Irrigation Uniformity

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It is an unfortunate fact that even the most efficient state-of-the-art irrigation systems are not that great. Based upon results of field irrigation audits conducted throughout California by the California State Polytechnic University Irrigation Training and Research Center a distribution uniformity (DU) of 85% in the field is considered excellent. This means that even the best irrigation systems begin with at least 15% inefficiency. As age, wear and tear take place things only get worse. Now, imagine how bad it can get if corners are cut during the initial design or installation!

Evaluating sprinklers for new irrigation systems – It must be remembered that different sprinkler brands, models and nozzle combinations produce different and unique application profiles (See fig. 1 & 2) which ultimately affect performance of the system. In turn, some profiles perform better than others do so a good way to avoid disaster is to analyze sprinkler and nozzle application profiles before making a final product selection. In other words, know what you are buying!

How does one analyze a sprinkler & profile? Profile analysis can be accomplished for a small charge at the laboratory of the Center for Irrigation Technology (CIT) located at the California State University Fresno, (559)-278-2066 or visit: http://cati.csufresno.edu/cit/. After the profile data is collected coverage can be simulated in a two-dimensional graphic called a densogram (See fig. 3 - 6) using their "SPACE" (**S**prinkler **P**rofile **A**nd **C**overage **E**valuation) software. What is learned in the process is which sprinkler and/or nozzle combination should deliver the most uniform coverage at a specified spacing and operating pressure.

What are you looking for in a sprinkler profile? Generally irrigation texts agree that the best profile for turf irrigation is a wedge shape (see fig.1). This is because an overlapped wedge maintains more uniform application rates when slight adjustments in sprinkler spacing are required. So, one may ask, don't all large turf rotors deliver water in such a pattern? Not always as you can see by the two examples provided in figures 1 & 2 which are ***actual profiles*** from the CIT Laboratory tests. These profiles are from turf rotors typically recommended for use on 65-foot triangular spacing that is commonly specified in desert southwest areas.

Visualizing what the uniformity of water accumulation will look like when profiles are overlapped can be difficult and this is where the densogram (See figures 3 through 6) becomes useful. The densogram demonstrates wet and dry areas of an overlapped profile by light and dark areas in the pattern. For the sake of discussion the previously used profiles will both be overlapped at 65' equilateral triangular and square spacing.

The densograms representing the wedge profile overlaps (Figure 3 & 4) show more uniform shading representing a more uniform application of water throughout the area of coverage. The densograms representing the flat profile overlaps (Figure 5 & 6) show lighter, less uniform shading where dryer areas would form. The red square shown on each pattern represents the driest location in the pattern while the green square represents the wettest location.

In addition to the graphics the software also calculates a scheduling coefficient (SC). The SC is a run time multiplier that compares the driest 5% area of the overlapped patterns. In our example the SC of the two patterns when overlapped at 65' are 1.2 (Wedge Profile – Triangular Spacing) 1.3 (Wedge Profile – Square Spacing), 1.8 (Flat Profile – Triangular Spacing) and 2.2 (Flat Profile – Square Spacing) respectively. If the application rates of each sprinkler were 1/2" per hour and 1/4" of water (30 minutes of irrigation) is the desired amount to apply, 36 minutes of run time are required to adequately irrigate the driest portion of the 1.2 scheduling coefficient pattern (wedge profile). While 54 minutes are required with the 1.8 scheduling coefficient pattern (flat profile). So, with the flat profile, while you are getting the driest spot "green" the rest of the pattern turns into a bog. On a golf course no one wants wet areas so we end up living with dry spots instead.

Evaluating existing irrigation systems - An irrigation audit / catch-can test is a good method to evaluate and document an existing sprinkler system's performance. Several factors affect distribution uniformity and often require adjustment or repair before performing a catch-can evaluation. A checklist is suggested to document the before and after conditions of the following factors:

> Spacing and geometric configuration - Sprinkler head spacing should be uniform. The distance between sprinklers as well as geometric configuration (squares or equilateral triangles) affect both distribution uniformity and application rate. Although adjustment of these factors is not always practical, documentation as part of the audit is recommended as a diagnostic tool.

> Sprinkler brand, model and nozzle combinations - Replacing worn nozzles or nozzles not of the same size is often the least expensive repair that provides the greatest improvement in performance. A recent case study conducted by the Center for Irrigation Technology in California found improving distribution uniformity by selecting a more efficient nozzle combination saved an average of 5.7% water. For additional information visit: http://cati.csufresno.edu/cit/Golf%20Course%20Survey-lo-res.pdf Sprinkler brands, models, and nozzles are not interchangeable and should never be mixed within the same areas of coverage and control because application rates and profile patterns can vary considerably.

> Operating pressure - Uniform coverage is compromised when operating pressures are not within manufacturers specified ranges. Operating pressure should be checked at the nozzle with a pressure gauge and pitot tube. Pressure regulation valves and pumps should be adjusted to deliver optimum pressures.

Rotation speed – Sprinkler rotation speed should be checked and recorded. Rotation speed will vary with nozzle size, stator size, operating pressure, and condition of the gear or impact drive mechanism. Rotation speed should be consistent between sprinklers for the most uniform water distribution. Impact sprinklers should complete one revolution in 2.00 minutes (+/- 15 seconds) while gear drive sprinklers my rotate more slowly requiring 2 minutes 30 seconds to three minutes to complete one rotation. Under no circumstance should sprinklers complete one rotation in less that 1 minute and 45 seconds.

Other - Site specific data such as stations tested, general conditions of the surrounding turf, raise low sprinklers that are not at proper grade, land slope, etc. should be noted for future reference. Wind velocity should be at less than 8 miles per hour to collect meaningful data.

Performing the catch-can test - After collecting the above data and making any needed adjustments a catch can test should be performed to evaluate distribution uniformity. Catchments are placed in symmetrical patterns between at least two sprinkler rows. At a minimum, cans are placed near each head being tested and one-half way in between. (Nine catchments between four sprinklers.) Where more precise data is desired, additional cans can be placed on closer spacing.

Sprinklers are then operated for a sufficient amount of time to collect an average of 25 ml water and/or allow 5 revolutions of each rotor. Cylindrical shaped catchments allow direct measurement with a thin ruler; non-cylindrical catchments require using a graduated cylinder and conversion of the data. Calibrated catchments are available that allow measurements to be directly read. Normally, catch-can tests are conducted after completing repairs and adjustments, however, to document improvements performing tests prior to making adjustments is worthwhile the first time a system is evaluated.

Evaluating results - Results of catch-can tests are used to calculate application efficiency. The formula known as *Low Quarter Distribution Uniformity* (DU_{LQ}) is most commonly used. DU_{LQ} is determined by sorting all catch-can data from the lowest to highest values. The average of the lowest 25 percent of values is divided by the average of all the values. Based upon results of audits conducted throughout California by the Cal Poly University Irrigation Training and Research Center the following interpretative guidelines are offered:

Distribution Uniformity % and Relative System Performance

Excellent	Very Good	Good	Fair	Poor
85% or greater	80%	75%	70%	65% or less

Source: California State Polytechnic University Irrigation Research and Training Center

DU_{LQ} below 65% following a tune-up is an indicator that major repairs, nozzle, sprinkler or complete system replacement may be warranted. Under these circumstances, a more extensive evaluation by a golf course irrigation designer is suggested. Remember that distribution uniformity of 80% is achievable and a realistic expectation with a properly designed properly installed and properly maintained system.

Description of Graphics (See next page) -

Figure 1 – Wedge shaped profile

Figure 2 – Flat shaped profile

Figure 3 – Densogram representing overlap of wedge shaped profile on 65 foot triangular spacing.

Figure 4 – Densogram representing overlap of wedge shaped profile on 65 foot square spacing.

Figure 5 – Densogram representing overlap of flat shaped profile on 65 foot triangular spacing.

Figure 6 – Densogram representing overlap of flat shaped profile on 65 foot square spacing.

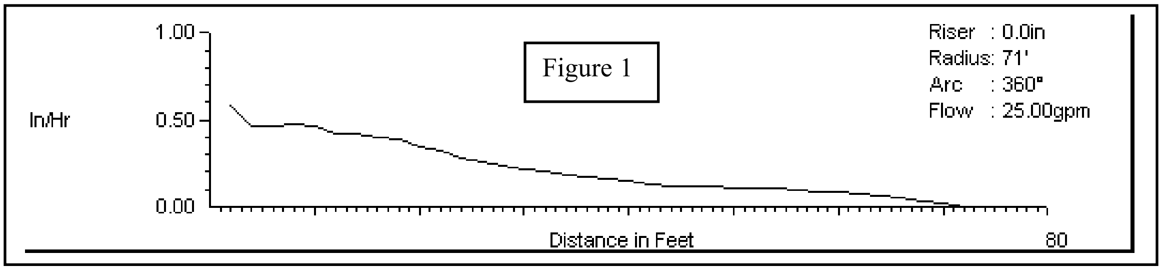

Figure 1

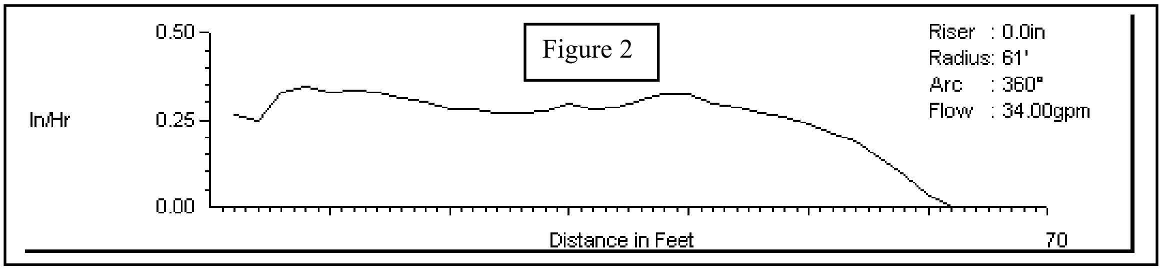

Figure 2

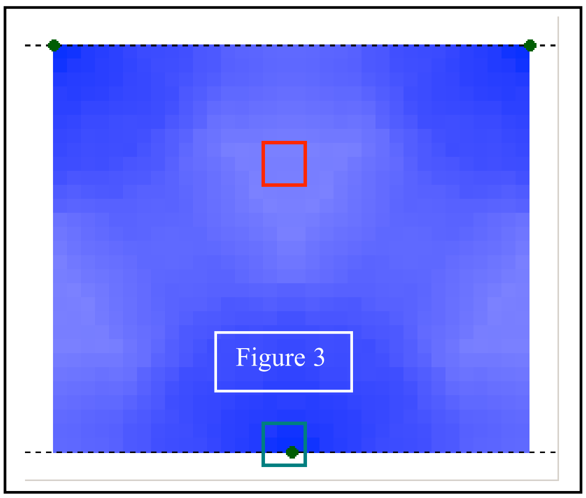
Figure 3

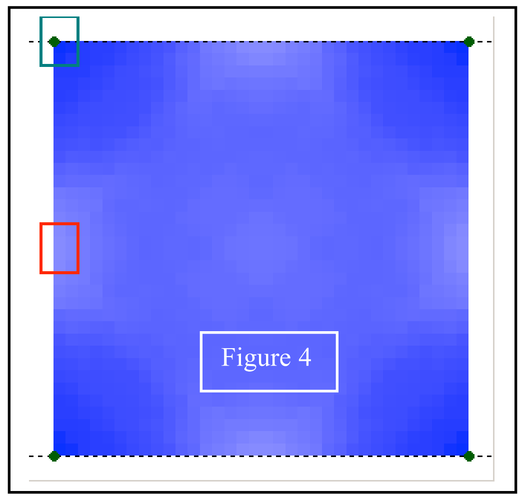
Figure 4

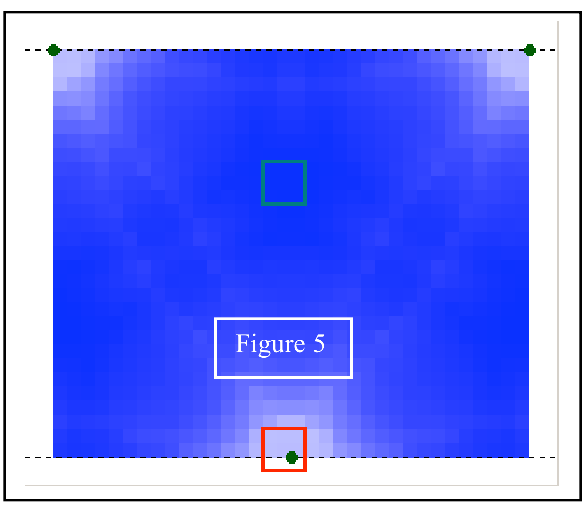
Figure 5

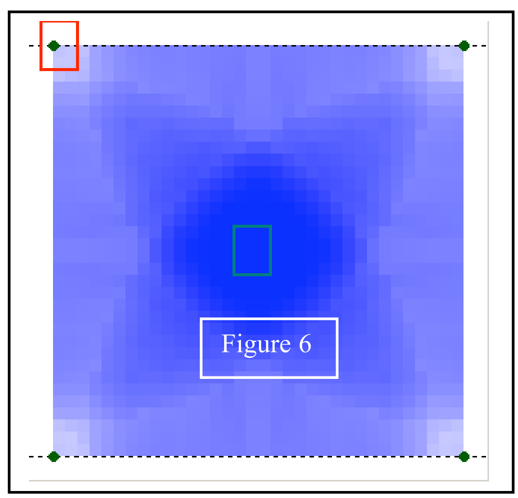
Figure 6