

DIY: Spray Irrigation Performance Evaluation

Purpose of This Guide

The purpose of this guide is to help farmers check the performance of their irrigation systems. This is done using the same basic principles that irrigation evaluation professionals use.

Checking your irrigation system will help you understand its performance. This can help identify areas for improvement, leading to better efficiency, more production, and more profit.

This guide will help you record performance values for your system. These can be compared with the system's design to see if it is doing what it should. This should be done at least once each year to ensure that the system is in top shape.

Step 1: Know Your System

The first step is to know what the system is supposed to be doing.

Before starting the evaluation, fill in the list (below) of the things your system provider said your system could do.

Most of these things should be listed in the information from the system's supplier. If it is not, contact the supplier to get it.

It is also useful to know the "meter factor" of the power meter in the pump shed. Sometimes this is written on the power meter. If it is not, call the electricity supplier to get it.

Also find out how much water your soil can hold. A value for plant available water (PAW) should be available from a soils map, the local council, or an irrigation consultant.

Complete the remaining steps:

- Step 2: Walk the Farm..... p 2
- Step 3: At the Pump Shed p 3
- Step 4: At the Irrigator(s) p 6
- Step 5: Calculate & Compare.... p 8

Fill in the attached data sheet, using the "How To" boxes for help.

Copy the results of your evaluation into the box below and compare them to Step 1.

Step 1: Know Your System

Information from your system supplier:

			Units (circle one)
Pump flow rate	=	<input style="width: 80px;" type="text"/>	ℓ/s, m ³ /hr, gpm
Pump delivery pressure	=	<input style="width: 80px;" type="text"/>	m, kPa, bar, psi
Surface pump suction, or depth to water	=	<input style="width: 80px;" type="text"/>	m
Pump power rating	=	<input style="width: 80px;" type="text"/>	kW, hp
Pressure to run the irrigator	=	<input style="width: 80px;" type="text"/>	m, kPa, bar, psi
Application depth	=	<input style="width: 80px;" type="text"/>	mm/pass
Irrigated area	=	<input style="width: 80px;" type="text"/>	ha
Return interval	=	<input style="width: 80px;" type="text"/>	days
Irrigator flow rate	=	<input style="width: 80px;" type="text"/>	ℓ/s, m ³ /hr, gpm
System capacity	=	<input style="width: 80px;" type="text"/>	mm/day, ℓ/s/ha

Other useful information:

Meter factor of power meter = (i.e. 40x)

Soil plant available water (PAW) mm

Compare Your Results

Copy your results from Steps 3 to 5 and compare to Step 1:

3a ℓ/s, m³/hr, gpm

3b m, kPa, bar, psi

3c m

3d kW, hp

4a m, kPa, bar, psi

4b mm/pass

4e ha

4f days

4g ℓ/s, m³/hr, gpm

5a mm/day, ℓ/s/ha

Time for soil to dry out:

5b days

Pumping efficiency

5d (e.g. 0.65)

Step 2: Walk the Farm

A close-up inspection should be a regular part of operating any irrigation system.

Take the time to walk around the irrigation areas and check for:

- Leaky Pipes or Connections
- Noisy Pumps
- Blocked Screens/Filters
- Broken Pressure Gauges
- Blocked Sprinklers
- Broken Sprinklers
- Off-Target Irrigation
- Ponding

While many of these things seem obvious, they often go unnoticed.

There is a checklist on the attached data sheet to help with this step.

a) Any leaks, even minor ones, should be fixed. Leaks mean wasted water, lost pressure, and extra pumping. This costs more money and limits production.

Many leaks occur underground. Wet ground or green patches in otherwise dry areas are common signs of underground pipe leaks.

b) Listen for loud noises in any part of the system, such as cracking or high-pitched whining. Cracking is a symptom of cavitation, which can cause damage to pipes, pumps, and other fittings.

Whining noises or vibration of pumps or pipes can also be a sign of poor performance. Call your pump supplier to inspect if any of these symptoms arise.

c) Check all screens and filters to make sure that the flow of water is not restricted.

d) Pressure gauges are a quick and easy way to check performance. If pressure gauges aren't installed on the system, get them installed. If pressure gauges are broken, replace them.

Working pressure gauges should be installed on all:

- Pump Delivery Pipes
- Pump Inlet Pipes
- Irrigator Inlets

e) Inspect the spray pattern of each irrigator, looking for an even spray. Poorly performing sprinklers will often emit a single jet of water, or a fine mist that blows away in a slight wind.

Broken sprinklers should be replaced immediately to restore the design spray pattern.

f) Also take the time to stop and check individual sprinklers, even if the spray pattern looks good.

Remove several sprinklers to see if there is any build-up inside the sprinkler or pressure regulator. Silt, algae, or other blockage in one sprinkler probably means they all need cleaning.

g) Off-target irrigation is water that is sprayed where it should not be. Some common examples of off-target irrigation are:

- Spraying over fence lines (onto neighbour's property)
- Spraying onto roads or lanes
- Double-watering where lane spacing is incorrect

Off-target irrigation can be a big waste of water, a waste of electricity, and can mean less production. Make any changes that you can to reduce off-target irrigation.

If any problems are identified during the site walk, try to fix them before moving on to Step 3. An irrigation expert may need to be called to fix some problems, such as noisy pumps or leaky irrigator spans.

h) Some ponding is likely under any type of irrigation. Minor ponding is acceptable, but too much will cause problems. The more ponding and runoff that occurs, the less evenly watered the plant roots will be.

Ponding becomes a problem when:

- it lasts more than about an hour
- it is very deep (more than a few millimetres)
- it runs downhill, or
- it collects in the same spots after every application.

Ponding and runoff may be caused by:

- Applying too much water on each pass (Step 5c)
- Applying water too quickly for the soil type
- Damaged soil (i.e. pugged or compacted soil) doesn't let water in as quickly

If ponding or runoff are problems, work will need to be done to figure out ways to fix it.

Step 3: At the Pump Shed

Reading gauges at the pump shed is an easy step that can quickly give some very useful information.

Always start at the pump shed because it is the start of the flow of water into the system. There is no point in making changes at the irrigator if you are unsure if the pump is doing its job.

Operate your system as usual. Record the following under “Step 3” on the attached data sheet:

- Pump Pressures
- Flow Meter (total flow)
- Flow Meter (flow rate)
- Pump Power Use

Compare all of your readings in Step 3 to the design values in Step 1. If they do not match up, more work will need to be done to figure out why.

Fix any problems at the pump shed before moving on to Step 4.

a) If a flow meter is installed, record the total flow and the flow rate. See “how to” boxes #1 and #2 for help with this.

If there is no flow meter, it is possible to get a one-off flow rate using a portable meter. Many irrigation companies or consultants can do this for you.

How to #1: Read a Flow Meter

There are two kinds of readings a flow meter can give:

- Total Volume (m³) – total amount of water that has passed through the pipe since it was set up
- Flow Rate (ℓ/s) – speed at which water is moving through the pipe

Digital Meters give an instant readout (total volume of 52,052 m³ and flow rate of 61 ℓ/s in the photo below):



Analog Meters give an instant readout, but may need to be adjusted by a meter factor (10x in the photo below). Not all meters have a meter factor.



To read an analog meter:

- Multiply the readout (total volume of 67,577 m³ in this example) by the meter factor (if used).
- Total Volume = Reading * Meter Factor (67,577 x 10 = 675,770 m³ in this example).
- See “how to” box #2 to calculate flow rate

How to #2: Calculate Flow Rate

Most digital meters will display flow rate along with total flow (61 ℓ/s in the first photo in “how to” box #1).

Most analog meters will not show flow rate, and you will need to calculate it.

Read total flow twice and write down the number of minutes between readings. Wait 20 to 60 minutes to give the best results.

Reading 1	=	A	<input style="width: 100%;" type="text"/>	m ³
Reading 2	=	B	<input style="width: 100%;" type="text"/>	m ³
Time	=	C	<input style="width: 100%;" type="text"/>	min
Volume used	=	D = B - A	<input style="width: 100%;" type="text"/>	m ³
Flow Rate	=	E = D / C	<input style="width: 100%;" type="text"/>	m ³ /min
Flow Rate	=	16.7 * E	<input style="width: 100%;" type="text"/>	ℓ/s

Step 3: At the Pump Shed

b,c) For surface pumps, read both the inlet and outlet pressure. See “how to” box #3 for help.

If the inlet is flooded, there may be a positive pressure in the inlet pipe. If the inlet is not flooded, there will be a negative pressure in the inlet pipe.

b, c) For groundwater pumps read the outlet pressure and depth to water in the well. See “how to” boxes #3 and #4 for help.

The depth to water in the well should be measured while the pump is running. This tells you how far the pump lifts the water before it enters the mainline.

How to #3: Read a Pressure Gauge

Read the number that the needle points to, but be aware of which units are being used!



Multiply the reading by the value in the table, to change units:

		Desired Unit			
		psi	kPa	bar	m
Gauge Unit	psi	1	6.9	0.069	0.7
	kPa	0.145	1	0.01	0.1
	bar	14.5	100	1	10
	m	1.4	9.8	0.098	1

For example, if the pressure on your gauge says 65 psi (as in the photo above), and you want to convert that into kPa, then you would multiply 65 by 6.9:

$$65 \text{ psi} * 6.9 = 449 \text{ kPa}$$

NOTE: Pressure gauges are easily damaged, and wear out over time. If a gauge doesn't look right (e.g. it has a bent needle, or doesn't read zero when the system is off) it probably needs replacing. Isolating taps can help prevent this. Also, try to have one reliable gauge that can be carried around to check the other gauges.

How to #4: Measure Depth to Water in a Well

There are several ways to measure the depth to water in a well. Three of these are described below.

For all methods:

- Measure the depth to water when the pump is off to get static water level.
- Measure when the pump is on to get pumping depth.
- Wait about 20 minutes after turning the pump on or off for the water level in the well to equalise.

1. Water Level Meter

If you have a water level meter, just drop the end down the well until it indicates that you've hit water. Read the measuring tape where it comes out of the well casing.

Many irrigation companies or consultants can do this for you if you do not have a water level meter.

2. Air Pressure

Pump up the pressure in the hose until the gauge reading stops rising:

Pressure = A m

(see “How To: Read a Pressure Gauge” to convert units)

Depth down to the pump = B m

Tube distance above the pump = C m
(get B and C from the pump installer)

Depth of tube in the well D = B - C m

Depth to water E = D - A m

3. Permanent Transducer

Some newer installations have a permanent electronic measuring device down the well. Water level can usually be read from a display in the pump shed, or downloaded from a data logger. Be sure to find out if it shows the depth down to the water, or the depth of water above the probe (they are not the same!).

Step 3: At the Pump Shed

d) Read the total power use and rate of power use for the pump from the power meter. See “how to” box #5 for help with this.

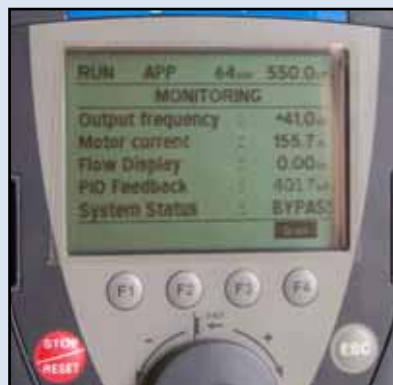
How to #5: Measure Power Use

Pump power is measured in kilowatts (kW). A higher value of kW means the pump uses energy faster, and results in more total kWh being used. kWh is a running total of how much power has been used. This is what the power company charges for.

There are three main ways to measure pump power use at the pump shed:



Power Meter



Electronic Display



Ammeter

1. kW can be calculated from the power company’s meter (see Photo 1, above). To do this, you will need to get the meter factor from the power company.

Collect two readings of kWh from the power meter, and write down the number of minutes between readings. Wait about 60 minutes to give the best results with this method.

Reading 1 = A kWh (read this from the power meter)
 Reading 2 = B kWh (read this from the power meter)
 Time = C min (minutes between Reading 1 and Reading 2)
 Meter Factor = D e.g. 40x (get this from the power company)

Power used = E = B - A kWh
kW = D * E * 60 / C kW

2. Some pumps have a kW display in the pump shed. Read operating kW directly from here (64 kW in Photo 2, above).
3. kW can be estimated from motor amps, which is read from an ammeter. Most systems have an ammeter (see Photo 3, above). Some systems include motor amps on an electronic display (155.7 Amps in Photo 2, above).

Current = A amps (read from the ammeter)
 Voltage = B V (most pumps are 400 V, there may also be a gauge for this)
 Power factor = C (no units) (“cos φ” is sometimes listed on the pump motor plate)
 (a value of 0.85 is common)

For a 3-phase power supply:

kW = A * B * C / 578 kW

For a single-phase power supply:

kW = A * B * C / 1,000 kW

Step 4: At the Irrigator(s)

After checking that the pump runs well, check the irrigator(s). Operate your system as usual, and fill in “Step 4” on the attached data sheet:

Compare all of your readings in Step 4 to the design values listed in Step 1. If they do not match up, more work will need to be done to figure out why.

a) Most irrigators have a pressure gauge at the inlet to the machine. See “how to” #3 for help with reading this gauge.

Some irrigators do not have a pressure gauge (e.g. most K-Line). You can skip this reading, attach a portable gauge to the sprinkler, or call an irrigation expert for help.

b, c) Measure the application depth at least once, even if there is a digital readout on the machine. Due to differences in electrical systems (many machines are made overseas), the digital readout can sometimes be wrong.

See “how to” #6 for help with checking application depth.

How to #6: Measure Application Depth

Use a set of buckets to measure how much water is being applied by the irrigator:

1. Spread 10 to 20 buckets evenly across the irrigated area.
2. Operate the irrigation on that area as per normal procedure.
3. Measure how much water is in the buckets at the end of a normal irrigation event, and calculate the average depth. To do this:

If the buckets have straight sides:

Measure how deep the water is in each of the buckets using a ruler or tape:

Add all the depths together	=	A	<input type="text"/>	mm
Number of buckets	=	B	<input type="text"/>	
Average application depth	=	A / B	<input type="text"/>	mm

If the buckets have sloped sides:

Measure the volume of water in each bucket (you can use a kitchen measuring cup):

Add all the volumes together	=	A	<input type="text"/>	mℓ
Number of buckets	=	B	<input type="text"/>	
Width across the bucket (diameter)	=	C	<input type="text"/>	mm
Bucket radius	=	$D = C / 2$	<input type="text"/>	mm
Average volume	=	$E = A / B$	<input type="text"/>	mℓ
Bucket area	=	$F = 3.14 * D * D$	<input type="text"/>	mm ² (πr^2)
Average application depth	=	$1,000 * E / F$	<input type="text"/>	mm

Refer to *Irrig8Quick*: www.pagebloomer.co.nz if you want to measure application uniformity (e.g. DU or CU).

Step 4: At the Irrigator(s)

d) Record the number of hours it takes for your irrigator to complete one shift.

For example, record 12 hours for a K-Line that gets shifted twice per day.

Keep in mind that a travelling irrigator that gets shifted once per day may finish in less than 24 hours.

For centre-pivots, record 24 hours.

e) Record the area covered by each run. This can be used in estimating the flow rate to the irrigator (step 4g and “How To” # 7).

f) Record the number of days it takes your irrigator to return back to the same point on the farm. This is known as the “return interval.”

g) If possible, measure or estimate the flow rate to the individual irrigator. See “how to” #7 for help.

How to #7: Measure Flow Rate at the Irrigator

There are three ways to estimate the flow rate to an individual irrigator:

1. If there's only one irrigator, just calculate the flow rate at the pump. (see “How To” #2)
2. Flow rate can usually be measured using a portable, “strap-on” flow meter. Many irrigation companies or consultants can do this for you.
3. You can get a rough idea of flow rate from application depth: (see “How To” #6)

Average application depth	=	A	<input type="text"/>	mm
Area covered by one run	=	B	<input type="text"/>	ha
Time taken to complete run	=	C	<input type="text"/>	hours

Volume of water used	=	$D = 10 * A * B$	<input type="text"/>	m^3
Flow rate to the irrigator	=	$E = D / C$	<input type="text"/>	m^3/hr
Flow rate to the irrigator	=	$E / 3.6$	<input type="text"/>	l/s

Step 5: Calculate & Compare

Copy your results from Steps 3 to 4 into the boxes on the front of this guide. Compare these to the design values. If the two sets of numbers are very different, you may have a problem.

See the next section for guidance about what to do with the results.

Also check your results against your local soil and climate conditions:

a) System capacity will tell you if your system can apply enough water to keep up with evapotranspiration (ET) See “how to” #8 for help with calculating system capacity.

Typical system capacities range from about 4 to 5 mm/day in Canterbury. Talk to an irrigation expert if you are unsure what your system capacity should be.

b) Check that your return interval isn't too long. See “how to” #9 for help with this.

c) Check the application depth to see that you are not applying too much water on each pass. The applied depth should be less than the PAW of the soil.

d) Calculating pump efficiency can also help you compare one pumping system to another. See “how to” #10 for help with this.

How to #8: Calculate System Capacity

System capacity is commonly calculated two different ways:

Option 1

Total flow rate = A ℓ/s

Total irrigated area = B ha

System Capacity = A / B ℓ/s/ha

Option 2

Application depth = A mm

Time to complete one run = B hours
(use “24” for centre-pivots)

Return interval = C days

System Capacity = 24 * A / B / C mm/day

Conversion:

Multiply ℓ/s/ha * 8.64 to get mm/day

Multiply mm/day * 0.116 to get ℓ/s/ha.

How to #9: Check the Return Interval Against the Soil Type

Return interval is the time it takes to complete one full round of irrigation. For example:

- A centre-pivot that takes 3 days to complete one full circle has a return interval of 3 days.
- A travelling gun that irrigates 10 runs, and is shifted once per day, will have a return interval of 10 days.
- A K-Line that operates on 16 runs, and is shifted twice per day, will have a return interval of 8 days.

Does the Return Interval Match the Soil?

The return interval should be short enough so that the soil does not dry out too much before the irrigator can make a full round.

Application depth = A mm/pass

Soil PAW = B mm

The smaller of A or B = C mm

Normal Evapotranspiration = D mm/day
(summer ET is assumed to be 5 mm/day in Canterbury)

Time for soil to dry = C / D days
(the return interval should be less than this)

How to #10: Calculate Pump Efficiency

Overall pumping efficiency tells you how good your pump and motor are at converting electricity into pressure and flow:

Pump flow rate = A ℓ/s

Pump pressure = B m

Power use = C kW

Pumping efficiency = (i.e. 0.65)
 $0.098 * A * B / C$

Efficiencies can typically range from 0.3 (30%) in small pumping systems, up to 0.8 (80%) for large, highly efficient pumps and motors.

Most irrigation pumps operate between about 0.6 and 0.7 (60-70%).

Common Signs & Symptoms

The most common signs of poor performance are:

- Pump is under-pressure or under-flow
- Irrigator is under-pressure or under-flow
- Incorrect depth applied
- Off-target irrigation
- Ponding or runoff
- Brown grass or dry ground

The most common reasons for under-performance are:

- Maintenance has fallen behind. For example, broken sprinklers, blocked screens, or worn pumps.
- Pushing the system too hard. For example, adding new sprinklers without upgrading mainline or pumps.
- Long return interval. Irrigators that take too long to come back around result in stressed plants.
- Application depth is too high, and some of the applied water is lost to drainage.
- Wear and tear due to normal system operation. Equipment just wears out over time, especially pumps.
- The system simply isn't designed to do what it says it can do.

What Can I Do About It?

Firstly, it is important to:

- Keep up to speed with system maintenance.
- Check the system regularly.
- Keep records so you can compare new readings to past readings.
- Consult your system supplier before making any changes to the system.

If simple problems are encountered, you can fix them yourself. However, the system supplier should be the usual first port of call for anything more complex.

Call the irrigation system supplier when:

- The design information has not been supplied (Step 1).
- Instructions have not been provided for operating or maintaining the system.
- The performance that you measure does not match up with what the supplier said the system would do.
- Specific components are not working or are worn out.

Sometimes you may need to call in a third-party irrigation expert.

Ask for outside advice when:

- The cause of a problem cannot be found using the basic steps in this guide, or by the system supplier.
- You and the system supplier cannot agree on who is responsible for a problem with the system.

- The system is very complex or has multiple suppliers.
- The basic checks show good performance, but you want more detailed checks to maximise efficiency.

Other Tools

a) *Soil moisture monitoring*

There are many methods available to show how irrigation is affecting the plant root zone.

www.myirrigation.co.nz
click on "free guides"

a) *Irrig8Quick*

For measuring performance parameters in more detail. Includes application uniformity (e.g. CU or DU)

www.pagebloomer.co.nz
click on "resources"

References

INZ, *Irrigation Code of Practice and Irrigation Design Standard*.

INZ, *Irrigation Evaluation Code of Practice*.

www.irrigationnz.co.nz

Prepared By:

Joe Powers
of Aqualinc Research Ltd.

Sue Cumberworth
Geoff Dunham
of The AgriBusiness Group

Claire Mulcock
of Mulgor Consulting Ltd

Funded By

Sustainable Farming Fund grant
No. C07/004

Common Unit Conversions

Flow Rate

		Desired Unit			
		m ³ /hr	m ³ /min	gpm	ℓ/s
Starting Unit	m ³ /hr	1	0.017	4.4	0.28
	m ³ /min	60	1	264	16.7
	gpm	0.23	0.004	1	0.063
	ℓ/s	3.6	0.06	15.9	1

Pressure

		Desired Unit			
		psi	kPa	bar	m
Starting Unit	psi	1	6.9	0.069	0.7
	kPa	0.145	1	0.01	0.1
	bar	14.5	100	1	10
	m	1.4	9.8	0.098	1

System Capacity

$$\ell/s/ha * 8.64 = mm/day$$

$$mm/day * 0.116 = \ell/s/ha$$

Water Depths and Volumes

$$1 \text{ mm applied to } 1 \text{ m}^2 = 1 \text{ litre}$$

$$1 \text{ mm applied to } 1 \text{ ha} = 10 \text{ m}^3$$

$$\text{Seasonal volume (m}^3\text{)} \rightarrow \text{mm applied}$$

$$\text{m}^3 \div \text{ha} \div 10 = \text{mm}$$

$$\text{mm applied (irrigation or rainfall)} \rightarrow \text{m}^3$$

$$\text{mm} * 10 * \text{ha} = \text{m}^3$$