Irrigation System Evaluation
Why and How

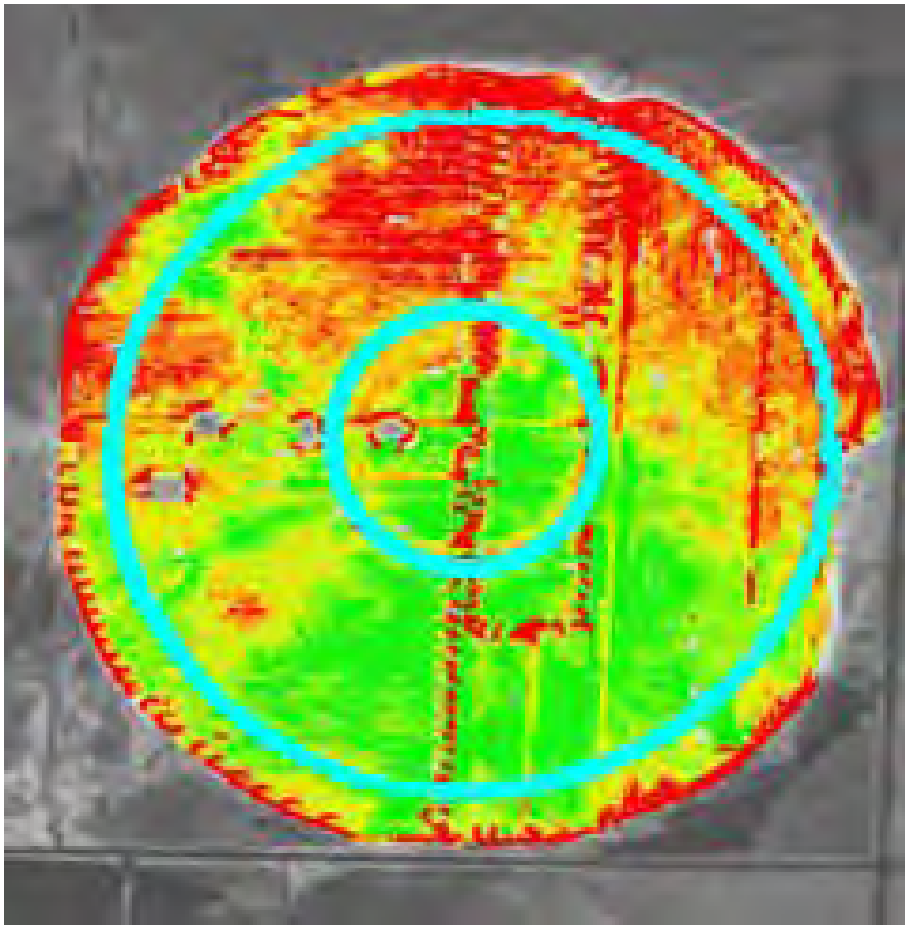
Lyndon Kelley

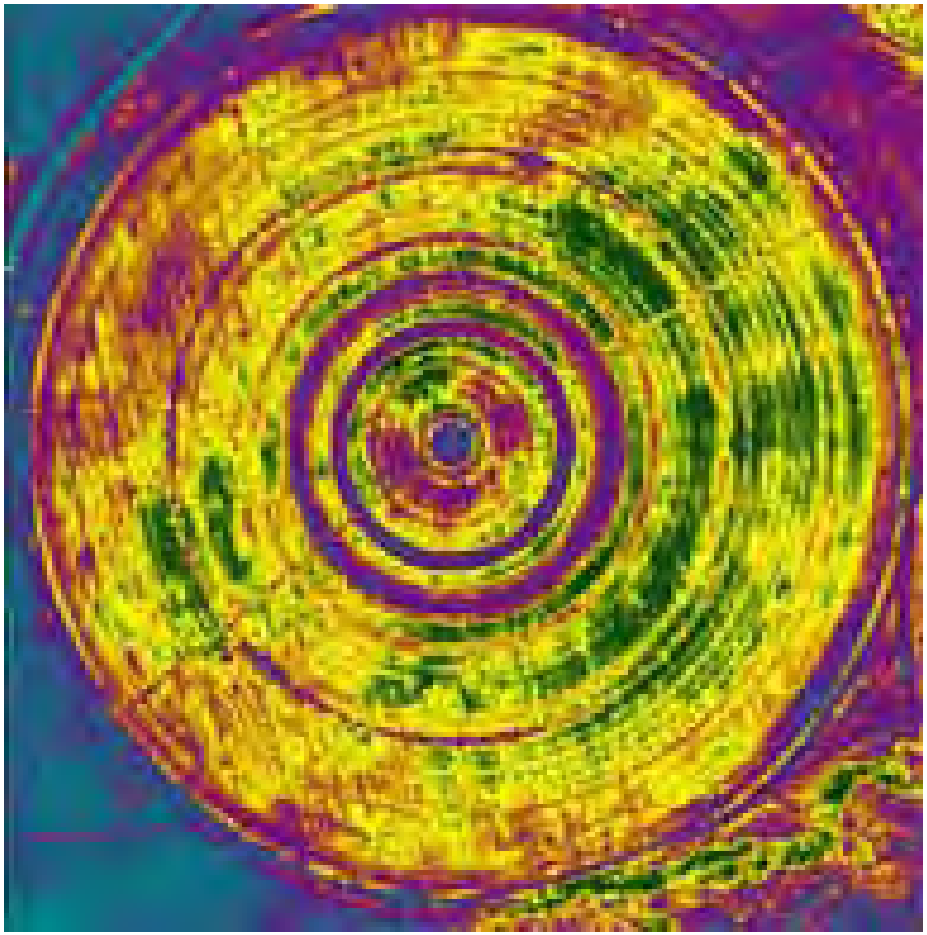
MSU Extension/Purdue University Irrigation Management Agent

www.msu.edu

- find St. Joseph Co.
- then hit the Irrigation button

Have you seen yield map patterns that match the irrigation system configuration?





Irrigation System Uniformity

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

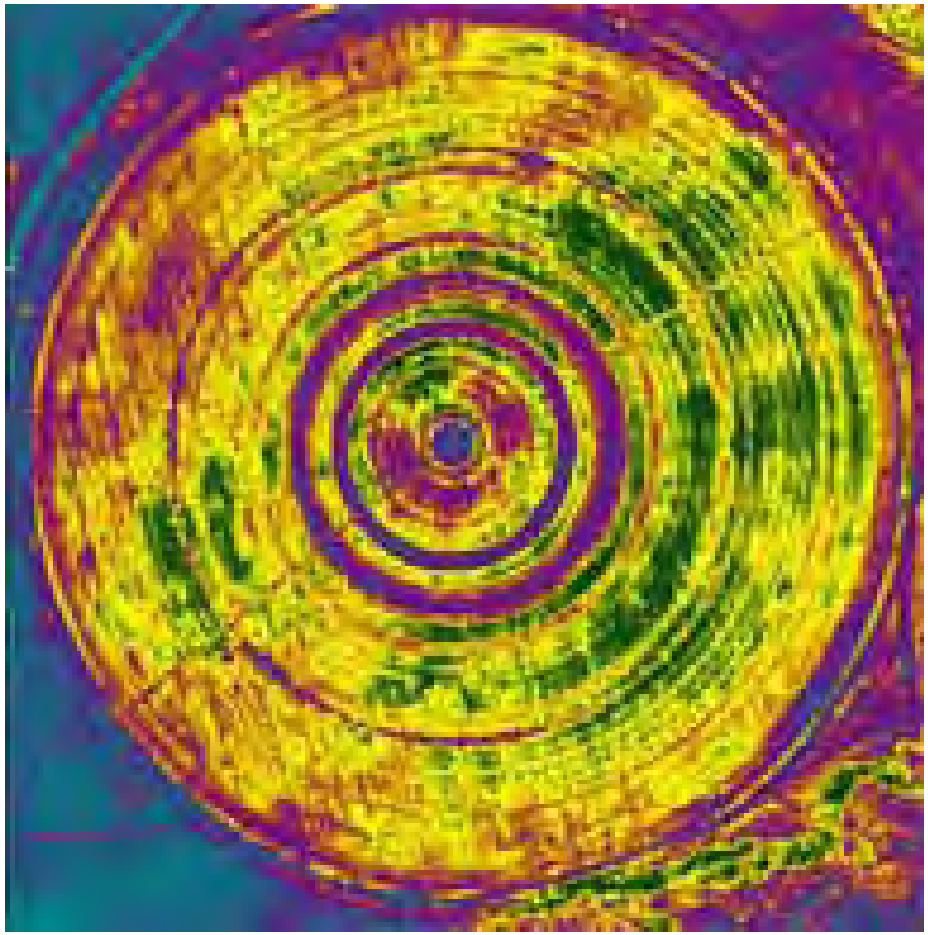
- 10% or less deviation from the average is ideal
- Over applied area will likely be over applied each application
- Under applied areas will likely be under applied each application

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?

Irrigation System Uniformity

Over 20 Irrigation uniformity trainings since May 2005

Over 200 Private consultants, Farmers, Extension, SCD, and NRCS personal have been trained on evaluation of system uniformity

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://www.kbs.msu.edu/mgsp/resources.htm

- NRCS Handbook — Available at your local Natural Resource Conservation Service office or http://www.wcc.nrcs.usda.gov/nrcsirrig/irrig-handbooks-part652-chapter15.html

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.

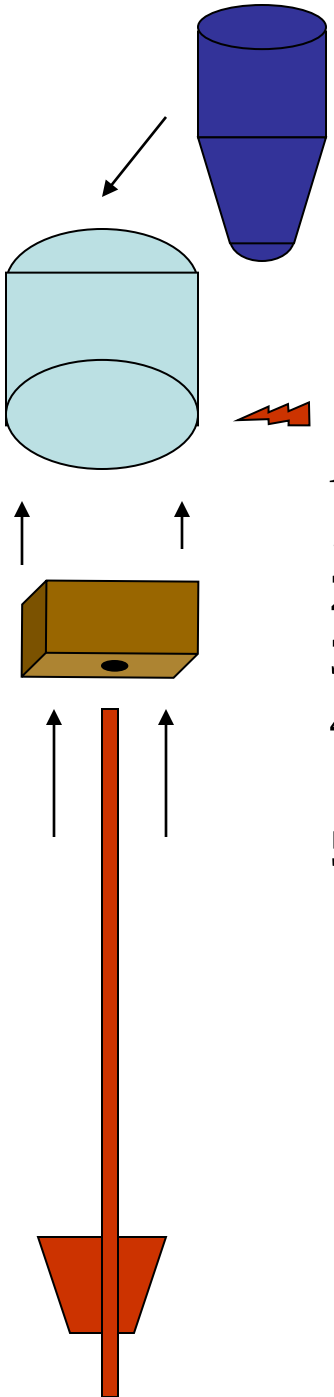
Spread the container every ten feet from the center point to the outside edge of the application area.

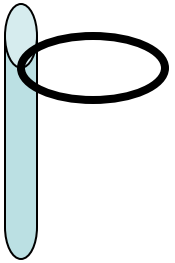
Run the system at standard setting over the container.

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 may be placed 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.

Uniformity and coverage area is often a trade off.

Uniformity and coverage area is often a trade off.

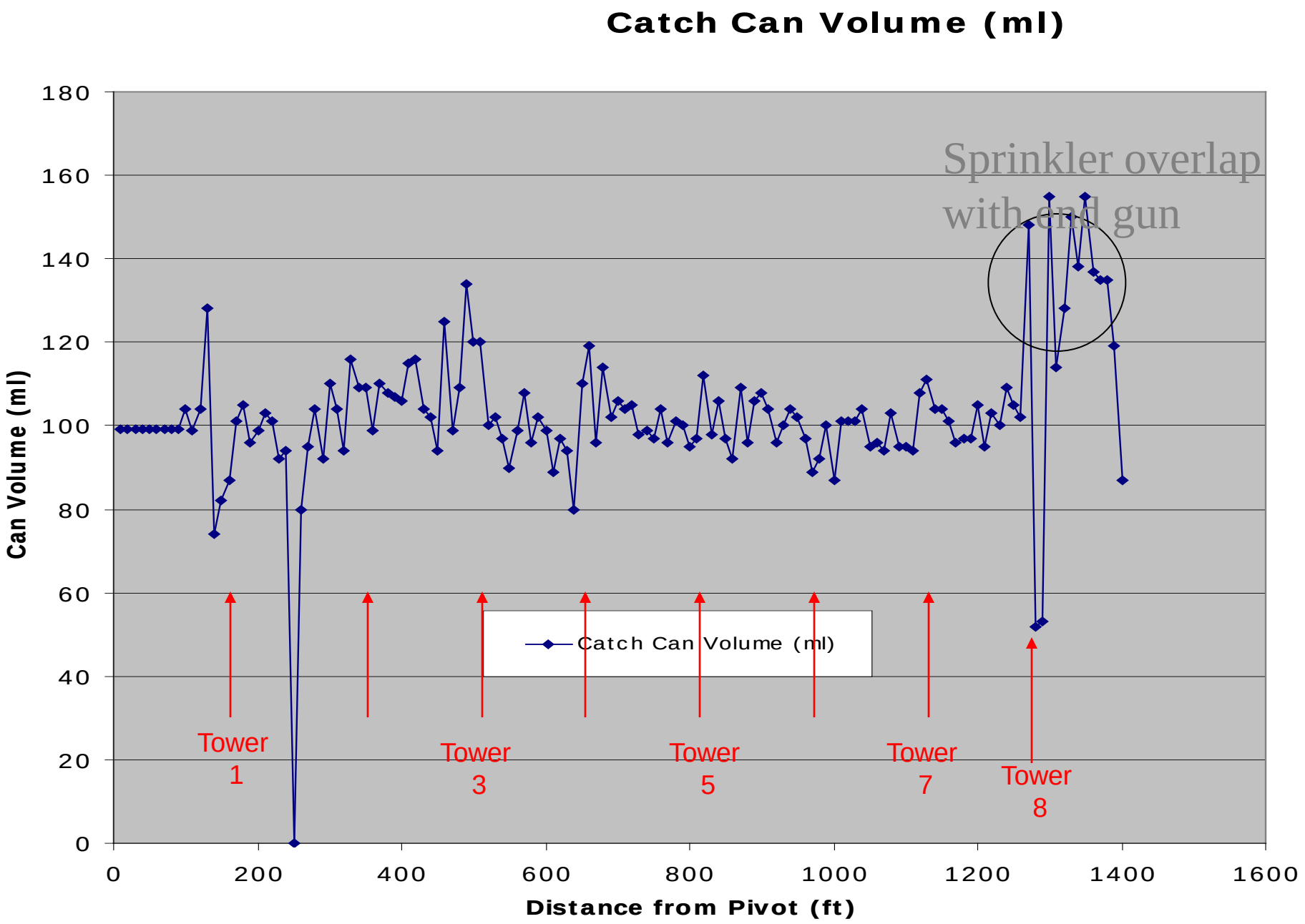
Labor…

Uniformity and coverage area is often a trade off.

Alternate years.

Uniformity and coverage area is often a trade off.

Expansion



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

2	Farm Name	NRCS 1-20-10 raw											
3											**System Uniformity Coefficient =**		**67**
4	System Identification										Good System uniformity coefficient are 85 or greater		
5											**Deviation from desired application =**		-0.34
6	System Settings												
7	Application rate (in)	0.7							Wind speed (mph)		1		
8	Percent timer Setting (%)	8							Wind Condition (variable or steady)		steady		
9	Operating Pressue (psi)	55											
10		**Rate of application calculator**											
11		Time from start to end of application at highest rate section of system (min.)							20		Inches/Hour	1.09	
12		Rate of application for the highest rate section of system (minute /one inch)							54.81				
13									Average Application (cm)		0.927		
14		Length of evaluation area (ft)	670						Average Application (in)		0.36		
15		Catch Can Spacing Distance (ft)	10										
16									Average catch, collected only (ml)		73.54		
17		number of cans data collected from	65						*70% average catch can (ml)*		*49.94*		
18		number of cans set	67						Evaluation area, full circle (acres)		30.94		
19									catch can openning area (sq cm)		76.977		
20		Diameter of catch can (cm)	9.9						catch can openning area (sq in)		11.767		
21													

22													
23	catch can		Distance from center	catch volume in	Data adjustment		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)
24	number		point	ml		Comments						
25	1		10	5	0.00		0.065	0.026	7.01%	-92.99%	0.01623	0.05%
26	2		20	20	0.00		0.260	0.102	28.03%	-71.97%	0.02885	0.09%
27	3		30	25	0.00		0.325	0.128	35.04%	-64.96%	0.04327	0.14%
28	4		40	80	0.00		1.039	0.409	112.13%	12.13%	0.05770	0.19%
29	5		50	20	0.00		0.260	0.102	28.03%	-71.97%	0.07212	0.23%
30	6		60	25	0.00		0.325	0.128	35.04%	-64.96%	0.08655	0.28%
31	7		70	80	0.00		1.039	0.409	112.13%	12.13%	0.10097	0.33%
32	8		80	20	0.00		0.260	0.102	28.03%	-71.97%	0.11539	0.37%

Data Entry | Uniformity Graph

82	58	580	105	0.00	1.364	0.537	147.18%	47.18%	0.83661	2.70%	
83	59	590	90	0.00	1.169	0.460	126.15%	26.15%	0.85103	2.75%	
84	60	600	130	0.00	1.689	0.665	182.22%	82.22%	0.86545	2.80%	
85	61	610	115	0.00	1.494	0.588	161.19%	61.19%	0.87988	2.84%	
86	62	620	70	0.00	0.909	0.358	98.12%	-1.88%	0.89430	2.89%	
87	63	630	40	0.00	0.520	0.205	56.07%	-43.93%	0.90873	2.94%	
88	64	640	30	0.00	0.390	0.153	42.05%	-57.95%	0.92315	2.98%	
89	65	650	20	0.00	0.260	0.102	28.03%	-71.97%	0.93758	3.03%	
90	66			0.00	0.000	0.000	0.00%	0.00%	0.00000	0.00%	

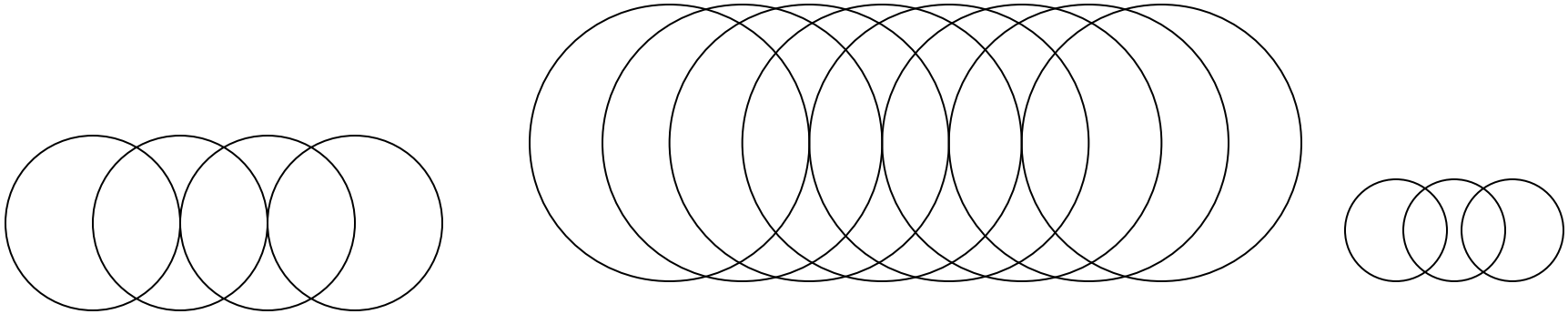
Farm Name	NRCS 1-20-10 clean											
									System Uniformity Coefficient =		**71**	
System Identification									Good System uniformity coefficient are 85 or greater			
									Deviation from desired application =		-0.31	
System Settings												
Application rate (in)	0.7							Wind speed (mph)		1		
Percent timer Setting (%)	8							Wind Condition (variable or steady)		steady		
Operating Pressue (psi)	55											
Rate of application calculator												
Time from start to end of application at highest rate section of system (min.)							20			Inches/Hour	1.18	
Rate of application for the highest rate section of system (minute /one inch)							50.99					
								Average Application (cm)		0.996		
Length of evaluation area (ft)	670							Average Application (in)		0.39		
Catch Can Spacing Distance (ft)	10											
								Average catch, collected only (ml)		64.23		
number of cans data collected from	65							*70% average catch can (ml)*		*43.62*		
number of cans set	67							Evaluation area, full circle (acres)		28.17		
								catch can openning area (sq cm)		76.977		
Diameter of catch can (cm)	9.9							catch can openning area (sq in)		11.767		

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)
1	10		64.23		0.834	0.329	83.75%	-16.25%	0.01623	0.06%
2	20		64.23		0.834	0.329	83.75%	-16.25%	0.02885	0.10%
3	30		64.23		0.834	0.329	83.75%	-16.25%	0.04327	0.15%
4	40		64.23		0.834	0.329	83.75%	-16.25%	0.05770	0.20%
5	50		64.23		0.834	0.329	83.75%	-16.25%	0.07212	0.26%
6	60		64.23		0.834	0.329	83.75%	-16.25%	0.08655	0.31%
7	70		64.23		0.834	0.329	83.75%	-16.25%	0.10097	0.36%
8	80		64.23		0.834	0.329	83.75%	-16.25%	0.11539	0.41%
53	530	110	0.00		1.429	0.563	143.43%	43.43%	0.76448	2.71%
54	540	85	0.00		1.104	0.435	110.83%	10.83%	0.77891	2.76%
55	550	80	0.00		1.039	0.409	104.31%	4.31%	0.79333	2.82%
56	560	70	0.00		0.909	0.358	91.27%	-8.73%	0.80776	2.87%
57	570	70	0.00		0.909	0.358	91.27%	-8.73%	0.82218	2.92%
58	580	105	0.00		1.364	0.537	136.91%	36.91%	0.83661	2.97%
59	590	90	0.00		1.169	0.460	117.35%	17.35%	0.85103	3.02%
60	600	130	0.00		1.689	0.665	169.51%	69.51%	0.86545	3.07%
61	610	115	0.00		1.494	0.588	149.95%	49.95%	0.87988	3.12%
62	620	70	0.00		0.909	0.358	91.27%	-8.73%	0.89430	3.17%

Data Entry / Uniformity Graph /

Irrigation System Uniformity

- Most systems 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



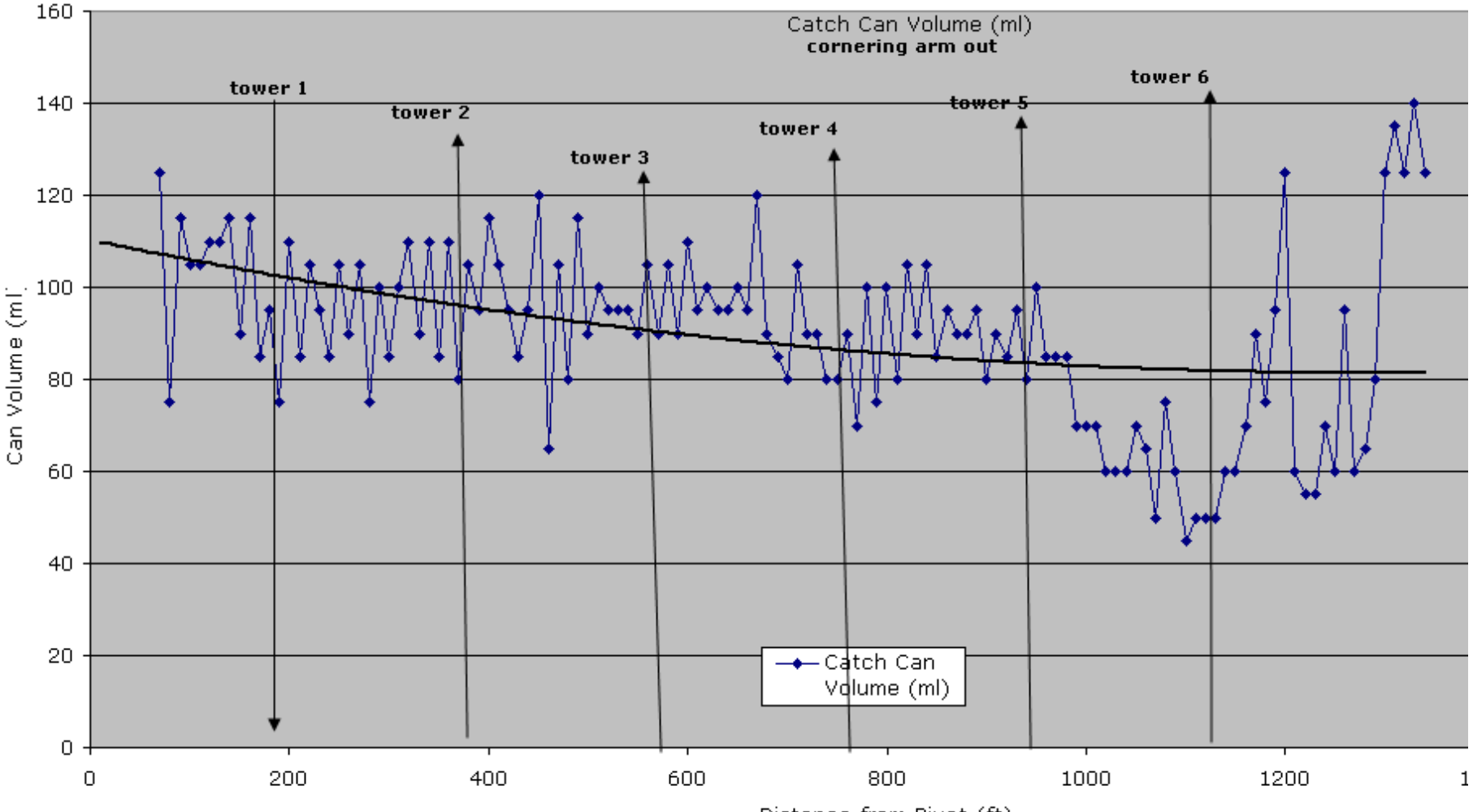
Greatest improvement needed

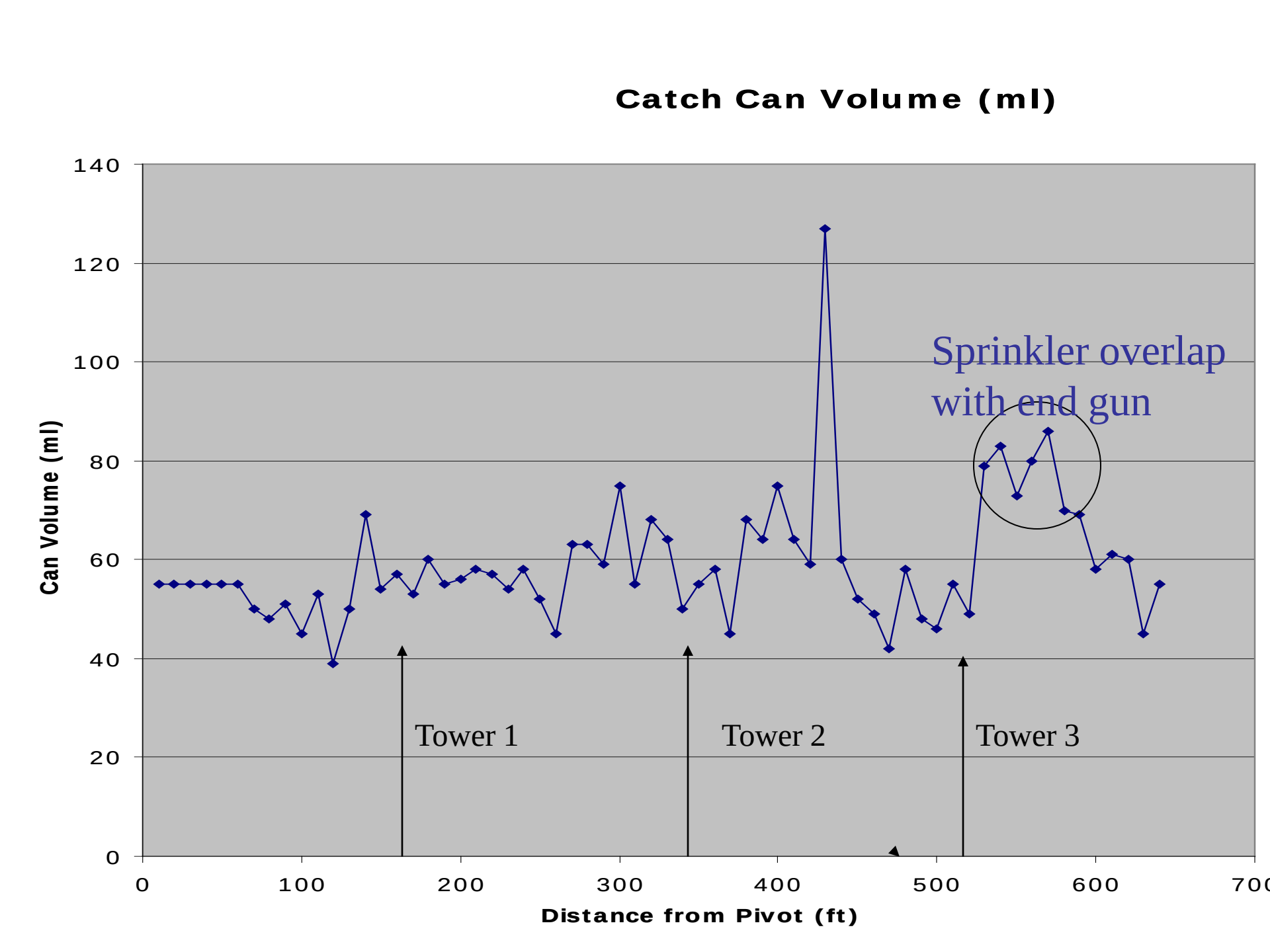
- End gun stop adjustment
- Water supply over or under design
- End gun orifice, too little or too much
- Wrong sprinkler or tip
- Leaks, plugs and **no turn sprinklers**

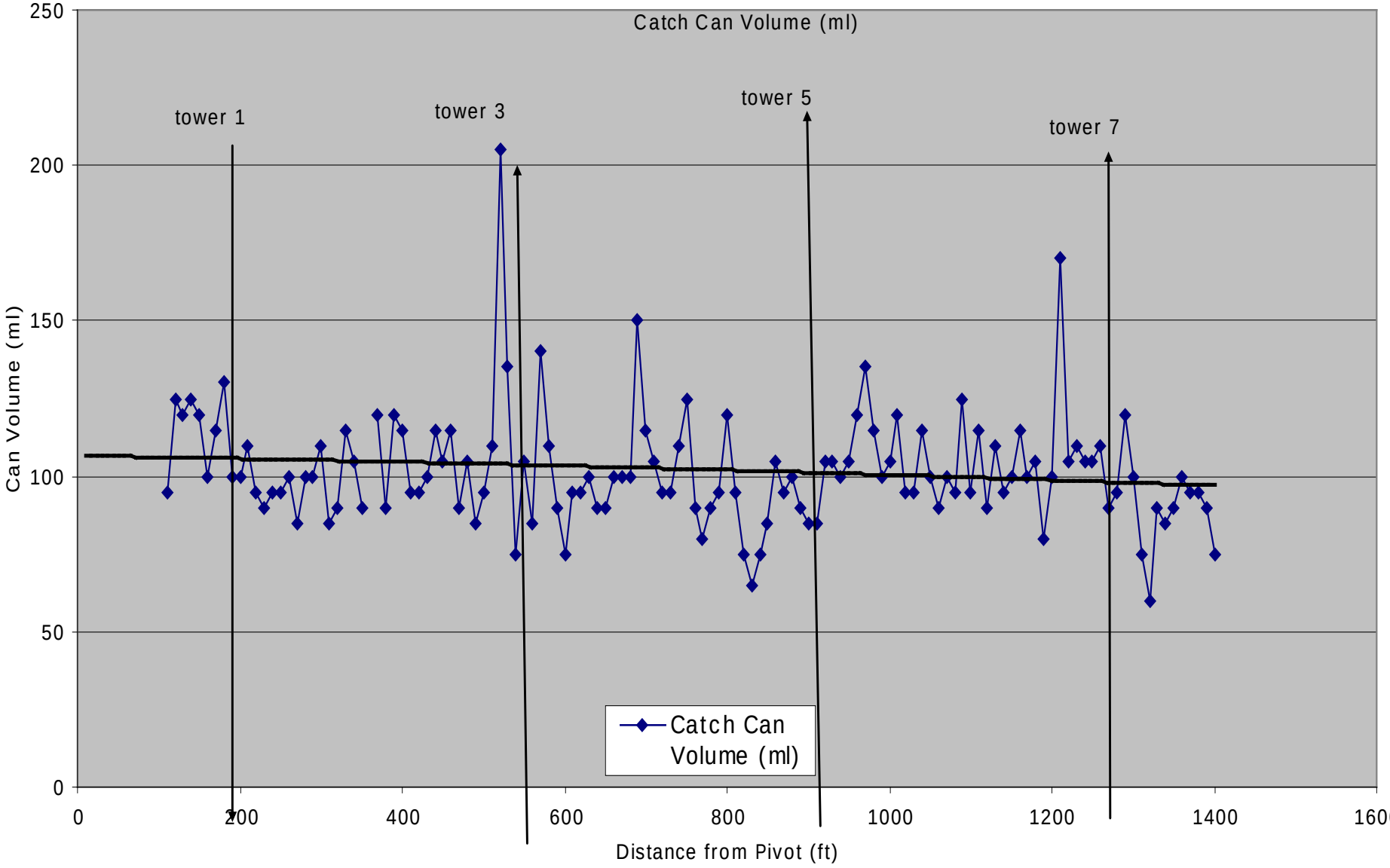
Water supply over or under design

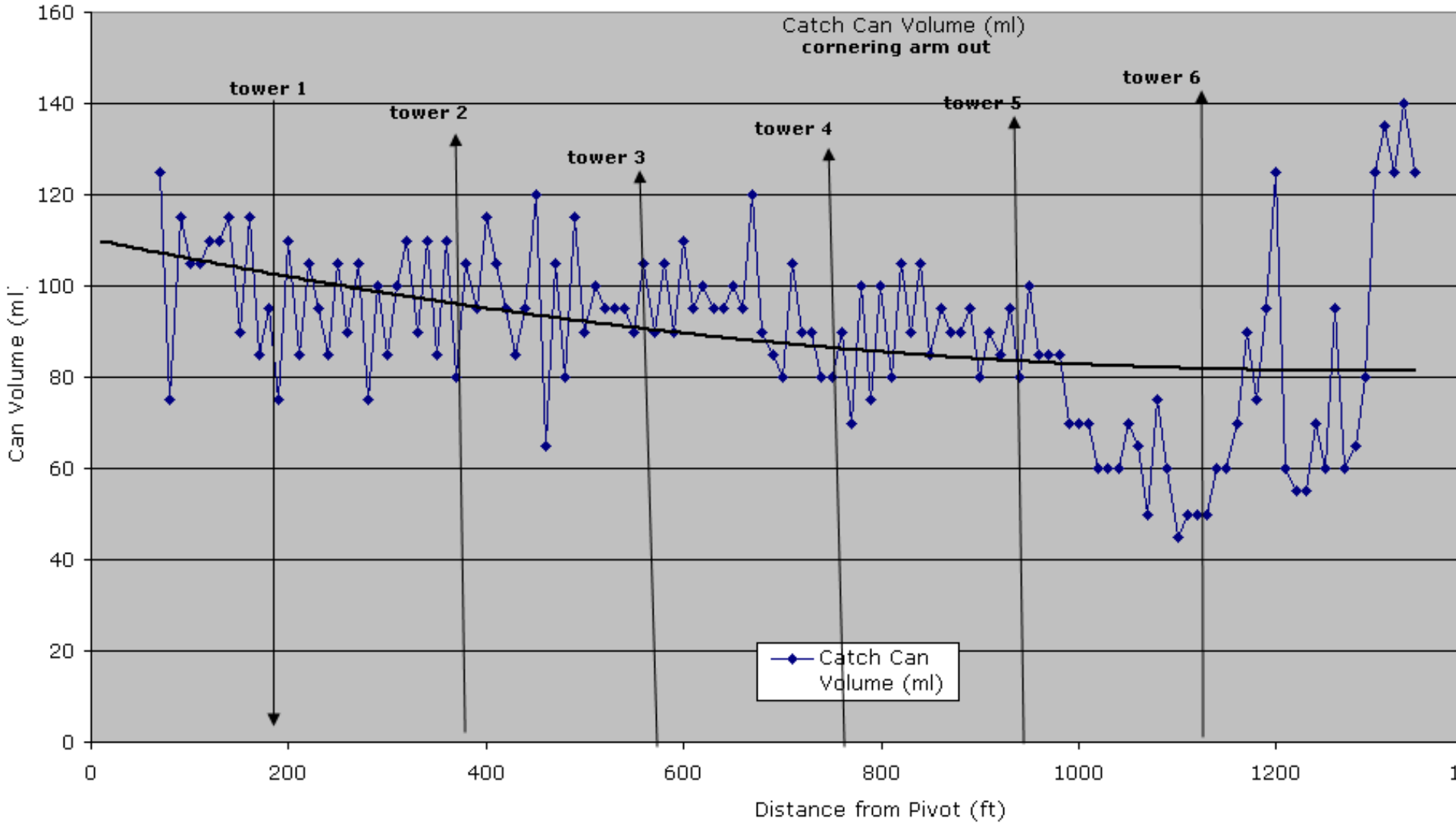
supply over design yield tail up, supply under design yield tail down

Example of Water supply under volume for sprinkler design

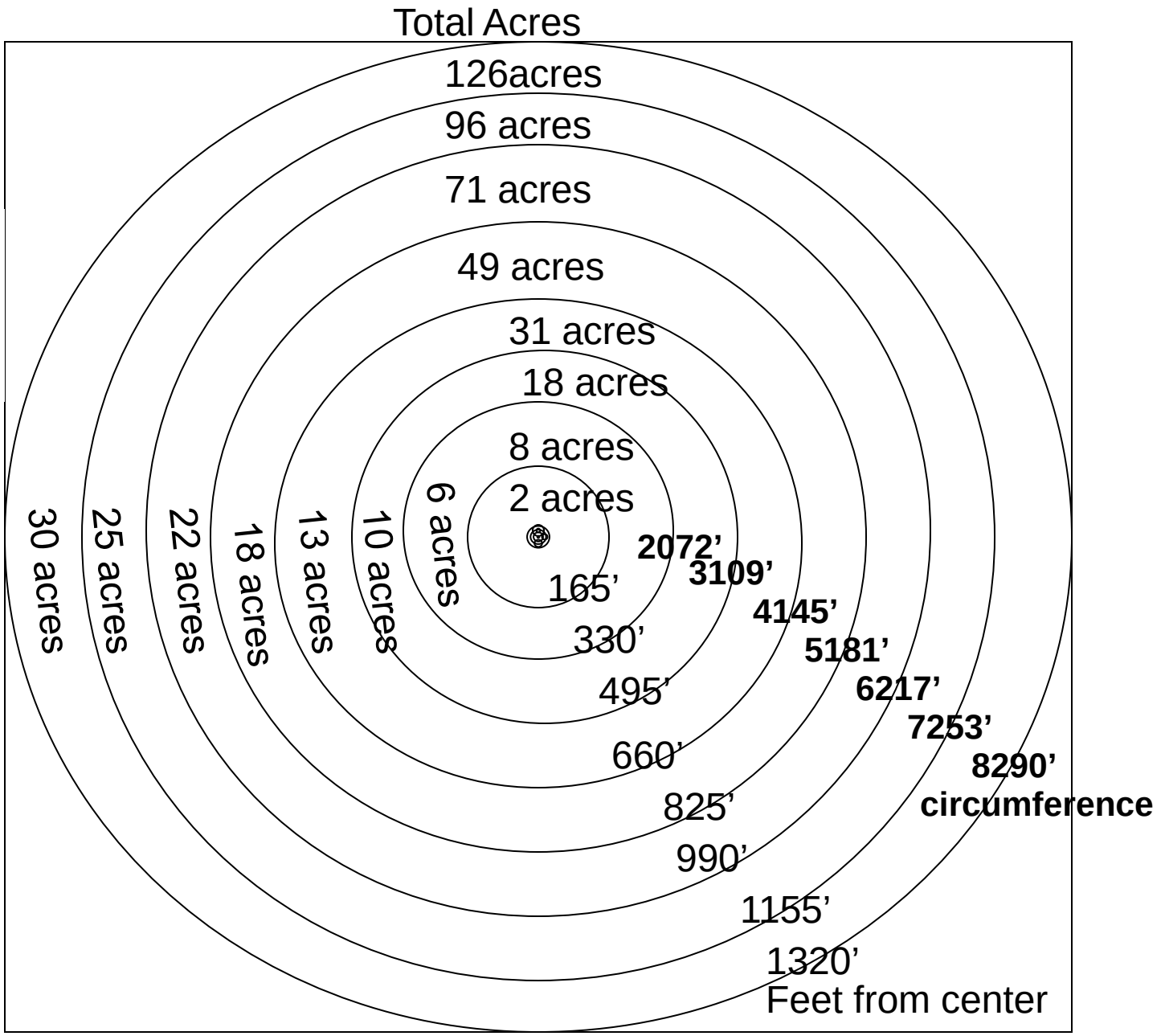



Catch Can Volume (ml)
Can Volume (ml)
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
Distance from Pivot (ft)
Sprinkler overlap with end gun
Tower 1
Tower 2
Tower 3


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

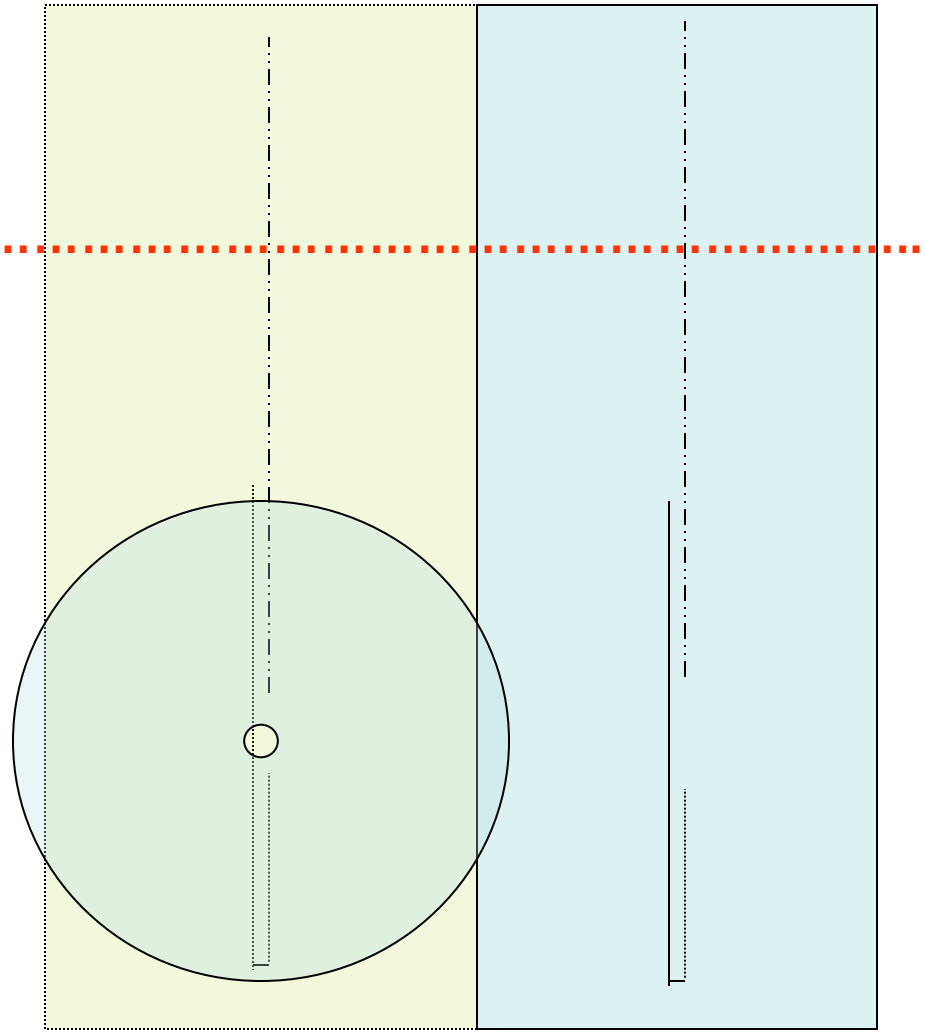

Catch Can Volume (ml)
cornering arm out
tower 1
tower 2
tower 3
tower 4
tower 5
tower 6
Catch Can Volume (ml)
Can Volume (ml)
Distance from Pivot (ft)
0
20
40
60
80
100
120
140
160
0
200
400
600
800
1000
1200

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



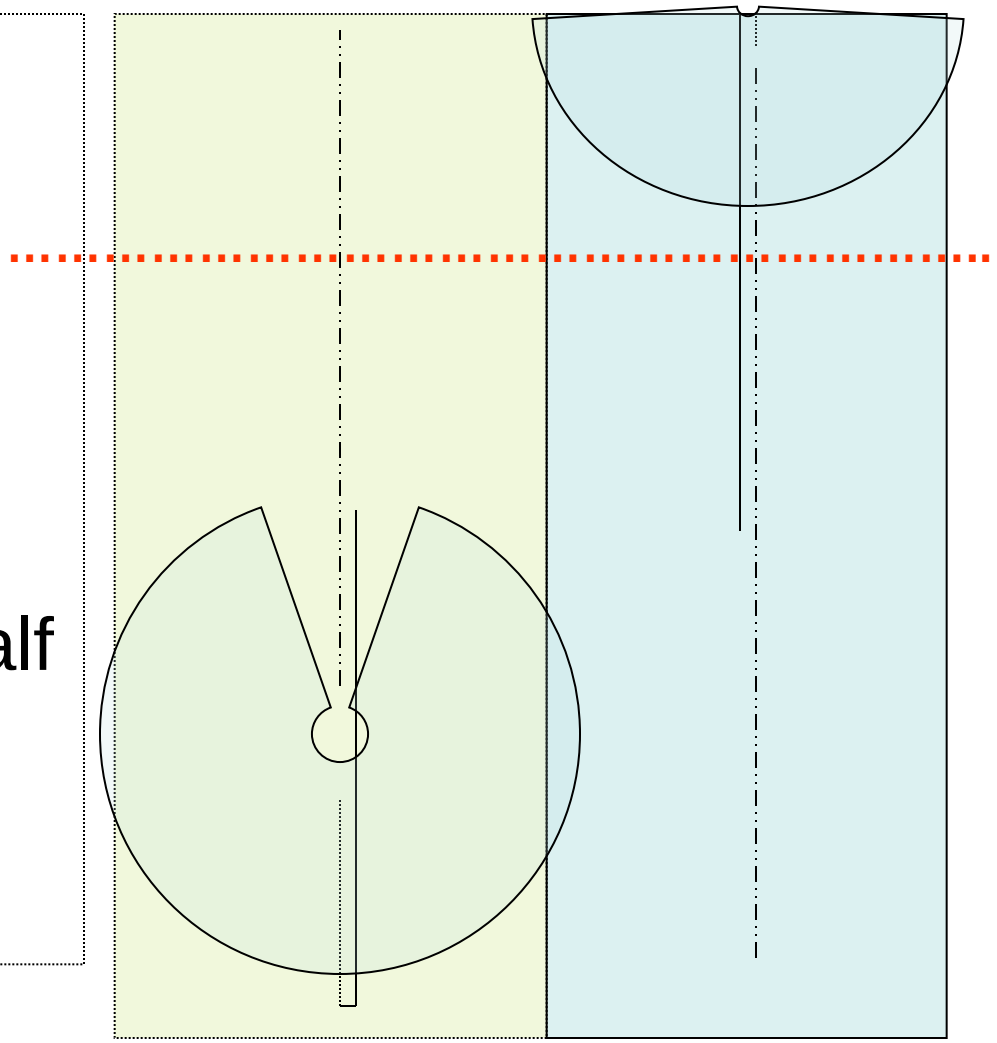
Improving Traveler Uniformity

- 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 may be reduce as more hose is being pulled in the second half of the run.
- Adjust speed accordingly.



Trickle, Solid Set and Manual Move System Uniformity

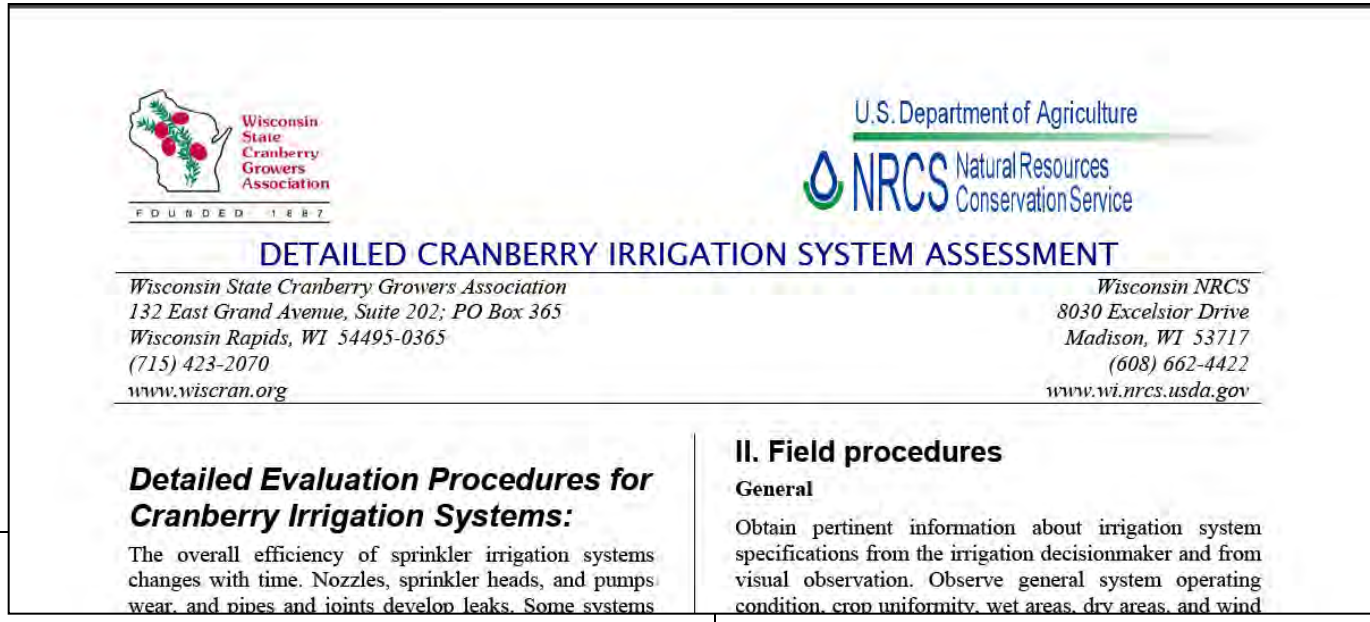
- Stick with the Plan!!!!

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 ?
- …..

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]

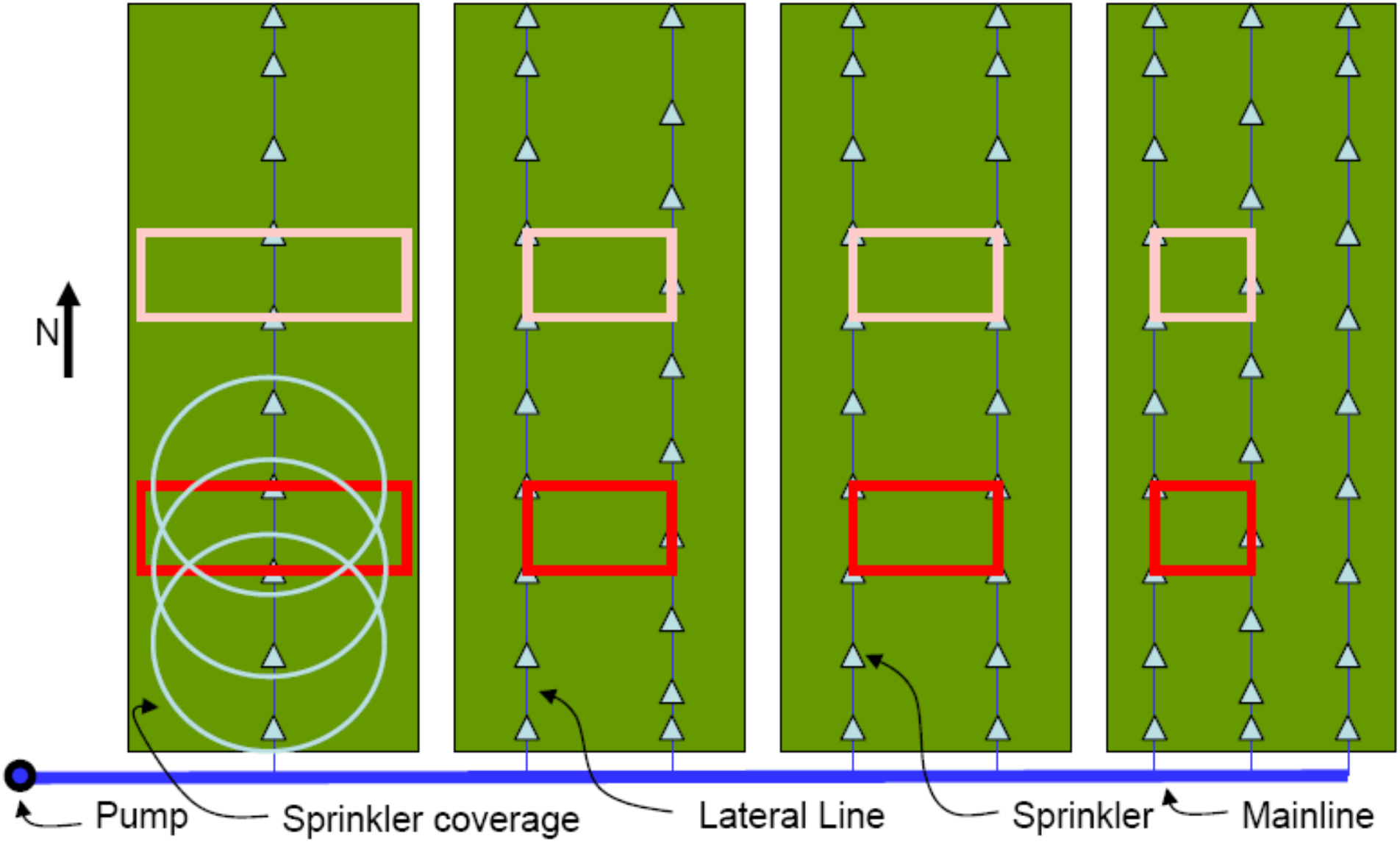
Introduction

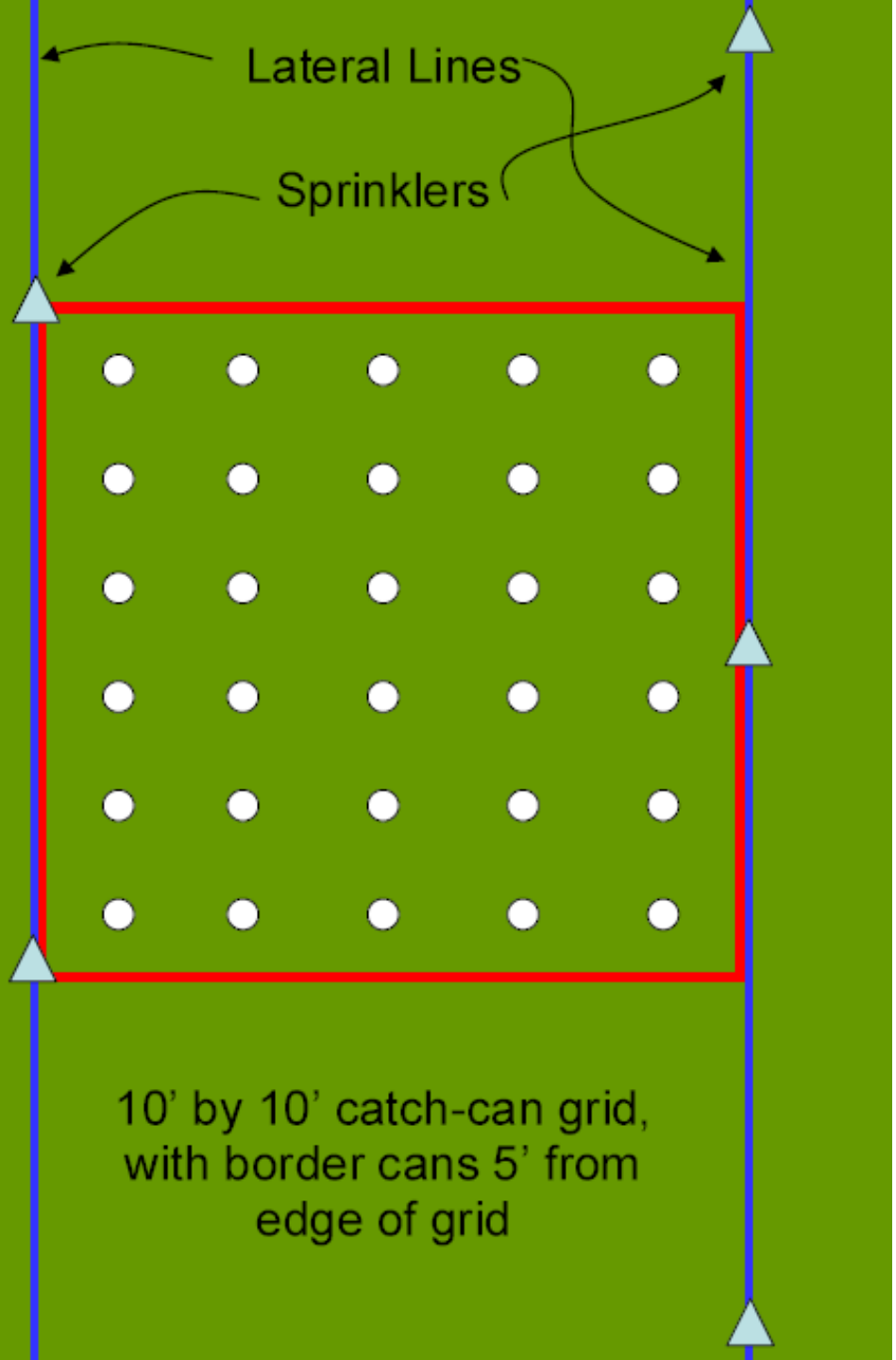
This bulletin describes techniques for measuring operating pressures, water application rates and uniformity during field evaluations of solid set or portable sprinkler irrigation systems. These irrigation

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

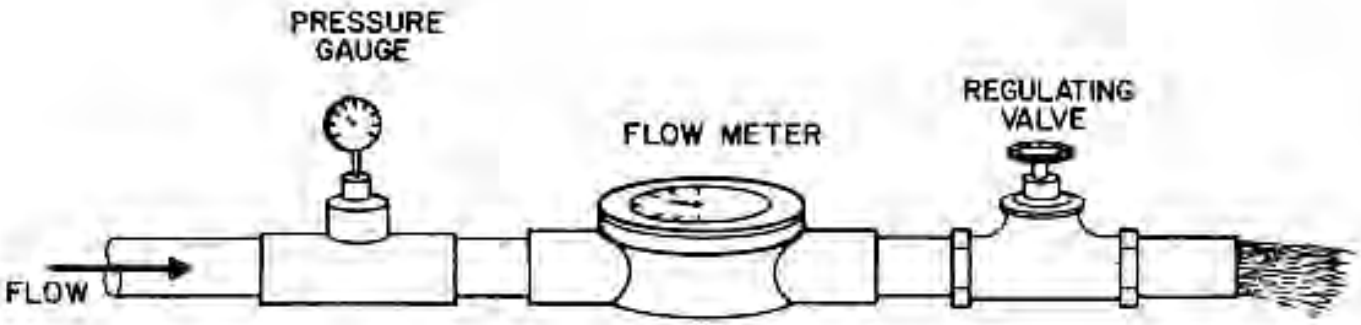
Time from start to end of application at highest rate section of system (min.)	22	Inches/Hour	1.25
Rate of application for the highest rate section of system (minute /one inch)	48.00		
Average Application (cm)			1.164
Average Application (in)			0.46
Length of evaluation area (ft)	1340		
Catch Can Spacing 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

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.

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)

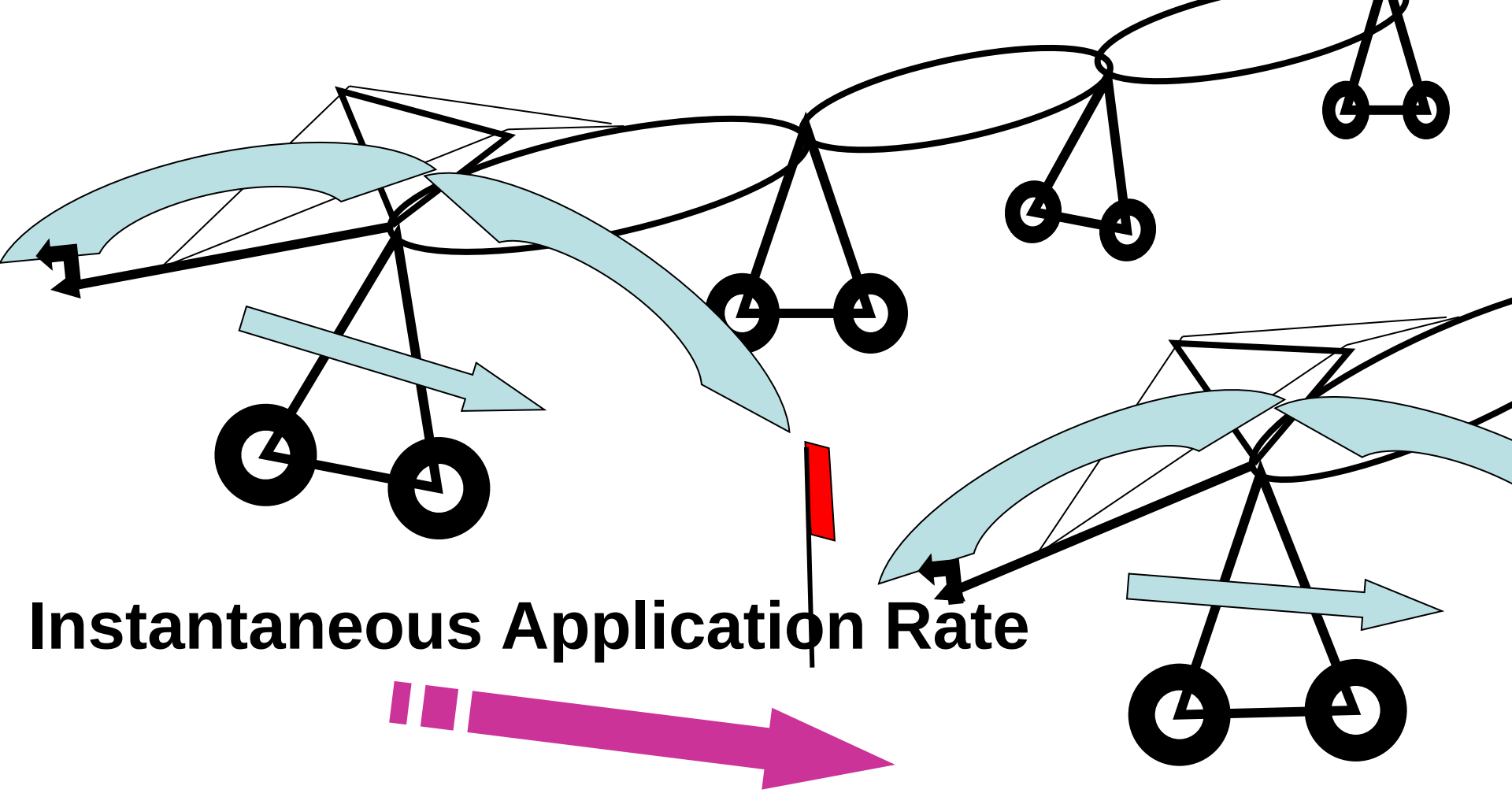
Preventing Irrigation Runoff

(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

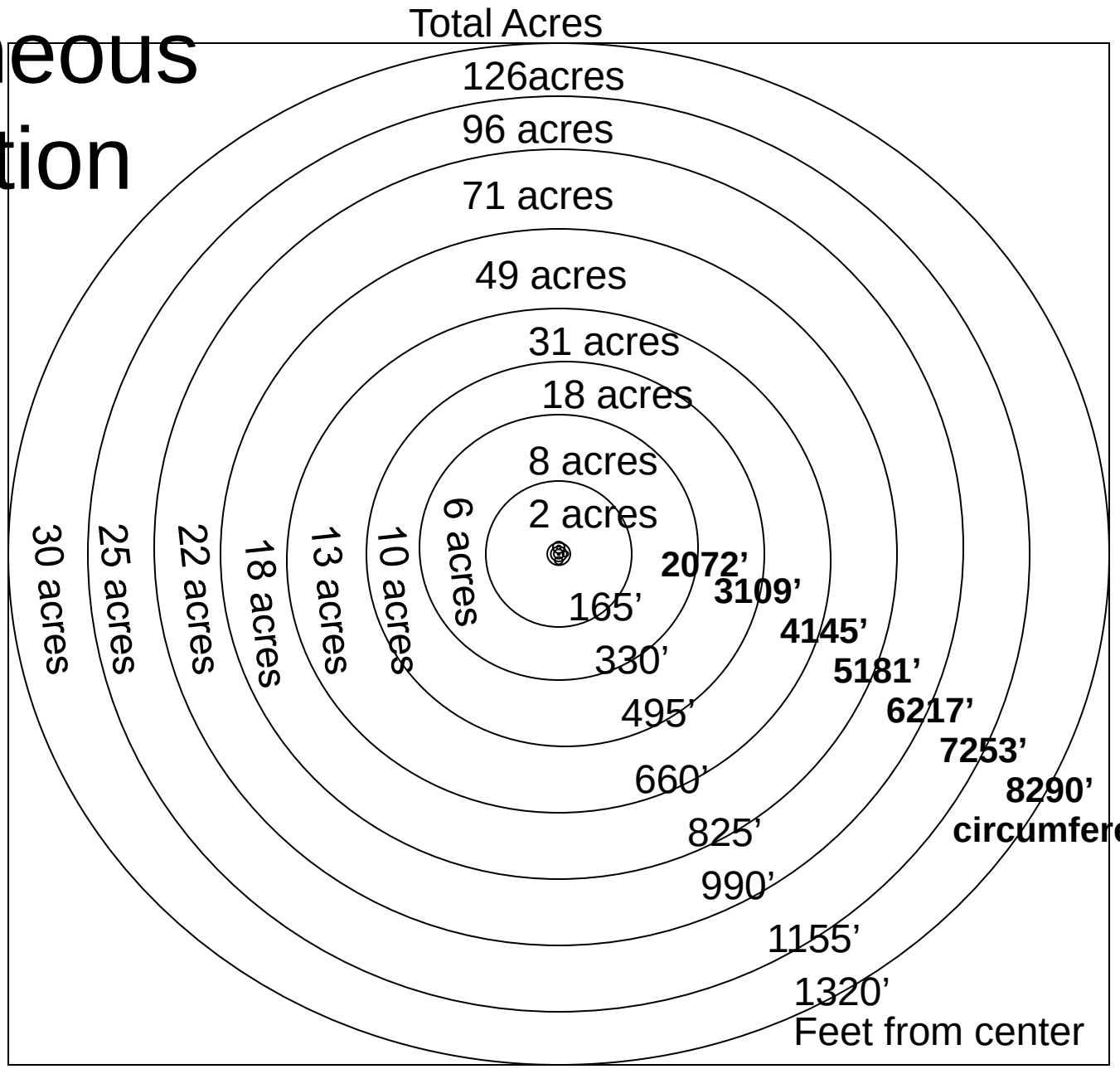


Instantaneous Application Rate

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

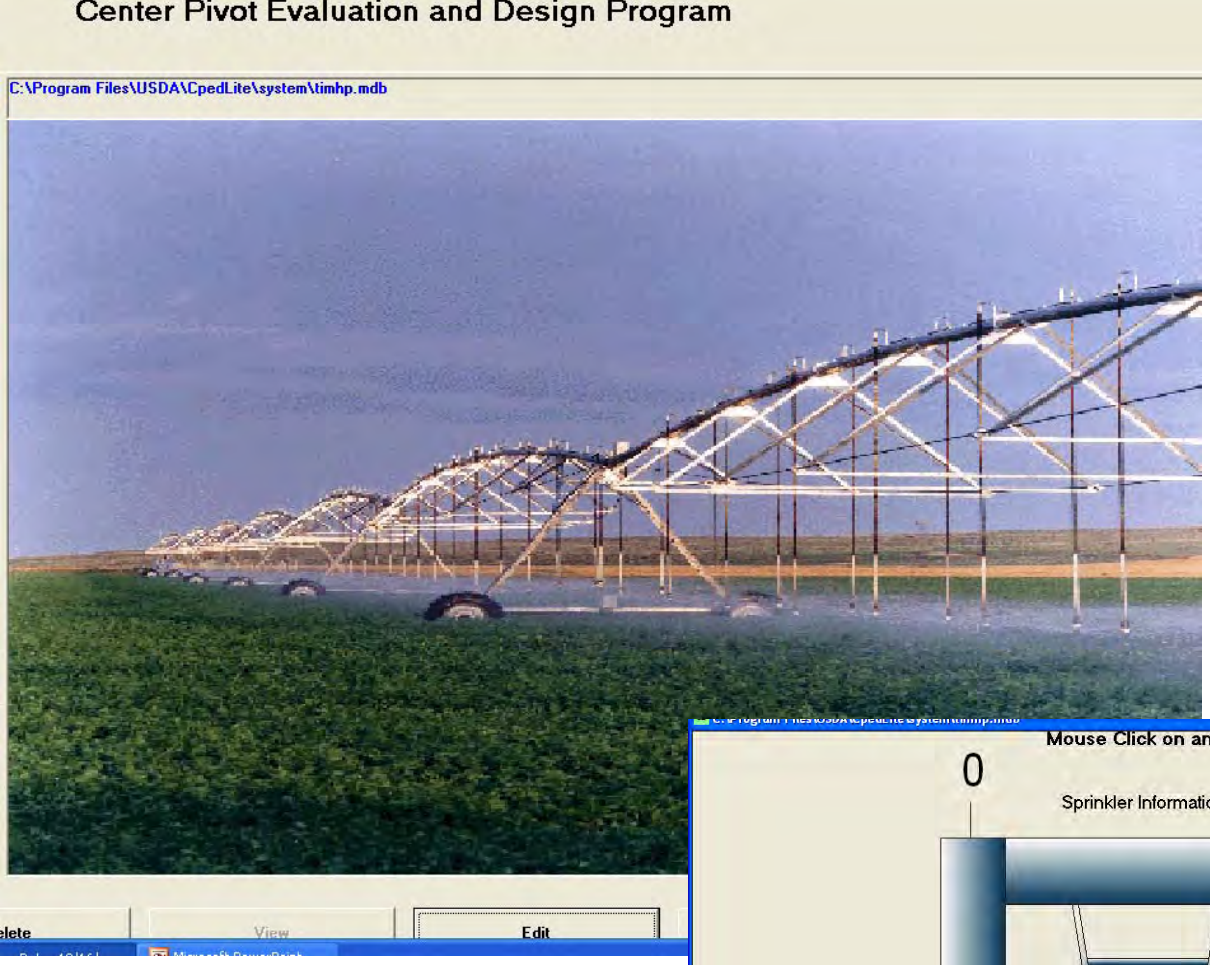


3 days / circle @ 1”
3 days = 4320 min.

8290’ / 4320 min.=
= 1.92’/minute

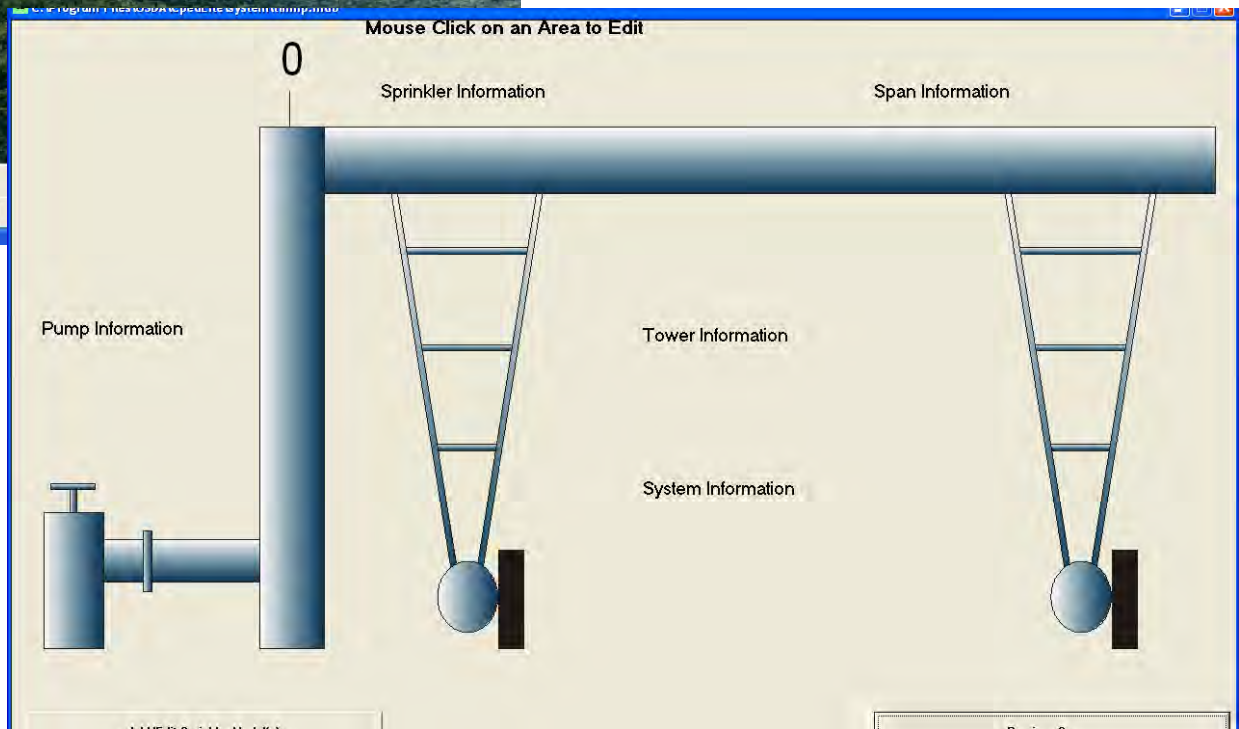
20’ ft. wetted area=
= 1” / 10.4 Minutes

40’ ft. wetted area=
= 1” / 20.8 Minutes

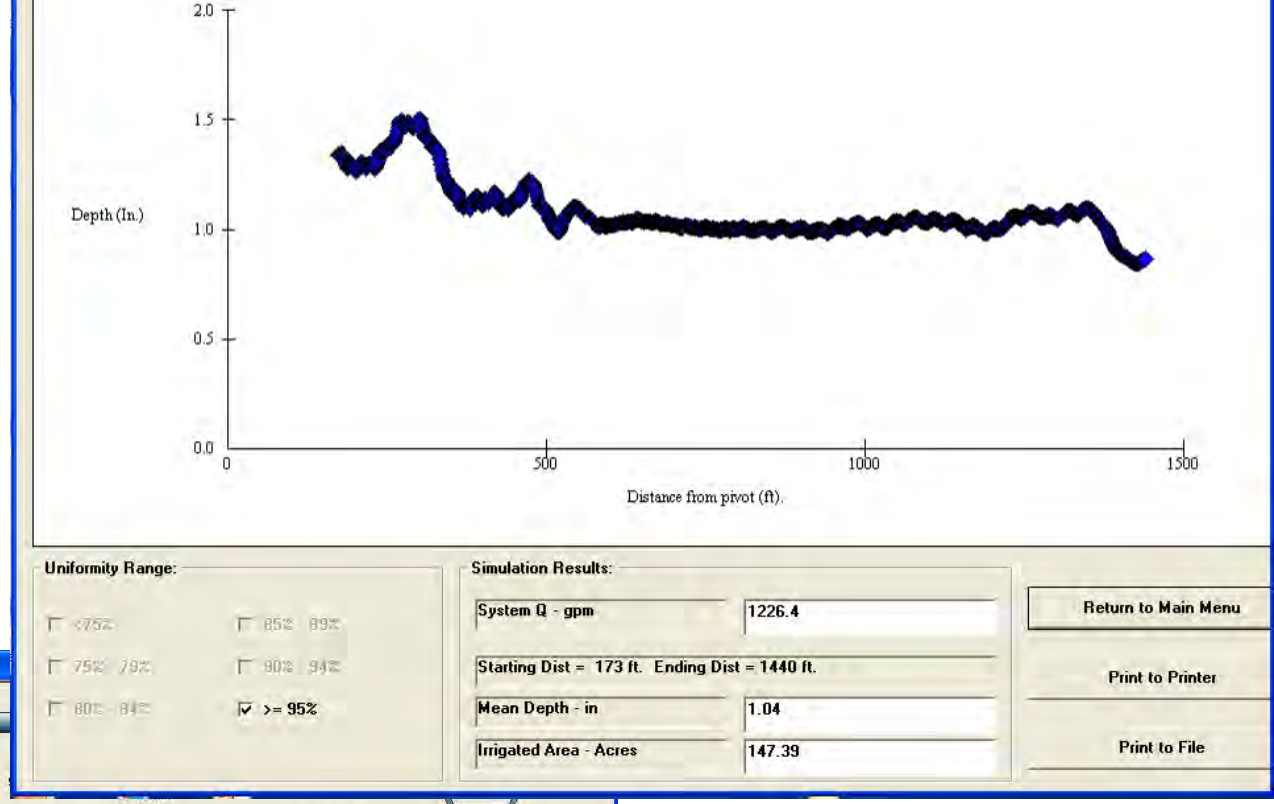


CEPD

Center Pivot Evaluation & Design



Michigan NRCS has accepted CEPD as an alternative to in field testing for sprinkler upgrade cost share.



Sprinkler Number	Sprinkler Model Name	Sprinkler Distance (ft.)	Sprinkler Pattern	Range Nozzle diameter (64th	Spread Nozzle Diameter (64th in.)	Pressure Control (psi or 64th)	Starting Part Circle Angle (deg.)	Stopping Part Circle Angle (deg.)	Right Offset Distance (ft.)	Left Offset Distance (ft.)
1	RBL30	30	1	8	0					
2	RBL30	60	1	8	0					
3	RBL30	90	1	8	0					
4	RBL30	120	1	9	0					
5	RBL30	150	1	11	0					
6	RBL30	180	1	11	0					
7	RBL30	210	1	12	0					
8	RBL30	240	1	13	0					
9	RBL30	270	1	15	0					
10	RBL30	300	1	16	0					
11	RBL30	330	1	16	0					
12	RBL30	360	1	15	0					
13	RBL30	390	1	16	0					
14	RBL30	420	1	17	0					
15	RBL30	450	1	17	0					
16	RBL30	480	1	16	0					
17	RB70	510	1	16	12					
18	RB70	540	1	14	11					
19	RB70	570	1	14	11					
20	RB70	600	1	14	11					
21	RB70	630	1	16	12					
22	RB70	660	1	16	12					
23	RB70	690	1	16	12					
24	RB70	720	1	16	12					
25	RB70	750	1	18	12					

Add Sprinkler | Delete Sprinkler(s) | Reorder Sprinklers | Previous Screen

To Add or Delete Sprinkler: Place Cursor on Desired Position for Change, then Click Add or Delete Button.

Sprinkler Package Design Chart

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

CPED PRINTOUT FOR WISHNE-SAMPLE-C

PUMP TO PIVOT PIPE DATA

I.D. INCHES	LENGTH FT.	D-W RES COEF	TOTAL DYNAMIC LIFT FT.
10	1	0.02	0

SPRINKLER PIPE DATA

I.D. RISER PIPE INCHES	SPRINKLER I.D. INCHES	D-W RES COEF	START DIST FT.
10	6.417	0.02	158.16

GENERAL SPRINKLER DATA

TOTAL # SPRINKLERS	TOTAL # DIFF MODELS	BOOSTER PUMP INCREASE - PSI	TYPE PRESS CONTROL	HRS/REV
96	2	30.28	CONSTANT PRESSURE	14.68

SIMULATION RESULTS

HEAD AT PUMP FT/STAGE	PIVOT PRESS PSI	Q-PUMP CURVE GPM	Q-DEPTHS GPM	EFFECTIVE Q-DEPTHS GPM
98.8	38.85	800.2	667.9	667.9

EFFECTIVE IRR AREA - ACRES	FIELD BOUNDARY FT.	MIN DEPTH INCHES	MEAN DEPTH INCHES
123.4	1317.66	0	0.18

UNIFORMITY

UNIFORMITY COEF	LOW QUARTER DISTRIBUTION UNIFORMITY
97.2	95.2

Sample CPED Printout – WISH corp.