WaterWise on the Farm

Introduction to Irrigation Management

Evaluating your pressurised system

System 2

Lateral boom and linear move

160501

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CONTENTS

Aim

The aim of this workshop is to evaluate your lateral move or linear move irrigation system.

To do this you need to determine the rate that water is being applied, and how uniformly that water is being distributed over your irrigation area.

To check these aspects you need to know the MAR and DU for your system. These worksheets outline the equipment and procedure needed for you to complete these tasks.

Overview of lateral boom and linear move systems

Lateral booms and linear move irrigation systems consist of a boom or booms that travel down the field. They do not rotate. There are a variety of configurations and may consist of a single drive unit (for booms up to 40 metres long cantilevered on either side) or multiple drives for a number of spans of total length up to 1500metres.

On larger units a diesel powered generator provides power to small electric motors located on each spans' drive wheels. A computer control adjusts the speed of movement and corrects any misalignment of the booms.

There are several methods for accurately guiding the system along the run path. These include a buried electric signal guidance wire, an above ground cable, post or ditch guided systems. Smaller units are usually winch and cable driven similar to many other travelling irrigator systems, although some do have a diesel engine.

Generally sprinkler configuration consists of either medium pressure impact sprinklers positioned along the top of the boom, or low pressure sprinklers fixed to the low side, or slung below the boom by dropper pipes.

The use of dropper pipes, set for the height of the crop, reduces wind drift giving a more even application. Some systems have bubblers or 'socks' dragging on the end of these dropper pipes to apply water to furrows where overhead watering is undesirable for the crop.

Many linear move systems have a very high instantaneous water application rate, some up to 150mm per hour, however this water is only applied for a short time as the machine moves relatively quickly. To help reduce this application rate some machines have two or more rows of smaller sprinklers spaced before and after the boom on spreader pipes effectively increasing the wetted diameter of the sprinklers.

Most systems are suitable for fertigation (application of fertiliser though irrigation water) and application of chemicals, provided they are operating efficiently and applying water evenly.

Paddock requirements

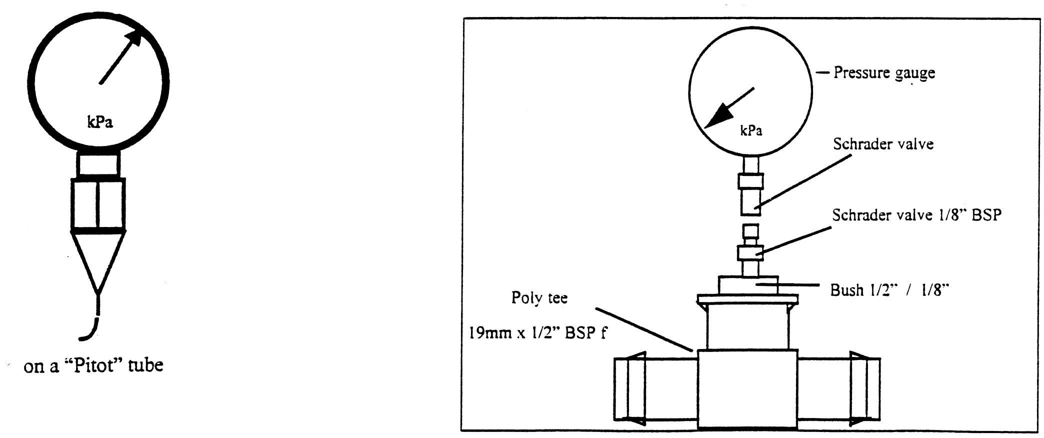
These systems are best suited to fields that are rectangular and free of obstructions. Internal fences should be along the direction of run or alternatively gates or electric lay-down fences can be used.

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 & b)



Schrader valve

To measure flow:

- plastic tubing or a hose 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 coverage:

- catch cans (sufficient for 3 m to 5 m spacings across the complete coverage width)
- gravel pieces to place in containers to stop them blowing away
- a 30-metre measuring tape
- a shovel for smoothing areas to set containers
- a measuring cylinder or jug with graduations in millilitres
- a calculator, a pen and evaluation sheets
- if possible, manufacturers performance charts giving pressure versus wetted diameter, pressure range, and output rates.

Evaluation method

To assess the performance of lateral or linear move irrigation system, you need to measure the pressure at various points in the system, its operating speed and the output of the sprinklers using catch cans. To do this work though the following procedure.

Occupational health and safety

Whilst working with mobile irrigation systems you, and anyone assisting you, should at all times be aware of the inherent dangers associated with working near moving machinery and high pressure water outlets. Safety should by the primary concern at all times.

1. Choose a suitable location for the test so that catch cans can be placed across the pathway of the boom or linear move. The location should be far enough ahead of the boom so that no water enters the catch cans before they are all set up.
2. Set out the catch cans 3 metres apart for small booms and up to 10 metres apart for large linear move systems. The cans on each side of the boom should be about 1.5 metres each side of the cable (5 metres for the large linear booms).
    - Ensure that the cans are in a straight line parallel to the boom and that none will be displaced as the irrigator moves past.
    - Add at least two extra containers on each side to allow changes in wind speed or direction.
    - If rain is likely, place another can away from the boom to record rain during the test. Any rain must be deducted from the amount caught in **each** catch can.
3. Record the make, model and nozzle size or colour of the jets or sprinklers.
4. When the system is operating, measure the pressure and flow rate. Take the measurements at the first and last sprinklers and at a minimum of two other positions along the boom.
5. When the system is operating at normal speed (and any slack has been taken up on any cable), measure the speed.
    - Place a marker (a peg) next to one wheel and then, say, 20 minutes later, place another next to the same wheel. (A longer time will give a more accurate result.)
    - Record the distance covered and time.
6. Measure the length of the wetted pattern from the front to the rear of the boom.
7. Measure the time that water is received by the catch cans.
8. Record wind speed and direction (see table on next page).
9. When the irrigator has completely passed over all of the catch cans, measure and record the volumes in **each** container. Each volume MUST be written in the correct space on the field record sheet.

Make sure all field data has been recorded and entered onto the field record sheet

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

Field record sheet (example)

Name: **Peter Johnstone**	Crop: **Pasture**	Effective root depth: **300 mm**
Location/Block:	Soil texture: **Sandy Loam**	RAW: **25 mm**
		Irrigation frequency **6 days**
Sprinkler make: **BigSquirt**	Sprinkler model: **2000/1**	Design flow rate **0.55 L/s @ 100 kPa**
Nozzle type:	Nozzle size: **5/16" (8mm)**	
Irrigation run length **400 m**	Length of boom: **80 m**	No. of sprinklers per boom **27**
Lane spacing **80** m	Sprinkler wetted diameter **6 m**	Sprinkler spacing **3 m**

Test details:	**Speed measurements**:
Distance between catch cans : **3 m**	Distance covered **20 m** Time to covered above distance **54 mins**
First time water hits catch cans : **12.30 pm** Latest time water hits catch cans **12.48 pm** Catch can collection time **18 minutes**	

Catch can record sheet (example)

Catch Can ID	Volume collected mL	Equivalent depth mm		Catch Can ID	Volume collected mL	Equivalent depth mm
1	0	0		16	380	38
2	190	19		17	280	28
3	250	25		18	190	19
4	210	21		19	170	17
5	230	23		20	200	20
6	250	25		21	250	25
7	300	30		22	280	28
8	300	30		23	250	25
9	310	31		24	250	25
10	380	38		25	180	18
11	400	40		26	220	22
12	380	38		27	200	20
13	200	20		28	0	0
14	250	25		29	-	-
15	300	30		30	-	-
TOTAL		**395**		TOTAL		**285**
GRAND TOTAL OF DEPTHS FOR ALL CANS {A}						**680**
NUMBER OF CANS WITH WATER IN THEM {CC}						**26**

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 the table alongside.
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.

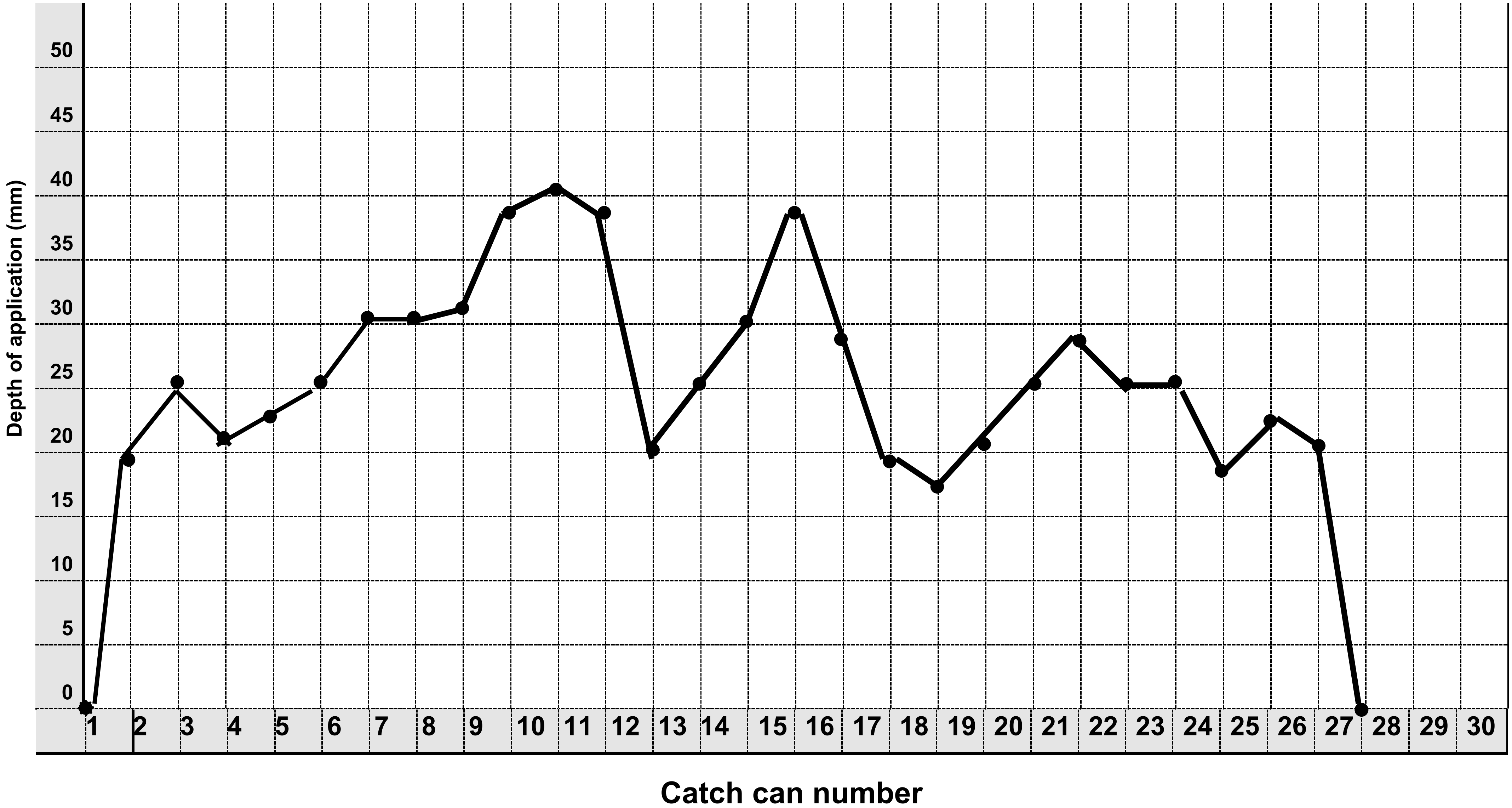
On a calculator, use **“water collected in mL” ÷ 40 = mm**

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

Graph of depths

You may wish to mark the tow path centre line down the chart if your irrigator is a lateral boom.



Calculating the mean application rate (MAR)

The mean application rate (MAR) is the average rate (in mm/h) that water is applied to the wetted area of the soil.

	Example	Your data
Add up depths in all catch cans Call this [A]	= 680 mm	
Number of catch cans used [CC]	= 26	
Calculate the average depth applied by dividing [A] by [CC]	= [A] ÷ [CC]	
	= 680 ÷ 26	
Call the answer [B]	= 26.1 mm only slightly above the RAW	
RAW for this crop	25 mm	
If the depth applied is significantly greater than the RAW there it is likely that water will be lost due to run-off. In such cases remedial action needs to be taken.		
Time water was landing in cans	= 18 minutes	
Convert to hours by dividing by 60	= 18/60 hs	
Call this [C]	= 0.3 hs	
Mean Application Rate = [B] ÷ [C]	= [B] ÷ [C]	
	= 26.1 ÷ 0.3	
	= 87 mm/h	

The sample **MAR of 87 mm/h** is a high application rate and would be above the infiltration rate of many soils. Depending on how quickly the irrigator moves over the field, this may or may not be a problem. In the example the irrigator moves over in 18 minutes so it may not be a problem.

High application rates are an inherent characteristic with many moving irrigators as mentioned in the introductory notes.

Calculating distribution uniformity (DU)

This is a calculation of how evenly an area is watered. 100% is perfect.

	Example	Your data
One quarter of the total number of catch cans is [CC] ÷ 4	[CC] ÷ 4	
	= 26 ÷ 4	
(If this is not a whole number, round down to a whole number.)	= 6.5	
Call this [F]	= 6	
On your catch can record sheet, circle the quarter of cans with the lowest amounts. (the LQ cans)	Circle 6 LQ cans	
Add up the depths in the LQ cans	+19 +20 +19	
Call this [G]	+17+20 +18	
	= 113 mm	
Average LQ depth = [G] ÷ [F]	= [G] ÷ [F]	
	= 113 ÷ 6	
Call this [H]	= 18.8 mm	
The Distribution Uniformity is the average LQ amount divided by the average of all cans - [H] ÷ [B]	= [H] ÷ [B]	
	= 18.8 ÷ 26.1	
	= 0.72	
Multiply by 100 for a percentage	= 0.72 x 100	
	= 72 %	
A desirable minimum DU would be at least 85%.		

If the DU is too low, ways of improving this should be considered. This may mean the flow rate and pressure need to be adjusted or different nozzle sizes fitted.

It's a good idea to check the original specifications supplied with the irrigator to make sure the system is operating correctly.

Measuring pressure and flow

STEP 1: Select which sprinklers are to be checked.

STEP 2: Measure the pressure and flow at each position. Make sure the system is operating at the normal pressures you use whilst testing.

- 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. Record the volume and time.

STEP 3: 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.

Pressure and flow record sheet

	Example data				Your data			
Sprinkler position	**1st Sprinkler**	**1st mid-position**	**2nd mid-position**	**Last sprinkler**				
Pressure – (kPa)	110	103	105	95				
Container volume (litres)	13.3	12.5	12.2	12				
Catch time (s)	20	21.5	21.5	21				
Calculated flow rate (L/s)	0.66	0.58	0.57	0.57				

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**	
	=	**110 + 95**	
	=	**205**	
Divide the result by two.	=	**205 ÷ 2**	
This gives the midpoint pressure.	=	**102.5 kPa**	
To calculate the pressure variation			
Take the midpoint from the maximum.	=	**max – midpoint**	
	=	**110 – 102.5 kPa**	
	=	**7.5 kPa**	
Divide the difference by the midpoint.	=	**7.5 ÷ 102.5**	
	=	**0.073**	
Multiply by 100 to get a percentage.		**0.073 x 100**	
		7.3 %	
Pressure variation is:	=	**± 7.3%**	

In the above example the pressure variation is **± 7.3.%** 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.	=	**110 +103 +105 +95**	
	=	**413**	
Divide the total by the number of the number of measurement sites.	=	**413 ÷ 4**	
This gives the average pressure.	=	**103.25 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** **0.66 + 0.57**	
	=	**1.23**	
Divide the result by two to give the midpoint.	=	**1.23 ÷ 2**	
Midpoint flow is	=	**0.615 L/min**	
Take the midpoint from the maximum		**Max – midpoint**	
	=	**0.66 – 0.615** **=0 045**	
Divide the difference by the midpoint		**0.045 ÷ 0.615**	
	=	**0.073**	
Multiply by 100 to get a percentage.	=	**0.073 x 100**	
Flow variation is :	=	**± 7.3 %**	

A variation of more than ± 5% is unacceptable.

Calculating average flow

	Example	**Your data**
Add all the flow readings together.	= **0.66** **0.58** **0.57** **0.57** = **2.38**	
Divide the total by the number of flow readings.	= **2.38 4**	
This gives the average flow.	= **0.595 L/s (say 0.6)**	

In the examples we have calculated the average flow rate (0.6 L/s) and the average pressure (103 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:	Effective root depth: **mm**
Location/Block:	Soil texture:	RAW:
		Irrigation frequency **days**
Sprinkler make:	Sprinkler model:	Design flow rate … ….**L/s @……… kPa**
Nozzle type:	Nozzle size:	
Irrigation run length **m**	Length of boom	No. of sprinklers per boom
Lane spacing **m**	Sprinkler wetted diameter **m**	Sprinkler spacing **m**

Test details:	**Speed measurements**:
Distance between catch cans : **m**	Distance covered **m** Time to covered above distance **mins**
First time water hits catch cans : Latest time water hits catch cans Catch can collection time **mins**	

Catch can record sheet

Catch Can ID	Volume collected mL	Equivalent depth mm		Catch Can ID	Volume collected mL	Equivalent depth mm
1				16		
2				17		
3				18		
4				19		
5				20		
6				21		
7				22		
8				23		
9				24		
10				25		
11				26		
12				27		
13				28		
14				29		
15				30		
TOTAL				TOTAL		
GRAND TOTAL OF DEPTHS FOR ALL CANS [A]						
NUMBER OF CANS THAT HAD WATER IN THEM [CC]						

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 the table alongside.

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.

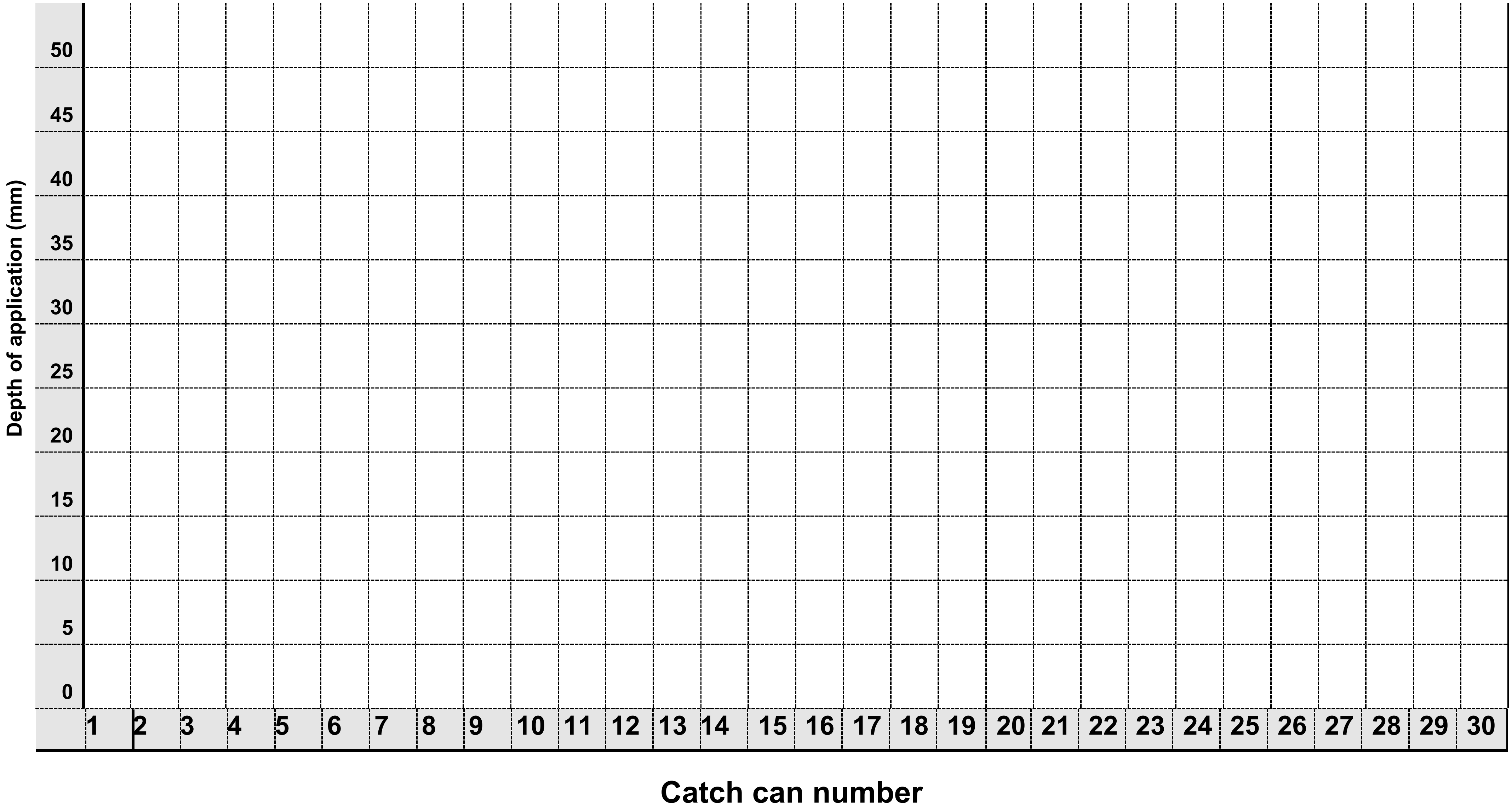
On a calculator, use
"water collected in mL" ÷ 40 = mm

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

Graph of depths

You may wish to mark the tow path centre line down the chart if your irrigator is a lateral boom.



Calculating the mean application rate (MAR)

The Mean Application Rate (MAR) is the average rate (in mm/h) that water is applied to the wetted area of the soil.

	Example	**Your data**
Add up depths in all catch cans Call this **[A]**	**= 680 mm**	
Number of catch cans used **[CC]**	**= 26**	
Calculate the average depth applied by dividing [A] by [CC] Call the answer **[B]**	**= [A] ÷ [C]** **= 680 ÷ 26** **= 26.1 mm** **only slightly above the RAW**	
RAW for this crop	**25 mm**	

If the depth applied is significantly greater than the RAW there it is likely that water will be lost due to run-off. In such cases remedial action needs to be taken.

Time water was landing in cans Convert to hours by dividing by 60 Call this **[C]**	**= 18 minutes** **= 18 ÷ 60 hs** **= 0.3 hs**	
Mean Application Rate = [B] ÷ [C]	**= [B] ÷ [C]** **= 26.1 ÷ 0.3** **= 87 mm/h**	

Calculating distribution uniformity (DU)

This is a calculation of how evenly an area is watered. 100% is perfect.

	Example	**Your data**
One quarter of the total number of catch cans is [CC] ÷ 4 (If this is not a whole number round down to a whole number.) Call this **[F]**	**[CC] ÷ 4** **= 26 ÷ 4** **= 6.5** **= 6**	
On your catch can record sheet, circle the quarter of cans with the lowest amounts (the LQ cans)	**Circle 6 LQ cans**	
Add up the depths in the LQ cans Call this **[G]**	**+19 +20 +19** **+17+20 +18** **= 113 mm**	
Average LQ depth = [G] ÷ [F] Call this **[H]**	**= [G] ÷ [F]** **= 113 ÷ 6** **= 18.8 mm**	
The **Distribution Uniformity** is the average LQ amount divided by the average of all cans - [H] ÷ [B] Multiply by 100 for a percentage	**= [H] ÷ [B]** **= 18.8 ÷ 26.1** **= 0.72** **= 0.72 x 100** **= 72 %**	

A desirable minimum DU would be at least 85%.

Pressure and flow record sheet

	Example data				Your data			
Sprinkler position	**1st Sprinkler**	**1st mid-position**	**2nd mid-position**	**Last sprinkler**				
Pressure (kPa)	**110**	**103**	**105**	**95**				
Container volume (litres)	**13.3**	**12.5**	**12.2**	**12**				
Catch time (s)	**20**	**21.5**	**21.5**	**21**				
Calculated flow rate (L/s)	**0.66**	**0.58**	**0.57**	**0.57**				

Calculating pressure variation

		Example	Your data
Add the maximum and minimum pressures.	=	max + min	
	=	110 + 95	
	=	205	
Divide the result by two.	=	205 ÷ 2	
This gives the midpoint pressure.	=	102.5 kPa	
To calculate the pressure variation			
Take the midpoint from the maximum.	=	max – midpoint	
	=	110 – 102.5 kPa	
	=	7.5 kPa	
Divide the difference by the midpoint.	=	7.5 ÷ 102.5	
	=	0.073	
Multiply by 100 to get a percentage.		0.073 x 100	
		7.3 %	
Pressure variation is:	=	± 7.3%	

Calculating average pressure

		Example	Your data
Add all pressure readings together.	=	110 +103 +105 +95	
	=	413	
Divide the total by the number of the number of measurement sites.	=	413 ÷ 4	
This gives the average pressure.	=	103.25 kPa	

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** = **0.66 + 0.57** = **1.23**	
Divide the result by two to give the midpoint. Midpoint flow is:	= **1.23 ÷ 2** = **0.615 L/min**	
Take the midpoint from the maximum.	**Max – midpoint** = **0.66 – 0.615** **=0.045**	
Divide the difference by the midpoint. Multiply by 100 to get a percentage. Flow variation is :	**0.045 ÷ 0.615** = **0.073** = **0.073 x 100** = **± 7.3 %**	

A variation of more than ± 5% is unacceptable.

Calculating average flow

	Example	Your data
Add all the flow readings together.	= **0.66** **0.58** **0.57** **0.57** = **2.38**	
Divide the total by the number of flow readings.	= **2.38 ÷ 4**	
This gives the average flow.	= **0.595 L/s (say 0.6)**	

In the examples we have calculated the average flow rate (0.6 L/s) and the average pressure (103 kPa).

Check these figures out against standard manufacturer's data for your sprinklers. How close was this set?