Introduction to Irrigation Management

Evaluating your pressurised system

System 3

Centre Pivots

Version: WA 20 September 2011

These materials are part of the WaterWise on the Farm education program *Introduction to Irrigation Management*. They were developed by NSW Agriculture staff from the Water Management subprogram with major input from Lindsay Evans.

CONTENTS

AIM

The aim of this workshop is to evaluate your centre pivot 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 you need to know the mean application (MA) and distribution uniformity (DU) for your system. These worksheets outline the equipment and procedure needed for you to complete these tasks.

SYSTEM OVERVIEW

A centre pivot is a travelling irrigation line that pivots at one end and rotates in a circle. It is made up of towers (commonly 4 to 12) that support the irrigation pipe and spray outlets. They have a pair of wheels at the junction of each tower that is driven by electric motors or hydraulic motors (oil or water). The speed of the pivot system is usually set on the outside wheels with the other drive points engaging when they get behind or a valve is adjusted with the angle of that joint.

The size of the sprinkler outlets increases as you move away from the centre, as the outer sections of the pivot are covering a larger area than the centre sections. This means that the longer a pivot is, the greater the application rate needed at the end.

A major advantage of centre pivots is that they can operate at quite low pressures, thus reducing pumping cost. If the site is undulating, pressure regulators are fitted to each sprinkler outlet to equalise the output at varying heights. Most modern centre pivots operate at only 100 kPa. With pipes from the centre to the pump site, the total pressure required can be as low as 300 kPa.

Some centre pivots have end guns fitted to increase the area irrigated. The application pattern and rate of end guns is often very different to the rest of the irrigator, creating uneven watering. End guns often require a booster pump to increase the operating pressure.

EQUIPMENT NEEDED

To measure sprinkler coverage:

- Catch cans
- Weights to prevent catch cans blowing away
- A shovel to smooth catch can area, and where necessary for partially burying the cans
- A measuring cylinder or jug with graduations in millilitres
- A 30-metre measuring tape; and possibly a short rule
- A calculator, a pen and evaluation sheets
- Manufacturer's sprinkler performance charts

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) to 1000 kPa
- A Pitot tube attachment (pronounced pit-oh) (Figure 1), or a threaded 15 mm PVC tee and fittings such as reducing bushes for small low-level sprinklers, or a Schrader valve, or a needle valve fitting (Figure 2)

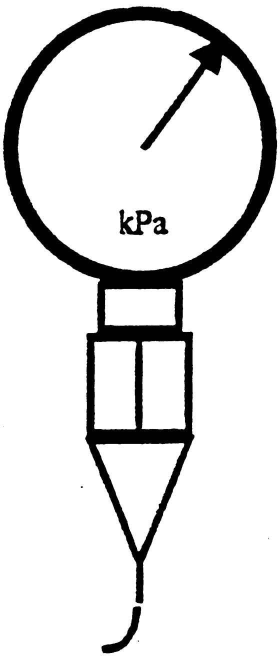


Figure 1: Pitot Tube

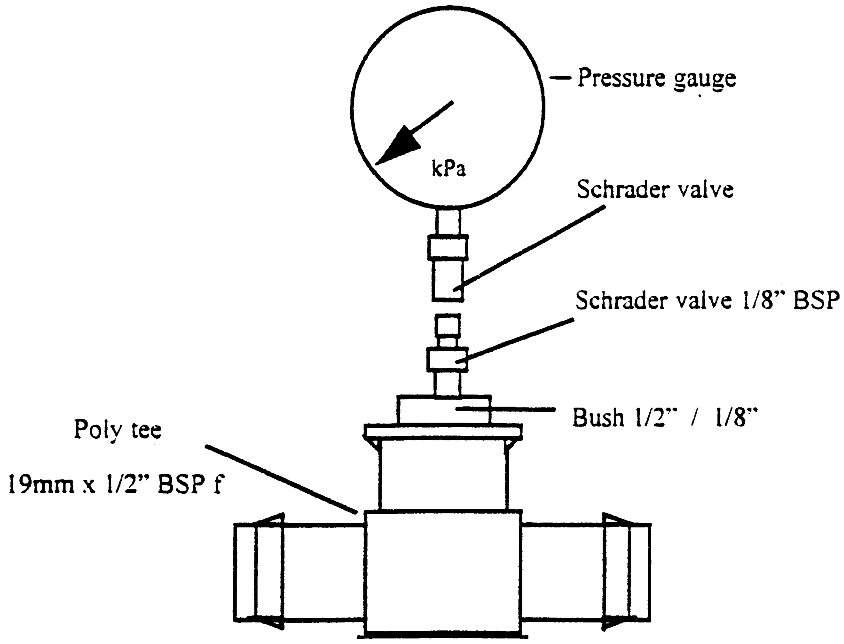


Figure 2: Schrader Valve

EVALUATION METHOD

To assess the performance of your centre pivot system, you need to measure the pressure and flow at various points in the system, the operating speed at the far end, and the output of the sprinklers using catch cans. From these you will be able to calculate the application and uniformity. To do this, work through the following procedure.

Occupational Health and Safety

Whilst working with your centre pivot irrigator you, and anyone assisting you, should at all times be aware of the inherent dangers associated with working near moving machinery. Safety should be the primary concern at all times.

1. Fill out the first sections of the centre pivot data sheet with details about the crop, soils and the centre pivot. You will need to measure the length of each span and the distance to the last wheel track (where the travel speed will be measured).

Speed measurement

Note that the pivot must be moving (at its normal speed) throughout the test, otherwise the difference in flow rates between the inboard and outboard sprinklers will give you incorrect results. If all is correct, the depths in all of the catch cans will be similar.

2. Measure the pivot's speed by staking out a measured distance (10 m) around the outer wheel track and recording the time required for the end drive unit to travel between the stakes. Record the time and distance on the data sheet.

Water output measurement

3. Place the catch cans at intervals no greater than 6 m to cover the whole wetted length of the pivot.

4. Measure the width of the wetting pattern near the end drive unit and record this.

5. After the system has passed all catch cans, and no more water is landing in them, measure the volumes in the catch cans and record these on the catch can sheet. (For long pivots, the catch cans under the first one or two spans need not be recorded, as the time to pass over them is too great. There will be little effect on the calculations. However, the catch can positions under these spans ***must*** be noted and the catch volume recorded as an 'X'.)

Measuring pressure and flow

6. Measure and record the pressure and flow at outlets near the start and end of the pivot and also at other positions on towers along the pivot.

Calculating the results

7. After taking all measurements, complete the calculations. As the calculations for a centre pivot are quite complex, it is best to put the figures into a computer spreadsheet and let the computer work out the results. Your trainer should have the appropriate program. If you are doing the evaluation at home, ask for a copy of the program or get your local irrigation adviser to assist you. The program may be available to download from the WaterWise web pages on NSW Agriculture's web site.

8. Record the results in the application results table. For those who wish to avoid the use of the computer, you may use a calculator. The procedure is fully detailed in these notes.

9. Rank the volumes starting with the lowest amount, (1st, 2nd 3rd, and so forth). Do this for about one third of the cans

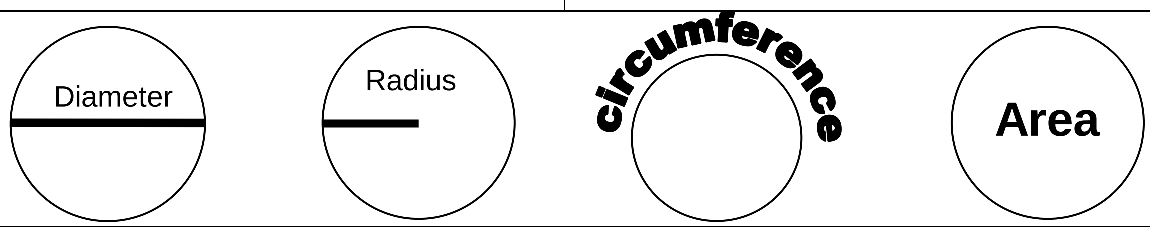
10. Calculate the "weighted catch" by multiplying the volume collected in the catch can by the number of that catch can. Follow the steps in your field record sheet

11. Calculate the Average Application per Pass of your system using the Table given. Record the results in the Application Results table

12. Calculate the Distribution Uniformity (DU) of your system using the DU Table. Record the results in the Application Results table

Data Sheet Example

Data sheet	**Date**
Name	Rotundo Douse
Crop	Lucerne
Location/block	Paddock 2/3
Soil texture of Block	Sandy loam over sand
Effective root depth	1.0 **metres**
Rootzone RAW	48 **mm**
Irrigator make	Lindsay Zimmatic
Emitter model	Nelson R3000 Rotators
Number of Spans	6
Number of emitters along span	20
Total length of spans (Pivot length)	324 **metres**
Wetted width (end span)	8 M
Length of overhang	25 metres
Sprinklers on overhang	8 sprinklers
End gun present	**Yes** **No**
End gun radius	0
Pressure Compensated	**Yes** **No**
Specified operating pressure at pivot	175 **kPa**
Specified flow rate	53.0 **L/s** 0.19 **ML/hr**
Irrigation frequency	2 - 4 **days**
Wind direction and speed during test (Table 1)	LIGHT BREEZE
Catch Can Diameter	113 **MM**
Time to travel test distance	12 **MINUTES** 9 **SECONDS**
Distance travelled	10 **METRES**



Irrigation System Calculations

Determine the wetted radius of the pivot		
Wetted radius = pivot length + length of overhang + end gun reach		
Pivot length (distance to outside track)	324 metres	**A**
Length of overhang	25 metres	**B**
End gun reach	No end gun = 0 metres	**C**
Wetted radius	**A + B + C**	
	324 + 25 + 0 = 349 metres	**D**
Determine the area that is wet by the pivot		
Wetted area = ∏ (Pi) x (wetted radius)^2 ÷ 10 000 *		
∏ (Pi)	3.14	**Pi**
**** ÷ by 10 000 to convert into hectares***	= Pi x D^2 ÷ 10 000 = 3.14 x 349^2 ÷ 10 000 = 3.14 x 121801 ÷ 10 000 = 38.2 ha	**WA**

Estimate the speed of the Pivot		
Distance Travelled	10 **metres**	**E**
Time for distance travelled	12 **MINUTES** 9 **SECONDS**	
Time in seconds	729 seconds	**F**
Travel Speed = Distance travelled ÷ Time (seconds) x 3600		
***multiply by 3600 to convert the speed into metres per Hour**	**E ÷ F x 3600*** 10 ÷ 729 x 3600 = 49.4 **metres per hour**	**G**
Estimate how large your irrigation circle is		
Circumference (Outside wheel track) = 6.28* x pivot radius		
*** Circumference of a circle** **= 2 x pi x radius of circle** **2 x pi = 6.28**	**6.28 x A** **6.28 x** 324 **=** 2035 **metres**	**H**
Calculate the time for one revolution (complete circle) of the pivot		
Time for one revolution = Circumference ÷ Travel speed		
	H ÷ G 2035 ÷ 49.4 = 41.2 **hours**	**K**

Field Record Sheet (example)

If you have access to the computer program, you only need to fill in columns A and B of this table. The computer will do the rest.

Property location:	Roundabout	**Date**	16th Aug 2000
System	Centre pivot - no end gun		

Span #	**Catch can number**	**Volume collected in can (mL)**	**Ranked volume**	**Weighted catch A x B**
	A	**B**	**C**	**D**
1	1	X		
1	2	X		
1	3	X		
1	4	X		
1	5	X		
1	6	X		
1	7	X		
1	8	X		
1	9	X		
2	10	183		1830
2	11	221		2431
2	12	202		2424
2	13	209		2717
2	14	175	11	2450
2	15	206		3090
2	16	183		2928
2	17	177		3009
2	18	168	10	3024
3	19	143	6	2717
3	20	197		3940
3	21	177		3717
3	22	237		5214
3	23	197		4531
3	24	211		5064
3	25	189		4725
3	26	206		5356
3	27	191		5157
4	28	157	7	4396
4	29	210		6090
4	30	238		7140
4	31	250		7750
4	32	330		10560
4	33	272		8976
4	34	167	8	5678
4	35	259		9065
4	36	244		8784

Span number	Catch can number	Volume collected in can (mL)	Ranked volume	Weighted catch A x B
	A	B	C	D
5	37	142	5	5254
5	38	184		6992
5	39	208		8112
5	40	230		9200
5	41	224		9184
5	42	227		9534
5	43	212		9116
5	44	176		7744
5	45	189		8505
6	46	136	4	6256
6	47	168	9	7896
6	48	191		9168
6	49	194		9506
6	50	175	12	8750
6	51	224		11424
6	52	221		11492
6	53	187		9911
6	54	227		12258
O'hang	55	115	1	6325
O'hang	56	187		10472
O'hang	57	136	3	7752
O'hang	58	133	2	7714
	59			
	60			
	61			
	62			
	63			
	64			
	65			
	66			
	67			
	68			
	69			
Total TN = 1666			**TC = 325328**	

Lowest Quarter Table

Rank C	Catch Can Number A	Cumulative Catch Can Number	Weighted Catch D	Cumulative Weighted Catch
1	55	55	6325	6325
2	58	113	7714	14039
3	57	170	7752	21791
4	46	216	6256	28047
5	37	253	5254	33301
6	19	272	2717	36018
7	28	300	4396	40414
8	34	334	5678	46092
9	47	381	7896	53988
10	18	399	3024	57012
11	14	413	2450	59462
12	50	463	8750	68212
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

LQ limit = TN ÷ 4

= 1666 ÷ 4

= 416.5

413 is the closest cumulative catch can number.

Therefore we take catch can number 14 with the Low quarter weighted catch of 59462

LQWC = 59462

Calculating the Average Application and Instantaneous Application Rate

Calculate the average amount of water being applied with each pass		
Average Application = Total of weighted catch can ÷ Total sum of catch can Numbers ÷ Conversion factor		
Total Sum of catch can Numbers Add up the numbers in Column A where water was collected in the can. Ignore empty can numbers.	**1666**	**TN**
Total of all weighted catches Add up the numbers in column D.	**325328**	**TC**
Conversion Factor (Table 2) Our catch cans for this example were 113 mm in diameter	**10.0**	**CF**
Average Application per pass =	**TC ÷ TN ÷ CF**	
	325328 ÷ 1666 ÷ 10.0 = **19.5 mm**	**AA**
Transfer the AA figure to the Application Results Table (earlier).		
Calculate the amount of water being applied each hour		
Wetted diameter	**8 metres**	**WD**
Instantaneous Application Rate at outer tower **= Average Application x Travel speed ÷ wetted width**		
	AA x G ÷ WD **19.5 x 49.4 ÷ 8** = **120.4 mm / hour**	**IAR**

IAR should be compared to the infiltration rate of your soil. If the IAR at the outer end of centre pivot is much greater than the infiltration rate, runoff will occur. Methods of reducing this problem should be investigated eg. Installing outlets with a larger wetted diameter, increasing soil organic matter, using soil conditioners, etc.

Conversion from Volume into depth

Table 2 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

In order to convert Volume into depth (millimetres) we need to use a conversion factor. The conversion factors are listed in Table 2. You select your conversion factor by measuring the diameter of the mouth of your catch can

For instance, if the diameter of your catch can is 110 mm then our conversion factor from Table 2 will be 9.5 (circled).

If our cans collected 674 mL, then the conversion is our volume divided by the conversion factor;

674 mL ÷ 9.5 = 71 mm

Therefore, the depth of water applied during the example test was 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

Calculating the Distribution Uniformity

Step 1 Determine the lowest quarter limit (LQ limit)

Step 2 Use the Lowest Quarter Catch table to add up the figures in column C of your Field record sheet, starting at the lowest volume rank (1st).

Step 3 Continue to add the weighted catch until the total exceeds the figure for LQ limit. Subtract the last figure, so the total is less than LQ limit.

Step 4 The figures you have added are your LQ catches- shade or highlight them on your Field record sheet

Step 5 Follow the steps in the Distribution Uniformity Table

Step 6 Record your results in the Application Results Table

Distribution Uniformity

Calculate the number of Lowest Quarter of catch cans (LQ Limit)		
Lowest quarter Limit	**= TN ÷ 4**	
	= **1666** ÷ **4** = **416.5**	**LQ Limit**
Add up the Depth of water caught in the Lowest Quarter Cans (LQ Depth)		
Lowest quarter Depth = Total Lowest quarter weighted volumes ÷ Total lowest quarter can positions ÷ conversion factor		
From the LQ Table, find the Cumulative (or Total) Catch Can Position Number closest to LQ Limit.	= **413**	**TNLQ**
From the LQ Table, find Cumulative (or Total) Weighted Catch for TNLQ	= **59462**	**LQWC**
Lowest quarter depth	**= LQWC ÷ TNLQ ÷ CF**	
	= **59462** ÷ **413** ÷ **10** = **14.4 mm**	**LQ depth**
Calculate the Distribution Uniformity of the Pivot		
Distribution Uniformity = LQ Depth ÷ AA		
	= **14.4** ÷ **19.5** = **0.74**	**DU**
Convert into a percentage by multiplying by 100	**DU x 100**	
	= **0.74 x 100** = **74 %**	
Transfer the DU figure to the Application Results Table		

Application results

Calculate the expected application per pass of the pivot		
Specified Flow Rate		**0.19 ML/h**
Hour per revolution	**K**	**41.2 Hours**
Wetted Area	**WA**	**38.2 Ha**

Nominal Average Application per pass: = Specified flow rate (ML/hr) x Hours per revolution ÷ Wetted Area (ha) x 100

= 0.19 x 41.2 ÷ 38.2 x 100

= 20.5 mm

Compare the expected application per pass to the Measured application per pass		
Measured Average Application per pass: From computer program OR your own calculations using procedure at end of these notes.	**AA**	**19.5 .mm**

If the Measured Average Application per pass is greatly different from the Nominal Average Application per pass, something is significantly wrong.

The measured application per pass should be compared to the rootzone RAW on the data sheet. For the example, the application depth is one quarter of the RAW.

Estimate the distribution Uniformity of the pivot		
Lower quarter output per pass From computer program OR your own calculations using procedure in these notes.	**LQ Depth**	**14.4 mm**
Distribution uniformity From computer program OR your own calculations using procedure in these notes.	**DU**	**74 %**

Distribution uniformity above 75% is quite acceptable for field crops. If the DU is too low, this means that at least 25% of the area being irrigated is receiving less water than the rest.

How long to irrigate

Using the AAR value and the RAW value for the crop on this soil, you may estimate how long you need to irrigate to ensure adequate wetting from this sprinkler.

To estimate how long to irrigate to fill the RAW you need to compare the Average application per pass with the RAW. You will also need to take into account the DU.

<table>
<tr><th colspan="3">Calculate the best amount of water to apply each pass of the pivot</th></tr>
<tr><td>Average application per pass</td><td>= 19.5 mm</td><td>AA</td></tr>
<tr><td>DU calculated</td><td>= 0.74 (74%)</td><td>DU</td></tr>
<tr><td>Ideal application per pass to compensate for the DU</td><td>AA ÷ DU
19.5 ÷ 0.74
= 26 mm</td><td>N</td></tr>
<tr><th colspan="3">Calculate how much of the Rootzone RAW is applied with each pass</th></tr>
<tr><td>RAW for this crop from Centre pivot data sheet.</td><td>= 48 mm</td><td>RAW</td></tr>
<tr><td>Percentage of RAW applied per pass</td><td>= AA ÷ RAW x 100
= 19.5 ÷ 48 x 100
= 41 %</td><td>P</td></tr>
<tr><th colspan="3">Calculate pivot speed required to apply the full rootzone RAW</th></tr>
<tr><td>Travel speed required
to apply the full RAW on each pass of the Pivot</td><td>Percentage x Travel Speed x DU%
RAW</td><td></td></tr>
<tr><td></td><td>P x G x DU%
0.41 x 49.4 x 74% (0.74)
= 15 m/hr</td><td>R</td></tr>
<tr><th colspan="3">Calculate time of one revolution to applying the rootzone RAW</th></tr>
<tr><th colspan="3">Time for one revolution at this speed = Circumference ÷ Travel speed</th></tr>
<tr><td></td><td>H ÷ R
2035 ÷ 15
= 135.6 hours.
or 5.6 days</td><td></td></tr>
</table>

Flow Record Sheet (example)

	Nozzle type	Time for 10L Seconds	Flow measured L/s	Flow as per system design L/s	Flow difference C - D	Flow variation E ÷ D x 100
	A	**B**	**C**	**D**	**E**	**F**
Span 1, last sprinkler	#15 15/128	71.4	0.14	0.13	0.01	+7.7%
Span 2, last sprinkler	#22 11/64	37.6	0.26	0.25	0.01	+4%
Span 3, last sprinkler	#29 29/128	23.8	0.42	0.40	0.02	+5%
Span 4, last sprinkler	#34 17/64	18.75	0.53	0.52	0.01	+4%
Span 5, last sprinkler	#40 5/16	14.29	0.70	0.67	0.03	+4.5%
Span 6, last sprinkler	#44 11/32	12.09	0.83	0.76	0.07	+9.2%

Pressure Record Sheet (example)

	Pressure measured	Pressure as per system design	Pressure difference A - B	Pressure Variation C ÷ B x 100
	A	**B**	**C**	**D**
At Pivot centre	200 kPa	175 kPa	+25 kPa	+14.3 %
Span 1, last sprinkler	177 kPa	155 kPa	+22 kPa	+14.2 %
Span 2, last sprinkler	152 kPa	137 kPa	+15 kPa	+10.9 %
Span 3, last sprinkler	141 kPa	123 kPa	+18 kPa	+14.6 %
Span 4, last sprinkler	138 kPa	112 kPa	+26 kPa	+23.2 %
Span 5, last sprinkler	115 kPa	107 kPa	+8 kPa	+7.5 %
Span 6, last sprinkler	102 kPa	105 kPa	-3 kPa	-2.9 %

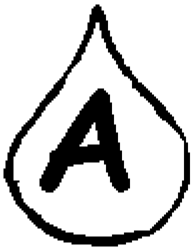
What do the pressure and flow readings tell us?

You have collected a series of figures on your record sheet. Using these figures, you can calculate the variations for the system. Too great a variation indicates that the system is not operating most effectively. Pressure variation may be 'above' or 'below' the desired figure. A negative (minus) figure indicates variation below the specification.

A variation of more than ± 10% is unacceptable and indicates that there may be some problems with your irrigation set up or design.

(Note: if pressure compensators are used in your system, then all the sprinkler pressures should be almost the same.)

If both pressure and flow are above specification, the pump is probably giving a flow rate greater than specified. If pressure is below specification and flow is above specification in many outlets, the outlets are probably bigger than specified, perhaps through wear or being replaced with wrong sized outlets. If pressure is above and flow is lower, there is a blockage somewhere, most likely in the outlets. If pressure and flow are below specification, there is a restriction in the main line before the pivot or the pump is giving a flow rate lower than specified.



The following sheets are provided to complete the activities presented at the workshop and for use on your own centre pivot

EVALUATION SHEETS

Data sheet	Date
Name	
Crop	
Location/block	
Soil texture of Block	
Effective root depth	metres
Rootzone RAW	mm
Irrigator make	
Emitter model	
Number of Spans	
Number of emitters along span	
Total length of spans (Pivot lenght)	metres
Wetted width (end span)	m
Length of overhang	metres
Sprinklers on overhang	sprinklers
End gun present	Yes No
End gun radius	
Pressure Compensated	Yes No
Specified operating pressure at pivot	kPa
Specified flow rate	L/s ML/hr
Irrigation frequency	days
Wind direction and speed during test (Table 1)	
Catch Can Diameter	mm
Time to travel test distance	minutes seconds
Distance travelled	metres

Irrigation System Calculations

Determine the wetted radius of the pivot		
Wetted radius = pivot length + length of overhang + end gun reach		
Pivot length (distance to outside track)	**……………………… metres**	**A**
Length of overhang	**……………………… metres**	**B**
End gun reach	**……………………… metres**	**C**
Wetted radius	**A + B + C**	
	………….. + ………….. + ………….. **= ……………………… metres**	**D**
Determine the area that is wet by the pivot		
Wetted area = Pi x $(\text{wetted radius})^2$ ÷ 10 000 *		
Pi	**3.14**	**Pi**
**** ÷ by 10 000 to convert into hectares***	**= Pi x D^2 ÷ 10 000** **= 3.14 x $\ldots\ldots\ldots\ldots\ldots^2$ ÷ 10 000** **= …………………………… ha**	**WA**

Estimate the speed of the Pivot		
Distance Travelled	**……………………………………. metres**	**E**
Time for distance travelled	**…………………… minutes …………….. seconds**	
Time in seconds	**……………. seconds**	**F**
Travel Speed = Distance travelled ÷ Time (seconds) x 3600		
multiply by 3600 to convert the speed into metres per Hour	**E ÷ F x 3600*** **………….. ÷ ………….. x 3600*** **= ………………………… metres per hour**	**G**
Estimate how large your irrigation circle is		
Circumference (Outside wheel track) = 6.28* x pivot radius		
*** Circumference of a circle** **= 2 x pi x radius of circle** **2 x pi = 6.28**	**6.28 x A** **6.28 x …………………………….** **=……………………………. metres**	**H**
Calculate the time for one revolution (complete circle) of the pivot		
Time for one revolution = Circumference ÷ Travel speed		
	H ÷ G **……………….. ÷ ………………..** **=……………….. hours**	**K**

Field Record Sheet

If you have access to the computer program, you only need to fill in columns A and B of this table. The computer will do the rest.

Property location:		**Date**	
System			

Span #	**Catch can number**	**Volume collected in can (mL)**	**Ranked volume**	**Weighted catch A x B**
	A	**B**		**C**
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			
	21			
	22			
	23			
	24			
	25			
	26			
	27			
	28			
	29			
	30			
	31			
	32			
	33			
	34			
	35			
	36			

Span number	Catch can number	Volume collected in can (mL)	Ranked volume	Weighted catch A x B
	A	B	C	D
	37			
	38			
	39			
	40			
	41			
	42			
	43			
	44			
	45			
	46			
	47			
	48			
	49			
	50			
	51			
	52			
	53			
	54			
	55			
	56			
	57			
	58			
	59			
	60			
	61			
	62			
	63			
	64			
	65			
	66			
	67			
	68			
	69			
Total TN =			**TC =**	

Lowest Quarter Table

Rank C	Catch Can Number A	Cumulative Catch Can Number	Weighted Catch D	Cumulative Weighted Catch
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

LQ limit = TN ÷ 4
= ………. ÷ 4
= …………….

Closest cumulative catch can number ………..

Therefore we take catch can number ………..

with the Low quarter weighted catch of ……….

LQWC = …………..

Calculating the Average Application and Instantaneous Application Rate

Calculate the average amount of water being applied with each pass		
Average Application = Total of weighted catch can ÷ Total sum of catch can Numbers ÷ Conversion factor		
Total Sum of catch can Numbers Add up the numbers in Column A where water was collected in the can. Ignore empty can numbers.	**…………………………**	**TN**
Total of all weighted catches Add up the numbers in column D.	**…………………………**	**TC**
Conversion Factor (Table 2) Our catch cans for this example were 113 mm in diameter	**…………………………**	**CF**
Average Application per pass =	**TC ÷ TN ÷ CF**	
	……… ÷ ……… ÷ ……… **= ……………… mm**	**AA**
Transfer the AA figure to the Application Results Table (earlier).		
Calculate the amount of water being applied each hour		
Wetted diameter	**………………………. metres**	**WD**
Instantaneous Application Rate = Average Application x Travel speed ÷ wetted width		
	AA x G ÷ WD **………. x ………. ÷ ……….** **= ………………… mm/hour**	**IAR**

IAR should be compared to the infiltration rate of your soil. If the IAR at the outer end of centre pivot is much greater than the infiltration rate, runoff will occur. Methods of reducing this problem should be investigated eg. Installing outlets with a larger wetted diameter, increasing soil organic matter, using soil conditioners, etc.

Conversion from Volume into depth

Table 2 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

In order to convert Volume into depth (millimetres) we need to use a conversion factor. The conversion factors are listed in Table 2. You select your conversion factor by measuring the diameter of the mouth of your catch can

For instance, if the diameter of your catch can is 110 mm then our conversion factor from Table 2 will be 9.5 (circled).

If our cans collected 674 mL, then the conversion is our volume divided by the conversion factor;

674 mL ÷ 9.5 = 71 mm

Therefore, the depth of water applied during the example test was 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

Calculating the Distribution Uniformity

Step 1 Determine the lowest quarter limit (LQ limit)

Step 2 Use the Lowest Quarter Catch table to add up the figures in column C of your Field record sheet, starting at the lowest volume rank (1st).

Step 3 Continue to add the weighted catch until the total exceeds the figure for LQ limit. Subtract the last figure, so the total is less than LQ limit.

Step 4 The figures you have added are your LQ catches- shade or highlight them on your_Field record sheet

Step 5 Follow the steps in the Distribution Uniformity Table

Step 6 Record your results in the Application Results Table

Distribution Uniformity

Calculate the number of Lowest Quarter of catch cans (LQ Limit)		
Lowest quarter Limit	= **TN ÷ 4**	
	= **………... ÷ 4** = **…………………………**	**LQ Limit**
Add up the Depth of water caught in the Lowest Quarter Cans (LQ Depth)		
Lowest quarter Depth = Total Lowest quarter weighted volumes ÷ Total lowest quarter can positions ÷ conversion factor		
From the LQ Table, find the Cumulative (or Total) Catch Can Position Number closest to LQ Limit.	**………………………………**	**TNLQ**
From the LQ Table, find Cumulative (or Total) Weighted Catch for TNLQ	**………………………………**	**LQWC**
Lowest quarter depth	= **LQWC ÷ TNLQ ÷ CF**	
	………… ÷ ………… ÷ ………… = **…………………. mm**	**LQ depth**
Calculate the Distribution Uniformity of the Pivot		
Distribution Uniformity = LQ Depth ÷ AA		
	………………… ÷ …………………… = **…………………………..**	**DU**
Convert into a percentage by multiplying by 100	**DU x 100**	
	= **………………. x 100** = **…………………%**	
Transfer the DU figure to the Application Results Table		

Application results

<table>
<tr><th colspan="3">Calculate the expected application per pass of the pivot</th></tr>
<tr><td>Specified Flow Rate</td><td></td><td>ML/h</td></tr>
<tr><td>Hour per revolution</td><td>K</td><td>Hours</td></tr>
<tr><td>Wetted Area</td><td>WA</td><td>Ha</td></tr>
<tr><td colspan="3">Nominal Average Application per pass: = Specified flow rate (ML/hr) x Hours per revolution ÷ Wetted Area (ha) x 100

= ……………… x ………… ÷ …………… x 100

= ………………………… mm</td></tr>
<tr><th colspan="3">Compare the expected application per pass to the Measured application per pass</th></tr>
<tr><td>Measured Average Application per pass:
From computer program OR your own calculations using procedure at end of these notes.</td><td>AA</td><td>…………….. mm</td></tr>
<tr><td colspan="3">If the Measured Average Application per pass is greatly different from the Nominal Average Application per pass, something is significantly wrong.</td></tr>
<tr><td colspan="3">The measured application per pass should be compared to the rootzone RAW on the data sheet. For the example, the application depth is one quarter of the RAW.</td></tr>
<tr><th colspan="3">Estimate the distribution Uniformity of the pivot</th></tr>
<tr><td>Lower quarter output per pass

From computer program OR your own calculations using procedure in these notes.</td><td>LQ Depth</td><td>……………… mm</td></tr>
<tr><td>Distribution uniformity

From computer program OR your own calculations using procedure in these notes.</td><td>DU</td><td>……………… %</td></tr>
</table>

Distribution uniformity above 75% is quite acceptable for field crops. If the DU is too low, this means that at least 25% of the area being irrigated is receiving less water than the rest.

How long to irrigate

Using the AAR value and the RAW value for the crop on this soil, you may estimate how long you need to irrigate to ensure adequate wetting from this sprinkler. To estimate how long to irrigate to fill the RAW you need to compare the Average application per pass with the RAW. You will also need to take into account the DU.

Calculate the best amount of water to apply each pass of the pivot		
Average application per pass	**………………………………. mm**	**AA**
DU calculated	**……………………………. %**	**DU**
Ideal application per pass to compensate for the DU	**AA ÷ DU** **……………… ÷ ……………….** **= ……………………………………… mm**	**N**
Calculate how much of the Rootzone RAW is applied with each pass		
RAW for this crop from Centre pivot data sheet.	**…………………………. mm**	**RAW**
Percentage of RAW applied per pass	**= AA ÷ RAW x 100** **= …………… ÷ …………… x 100** **= …………… %**	**P**
Calculate pivot speed required to apply the full rootzone RAW		
Travel speed required to apply = Percentage RAW x Travel Speed x DU% **the full RAW on each pass**		
	P x G x DU **…………….. x …………….. x ……………..** **= …………….. m/hr**	**R**
Calculate time of one revolution to applying the rootzone RAW		
Time for one revolution at this speed = Circumference ÷ Travel speed		
	H ÷ R = …………….. ÷ …………….. = …………….. hours or ………….days	

Flow Record Sheet

	Nozzle type	Time for 10L Seconds	Flow measured L/s	Flow as per system design L/s	Flow difference C - D	Flow variation E ÷ D x 100
	A	**B**	**C**	**D**	**E**	**F**
Span 1, last sprinkler						
Span 2, last sprinkler						
Span 3, last sprinkler						
Span 4, last sprinkler						
Span 5, last sprinkler						
Span 6, last sprinkler						

Pressure Record Sheet

	Pressure measured	Pressure as per system design	Pressure difference A - B	Pressure Variation C ÷ B x 100
	A	B	C	D
At Pivot centre				
Span 1, last sprinkler				
Span 2, last sprinkler				
Span 3, last sprinkler				
Span 4, last sprinkler				
Span 5, last sprinkler				
Span 6, last sprinkler				

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 for the system. Too great a variation indicates that the system is not operating most effectively. Pressure variation may be 'above' or 'below' the desired figure. A negative (minus) figure indicates variation below the specification. A variation of more than ± 10% is unacceptable and indicates that there may be some problems with your irrigation set up or design.

If both pressure and flow are above specification, the pump is probably giving a flow rate greater than specified. If pressure is below specification and flow is above specification in many outlets, the outlets are probably bigger than specified, perhaps through wear or being replaced with wrong sized outlets. If pressure is above and flow is lower, there is a blockage somewhere, most likely in the outlets. If pressure and flow are below specification, there is a restriction in the main line before the pivot or the pump is giving a flow rate lower than specified.