WaterWise on the Farm

Introduction to Irrigation Management

Evaluating your pressurised system

System 4

Spraylines

Side roll; end tow; hand shift

160501

Aim

To assess your irrigation system you need to determine the rate that water is being applied, and how uniformly that water is being distributed. To check these you need to know the MAR and DU for your system. These worksheets outline the equipment and procedure needed for you to do this.

Overview

Three pressurised irrigation systems are covered by these worksheets. Here is a brief description of each:

Hand shift

This system consists of lengths of aluminium irrigation pipe, usually 9 m long, with quick connect and release couplings at both ends and a sprinkler at one end. These are moved and fitted together by hand. They are used for irrigating pasture or short crops such as lucerne and vegetables.

The sprinklers may be mounted on risers to get above a crop. They are usually designed to cover a rectangular grid which is determined by the sprinkler spacing along the pipe (often 9 m) and the distance the pipes are moved each time (often 18 m). They operate over a very wide range, making them suitable for a wide range of circumstances, and they can be used on irregularly shaped fields like those found alongside creek and river banks.

Pressure ranges from 150 to 450 kPa, and discharge ranges from 0.1 L/s to 1.5 L/s per sprinkler. When designed and operated correctly, uniformity is high, and the application rate can be high without causing run-off. The system is relatively cheap and reliable. Its biggest disadvantage is the labour required to move the pipes.

End tow

End tow systems are similar to hand shift except each coupling is fitted with a skid or pair of small wheels. This allows the entire length of connected pipes to be towed by the end from one position to the next, reducing the labour requirement. The couplings have to be more robust than for hand shift, and the system is prone to damage from being towed. The system must be moved when it is empty of water, so the couplings have valves for draining the pipes. The direction of tow must be in line with the pipes if fitted with skids, so it can only be moved directly to an adjacent field. If it is fitted with wheels, it can be moved at an angle of 45°, so the movement between positions is often zig-zag.

Side roll

Side roll is also similar to hand shift except each length of pipe is mounted though the centre of a large (around 2-metre diameter) wheel. The entire length of pipe can then be shifted to the next position in a few minutes by rolling it sideways.

There is often a small motor and drive mechanism at the centre of the length of pipes to eliminate any manual effort. The sprinklers are mounted on a swivel so they remain upright. The system must be moved empty of water, so the couplings have spring-loaded valves that open when the pressure has stopped, allowing the water to drain out.

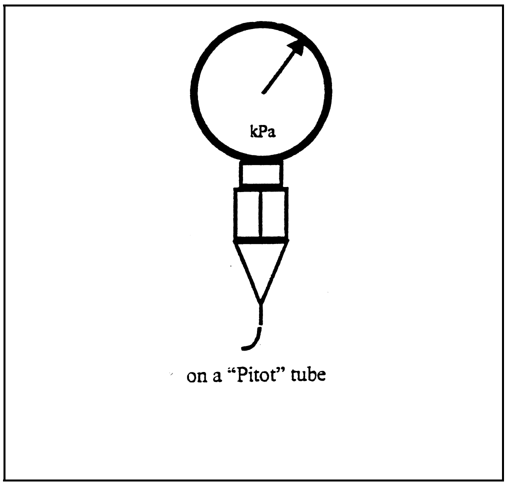
This system is best suited to rectangular fields.

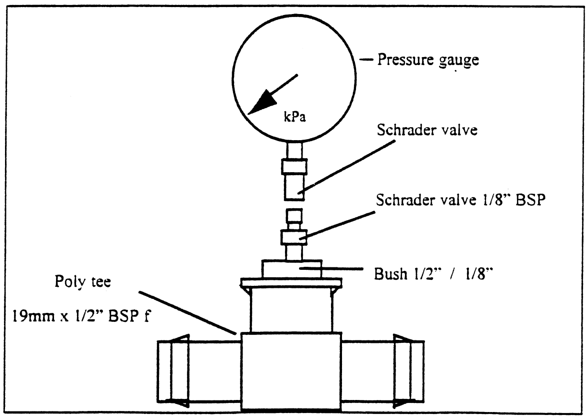
Equipment needed

To measure pressure:

- an accurate pressure gauge with an appropriate scale so it works mid-range at your normal pressures (say 0 to 400 kPa for low pressure systems, or 0 to1000kPa for high pressure systems)
- a pitot tube attachment (pronounced pit-oh) if you have overhead or large low-level sprinklers, or a theaded 15 mm PVC tee and fittings such as reducing bushes for small low-level sprinklers, or a Schader valve.

Figure 1, a and b





Schrader valve

To measure flow:

- plastic tubing that can be placed over the sprinkler nozzles and long enough to go from the sprinkler to a bucket
- a large bucket or small drum of known volume
- a watch capable of measuring seconds

To measure sprinkler coverage:

- catch cans
- a 30-metre measuring tape
- weights to place in containers to stop them blowing away
- a shovel for smoothing areas to set containers
- a measuring cylinder or jug with graduations in millilitres
- a calculator, a pen and the worksheets for recording your results.

Evaluation method

To assess the performance of your system, you need to measure the pressure and flow at various points in the system and, to measure evenness of application, collect the output of the sprinklers using catch cans. Work though the following procedure.

Step 1 On your field record sheet, note the brand, type, model, colour nozzle sizes and normal operating pressures of the sprinklers to be used as well as the spacings of the sprinklers and catch cans.

Step 2 Place the catch cans in a grid pattern and use a tape to make sure they are the correct distance apart. Typical spacings might be 3 metres but this will depend on your system. Make sure that the catch cans are upright and stable, and if necessary weight them down with stones or gravel. You should also make sure that grass and other foliage does not interfere with water entering the catch cans.

Step 3 Turn on the water to fill and pressurise the lines. When the system has been fully pressurised, measure and record the pressure and flow at the sprinklers to be tested. (If any sprinklers have double jets, take a measurement at each jet and the results added together.) **Make sure you stop the sprinklers rotating and direct water away from the catch cans.**

Step 4 **Start the test.** Release the sprinkler arms and run the test, recording the start time. Ideally the test time should be for one hour.

Step 5 While the test is in progress, check the pressures and flows at a number of other positions on other laterals and record these.

Step 6 Whilst the test is in progress record the wind direction and strength (see following table).

Step 7 At the end of the test period stop the sprinklers and collect the water in the catch cans. Do this by accurately measuring the volume of water collected in each can. Use a graduated jug or measuring cylinder.

Step 8 Record these volumes in the space provided on the record sheet.

Step 9 Convert the volumes collected (mL) to irrigation depth (mm) using table 1 then calculate the MAR and DU for your system.

If/when time permits:

Step 10 Repeat the test for several sites and under different conditions (for example, windy or calm).

Step 11 Calculate the average pressure, and average flow for the sprinklers tested.

Wind speed guide		
Visible effect	**Wind description**	**Speed - knots**
Calm. Smoke rises vertically.	Calm.	00
Direction of wind shown by smoke drift but not wind vane.	Light air.	02
Wind felt on face. Leaves rustle. Vane moved by wind.	Light breeze.	05
Leaves and small twigs in constant motion. Wind extends light flag.	Gentle breeze.	09
Raises dust and loose paper. Small branches are moved.	Moderate breeze.	13
Small trees in leaf begin to sway. Crested wavelets on inland waters.	Fresh breeze.	18
Large branches in motion. Whistling heard in telegraph wires.	Strong breeze.	24
Whole trees in motion. Inconvenience felt when walking against wind.	Moderate gale.	30
Breaks twigs off trees. Generally impedes progress.	Fresh gale.	37
Slight structural damage occurs.	Strong gale.	44
Trees uprooted. Considerable structural damage. Seldom experienced inland.	Whole gale.	52
Very rarely experienced. Accompanied by widespread damage.	Storm. Hurricane.	60 68

Source: Bureau of Meteorology

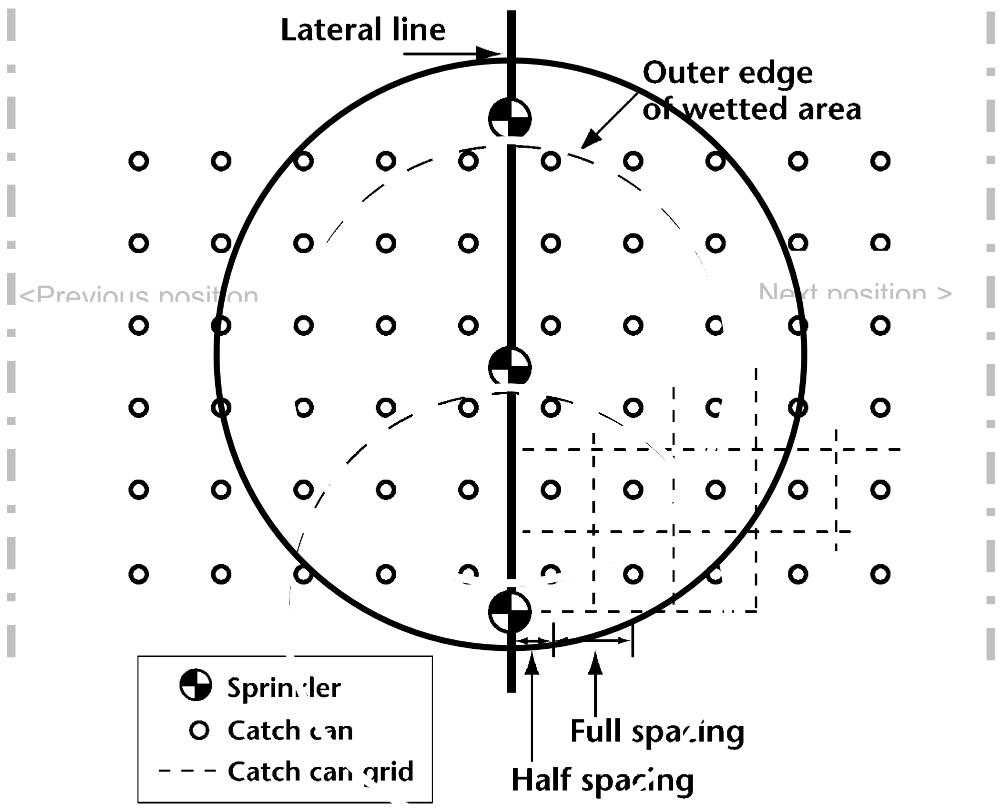
Catch can layout

Set out the catch cans as shown in figure 2. The idea is to measure the output from one central sprinkler plus the overlap from two adjacent sprinklers. Use a grid size that suits your sprinkler spacing. For instance, if sprinklers are spaced 9 metres apart you may use a 3-metre spacing.

The catch cans must collect all output stretching out towards the next shift. In the test we add the amounts from each side to simulate the coverage from the next 'shift' to be simulated. In figure 2, each 'shift' will move the line 18 metres.

Figure 2. Typical catch can layout

Figure 2



Worked example

Here is a partially completed record sheet for sprayline.

Field record sheet

Name: Fred Nirk	Crop: Lucerne
Location: Tamworth	Effective root depth: 1.0 m
Soil texture Sandy-loam	RAW for crop: 25 mm
Sprinkler spacing along sprayline 9 m	Spacing between sprayline positions 18 m
Sprinkler make	Sprinkler model
Nozzle size 5.2 x 1.4 mm	
Frequency of irrigation 5 days	

Pressure and flow record sheet

Sprinkler position on laterals

	Example				Your data			
USE EITHER THESE HEADINGS >>> OR	**1st Sprinkler**	**1st mid-position**	**2nd mid-position**	**Last sprinkler**	**1st Sprinkler**	**1st mid-position**	**2nd mid-position**	**Last sprinkler**
THESE HEADINGS >>>	**Near**	**High**	**Low**	**Far**	**Near**	**High**	**Low**	**Far**
Pressure – (kPa)	225	203	205	200				
Container volume (litres)	13.3	12.5	12.2	12				
Catch time (s)	20	21.5	21.5	21				
Calculated flow rate (L/min) Flow = L/s x 60	40	35	34	34				

Catch can record sheet

	Left side						Right side						
	6	5	4	3	2	1	1	2	3	4	5	6	
Row 1 mL	dry	dry	7	10	37	78	66	48	53	27	13	dry	Row 1 mL
Row 1 *mm*	0	0	0.7	1.0	3.7	7.8	6.6	4.8	5.3	2.7	1.3	0	Row 1 *mm*
Row 2 mL	dry	dry	8.0	18	44	74	66	53	44	27	20	dry	Row 2 mL
Row 2 *mm*	0	0	0.8	1.8	4.4	7.4	6.6	5.3	4.4	2.7	2.0	0	Row 2 *mm*
Row 3 mL	dry	dry	12	14	63	89	78	52	53	23	11	dry	Row 3 mL
Row 3 *mm*	0	0	1.2	1.4	6.3	8.9	7.8	5.2	5.3	2.3	1.1	0	Row 3 *mm*
Row 4 mL	dry	dry	6	12	41	73	74	49	40	35	20	dry	Row 4 mL
Row 4 *mm*	0	0	0.6	1.2	4.1	7.3	7.4	4.9	4.0	3.5	2.0	0	Row 4 *mm*
Row 5 mL	dry	dry	10	13	44	75	79	47	46	24	15	dry	Row 5 mL
Row 5 *mm*	0	0	1.0	1.3	4.4	7.5	7.9	4.7	4.6	2.4	1.5	0	Row 5 *mm*
Row 6 mL	dry	dry	7	12	48	69	63	53	44	19	10	dry	Row 6 mL
Row 6 *mm*	0	0	0.7	1.2	4.8	6.9	6.3	5.3	4.4	1.9	1.0	0	Row 6 *mm*
Row 7 mL	dry	dry	16	29	55	68	65	48	39	22	14	dry	Row 7 mL
Row 7 *mm*	0	0	1.6	2.9	5.5	6.8	6.5	4.8	3.9	2.2	1.4	0	Row 7 *mm*
Row 8 mL													Row 8 mL
Row 8 *mm*													Row 8 *mm*
Row 9 mL													Row 9 mL
Row 9 *mm*													Row 9 *mm*

(NB position of sprinklers shown is not to scale. Cans near sprinklers are to be half normal can spacing from sprinkler in each direction)

Start time ……10.50 am……. Finish Time……11.20 am………… Test duration 30 minutes…Mark wind direction

Table 1. Converting mL to mm of irrigation

For catch-cans of 110 to 115 mm diameter across the top, just divide the collected amount by 10 to get mm of irrigation.

For instance if you collected 674 mL, this is equivalent to a depth of 67.4 mm.

If the size of the catch cans is different, or you wish to be more accurate, use table 1.

Divide the amount caught by the figure in the right hand column. For instance, if the diameter is 110 mm and you catch 674 mL this is 674 ÷ 9.5 = 71 mm

If you use 4-litre square plastic ice cream containers,1 litre collected in one of these is equivalent to 25 mm of irrigation.

On a calculator, use **"water collected in mL" ÷ 40 = mm**

Converting mL to mm

Diameter of catch can (mm)	Figure to divide the collected amount by
75	4.4
80	5.0
90	6.4
100	7.9
102	8.2
104	8.5
106	8.8
108	9.2
110	9.5
112	9.9
113	10.0
114	10.2
115	10.4
120	11.3
125	12.25
145	16.5
165	21.3
200	31.4
220	38.0

Overlap addition table

Purpose of table: In a complete irrigation, the sprayline would be moved across to the next position (set) – thus the crop would be watered first by the left hand side of the line, then after the move, from the right hand side of the line. To account for this overlap the left and right sides must be added together .

For example, if there were 6 catch cans between the sprayline positions, left side can 6 (L6) is added to right side can 1 (R1), then L5 to R2, and L4 to R3 etc..

Catch can	L6	R1	Total	L5	R2	Total	L4	R3	Total	L3	R4	Total	L2	R5	Total	L1	R6	Total
Row 1	0	6.6	**6.6**	0	4.8	**4.8**	0.7	5.3	**6.0**	1.0	2.7	**3.7**	3.7	1.3	**5.0**	7.8	0	**7.8**
Row 2	0	6.6	**6.6**	0	5.3	**5.3**	0.8	4.4	**5.2**	1.8	2.7	**4.5**	4.4	2.0	**6.4**	7.4	0	**7.4**
Row 3	0	7.8	**7.8**	0	5.2	**5.2**	1.2	5.3	**6.5**	1.4	2.3	**3.7**	6.3	1.1	**7.4**	8.9	0	**8.9**
Row 4	0	7.4	**7.4**	0	4.9	**4.9**	0.6	4.0	**4.6**	1.2	3.5	**4.7**	4.1	2.0	**6.1**	7.3	0	**7.3**
Row 5	0	7.9	**7.9**	0	4.7	**4.7**	1.0	4.6	**5.6**	1.3	2.4	**3.7**	4.4	1.5	**5.9**	7.5	0	**7.5**
Row 6	0	6.3	**6.3**	0	5.3	**5.3**	0.7	4.4	**5.1**	1.2	1.9	**3.1**	4.8	1.0	**5.8**	6.9	0	**6.9**
Row 7	0	6.5	**6.5**	0	4.8	**4.8**	1.6	3.9	**5.5**	2.9	2.2	**5.1**	5.5	1.4	**6.9**	6.8	0	**6.8**
Row 8																		
Row 9																		
Sum			**49.1**			**35.0**			**38.5**			**28.5**			**43.5**			**52.6**

Sum of Totals **247.2**

Total catch cans = 84	**Number of catch totals CT, = 42 (i.e. CT=½ the catch cans)**	**No. of LQ (low quarter) totals = 42 / 4 = 10.5 say 10** **LQ totals are marked by the darker shading.**	**Sum of LQ totals** **= 42.3**

Calculating MAR – side roll, end tow, hand shift

Firstly make sure you have completed all sections of the catch can record sheet, by converting all figures to 'mm' using table 1, and then fill in the overlap addition table.

Step 1 If the test duration was NOT exactly one hour you must convert the **sum of totals** to a per hour equivalent**.** (Do this by dividing the totals by the test duration (minutes) and then multiplying by 60, as in the example.)

Step 2 Calculate the **MAR** by taking the **sum of totals** (per hour rate) and dividing it by the number of catch cans used (that is, ***all*** of the cans used).

NB The amount of water applied to the soil profile per hour is the MAR.

Step 3 When you calculate the total water added by **each irrigation** you need to consider how much overlap your system gives. Many areas will receive twice the MAR.

Example: Calculating MAR

	Example	**Your data**
On the "overlap addition sheet" the: **Sum of totals is**	**247.2 mm**	
Convert to 'per hour' figure **Sum of totals is**	**= 247.2 ÷ mins of test x 60** **= 247.2 ÷ 30 x 60** **= 494.4mm/h**	
MAR = Sum of totals ÷ number of catch cans used.	**= 494.4 ÷ 84 = 5.9 mm/h**	

In a well-designed system, the MAR figure for the whole irrigation should be less than or equal to the infiltration rate of the soil.

Calculating DU – side roll, end tow, hand shift

For this calculation we work with the catch totals rather than individual catch can amounts.

Step 1 Multiply the **sum of the LQ totals** by 4 (this gives the amount that would be applied if all positions were as bad as the lowest 25%)

Step 2 Divide the figure obtained above by the **sum of the totals** (all cans).

Step 3 Multiply the result by 100 to make it into a percentage.

Example: Calculating the DU%

	Example	**Your data**
Sum of the LQ totals multiplied by 4	**42.3 x 4 = 169.2 mm**	
4LQ ÷ Sum of totals	**= 169.2 ÷ 247.2** **= 0.684**	
Multiply by 100 for DU%	**= 0.684 x 100** **= 68%**	

How long to irrigate

Take the RAW for the soil and divide this by the MAR. The result indicates how long it will take to apply the RAW amount, if the system is 100% uniform.

Example: How long to irrigate to replenish RAW

	Example	Your data
RAW for this crop	Say **63 mm**	
MAR calculated earlier	**5.9 mm/h**	
	RAW ÷ MAR	
If the system was 100% efficient you would need to run the system for	**63 ÷ 5.9** **= 10.6 hours**	

Because the system overlaps and all areas get irrigated twice, the time for each shift is half the time needed to replenish the RAW.

Time for each shift	**= 5.3 hours**	

The irrigation time is sometimes increased to compensate for uneven application. **This is a management decision** and you must carefully consider the points below. The consequences of increasing the irrigation time are:

- increased water use
- increased pumping costs
- excessive run-off and losses to deep drainage
- allocation/supply may mean smaller areas can be irrigated
- yield may decrease due to waterlogged roots
- yield may increase as all areas get sufficient water

The example below demonstrates the additional time needed to compensate for an inefficient system.

	Example	Your data
Time required for 100% uniformity	**5.3 hs**	
Adjusted time to account for DU % - for EACH shift	**= 5.3 ÷ DU** **5.3 ÷ 68 x 100** **= 7.8 hours**	

Maintain your irrigation system and MAXIMISE distribution uniformity (DU).

Measuring pressure and flow

Step 1 Select which sprinklers are to be checked. Check the near, far, high and low positions as a minimum.

Step 2 For each sprinkler tested, note down the brand/model, nozzle size, colour, nominal flow rate and spacings on your evaluation sheet.

Hint: straight-drilled nozzle sizes can be checked using the shank end of unworn drill bits. The one with the snuggest fit is the current size of the nozzle. Check against the manufacturer's charts for the correct size.

Step 3 Measure the pressure and flow at each position. Make sure the system is operating at the normal pressure in the normal shift arrangement!

- Pressure: Position the pitot tube and gauge with the point of the tube about 3 mm (1/8') from the nozzle in the stream of the water.

- Flow: Place a length of flexible plastic tubing over the nozzle and direct the discharge into a container for a minimum of 15 seconds. If two nozzles are fitted, they need to be tested separately and their flows (L/min) need to be added together to give the total flow rate of the sprinkler.

  For impact arm sprinklers, hold the arm back and direct the stream into the container. Avoid losses from splashing!

  Use a measuring cylinder to record the volume (mL).

Step 4 Make sure all results are recorded.

If a large variation occurs between readings, you should conduct more checks to ensure your readings are true. If they are, you then need to identify why there is such a large variation in the system.

What do the pressure and flow readings tell us?

You have collected a series of figures on your record sheet. Using these figures you can calculate the variations and averages for the system.

Too great a variation indicates that the system is not operating most effectively. Pressure variation is written as ± % indicating if is ‘above’ or ‘below’ the desired figure.

Calculating pressure variation

		Example	Your data
Add the maximum and minimum pressures.	=	**max + min**	
	=	**225 + 200**	
	=	**425**	
Divide the result by two.	=	**425 ÷ 2**	
This gives the midpoint pressure.	=	**212.5 kPa**	
To calculate the pressure variation			
Take the midpoint from the maximum	=	**max – midpoint**	
	=	**225 – 212.5 kPa**	
	=	**12.5 kPa**	
Divide the difference by the midpoint.	=	**12.5 ÷ 212.5**	
	=	**0.059**	
Multiply by 100 to get a percentage.		**0.059 x 100**	
		5.9 %	
Pressure variation is:	=	**± 5.9%**	

In the above example the pressure variation is **± 5.9.%** A variation of more than **± 10%** is unacceptable and indicates either a poor system design or that the valve unit has a problem.

(Note that pressure variation comparisons are only valid if all outlets/nozzles are the same and there is no pressure-compensation.)

Calculating average pressure

Average pressure provides an indication of whether the valve unit is operating as it was designed to do. It can also be used in conjunction with manufacturer's information to calculate flow rate. The table below gives an indication of the typical operating pressures of various irrigation systems.

		Example	Your data
Add all pressure readings together.	=	225 +205 +203 +200	
	=	833	
Divide the total by the number of the number of measurement sites	=	833 ÷ 4	
This gives the average pressure	=	208 kPa	

The average pressure calculated should be compared against the correct pressure rates for the sprinklers being used. This can also enable the correct flow rate for that pressure to be determined.

Compare your results to the correct rate.

How do you think these difference will affect system performance?

Calculating flow variation

		Example	Your data
Add the maximum and minimum flow.		Max + min	
	=	40 + 34	
	=	74	
Divide the result by two to give the midpoint.	=	74 ÷ 2	
Midpoint flow is	=	37 L/min	
Take the midpoint from the maximum.		Max – midpoint	
	=	40 – 37	
		= 3	
Divide the difference by the midpoint.		3 ÷ 37	
	=	0.081	
Multiply by 100 to get a percentage.	=	0.081 x 100	
Flow variation is:	=	± 8.1 %	

A variation of more than ± 5% is unacceptable.

Calculating average flow

		Example	Your data
Add all the flow readings together.	=	34 +34 +35 +40	
	=	143	
Divide the total by the number of flow readings.	=	143 ÷ 4	
This gives the average flow.	=	35.75L/min (say 36)	

In the examples we have calculated the average flow rate (36 L/h) and the average pressure (208 kPa).

Check these figures out against standard manufacturers data for your sprinklers.

How close was this set?

Blank evaluation sheets

Field record sheet

Name:	Crop:
Location:	Effective root depth:
Soil texture	RAW for crop:
Sprinkler spacing along sprayline	Spacing between sprayline positions
Sprinkler make	Sprinkler model
Nozzle size	
Frequency of irrigation **days**	

Pressure & Flow record sheet

Sprinkler position on laterals

	Example				**Your data**			
USE EITHER THESE HEADINGS >>> **OR**	**1st Sprinkler**	**1st mid-position**	**2nd mid-position**	**Last sprinkler**	**1st Sprinkler**	**1st mid-position**	**2nd mid-position**	**Last sprinkler**
THESE HEADINGS >>>	**Near**	**High**	**Low**	**Far**	**Near**	**High**	**Low**	**Far**
Pressure – (kPa)								
Container volume (litres)								
Catch time (s)								
Calculated flow rate (L/min) *Flow = L/s x 60*								

Table 1. Converting mL to mm of irrigation

For catch-cans of 110 to 115 mm diameter across the top, just divide the collected amount by 10 to get mm of irrigation.

For instance if you collected 674 mL, this is equivalent to a depth of 67.4 mm.

If the size of the catch cans is different, or you wish to be more accurate, use table 1.

Divide the amount caught by the figure in the right hand column. For instance, if the diameter is 110 mm and you catch 674 mL this is 674 ÷ 9.5 = 71 mm

If you use 4-litre square plastic ice cream containers, 1 litre collected in one of these is equivalent to 25 mm of irrigation.
On a calculator, use **"water collected in mL" ÷ 40 = mm**

Converting mL to mm

Diameter of catch can (mm)	Figure to divide the collected amount by
75	4.4
80	5.0
90	6.4
100	7.9
102	8.2
104	8.5
106	8.8
108	9.2
110	9.5
112	9.9
113	10.0
114	10.2
115	10.4
120	11.3
125	12.25
145	16.5
165	21.3
200	31.4
220	38.0

Catch can record sheet.

	Left side						Right side						
	6	5	4	3	2	1	1	2	3	4	5	6	
mL Row 1 *mm*													mL Row 1 *mm*
mL Row 2 *mm*													mL Row 2 *mm*
mL Row 3 *mm*													mL Row 3 *mm*
mL Row 4 *mm*													mL Row 4 *mm*
mL Row 5 *mm*													mL Row 5 *mm*
mL Row 6 *mm*													mL Row 6 *mm*
mL Row 7 *mm*													mL Row 7 *mm*
mL Row 8 *mm*													mL Row 8 *mm*
mL Row 9 *mm*													mL Row 9 *mm*

(NB position of sprinklers shown is not to scale. Cans near sprinklers are to be half normal can spacing from sprinkler in each direction)

Start time ……………………. Finish Time……………………… Test duration ………………Mark wind direction

Overlap addition table

Purpose of table: In a complete irrigation, the sprayline would be moved across to the next position (set) – thus the crop would be watered first by the left hand side of the line, then after the move, from the right hand side of the line. To account for this overlap the left and right sides must be added together .

For example, if there were 6 catch cans between the sprayline positions, left side can 6 (L6) is added to right side can 1 (R1), then L5 to R2, and L4 to R3 etc..

Catch can	L	R	Total	L	R	Total	L	R	Total	L	R	Total	L	R	Total	L	R	Total
Row 1																		
Row 2																		
Row 3																		
Row 4																		
Row 5																		
Row 6																		
Row 7																		
Row 8																		
Row 9																		
Sum																		

Sum of Totals	

No. of catch cans = …….

No. of catch totals CT, = ……
(i.e CT = ½ the catch totals)

No. of LQ (low quarter) totals = … / 4 = …..

Sum of LQ totals

= …….

Calculating MAR – side roll, end tow, hand shift

	Example	Your data
On the overlap addition sheet the s**um of totals is**	**247.2 mm**	
Convert to 'per hour' figure **sum of totals is**	**= 247.2 ÷ mins of test x 60** **= 247.2 ÷ 30 x 60** **= 494.4mm/h**	
MAR = Sum of totals ÷ number of catch cans used.	**= 494.4 ÷ 84 = 5.9 mm/h**	

Calculating DU – side roll, end tow, hand shift

	Example	Your data
Sum of the LQ totals multiplied by 4	**42.3 x 4 = 169.2 mm**	
4LQ ÷ Sum of totals	**= 169.2 ÷ 247.2** **= 0.684**	
Multiply by 100 for DU%	**= 0.684 x 100** **= 68%**	

How long to irrigate

	Example	Your data
RAW for this crop	Say **63 mm**	
MAR calculated earlier	**5.9 mm/h**	
	RAW ÷ MAR	
If the system was 100% efficient you would need to run the system for	**63 ÷ 5.9** **= 10.6 hours**	

Because the system overlaps and all areas get irrigated twice, the time for each shift is half the time needed to replenish the RAW.

Time for each shift	**= 5.3 hours**	

	Example	Your data
Time required for 100% uniformity	**5.3 hs**	
Adjusted time to account for DU % - for **each** shift	**= 5.3 ÷ DU** **5.3 ÷ 68 x 100** **= 7.8 hours**	

Calculating pressure variation

		Example	Your data
Add the maximum and minimum pressures.	=	max + min	
	=	225 + 200	
	=	425	
Divide the result by two.	=	425 ÷ 2	
This gives the midpoint pressure	=	212.5 kPa	
To calculate the pressure variation			
Take the midpoint from the maximum.	=	max – midpoint	
	=	225 – 212.5 kPa	
	=	12.5 kPa	
Divide the difference by the midpoint.	=	12.5 ÷ 212.5	
	=	0.059	
Multiply by 100 to get a percentage.		0.059 x 100	
		5.9 %	
Pressure variation is:	=	± 5.9%	

Calculating average pressure

		Example	Your data
Add all pressure readings together.	=	225 +205 +203 +200	
	=	833	
Divide the total by the number of the number of measurement sites.	=	833 ÷ 4	
This gives the average pressure.	=	208 kPa	

Calculating flow variation

	Example	Your data
Add the maximum and minimum flow	=Max + min 40 + 34 = 74	
Divide the result by two to give the midpoint.	= 74 ÷ 2	
Midpoint flow is	= 37 L/min	
Take the midpoint from the maximum	Max – midpoint = 40 – 37 = 3	
Divide the difference by the midpoint	3 ÷ 37 = 0.081	
Multiply by 100 to get a percentage.	= 0.081 x 100	
Flow variation is :	= ± 8.1 %	

A variation of more than ± 5% is unacceptable.

Calculating average flow

	Example	Your data
Add all the flow readings together.	= **34 +34 +35 +40** = **143**	
Divide the total by the number of flow readings.	= **143 ÷ 4**	
This gives the average flow.	= **35.75L/min (say 36)**	