Virtual Irrigation Audits in Real Time

Larry Stowell
Wendy Gelernter
www.paceturf.org

Objective

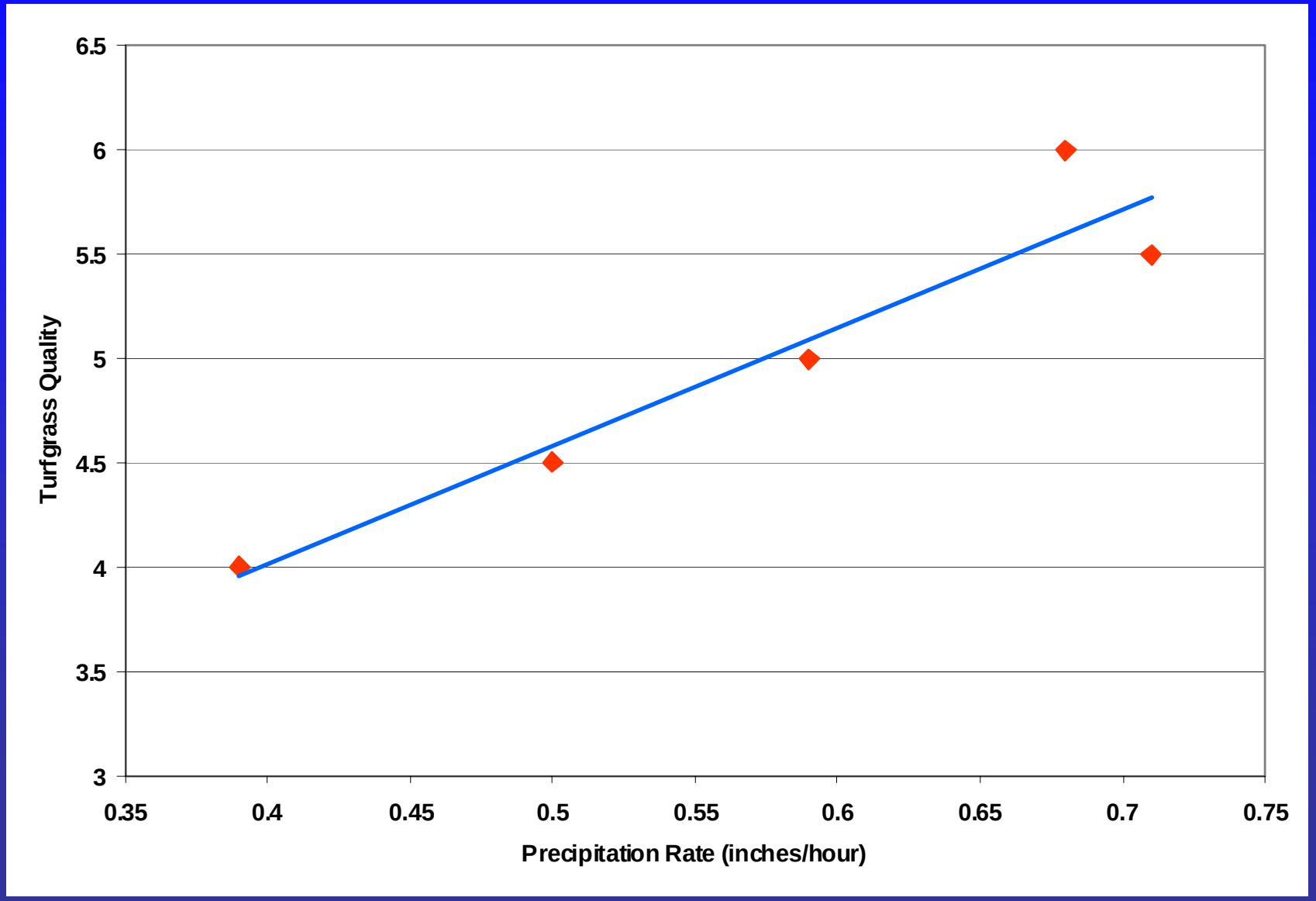
- Develop a rapid, in-field irrigation distribution auditing system based upon geospatial arrangement of irrigation heads
- Validate the audit system using catch cans and theoretical irrigation distribution

Why Bother?

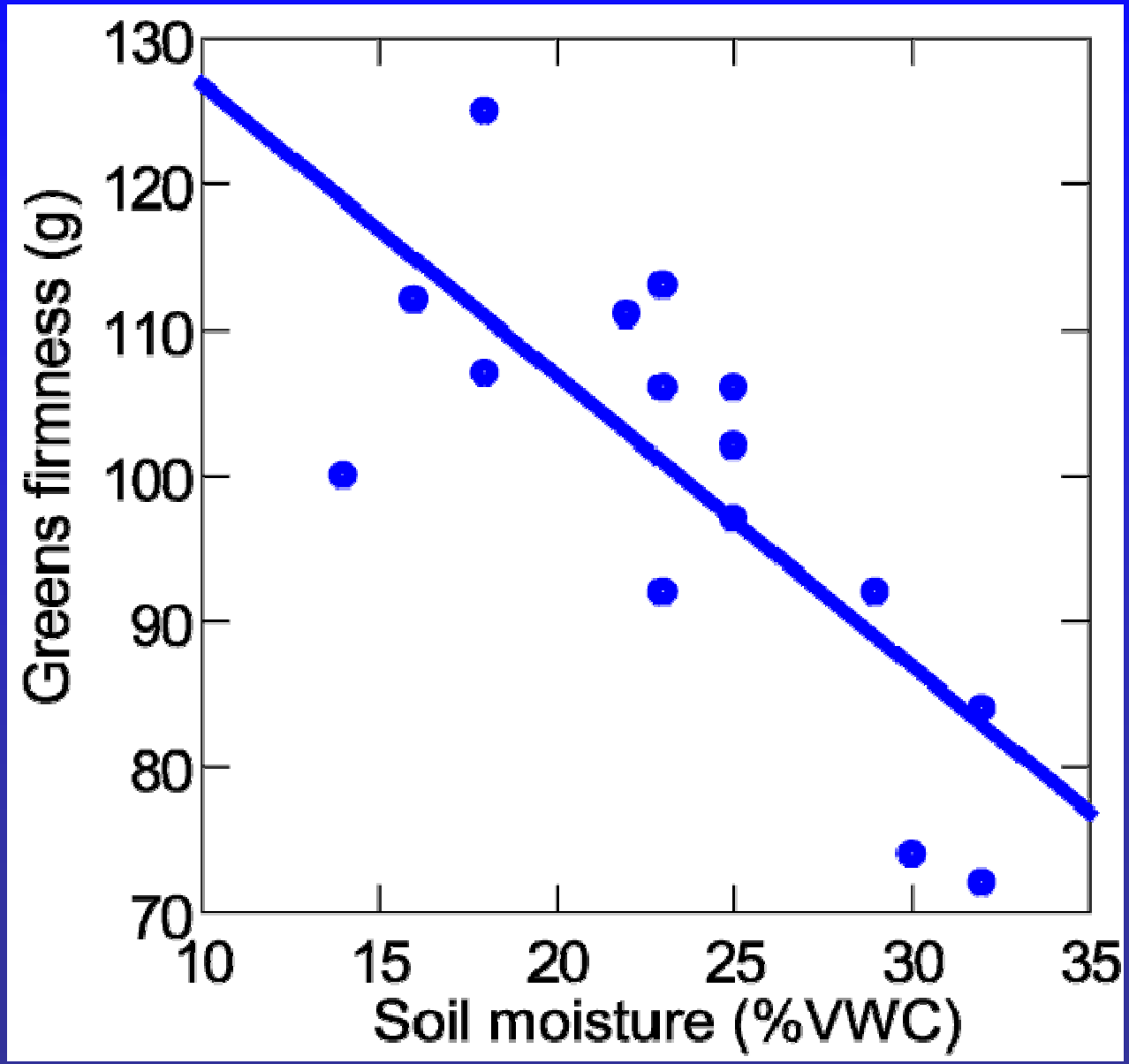
- Poor irrigation distribution leads to:
  - unnecessary water use
  - poor playability, with overly wet/soft and overly dry/hard areas
- Current audit procedures (catch-cans) are time consuming, infrequently used
- There is a need for a more rapid procedure that can diagnose irrigation distribution/design problems

Irrigation Distribution Problem

Turfgrass Quality Vs. Precipitation Rate



Greens Firmness



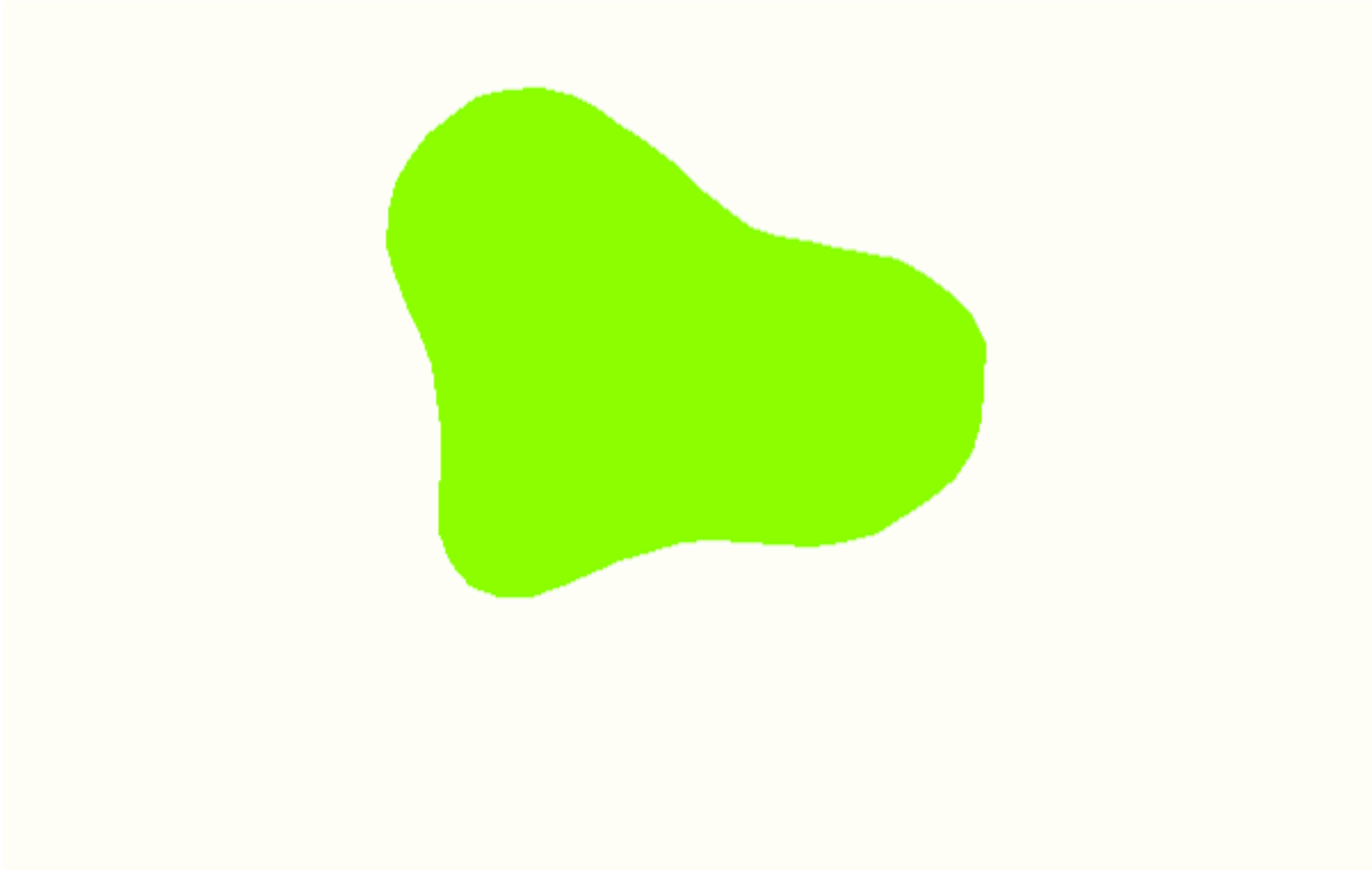
Virtual Irrigation Audit Defined

Rapid in-field geospatial evaluation of irrigation distribution to identify areas of probable low or high precipitation rate.

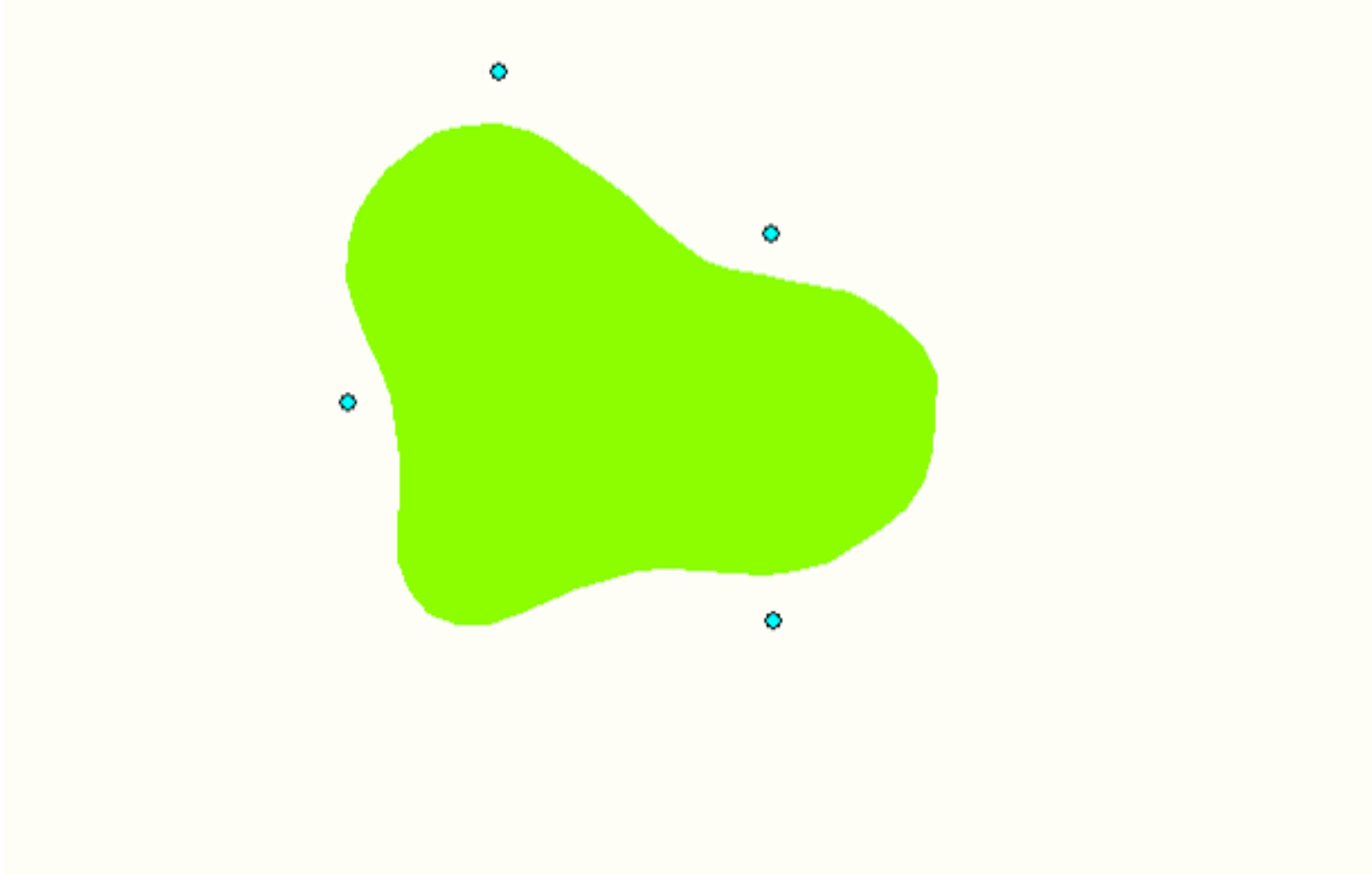
Simple as 1, 2, 3

1. Map the perimeter of the green (GPS/GIS)
2. Map the location of each irrigation head (GPS/GIS)
3. Project the theoretical throw (based on system specifications) of each irrigation head, and the number of heads impacting each area (GIS)

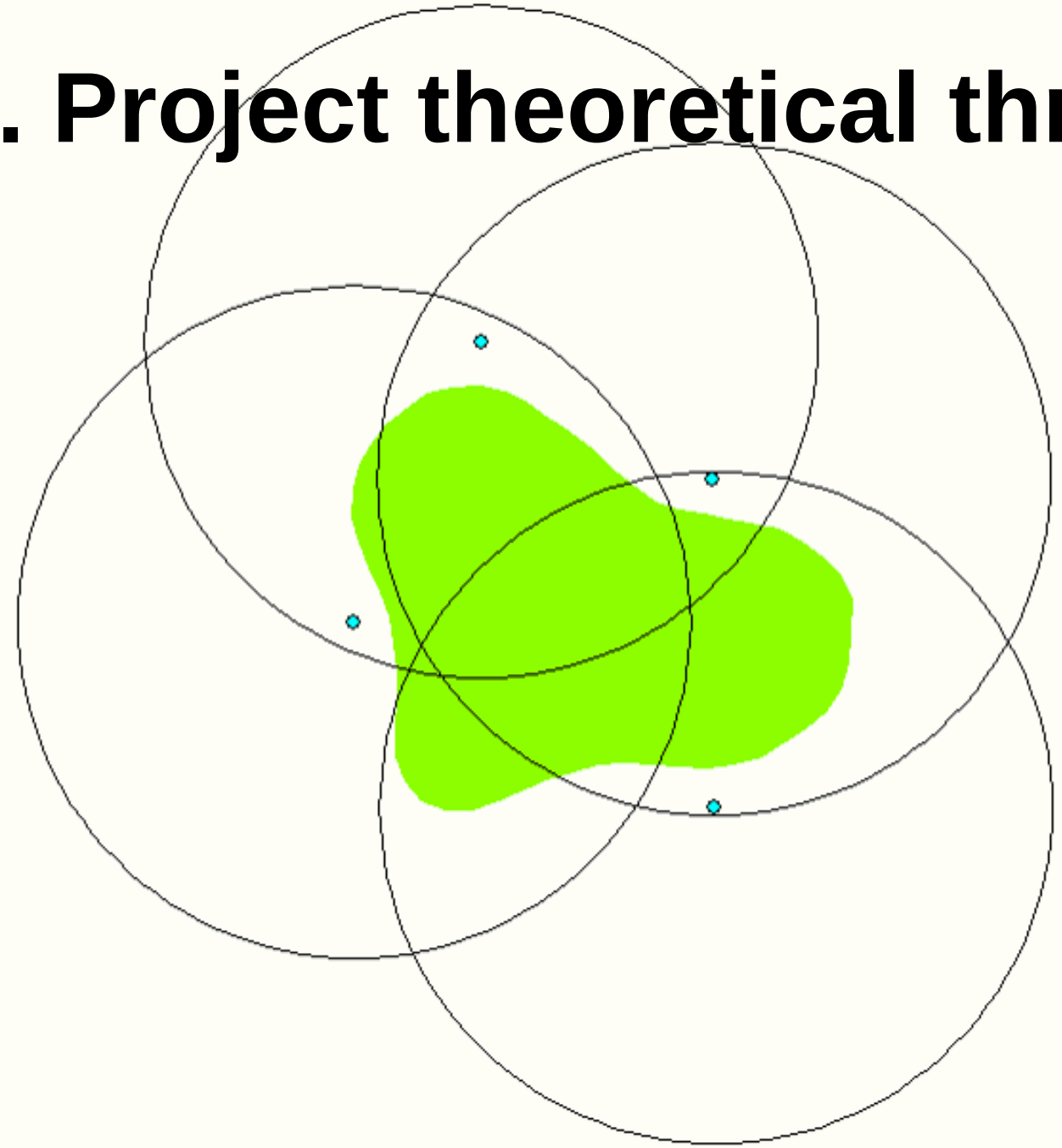
1. Map perimeter



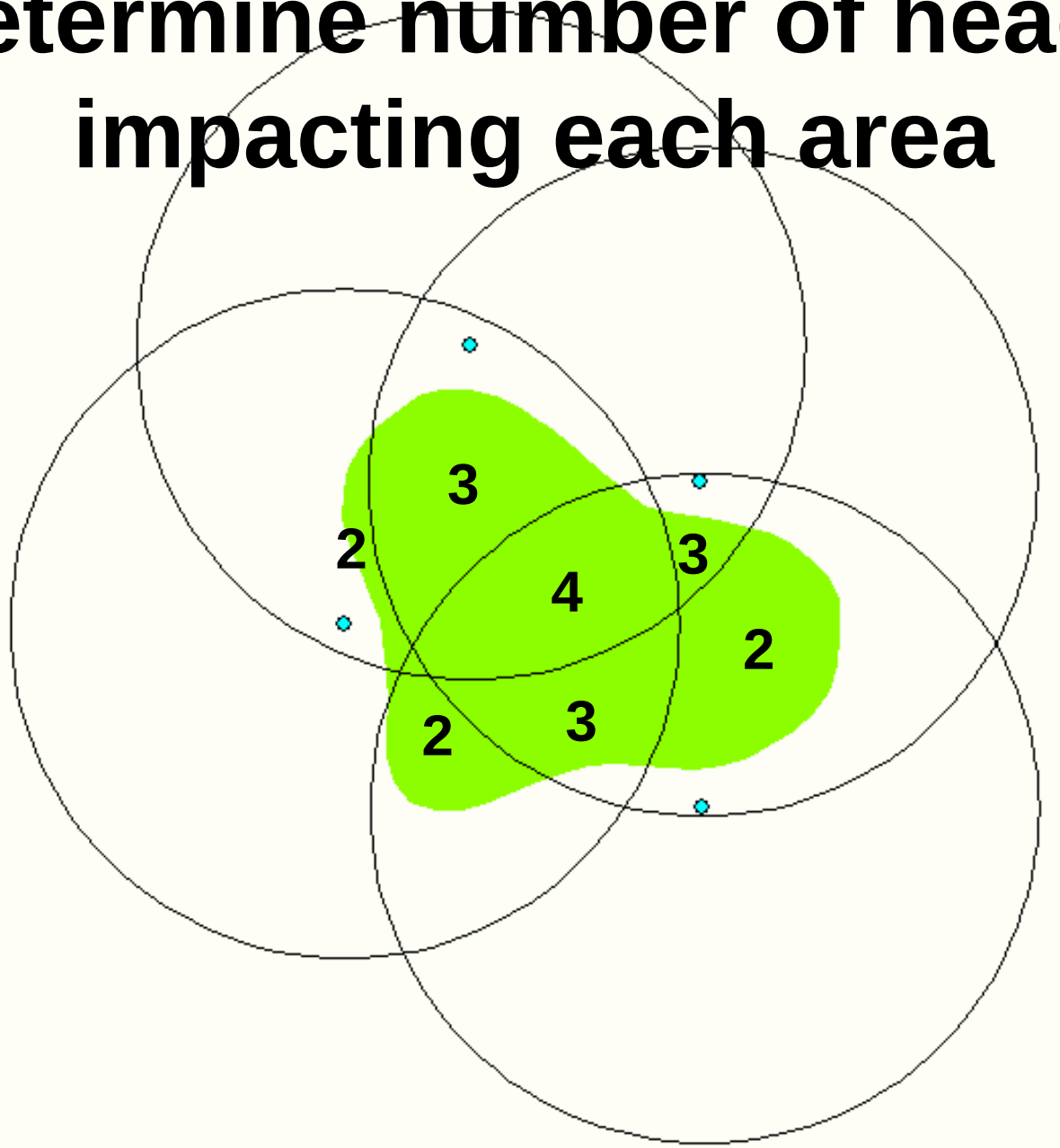
2. Map head locations



3. Project theoretical throw



Determine number of heads impacting each area



Equipment

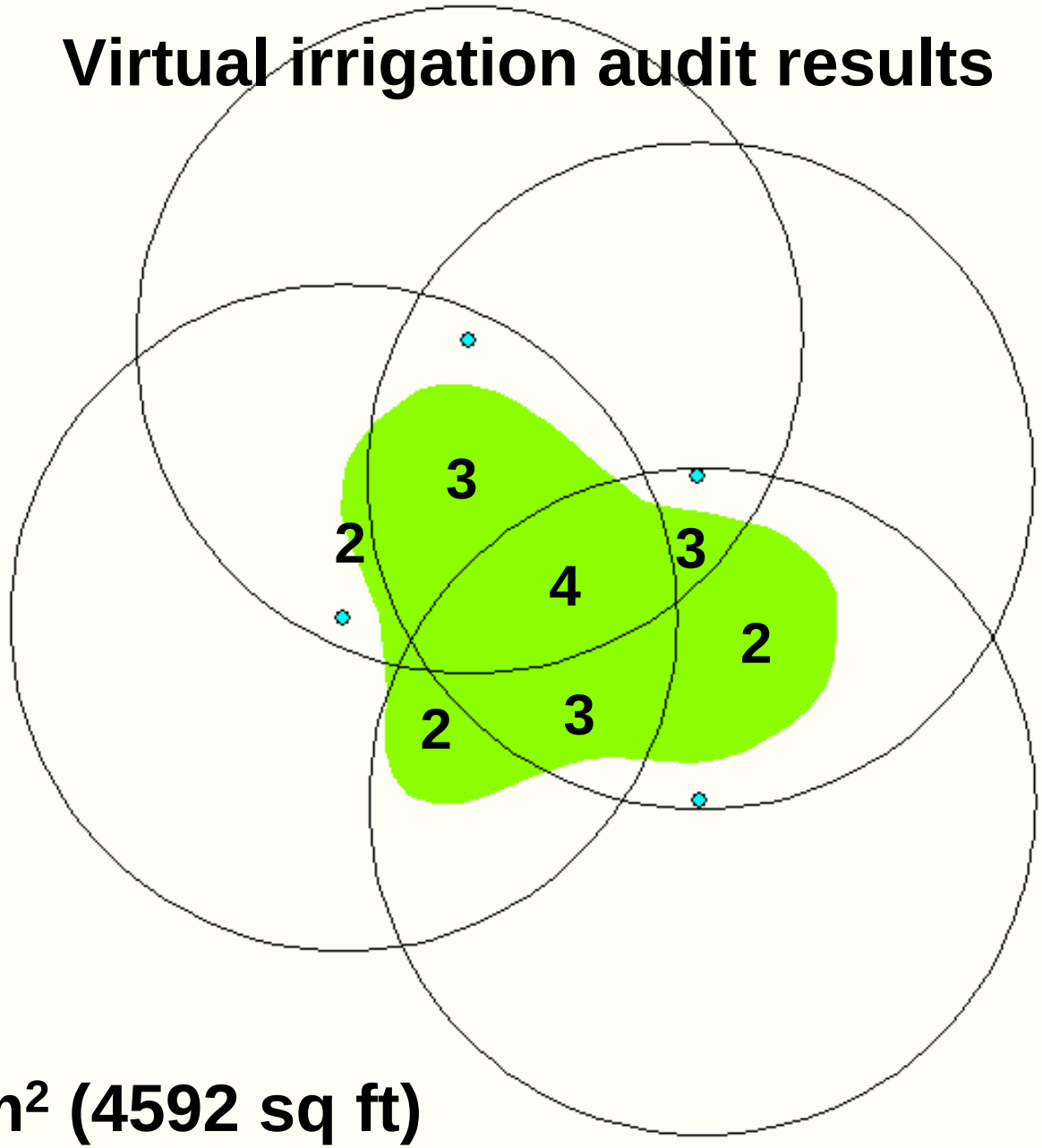
- Trimble AgGPS 132 sub meter GPS www.trimble.com
- HGIS handheld GIS system from StarPal www.starpal.com
- Tripod Data Systems (TDS) 400 handheld computer www.tdsway.com

Validation

The number of heads that the virtual audit predicts will impact an area was compared to:

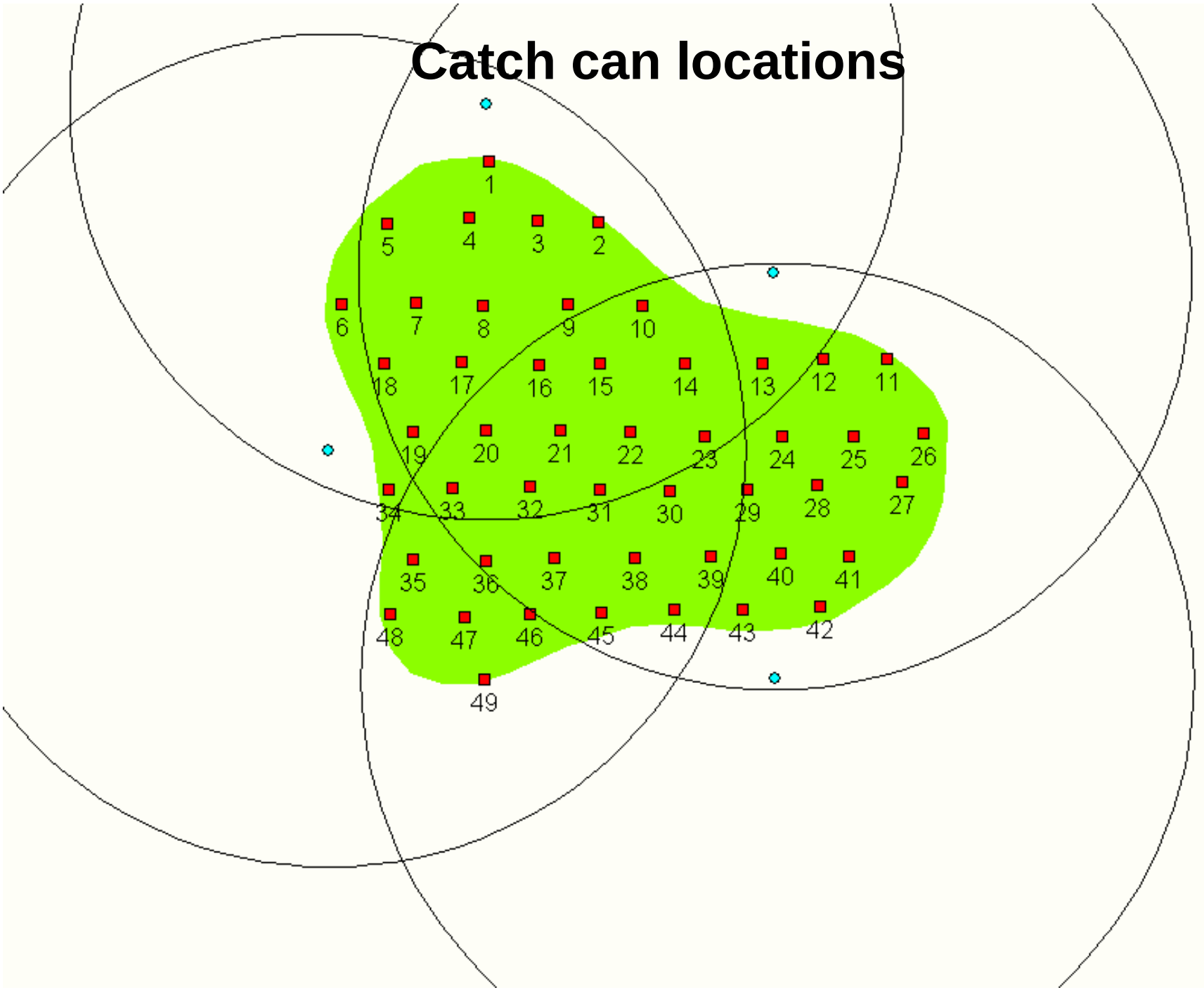
- the observed precipitation rate (as determined by a catch can assay)
- the theoretical precipitation rate (calculated based on system specifications)
- soil moisture

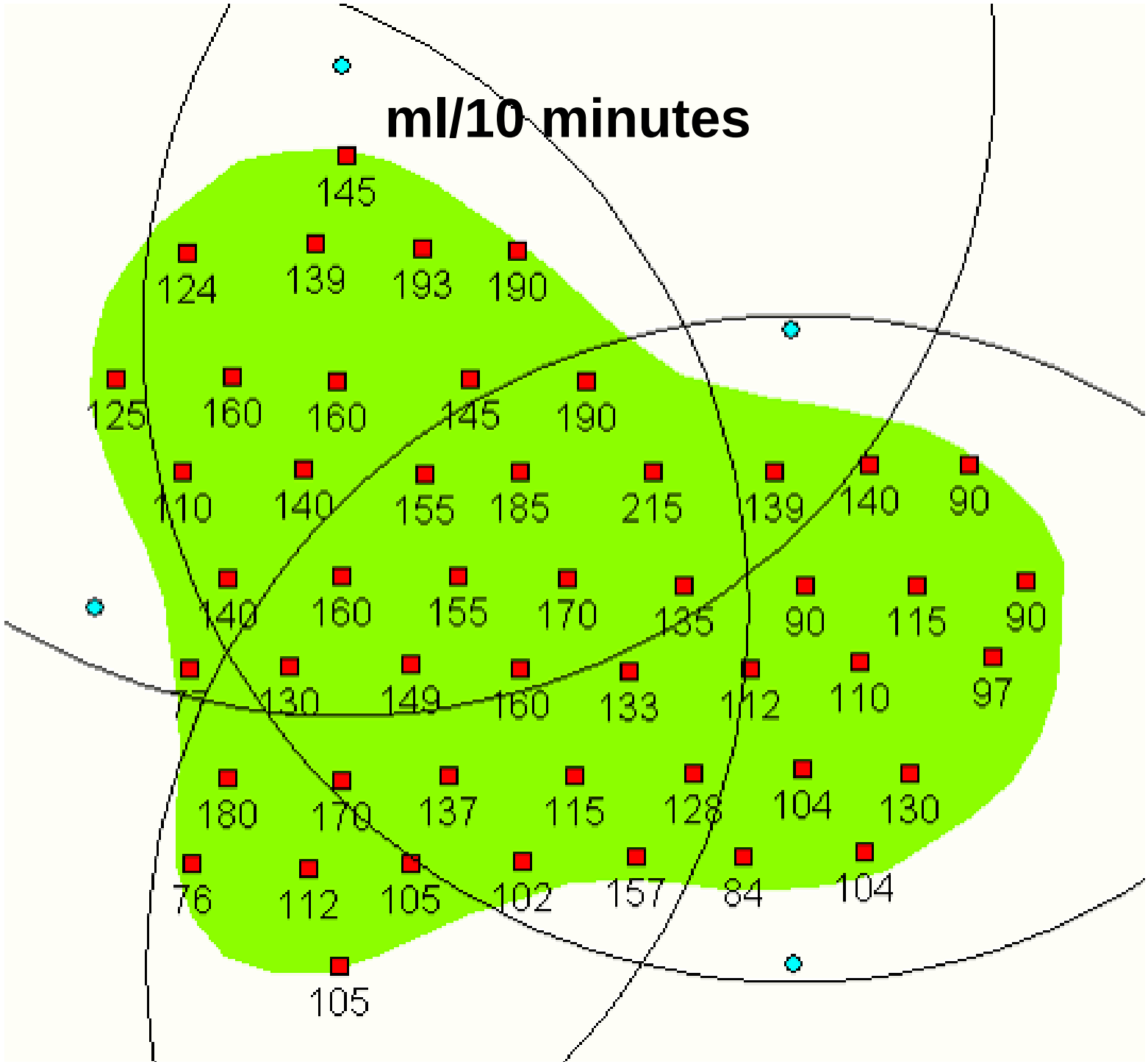
Virtual irrigation audit results

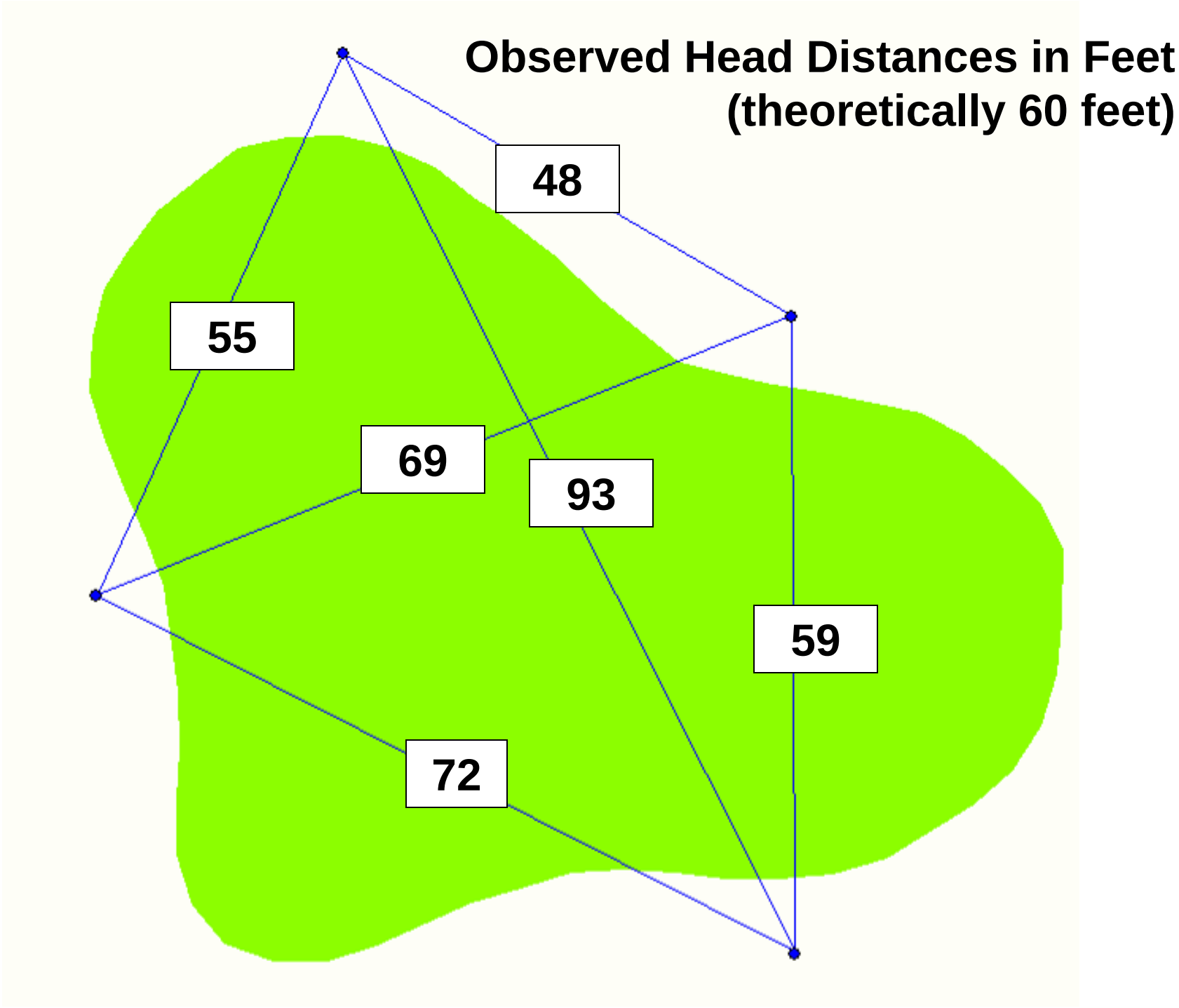


413 m^2 (4592 sq ft)

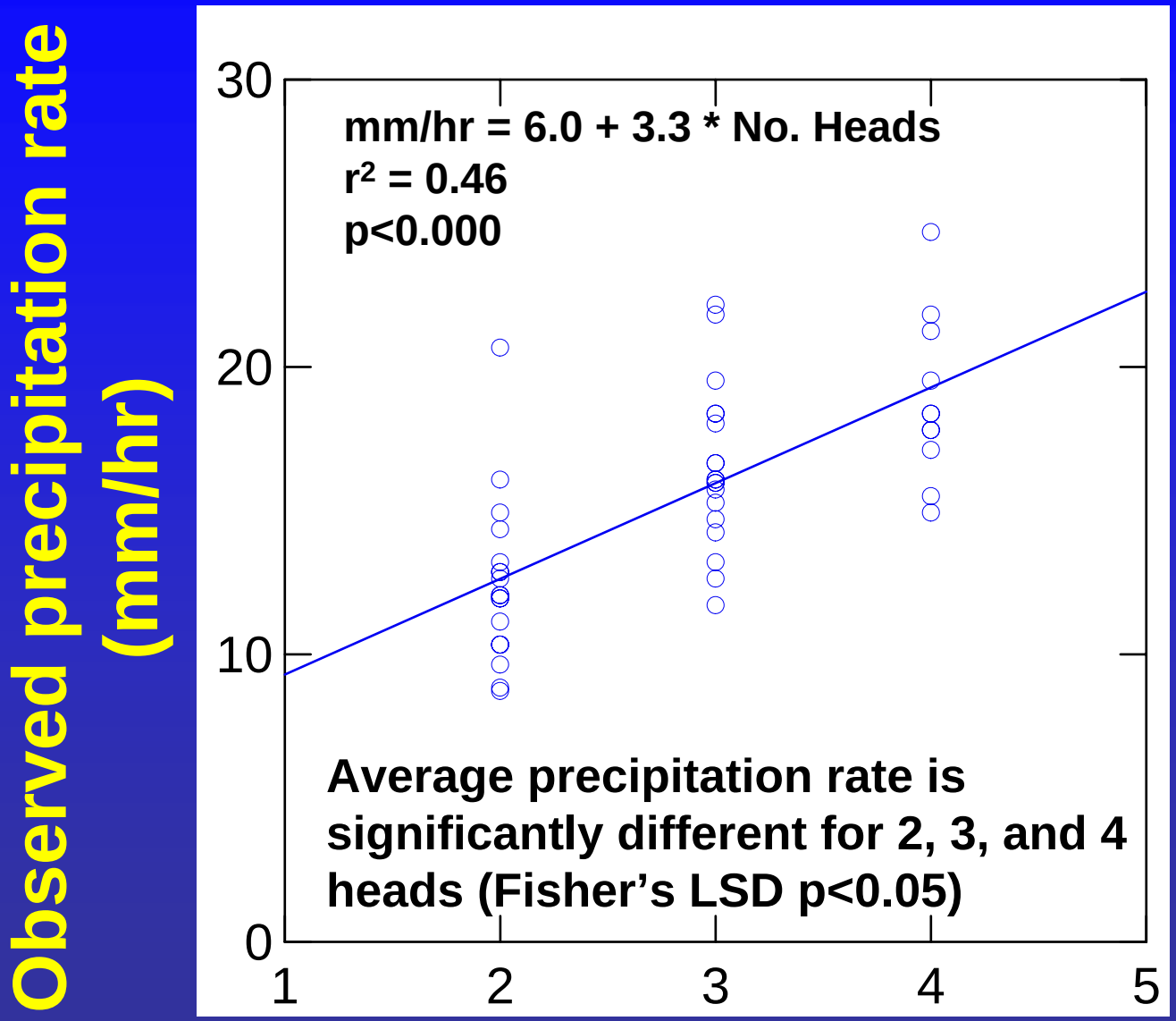
Catch can locations




ml/10 minutes
145
124
139
193
190
125
160
160
145
190
110
140
155
185
215
139
140
90
140
160
155
170
135
90
115
90
130
149
160
133
112
110
97
180
170
137
115
128
104
130
76
112
105
102
157
84
104
105


Observed Head Distances in Feet
(theoretically 60 feet)
48
55
69
93
59
72

Observed Precipitation vs. Number of Heads

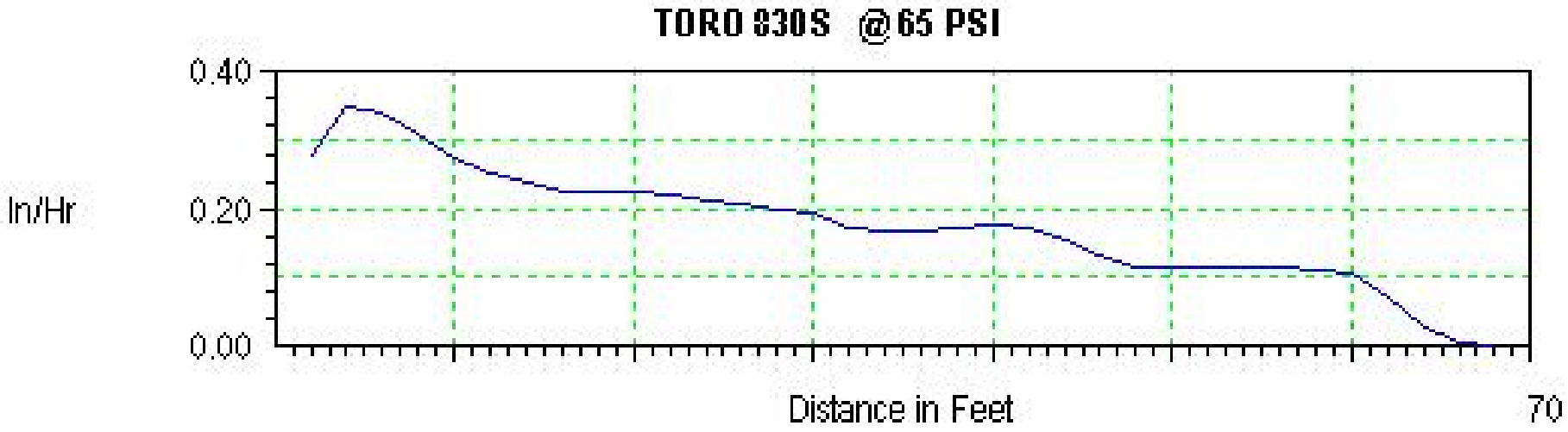


Theoretical Precipitation

- Georeference heads and catch cans and then compute distances between heads and catch cans.
- Theoretical precipitation rate determined based upon head performance (Center for Irrigation Technology assay) and distance from head to catch can.

$$\text{Distance (ft)} = 5280 \times \sqrt{\left((69.1 * (lat1 - lat2)\right)^2 + \left(\left(69.1 * (lon1 - lon2) * \cos\left(\frac{lat1}{57.3}\right)\right)\right)^2}$$

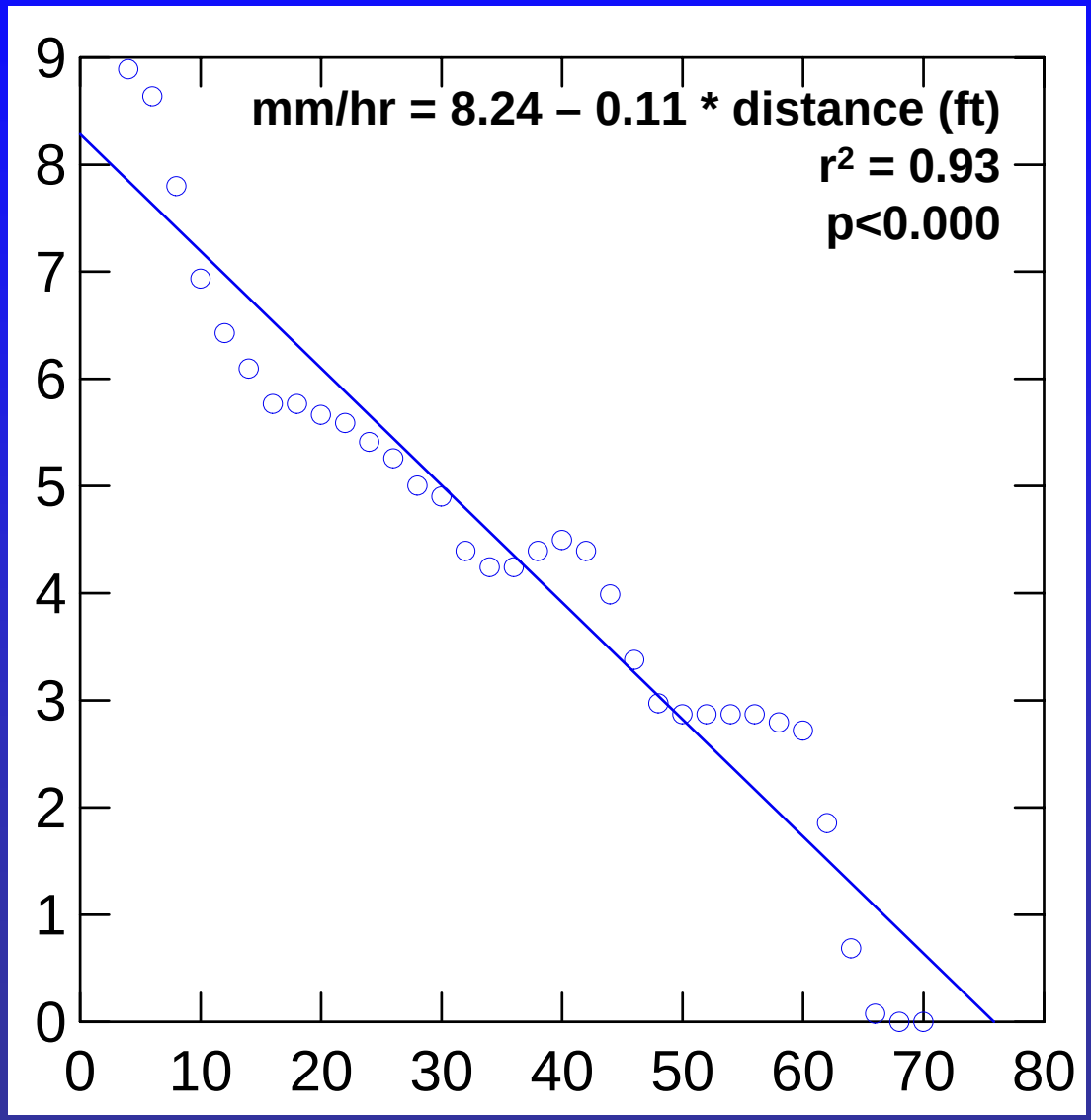
Center for Irrigation Technology Assay



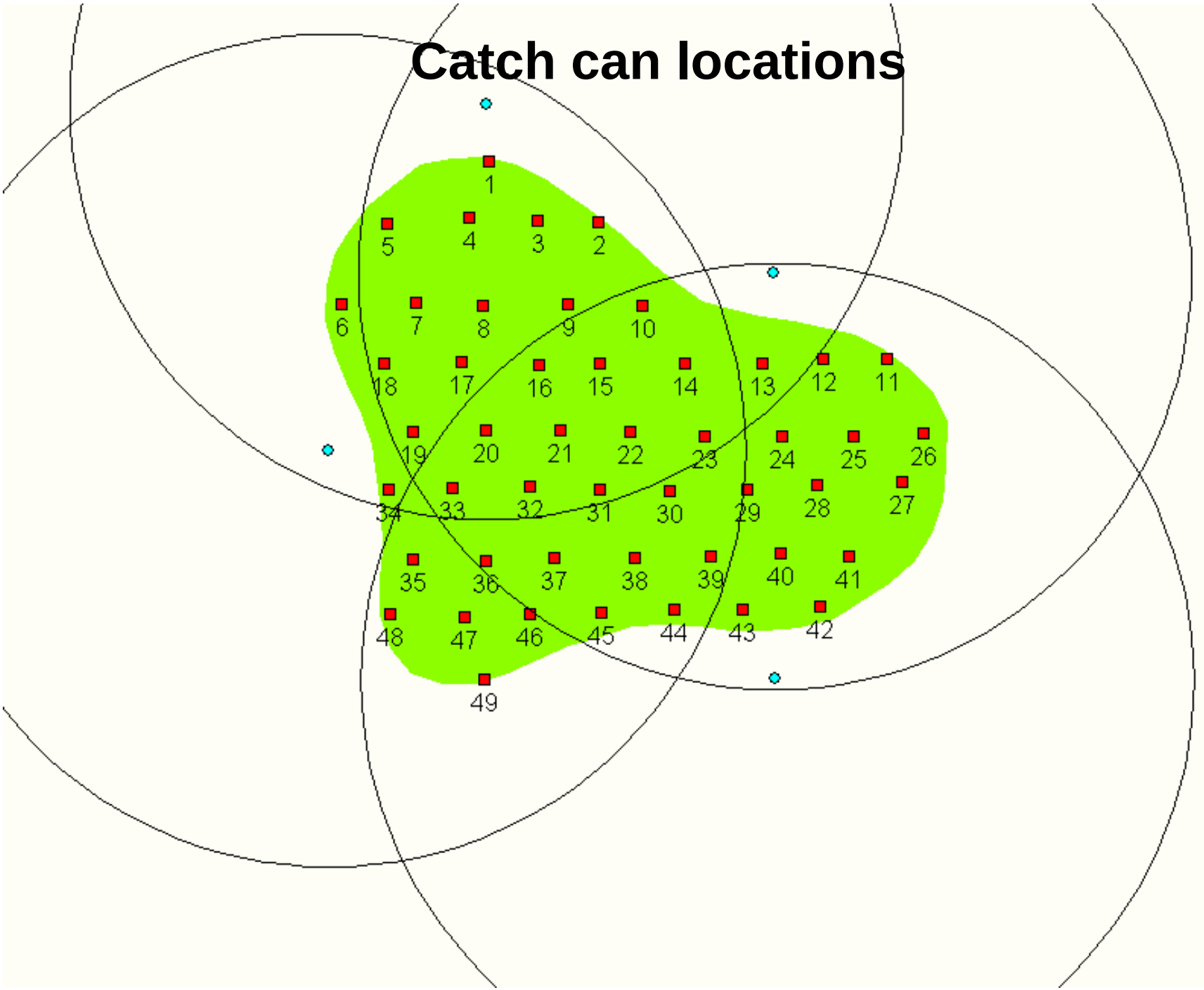
http://cati.csufresno.edu/cit/good/citprofiles.html

2.0 =	0.277	20.0 =	0.223	38.0 =	0.173	56.0 =	0.113
4.0 =	0.350	22.0 =	0.220	40.0 =	0.177	58.0 =	0.110
6.0 =	0.340	24.0 =	0.213	42.0 =	0.173	60.0 =	0.107
8.0 =	0.307	26.0 =	0.207	44.0 =	0.157	62.0 =	0.073
10.0 =	0.273	28.0 =	0.197	46.0 =	0.133	64.0 =	0.027
12.0 =	0.253	30.0 =	0.193	48.0 =	0.117	66.0 =	0.003
14.0 =	0.240	32.0 =	0.173	50.0 =	0.113		
16.0 =	0.227	34.0 =	0.167	52.0 =	0.113		
18.0 =	0.227	36.0 =	0.167	54.0 =	0.113		

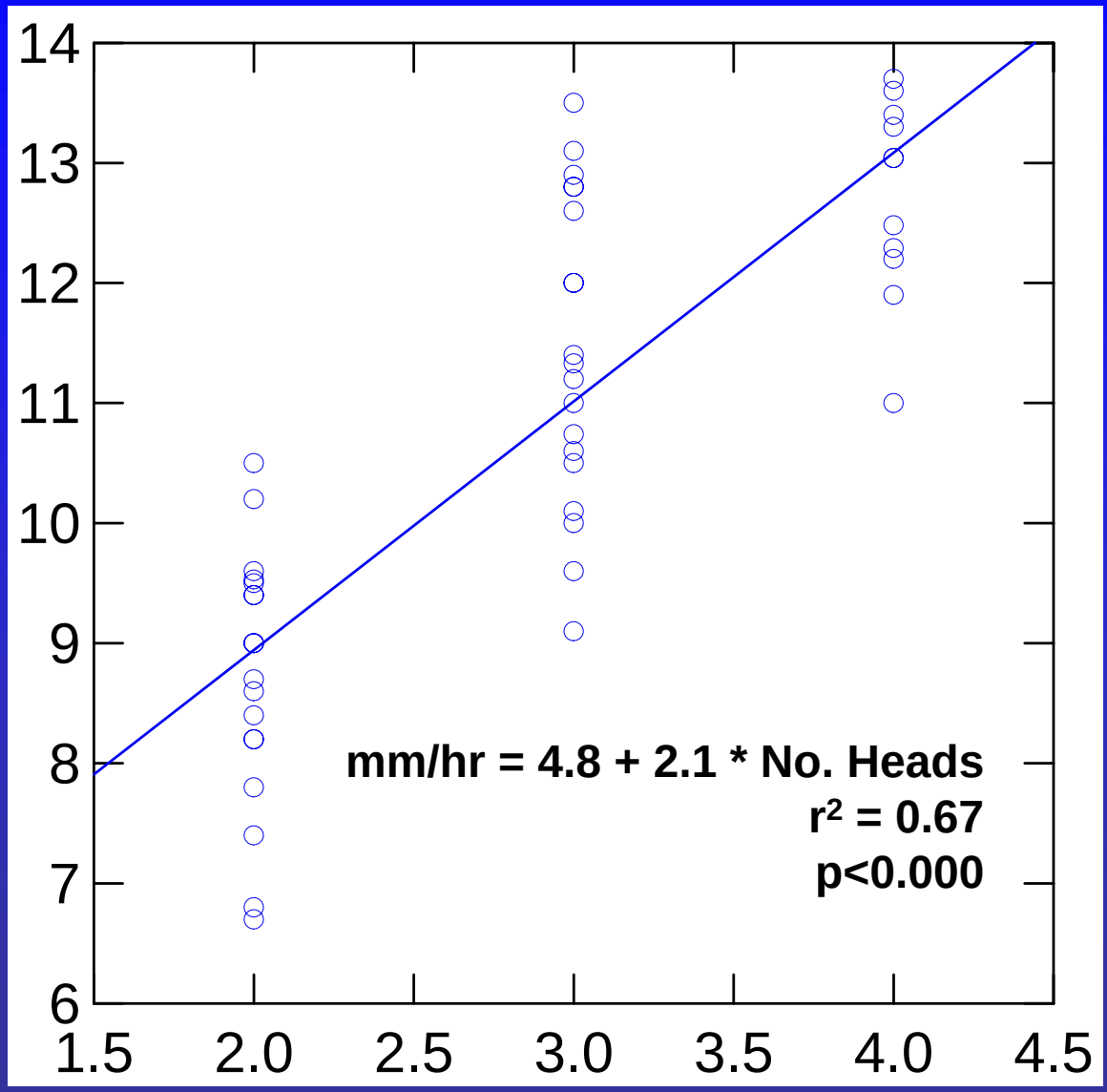
Toro 830 Head Performance



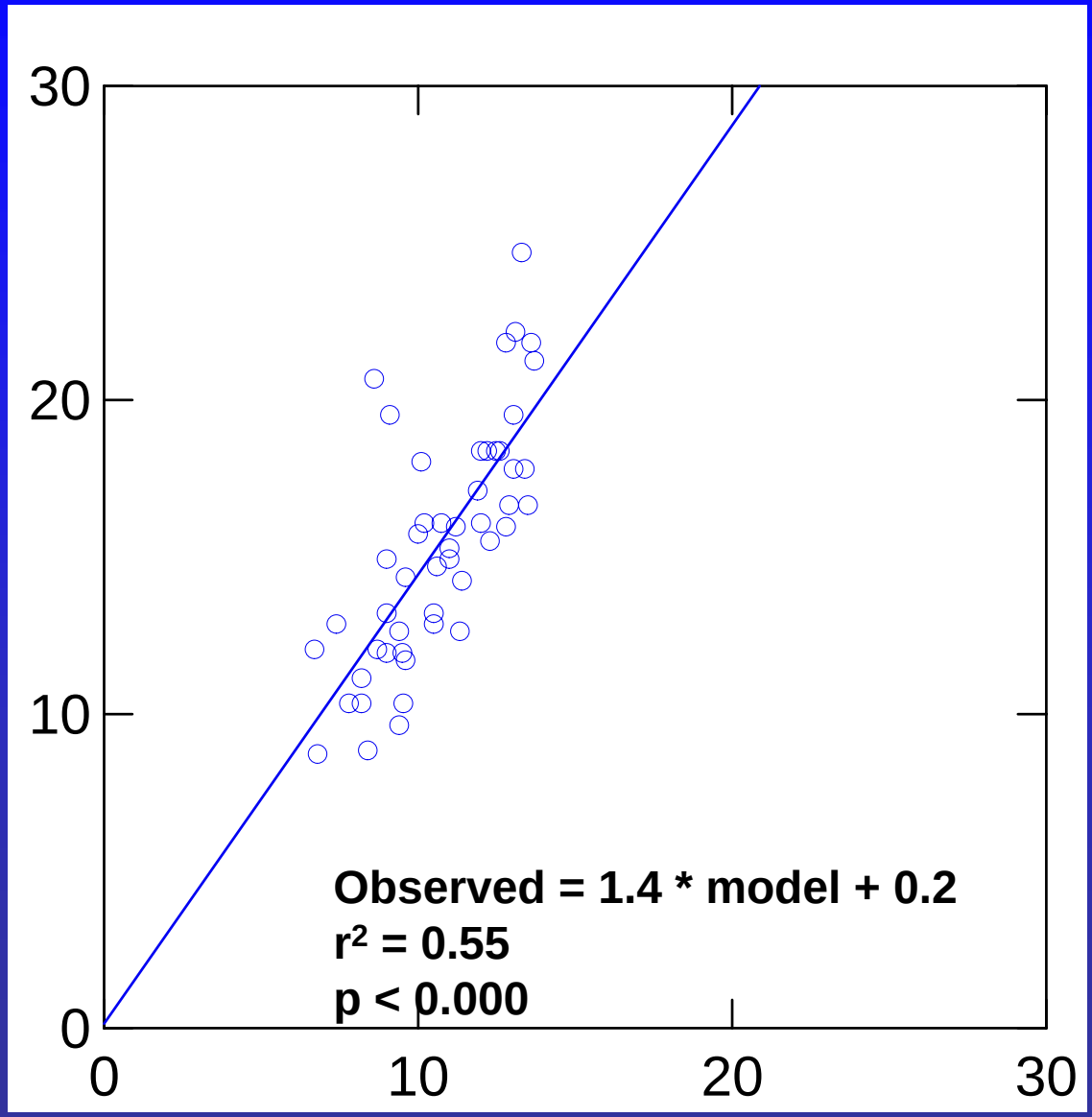
Catch can locations



Toro 830 Theoretical Precipitation



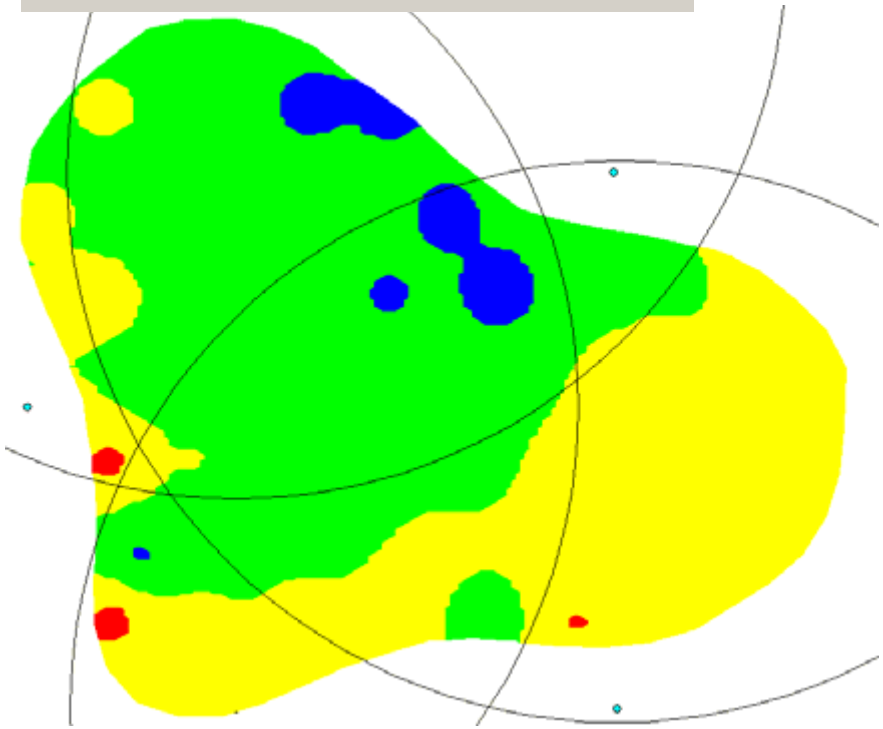
Observed vs. Theoretical Precipitation



Observed vs. Theoretical Distribution

mm/hr Observed

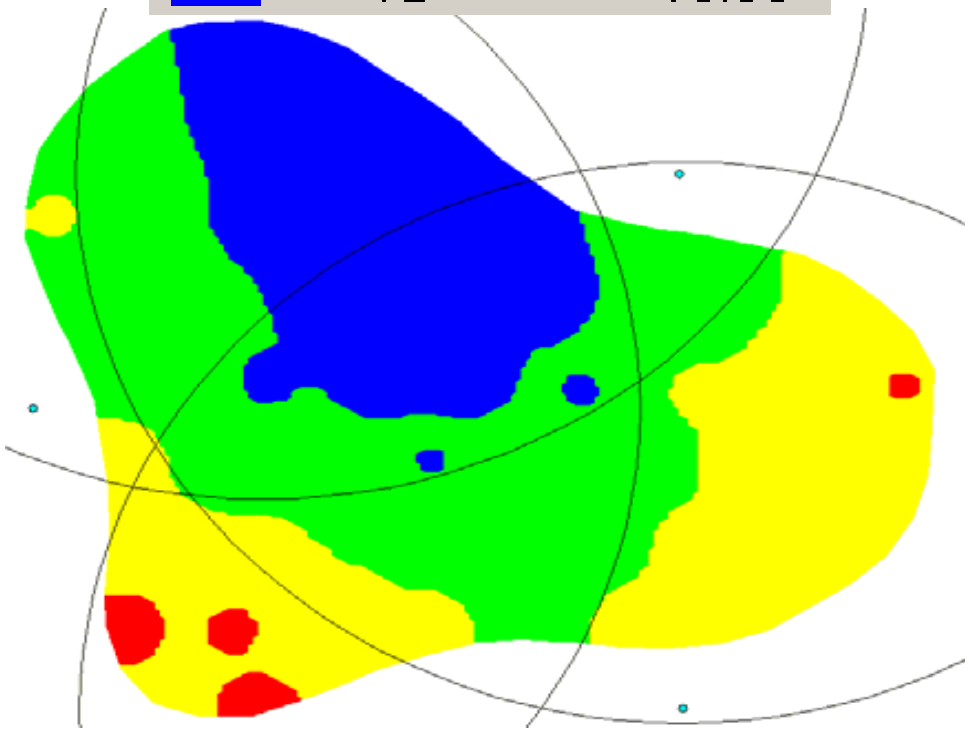
	5	-	10
	10	-	15
	15	-	20
	20	-	24.68



DU = 69

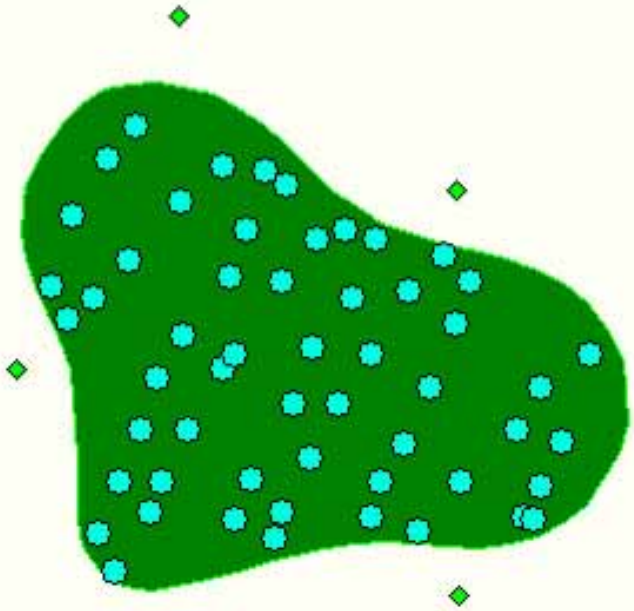
mm/hr Theoretical

	6	-	8
	8	-	10
	10	-	12
	12	-	13.69



DU = 76

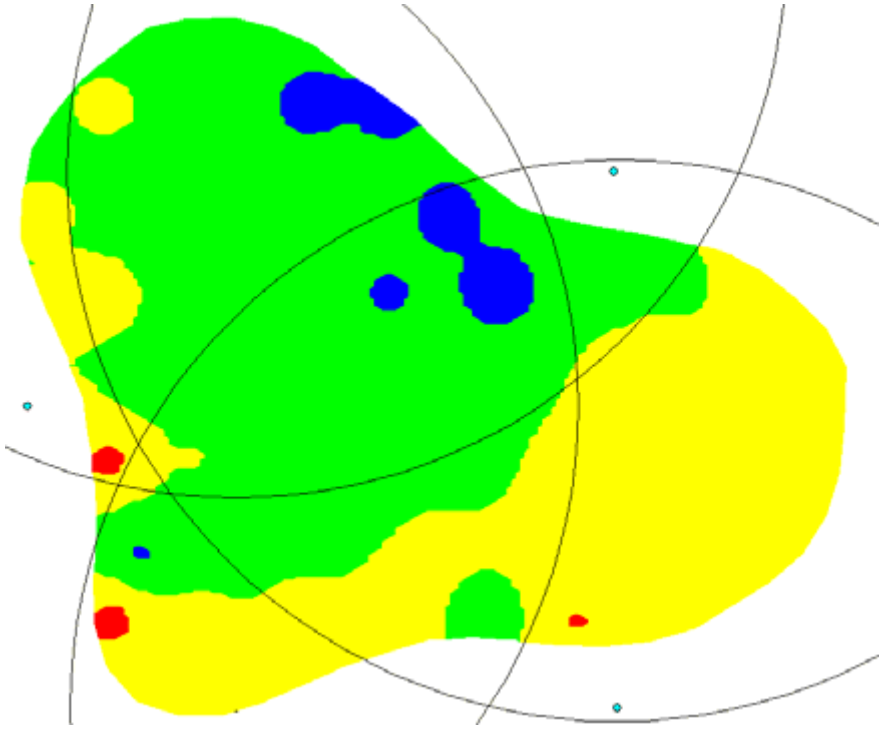
Soil moisture survey



Observed Precipitation vs. Soil Moisture

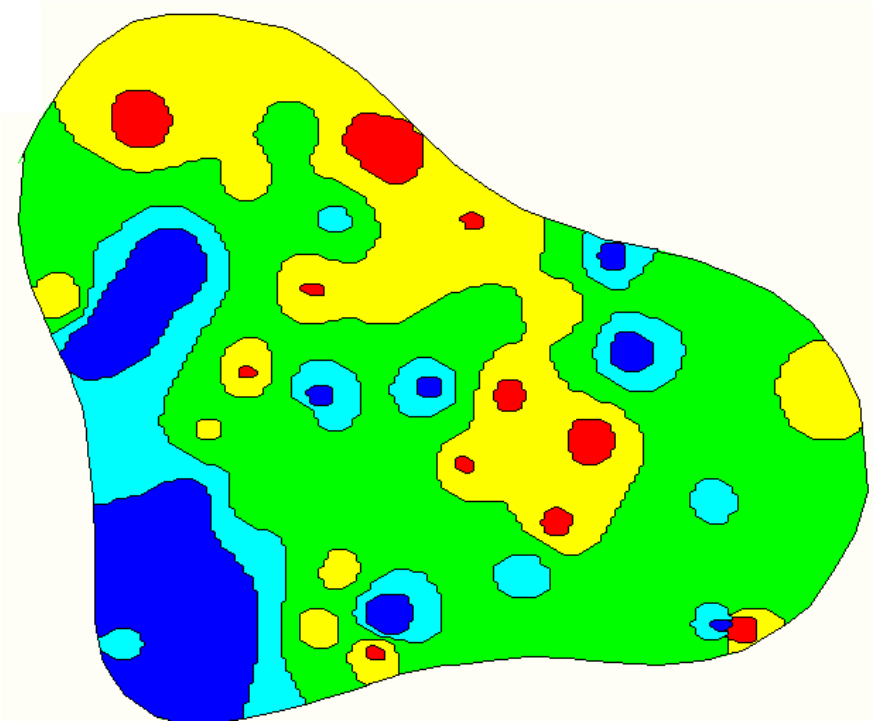
mm/hr Observed

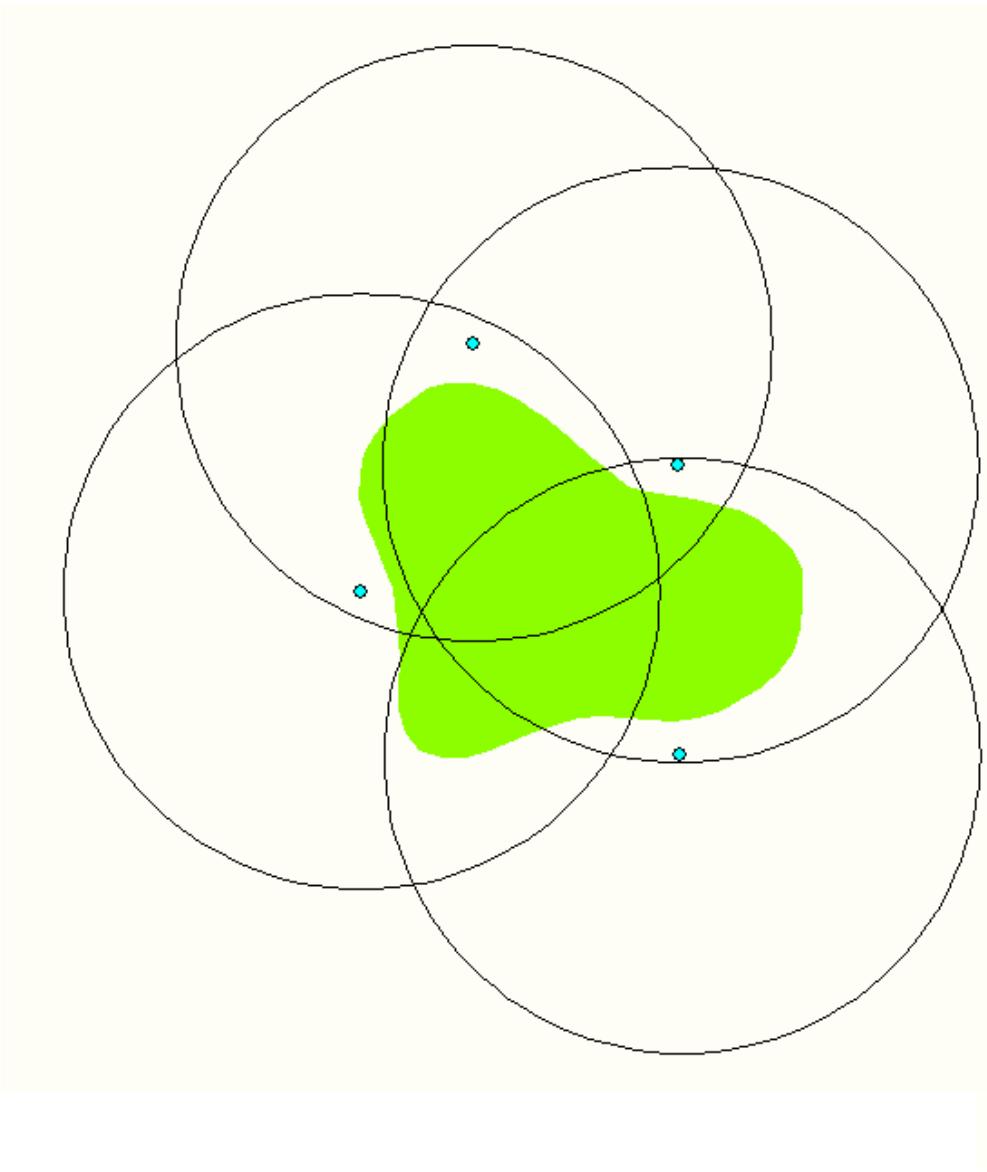
	5	-	10
	10	-	15
	15	-	20
	20	-	24.68

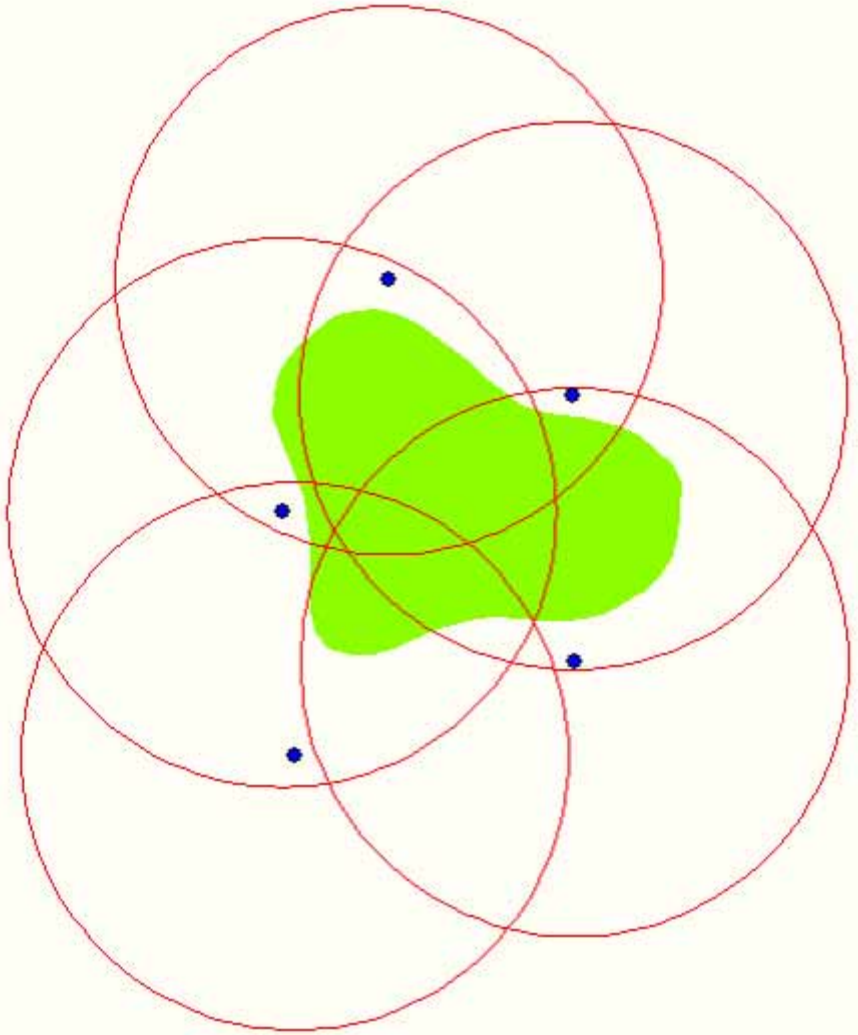


Volumetric Water Content %

	16	-	24
	24	-	28
	28	-	32
	32	-	36
	36	-	56.82

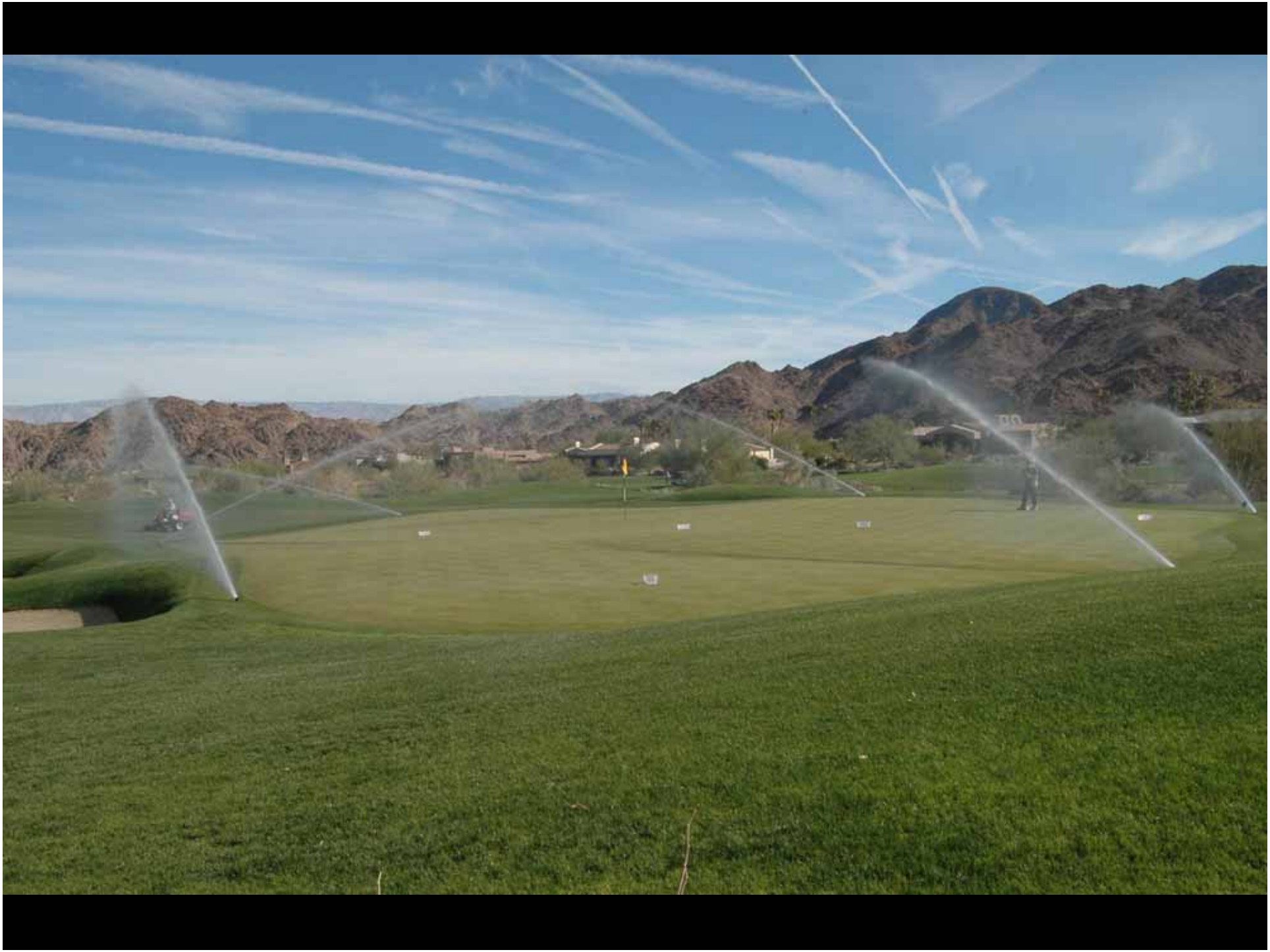




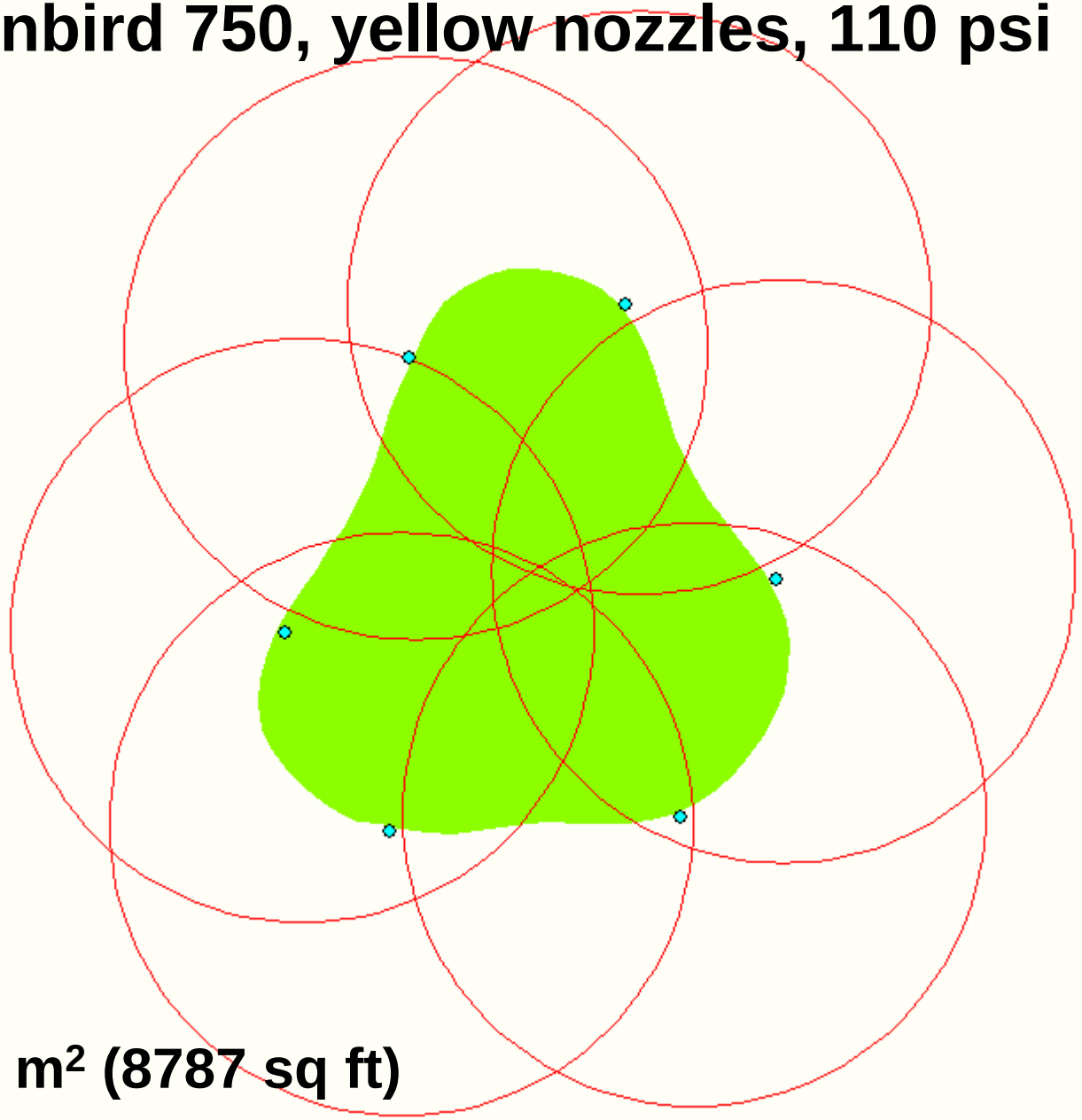


Conclusions

- Virtual irrigation audits are fast and easy
- Accuracy of the audit is sufficient for real-time diagnostic purposes – helping identify design problems that lead to wet and dry areas
- TDR soil moisture surveys add value to the virtual audit

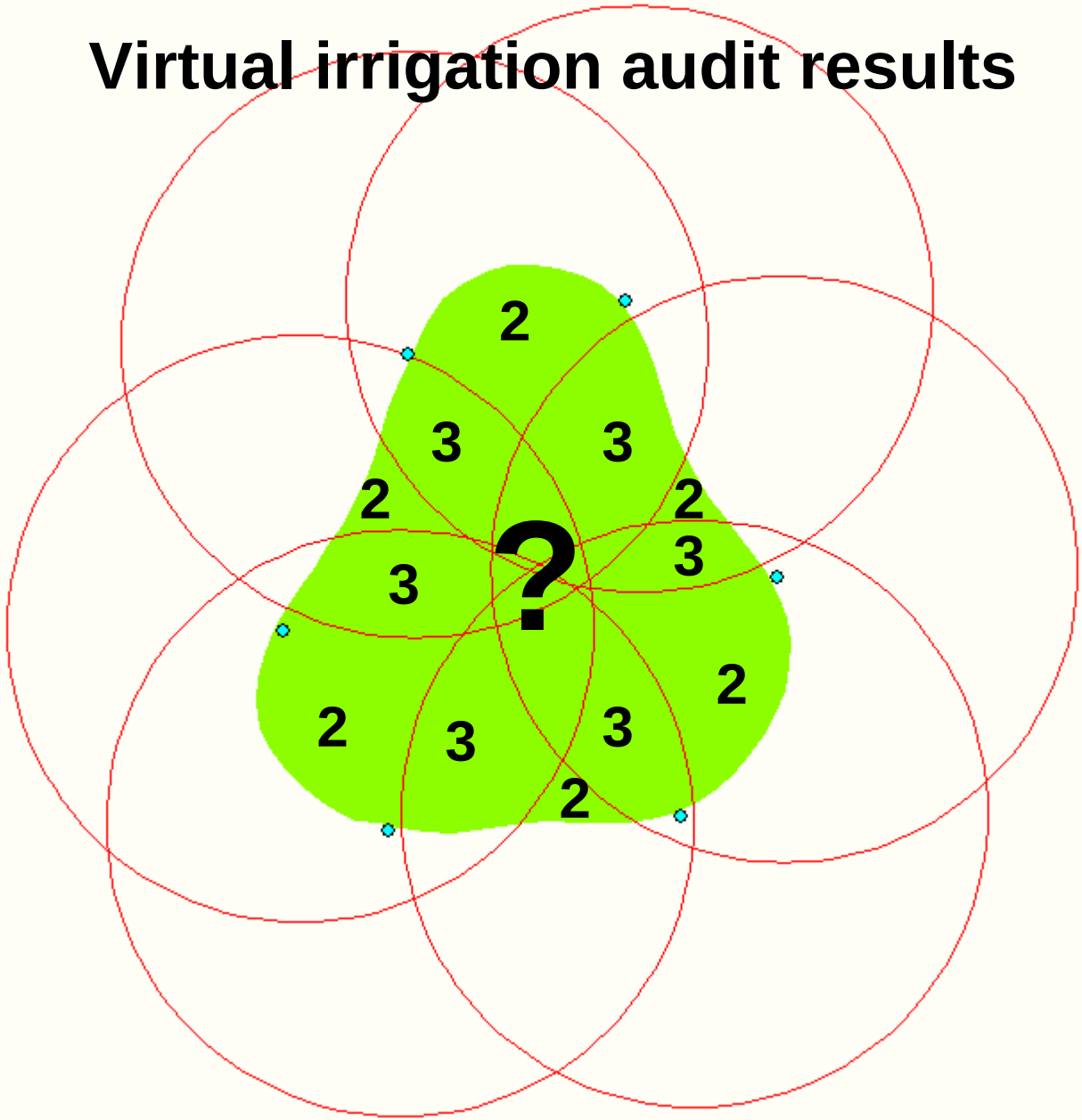


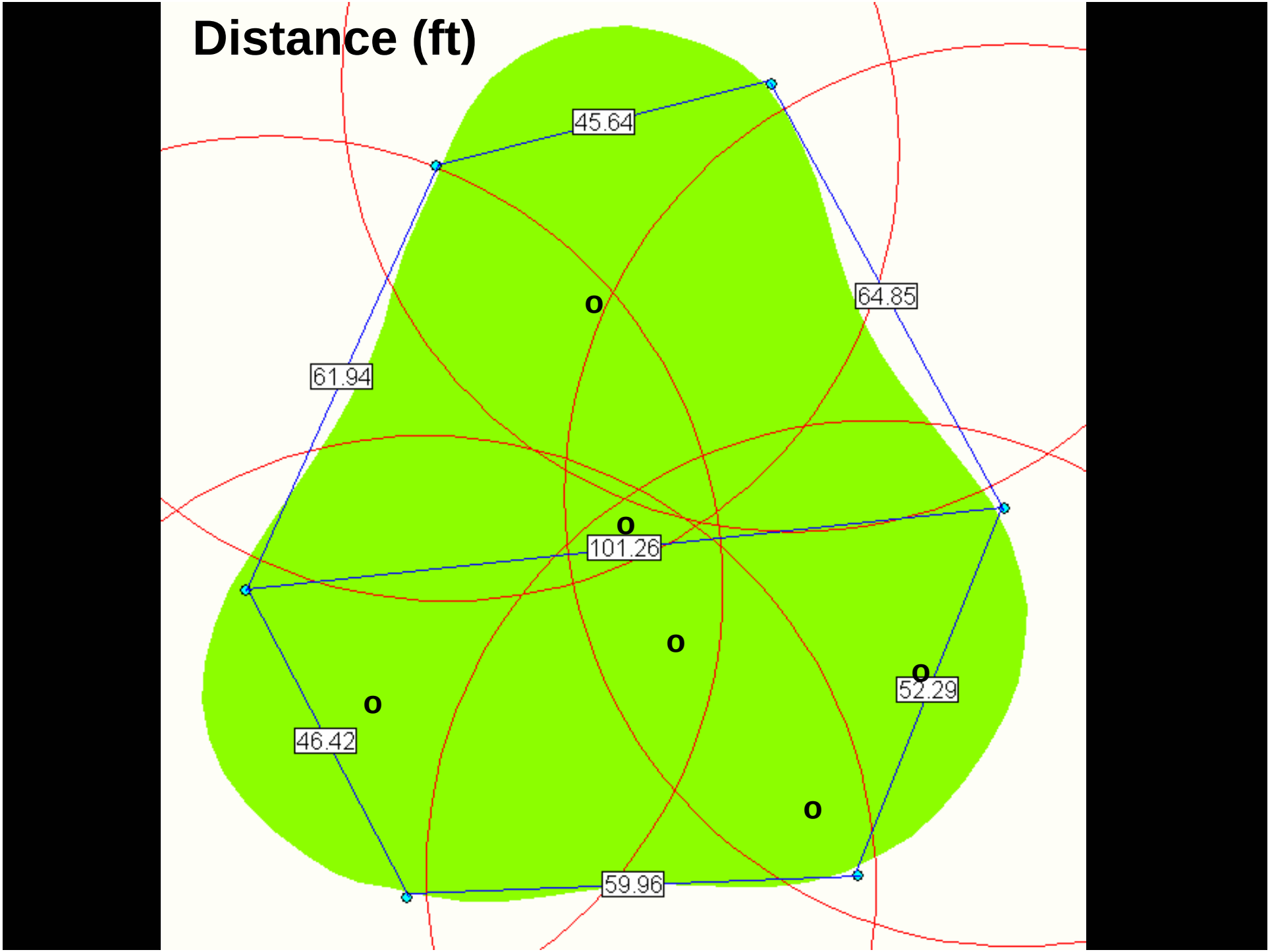
Rainbird 750, yellow nozzles, 110 psi



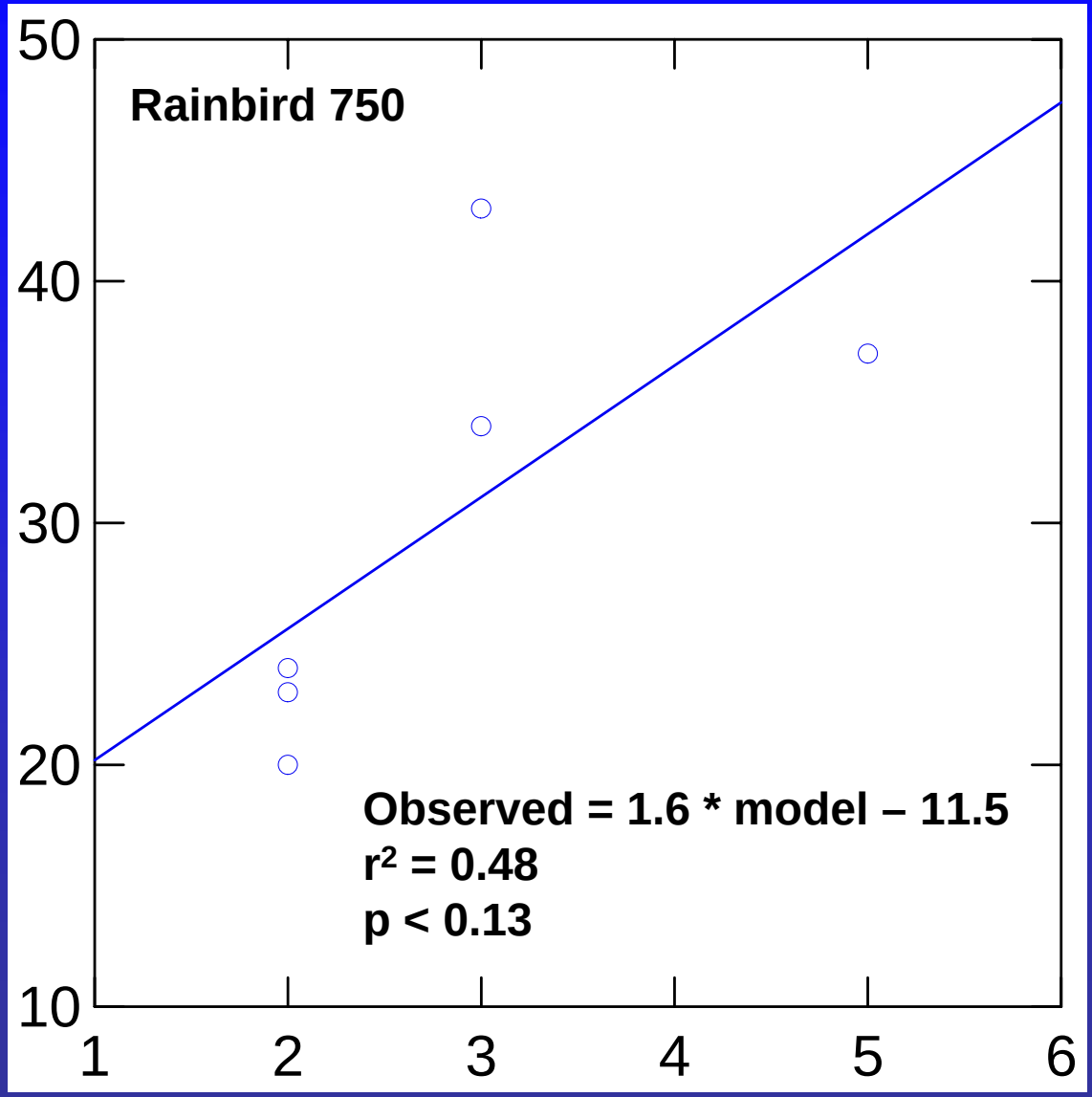
791 m² (8787 sq ft)

Virtual irrigation audit results




Distance (ft)
45.64
64.85
61.94
101.26
52.29
46.42
59.96

Observed Precipitation vs. Number of Heads



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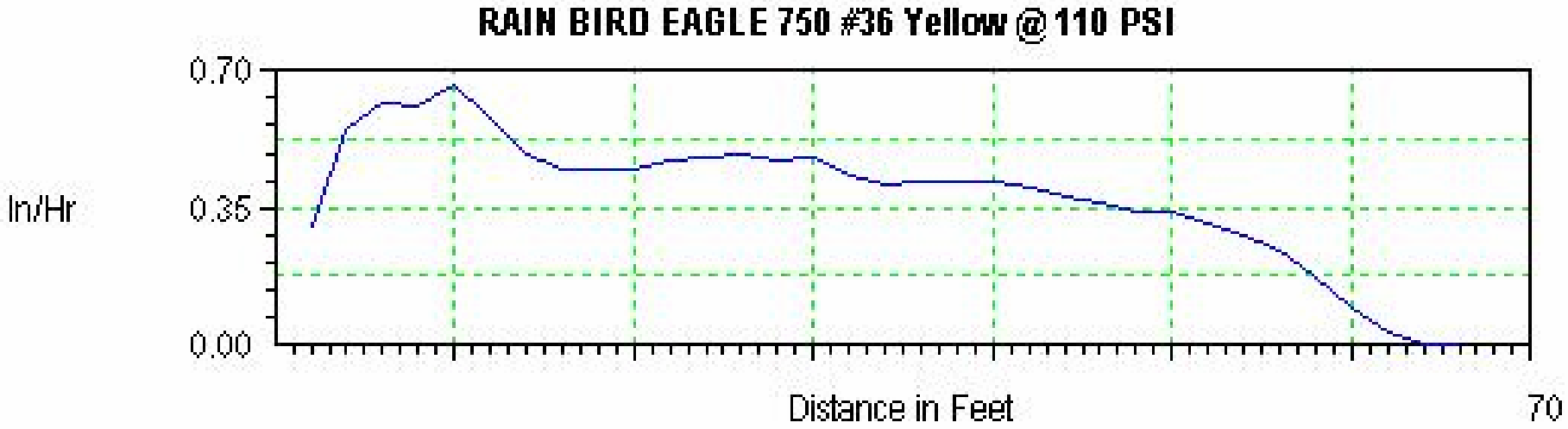
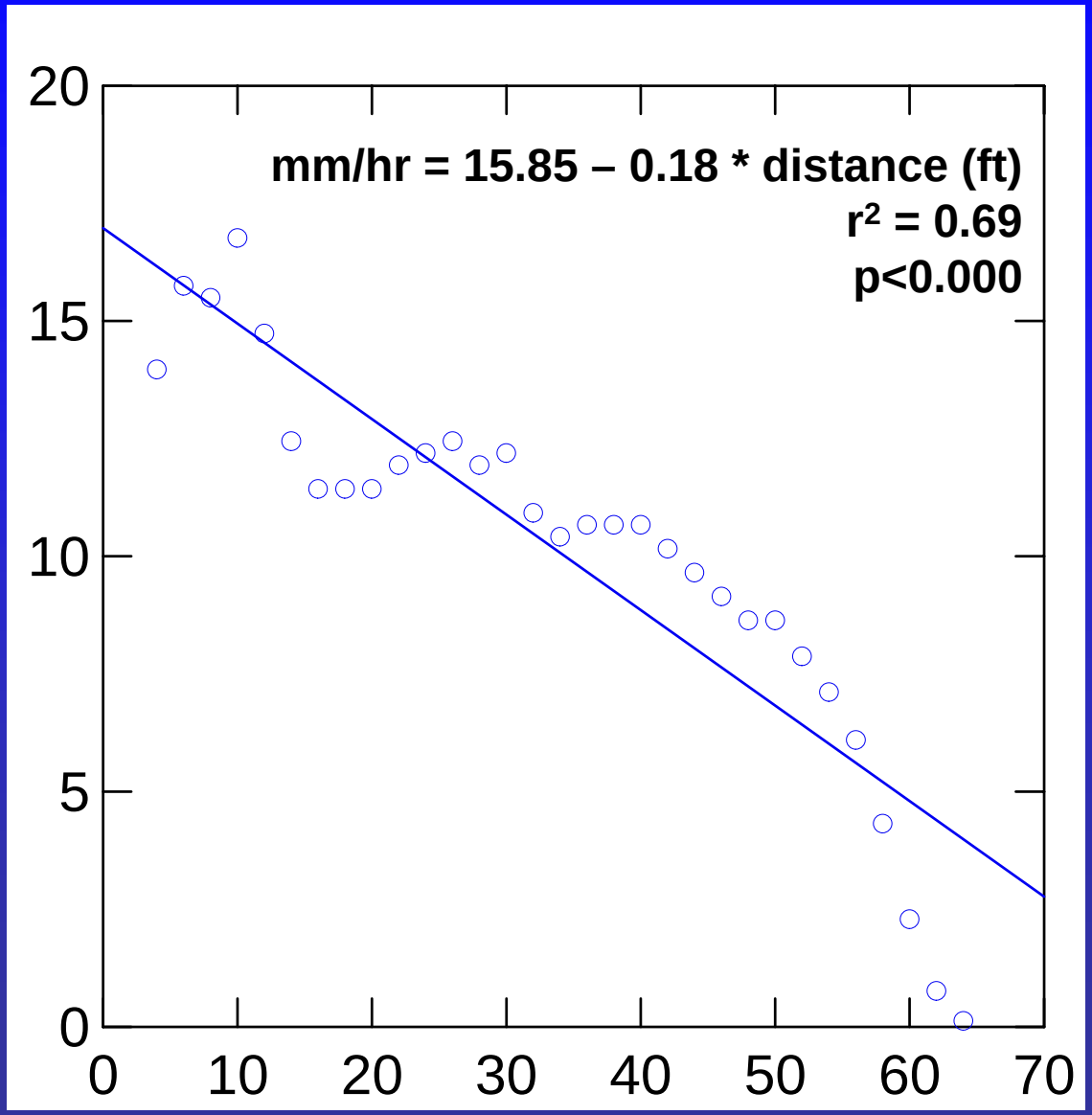
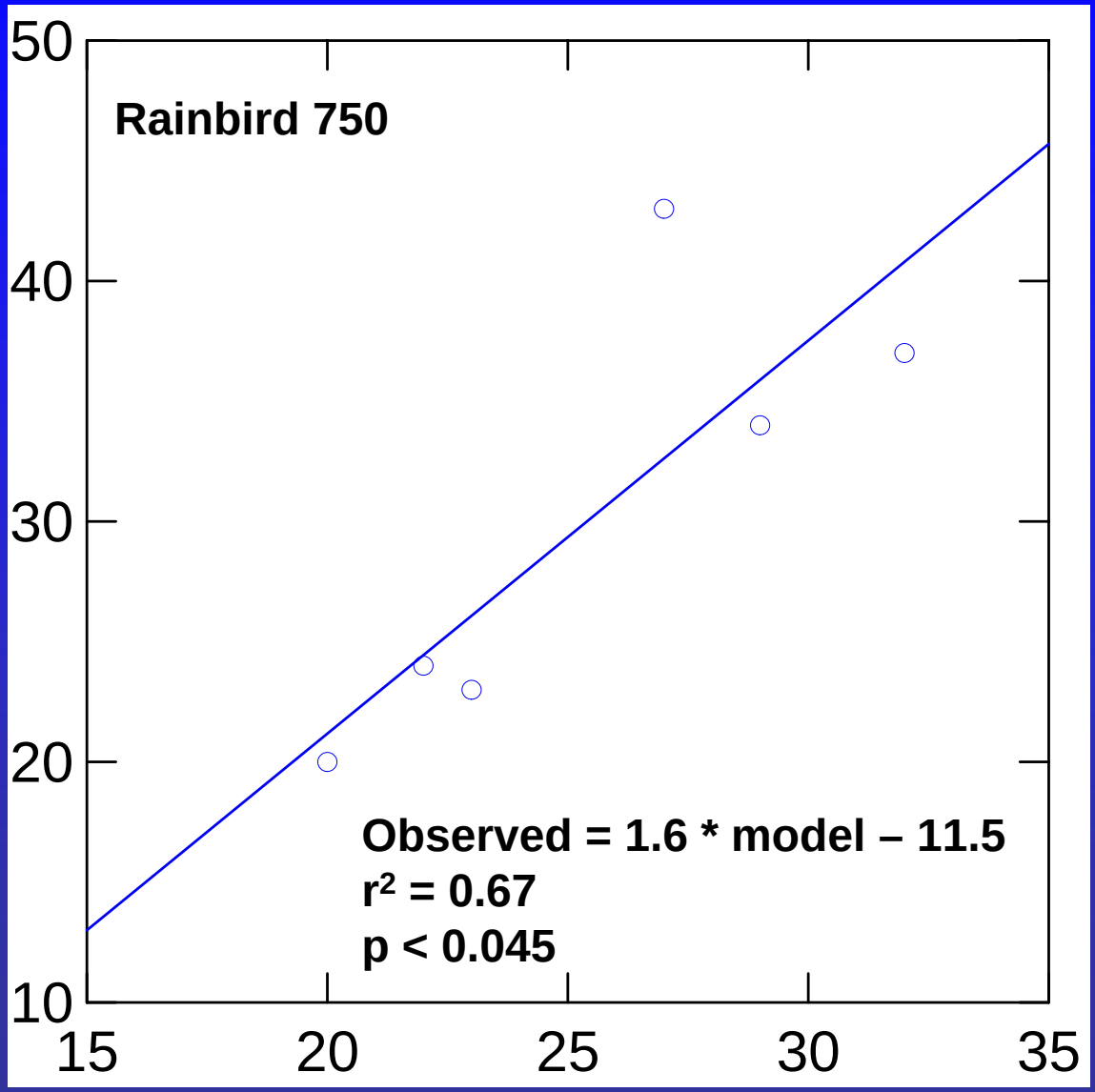


2.0 =	0.300	18.0 =	0.450	34.0 =	0.410	50.0 =	0.340
4.0 =	0.550	20.0 =	0.450	36.0 =	0.420	52.0 =	0.310
6.0 =	0.620	22.0 =	0.470	38.0 =	0.420	54.0 =	0.280
8.0 =	0.610	24.0 =	0.480	40.0 =	0.420	56.0 =	0.240
10.0 =	0.660	26.0 =	0.490	42.0 =	0.400	58.0 =	0.170
12.0 =	0.580	28.0 =	0.470	44.0 =	0.380	60.0 =	0.090
14.0 =	0.490	30.0 =	0.480	46.0 =	0.360	62.0 =	0.030
16.0 =	0.450	32.0 =	0.430	48.0 =	0.340	64.0 =	0.005

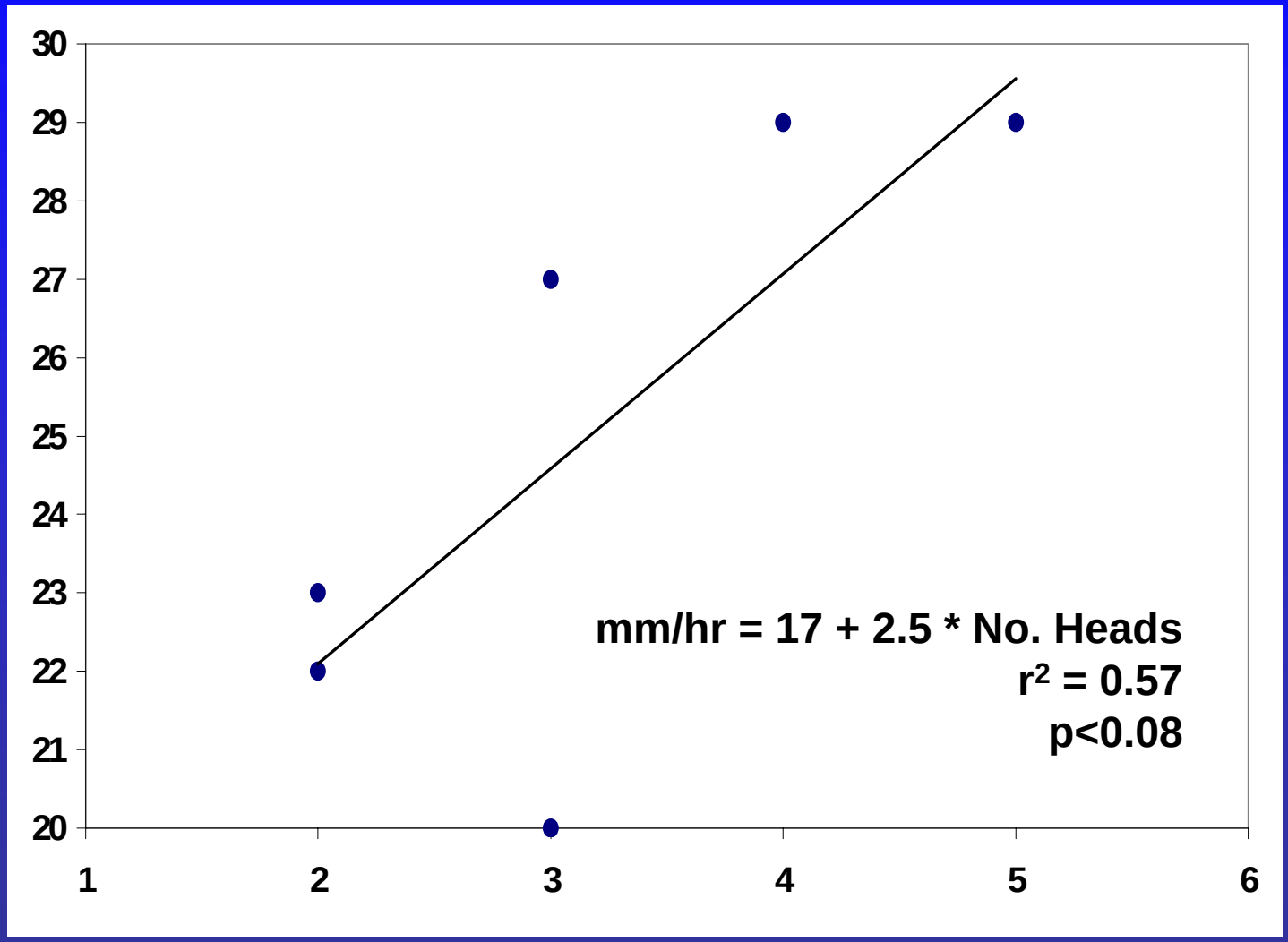
Rainbird 750 Head Performance



Observed vs. Theoretical Precipitation Rates



Rainbird 750 Theoretical Precipitation



observed (theoretical) mm/hr