Conducting an Irrigation Audit

Irrigation audits are performed on sports fields to check the operation and efficiency of the irrigation system and to make sure all areas are receiving the appropriate amounts of water. When an irrigation audit is conducted properly, it can provide information to improve irrigation efficiency, reduce water costs, lessen turfgrass plant damage, significantly decrease the likelihood of water runoff, and in some cases, help convince decision makers that a new irrigation system may be needed. An irrigation audit measures the precipitation rate and the uniformity of water that is being applied. The audit process documents irrigation issues in a qualitative way that is valuable when used as a benchmark for the operation of the irrigation system.

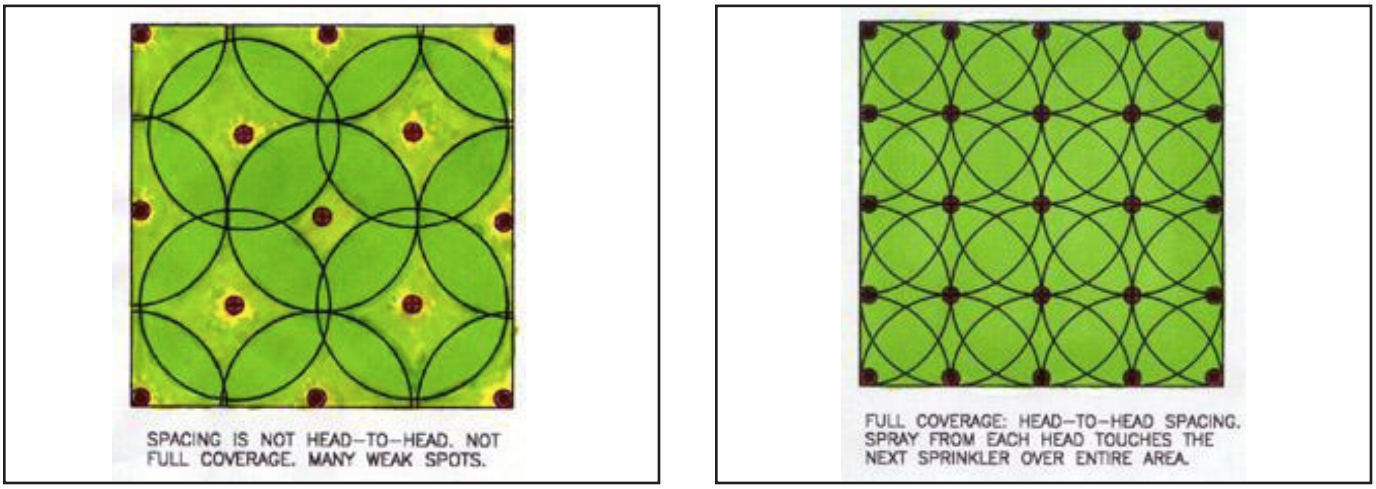
Photo courtesy of Jerad Minnick

Pre-Audit

Before conducting an irrigation audit, the irrigation system should be in optimal working condition. Check that the system complies with local codes, identify operational defects or deficiencies, and make repairs to the system. Repairing and adjusting malfunctioning irrigation components will make a huge improvement in the efficiency of the system and decrease water consumption. Common causes of breaks or inconsistencies in the system that contribute to water waste include:

- Tree roots
- Sprinkler heads that do not turn due to wear
- Heads that turn, but don't follow a preset pattern due to misalignment
- Broken or missing sprinkler heads
- Incorrect or mismatched nozzles
- Mixed zones (for example: full circle and half circle rotors utilizing nozzles with the same precipitation rate)
- Leaking heads and pipe connections
- Bent risers due to damage from a mower or other vehicle which results in water being delivered at an incorrect angle
- Risers that do not rise above the turfgrass
- Geysers from a missing nozzle, vandalism, or age
- Orifices clogged due to sand and other debris
- Sunken sprinkler heads

- Sprinkler heads spaced too far apart or too close together
- Insufficient or excessive operating pressure



Low pressure and poor coverage (left) compared to correct pressure and full coverage (right) – Photos courtesy of Jeff Gilbert

Use Worksheet #1 – Site Inspection at the end of the bulletin to assist with identifying irrigation problems that need to be corrected.

In some cases, it may be better to conduct the audit "as-is" with the irrigation system. This is dependent on if the manager is trying to prove or show inadequacy and can help in the effort to install a new irrigation system or update an existing system.

Irrigation Audit

Conducting an irrigation audit on the entire irrigation system is recommended; especially if the site has never undergone an audit. However, depending on goals, you may choose to engage in linking. Linking uses information from one station or zone and applies it to another, and can be used when there are a large number of sprinkler zones that are identical. For example, zones may have the same sprinkler head, nozzles, spacing, operating pressure, or similar soil and plant types. Catch device tests can be performed on one-third to one-half of the sprinkler zones to get an average value that could be applied to all sprinkler zones that are identical. If you choose to use linking, be sure to audit a variety of areas. For example, select areas where you are having trouble, areas that perform well, and average areas to determine how well your irrigation system is performing. Be sure to audit problematic features from an irrigation standpoint, such as sprinkler spacing, nozzle pressure, or sunken or tilted sprinkler heads. Linking can be an effective practice, however, it is suggested that every zone eventually receives an audit.

Catch can testing – Photo courtesy of Jeff Gilbert

The audit should reflect normal operating conditions. If normal operating conditions occur at odd hours, some assessment of the impact of these conditions should be made during the tested conditions.

Conducting an Irrigation Audit

The most accurate determination of precipitation rate and distribution uniformity is achieved by conducting catch can tests. Catch can tests measure the amount of water that actually hits the ground at various points on each field or landscape feature. Catch devices are laid out on a set spacing to collect water for a predetermined amount of time. The amount of water collected is measured to calculate distribution uniformity and net precipitation rate of the irrigation system. For best results, all catch devices must be uniform in size and shape. Larger collectors give better repeatable results. It is important to conduct catch can tests for each individual zone or station of an irrigation system. Using catch cans is the best way to determine how well or how poorly the irrigation system applies water.

Steps to Perform a Catch Can Test:

Step 1: Obtain the materials needed to conduct the audit. You may be able to obtain an Irrigation Audit Kit from your local Cooperative Extension or a local commercial company. Otherwise, collect the following items to perform an irrigation audit:

- Flags
- Tape measure
- Catch devices
- Stopwatch
- Ruler with inches/centimeter
- Nozzle pressure gauge
- Graduated cylinder
- Calculator
- Worksheets (provided at the end of the bulletin)

Photo courtesy of Jeff Gilbert

Step 2: Turn on the irrigation system one zone at a time to locate and mark sprinkler heads. Use Worksheet #2 – Test Area Data and Map provided at the end of the bulletin to help map out the area being audited.

Step 3: Starting with Zone 1, lay out catch devices only on the turfgrass area covered by Zone 1. Catch devices should be placed in a grid-like pattern throughout the zone to achieve an accurate representation of sprinkler performance. Be sure not to place catch devices too close to sprinkler heads to avoid altering spray patterns. A minimum of 24 catch devices should be used. Minimum catchment device spacing:

- Fixed spray sprinklers – near a head (within 2-3 feet) and half-way between the heads.
- Rotor sprinkler heads spaced less than 40 feet on center - near a head (within 2-3 feet) and every one-third of the distance between the heads.
- Rotor heads spaced greater than 40 feet on center - near a head (within 2-3 feet) and every one-fourth of the distance between the heads.

Photo courtesy of Jeff Gilbert

- The catchments along the edge of the zones should be placed 12 to 24 inches in from the edge.
- On unusual or irregularly shaped areas (such as a baseball infield) that utilizes rotor sprinklers, set up a uniform grid

of catch devices that is 10-20 feet on center spacing. Areas that utilize spray sprinklers (such as curvilinear areas without defined rows of sprinklers) should be set up as a uniform grid of catch devices that are 5-8 feet on center spacing.

Step 4: Turn on Zone 1 and allow water to partially fill catch devices. Record the number of minutes the zone is allowed to operate. Test run times must be consistent and appropriate for the sprinkler type and arc. While the zone is running, check the effectiveness of repairs made to the irrigation system. Take notes such as "west head not turning properly", "riser may have been driven over", or "possible leak". If problems exist, repair or make appropriate adjustments. Use Worksheet #1 – Site Inspection at the end of the bulletin to identify additional problems that may need to be corrected.

Catch device – Photo courtesy of Jeff Gilbert

Step 5: While each zone is running, record and document the following information about the irrigation system and performance (use the worksheets provided at the end of the bulletin to help document information):

- Date and time of testing
- Weather conditions
- Soil types and rootzone depths
- Approximate catchment device locations outlined on a map or grid
- Catchment readings
- Test run time in minutes
- Meter readings (if available)
- Pressure readings with locations. Pressure tests should be conducted at normal operating conditions at the sprinkler using the appropriate pressure testing device at the beginning and end of each zone audited. Sprinkler heads are designed to operate within specific operating pressures and head spacing. A pitot tube can be used to measure the sprinkler's operating pressure as the water exits the sprinkler. The tube is placed in the stream of water just as it is exiting the sprinkler. The operating pressure can be compared to the operating pressure recommended by the manufacturer.

Measure operating pressure – Photo courtesy of Jeff Gilbert

- Wind speed readings. Wind speed should be 5 mph or less during the audit. Monitor and record wind speed every 5 minutes during the audit.

Step 6: Once the system has run for the predetermined time period, measure the amount of water collected in each catch device. Record values on Worksheet #3 – DU and PR Calculations provided at the end of this bulletin. Catchments for a test area should be documented to facilitate repeatability.

Step 7: Repeat steps 1-5 for each remaining zone in the turfgrass area. When the test area contains multiple stations, the test run times for each station or zone must be adjusted to achieve a matched precipitation rate across the test area. Ideally, each catch device should contain approximately the same amount of water. The goal is to achieve uniform distribution. No irrigation system is perfect, but it is important to get close in order to reduce turfgrass and irrigation system problems.

Post-Audit

Once the audit has been completed, it is time to calculate the distribution uniformity and precipitation rate based on the data collected using Worksheet #3.

Calculating Precipitation Rate

Depending on the type of catch device used, precipitation rate can be calculated by using milliliters or inches. If catch cans do not have parallel sides, it is best to measure volume (in mL, which is equivalent to cm^3) and determine depth by dividing volume by area (in cm^2) of the containers opening.

Calculating Precipitation Rate Using mL:

Measure catch volume: _____ mL (mL converts directly to cm^3)

$$\text{Calculate area of catch device opening: } \frac{\text{\_\_\_\_\_ mL}}{\text{Area } (\pi r^2)} = \text{\_\_\_\_\_ } cm^2$$

$$cm = \frac{\text{\_\_\_\_\_ } cm^3}{\text{\_\_\_\_\_ } cm^2}$$

$$\text{inches of water in catch device} = \frac{\text{\_\_\_\_\_ cm}}{2.54 \text{ cm}}$$

$$PR = \frac{\text{\_\_\_\_\_ inches of water in catch device}}{\text{\_\_\_\_\_ minutes run time}} \times 60$$

PRECIPITATION RATE = _____ in/hr

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If using catch cans with parallel sides, inches per hour can be found by measuring the depth of water captured in the cans.

Calculating Precipitation Rate Using Inches:

$$PR = \frac{\text{Average Catch Can Depth}}{\text{Testing Run Time}}$$

$$PR = \left[\frac{(\_\_\_\_\_ \text{ inches})}{(\_\_\_\_\_ \text{ minutes})} \right] \times 60$$

PRECIPITATION RATE = _____ in/hr

Calculating Distribution Uniformity

The most common measure of distribution uniformity is the Low Quarter Distribution Uniformity. This is a measure of the average of the lowest quarter of catchment samples, divided by the average of all catchment samples. A higher distribution uniformity indicates a better performing irrigation system. If all catchment samples are equal, the distribution uniformity is 100%. There is no universal value of distribution uniformity for satisfactory system performance, but generally a value greater than 70% is considered acceptable. The lower the distribution uniformity, the less efficient the distribution, which means more water must be applied to meet the minimum requirement.

Make sure to maximize distribution uniformity – Photo courtesy of Jeff Gilbert

$$DU \text{ (of lower quarter)} = \frac{\text{Avg Catch in lower quarter}}{\text{Avg Catch Overall}}$$

$$DU = \frac{\_\_\_\_\_ \text{ mL}}{\_\_\_\_\_ \text{ mL}}$$

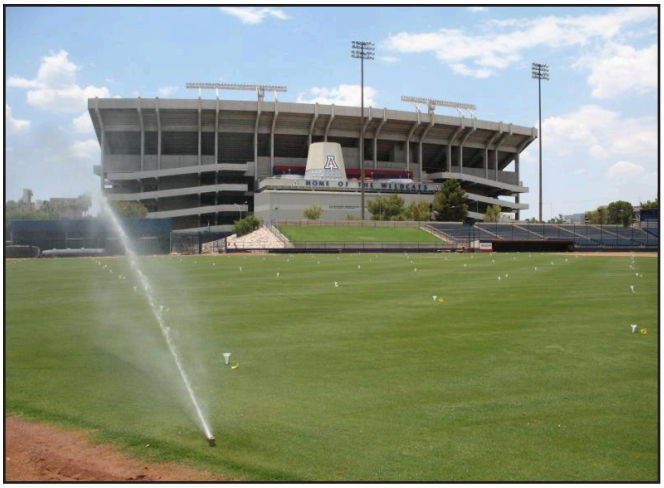
DISTRIBUTION UNIFORMITY (DU) = _____

Distribution uniformity is useful when determining the total watering requirement during irrigation scheduling.

> **For example:** An irrigator does not want to apply less than one inch of water to an area. If the distribution uniformity is 75%, total amount of water to be applied would be the desired amount of water divided by the distribution uniformity (1 inch / 0.75). In this case, the required irrigation would be 1.33 inches of water. Keep in mind that applying at least 1 inch of water to the entire area will result in over irrigating some areas.

Applying the Results

Irrigation audits are extremely beneficial when it comes to determining the irrigation schedule for turfgrass areas. When and how long to irrigate are often based on assumptions and generalizations in regards to sprinkler system performance and plant-water requirements. Audits provide data that allows irrigation schedules to be customized to both the irrigation system, the plants, and watering based on evapotranspiration. Rather than using long time recommendations such as "15 minutes, 3 times per week", run times can be adjusted for individual zones based on the measured precipitation rate and distribution uniformity.



Catch can testing – Photo courtesy of Jeff Gilbert

In addition to applying the results of an audit to an irrigation program, plant and soil factors must be taken into consideration. Determining when to irrigate should be based on the depth of plant roots and the type of soil rootzone. For example, turfgrass with a shallow rootzone growing in a predominantly sandy soil will require more frequent irrigation. In comparison, turfgrass with a deep rootzone growing in predominantly loam soil will require less frequent irrigation. Plant-water requirements also vary significantly depending on the variety of plant species, maintenance practices, microclimates, climate trends, and rainfall patterns. Be sure to assess plant-water needs, rootzone depth, and type of rootzone when determining frequency and amount of water to be applied in an irrigation program.

To determine how much water needs to be applied during each irrigation event, convert to zone run time:

$$\text{Run Time per Irrigation Cycle} = \frac{\text{Target Irrigation Depth}}{\text{Zone Precipitation Rate}}$$

$$\text{Run Time } \_\_\_\_\_ \text{ minutes} = \frac{\_\_\_\_\_ \text{ inches}}{\_\_\_\_\_ \text{ inches/hour}} \times 60$$

Run Time per Irrigation Cycle = _____

Conclusion

An irrigation audit will provide insight into the operation of your irrigation system and help you determine how to improve its efficiency. Keeping accurate and up-to-date records throughout the year will help during the auditing process. Records should include water use and weather information such as rainfall amounts, evapotranspiration rates, and high temperatures. Information about the irrigation system such as controllers, number of irrigated acres, system improvements, head locations, spacing, operating pressure, sprinkler make, model, and nozzle sizes should also be recorded.

Conducting annual audits and making simple repairs and adjustments to malfunctioning irrigation components will make a huge improvement in the efficiency of the system and decrease water consumption. All systems require periodic maintenance and repairs to be sure the system is operating efficiently and minimizing water waste.

Conversions

1 inch = 25mm
1 inch^2 = 6.45 cm^2
1 inch^3 = 16.387064 mL
1 US gallon = 5/8 of 1 Imperial gallon
1 Imperial gallon = 4.54 liters
1 US gallon = 3.785 liters

Resources:
Contributions from STMA Information Outreach Committee
Irrigation Association – Irrigation Audit Guidelines - http://www.irrigation.org/Resources/Audit_Guidelines.aspx
Irrigation Association SuperTip – Superintendent Magazine - http://www.superintendentmagazine.com/article-9132.aspx
Irrigation Audits: Pinpoint Problems - John Fech - http://www.turf-digital.com/mar2012/North/0/0#&pageSet=14
General Landscape Irrigation Audit Procedures – North Carolina State University - http://www.turffiles.ncsu.edu/pdffiles/004509/General_Landscape_Irrigation_Audit_Procedures.pdf
Water Reduction 101 – An Audit Competition – Michael Carr and Gordon Kunkle – 2011 STMA Conference Presentation - http://www.stma.org/sites/stma/files/Conference/2012_Conference/Carr.pdf

WORKSHEET #1 – SITE INSPECTION

Site Name: _____

Audit Date/Time: _____ **Current Weather Conditions** _____

Site inspection is only necessary on the zones being audited. Record the number of defects for each sprinkler problem or check mark for zone problems; leave blank if no problem exists.

Controller Identification

Station Number:										
Turfgrass Species/ Cultivar										
Sprinkler Type - Manufacturer - Model Name/Number										
Observed Problems:										
Valve Malfunctions										
Low Pressure										
High Pressure										
Tilted Sprinklers										
Spray Deflection										
Sunken Sprinklers										
Plugged Equipment										
Arc Misalignment										
Low Sprinkler Drainage										
Leaky Seals or Fittings										
Lateral or Drip Line Leaks										
Missing or Broken Heads										
Slow Drainage or Ponding										
Compaction/ Thatch/Runoff										
Notes and Comments:										

*Adapted from Golf Audit Worksheets available from the Irrigation Association

WORKSHEET #2 – TEST AREA DATA AND MAP

Site Name: _____

Audit Date/Time: _____

Station #: _____ **Rootzone Depth** _____ inches

Controller _____

Run time _____min.

Pressure _____psi

Meter Reading _____

Wind Speed: _____mph

Soil Type

☐ Clay

☐ Loam

☐ Sand

Plant Material

☐ Cool-season turfgrass

☐ Warm-season turfgrass

☐ Ground cover

☐ Shrubs

Zone

☐ Overlap

☐ Stand-alone

Indicate north and ALL audit area dimensions

O = SPRINKLER – Record the location of each sprinkler and sprinkler spacing.

X = CATCH DEVICE – Record the location of each catch device and catch amount.

*Adapted from Golf Audit Worksheets available from the Irrigation Association

WORKSHEET #3 – DU AND PR CALCULATIONS

Site Name: _____

Audit Date/Time: _____

All values and calculations must be completed for Worksheet #3.

Run time _____min.

Catchment Type_____

Catchment Device Area _____ sq. in.

1) Record ALL catch device values.

2) Circle ALL values used to calculate lower quarter.

Can #1 ____	#11 ____	#21 ____	#31 ____	#41 ____	#51 ____	#61 ____
Can #2 ____	#12 ____	#22 ____	#32 ____	#42 ____	#52 ____	#62 ____
Can #3 ____	#13 ____	#23 ____	#33 ____	#43 ____	#53 ____	#63 ____
Can #4 ____	#14 ____	#24 ____	#34 ____	#44 ____	#54 ____	#64 ____
Can #5 ____	#15 ____	#25 ____	#35 ____	#45 ____	#55 ____	#65 ____
Can #6 ____	#16 ____	#26 ____	#36 ____	#46 ____	#56 ____	#66 ____
Can #7 ____	#17 ____	#27 ____	#37 ____	#47 ____	#57 ____	#67 ____
Can #8 ____	#18 ____	#28 ____	#38 ____	#48 ____	#58 ____	#68 ____
Can #9 ____	#19 ____	#29 ____	#39 ____	#49 ____	#59 ____	#69 ____
Can#10 ____	#20 ____	#30 ____	#40 ____	#50 ____	#60 ____	#70 ____
Column Subtotals						
_____	_____	_____	_____	_____	_____	_____

TOTAL CATCH _____ mL

TOTAL CATCH IN LOWER QUARTER_____ mL

AVERAGE CATCH _____mL

AVERAGE CATCH IN LOWER QUARTER_____mL

*Adapted from Golf Audit Worksheets available from the Irrigation Association

WORKSHEET #3 – DU AND PR CALCULATIONS

Site Name: _____

Audit Date/Time: _____

Calculate Precipitation Rate (PR) (using mL)

Measure catch volume: _____ mL (mL converts directly to cm^3)

Calculate area of catch device opening: $\frac{\text{\_\_\_\_\_ mL}}{\text{Area } (\pi r^2)} = \text{\_\_\_\_\_ } cm^2$

$$cm = \frac{\text{\_\_\_\_\_ } cm^3}{\text{\_\_\_\_\_ } cm^2}$$

$$\text{inches of water in catch device} = \frac{\text{\_\_\_\_\_ cm}}{2.54 \text{ cm}}$$

$$PR = \frac{\text{\_\_\_\_\_ inches of water in catch device}}{\text{\_\_\_\_\_ minutes run time}} \times 60$$

PRECIPITATION RATE = _____ in/hr

Calculate Distribution Uniformity (DU)

$$\text{DU (of lower quarter)} = \frac{\text{Avg Catch in lower quarter}}{\text{Avg Catch Overall}}$$

$$DU = \frac{\text{\_\_\_\_\_ mL}}{\text{\_\_\_\_\_ mL}}$$

DISTRIBUTION UNIFORMITY (DU) = _____

Calculate Precipitation Rate (PR) (using in)

$$PR = \frac{\text{Average Catch Can Depth}}{\text{Testing Run Time}}$$

$$PR = \left[\frac{(\text{\_\_\_\_\_ inches})}{(\text{\_\_\_\_\_ minutes})} \right] \times 60$$

PRECIPITATION RATE = _____ in/hr