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FINAL REPORT  
To  
North Carolina Pork Council

TITLE: A Rapid Assessment Tool for Determining Uniformity of Irrigation-Type Animal Waste  
Land Application Systems

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Report:

**Summary:** The objective of this study is to determine if field measurement of a few easily measured factors can adequately predict application uniformity, and if so to develop a model and resultant tables that show predicted uniformity from these easily measured factors.

A graduate student was recruited for this project and she began her assistantship Spring semester 2008. She has completed a literature review on the subject of irrigation system uniformity and its evaluation and is assisting with field trials and data management.

Files of previously performed calibrations have been entered into a computerized database. Uniformity assessments were conducted on farms and at the Lake Wheeler Land Application and Training Unit. In the first year of the study, a total of 32 trials were completed; 17 for traveling gun and 15 for stationary systems. Calibration data will continue to be collected through the fall of 2008.

Software was developed to evaluate uniformity of traveling gun systems at various lane spacings using rain gage data (gage transect normal to direction of pull) from a single field trial. Software was also developed to determine uniformity of traveling gun systems at various lane spacings and gun angles using field collected rain gage profile data (gages set on a radii from gun). Similar software has been developed for stationary systems. In addition to the field trials and custom software, manufacturer software designed to estimate uniformity of select sprinklers has been obtained.

A database of field trial results is being built for input into a statistical model that will predict application uniformity from easily obtained factors. The candidate factors being evaluated are nozzle pressure, nozzle size, wetted diameter, lane or sprinkler spacing, gun angle, and wind speed. A preliminary model was run using all candidate factors and results indicated that there is good correlation of uniformity with some of the factors. Dr. Jason Osborne of the Dept. of Statistics at NC State has been added to the committee of the graduate student on this project. He will assist in the development and finalization of the statistical model that will predict uniformity.

Expended funds have been primarily for graduate student support and for travel. An updated schedule is presented in Table 1. Work in year two of the project will include

conclusion of field trials, finalization of the predictive statistical model, and development of charts with estimates of uniformity from the finally selected predicted factors.

## **Methodology and Work Completed**

The methodology to accomplish the goals of the study consist of collection of historic data, generation of data from new field trials, development of software to evaluate various lane and sprinkler spacings from field collected data, development of a statistical model to predict application uniformity from field collected and software generated data, and finally the construction of uniformity prediction tables for use by operators of animal waste systems.

## **Collection of Historic Data**

Data from historic field trials were located and entered into a spreadsheet database. These calibrations were performed primarily on producer farms from 1996-1999. These data include 28 calibrations for traveling gun systems and 22 calibrations for stationary systems. The traveling gun systems include Nelson 100, 150, and 200 model guns. The stationary systems include primarily Nelson Model 100 big guns and Senninger Model 7025 sprinklers. Information entered into the database for traveling gun systems included gun model, nozzle, type, nozzle diameter, nozzle pressure, wetted diameter, gun angle, average wind speed, relative wind direction (relative to gage transect), and gage data. For stationary systems, the entered data included, sprinkler model, nozzle diameter, nozzle pressure, wetted diameter, and gage data and coefficient of uniformity.

## **Field Trials**

Field trials were performed at the Lake Wheeler Land Application and Demonstration Unit of the Lake Wheeler Field Laboratories (LWFL) and at producer farms (see Figures 1 and 2). The field trials involved both traveling gun and stationary systems. The trials at Lake Wheeler allowed for control of pressure and nozzle size. For all field trials wind data was collected using a Spectrum Watchdog 900 ET station (see Figure 3). Wind speed and direction were collected at one minute intervals. Software was written in R (2008, The R Foundation for Statistical Computing) to calculate average wind speed and to calculate wind direction relative to the collection gages.

### ***Traveling Gun***

Fifteen trials were performed at the Lake Wheeler land Application Training and Demonstration Unit. Two types of trial were performed; trials with the cart moving completely through a transect of rain gages as normally done in a field calibration (complete pull), and trials with the gun in a stationary position with gages positioned along a radii from the gun. Five pressures for two ring sizes and 3 for a third ring size were run with complete pulls for a total of 13 complete pull trials. In addition two gun profiles were obtained with the cart stationary at settings (nozzle size and pressure) the same as two of the complete pulls. The profile data were used to compare the estimate of uniformity using custom software and profile data to the estimates using complete pull data. The profile data also allows for estimating the impact of gun angle on application uniformity using the custom software. In addition to the trials at LWFL, four calibrations of traveling systems were done on producer farms. Two more calibrations on a research station are planned for the week of July 21, 2008.

### ***Stationary***

Stationary trials involved collecting profile data for gun and sprinkler systems. Eight trials (profiles) of Senninger Model 7025 sprinklers were done in July 2008 at LWFL. Profiles data

were collected for two nozzle sizes and four pressures each. In addition, 2 trials of Senninger Model 7025 sprinklers were done on producer fields. Three profiles for model 100 stationary guns were collected on producer fields and two profiles for Nelson Model 100 guns were collected at LWFL.

## **Software**

A program was written in R version 2.70 (2008, The R Foundation for Statistical Computing) to take field collected data and calculate traveling gun uniformity for several lane spacings from one field trial. Input data is gage data from complete pulls. Uniformity for spacings of 70, 75, 80, 85 and 90 percent of wetted diameter were calculated for each trial. The program produces graphical results and writes results to a output database. See Figure 4 for sample output.

Another analytical tool was developed to calculate uniformity for traveling gun systems using profile data collected from big guns. The program is written in Visual Basic for Applications and runs under an Excel interface. Input to the program is gage data from gun profiles. Output is uniformity for various lane spacings expressed as percent of wetted diameter and for various gun angles. Sample input and output are shown in Figures 5 and 6.

A third program has been written in S-Plus (Insightful Corporation) to calculate uniformity for stationary systems at various gun or sprinkler spacings. Input data is sprinkler/gun profile data.

In addition to the custom software written for this project, manufacturer software was obtained to compare with results from field trials and to fill in missing information. Winsipp (Senninger Irrigation) and Overlap (Nelson Irrigation) are the two manufacturer software programs. Both estimate uniformity for their respective sprinklers for stationary layouts. A few profiles have been obtained for big guns from Nelson Irrigation and electronic data for big guns is being requested for use in Overlap.

## **Statistical Analysis**

A preliminary statistical model was constructed containing the main effects (nozzle diameter, nozzle pressure, wetted diameter and percent overlap) and all interactions. The model was run in April with preliminary data to see if uniformity as measured by CU (Christensen's uniformity coefficient) was correlated to the factors measured in the field trials. Preliminary results hold promise that satisfactory prediction can be made for CU for traveling gun systems. A model has not yet been run for stationary systems. The final statistical model will be constructed by looking at the relative effect of all factors and checking for collinearity (two or more predictive factors having the same correlation to uniformity). Only those factors that uniquely predict uniformity will be retained in the model.

## **Work to Be Done**

Field trials will be completed this fall. Data from field trials needs to be processed through the custom software that calculates CU. A statistical model needs to be developed to predict CU for both traveling gun and stationary systems. If satisfactory predictive models are developed, the predicted uniformity coefficients will be entered into tables based upon the retained predictive factors (e.g., lane or sprinkler spacing, pressure, nozzle size, etc.). Table 1 shows an updated schedule.

Table 1. Updated Schedule

Task	Year								
	2007		2008				2009		
	J	O	J	A	J	O	J	A	J
1. Collect/Organize Existing Data	-----								
2. Field Trials Lake Wheeler				-----					
3. Field Trials Cooperator Sites		---		-----					
4. Statistical Analysis					-----				
6. Reports/Extension Guidance					-----			-----	



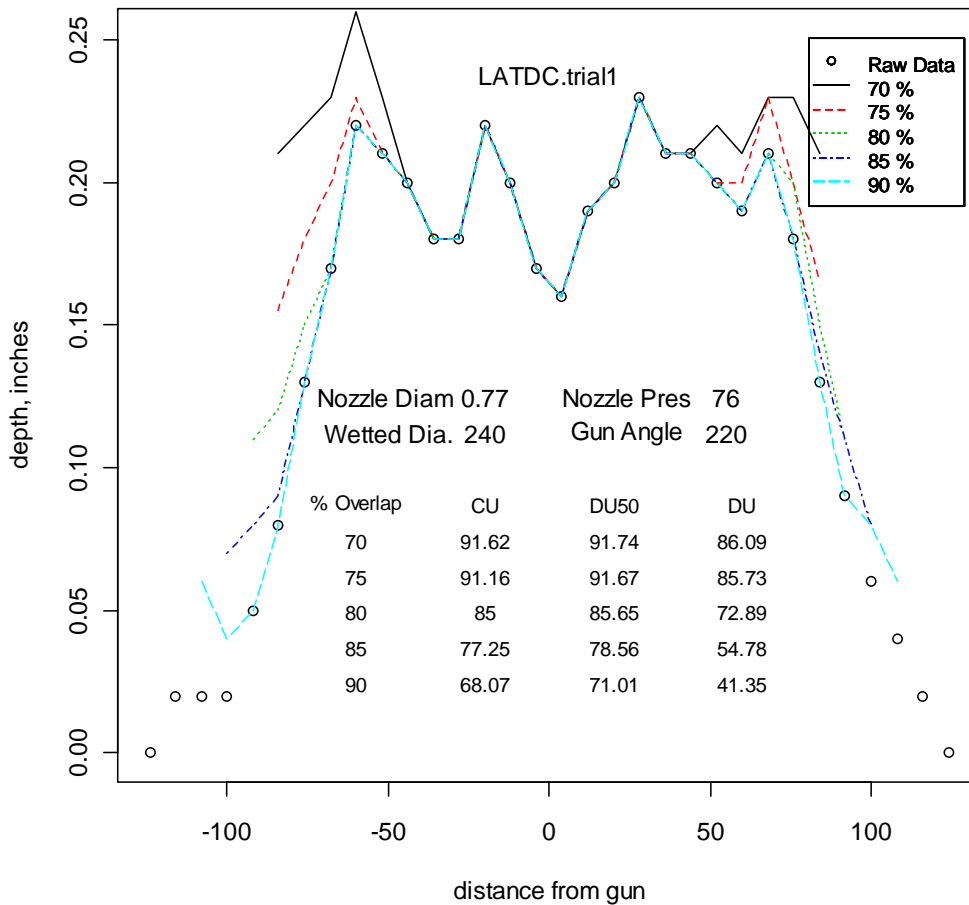
**Figure 1. Field trial for a traveling gun system at producer farm**



**Figure 2. Field trials at LWFL. Profile data for a Senninger stationary system is being collected in this photo.**



**Figure 3. Watchdog weather station used to collect wind speed and direction data. Collection gages in background.**



**Figure 4. Output from program used to generate traveling gun uniformity for several different lane spacings for each field trial.**

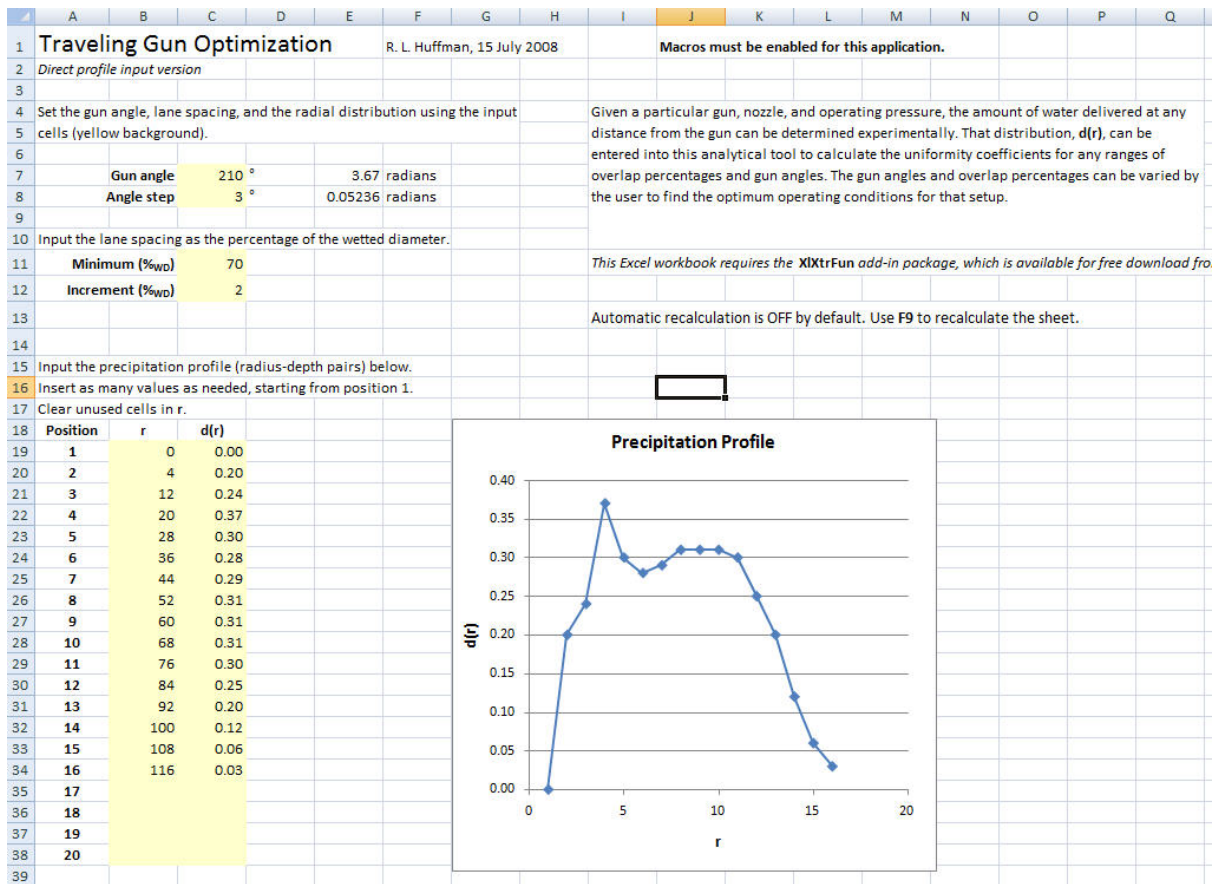


Figure 5. Input screen for spreadsheet model that uses big gun profile data to calculate uniformity.

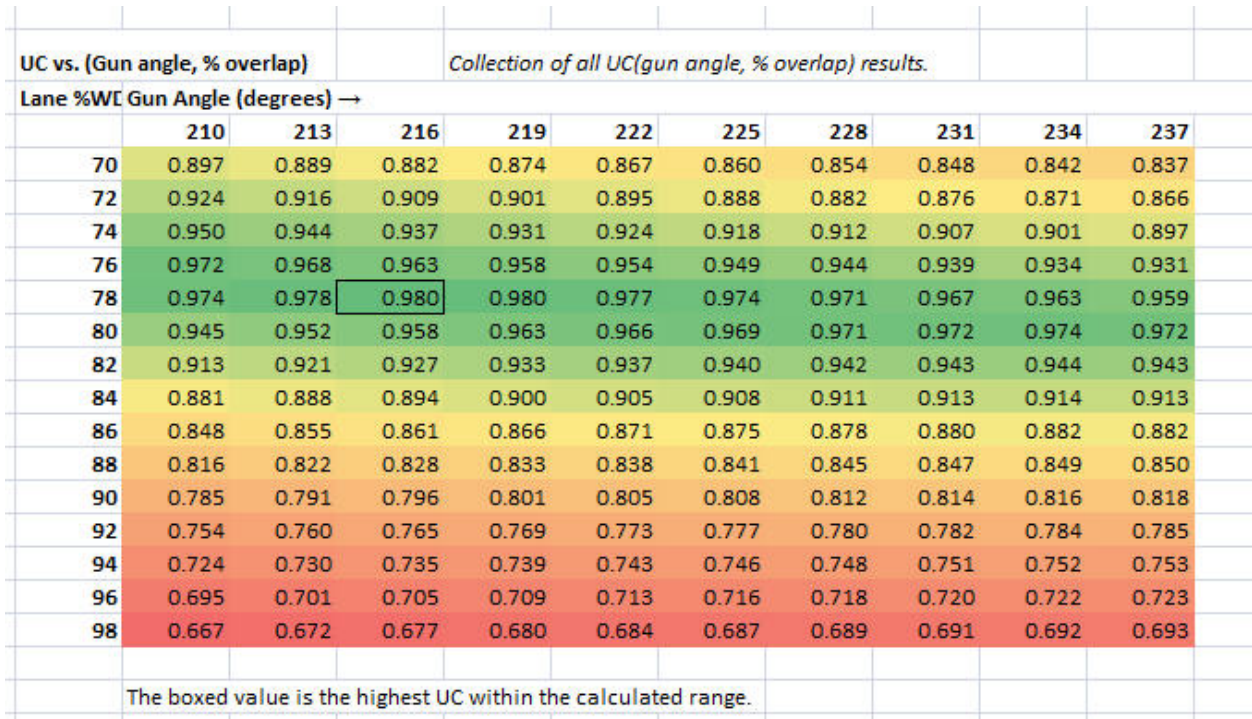
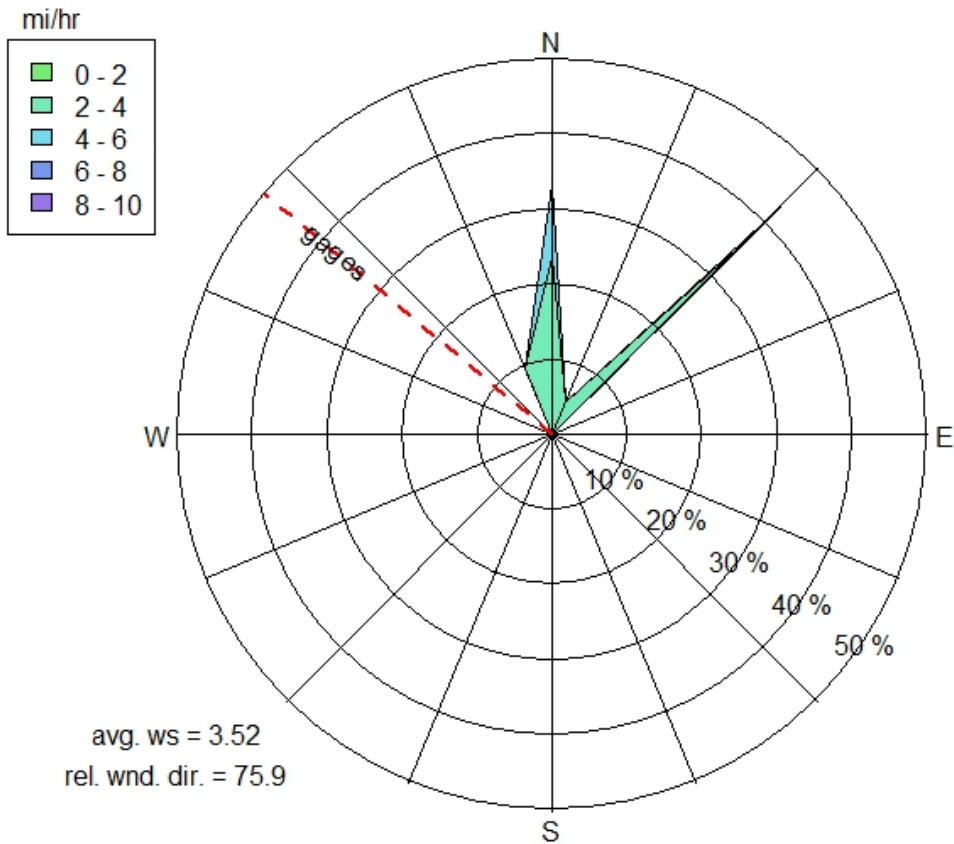


Figure 6 . Output screen for input data in Figure 5. UC (uniformity coefficient) is shown in table as a function of lane spacing (percent of wetted diameter) and gun angle.

### Trial Wind



**Figure 7. Output from custom R program to calculate average wind speed and wind direction relative to collection gages. Concentric circles indicate percentage of time wind is from the direction indicated by colored polygons.**