hectare per week in summer. Over a full season the irrigation required in addition to rainfall may be up to 600mm per hectare. Water supplies need to be large and low cost to be economically viable.

In areas with high irrigation demand water resources are usually fully allocated – the quantity of water available for irrigation has been given out. Figure 9 shows the extent of surface water allocation in New Zealand for 2007 and 2012. Natural river system flows are typically at their lowest during summer when the irrigation demand is highest. So while on an annual basis there is plenty of water, it is not always available when required.

Many community irrigation schemes use storage dams (both at the scheme and farm level) to harvest winter flows for release in summer. Other schemes use ‘run of river’ water as the supply for irrigation.

Figure 9. Major catchment boundaries – percent of surface water allocation 2007 and 2012.

IRRIGATION SCHEME DEVELOPMENT

Large-scale irrigation in New Zealand began in the late 19th century. During the Great Depression of the 1930s, several large-scale storage and irrigation projects, such as the Rangitata Diversion Race, were built using government funding. The majority of major schemes were constructed after 1960 in the Canterbury and Central Otago regions.

Figure 10 overleaf shows government-owned irrigation schemes prior to 1989, and the number of hectares they irrigated. It excludes on-farm irrigation owned by private individuals or entities.

The rationale for government involvement in developing, subsidising and maintaining community irrigation schemes changed from period to period:

• Between 1910 and 1935, New Zealand government involvement followed the history of government assistance of irrigation by colonial governments in Australia. Policies aimed to mitigate drought, take advantage of existing water rights and reclaim mining land.

• After 1935, the first Labour government expanded the irrigation programme to boost employment and make greater use of the water resource.

• In the 1950s the government deemed direct intervention was necessary because individual farmers could not obtain the required finance, technology and labour, despite concerns being raised about the financial implications of the schemes. The 1950’s also saw large scale hydro projects begin creating or controlling lakes. Creating opportunity for irrigation.

• From the 1960s to 1980s, community schemes were increasingly viewed as a farm management tool to intensify agricultural production, and new irrigation schemes were justified as being in the national interest by virtue of having economy-wide benefits.

The late 1980s saw government begin to transfer ownership of the Crown schemes to farmers. There is now no government involvement in any schemes.

Several major schemes have been developed since then, including Opuha (1998, 16,000 ha), Waimakariri (1999, 18,000 ha), North Otago Stage 1 (2006, 10,000 ha), and the Wai-iti Valley Augmentation Dam (2006, 800,000 m²).

Today, farmer owned companies are responsible and accountable for scheme management and development. In combination with the RMA – which enables a decentralised approach to resource use - this has facilitated innovation in scheme design, more efficient management, and better water use. Over time as irrigation technology has improved the predominant Borderdyke design of the original government schemes, has changed to more efficient and in many cases more suitable spray irrigation.

This decentralised and privatised system has also highlighted the difficulties for many communities to raise early commitment and funding to determine the viability. It has also revealed more precisely the value of water in irrigation.

More recently central government has focused its efforts on funding science and technology development, and on facilitating the planning and proposal development process, through initiatives such as the Sustainable Farming Fund, the Community Irrigation Fund and the Irrigation Acceleration Fund.

Figures 11 and 12 show the extent of proposed schemes in Canterbury and Otago in relation to the existing schemes. Further community schemes are proposed in Hawke’s Bay, Wairarapa, Nelson and Marlborough.
Figure 10. Early irrigation scheme development.

Figure 11. Canterbury irrigation schemes 2012 (Source: Ministry for Primary Industries)

Figure 12. Otago/Southland irrigation schemes 2012 (Source: Ministry for Primary Industries)
Irrigation system types

Surface irrigation

BORDER DYKE
Border dyke irrigation is common in older Canterbury and Otago irrigation scheme areas. Water is carried by canal and race networks to head-races on farm. A series of gates in the head-race progressively hold water back, raising its level until it spills over a sill and on to graded land contained within borders. The gates are controlled by clocks connected to a release mechanism and they fall at set intervals along the race.

CONTROLLED FLOOD IRRIGATION
Water is directed to areas of land via a network of channels and ditches. They utilise the natural contours and fall of the land to distribute the water. It is common only in older Central Otago schemes.

FURROW IRRIGATION
Common in some countries, furrow irrigation is practically unknown in New Zealand.

Pressurised irrigation

All of the following systems operate with water delivered to them under pressure. The required pressures to operate optimally differ per system and these are summarised in Table 1 on page 20.

Solid set

Solid set irrigation systems are characterised by permanently fixed sprinklers on rigid supports. They are typically arranged in a triangular or rectangular grid pattern with spacing dependent on sprinkler throw capacity.

Solid set sprinkler systems are commonly used for over-head frost protection and under-tree orchard irrigation.

They are also used for nurseries and amenity irrigation including sports grounds and golf courses. Pastoral applications are increasing.

Figure 13. Border dyke control gate in raised position.
Figure 14. Fixed sprinklers used along a boundary to maximise irrigation area.
Figure 15. Regularly spaced fixed sprinklers apply water to prevent frost damage to grape vines.
Micro-irrigation (drip and sprinkler)

A micro-irrigation system consists of a network of lateral pipelines fitted with low discharge emitters or sprinklers. It encompasses a number of methods; drip, subsurface, bubbler and micro-spray irrigation.

**DRIP**

In a drip system, water is discharged under low pressure from emitters mounted on or built into the laterals which may lie on or above the soil surface, or be buried below the ground in the crop root zone.

These systems are distinguished by the fact that water is delivered by the system to some point, for distribution laterally (and vertically) by the soil medium. Discharge rates are generally less than 8 litres/hour for point-source emitters and 12 litres/hour per metre for line-source emitters.

**SPRINKLER**

Micro-sprayer (micro-jet) and mini-sprinkler systems rely on aerial spread of water droplets to achieve significant lateral displacement before water enters the soil. There may be further lateral spread within the soil itself. Discharge rates are typically less than 60 L/h.

Micro-irrigation systems are potentially a very efficient way to irrigate. Water can be applied precisely to the point where it is required for crop growth, and not to inter-row or other non-beneficial areas.

The system is virtually unaffected by wind or surface evaporation. Because of the very low labour requirement per irrigation, such systems allow frequent light irrigations as needed to best fit crop water requirements and optimise production.
Spraylines

A sprayline irrigation system irrigates a field by sequentially moving a static line of sprinklers to predetermined parallel locations across a field. Water is discharged under pressure from the sprinklers which are set at even intervals along a lateral pipeline.

Irrigated strips overlap at the edges to ensure even coverage. The evenness of application across the irrigated strip, and along the length of the sprayline both contribute to overall irrigation distribution uniformity.

1. HAND-SHIFT PIPES
Hand-move pipes are typically aluminium lengths that clip together with quick couplings to fit field dimensions. Shifting is manual, with pipe sections separated, moved and rejoined at each position. A sprinkler is mounted on a riser at one end of each pipe section, so the sprinkler spacing is set.

2. SIDE-ROLL SYSTEMS
Side-roll systems consist of sprinklers mounted on aluminium or steel pipeline sections. Each section acts as the spindle of a centrally fitted wheel. Repeating units are joined to form the sprayline to fit field dimensions. The sprinklers are mounted on rotating couplings to ensure horizontal alignment regardless of spindle position. Sprinklers are mounted at pipeline height, and spacing is essentially set.

Shifting is done by rolling the complete line sideways to the next position in the irrigation sequence.
3. **TOWABLE SPRAYLINES**

Towable spraylines consist of smaller sized impact sprinklers fitted at set intervals on a alkathene pipe. The laterals are connected to hydrants off buried mainlines. The sprayline length is set. Shifting is by towing the complete sprayline by one end to the next position in the field. Each lateral is moved manually around 6–14 positions.

Sprayline systems make irrigation feasible in irregularly shaped areas where other techniques are not suited. They are easily transported between fields and can be put aside to allow cultivation and other practices to be carried out unhindered.

Sprayline irrigation systems are arranged so successive shifts create a grid pattern of sprinkler positions. The spacing between sprinklers may vary considerably. The sprinkler layout pattern that is achieved in practice may be either square, triangular or somewhere in between. Multiple shifts over time overlap to water all of the area.

4. **LONG LATERAL**

Long-lateral systems have medium sized impact sprinklers mounted on a moveable stand on the end of a length of alkathene pipe. The pipe is connected to hydrants off buried mainlines. The pipe length is typically 60–80 metres long and each sprinkler is moved manually usually by motorbike around 6–10 positions to cover an average 0.8 hectares.
Travelling irrigators

There are three categories of travellers; either gun, fixed boom and rotating boom. Each consists of two parts:

a. winch mechanism and a reel or spool
b. gun-cart carrying the water distribution system.

A travelling irrigator moves across a field sequentially, strip by strip drawing the gun-cart. They are connected to successive hydrants along a buried mainline.

Irrigated strips overlap at the edges to ensure even coverage. The evenness of application across the irrigated strip, and as the traveller passes across the field both contribute to the irrigation distribution uniformity.

Traveller irrigators are easily transported around properties. Compact booms and guns can be moved over relatively long distances, and used to irrigate irregularly shaped areas. Travelling irrigators are characterised by either a soft hose or hard hose.
SOFT HOSE
Soft hose travelling irrigators have a wire rope anchored at the end of the run. The water distribution system and a winch are mounted on the gun-cart. The winch pulls the gun-cart along by coiling the rope on to the reel. The hose, pulled by the gun-cart, drags behind. At the end of each run the hose is flattened and coiled onto a drum to move positions.

HARD HOSE
Hard hose travellers have a large stationary reel anchored at the run end. The reel acts as a winch, coiling a delivery tube that both supplies water to the distribution system and drags the gun-cart along the field.
IRRIGATION SYSTEM TYPES

Linear and centre pivots

Laterals and pivots have a main pipeline supported above the field by a series of A-frame towers, each having two driven wheels at the base. The wheels are driven by individual electric motors pulsing on and off. Electronic guidance connected to the electric motors is used to keep the machines travelling in a straight formation.

Water is discharged under pressure from sprinklers or sprayers mounted along the pipeline. Evenness of application at points along the machine, and the evenness of application as the machine passes across the field both contribute to high overall irrigation uniformity of both laterals and pivots.

Laterals traverse the field in a straight path creating a rectangular wetted area. Water is supplied from a drag hose connected to a series of hydrants off a mainline.

Figure 30. Linear move irrigator with nutrient tank for fertigation.

Figure 31. Sprinkler for linear or pivot with weight (top), pressure regulator (middle), orifice and rotating disc (bottom).

Figure 32. Centre pivot with corner arm.
A centre pivot machine consists of a lateral circulating around a fixed pivot point. Depending on field layout, the pivot may complete a full circle or only part segments.

The inside of the pivot covers less area than the outside of the pivot. The water discharge has to be tailored accordingly to ensure the same amount is applied along the length of the pivot. This is achieved by steadily increasing rates of discharge per sprinkler as distance increases away from the pivot point.

Because of the automated nature, flexibility and very low labour requirement of centre pivots and, to a lesser extent, laterals, they allow farmers to tailor applications to best fit crop water requirements and maximise production.
Comparison of irrigation system types

<table>
<thead>
<tr>
<th>System Type</th>
<th>Capital Invest</th>
<th>Construction Method</th>
<th>Hydrant Pressure kPa</th>
<th>Hydrant Pressure Range</th>
<th>Reliability</th>
<th>Labour Required</th>
<th>Irrigation Practice</th>
<th>Run Length m</th>
<th>Shift Time mins</th>
<th>Movement</th>
<th>Applic Rate mm/hr</th>
<th>Applic Depth mm</th>
<th>Distribution Uniformity</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre Pivot – fixed</td>
<td>Medium / high</td>
<td>Bow string self propelled spans, fixed at centre</td>
<td>Low, 200–300</td>
<td>Excellent if maintain</td>
<td>Extremely low</td>
<td>Complete circles in up to 35 hrs</td>
<td>60–1000</td>
<td>N/A</td>
<td>N/A</td>
<td>15–75</td>
<td>5–100</td>
<td>Very high</td>
<td>Shallow, farm shape, corners missed, water supply</td>
<td></td>
</tr>
<tr>
<td>Centre Pivot – towable</td>
<td>Low / medium</td>
<td>Bow string self propelled spans, fixed at centre</td>
<td>Low, 200–300</td>
<td>Good if maintain</td>
<td>Low, 1 shift per 2–3 days</td>
<td>Complete circles in up to 35 hrs</td>
<td>60–1000</td>
<td>Slow 60–90</td>
<td>Tractor towed</td>
<td>15–50</td>
<td>5–100</td>
<td>Excellent</td>
<td>Flat tow path, shelter, farm shape, corners, water supply</td>
<td></td>
</tr>
<tr>
<td>Linear Move (Lateral Move)</td>
<td>Medium / high</td>
<td>Bow string self propelled spans &lt; 800m</td>
<td>Low, 200–400</td>
<td>Good if maintain</td>
<td>Low, 1–2 shifts/day</td>
<td>Irrigation shifts &lt; 400m, hose dragged behind drive unit</td>
<td>200–400</td>
<td>Quick 15–20</td>
<td>Run to next shift or pivot for return run</td>
<td>25–40</td>
<td>5–100</td>
<td>Very high</td>
<td>Farm shape, shelter, flat land</td>
<td></td>
</tr>
<tr>
<td>Hard Hose Guns</td>
<td>Medium – high</td>
<td>Poly pipe, gun carriage</td>
<td>High, 600–1200</td>
<td>Good if maintain</td>
<td>Low, 1–2 shifts/day</td>
<td>Irrigation lanes up to 90m, gun pulled to reel</td>
<td>&lt; 400</td>
<td>Mod quick</td>
<td>Towed by tractor to next shift</td>
<td>10–20</td>
<td>10–100</td>
<td>Average, poor in wind</td>
<td>Wind, crop damage (hose and water)</td>
<td></td>
</tr>
<tr>
<td>Soft Hose Guns</td>
<td>Medium – high</td>
<td>Soft lay flat hose, gun carriage</td>
<td>High, 600–1200</td>
<td>Good if maintain</td>
<td>Low, 1–2 shifts/day</td>
<td>Irrigation lanes up to 90m, gun carriage pulled on wire rope</td>
<td>&lt; 400</td>
<td>Moderately quick, 20–30</td>
<td>Towed by tractor to next shift after hose wound up</td>
<td>10–15</td>
<td>10–100</td>
<td>Average, poor in wind</td>
<td>Wind, crop damage (hose and water)</td>
<td></td>
</tr>
<tr>
<td>Rotating Boom</td>
<td>Medium – high</td>
<td>Rotating boom with end nozzles, some mid, on carriage</td>
<td>Medium, 400–600</td>
<td>Good if maintain</td>
<td>Low, 1–2 shifts/day</td>
<td>Irrigation lanes up to 100 m, gun carriage pulled in on wire rope</td>
<td>&lt; 600</td>
<td>Moderate 30–60</td>
<td>Towed by tractor to next shift</td>
<td>15–25</td>
<td>30–80</td>
<td>Average, poor in wind</td>
<td>Wind, crop damage (hose and water), miss corners</td>
<td></td>
</tr>
<tr>
<td>Fixed Boom</td>
<td>Medium – high</td>
<td>Fixed boom on carriage</td>
<td>Medium, 400–700</td>
<td>Good if maintain</td>
<td>Low, 1–2 shifts/day</td>
<td>Irrigation lanes up to 100 m, gun carriage pulled in on wire rope</td>
<td>&lt; 600</td>
<td>Moderate 30–60</td>
<td>Towed bytractor to next shift</td>
<td>20–50</td>
<td>10–100</td>
<td>Good, vulnerable in wind</td>
<td>Wind, crop damage (hose and water), unwieldy shifting</td>
<td></td>
</tr>
<tr>
<td>Side Roll Sprayline</td>
<td>Low</td>
<td>Aluminium pipes on carriage wheels</td>
<td>Medium, 300–500</td>
<td>Good if maintain</td>
<td>High, &lt; 3 shifts/day</td>
<td>Series of set positions</td>
<td>&lt; 400</td>
<td>Slow if not well planned</td>
<td>Rolled by motor unit to next position</td>
<td>7–15</td>
<td>5–100</td>
<td>Average</td>
<td>Shelter, fences, wind</td>
<td></td>
</tr>
<tr>
<td>Hand-shift Sprayline</td>
<td>Low</td>
<td>Aluminium pipes clip together</td>
<td>Medium, 300–500</td>
<td>Good</td>
<td>High, demanding</td>
<td>Series of set positions</td>
<td>&lt; 250</td>
<td>Slow if many</td>
<td>Move each pipe section by hand, reconnect</td>
<td>7–15</td>
<td>5–100</td>
<td>Good</td>
<td>Danger of powerline arc when shifting, muddy working conditions</td>
<td></td>
</tr>
<tr>
<td>Multiple Lateral Sprayline</td>
<td>Low / medium</td>
<td>Poly pipe, pods, sprinklers</td>
<td>Low medium, 250–350</td>
<td>Average</td>
<td>Medium high</td>
<td>Diagonal shift to next set position</td>
<td>&lt; 250</td>
<td>Slow for many lines</td>
<td>Towed, 4W bike or ute</td>
<td>3–8</td>
<td>50–80</td>
<td>Very poor / poor</td>
<td>Poor uniformity, limited crops, wind</td>
<td></td>
</tr>
<tr>
<td>Long lateral sprinklers</td>
<td>Medium</td>
<td>Poly pipe, sprinkler on stand</td>
<td>Medium, 400–500</td>
<td>Good / average</td>
<td>Medium high</td>
<td>Multiple positions around multiple hydrants</td>
<td>Slow for many lines</td>
<td>Individ hydrants sprinklers</td>
<td>Drag to next position, 2 or 4W bike</td>
<td>7–15</td>
<td>35+</td>
<td>Average</td>
<td>Wind, limited crops</td>
<td></td>
</tr>
<tr>
<td>Micro Spray, Dripline</td>
<td>High / very high</td>
<td>Low density poly-pipe, PVC mains</td>
<td>Low, 200–400</td>
<td>Good / very good</td>
<td>Very low</td>
<td>Automated series of blocks</td>
<td>Lateralls &lt; 300 m</td>
<td>None</td>
<td>None</td>
<td>3–6</td>
<td>5–30</td>
<td>Good / very good</td>
<td>Water quality, damage (equipment, pests)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Comparison of irrigation system types. Source: Adapted from Davoren.
Componentry guide

Supply

The origin of all irrigation water is from either:

- underground aquifer
- stored surface water
- or flowing surface water.

A range of equipment and infrastructure is needed to transport, manage and monitor the water to the irrigation system and its ultimate end use – the crop.

BORES

An irrigation bore is a drilled hole accessing underground aquifers. Bores are drilled vertically into the ground intercepting water at varying depths according to the hydrogeology of the location. Drilling uses pneumatic, hydraulic or mechanical methods either grinding or auguring the strata being drilled into. Depths range from shallow bores a few metres deep to over 200 metres. The depth is determined by where water is found at a sustainable and economic yield. Bores are lined with either PVC or steel pipes and sealed with a concrete collar at the surface. The section of liner that is accessing the water is a slotted pipe (usually stainless steel) acting as an initial screen. Submersible pumps are inserted inside the liner to the water depth and push the water back to the surface.
INTAKE SCREENS
Whether pumping water from a pond, stream, canal, river, irrigation ditch, pit, sump, or a golf course lake, you need the water to be free of trash and debris that could block water flow and damage the pump or clog water-distribution equipment.

Submerged screen and submerged self cleaning:
Baskets screens are ideally manufactured to have the open area a minimum of five times the pipe area. Lengths and shapes can be variable and the amount of debris in the water will determine how often manual cleaning is required. Figure 37 below shows a number of different designs.

Automatic cleaning may be preferred.
- Internal spray bars continually rotate and blast debris away from the screen
- No exterior moving parts that can foul and cause water blockage issues
- Housing utilises a removable and replaceable stainless steel screen drum saving on repair costs
- Can be installed at any angle without the operation being affected
- Improves primary filter downstream of pump by reducing the contaminant and loading concentration.

Floating screen and floating self cleaning:
Floating screens position the intake screen near the top of the water surface rather than resting on the bottom of the water source where silt and debris collect. An active self-cleaning screen may be a better alternative especially in shallow silt laden water.

PUMPS
There are two basic groups of pumps, positive displacement and centrifugal.

Positive displacement pumps move a fixed amount of liquid for every movement of the shaft. The shaft in these pumps moves a piston or diaphragm. Flow rate is determined by the size of the bore and speed that the pump is driven at. An application where irrigators may use this type of pump is fertigation units.
Centrifugal pumps are the most common pump in an irrigation system. All centrifugal pumps use an impeller which gives velocity energy to the water and this in turn is converted into pressure by the shape of the pump casing. These pumps come in a number of configurations to suit the physical constraints of the site. The motor is cooled by a fan forcing air across the fins.

Submersible pumps are a motor and a multistage centrifugal pumps operating in a vertical position. Suspended in the water column inside the bore casing, they are cooled by the passing water. Groundwater (greater than 7m) accessed via a bore requires a pump at or below the water level pumping to the surface.

CONTROLLERS
Controllers manage and can, in some situations, automatically update the watering schedule to allow for changes in water needs throughout the year. Some advanced controllers will automatically reduce the watering times as less water is needed by connecting soil moisture sensors to the system.

Controllers can range from the very simple home landscape tap controller to simple commercial controller with manual input of programmes, to fully integrated PLC and remote control systems.
HEADWORKS
This is a term used to describe the start of the irrigation distribution system. It contains exposed mainlines, pumps, valves, filters, meters, monitoring and telemetry equipment necessary to run the system.

Water meters
Regulation requires all takes greater than 5 l/sec to have a measuring device installed. As well as meeting regulatory requirements, meters provide very useful management information. An accurate measurement of flow is a base measurement enabling the irrigator to better manage and audit the performance of the irrigation system.

Meters are supplied in three main types:
1. Electro magnetic (commonly known as mag or mag-flow)
2. Ultrasonic
3. Mechanical.

It is recommended that the meter chosen suits the water source and is of high quality to ensure accuracy of the data collected. A guide to selecting a water meter is available on Irrigation New Zealand website.

The following section provides a brief overview of the different types of water meters.

ELECTROMAGNETIC
An electromagnetic meter consists of a section of pipe with a magnetic field around it and electrodes to detect electrical voltage changes. When a conductive fluid passes through the pipe an electrical voltage is created in the fluid, which is proportional to the fluid velocity. Electrodes in the probe detect the voltages generated by the flowing water. Measurement of the voltage is then converted to velocity from which the flow rate can be derived for a given pipe section. This type of meter is produced in a range of standard sizes and flow capacities.

Advantages:
• High degree of accuracy (+/- 0.5 to 2%) and consistent over full flow range.
• Wide flow range and no obstructions to flow.
• Robust with only minimal routine maintenance required.
• No moving parts.

Disadvantages:
• Power supply required.
• Electronic components vulnerable to lightning damage.
• Repairs require skilled technician and specialised equipment.
MECHANICAL
An impellor is rotated by water passing through the meter, which is translated to a volumetric reading. The mechanism is calibrated by an adjustable device which is pre-set and security sealed. The meters are available in various sizes and have to be full of water during measuring.

Advantages:
- Reliable and accurate means of measurement providing the meter is correctly installed.
- Relatively low initial cost.
- In-line maintenance with simple efficient mechanism.
- Headworks replacement readily available.

Disadvantages:
- Difficult to detect malfunction or unauthorised interference to meter while operating, if operated without a datalogger.
- Prone to wear in dirty water, potentially resulting in loss of accuracy.
- Some head loss characteristics.

ULTRASONIC
Ultrasonic meters use transducers to measure water velocity in full pipe applications and convert this to a flow rate. Transducers are fixed on the outside of the pipe and a transit time method is used to calculate the velocity of water within the pipe. The transit time method calculates velocity from the differences in time for an impulse to pass between two transducers located on the outside of the pipe.

Advantages:
- Robust with minimal routine maintenance required.
- Simple to install and no moving parts.
- Same meter can be used in a wide range of pipe sizes.
- Consistent over full flow range.

Disadvantages:
- Repairs require skilled technician and specialised equipment.
- Power supply required.
- Electronic components vulnerable to lightning damage.

SELECTING A FLOW METER
Water source
This could be a river, surface water, groundwater, open channel or pressurised pipe. Water source will have a bearing on water quality (silt, weed etc.), range of flow rates and head.

Head
How much head do you have? Do water levels fluctuate during a season? If so by how much? What is the minimum head a meter needs to work? Do you need to minimise head loss?

Flow range
What is the flow range throughout the year and what are the fluctuations in flow? Meters have a minimum flow below which they cannot provide an accurate reading. If you choose a large meter, you may lose accuracy at the lower end of the flow range. Meters continually operated in the high flow range wear out and fail much quicker than meters that operate in the middle of their flow range.
**Access to power**
When selecting meters for remote locations you will need to consider if they can run accurately on solar power, batteries or even need power at all. This also applies to dataloggers.

**Accuracy**
If there is a requirement for a data accuracy of 2% then it would not be useful to choose a meter that only reads with accuracy of 5%. A manufacturer’s claims for meter accuracy are usually well substantiated by laboratory tests supplemented by standardised field tests. A meter will only be accurate if the metering situation meets all the manufacturer’s requirements of flow profile, temperature, humidity, flow range, vibration etc.

**Reliability**
A meter needs to be reliably accurate so it provides the correct reading time after time.

**Data output**
What level of data accuracy do you need? What units do you need your data in? Does the data need to be a measure of instantaneous flow, totalised flow or both? Does the data need smoothing or integration?

**Tamper-proof**
Meters can be buried and some manufacturers provide special containers for just this purpose. Access to the meter can then become a problem.

**Longevity**
What is the average operating life? This will be dependent on the meter type and the situation the meter is used in.

**Cost**
One of the most crucial parameters is cost. Generally, the more accurate and reliable the meter, the more expensive it is. But, purchase price is not the only cost. Other aspects should be considered such as the cost of installation, maintenance, data collection, calibration and longevity.

**Table 2: Summary of Water Meter Characteristics.**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Electromagnetic</th>
<th>Mechanical (Propellor, Turbine &amp; Paddlewheel)</th>
<th>Ultrasonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (typical)</td>
<td>±/− 0.5–2%</td>
<td>±/− 2–5%</td>
<td>&lt; ±/− 2%</td>
</tr>
<tr>
<td>Reliability/tamper-proof protection</td>
<td>Very High</td>
<td>Medium</td>
<td>Medium–High</td>
</tr>
<tr>
<td>Flow rate indication available</td>
<td>Yes</td>
<td>Yes, with datalogger</td>
<td>Yes</td>
</tr>
<tr>
<td>Remote reading capability</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Average operating life</td>
<td>20 years</td>
<td>4 years (less if poor water quality)</td>
<td>15 Years</td>
</tr>
<tr>
<td>Pressure loss (Head loss)</td>
<td>Negligible</td>
<td>Paddle – Negligible Other – 0.4m</td>
<td>Negligible</td>
</tr>
<tr>
<td>Resistance to blockage</td>
<td>High</td>
<td>Low - Medium</td>
<td>High</td>
</tr>
<tr>
<td>Resistance to weed</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Water quality needs</td>
<td>Clean &amp; Dirty</td>
<td>Clean</td>
<td>Clean &amp; Dirty</td>
</tr>
<tr>
<td>Relative installed cost</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Power required</td>
<td>Yes or Solar/Battery</td>
<td>No</td>
<td>Yes or Solar/Battery</td>
</tr>
</tbody>
</table>
Backflow preventers

THE BACKFLOW PREVENTION SYSTEM
The installation of a backflow prevention system is required in an irrigation supply line to prevent backflow of diluted agrichemical into the water source (both surface water and groundwater bores) if the irrigation pump unexpectedly shuts down.

The key requirements for all backflow prevention systems include:

1. The backflow prevention device must be installed between the water supply pump outlet and the point of the agrichemical injection.
2. Injection and backflow prevention device must not be located on the suction side of a water supply pump.
3. All device(s) used in backflow prevention must be positioned and oriented according to the manufacturer’s specifications.
4. A backflow prevention device is also required in the agrichemical injection line to prevent water from flowing from the irrigation system into the agrichemical dilution tank. An appropriate check valve located in the agrichemical injection line meets this requirement. In addition, a normally closed solenoid valve at the agrichemical dilution tank outlet, placed in the suction line of the injection pump and energised (i.e. open) only when there is power to both the injection pump and the irrigation pump, will help guard against backflow and prevent dilution tank overflow under shutdown conditions.
5. Selection of the appropriate backflow prevention devices for the backflow prevention system depends upon the characteristics of the agrichemical that can backflow, the water source and the irrigation system. Concerns include whether injected material is toxic and whether there can be back-pressure or back-siphonage.
6. Local regulations must be followed in selecting the appropriate backflow prevention system.
7. Backflow prevention systems must be maintained and regularly tested to keep all check valves, low pressure drains, interlocking devices and vacuum breakers, free of corrosion or other build-up, and functioning properly any time the system is operating.

DEFINITIONS
Backflow prevention system – The combination of all the safety measures used in an irrigation system with agrichemical injection to prevent water pollution or contamination by preventing the flow of diluted agrichemical in the opposite direction of that intended.

Backflow prevention device – A safety device, usually used alongside other safety devices such as interlocking devices, to prevent water pollution or contamination by preventing the flow of diluted agrichemical in the opposite direction of that intended.

Check valve – A device to provide positive closure which effectively prohibits the flow of injected diluted agrichemicals in the opposite direction of normal flow when operation of the irrigation system pumping plant or injection unit fails or is shut down.

Interlock devices – Safety equipment used to ensure that if the irrigation pumping plant stops, the injection pump will also stop. Devices may also be used to shut down the irrigation system if the injection system fails.
TYPES OF BACKFLOW PREVENTION SYSTEMS

1. **Check valve with vacuum relief and low pressure drain.** This system, as shown in Figure 48, is primarily an anti-siphon device and should be constructed with corrosion-resistant materials. The check valve should be spring-loaded with a chemically resistant sealing surface capable of preventing leakage. Generally metal-to-metal seal surfaces are not acceptable. The direction of flow should be clearly indicated on the outside of the device. The vacuum relief valve is installed on top of the pipe on the inlet side of the check valve to provide for vacuum relief when flow discontinues. The vacuum relief should be 19mm in diameter. The low pressure drain is for monitoring check valve performance and bleeding off any leakage. It must be located on the inlet side of the check valve at the lowest point, usually directly under the vacuum relief valve. The drain must be mounted in the pipe such that any check valve leakage enters the drain rather than flowing toward the water supply. The drain should be at least 19mm in diameter with a closing pressure of at least 7kPa and not exceeding 35kPa. The drain discharge must not be allowed to contaminate any water source. Shutoff valves should not be located on the outlet side of the drain. An inspection port of at least 102mm diameter should be provided to check for malfunction of the check valve and drain where the irrigation pipeline is 102mm or larger. This inspection port can be combined with the mounting of the vacuum relief valve.

2. **Air gap.** An air gap is a physical separation between the free flowing discharge end of a water pipeline and an open or non-pressurised receiving vessel. To have an acceptable air gap, the end of the discharge pipe must be located at a distance of at least twice the diameter of the pipe above the topmost rim of the receiving vessel. In no case can this distance be less than 25mm. This is a simple and effective type of protection. However, an additional pump is required downstream of the receiving vessel to pressurise the water before it enters the irrigation system.

3. **Pressure-vacuum breaker.** The pressure-vacuum breaker contains, within a single body, a spring-loaded check valve and a spring loaded, air-entry valve which opens to admit air whenever the pressure within the body upstream of the check valve approaches atmospheric. The pressure-vacuum breaker should not be installed where there can be back-pressure, only where there can be back-siphonage. The pressure vacuum breaker can have shutoff valves downstream of the device. It must be installed at least 300mm above the highest downstream outlet.
4. **Double check valve.** The double check valve assembly is composed of two single, independently acting check valves and can handle both back-siphonage and back-pressure. A low pressure drain and inspection port as described under (1), should be installed immediately upstream of this system.

5. **Reduced-pressure-principle device.** This device consists of two independently acting check valves, plus a pressure differential relief valve that is located between the two check valves. It can be used for both back-siphonage and back-pressure control and can handle most agrichemicals. A minimum clearance of 300mm above ground level is suggested to ensure an air gap between the relief valve and any water that might puddle beneath the device.

6. **Atmospheric vacuum breaker.** An atmospheric vacuum breaker has a movable element or plunger which prevents spilling from the device during pressurised flow and opens to provide an air inlet following cessation of flow if a vacuum (back suction) occurs. This system cannot be installed where back-pressure persists and can be used only to prevent back-siphonage. An atmospheric unit should not be used with shut-off valves downstream and must be installed at least 150mm above the highest outlet or the topmost overflow rim of a non-pressurised tank. These units are installed primarily in lawn and turf irrigation systems that are connected to portable water supplies, but in some instances will work for field irrigation systems.

**Injection port location.** The injection port in the irrigation system must be located downstream from the mainline backflow prevention device and preferably located higher than the top of the agrichemical dilution tank. It should be located as close as practicable to the irrigation system to minimise the volume of water in the pipe between the point of injection and the irrigation system.

**Backflow prevention in the injection line.** An injection line backflow prevention device is required at the injection port of the irrigation system to prevent water from flowing from the irrigation system into the agrichemical supply tank when the injection pump is stopped. This will prevent the agrichemical dilution tank from overflowing. This device shall be a spring-loaded, chemically-resistant check valve having a minimum opening pressure of 69kPa.
INTERLOCKING IRRIGATION AND CHEMIGATION DEVICES

1. For an irrigation pump driven by an internal combustion engine, an easy method to interlock the injection pump with the irrigation pump is to drive the agri-chemical injection pump by belt from the drive shaft of the irrigation pump or an accessory pulley of the engine. This will ensure that the agrichemical injection pump stops operating if the irrigation pump stops.

2. For an electric motor-driven irrigation pump, a separate electric motor is usually used to power the chemical injection pump. The electric controls for the irrigation pump, irrigation system, and injection system should be wired so that all three systems shut down if any one of these fails. Figure 43 illustrates this configuration.

3. For an injection pump remotely situated from the irrigation pump and irrigation pump power source, a direct shutdown interlock of the irrigation and injection pump may be impractical. In this case an irrigation line flow sensor is recommended on the irrigation line immediately upstream of the point of agrichemical injection. The device should be wired to assure injection pump shutdown in the event water flow is lost in the irrigation line.

In addition:

1. An injection line flow sensor is recommended on the pressure side of the injection pump just upstream from the agrichemical line check valve. This device should be wired to assure system shutdown in case flow in the injection line ceases. This will safeguard against continued operation having electric power using a belt driven injection pump and engine power units after rupture or disconnection of injection line, injection pump failure, loss of prime, chemical tank is emptied, or injection port becomes plugged.

2. A normally closed solenoid valve is recommended on the suction side of the injection pump at the agrichemical tank. This solenoid valve should be wired to assure closure if either the irrigation system or the injection system is not in operation. This will safeguard against flow to or from the tank if either pump ceases operation and prevent chemical drainage from the tank if damage occurs to the chemical lines between the tank and the injection port on the irrigation system. A normally closed solenoid valve should not be used as a total shutoff backflow prevention device on the discharge side of the injection pump because the line may burst due to extremely high pressures if the valve malfunctions.
Pressure gauges

Pressure gauges are an essential management tool for use in irrigation systems. Used in conjunction with the water meter and other data, they can be used to evaluate what is happening when water is moving through the irrigation system.

A pressure gauge should be installed near to the pump in the headworks. If a filter is present a gauge should be installed after it, the difference between this gauge and the pump will give an indication of how dirty the filter is (whether it needs flushing or cleaning).

Pressure test points should also be installed at key points in the irrigation system, for example hydrants and field valves. Importantly they should also be fitted on the furthest points of the irrigation system, the end sprinkler on a centre pivot or linear move, on the gun or boom carriage, or for drip-micro systems on the ends of the furthest laterals from the valve.

Fitting and regularly using pressure test points will show whether the irrigation systems operating pressure is the same as as-built specifications. It is the first indicator to see if the irrigation system is working correctly.

Pressure can also be measured at the sprinkler outlets with the use of a pitot tube.

Chemical injectors

Chemical injectors are devices used to apply water-soluble fertilizers, pesticides, plant growth regulators, wetting agents and mineral acids during crop production.

VENTURI (VACUUM INJECTION)

Venturi-type injectors use a pressure difference between the water line and the stock tank to draw a concentrated solution into a faucet connect valve and mix it with water in the line. These inexpensive injectors can be easily attached to any pipeline but do not allow precise control over concentration because fluctuations of water pressure cause a variable amount of chemical to be injected. The injection ratios are low (typically 1:16) and therefore require a large stock tank, thus limiting the use of Venturi-type injectors to small growing areas.

POSITIVE DISPLACEMENT (DOSATRON)

Positive displacement injectors provide consistent injection ratios for the designed flow rates over wide variations in water pressure. A measured amount of stock solution, determined by filling a specifically sized chamber, is injected into the irrigation water, the rate of which also controlled by a unit. The amount of concentrate dispensed is directly proportional to the volume of water entering the injector, irrespective of variations in water flow or pressure that may occur in the main line. Precise control over the amount of injected chemicals, smaller stock tanks and broader injection ratios have made positive displacement injectors an industry standard.
Filters

Filters are used to remove particles and foreign matter from water to prevent damage and blockages within the system. Filters or screens at the water source are the first protection and are usually of a coarser grade primarily for the protection of equipment. Another important aspect of source screening from surface water is fish exclusion.

The type and grade of screening and filtration is dependent on application of irrigation and nozzle or emitter size.

Filters are generally screen or disc types. Screen filters provide a simple barrier to particles entering the irrigation system while disc filters have a depth of filtration with a convoluted pathway for water to pass through. Filters can be automatically controlled and back flushed based on the pressure difference across the filter. The two types are shown below:

Irrigation water is filtered to ensure harmful components such as sand, silt, clay and organic matter are removed before they can enter the system and cause blockages. Water quality (specific to your irrigation system) is the determining factor of which filter technology you choose. Some filters work well on inorganic particulate, such as sand and sediment. Others function better when dealing with organic contaminants such as algae. Knowing your water quality, coupled with a basic understanding of the filter types available, makes your filter-selection process easier.

SCREEN FILTERS

Screen filters are the most widely used filters and are available in a variety of sizes and configurations. Most of them employ a stainless-steel screen as the actual filter media, but some screen filters use a fabric sock as an alternative to a stainless-steel screen.

Screen filters, typically used for relatively clean water, filter contaminants such as sand, sediment or other solid particulate. They are not recommended for use on surface-water applications where algae are present. Algae tend to stick to the screen and may rapidly plug the filter screen.

Manufacturers of screen filters offer a variety of screen options referred to as ‘mesh options.’ The orifice sizes of the sprinklers used in your irrigation system determine the screen-size selection. As a rule of thumb, the hole opening in the filter screen must be roughly one-fifth the size of the smallest sprinkler orifice used in your system. For example, if your system uses micro-sprinklers with an orifice size of 0.050, you must consider a 50-mesh screen which has a hole opening of 0.01 (0.050 / 5 = 0.01).
**DISC FILTERS**

Disc filters offer a three dimensional filter action. The filter medium consists of a number of grooved circular plastic discs which are stacked in cylindrical form tightly positioned together. Water flows from the outside of the cylinder through the discs to the inside. All foreign matter, larger than the permeable opening of the specific grooves, is retained by the discs. The dirt is removed by flushing with filter water in the opposite direction through the discs.

Hydrocyclone Sand Separators utilise a conical shaped separator that accelerates the velocity of water maximising separation of sand and other solid matter.

**MANUAL CLEANING (BRUSH AWAY)**

The brush away assembly consists of nylon brushes fitted on a frame and inserted into the filter screen. A simple handle, outside the filter, brushes away particles from the screen surface, and expels them out from the filter. Brushing is done during the filtering process without having to stop the water supply.

**SELF CLEANING**

A self-cleaning filter is a type of water filter which utilises system pressure to clean itself. A rigid cylinder screen strains particles from a water source, trapping debris on the inside. This layer of buildup causes differential pressure across the inlet and outlet. A controller monitors the filter and opens a flush valve when it senses adequate differential pressure. This creates rapid flow through the internal cleaning apparatus, which vacuums buildup from the screen and expels it.

A unique characteristic of self cleaning filters is that the backwash cycle does not require the entire system flow to stop and reverse, as is the case for many other types of filters. Instead, a point-of-suction backwash reverses flow across the screen only directly in front of suction nozzles. This allows the cleaning mechanism to scan and clean the screen incrementally without disrupting the main flow through the filter.

Self cleaning screen filters are used in a variety of applications where continuous water flow is crucial, including equipment protection in industrial water filtration, nozzle protection in irrigation filtration systems, and membrane protection in municipal water filtration systems.
Valves

Valves are used for a number of purposes within an irrigation system. There are generally three categories of valve. They are:

1. Manual valves, such as butterfly and gate valves
2. Automatic control valves
3. Regulatory valves, such as check valves and pressure regulators.

Samples of these are shown below:

![Butterfly valve](image1)
![Automatic shut off](image2)
![Pressure regulator valve](image3)

A valve controls system flow and pressure by:

- Stopping and starting flow of water.
- Varying (throttling) the amount of flow of water.
- Regulating downstream system pressure.
- Controlling the direction of flow of fluid.
- Relieving component or piping over pressure.

In general, there are four methods of controlling flow through a valve.

1. Move a disc, or plug into or against an orifice (for example, saddle valve).
2. Slide a flat, cylindrical, or spherical surface across an orifice (for example, gate valve).
3. Rotate a disc or ellipse about a shaft extending across the diameter of an orifice (for example, a butterfly or ball valve).
4. Move a flexible material into the flow passage (for example, diaphragm valve).
SEALING MECHANISMS

Saddle
Saddle valves consist of a sealing disk that moves up and down in the body on a shaft, changing the flow path area and sealing the valve.

Gate
The gate valve, also known as a sluice valve, is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid. Gate valves are primarily used to permit or prevent the flow of liquids.

Figure 52. Gate closed (left) and gate open (right).

Ball
A ball valve has a spherical disc which controls the flow through it. The sphere has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked.

Ball valves are durable and usually work to achieve perfect shutoff and are therefore an excellent choice for shutoff applications.

Butterfly
A butterfly valve is commonly used for isolating or regulating flow. Operation is similar to that of a ball valve, which allows for quick shut off. The “butterfly” is a metal disc mounted on a rod. The disc is positioned in the centre of the pipe, passing through the disc is a rod connected to an actuator on the outside of the valve. Rotating the actuator turns the disc either parallel or perpendicular to the flow. Unlike a ball valve, the disc is always present within the flow, therefore a pressure drop is always induced in the flow, regardless of valve position.

Diaphragm
Diaphragm valves (or membrane valves) consists of a valve body with two or more ports, a diaphragm, and a saddle or seat upon which the diaphragm closes the valve.
CONTROL MECHANISM

Manual control
Manually controlled valves have a threaded mechanism or a lever to control the valve.

Hydraulic control
The hydraulic control system makes use of pipeline pressure to open and close the valve. The hydraulic mechanism may be equipped with a pilot valve, solenoid or relay for automatic valve control.

Pilot valve
The pilot valve is used to control hydraulic valves and is made up of a lid, body, spring, diaphragm and control piston. The three-way pilot valve is commonly used in irrigation and has a signal tube connected to the base of the diaphragm and the side of the pipeline at which the pressure must be kept constant (downstream for pressure reduction and upstream for maintaining pressure).

Solenoid
A solenoid valve is an electrical pilot valve used for controlling liquid flow. The solenoid valve is controlled by electrical current, which is run through a coil. When the coil is energised, a magnetic field is created, causing a plunger inside the coil to move. Depending on the design of the valve, the plunger will either open the solenoid valve or close the valve. When electrical current is removed from the coil, the valve will return to its de-energised state.

SPECIALTY VALVES

Pressure regulating
The pressure reduction valve makes use of a pilot valve to keep the downstream pressure constant at a pre-set value, irrespective of changes in the upstream pressure and/or flow in the system. Pressure reduction may be used to maintain constant pressures in irrigation systems, thereby ensuring effective and accurate system discharge.

Pressure sustaining
The pressure sustaining valve maintains a constant pre-set upstream pressure irrespective of changes in pressure and flow through the system. Pressure sustaining valves are used to:

- ensure that the pump does not deliver too much water with the filling of pipelines and switching between irrigation blocks;
- release excessive pressure from the system;
- ensure there is sufficient pressure in the system to serve elevated areas.

Pressure release
The pressure release valve discharges excessive pressure to the atmosphere, protecting irrigation systems against sudden pressure increases.

Pump control
The pump control valve is used to prevent pipeline shocks, motor overloading and pump cavitation, where pumps are switched on and off by remote control. The valve makes use of a limit switch and solenoid to ensure that the pump switches on and off against a closed valve. When the pump is started, the valve is activated and slowly opens. A pilot may also be used to open the valve to a certain point, avoiding overloading the motor and pump cavitation.

When the pump is shutting down, the valve closes slowly and the pump is then switched off as indicated by the limit switch. Pressure reduction can be simultaneously done with the valve to protect the system against high pressures at low flows. Certain pump control valves also serve as spring loaded non-return valves.
Flow control
The flow control valve prevents the flow through the valve from exceeding a pre-set rate. The purpose of this valve is to prevent borehole pumps, with large variation in the dynamic water level, from over pumping or to supply correct flows to numerous sections on one pipeline.

Non-return
A non-return valve allows flow in only one direction. A non-return valve is fitted to ensure that water flows through a pipe in the right direction, where pressure conditions may otherwise cause reversed flow. These valves are flow sensitive and rely on the line fluid to open and close. The internal disc allows flow to pass forward, which opens the valve. The disc begins closing the valve as forward flow decreases or is reversed.

There are different types of non-return valves, such as spring-loaded, swing, and clapper.

Spontaneous
Spontaneous valves function automatically without external influences.

Air Valves are used to release air from the pipelines. There are three types;
- Kinetic Air Valves – releases larger volumes of air during pipeline filling and closes in the presence of water. When the pipeline is draining air is drawn into the pipeline to prevent it from being flattened by atmospheric pressure.
- Automatic Air Valves – releases smaller volumes of air when the pipeline is under pressure and cannot be used as an anti-vacuum valve.
- Combination Air Valves – have kinetic and automatic function.

Foot valves are mounted at the end of the suction pipe where the pump is higher than the water level. The purpose is to prevent water from flowing backwards from the suction pipe and pump when the pump is turned off.
Reticulation

There are two means of water transportation used within irrigation systems:

1. Open channel
2. Piped

1. CHANNEL
Large volume irrigation schemes, from either stored or flowing surface water, use canals to deliver the water to property boundaries. Borderdyke and flood irrigation systems use open channels to deliver water to the paddock.

2. PIPES
All pressurised systems use pipe as the means of water reticulation. The three main types of pipe used in irrigation systems are:

Steel
Steel pipes are very rigid and strong, able to withstand significant pressures and physical conditions. They can be prone to chemical erosion and rust depending on the chemical composition of the water. Stainless steel pipes can be used to combat this.

PVC (polyvinyl chloride)
PVC has excellent chemical resistance across its operating temperature range, with a broad band of operating pressures governed by the thickness and density of wall. Due to its long-term strength characteristics, high stiffness (still flexible to a degree) and cost effectiveness, PVC systems account for a large proportion of underground piping installations.

Alkathene (extruded from heated polyethylene material)
Alkathene is a very versatile, flexible and chemical resistant material. It is not as rigid or robust as either steel or PVC, but it is very easy to work with and has many applications. Pressure ratings are determined by the density of the wall. A common way of describing alkathene pipe is LDPE Low Density, MDPE Medium Density or HDPE High Density. Pressure ratings, low to high, correspond to the density. HDPE can withstand pressures up to 12 bar but the material is more easily physically damaged potentially compromising the resistance.

PIPELINE FITTINGS
In each of the materials fittings are made to enable direction changes and alterations of water flow. Examples of fittings are:

- Bends – of various degrees to enable direction change
- Elbows – right angle bends
- Tees – splitting of flows
- Reducers – transition of pipe diameters.
Sensors

SOIL MOISTURE SENSORS
Soil moisture monitoring devices can provide a range of information. Some devices give simple ‘wet/dry’ measurements, which gives a basic guide to reducing plant stress and minimising irrigation water losses in the field. Other devices can gather more complex information:

- Depth and amount of irrigation,
- Root activity and development,
- Extent of water tables within or just below a crop’s root zone,
- Irrigation timing and forecasting based on water use (known as irrigation scheduling),
- Soil temperature.

As a minimum you need the device to provide soil moisture readings for the plant root zone before and after an irrigation event. A reading following a rainfall event is also of benefit.

- The reading before an irrigation shows how dry the soil is.
- The reading after the irrigation or rainfall event shows how deep the moisture has gone, and can be used to indicate how much irrigation was applied and if under irrigation has occurred.
- A reading taken below the active root zone of a crop can indicate whether over-irrigation (drainage) has occurred.
- If you take additional readings between irrigation events you can determine your crops pattern of water use.

There are many devices on the market to determine the moisture content of the soil. They range in price, complexity, use and methods of data collection, and the detail of data provided. For more information about soil moisture sensors refer to Book 11: Soil Moisture Monitoring.

Emitters

Emitters are the mechanism by which water is released from the laterals into the atmosphere. Emitters are found in a large variety of characteristics and shapes covering the whole spectrum from small button-shaped drippers to impact sprinklers.

DRIPPERS AND DRIP LINES
While surface irrigation methods rely on watering the whole surface of the field and overhead irrigation leaves the plants wet and produces runoff, drip irrigation is far more controlled. Water is slowly provided to a very specific area, close to the roots of the plant, by a network of drip emitters.

Drip lines have very small holes drilled into a tube, or are made from materials that create porous tubing walls that the water can slowly leak out of. Drip lines are laid along the ground and can even be buried beneath the soil. The advantage of these is obviously very low cost, but the disadvantage is that the tiny holes are very easily clogged. These products are typically used in agriculture, where the tubes are removed and thrown away or recycled at the end of each growing season.

Drippers are typically shaped like buttons or flags, and are either inserted along the line or on a stake that feeds off the main line. Drippers can be pressure compensating or non-pressure compensating.
Pressure compensating drippers give the same amount of flow within a range of pressures. Pressure compensating drippers may have a self-flushing mode in which, during the system start up and shutdown, the flow increases and allows the dripper to clean itself. This equates to a longer life span and better constant flow during the lifetime of the dripper. The main use of this type of dripper is on systems with long runs of drip tubing, to maximise the amount of drippers on a single line, while maintaining an even flow rate from each dripper.

Non-compensating drippers will discharge the same amount of flow at a constant pressure. In other words, the higher the pressure the more flow the dripper will release, and at lower pressure, less flow will be released. The non-compensating drippers cannot be self-flushed, and therefore will need a filter with a pressure regulator at the beginning of the line. The non-compensating drippers work well in smaller systems with short runs, and where there are no differences in elevation.

**MICRO SPRINKLERS**

Micro sprinklers are made up of micro tubing with a series of nozzles attached to risers. These risers may be fixed or designed to pop-up. Micro-spray is a cross between surface spray irrigation and drip irrigation. It has some of the advantages and some of the disadvantages of each type of irrigation. Like drip irrigation, micro-spray is considered a type of low-pressure irrigation and it creates a larger wetted area than drip irrigation.

**SPRINKLERS**

In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. There are various types of sprinklers available.

The impact rotating sprinkler is one of the most common. The impact drive has a weighted spring-loaded drive arm to provide the force to rotate the nozzle assembly. The stream of water pushes the arm sideways and the spring pulls the arm back to the nozzle assembly and into the path of the stream. As the drive arm completes each swing it impacts against the nozzle assembly rotating slightly. The advantage of the rotating sprinkler is its ability to apply water at a slower rate while using relatively large nozzle openings.

Large rotating sprinklers, operating at high pressures, are commonly referred to as guns. The term gun is derived from the large gun like nozzle and its ability to distribute large quantities of water over a wide area. They are typically mounted on risers, supported on a tripod or framework.

Spinner sprinklers use the force of the water passing through the nozzle to rotate the sprinkler.

The wobbler sprinkler’s design provides outstanding uniformity at low pressure. The key to Wobbler technology is the off-centre rotary motion and unique groove configuration of the water deflector. The grooves in the deflector divide the flow into numerous sections of water. The off-centre wobble further divides each section into relatively uniform-sized droplets. The rotary action evenly distributes these droplets over a large area.
References

i. Source Statistics New Zealand:

ii. Source Statistics New Zealand:


viii. The Opuha Dam: An ex post study of its impacts on the provincial economy and community, Aoraki Development Trust, 2006

ix. The Economic Benefit to the Community of the North Otago Irrigation Scheme, Waitaki Development Board 2010

REFERENCES
All photos © and courtesy of Dan Bloomer, Paul Reese, Andrew Curtis and Annette Scott.

DISCLAIMER AND COPYRIGHT
The information provided in this publication is intended as a guide and reference resource only and should not be used, relied upon or treated as a substitute for specific professional advice. While Irrigation New Zealand Limited (including its officers, employees, contractors and agents) (INZ) has taken all due care in the preparation of the information in this publication, INZ cannot guarantee that every statement is factually accurate.

INZ makes no warranties, guaranties or undertakings as to results that may be obtained from information in this publication. You are solely responsible for the actions you take in reliance on the content provided in this publication.

INZ shall not be liable for any errors or omissions in the information or for any loss, injury, damages of any type (including and without limitation direct, indirect, special or consequential damages) or other consequence whatsoever that you or any person might incur as a result of your use of or reliance upon the information which appears in this publication.

The information contained in this publication may change, be added to, deleted or otherwise updated or amended without notice.

Except where expressly stated, the information in this change is protected by copyright. You may not copy, reproduce, modify or distribute the publication or parts thereof in any way, other than a single copy for private use. Permission must be sort from INZ prior to reproduction of any material contained in this publication.

Any information that is referenced or links that are included in this publication are provided for your assistance and convenience. INZ provides no warranty or endorsement whatsoever and is not liable or responsible for the content or accuracy of any third party websites or publications.

Each page of this publication must be read in conjunction with this disclaimer and any other disclaimer that forms part of it.