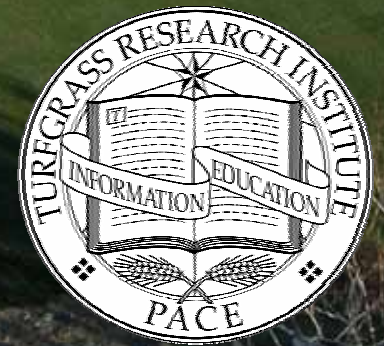


Virtual Irrigation Audits in Real Time

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**

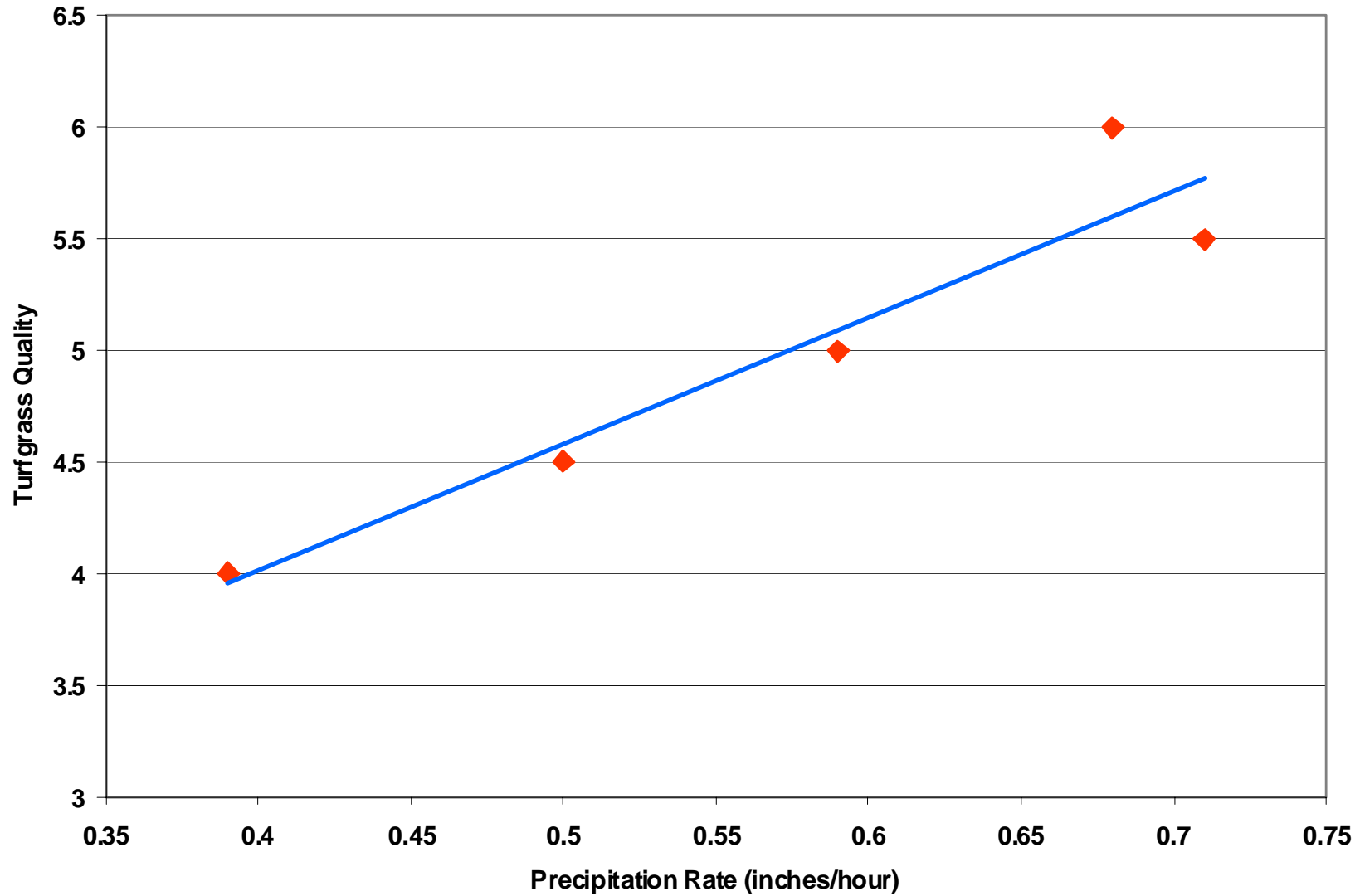
Why Bother?

- **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**

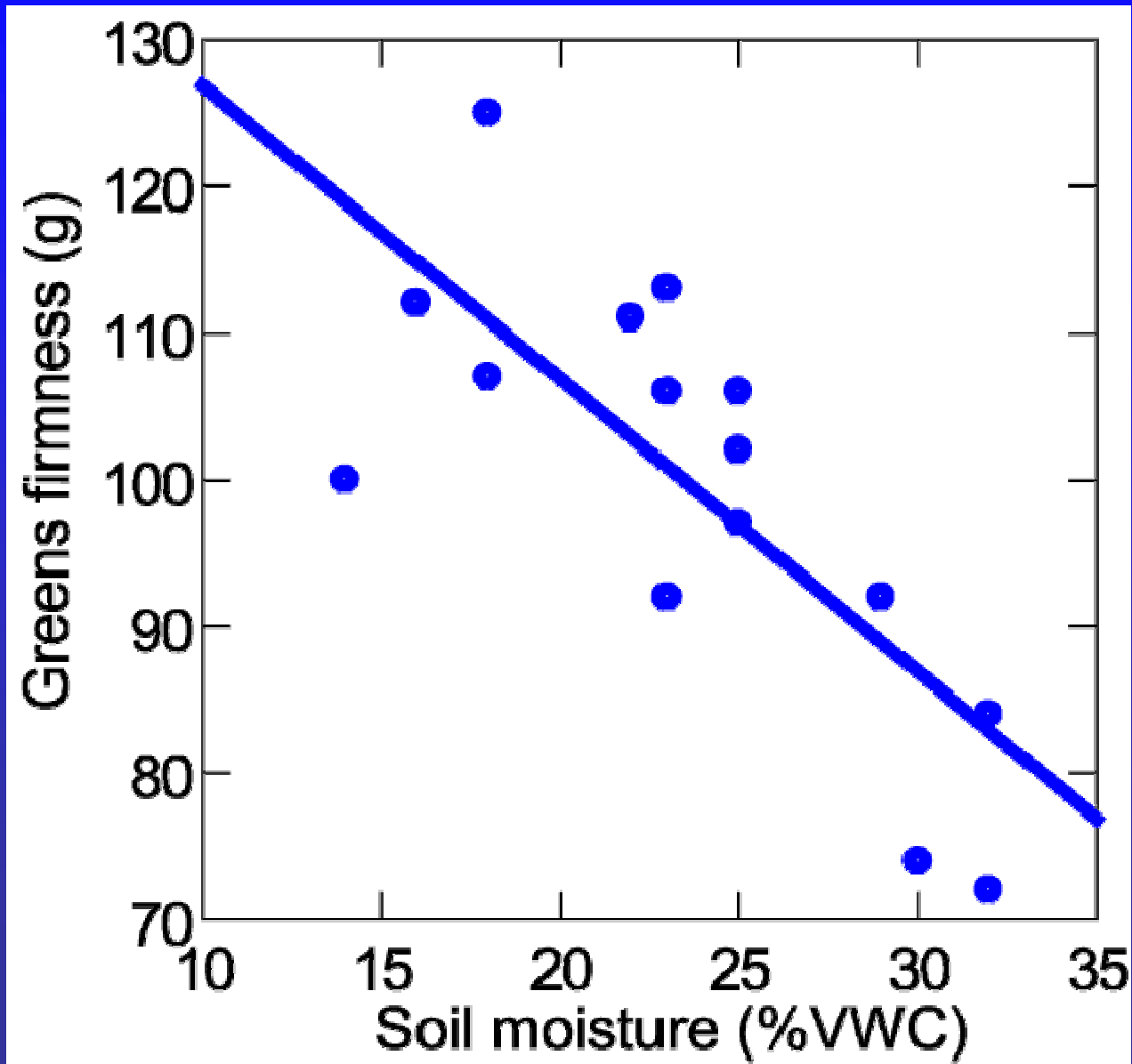
Irrigation Distribution Problem



Turfgrass Quality Vs. Precipitation Rate



Greens Firmness



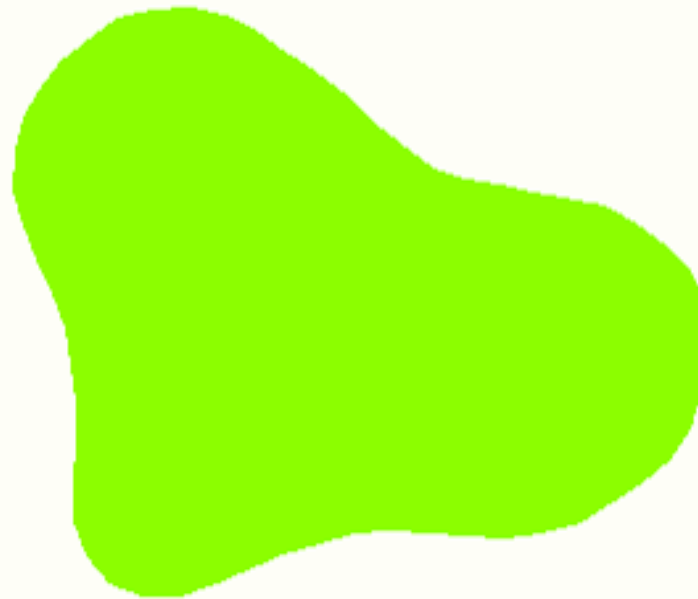
Virtual Irrigation Audit Defined

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

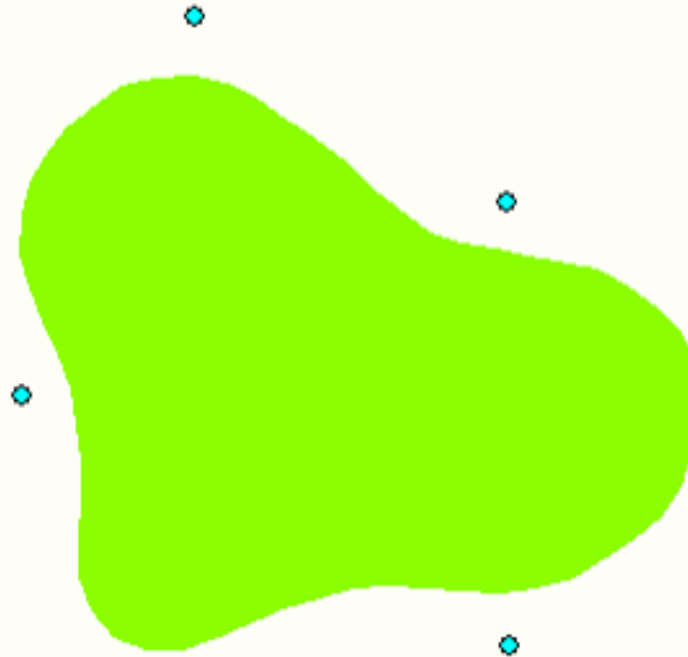
Simple as 1, 2, 3

- 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)**

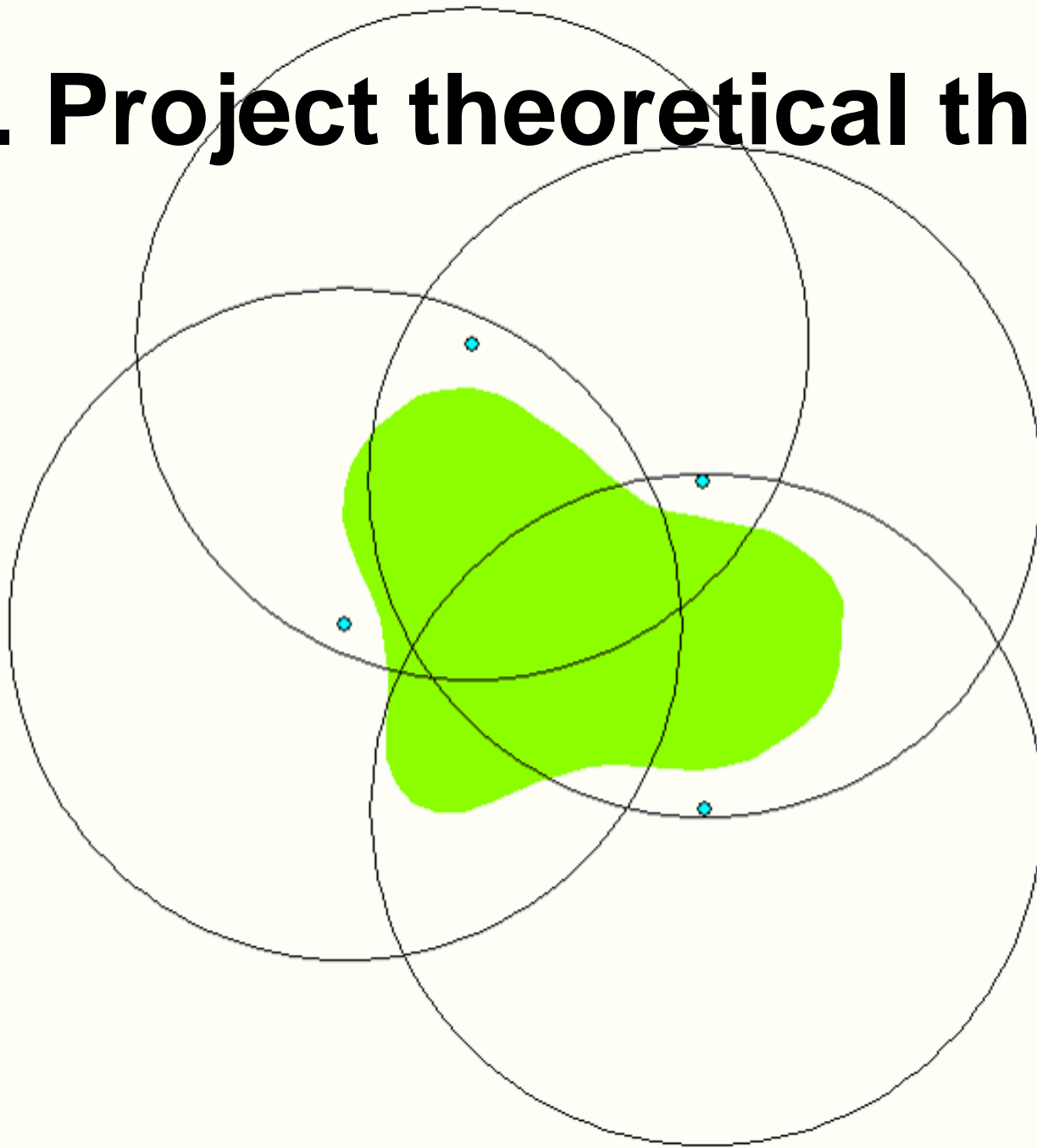
1. Map perimeter



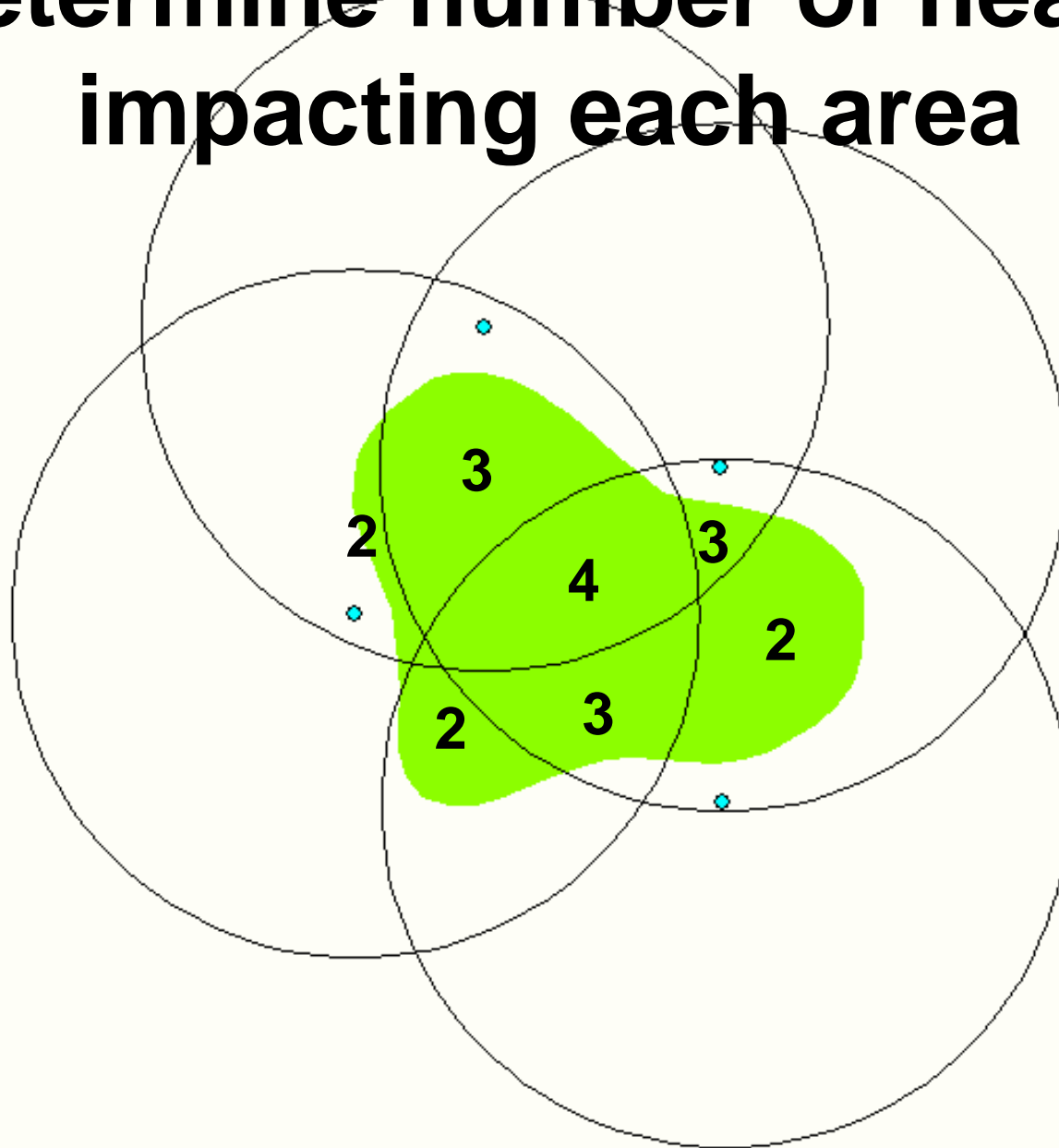
2. Map head locations



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

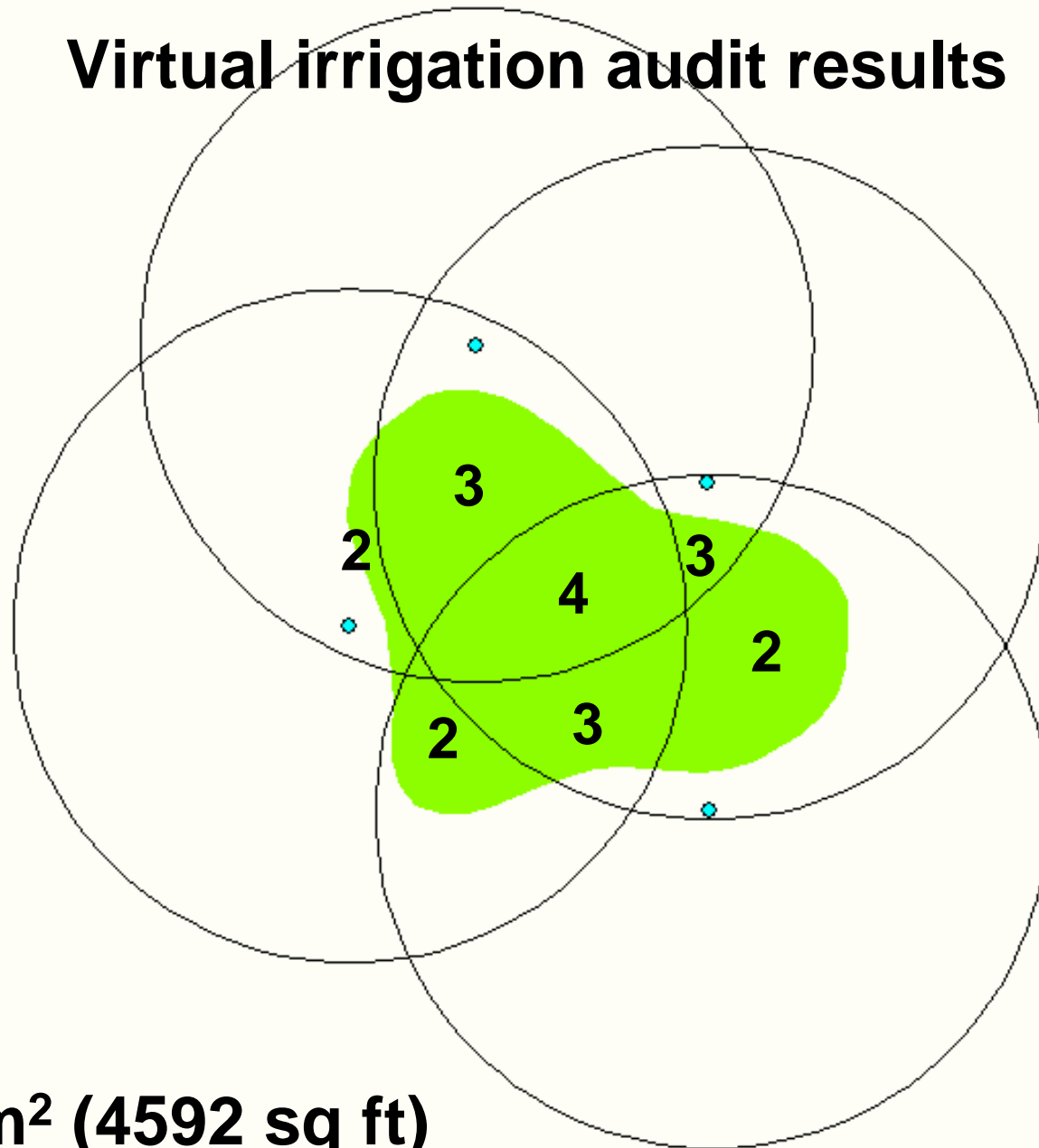


Validation

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

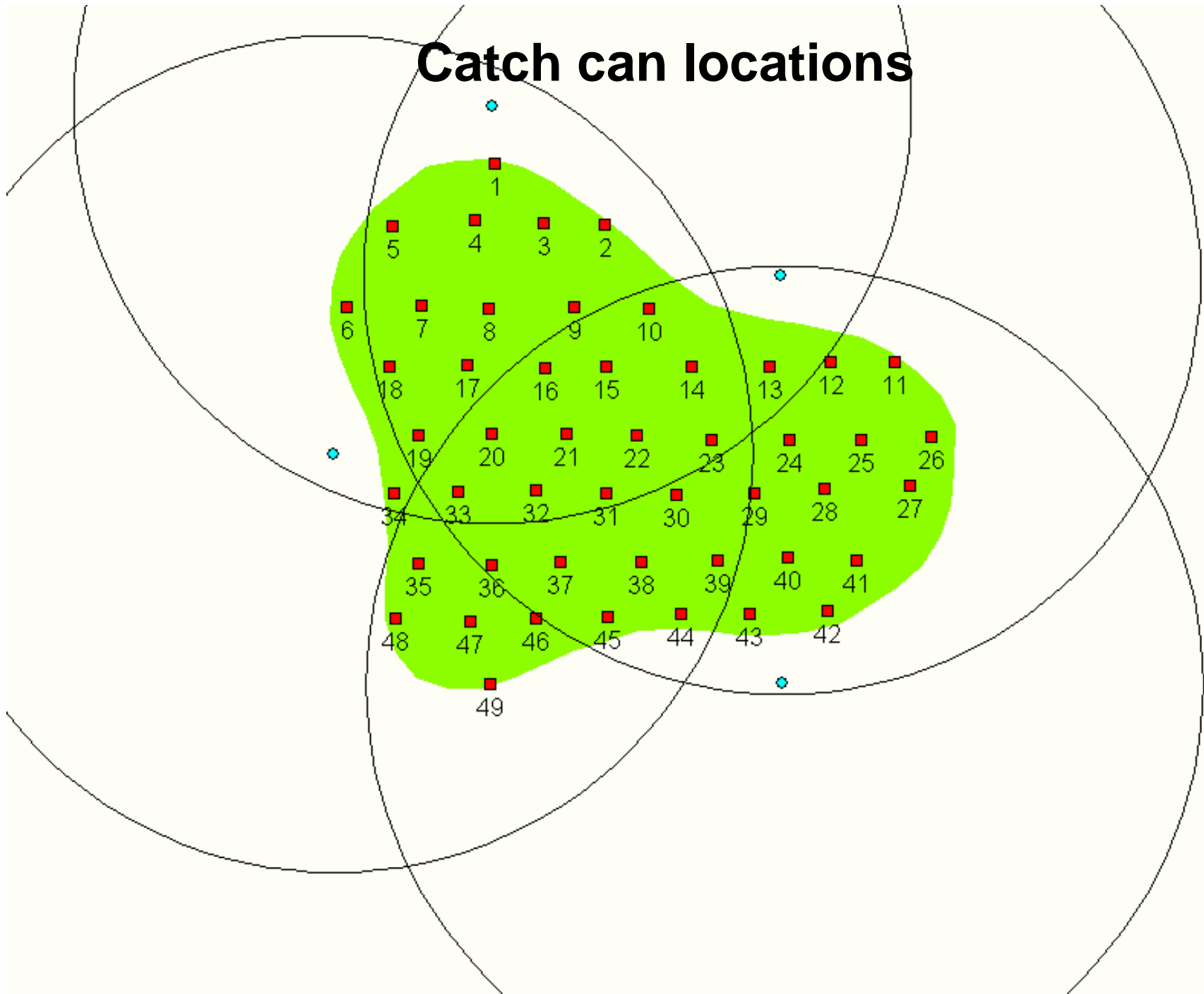


413 m² (4592 sq ft)

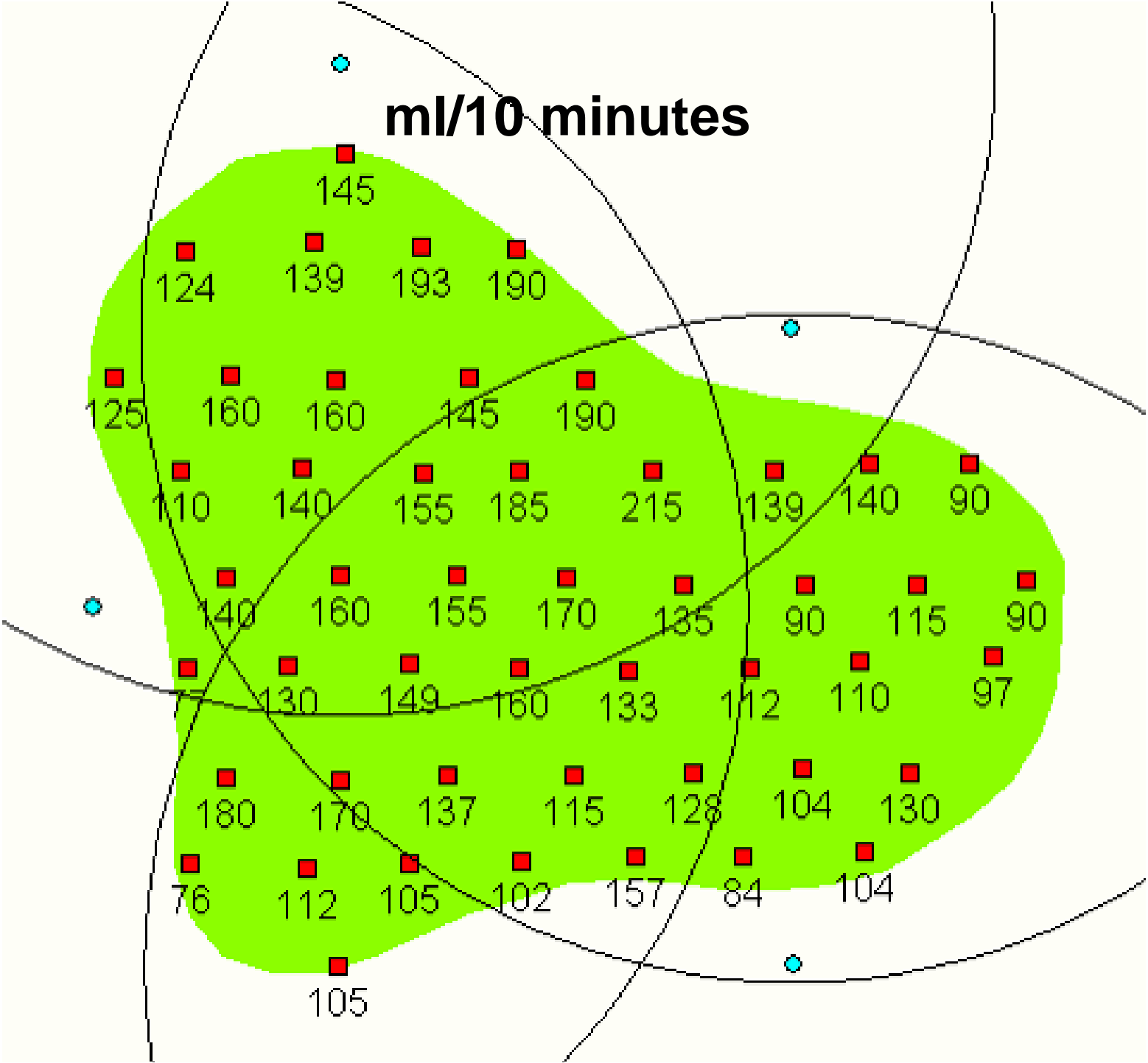




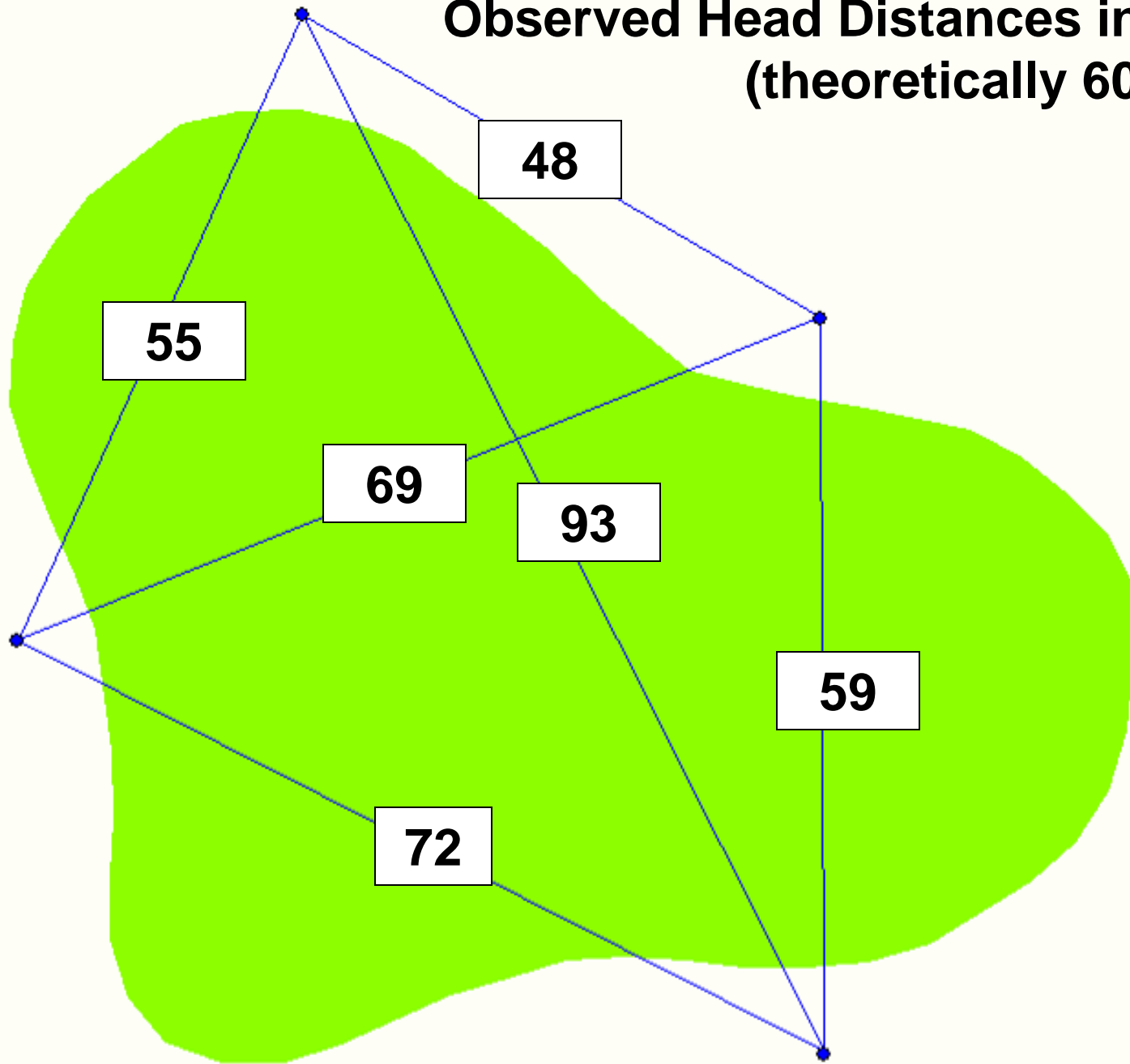
Catch can locations



ml/10 minutes

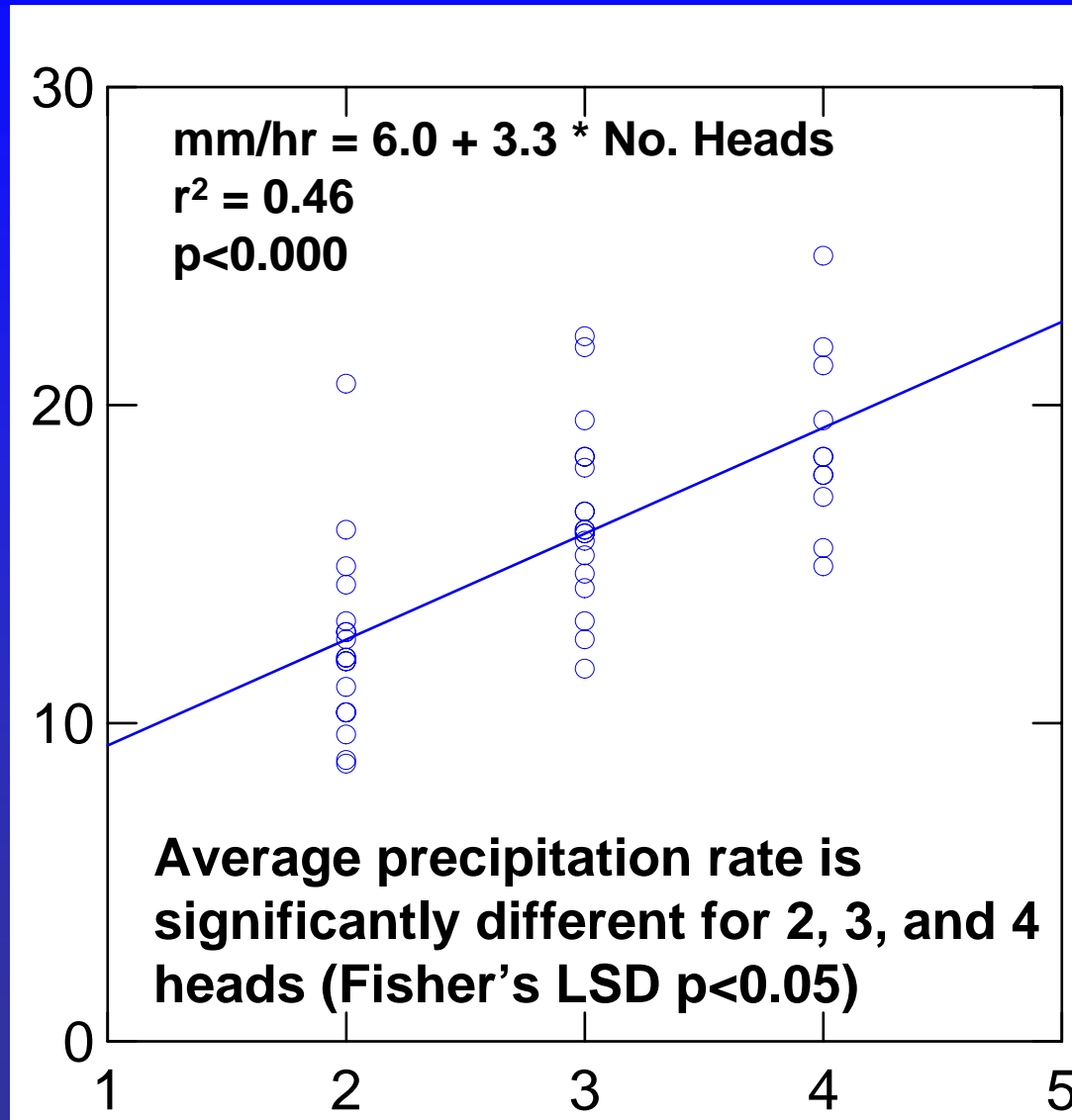


Observed Head Distances in Feet (theoretically 60 feet)



Observed Precipitation vs. Number of Heads

Observed precipitation rate
(mm/hr)



Number of Heads

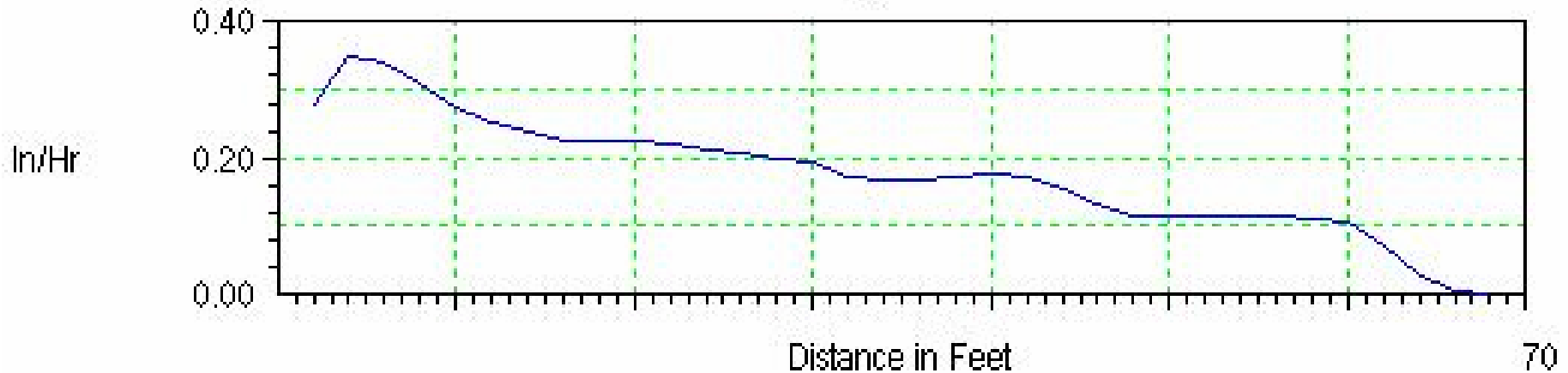
Theoretical Precipitation

- 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.

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

Center for Irrigation Technology Assay

TORO 830S @ 65 PSI

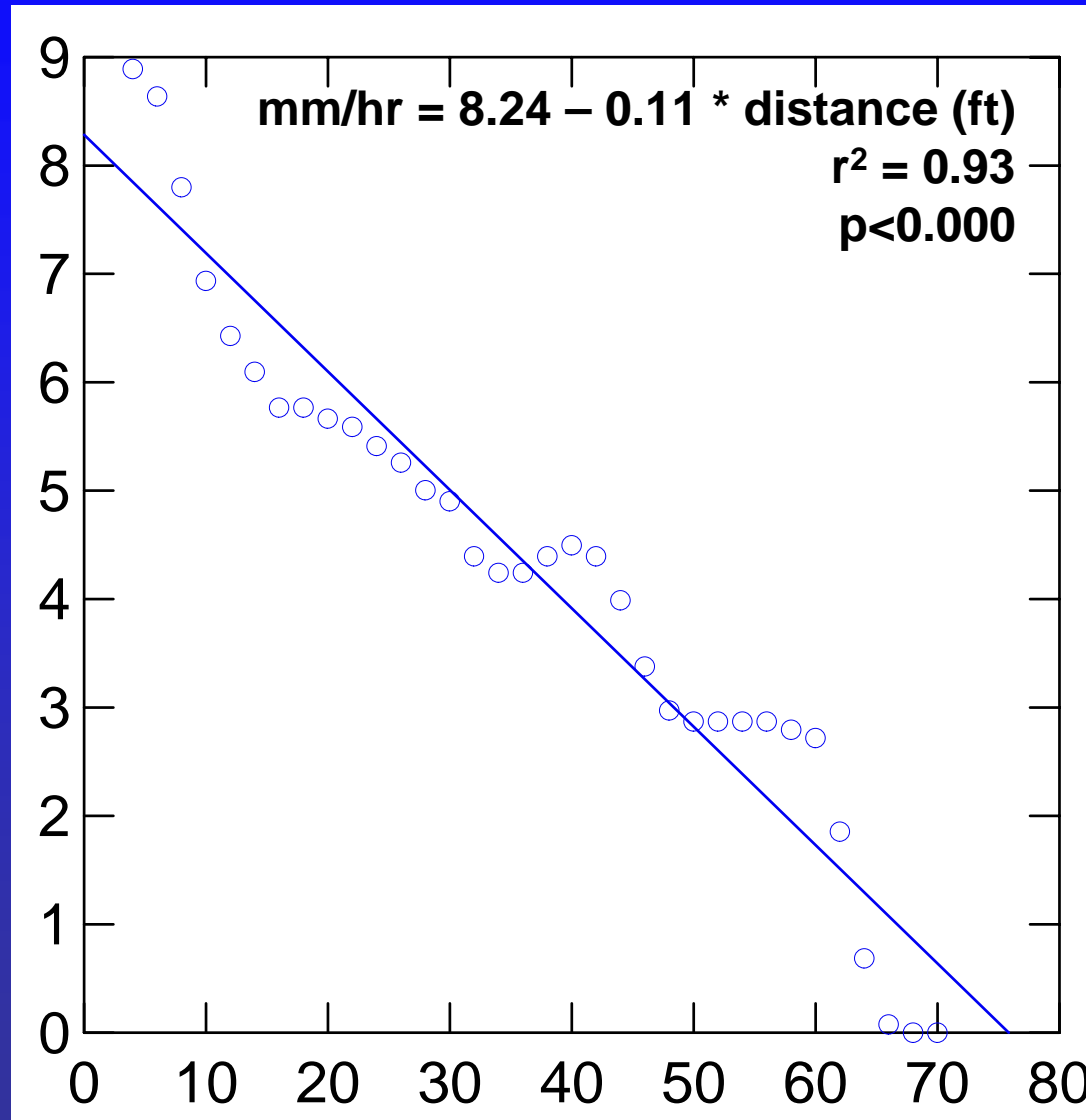


<http://cati.csufresno.edu/cit/good/citprofiles.html>

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		

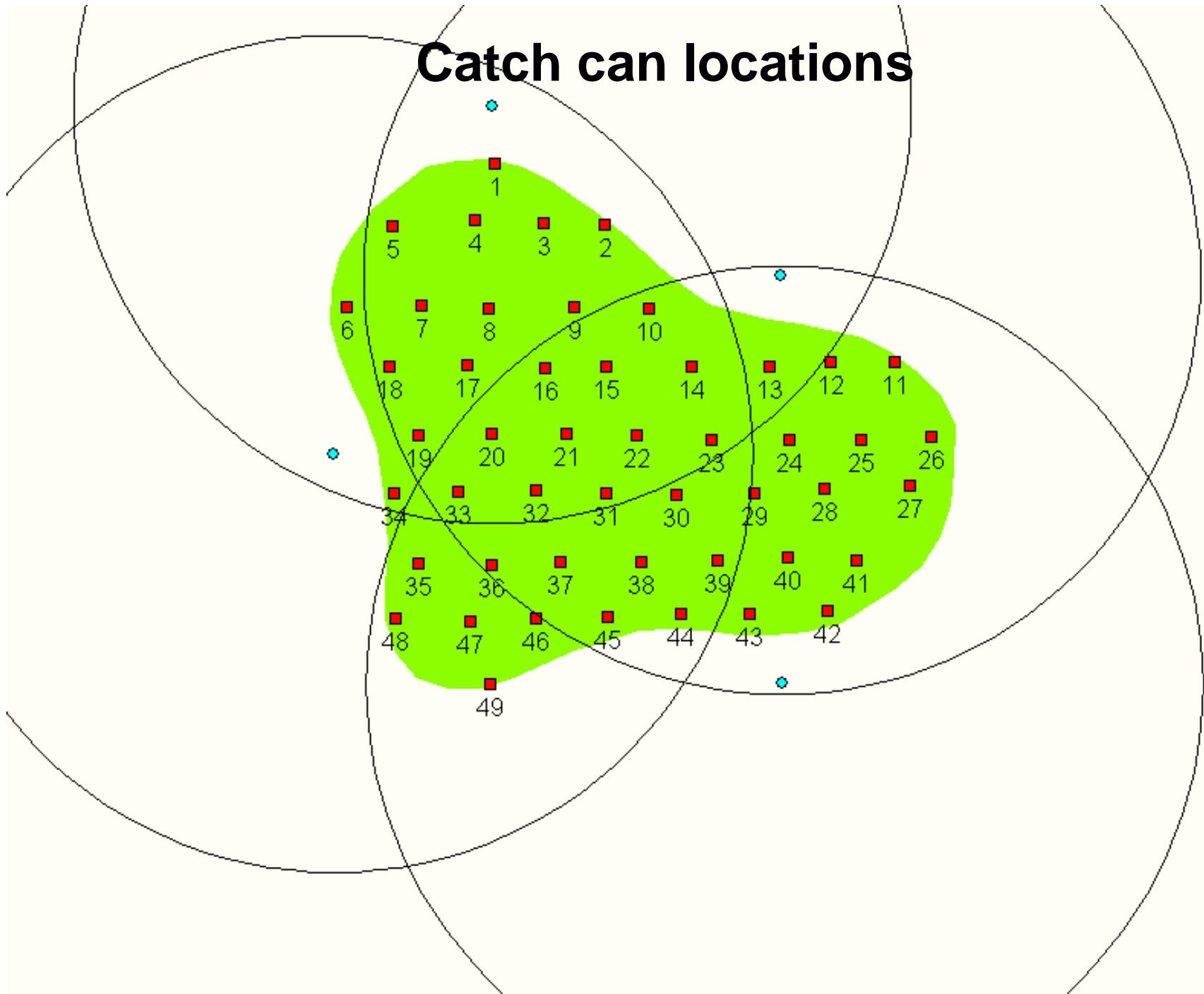
Toro 830 Head Performance

CIT assay precip rate
(mm/hr)



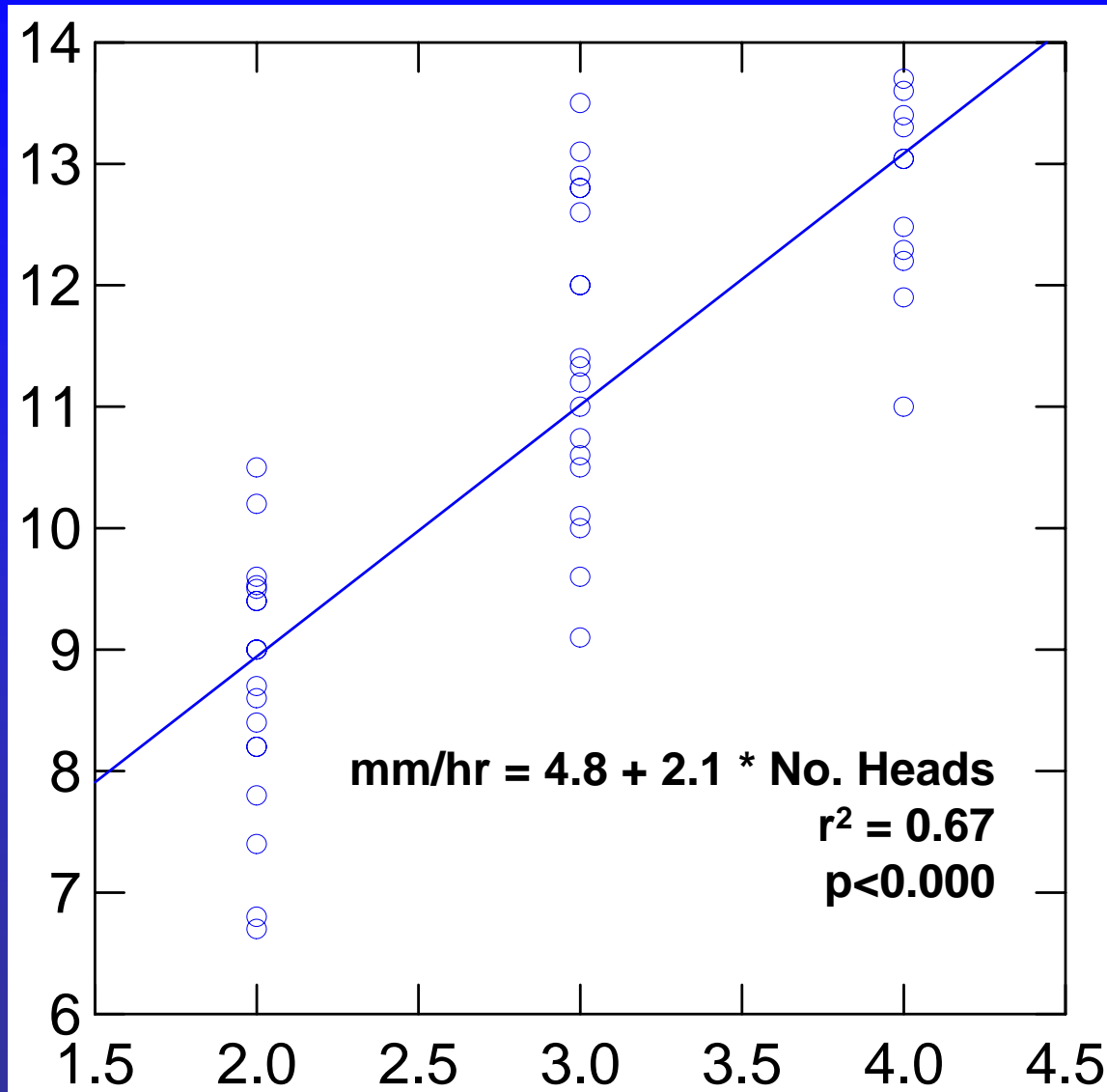
Distance from head (ft)

Catch can locations



Toro 830 Theoretical Precipitation

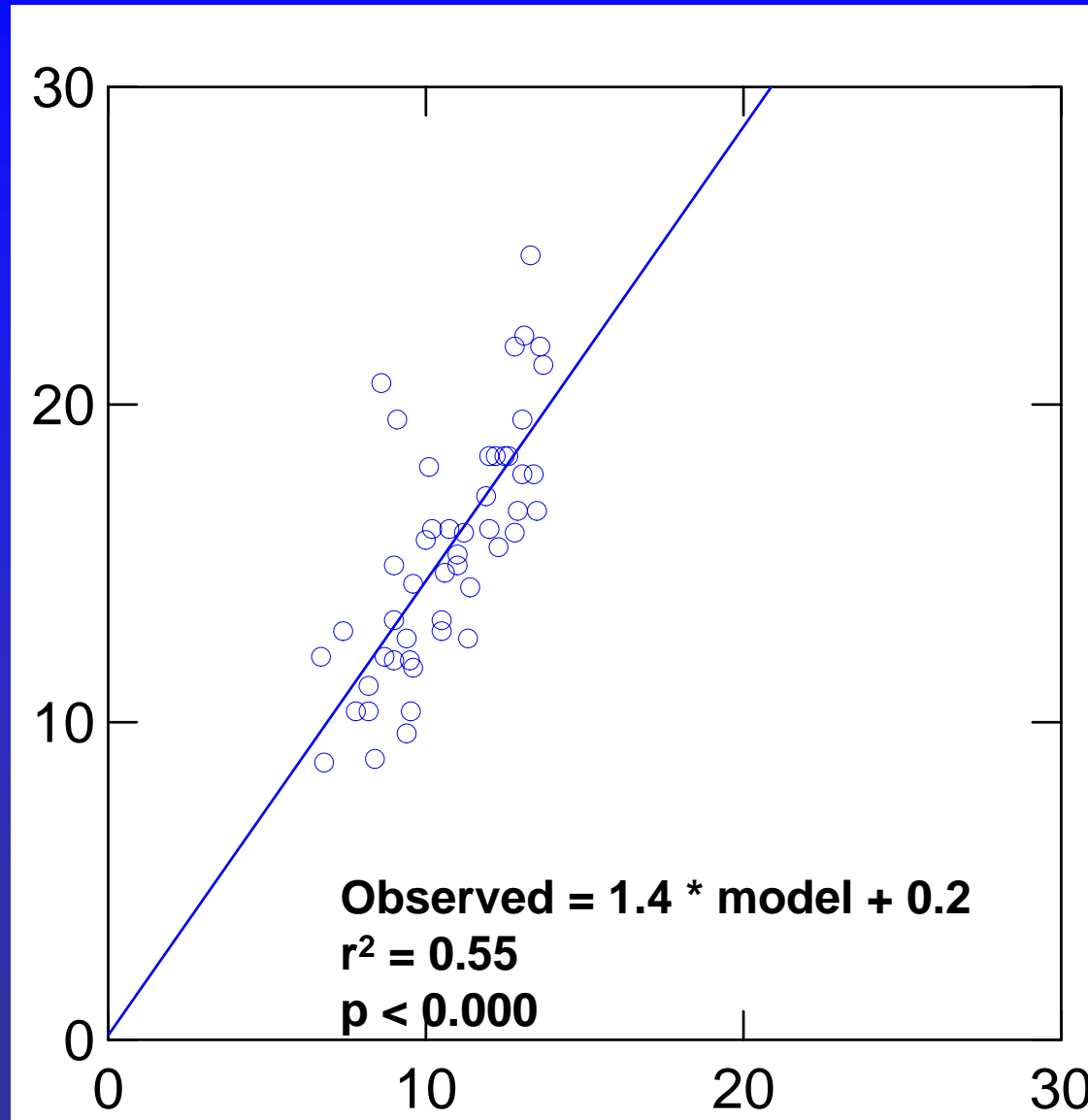
Theoretical Precipitation rate
(mm/hr)



Number of Heads

Observed vs. Theoretical Precipitation

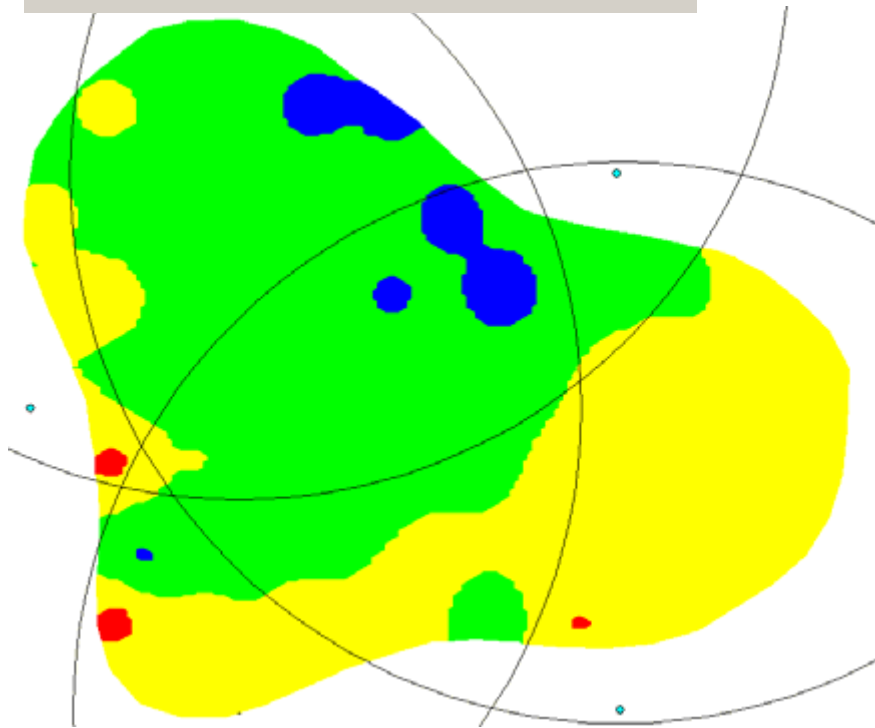
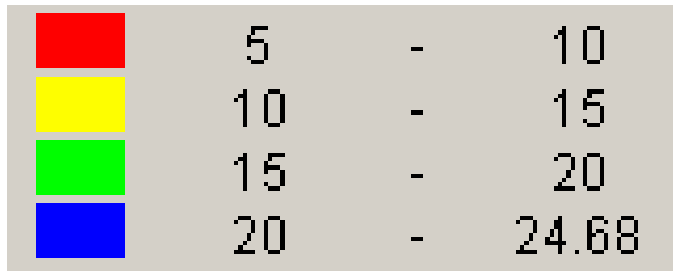
Observed mm/hr



Theoretical mm/hr

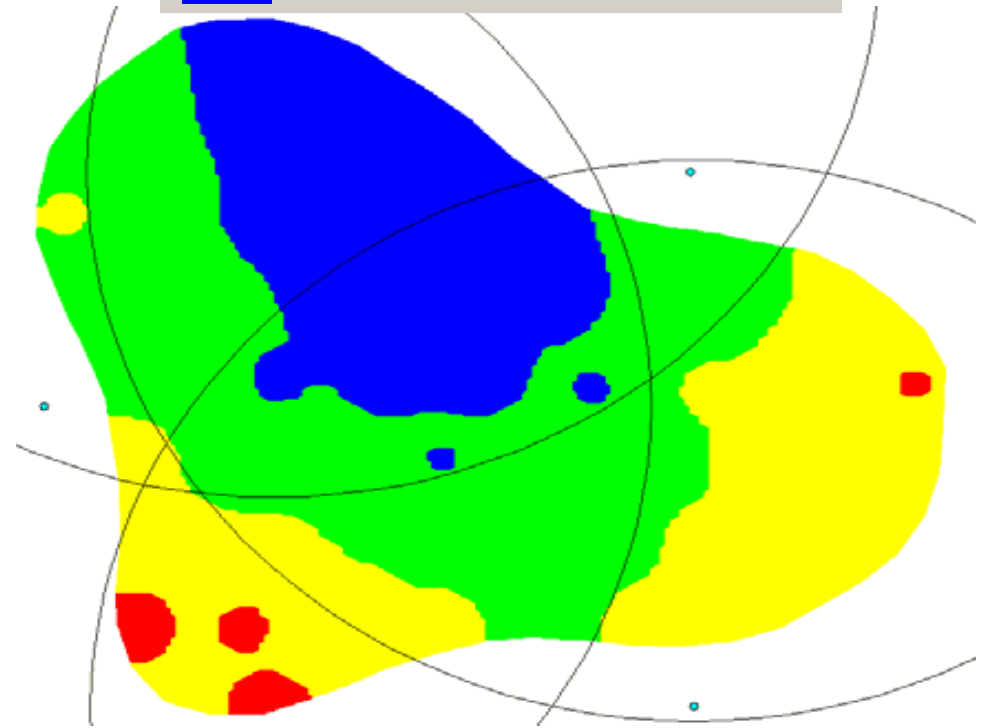
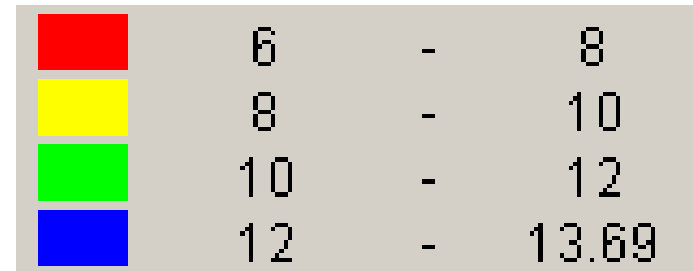
Observed vs. Theoretical Distribution

mm/hr Observed



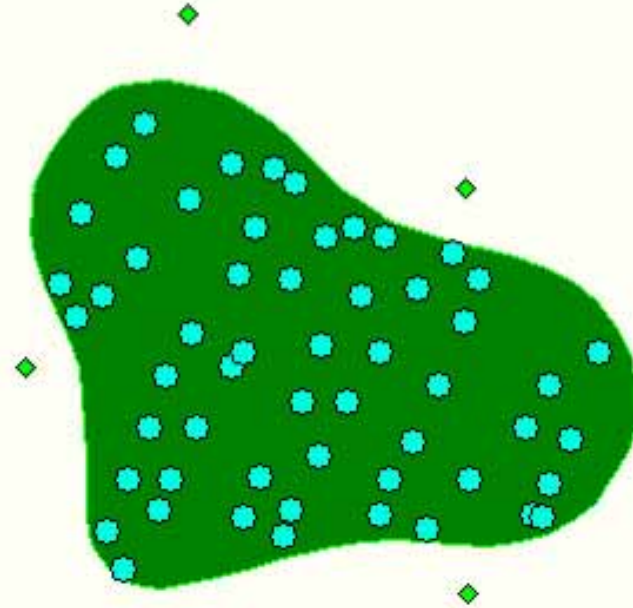
DU = 69

mm/hr Theoretical



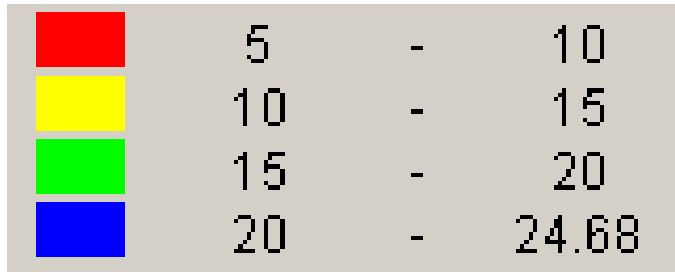
DU = 76

Soil moisture survey

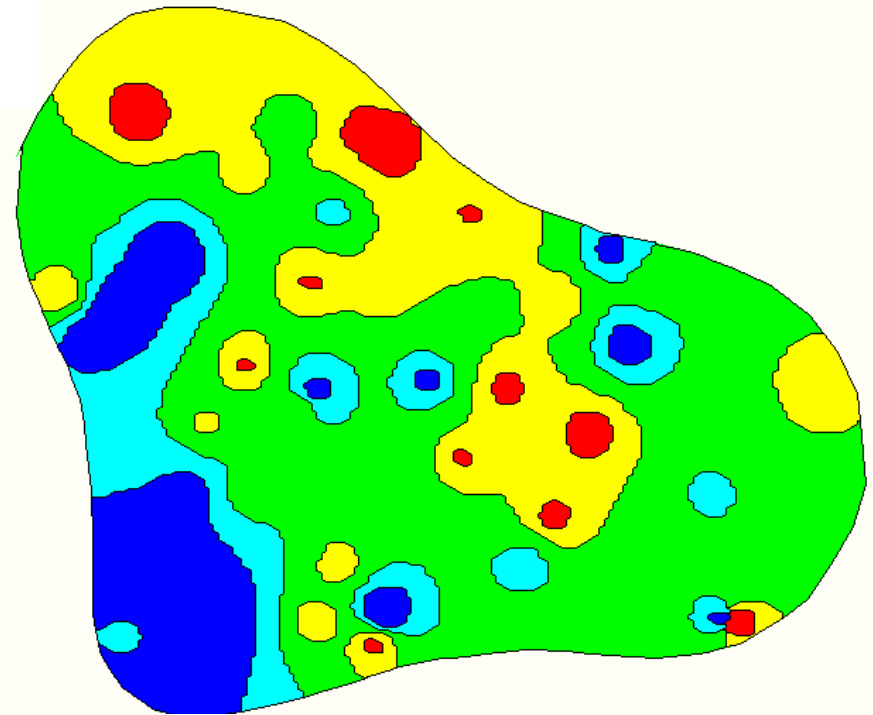
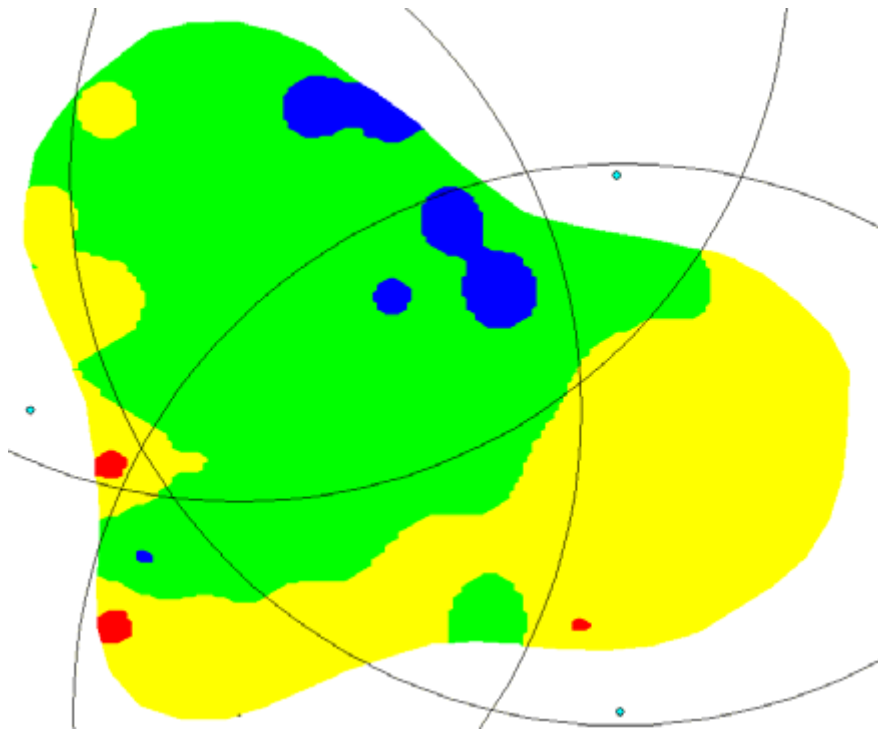
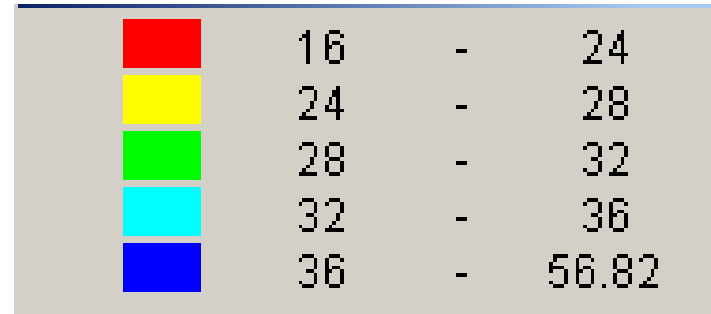


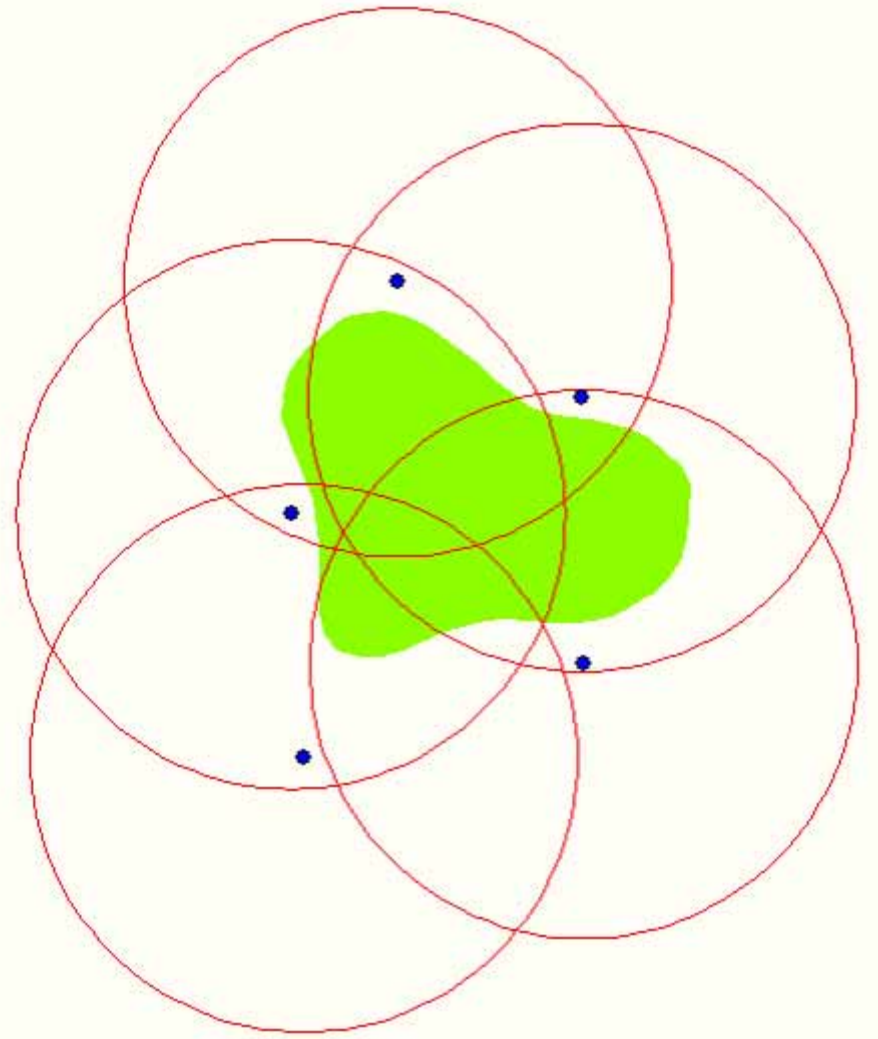
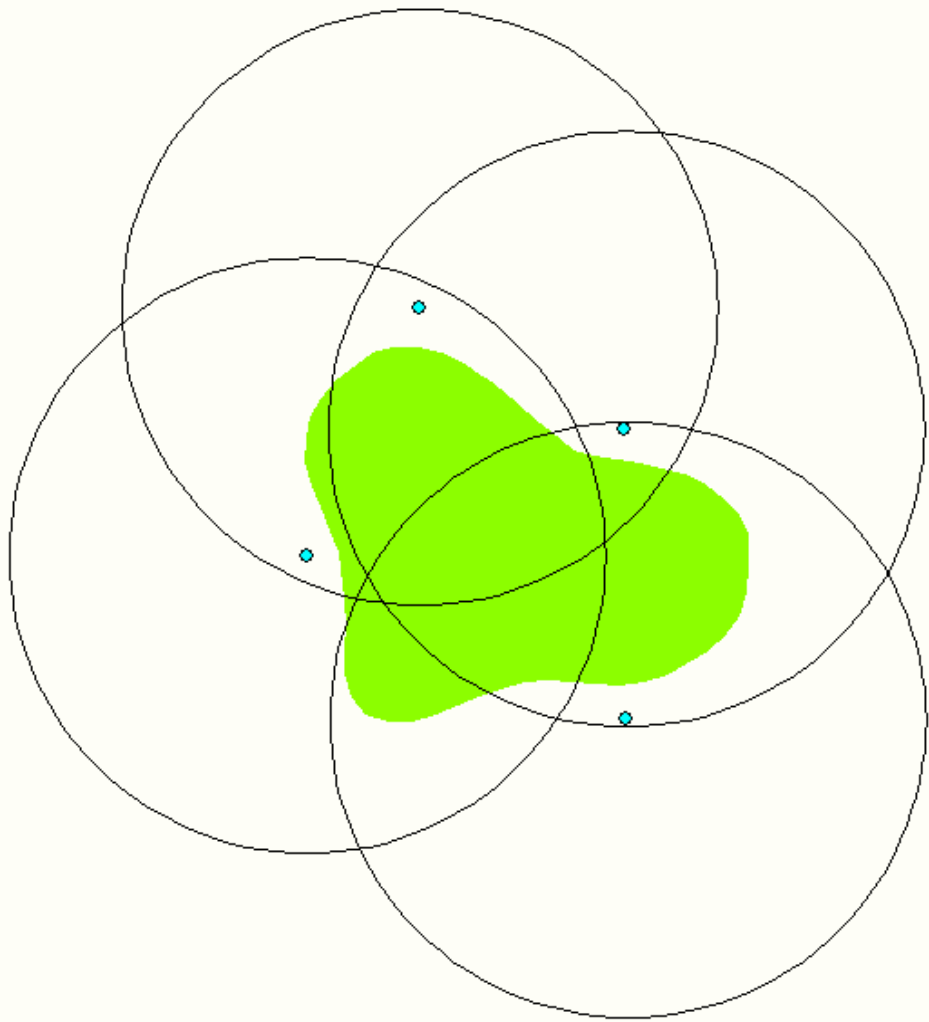
Observed Precipitation vs. Soil Moisture

mm/hr Observed



Volumetric Water Content %



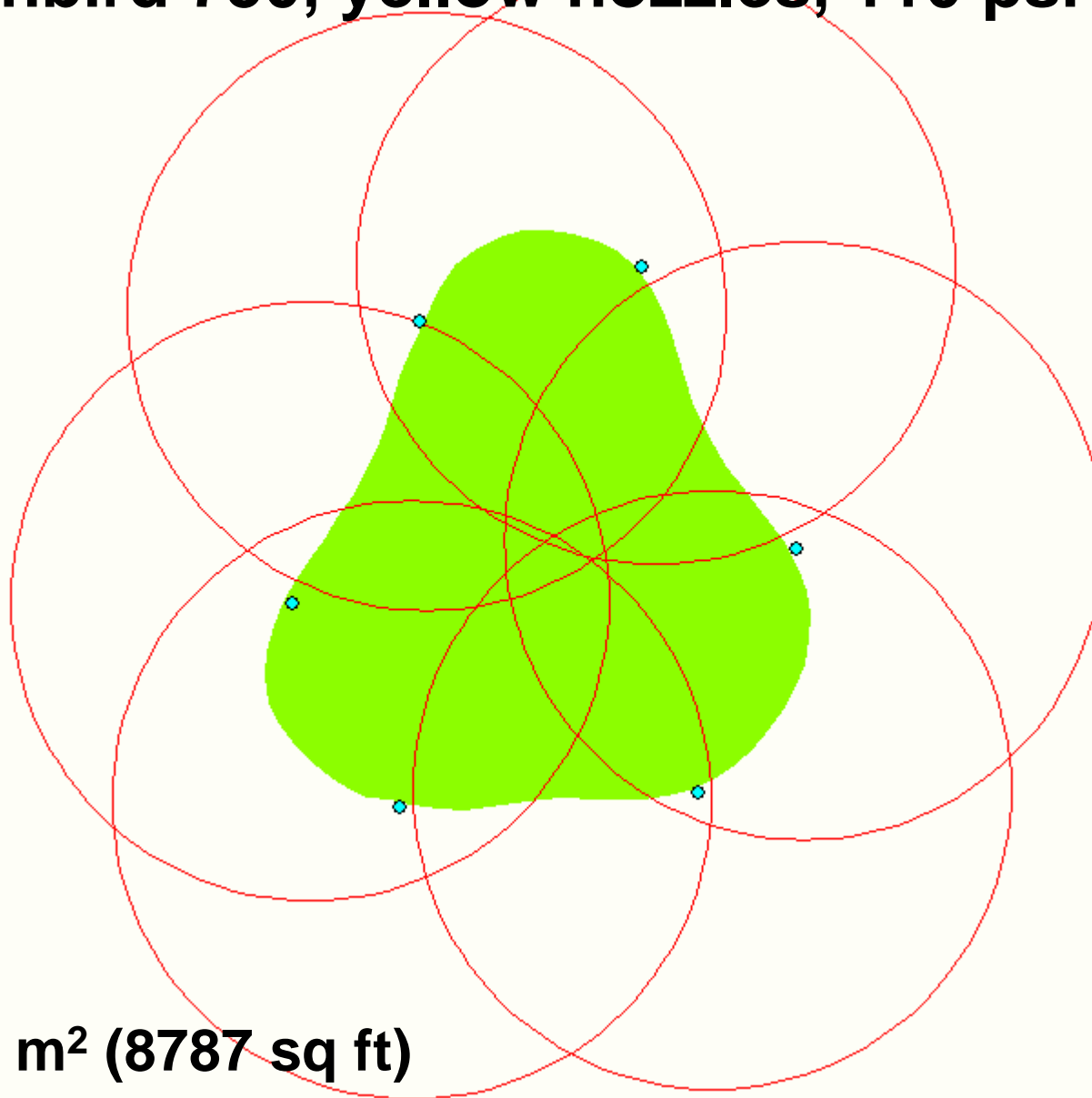


Conclusions

- **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**

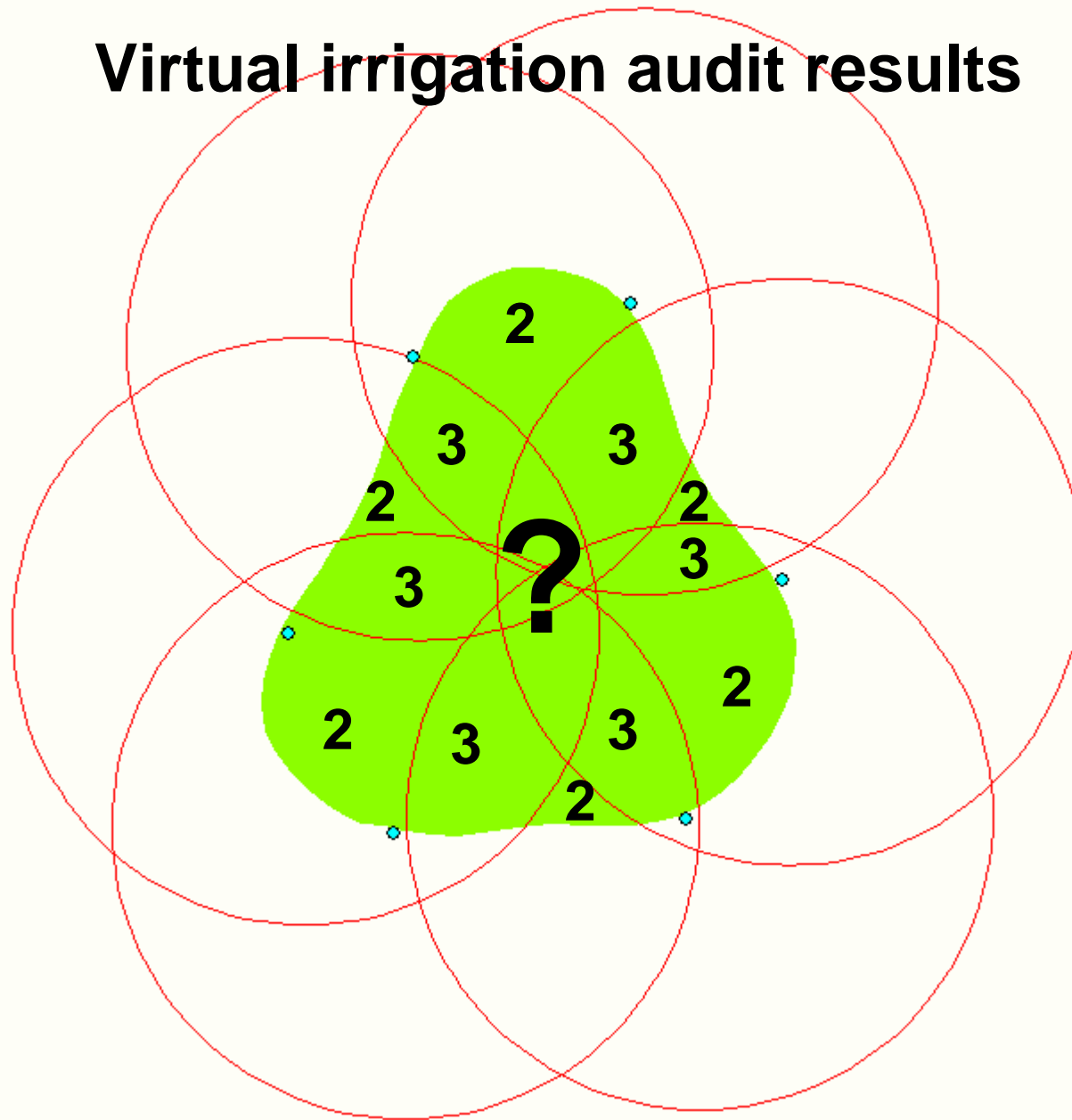


Rainbird 750, yellow nozzles, 110 psi

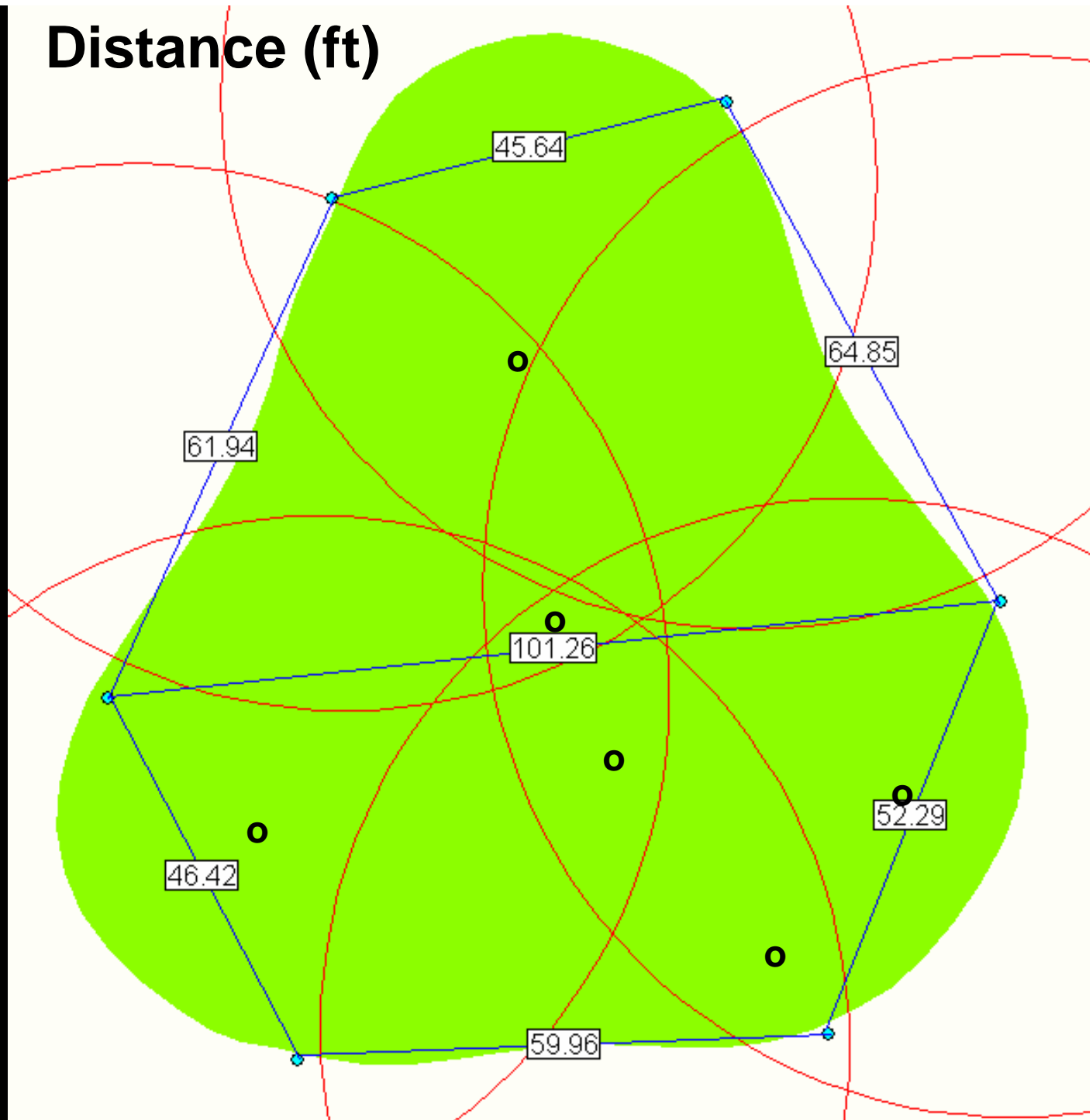


791 m² (8787 sq ft)

Virtual irrigation audit results

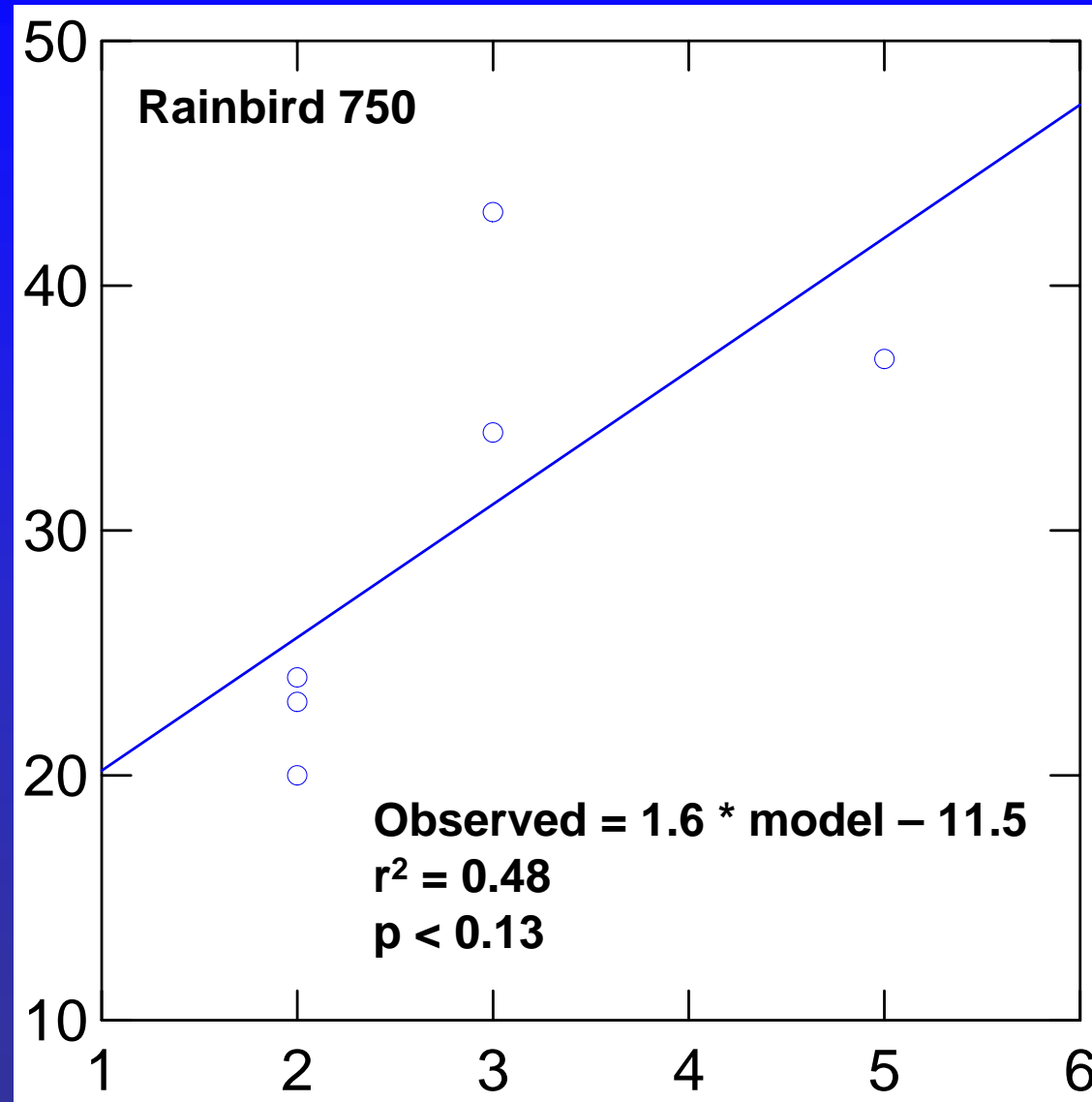


Distance (ft)



Observed Precipitation vs. Number of Heads

Observed mm/hr



Number of Heads

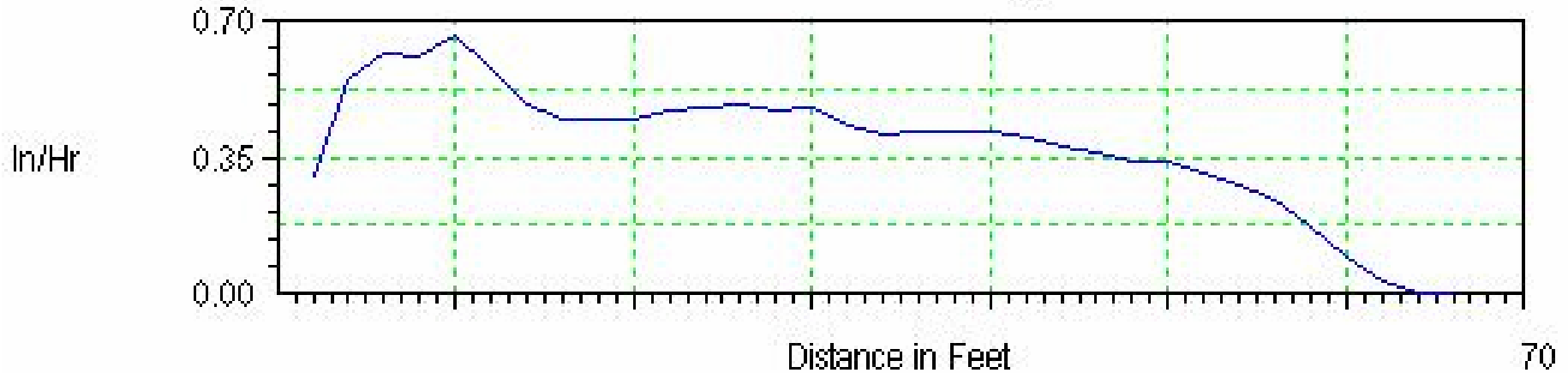
Theoretical Precipitation

- Georeference heads and catch cans and then compute distances between heads and catch cans.
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$$\text{Distance (ft)} = 5280 \times \sqrt{\left((69.1 * (lat1 - lat2)) \right)^2 + \left((69.1 * (lon1 - lon2)) * \cos\left(\frac{lat1}{57.3}\right) \right)^2}$$

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

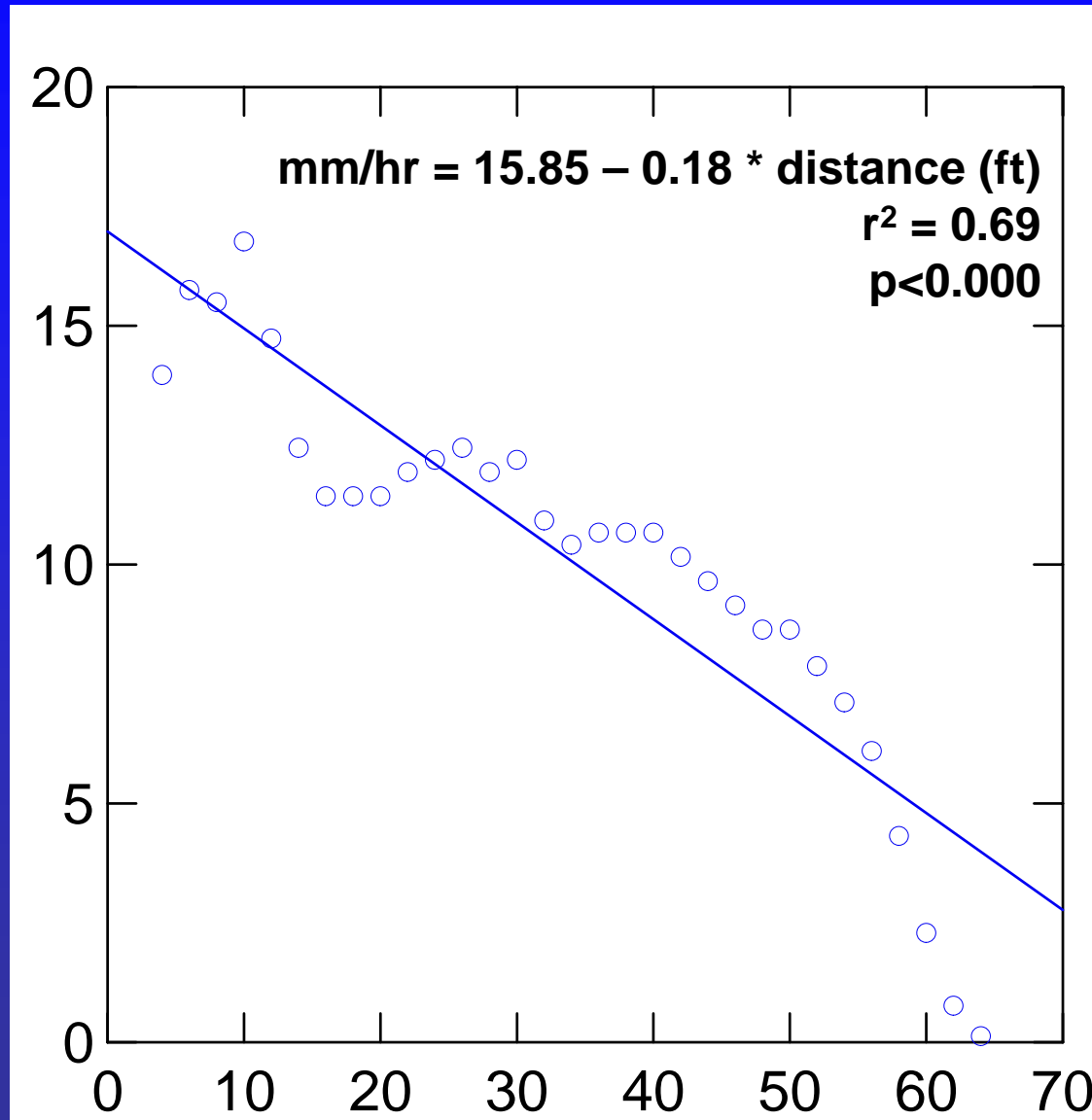
RAIN BIRD EAGLE 750 #36 Yellow @ 110 PSI



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

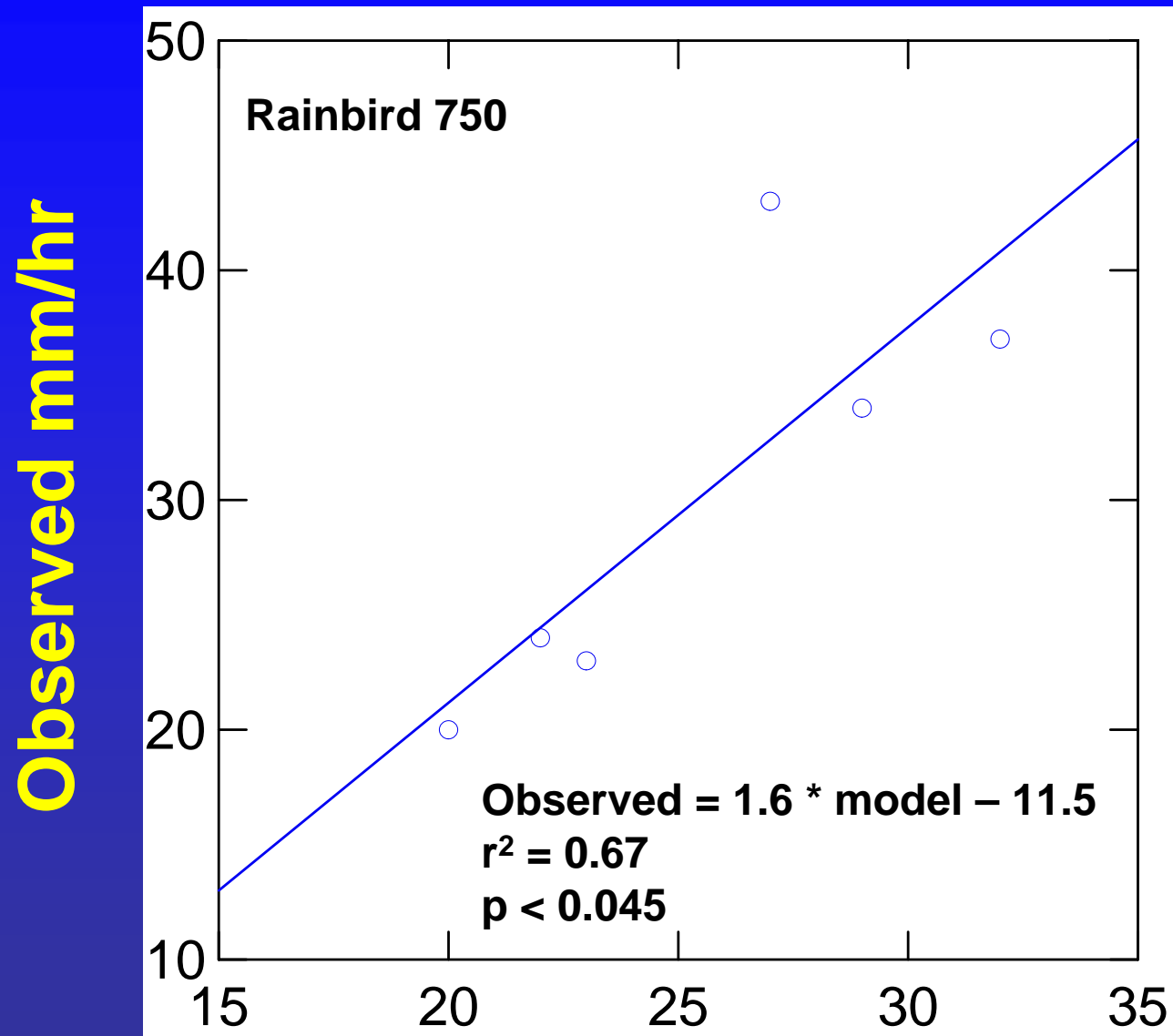
Rainbird 750 Head Performance

CIT assay precip rate
(mm/hr)



Distance from head (ft)

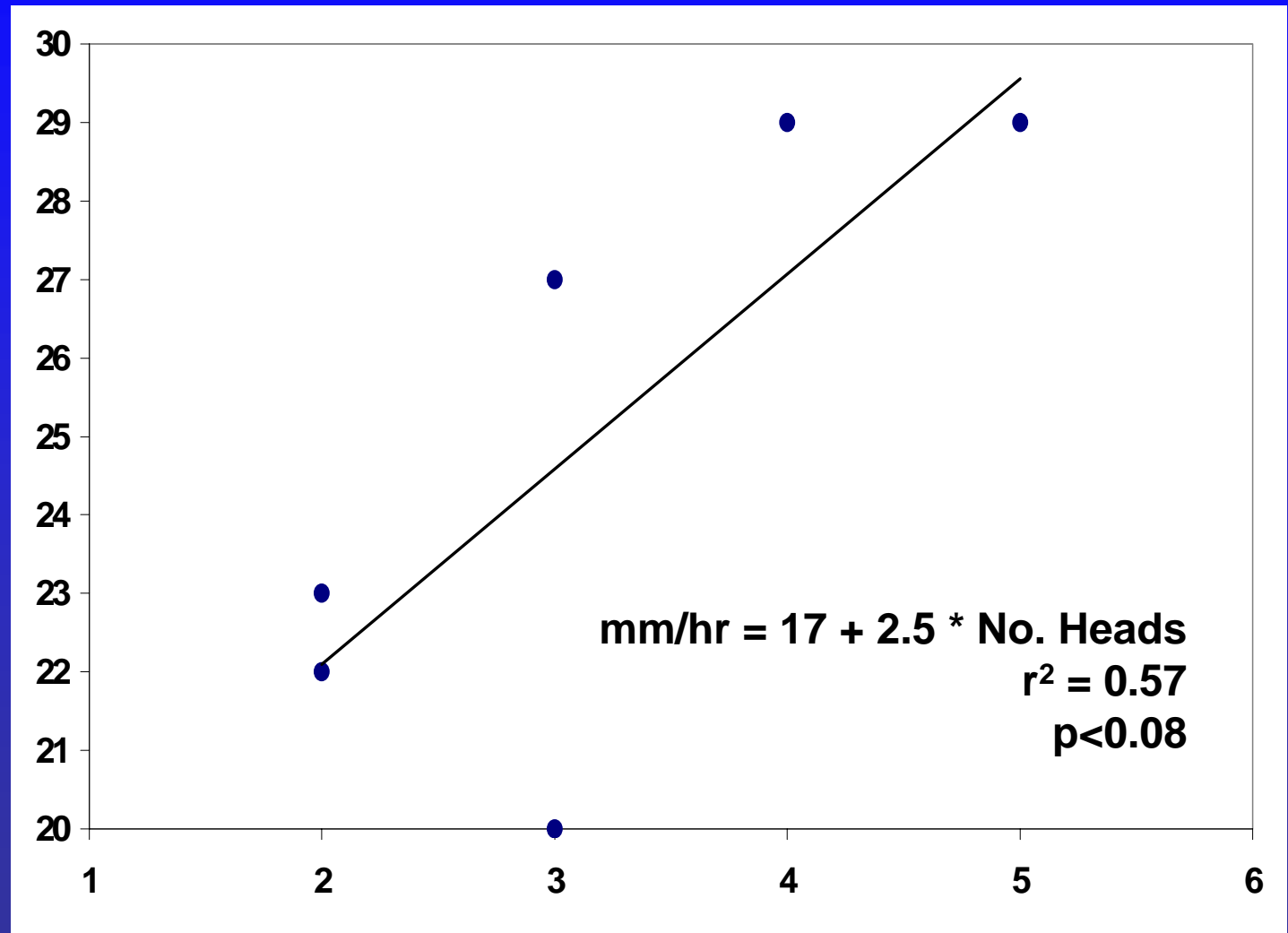
Observed vs. Theoretical Precipitation Rates



Theoretical mm/hr

Rainbird 750 Theoretical Precipitation

Theoretical Precipitation rate
(mm/hr)



Number of Heads

observed (theoretical) mm/hr

