Irrigation System Evaluation

Why and How

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http://msue.anr.msu.edu/resources/irrigation

https://engineering.purdue.edu/ABE/Engagement/Irrigation

Irrigation System Evaluation - Goal is to answer these questions

- How much water am I really applying
- How uniform is the application
- Am I applying water at a rate that the soil can take it in

Irrigation System Uniformity

An 1” application should be 1” everywhere in the irrigated field

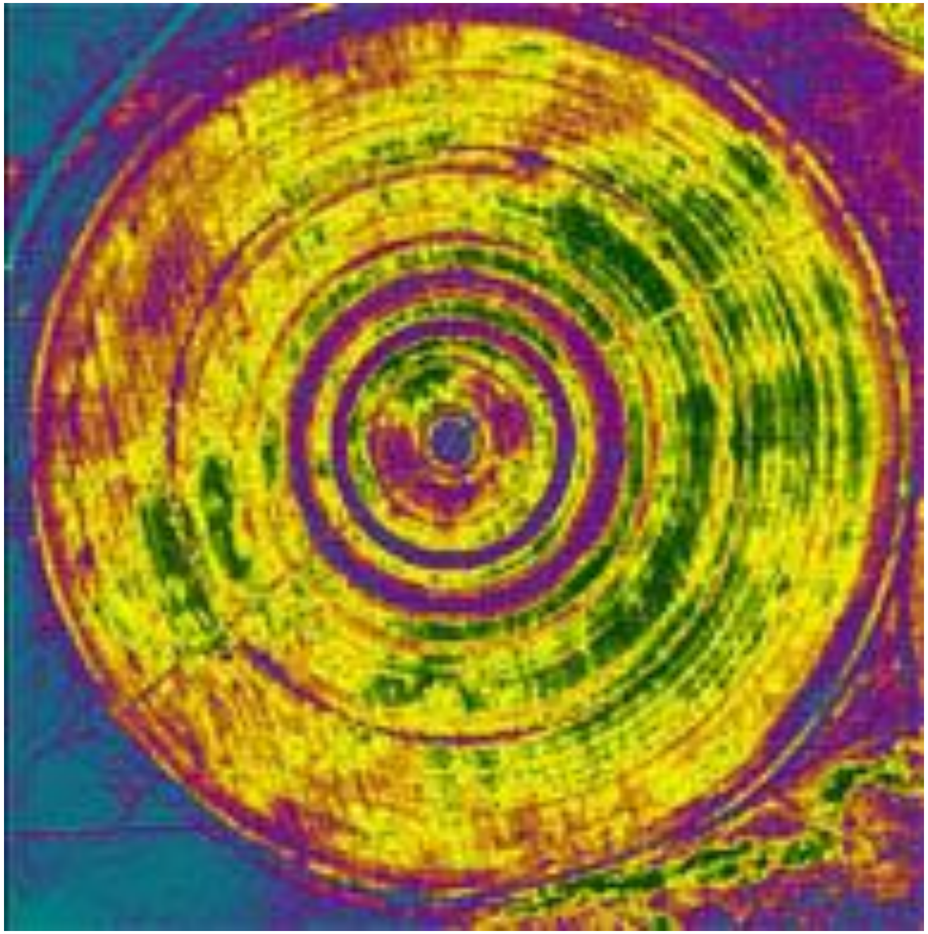
- 10% or less deviation from the average is ideal.
- Over applied area will likely be over applied each application
- Under applied areas will likely be under applied each application

A 30% deviation on a field in an 8” irrigation application year will have areas receiving as little as 5.6” and as great as 10.4”

Repair all visible system leaks and problems first.

Low Uniformity
= Under Application in areas
= Reduced Yields

Even with adequate scheduling a 30% deviation is application uniformity can result in a 40% yield reduction in low application areas of the field.



Water savings
= Energy Savings
= Reduced Expenses
= Increase Profitability

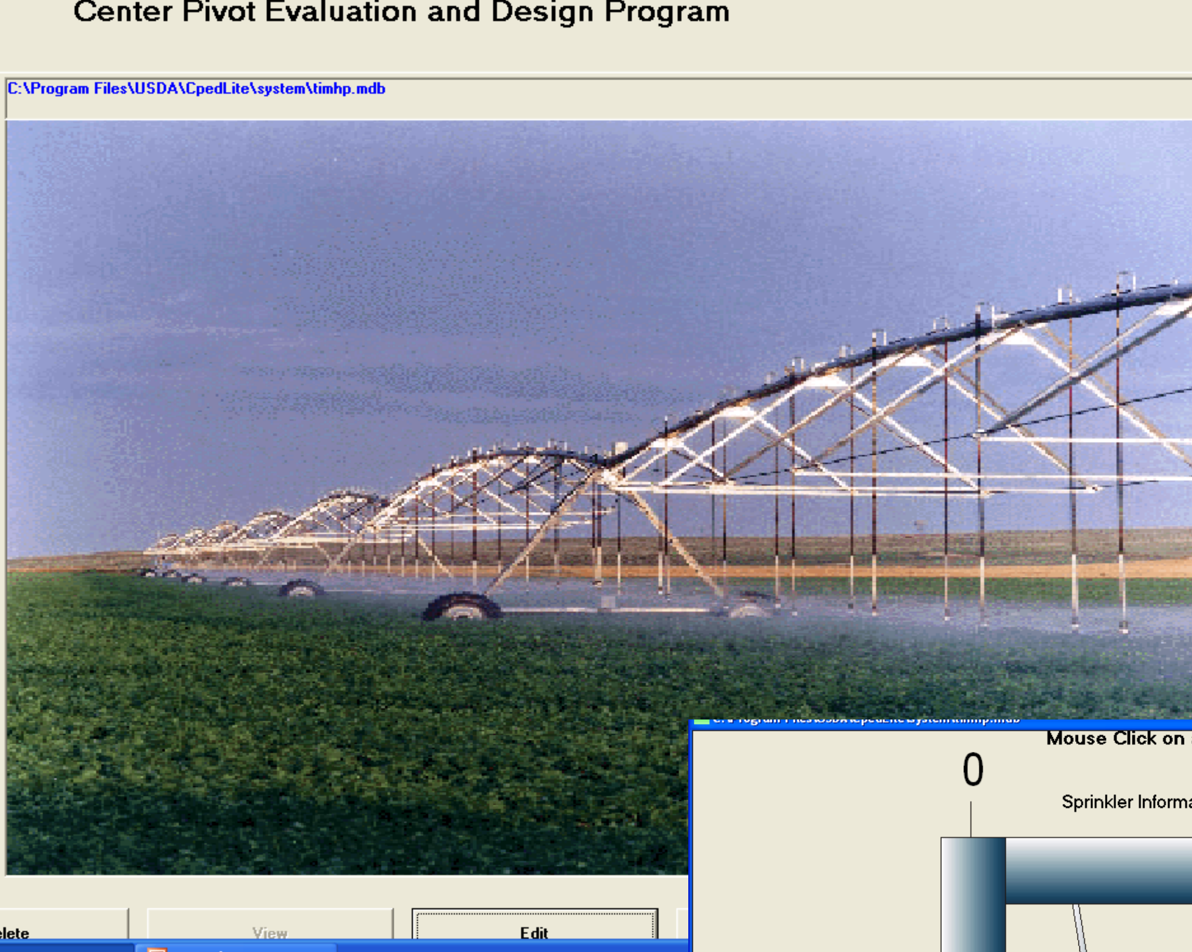
A 30% deviation on a field in an 8” irrigation application year will have areas receiving as little as 5.6” and as great as 10.4”

- To over apply by 30% to make up for lack of uniformity will take an additional 2.4”of water.
- With average energy cost nearing $3.00/ acre”
- A typical 140 acre irrigated field with a 30% deviation will cost over $1000/ year more than uniform system to irrigate.

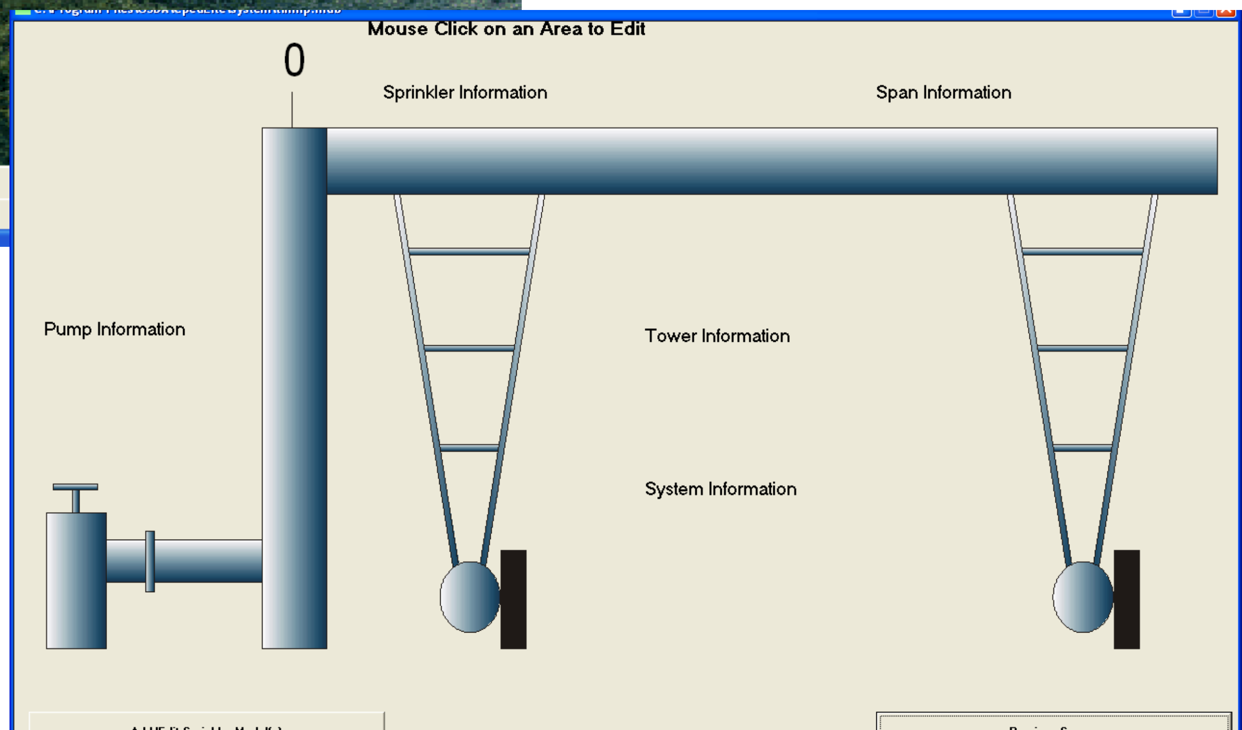
Stick with the Plan!!!!

Make sure the system is within it’s design.

- Has the system changed in length or coverage area?
- **Is the water supply flow and pressure what was designed for?**
- Sprinkler height?
- End drive changes?
- Tire changes?



CEPD
Center Pivot Evaluation & Design



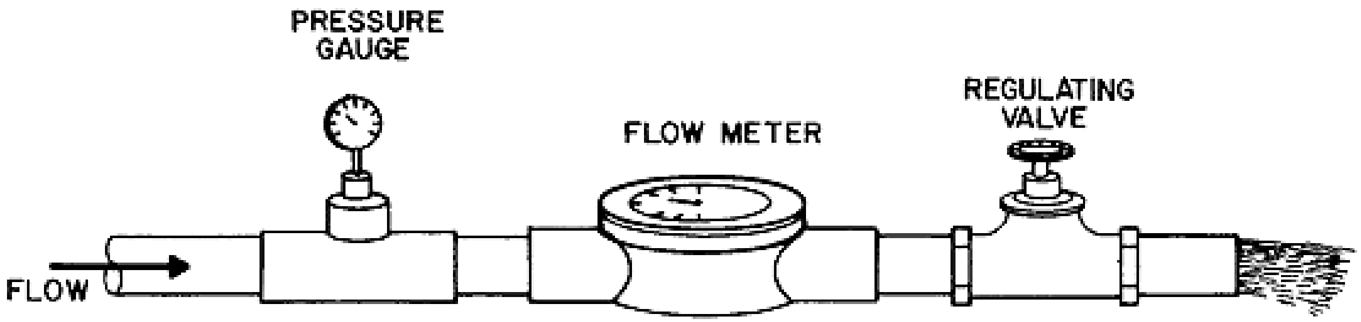
Reported as % C.U. (Christiansen Coefficient of Uniformity)

Measure Pressure:

- at pivot point and last sprinkler
- If pressure differ from chart specification > 10%, measure flow

Modern Farm Wife, World Press

Measure flow at desired pressure prior to ordering sprinkler package



Poor performance:

Ask dealer to measure flow at peak water use season and compare to design parameters.

Irrigation System Uniformity

- Over 20 Irrigation uniformity trainings since May 2005
- Private consultants, Farmers, Extension, SCD, and NRCS personal

Evaluating Irrigation System Uniformity

Standards and Methods for Evaluation of Irrigation System Uniformity

- Two commonly accepted standards or methods are available as guidelines for performing evaluations of Irrigation System Uniformity.
- ASAE Standards (436.1) — Available at: http://msue.anr.msu.edu/uploads/236/43605/ASAE_S436.1.pdf
- NRCS Handbook — Available at your local Natural Resource Conservation Service office

Irrigation System Uniformity

Basic system evaluation

Collect enough uniform container to place every 10 feet the length of the system or across the application pattern.

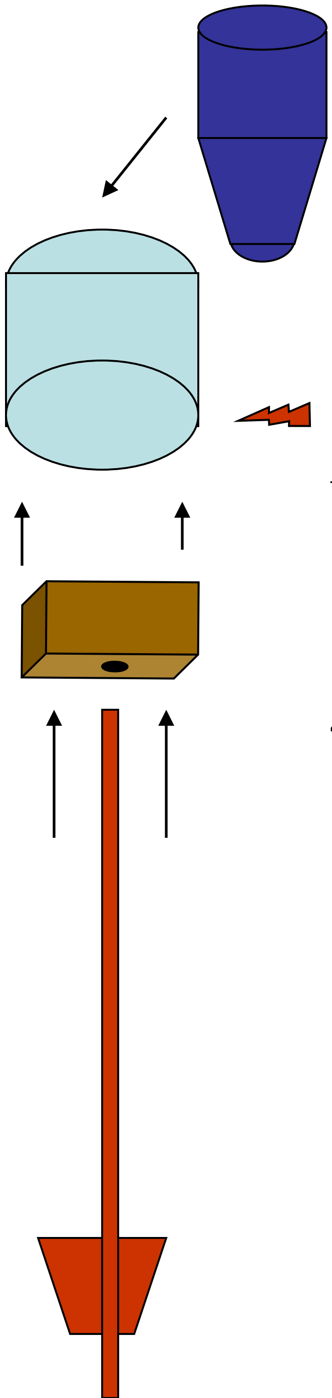
Spread the container every ten feet from the center point to the outside edge of the application area.

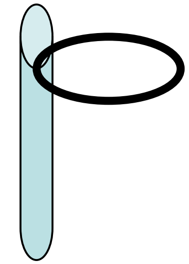
Run the system at standard setting over the container.

Measure and record the water volume caught by each container.

Note sample point varying greater than 50% of the average.

Evaluating Irrigation Uniformity Catch can stands





A simple, inexpensive catch can stand can be built using:

1. 32 oz. Deposable soda cup (Taco Bell cup)
2. 3” plastic drain pipe cut to 5” in length
3. 2”x3” stud cut to length to wedge into plastic drain pipe
4. Drill hole 1.5” into cut 2”x3” stud chucks, drill hole should snuggly fit electric fence post
5. Steel (step in) electric fence post

Electric fence post and cups can be stored and transported in separate stacks. The 2”x3” stud chucks wedge into the base of the cut plastic drain pipe sections and make the transition between the cup and post. Screw maybe pace through the side of the plastic drain pipe into the 2”x3” stud chucks.
Total cost per unit is less than a dollar and require only a saw, drill and screw driver. It will allow data collection

Evaluating Irrigation System Uniformity

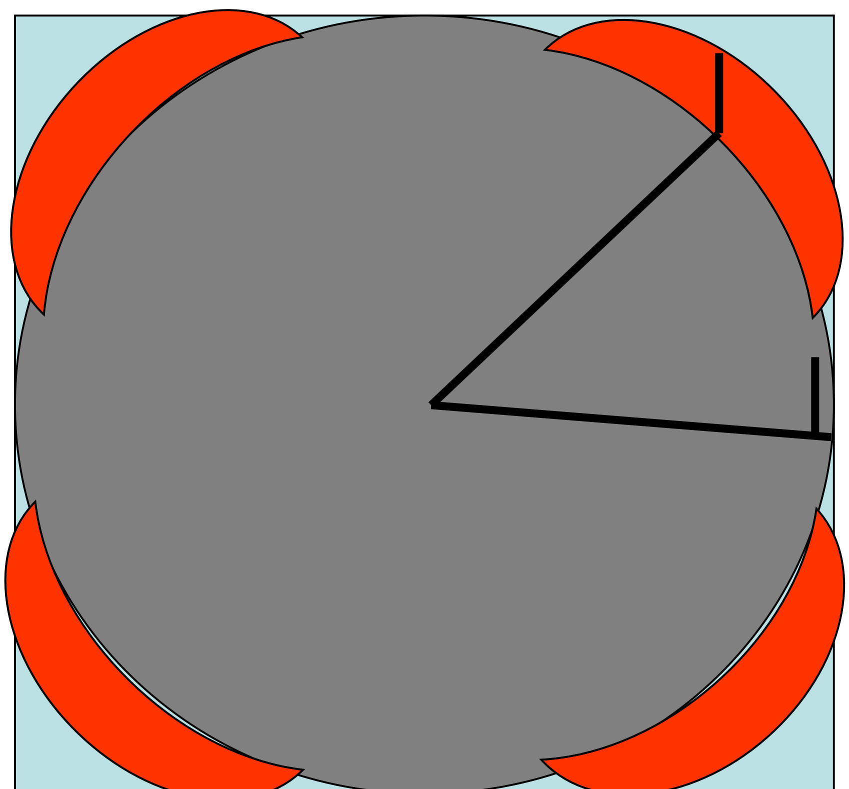
Pivot Extensions (cornering arm or Z-arm)

- Some center pivot irrigation systems are designed to expand the wetted area to allow coverage of corner or odd-shaped fields, often referred to as cornering arms or Z-arm.
- These systems require two separate evaluations if the extension accounts for 30 percent or more of the irrigated portion of the field.

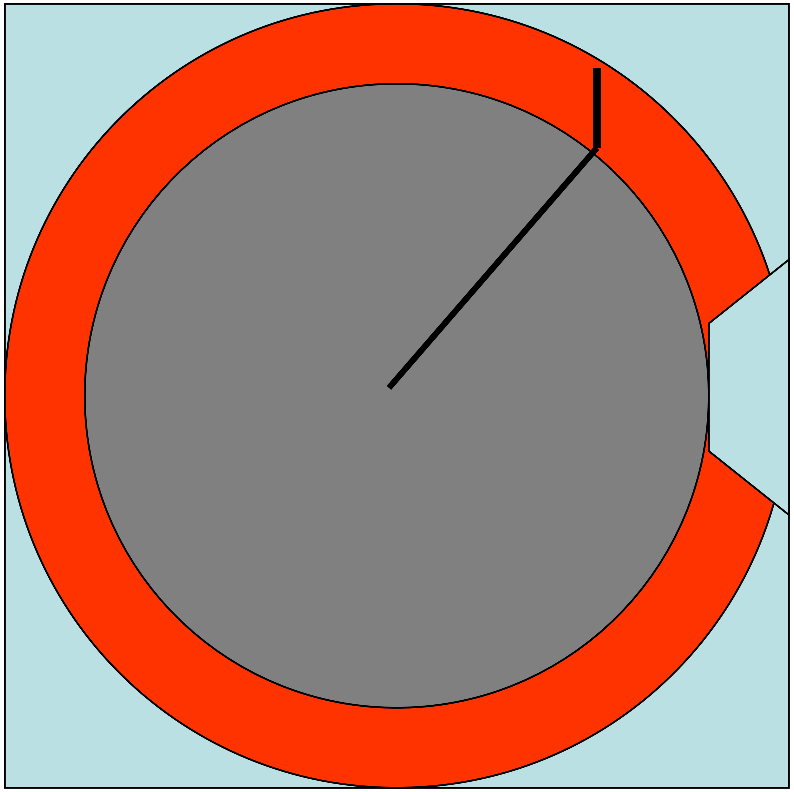
•One evaluation will evaluate the system while extended, and a second when the arm is not deployed.

Pivot Extensions (cornering arm or Z-arm)

60 % out, 40 in
Two tests needed



90 % out, 10 in
One test needed



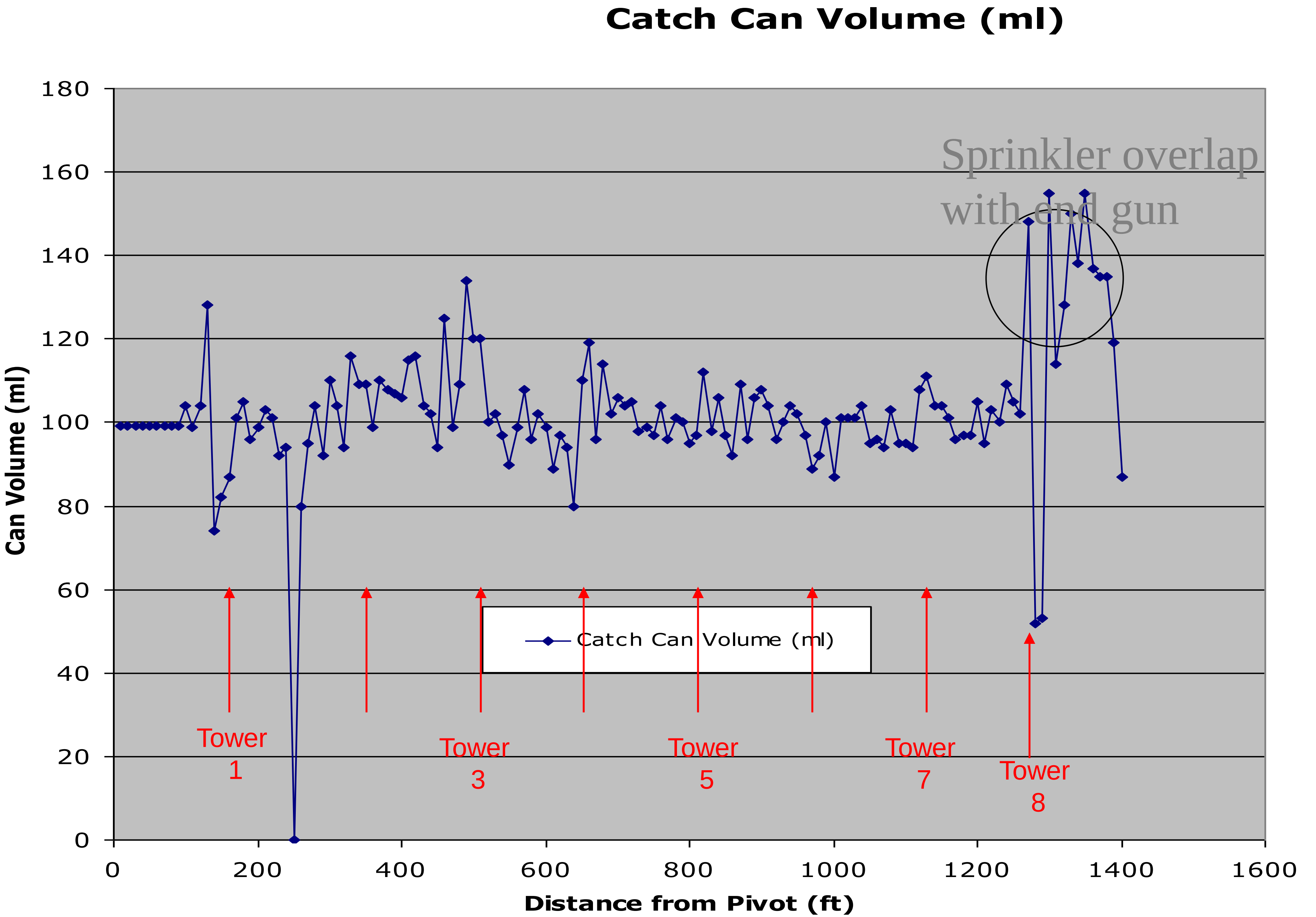
Uniformity and coverage area is often a trade off.

Uniformity and coverage area is often a trade off.

Labor…

Uniformity and coverage area is often a trade off.

Alternate years.



http://web1.msue.msu.edu/stjoseph/anr/anr.htm

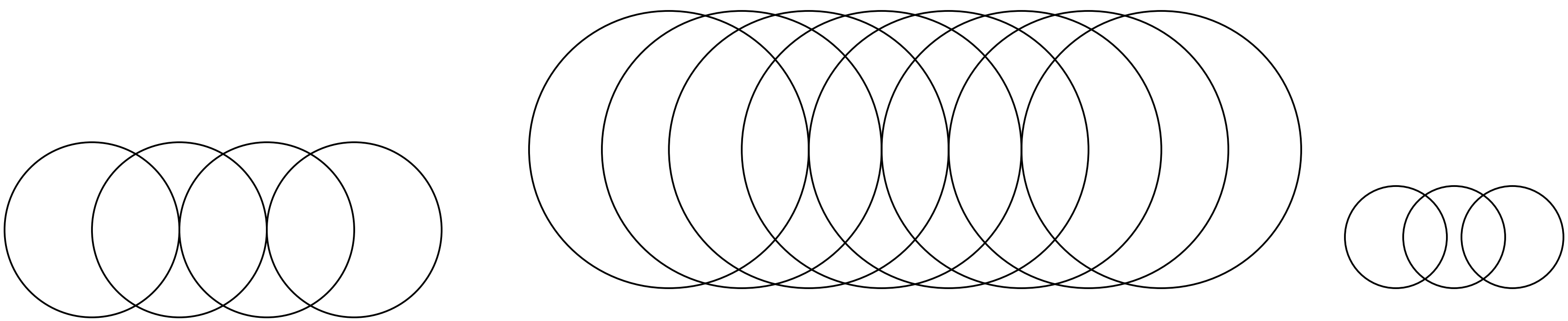
Irrigation System Uniformity

•Most system are designed to have 90% or better uniformity

•Changes in **volume** and **pressure** from design parameters will cause reduction in uniformity

•Some sprinklers can perform well over a large change in pressure over others

•Multiple overlaps tends to reduce potential problems



Pressure regulators

WISHNE-SAMPLE

WISH NEBRASKA INC

JANUARY 20, 2010	WISHNE-SAMPLE
CUSTOMER :	LOCKWOOD 2000 7 TOWER - 1317.98 FT SYSTEM 800 GPM @ 40 PSI AT TOP OF PIVOT
FIELD :	NELSON R3000 ROTATORS
LEGAL :	NELSON 20 PSI REGULATORS
P.O. NO. :	NELSON SR-100 .75 TB
CROP :	ELEVATION 5 FT UP, 5 FT DOWN

Pressure regulators

HOW MUCH ELEVATION CHANGE IS ACCEPTABLE?

LESS THAN 10% FLOW VARIATION IS A GOOD RULE OF THUMB.

Table I. Operating pressures and corresponding elevation differences which will cause a 10 percent variation in sprinkler flow rate.

Operating Pressure (Psi)	15	25	35	45	55	65	75	85
Elevation Difference (Feet)	7	11	15	20	24	29	33	37

Lower design pressure allows less elevation change before pressure regulators are recommended.

A 1% slope in \under a 1320' machine is 13'
A 2% slope in \under a 1320' machine is 26'

http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=742

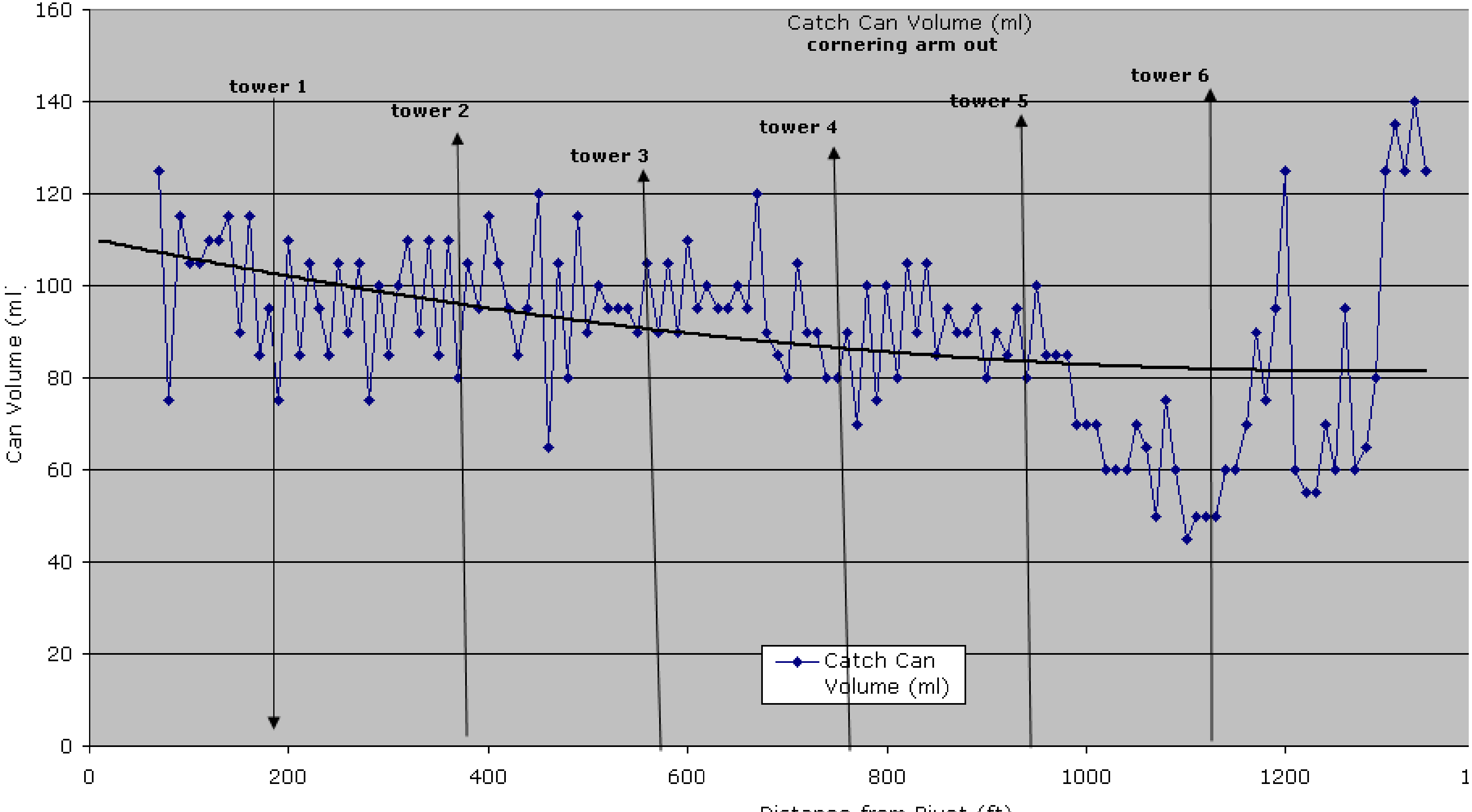
Greatest improvement needed

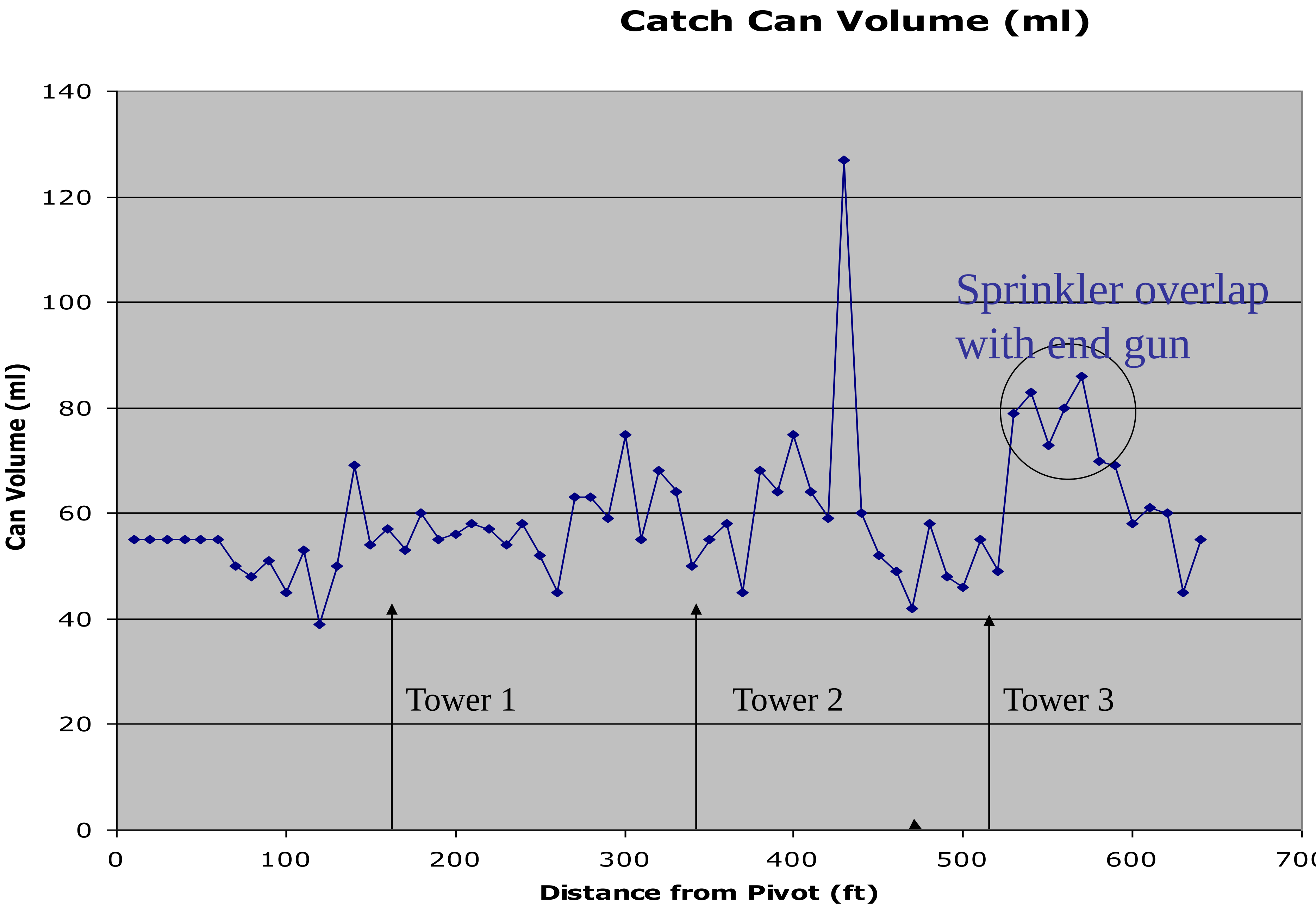
- End gun stop adjustment
- Water supply over or under design
- End gun orifice, too little or too much
- Wrong sprinkler or tip
- Leaks, plugs and **no turn sprinklers**

Water supply over or under design

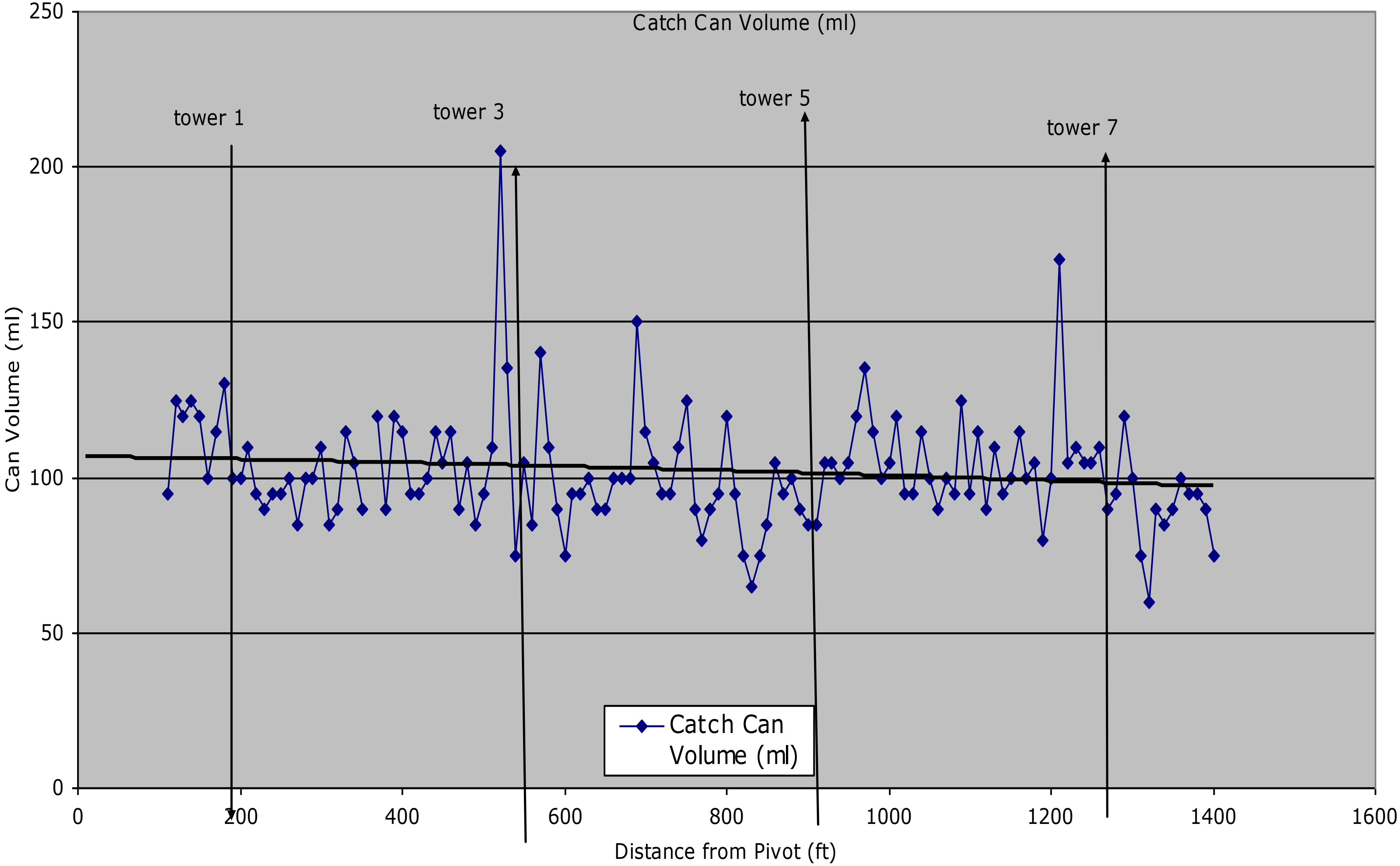
supply over design yield tail up, supply under design yield tail down

Example of Water supply under volume for sprinkler design

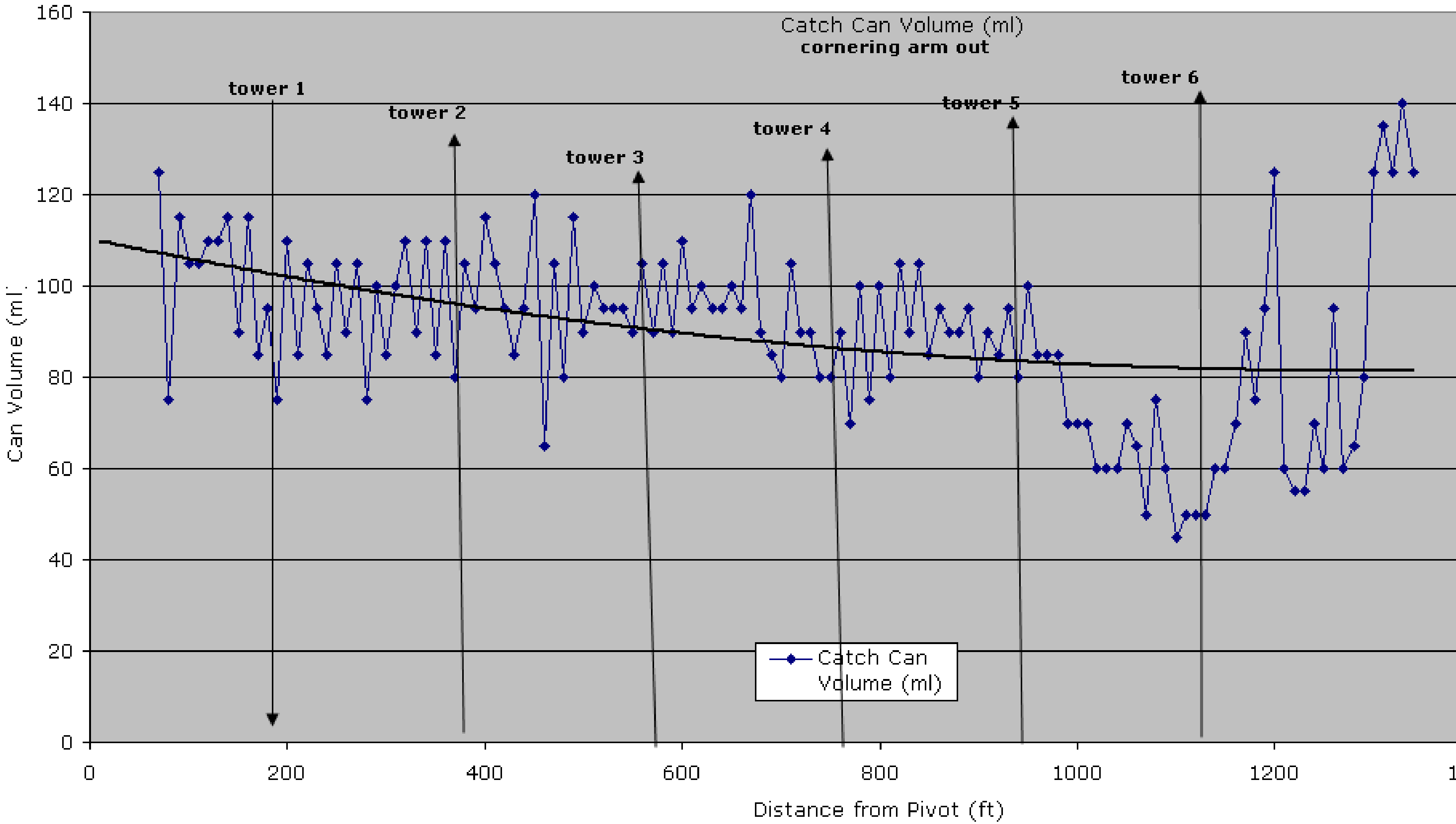




Catch Can Volume (ml)
Can Volume (ml)
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
Distance from Pivot (ft)
Sprinkler overlap with end gun
Tower 1
Tower 2
Tower 3



Catch Can Volume (ml)
tower 1
tower 3
tower 5
tower 7
Catch Can Volume (ml)
Can Volume (ml)
Distance from Pivot (ft)
0
50
100
150
200
250
0
200
400
600
800
1000
1200
1400
1600



Catch Can Volume (ml)
cornering arm out
tower 1
tower 2
tower 3
tower 4
tower 5
tower 6
Catch Can Volume (ml)
Can Volume (ml)
Distance from Pivot (ft)
0
20
40
60
80
100
120
140
160
0
200
400
600
800
1000
1200

Creating a Take-home Message for the Producer

The System Uniformity Coefficient provides the producer with a report of the overall performance of the system. Almost all systems will benefit from some corrections.

Correction of areas of the system with greater than 20 percent deviation from average (red in the spreadsheet) will improve performance.

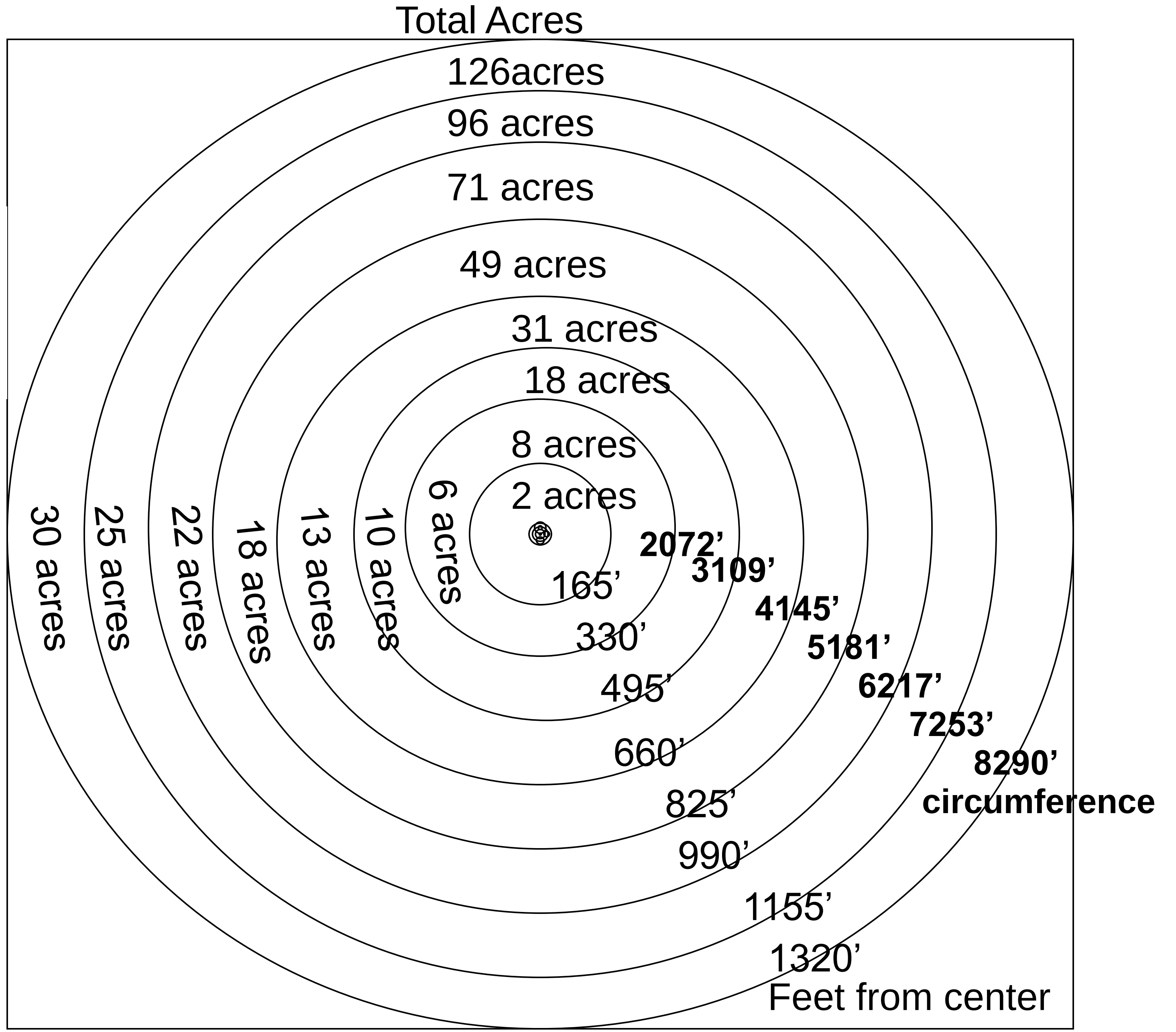
Entering a second data set, replacing the red (high deviation) data with the “average catch can (ml)” data, will create a before/after scenario that will identify the benefits of repairs or corrections to the system.

Graph of performance

The Excel spreadsheet can produce a line graph of systems uniformity. The data will not be weighted for coverage area represented by each cup.

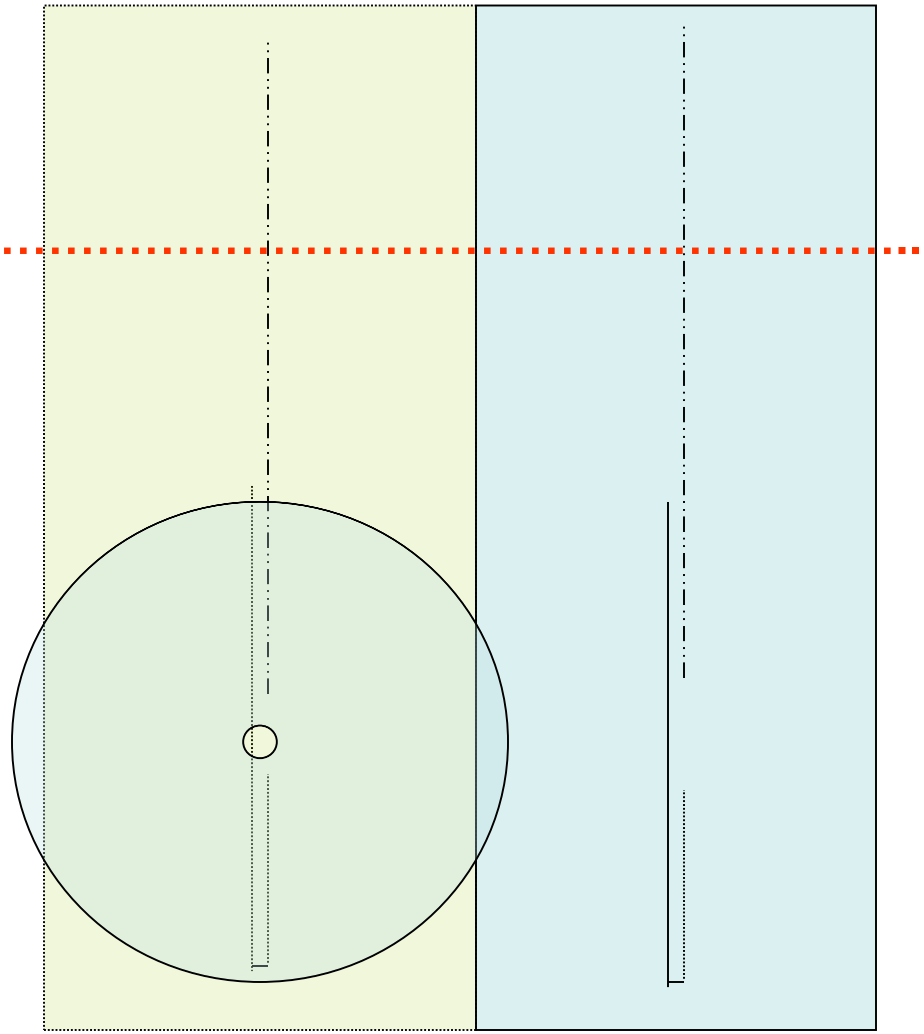
Entering pivot wheel tracks into the graph using Microsoft standard AutoShape will make the graph more usable to irrigators.

Over and under application issue affect the majority of the application area



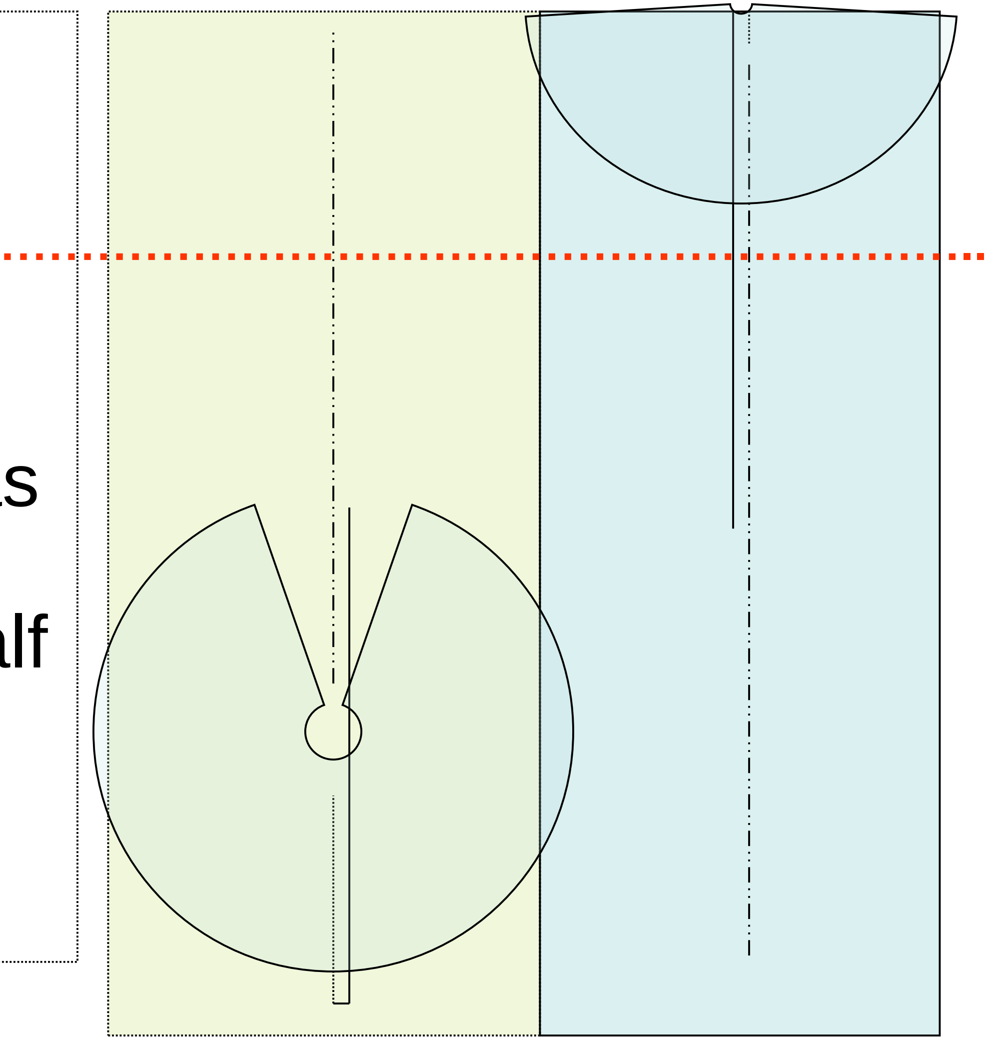
Improving Traveler Uniformity

- Check traveler uniformity by placing catch can every 10’ across the width of the coverage pattern
- Traveler lane spacing should be adjusted to create an even application between lanes.
- Spacing will be narrower further from pump or additional pressure will need to be provided

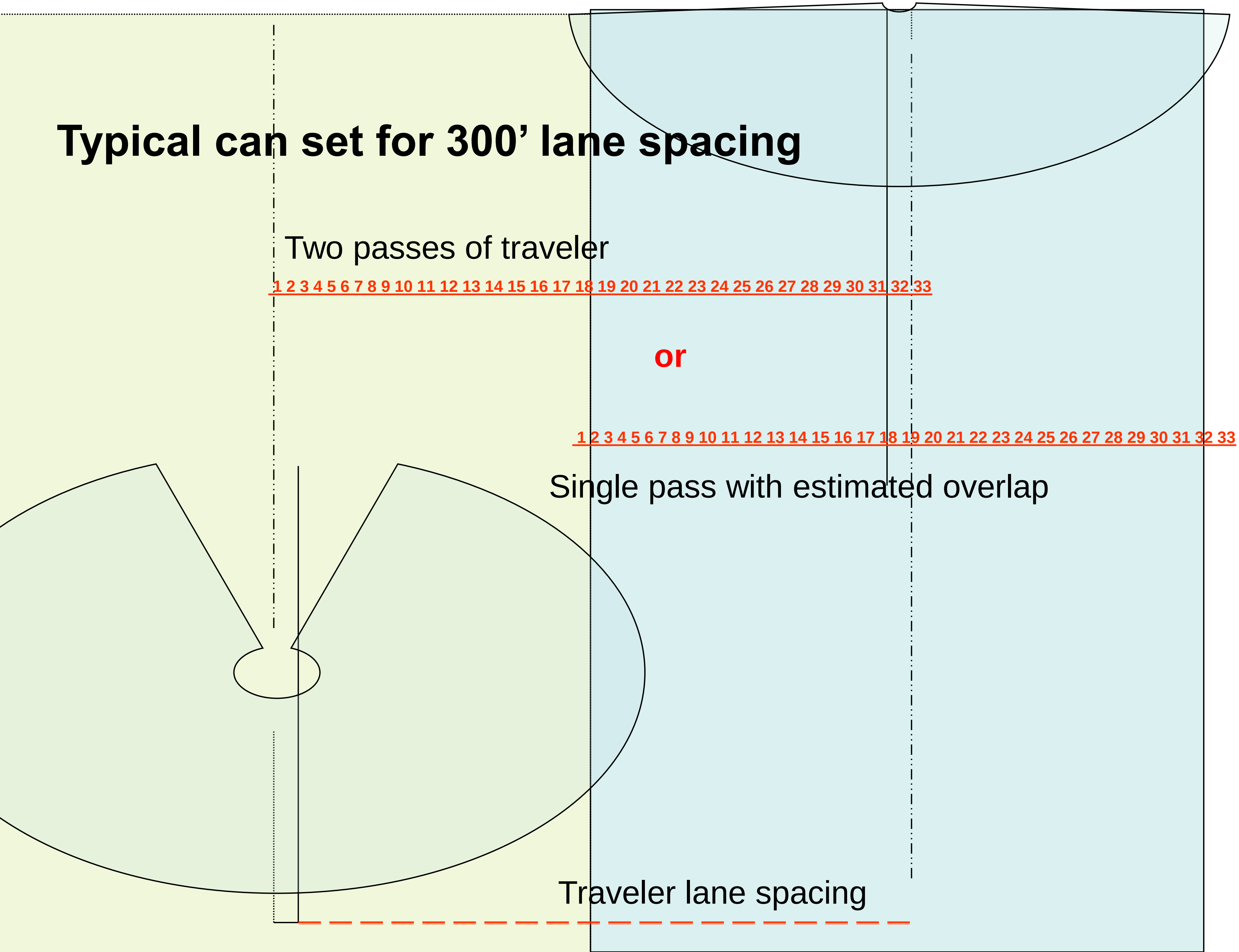


Improving traveler uniformity

- Measure traveler forward speed at the beginning middle and end of the run.
- Traveler forward travel speed maybe reduce as more hose is being pulled in the second half of the run.
- Adjust speed accordingly.



Typical can set for 300’ lane spacing



Trickle, Solid set and Manual Move System Uniformity

- Stick with the Plan!!!!

Make sure the system is with in it's design.

- Has the system changed in length or coverage area.
- Is the water supply flow and pressure what was designed for.
- Sprinkler height?

http://msue.anr.msu.edu/uploads/files/Microsoft%20Word%20-%20FactSheetTemplate%20Water%20Application.pdf

Solid set and manual move system uniformity

Sources of system uniformity evaluation.

Wisconsin State Cranberry Growers Association
FOUNDED 1887

U.S. Department of Agriculture
NRCS Natural Resources Conservation Service

DETAILED CRANBERRY IRRIGATION SYSTEM ASSESSMENT

Wisconsin State Cranberry Growers Association
132 East Grand Avenue, Suite 202; PO Box 365
Wisconsin Rapids, WI 54495-0365
(715) 423-2070
www.wiscran.org

Wisconsin NRCS
8030 Excelsior Drive
Madison, WI 53717
(608) 662-4422
www.wi.nrcs.usda.gov

Detailed Evaluation Procedures for Cranberry Irrigation Systems:

The overall efficiency of sprinkler irrigation systems changes with time. Nozzles, sprinkler heads, and pumps wear, and pipes and joints develop leaks. Some systems

II. Field procedures

General

Obtain pertinent information about irrigation system specifications from the irrigation decisionmaker and from visual observation. Observe general system operating condition, crop uniformity, wet areas, dry areas, and wind

UF UNIVERSITY *of* FLORIDA IFAS

Bulletin 266

Field Evaluations of Irrigation Systems: Solid Set or Portable Sprinkler Systems[1]

A.G. Smajstrla, B.J. Boman, G.A. Clark, D.Z. Haman, D.J. Pitts and F.S. Zazueta[2]

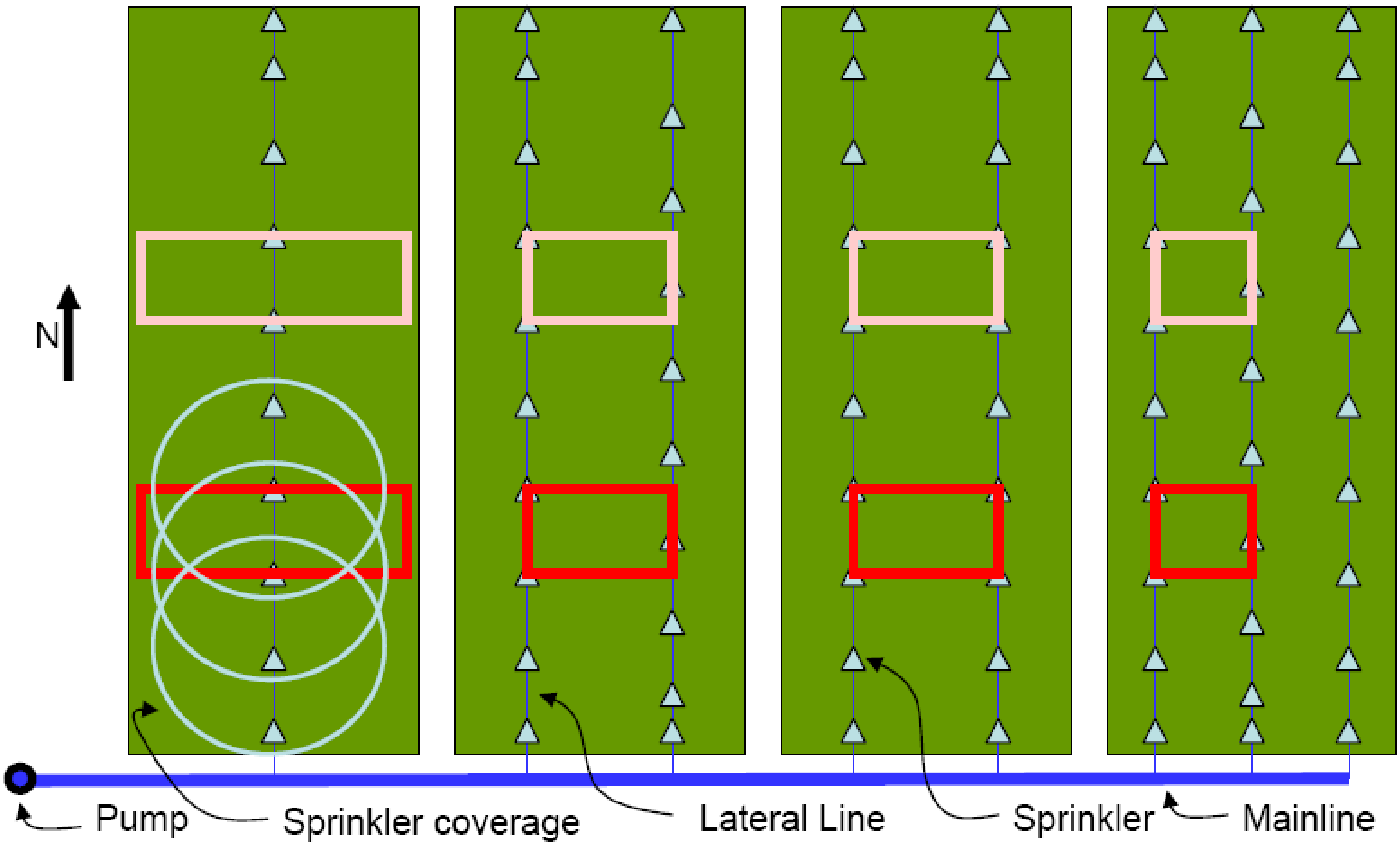
Introduction

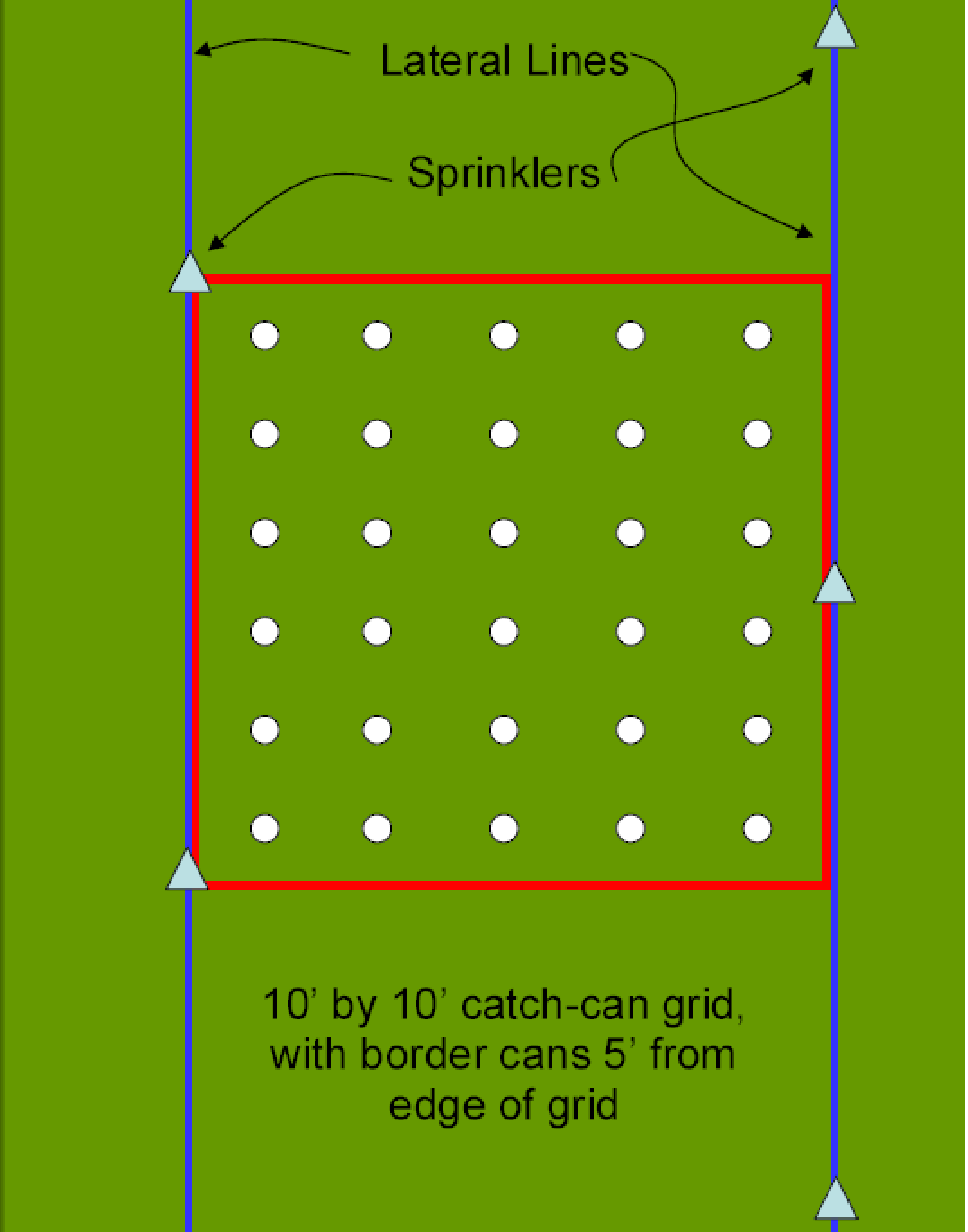
This bulletin describes techniques for measuring operating pressures, water application rates and uniformity during field evaluations of solid set or portable sprinkler irrigation systems. These irrigation

manifold pipes, are placed in a regular pattern over the entire irrigated area. All of the sprinklers may be operated at once, or the crop may be irrigated in zones by operating only a portion of the sprinkler laterals at a time.

Adapted from: NRCS National Engineering Handbook, Part 652 – Irrigation Guide, Chapter 9, September 1997

Figure 1





Adapted from: NRCS National Engineering Handbook, Part 652 – Irrigation Guide, Chapter 9, September 1997

Most system apply within 85% of the expected application

MSU Extension Irrigation System Evaluation Tool, 1-23-07

Farm Name [redacted] Farm

System Uniformity Coefficient = 79

System Identification: Cornering Arm System on [redacted] Farm-Behind House
Cornering Arm Extended

Good System uniformity coefficient are 85 or greater

Deviation from desired application = -0.04

Application is 4 % under expectation

System Settings

Application rate (in)	0.5	Wind speed (mph)	4 mph
Percent timer Setting (%)	19	Wind Condition (variable or steady)	steady
Operating Pressue (psi)			

Rate of application calculator

Time from start to end of application at highest rate section of system (min.)	22	Inches/Hour	1.25
Rate of application for the highest rate section of system (minute /one inch)	48.00		

		Average Application (cm)	1.164
Length of evaluation area (ft)	1340	Average Application (in)	0.46
Catch Can Spacing Distance (ft)	10		
		Average catch, collected only (ml)	88.95
number of cans data collected from	129	*70% average catch can (ml)*	*59.94*
number of cans set	134	Evaluation area, full circle (acres)	122.82
		catch can openning area (sq cm)	76.977
Diameter of catch can (cm)	9.9	catch can openning area (sq in)	11.767

Page 1

catch can number	Distance from center point	catch volume in ml	Data adjustment	Comments	Water volume (cm)	Water volume (in)	% applied of average	Deviation from average (%)	Area covered per catch can (acres)	Area covered per catch can (% of total)	Weighted Deviation
1	10		88.95		1.156	0.455	99.26%	-0.74%	0.01623	0.01%	0.0001
2	20		88.95		1.156	0.455	99.26%	-0.74%	0.02885	0.02%	0.0002
3	30		88.95		1.156	0.455	99.26%	-0.74%	0.04327	0.04%	0.0003
4	40		88.95		1.156	0.455	99.26%	-0.74%	0.05770	0.05%	0.0005
5	50		88.95		1.156	0.455	99.26%	-0.74%	0.07212	0.06%	0.0006
6	60		88.95		1.156	0.455	99.26%	-0.74%	0.08655	0.07%	0.0007
7	70	125	0.00		1.624	0.639	139.48%	39.48%	0.10097	0.08%	0.0011
8	80	75	0.00		0.974	0.384	83.69%	-16.31%	0.11539	0.09%	0.0008
9	90	115	0.00		1.494	0.588	128.32%	28.32%	0.12982	0.11%	0.0014
10	100	105	0.00		1.364	0.537	117.16%	17.16%	0.14424	0.12%	0.0014

Data Entry / Uniformity Graph

MICHIGAN STATE UNIVERSITY EXTENSION

PURDUE UNIVERSITY

Center Pivot Percent Timer , Water Applied Estimator Chart

MSU Extension, St. Joseph County **V 1.0**

7/24/2007

	% Timer Setting	Hours to Run Circle	Water Applied
Measured	40	72	1.25
Estimated	5	576.00	10.00
	10	288.00	5.00
	15	192.00	3.33
	20	144.00	2.50
	25	115.20	2.00
	30	96.00	1.67
	35	82.29	1.43
	40	72.00	1.25
	45	64.00	1.11
	50	57.60	1.00
	55	52.36	0.91
	60	48.00	0.83
	65	44.31	0.77
	70	41.14	0.71
	75	38.40	0.67
	80	36.00	0.63

Preventing Irrigation Runoff

(comparing irrigation application rate to soil infiltration rate)

Preventing Irrigation Runoff

(comparing irrigation application rate to soil infiltration rate)

Sprinkler package or nozzle selection along with pressure dictates water application rate .

Factors that **increase** runoff :

- Small Wetted area or throw of sprinkler
- Low Pressure
- Larger applications volumes
- Soil compaction
- Heavy soils
- Slope
- Row hilling

Instructions for completing the *Evaluating Potential Irrigation Runoff* form:

1. Identify the areas of the irrigated field that has the lowest infiltration rates. (heavy soils, slopes, surface compaction).

2. Select a transit line in the wetted area just behind the machine that covers the identified lowest infiltration rates of the field identified above.

Instructions for completing the *Evaluating Potential Irrigation Runoff* form – continued

3. Pace or measure 50 feet between observations starting at the pivot point and progressing to the furthest reaches of the machine.

4. Record observations for each location; look at several (4-5 areas) representing the row contour and differences in row traffic of the location. Record any specific concerns that may affect the application (drips or leaks) or affect the soils ability to take in water (compaction, row contours)

Key for *Observation* column

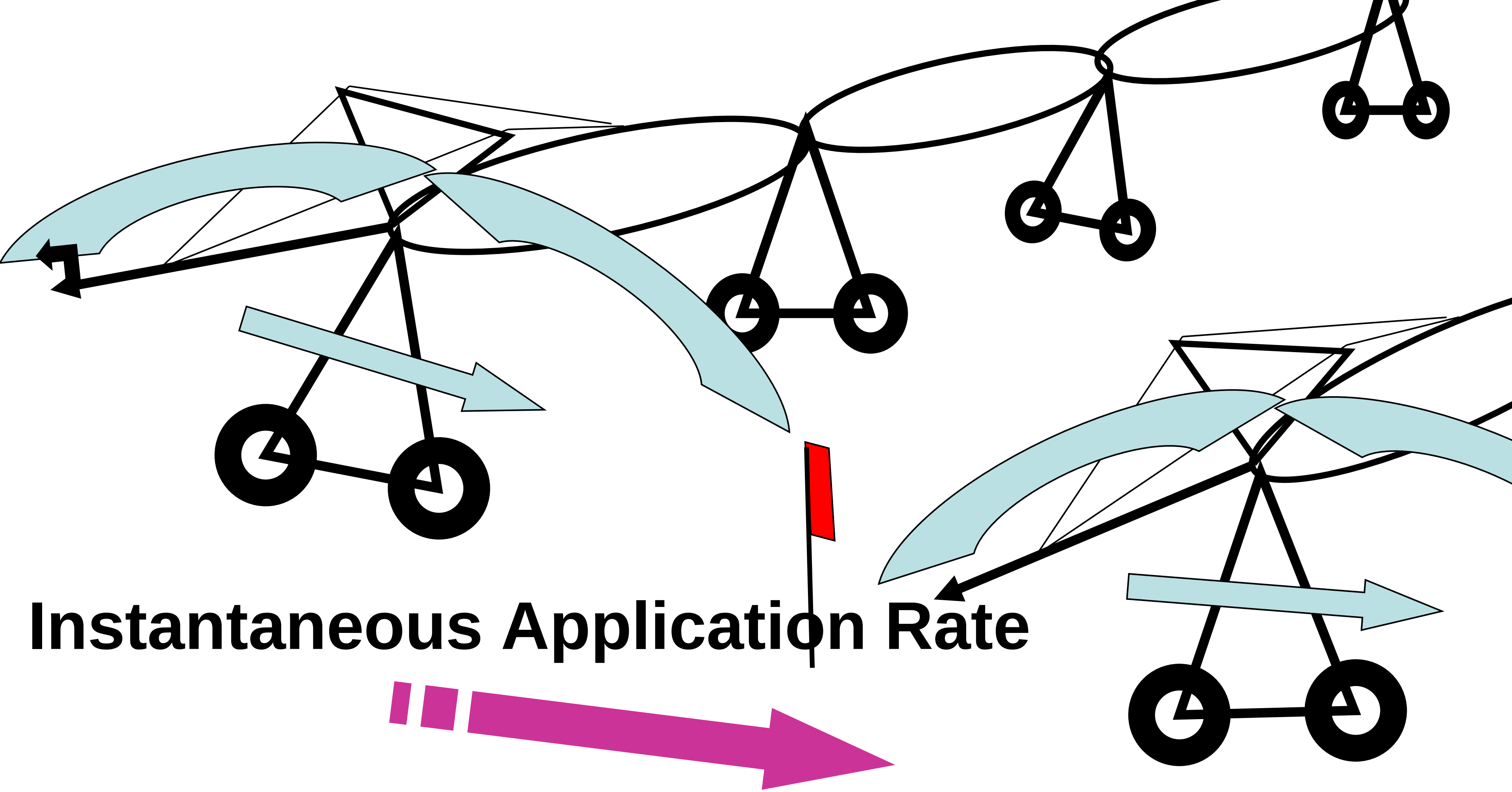
A- no observed puddling, ponding or sheen between rows

B- puddling, ponding or sheen between rows identified, but no observed runoff or flow of water

C-observed runoff or flow of water

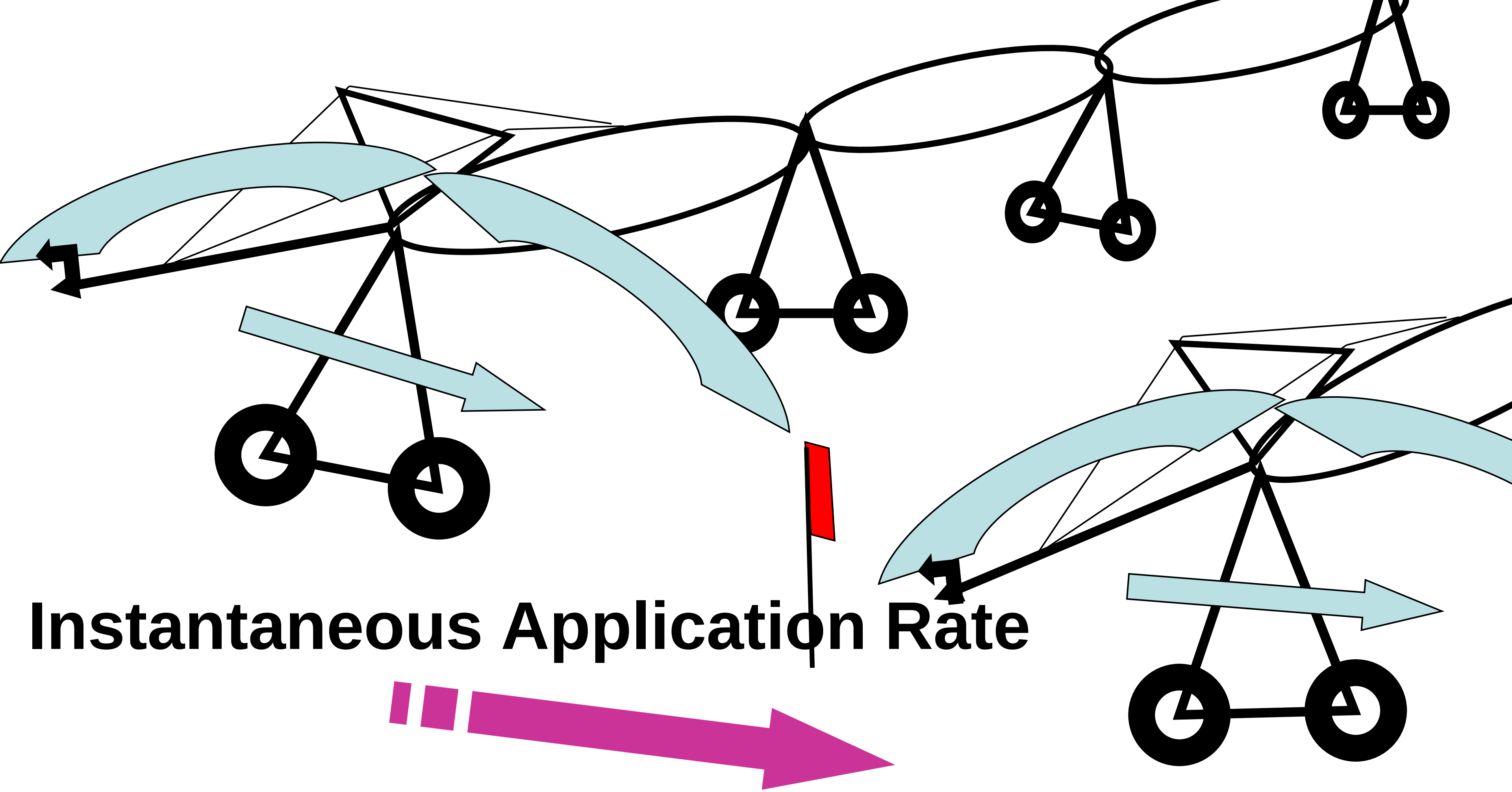
Calculating Instantaneous Application Rate

- Flag the leading edge of the wetted area just inside of the last tower of the pivot.
- Running the pivot at common speed with a measured and known application rate.
- Using a stop watch measure the time elapsed from the first drops hitting the flag till the last.
- Divide the measured and known application rate for the spot by the time elapsed.
- Convert to Minute to provide 1 inch application.



Instantaneous Application Rate

1. Time it from first drop of irrigation to last
2. Divide by know application rate
3. Convert to minute to provide 1” of irrigation

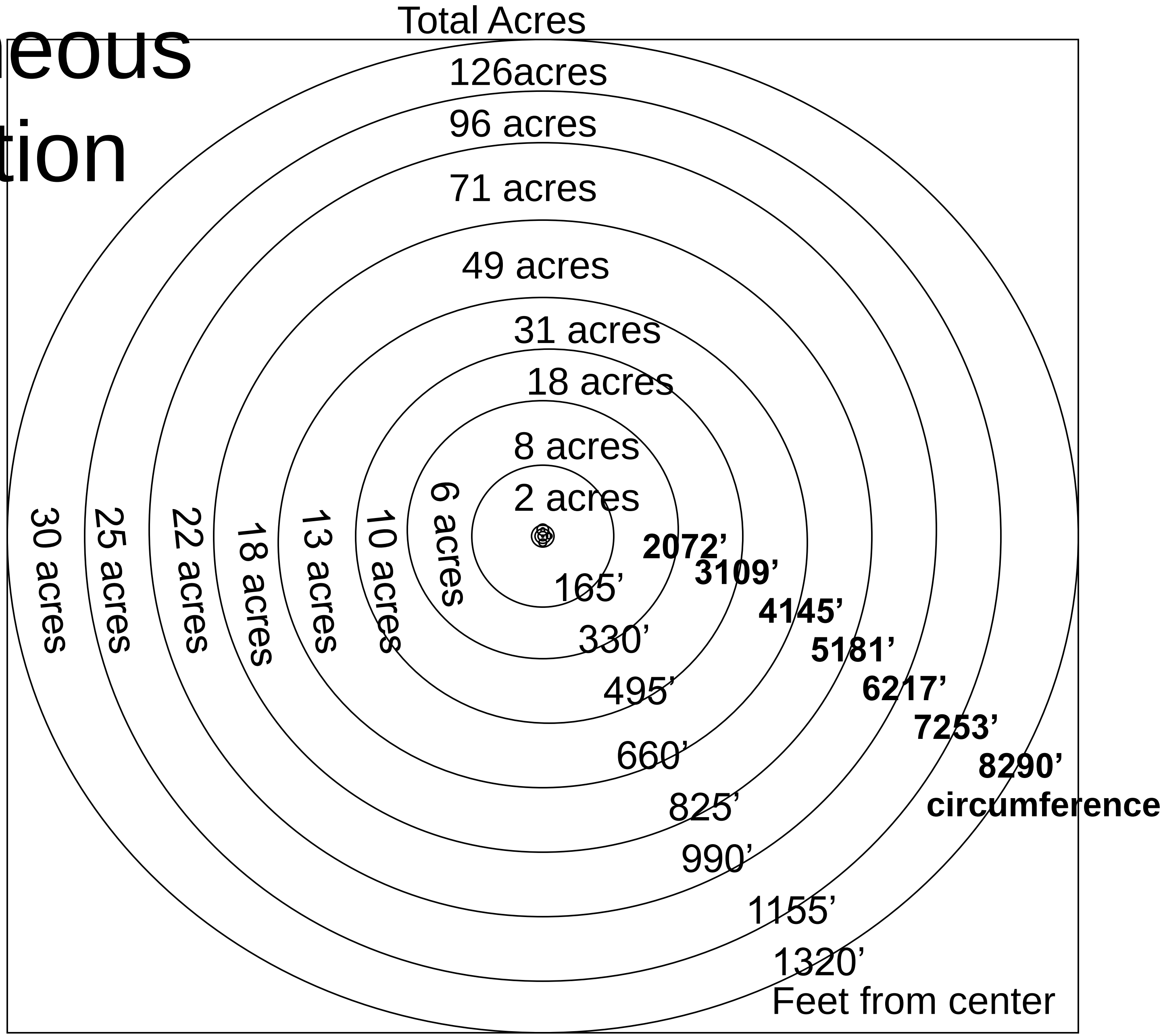


Instantaneous Application Rate

John applied .75 inches in 21 minute

$$\frac{.75 \text{ inches}}{21 \text{ min.}} = \frac{1.00 \text{ inches}}{?} = 28 \text{ min./inch}$$

Instantaneous application rate



3 days / circle @ 1"
3 days = 4320 min.

8290' / 4320 min.=
= 1.92'/minute

20' ft. wetted area=
= 1" / 10.4 Minutes

40' ft. wetted area=
= 1" / 20.8 Minutes

The larger the wetted area the slower the rate of application. Average 1’ rainfall comes over 4 hours.

An 1’ rainfall over an hour is considered a “toad strangler”

Sprinkler packages are commonly available with instantaneous application rates from 1” per 12 minutes to 1” per 80 minutes

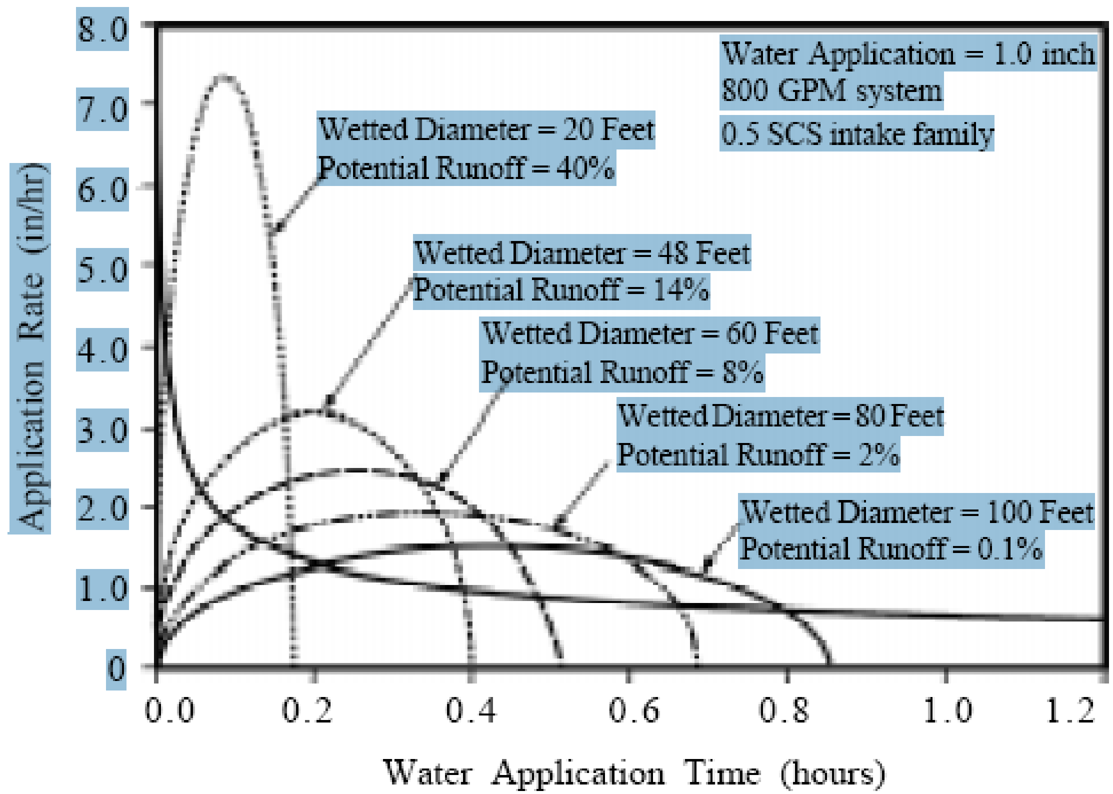


Figure 8. Effect of wetted diameters on the potential for runoff.

NebGuide – G-1532- Operating Characteristics of Center Pivot sprinklers