CHAPTER 5. Evaluation of Urban Irrigation Systems

The evaluation of urban systems is based on a test of the pressure throughout the system and a measurement of the uniformity with which the water is distributed over the field surface.

5.1 Common System Components in Urban Irrigation

Most residential irrigation systems consist of the following components: a pressurized water supply, poly-vinyl chloride (PVC) pipe or polyethylene (PE) pipe, a controller and control valves, a backflow prevention assembly, sprinklers and a rain shut-off device. In addition, the use of low volume irrigation components such as drip tubing and low-flow emitters is highly recommended for shrub areas.

The controller is a timer, either electronic or mechanical (see Figure 1), connected to a series of valves that turn the system on and off on specified intervals. Each area that is watered by a control valve is called a zone. Electronic controllers are often preferred because they can offer a variety of options such as allowing different operating schedules for each zone.

The backflow prevention assembly allows one way flow between the meter and the control valves. This prevents water from backing up into the main line and contaminating the metered water supply or a residential well (see Figure 2). Control valves allow flow to each individual zone and are operated by the controller (see Figure 3).

Sprinklers are divided into two basic types: rotors and spray heads. Spray heads are designed to apply water at a relatively high rate (approx. 1.5 inches/hr) to the immediate surrounding area (see Figure 4). Spray heads can be used to irrigate areas with radii from 8 to 17 feet, although they usually irrigate a radius of 10 to 15 feet. Because of their high application rate, spray heads are typically operated for 15-20 minutes per irrigation cycle.

Rotors are divided into two general categories: gear driven and impact. They have a lower application rate than spray heads (approx. 0.3 to 0.7 inches/hr). Impact rotors are usually the least expensive. They operate by using water pressure to cause a spring loaded arm to pivot, which turns the rotor (see Figure 5). Impact rotors are easy to adjust, but can easily stick in one position if sand or debris gets into the operating mechanism. Some common impact rotors are not available in a wide range of flow rates and do not have some useful features such as interchangeable nozzles.

Gear driven rotors are generally preferred over impact rotors to achieve a uniform application of water. The primary advantage of a gear driven rotor is that the operating mechanism is encased, protecting it from dirt and debris. Gear driven rotors are available in a wide range of flow rates and can be adjusted to rotate over a full or fraction of a circle (see Figure 6). High quality rotors that have interchangeable nozzles are available from many manufacturers. Interchangeable nozzles offer the most flexibility when determining irrigation duration.

Microirrigation such as drip or micro spray irrigation should be used for shrubs or trees. Drip irrigation delivers water directly to the root system with minimal loss to evaporation. Although this manual will not address testing drip systems for efficiency, drip systems should be inspected to insure proper function and to identify problems such as leaks. Historically, drip systems were plagued by problems of clogging from suspended solids in the water, polyethylene tubing that was prone to cracking, and valves that were unreliable at low flow rates. New emitters are virtually clog proof and more dependable when used in conjunction with high quality filters and valves designed for low volume irrigation (see Figure 7) (Sunset, 1988). If an irrigation system has a low flow irrigation zone, check to see if a filter has been properly installed. Most manufacturers will recommend a 200 mesh screen for drip systems and 80 mesh screen for micro spray emitters (Smajstrla, et al., 1994). The mesh number of a screen is the number of openings per square inch through which water can flow. Using drip irrigation, runoff can be eliminated and water loss due to evaporation can be greatly reduced for a water savings of up to 70 percent (Sunset, 1988).

One of the most important components in an efficient irrigation system is a device to turn the system off when sufficient rainfall occurs. Two such devices are rain shut-off devices and soil moisture sensors. Each type has benefits and drawbacks. Soil moisture sensors are usually more expensive than rain shut-off devices. They also do not meet current Florida Statute requirements that all new irrigation systems have a rain shut-off device installed. Soil moisture sensors do not actually measure water content in the soil, but they measure a parameter, such as electrical conductivity, that is associated with soil moisture content. The main problem with soil moisture sensors is that they are difficult to calibrate and may have to be adjusted after fertilization or pesticide application.

Rain shut-off devices are small devices, usually mounted on the eave of a house, connected to the irrigation controller (see Figure 8). They are required by law on all new irrigation systems. After sufficient rainfall, usually 0.5 inches, the irrigation system skips a scheduled watering cycle. When enough water evaporates, the irrigation system timer begins to control the system again. Some rain shut-off devices may require periodic cleaning to remove dirt and debris from the operating mechanism. One drawback is that rain shut-off devices operate on the assumption that evaporation occurs at the same rate as evapotranspiration (ET). ET is evaporation that occurs through plant stomata and from moist soil combined with water loss due to cellular respiration. Although this assumption is not quite accurate, it is adequate for non-commercial applications.

Figure 2

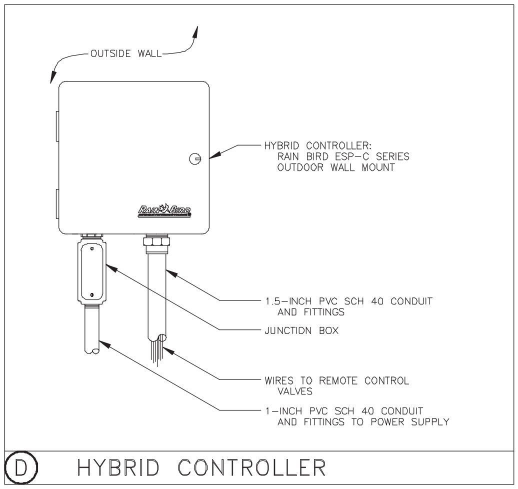


Figure 3

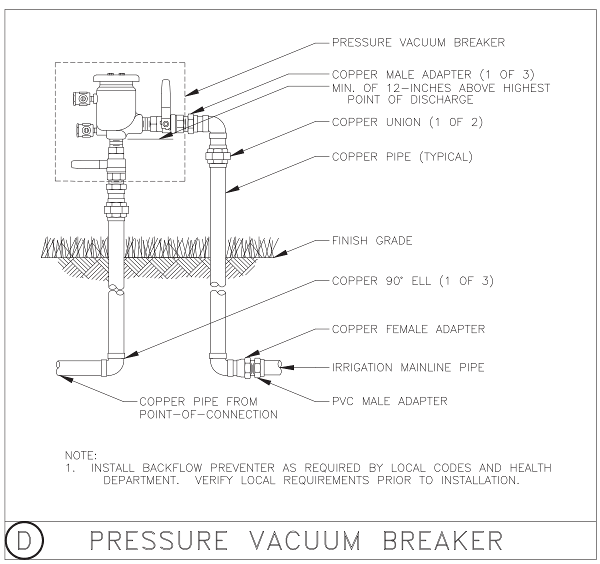


Figure 4

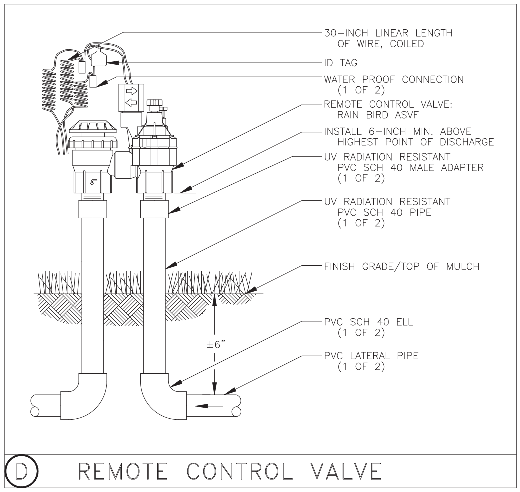


Figure 5

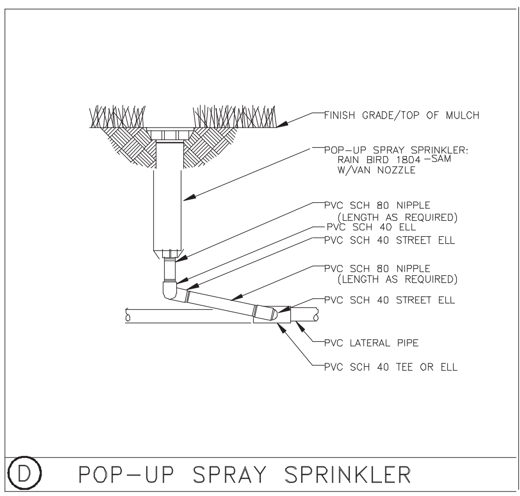


Figure 6

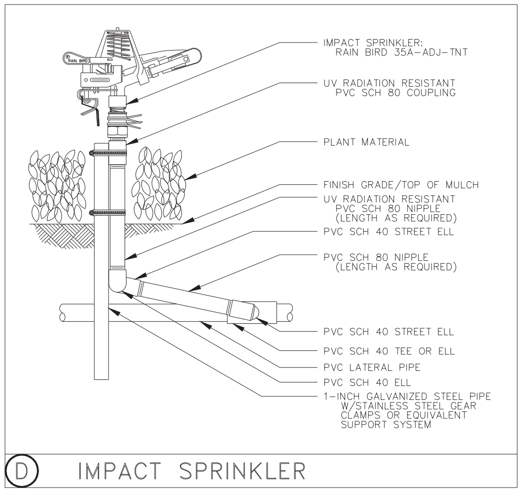


Figure 7

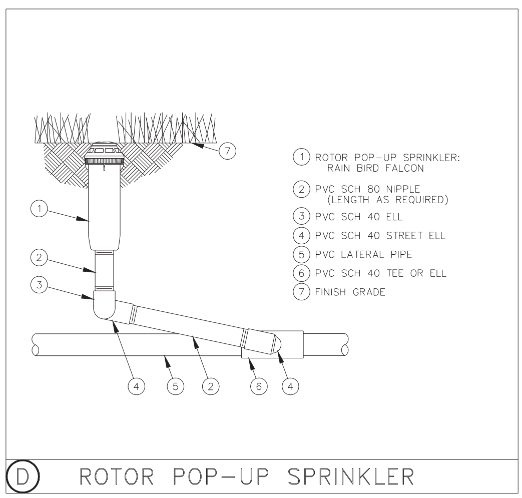


Figure 8

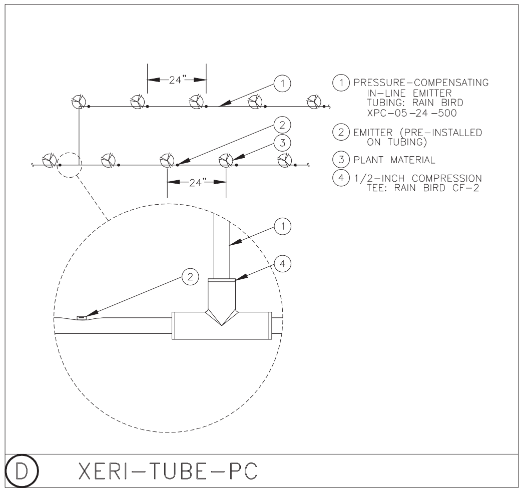
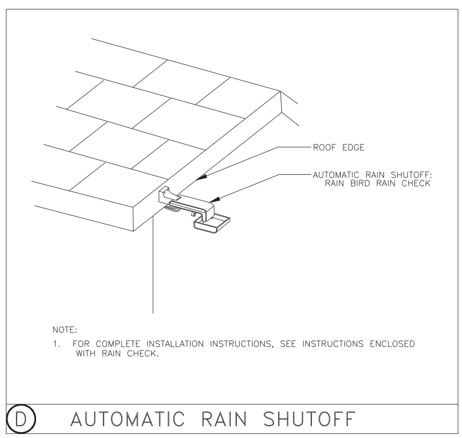


Figure 9



5.2 Determine average application rate

The **average application rate** is the amount of water that is applied to the irrigated area over a period of time, usually in units of inches per hour (iph). If a sprinkler system applied a layer of water 1 inch deep across an irrigated area in one hour, that system would have an application rate of 1iph. However, sprinkler systems do not apply water in a perfectly uniform pattern over the entire landscape. The **effective application rate** accounts for the uniformity with which water is applied. Average application rates and effective application rates will be calculated from data collected in the field. Depending on the data that is available, there are several ways to calculate these application rates.

5.2.1. Meter records water use in gallons

Turn one zone on and use a stop watch to record the time required for the needle on the water meter to make one complete revolution. The average application rate is determined by the following equation:

$$Average\ application\ rate = \frac{Volume}{Area * Time} * 5775$$

Where *Average application rate* = Inches per hour [iph]
Volume = Volume required for needle in water meter to make one complete revolution [gal]
Area = Irrigated area [ft^2]
Time = Time required for needle in water meter to make one complete revolution [sec]

If a sprinkler system applies 10 gallons of water to 1000 square feet in 30 seconds, that system will have an average application rate of 1.925 iph.

[10 gal/ (1000 ft^2*30 sec)] * 5775 = 1.925 iph

Another method can be used to determine the average application rate. Record the meter reading with the system turned off. Turn one zone on for a specified period of time (1 or 2 minutes) then turn the system off and record the meter reading again. The average application rate can be calculated by the following equation:

$$Average application rate = \frac{Final reading - Intitial reading}{Area * Operating time} * 96.25$$

Where *Average application rate* = Inches per hour [iph]
Final reading = Water meter value after system is turned off [gal]
Initial reading = Value taken at meter before system is operated [gal]
Area = Irrigated area [ft^2
Time = Duration that zone was operated [min]

5.2.2. Meter records water use in cubic feet

Some meters will have cubic feet instead of gallons, where one revolution of the water meter is 1 cubic foot. For these systems use the above equations, but multiply your final answer by 7.48. This will convert the volumetric reading in the numerator from cubic feet to gallons.

1 cubic foot = 7.4805 gallons

5.2.3. No meter is present

Some urban irrigation systems may be supplied by a well, and may not have water meters installed. In such a system the flow rate must be determined at each sprinkler, and the entire flow rate for a zone is determined by adding up all the individual flow rates. The total flow rate will then be divided by the area to find the average application rate.

There are two ways to determine the flow rate from a sprinkler. One way is to determine the pressure from a sprinkler, then compare that pressure with the manufacturers catalog to see what flow rate is associated with that pressure.

Pressure on rotor zones is determined by turning the system on holding a pitot tube attached to a pressure gauge in the stream of the rotor, about 1/8 of an inch from the nozzle. Pressure on spray head zones can be determined by installing a pressure gauge in line between the pop-up riser and the nozzle of a spray head sprinkler. There is no tool commercially available to make this measurement, but some NRCS field offices have constructed their own. The pressure should be checked at the first and last spray head in a zone.

Another method used is to measure the flow rate from a sprinkler using a stopwatch and some catchment such as a bucket. Flow rate should be measured on each sprinkler by placing a bucket in front of the rotor stream or spray nozzle for a timed duration using a stop watch. Measure the water collected using a 1000 mL graduated cylinder. Determine the flow rate from the following equation:

$$Flow\ rate = \frac{Volume}{Time} \times 0.01585$$

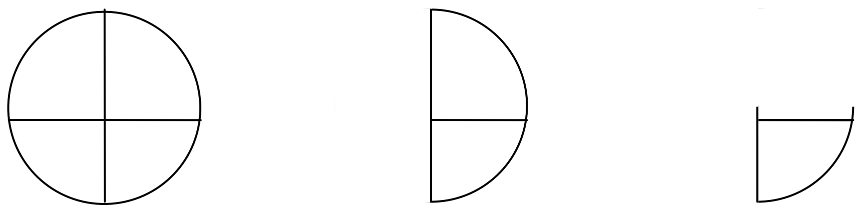
Where *Flow rate* = Gallons per minute [gpm]
Volume = Volume collected [mL]
Time = Time that water was collected [sec]

The average application rate is then determined using the following equation:

$$Average\ application\ rate = \frac{Total\ flow\ rate}{Area} \times 96.25$$

5.2.4 Matched Rates

A system with matched precipitation rates will have a uniform application rate throughout the system. When a rotor rotates over 1/4 of a circle it should apply water at 1/4 the rate of a rotor covering a full circle on the same zone. The rotor covering 90° of a circle will irrigate its area four times in the time required for a 360° rotor to cover a full circle. Spray heads are automatically matched when similar types are used.



4 GPM 360° Rotor 1 | 2 GPM 180° Rotor 2 | 1 GPM 90° Rotor 3

Example

Rotor 1 is irrigating 4 times the area of Rotor 3, and therefore should discharge 4 times the amount of water.

5.2.5 Sprinkler Spacing

Sprinkler spacing is critical for achieving a uniform application of water. Sprinklers should be spaced so that water from one sprinkler covers at least 100% of the distance to the adjacent sprinklers. This is not difficult to achieve on large rectangular fields, but requires careful planning on oddly shaped residential lots. The radius of the spray pattern is adjustable on most rotors and spray heads by turning an adjusting screw on top of the sprinkler. Adjustments should be made to achieve head to head coverage if possible, without spraying into the street or driveway. However, the full radius of the sprinkler should not be reduced by more than 25%. Significantly reducing the sprinkler radius will excessively degrade the spray pattern.

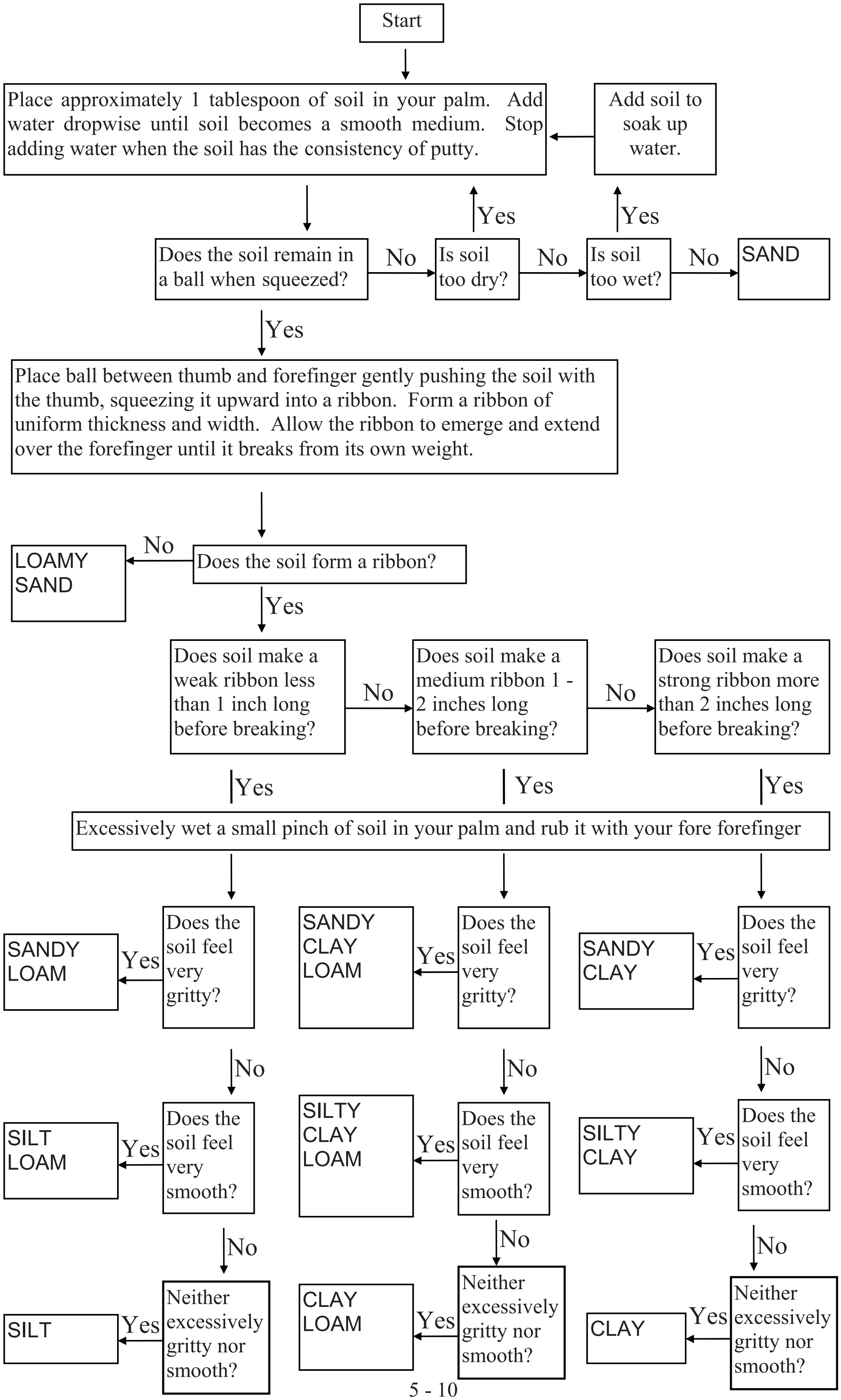
5.2.6 Mixed Zones

A mixed zone is one which has different types of sprinklers, such as rotors and spray heads. As stated earlier, uniform application requires matched rates. Spray heads usually apply water at a rate of 1.5 iph. Rotors used in residential systems will usually apply water at 0.3 to 0.7 iph. If an irrigation system is applying water to turf between the sidewalk and street with spray heads and watering the front lawn with rotors at the same time, the spray heads will run 2 to 5 times longer than necessary so that the front lawn will receive adequate irrigation. Therefore spray heads and rotors should be on different zones.

5.2.7 Soil Texture Determination

The maximum application rate that can be applied to a zone is determined by how fast water will infiltrate the soil in that zone. If water is applied faster than the infiltration rate, then runoff will occur. Soil texture in a particular area can be approximated using NRCS Soil Surveys. However, in urban areas where soil has been disturbed, the Soil Survey may not be accurate. The following flow chart was developed for the Hydric Soils of Florida Handbook (Carlisle, 1995) and may be used for determining the texture of soil at an evaluation site. For additional information on soil texture determination, consult from the local NRCS field office.

Field Determination of Soil Texture



Only a catch can test is conducted (no pressure and flow)

Use the following formula to calculate the average application rate from the DU test:

$$\textit{Average application rate} = \frac{\textit{Volume}}{D^2 * \textit{time}} * 4.66$$

Where *Average application rate* = Inches per hour [iph]
Volume = Average volume of water collected per catch [mL]
D = Diameter of the top of the catch can [in]
time = Time of zone operation [min]

5.9.2. Determine distribution uniformity

$$DU = \frac{\textit{Low quarter average}}{\textit{Total average}} * 100$$

Where *DU* = Distribution uniformity in percent
Low quarter average = Average volume in the 25% of cans that received the least water [mL]
Total average = Average volume of all cans [mL]

If no DU test is conducted, an estimate of 50% to 70% should be assumed based on spacing and system layout.

5.2 Materials List
The following materials will be required to conduct evaluations.

5.2.1 Visual Inspection

1. Pad and clipboard
2. Pen or pencil

5.2.2 Pressure and Flow Test

1. Pad and clipboard
2. Pen or pencil
3. Pitot tube and pressure gauge that reads up to 80 psi
4. Graduated cylinders (25 mL, 50 mL, 100 mL, and 1000 mL)
5. 100 foot plastic measuring tape
6. Stopwatch
7. Bucket or a one gallon container to collect water from a sprinkler nozzle
8. Survey wheel
9. Pressure gauge capable of measuring pressure from spray heads

5.2.3 Catch can Test

1. Pad and clipboard
2. Pen or pencil
3. Survey wheel
4. Cans or catchment devices to collect water
5. Method of securing cans in place (i.e. rubber bands and 18 inch wooden dowels)
6. Survey flags
7. Timer or stopwatch
8. Graduated cylinder

5.2.4 Other miscellaneous equipment

1. Tool kit with small screw drivers, pliers, and allen wrenches
2. Calculator
3. Manufacturer's catalogs for common system components

5.3 Visual Inspection

The visual inspection is a simple check list that requires a minimum investment of time. It is designed to be conducted in 15-30 minutes to make sure that the system appears to have been installed properly and complies with local regulations.

Are plant beds on separate zones from turf?

One of the most common over-watering problems encountered in residential systems is caused by shrub beds and turf being irrigated in the same zone. Most shrubs require less frequent watering than turf and some common landscape shrubs require no supplemental watering once they are established. When shrub beds are watered with turf, the beds are almost always over-watered.

Are rotors and spray heads on separate zones?

Spray heads apply water two to three times faster than rotors. Spray heads and rotors should be on separate zones for uniform application

Are spray heads turned off in areas with mature, natural shrubs?

Plant guides provided by the University of Florida Institute for Food and Agricultural Sciences (IFAS) define "natural" as surviving only on rainfall. Zones landscaped with natural shrubs and ground covers do not need to be operated once plants are established. Consult an IFAS Plant Guide for a complete list of natural trees, palms, shrubs, ground covers and vines.

Does the current irrigation schedule water excessively?

Without conducting either a pressure and flow test, or a catch can test, it is impossible to determine the application rate and therefore the correct operating time for an irrigation system. In general however, 45 minutes and 15 minutes is adequate for **most** rotor zones and spray zones respectively.

Is a rain shut-off device installed and is it functioning properly?

Make sure the property manager has an automatic rain shut-off device properly installed. It should be installed so that rainfall can reach the device easily and where it will not be watered by the sprinkler system. This allows the system to function automatically if the property manager forgets to check the soil wetness or is away from home.

Is the system operated during designated times?

Inspect the controller to make sure the operating schedule complies with local watering restrictions.

Is irrigation sprinkler spacing correct?

Proper spacing is necessary for uniform coverage. Inspect the system to see if the spray pattern from one sprinkler overlaps at least 80% of the radius (40 % diameter) of existing systems or 100% of the radius (50% diameter) in new systems to the adjacent sprinklers.

Are flow rates from sprinklers matched?

The flow rate from rotors covering 1/4 circles should be one fourth of the flow rate from rotors covering a full circle. Without conducting flow rate measurements this is determined by visual inspection. Rotors frequently have a number associated with their flow rate either stamped on top of the sprinkler or on the nozzle. Compare this number with manufacturers catalogs to make sure that rotors irrigating 1/4 circles and 1/2 circles are delivering water at 1/4 and 1/2 the rate of rotors watering full circles.

Is the irrigation stream from rotors free from obstacles?

Keeping turf trimmed low around rotors is the easiest way to improve system uniformity. Some rotors only rise 4 inches. If turf is allowed to grow up around rotors a substantial portion of the applied water is blocked and not available to the rest of the zone.

Is the spray pattern from spray heads free from obstacles?

If spray heads are used for shrub and ground cover irrigation, leaves and branches should be removed from around spray nozzles. Shrub interference around the spray stream can block most of the applied water, preventing water from reaching root zones.

Are risers used to place spray heads above or below shrub interference?
When spray heads are installed for shrub irrigation, they are designed for the shrub height at the time of installation. As shrubs grow, spray heads will need to be raised or lowered.

Is all water applied within the landscape area?

Water being applied to driveways or sidewalks can run off into the street, and into storm water drains. To reduce this waste, adjust sprinklers so that watering onto concrete areas is minimized.

Are sprinklers undamaged?

Inspect sprinklers for damage from lawn mowers, cars, etc.

Are sprinklers unclogged?

Inspect spray heads and rotors for clogging. If the flow from one spray head or rotor appears low and system pressure appears to be adequate throughout the zone and no leaks are found, the nozzle is probably clogged. Spray nozzles easily unscrew and can be washed out. If a gear driven rotor becomes clogged the nozzle must be removed and thoroughly cleaned.

Are sprinkler heads protected from hazards?

One of the most common irrigation system maintenance problems is broken sprinklers that have either been hit by a lawn mower or run over by a car. Sprinklers subjected to these possible hazards, especially along the driveway, should be protected with flex joints or concrete donuts.

Are rotors and spray heads in upright position?

Sprinklers must be perpendicular to the ground to more uniformly apply water across the zone.

Do all rotors have like characteristics?

There is no single best rotor. Most have a variety of features to distinguish themselves from their competition, and each has benefits and drawbacks. Each brand does have performance characteristics that define how it applies water over distance. For uniform applications, rotors with similar characteristics should be used throughout the zone.

Landscape (Optional)

For detailed information on drought tolerant plant material, consult IFAS personnel and literature.

Do turf and plants appear healthy?

Inspect leaves for fungus, or signs of over watering. Look for areas in the turf where water coverage may not be adequate.

Are beds planted with natural vegetation?

A good way to reduce the amount of required supplemental irrigation is through the use of natural vegetation. IFAS plant guides define "natural" as surviving only on rainfall. Zones landscaped with natural shrubs and ground covers do not need to be operated once plants are established. Turning shrub zones off completely can save thousands of gallons of water per year.

Has the property manager landscaped with drought tolerant turf?

St. Augustine turf has low drought tolerance. If the property manager is re-landscaping in the future or is planning to sod their yard, recommend a drought-tolerant turf such as Bahia. If the appearance of St. Augustine is desired, consider recommending FX-10 which is similar to St. Augustine, but develops a more extensive root system and is very drought tolerant.

Is mulch being used appropriately in beds?

At least 4 inches of mulch should be applied to shrub beds to keep moisture in the ground. This minimizes water lost to evaporation. When mulch is applied correctly, supplemental watering should be reduced. Too much water applied to the roots can result in fungus problems.

Are low volume emitters being used for bed irrigation?

Spray heads are most commonly used to irrigate shrub and ground cover beds. Spray heads apply water to the surface of leaves and to the surface of mulch where it is not useful to the vegetation. By using low flow emitters on the ground surface, below the mulch, water can be applied directly to the root zone. This reduces the required supplemental irrigation by as much as 70%.

Irrigation System Visual Inspection

Name ______________________________ Date____/____/____.

Address ______________________________ Phone (___)____-_____.

Layout	YES	NO
Are turf and shrub beds on separate irrigation zones?	☐	☐
Are rotors and spray heads on separate irrigation zones?	☐	☐
Are turf or plant areas that require irrigation receiving it?	☐	☐
Appropriate timer settings		
45-60 minutes or less for rotor zones?	☐	☐
15-20 minutes or less for spray zones?	☐	☐
Rain Shut-off Device		
Is a properly installed rain shut-off device present?	☐	☐
Designated Operating Times		
Is the irrigation system operating during designated times?	☐	☐
Are sprinklers covering at least 80% of the distance to the next sprinkler ?	☐	☐
Matched Sprinklers		
Are all flow rates matched to the area covered?	☐	☐
Interference		
Are spray patterns free from interference caused by vegetation or other objects?	☐	☐
Application Outside Landscape		
Is all the water applied within the landscape area (does not extend to driveways or sidewalks)?	☐	☐

Maintenance	YES	NO
Are sprinklers undamaged?	☐	☐
Are sprinklers unclogged?	☐	☐
Are sprinklers protected from hazards?	☐	☐
Are there leaks in pipes?	☐	☐
Are rotors and spray heads in an upright position?	☐	☐
Are all rotors and spray heads from the same manufacturer?	☐	☐
Turf and Plants (Optional)		
Do turf and plants appear healthy?	☐	☐
Are beds planted with natural vegetation?	☐	☐
Has the property manager landscaped with drought tolerant turf?	☐	☐
Is mulch being used appropriately in beds?	☐	☐
Are low volume emitters being used for bed irrigation?	☐	☐

5.4 Pressure and Flow Inspection

The pressure and flow inspection is a continuation from the previous questionnaire and involves a detailed inspection to evaluate the layout and operating condition of the irrigation system. The following additional questions are addressed in the pressure and flow test:

Does the current irrigation schedule water excessively?

The maximum water that should be applied during any one watering is 0.5 inches throughout most of the state (0.25 inches is used in parts of south Florida where the soil depth is very shallow). This represents the amount of water that can be held in one foot of sandy soil. One foot is assumed to be the maximum root depth that most types of turf achieve. Watering over 0.5 inches during one irrigation cycle will force water down below the root zone and provide no benefit to the landscape.

The operating time required to achieve 0.5 or 0.25 inches of precipitation is addressed in the application rates portion of the report.

Is there adequate system pressure in each zone?

System pressure on rotor zones is determined by turning the system on and holding a pitot tube attached to a pressure gauge in the stream of the rotor, about 1/8 of an inch from the nozzle. Although some manufacturers claim their rotors function correctly at 20 psi, in general the minimum acceptable pressure is 25 psi at the farthest head in a zone.

System pressure on spray head zones can be determined by installing a pressure gauge in line between the pop-up riser and the nozzle of a spray head sprinkler. There is no tool commercially available to make this measurement, but some NRCS field offices have constructed their own. The pressure should be checked at the first and last spray head in a zone. The farthest sprinkler should have a minimum operating pressure of 15 psi and all heads within the zone should operate in a range of 15-30 psi.

Visually inspect sprinklers for proper operating pressure. Inspect pop-up spray heads and gear driven rotors for leaks between the spray body and the pop-up riser. Inspect the spray pattern from gear driven rotors. Does the pattern appear to be a uniform application of water or is water applied in stream producing a donut shaped irrigation pattern. Finally, inspect impact rotors for proper functioning. Low water pressure will usually cause impact rotors to stick in one position.

Are flow rates from sprinklers matched?

The flow rate from rotors covering 1/4 circles should be one fourth the flow rate of rotors covering a full circle. Flow rate should be measured on each sprinkler by placing a bucket or a one gallon milk container in front of the rotor stream for a timed duration using a stop watch. Measure the water collected using a 1000 mL graduated cylinder. Determine the flow rate from the following equation:

$$Flow\ rate = \frac{Volume}{Time} \times 0.01585$$

Where *Flow rate* = Gallons per minute [gpm]
Volume = Volume collected [mL]
Time = Time that water was collected [sec]

If recommending changes to the rotors in the system, new flow rates can be predicted from system pressure and manufacturers catalogs. (Toro S-600 rotors for example are stamped on top with their design flow rate of either 1.3, 2.5, or 5.0 gpm at approximately 30 psi. Toro S-700 rotors have their design flow rate stamped directly on the nozzle; 1.5 gpm at 40 psi, 2.0 gpm at 45 psi, 3.0 gpm at 40 psi, 4.5 gpm at 55 psi, or 6.0 gpm at 45 psi. Hunter G-Type rotors are numbered 1-12. A number 1 nozzle delivers 0.7 gpm at 50 psi and a number 12 delivers 12.2 gpm at 50 psi. Typical matched rate applications for Hunter rotors would include No. 2, No. 5, and No. 8 nozzles for 90^o, 180^o, and 360^o applications respectively.) **Consult manufacturers catalogs for appropriate flow rates over a range of pressures.**

Flow rates from spray heads are automatically matched when similar spray heads are used. However, it may still be important to determine the flow rate from individual spray heads to determine water use on spray head zones. The flow rate from spray heads can be determined by either measuring the pressure at each sprinkler and looking up flow rates from manufacturer's catalogs or by directly measuring the flow rate. Direct measurement can be made with a stopwatch and some type of container such as a bucket. Allow the spray head to fill the bucket for a timed interval. Measure the water collected and use the equation above to calculate the flow rate. This method is usually only practical when measuring the flow rate from spray nozzles irrigating half of a circle or less. To determine flow rates from 270° or 360° spray nozzles, multiply the flow rate calculated for 90° spray nozzles by 3 and 4 respectively.

Irrigation System Pressure and Flow Inspection

	YES	NO
Does the current irrigation schedule water excessively ?	☐	☐
Is there adequate system pressure in each zone ?	☐	☐
Are flow rates from sprinklers matched ?	☐	☐

Pressure and flow worksheet:

$$Adjusted\ flow\ rate = \frac{Flow\ rate}{Fraction\ of\ circle\ watered}$$

The flow rate is derived by the following equation:

$$Flow\ rate = \frac{Volume, mL}{time, sec} \times 0.01585$$

Zone #____ Rotor #	Pressure (psi)	Volume (mL)	Time (sec)	Flow rate (gpm)	Fraction of circle watered	Adjusted flow rate

Zone #____ Rotor #	Pressure (psi)	Volume (mL)	Time (sec)	Flow rate (gpm)	Fraction of circle watered	Adjusted flow rate

5.5 Catch Can Distribution Uniformity Test

In addition to the pressure and flow inspection, some systems may benefit from a level three evaluation, or catch can test. The level three evaluation requires more time, but provides more precise information about the sprinkler system. A distribution uniformity (DU) test shows an evaluator the location of dry spots as well as the application rate of turf zones. This provides information that allows the evaluator to recommend how long to operate the system for improved efficiency. If a system is in a state of disrepair, then a catch can test is rarely helpful. If however, an irrigation system is well maintained and properly operated, then a DU test will allow the property manager to fine tune his or her watering practices. (For example, if a DU test shows that the operating time of a zone can be reduced by 5 minutes, this could save an additional 6000 gallons over the course of 1 year.)

The report generated by the level three test is designed to provide the property manager with precise information on a zone-by-zone basis with specific recommendations for each zone.

The catch can test requires placement of catch cans (usually a type of cup) throughout a zone. The zone is then turned on long enough for a measurable quantity of water to fall into the cans. Usually an operating time of 7-10 minutes is long enough for spray head zones. Rotor zones typically require 20-40 minutes.

5.5.1 Selecting catch containers

Many containers can be used for the DU test, however the following features should be considered (Schwankl, *et al*., 1992). In accordance with ASAE standard S398.1, “All collectors used for any one test shall be identical. They shall be such that the water does not splash in or out. The position of all collectors shall be maintained such that the entrance portion is level.”

- The top should be at least 2 inches in diameter, or 3 square inches in area.
- Containers should flare toward the top to allow easy stacking.
- Plastic containers are preferred to glass or metal because they do not break or rust.
- Containers should not tip over easily.

5.5.2 Selecting a zone or zones

For a residential system, the zone normally selected is the front yard, since it is usually the most visually important to the property manager and represents a large turf area within the system. If other turf zones are designed with the same brands of sprinklers and have a similar layout, then assume other zones will operate with similar efficiency and uniformity. For irrigation systems that have eight zones or less only one zone is required for testing. On large systems with more than eight zones, break zones up into groups of similar layout. Test at least one zone from within each group.

5.5.3 Placing catch cans

Catch cans should be arranged in a uniform grid using at least 16-24 cans (Smajstrla, *et al*., 1990). Using more cans will improve accuracy; however, the test can become cumbersome. In general, try to use 40-50 cans to provide a strong indication of the uniformity of the system.

The grid layout should be completely within a zone. If the test area is watered by more than one zone, then all zones watering the area will need to be operated. For example, if the front lawn is watered primarily by zone 1, but is also irrigated by zones 2 and 3, then only operating zone 1 will show a lower application rate on the front lawn than is actually being achieved. To place close to 50 cans the grid layout will usually be 10X5, 8X6, or 7X7, depending on the shape of the zone.

Using plastic 100 foot tape measure or a three foot surveyor's wheel, measure the length and width of a zone. The length to width ratio will decide which configuration of catch cans you use.

Table 6. Proposed catch can layout for varying length to width ratios.

L/W	Grid Layout
>1.75	10X5
1.25-1.75	8X6
<1.25	7X7

For a 10X5 layout, divide the length of the zone by 10. This will be the number of feet between each can in the length direction. Divide the length of the zone by 20. This will be the distance from the edge of the zone that you begin spacing the cans. Now divide the width by 5 to determine the number of feet between each can in the width direction. Divide the width by 10 to calculate how far from the edge to begin placing cans.

For an 8X6 grid of cans, divide the length by 8. This will be the number of feet between each can in the length direction. Divide the length by 16 to determine the distance from the edge that you begin spacing cans. Now divide the width by 6 to calculate the distance between each can in the width direction. Finally divide the width by 12 to see how far in from the edge to place the first can.

For a 7X7 grid divide both the length and width by 7 and then by 14, following the procedures outlined above.

This following example illustrates the principles above.

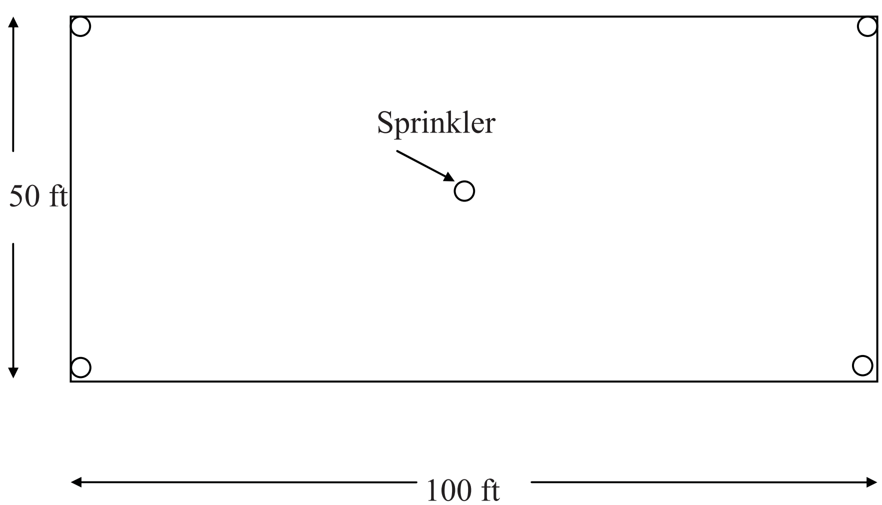


Figure 8. Sprinkler location for front lawn

Given: L=100 ft., W= 50 ft

Calculate: Grid spacing and catch can locations

L=100, W=50,
L/W = 2, A 10X5 grid of catch cans should be used.
L/10 = 10, Spacing between each can will be 10 feet in the direction of length.
L/20 = 5, Spacing should begin 5 feet in from the sides.
W/5 = 10, Spacing between cans should be 10 feet in the direction of width.
W/10 = 5, Begin grid 5 feet from top and bottom edge.

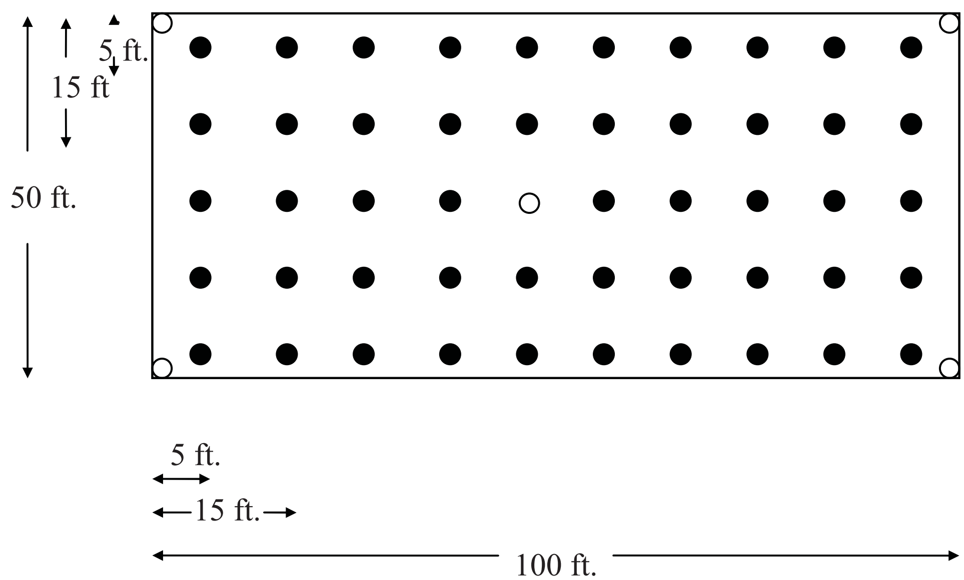


Figure 9. Catch can placement in front lawn

Notice that the center catch can has not been used. When the location of a can is close to a sprinkler, tree or other obstacle, remove that can. By planning for 48, 49, or 50 catch cans, enough information will be obtained to accurately describe the system, even if a few cans have to be removed.

5.5.4 Selecting subzones

For large zones, such as those on golf courses or some commercial properties, testing an entire zone may not be practical. In this case choose a subsection of the zone (Smajstrla, *et al*., 1990) as shown in Figure 10. Subsections should be completely within one zone and should be representative of the zone as a whole. There is no set rule for determining the grid layout for subzones. You will have to use your own judgment to place nearly 50 cans in a series of grids throughout the zone.

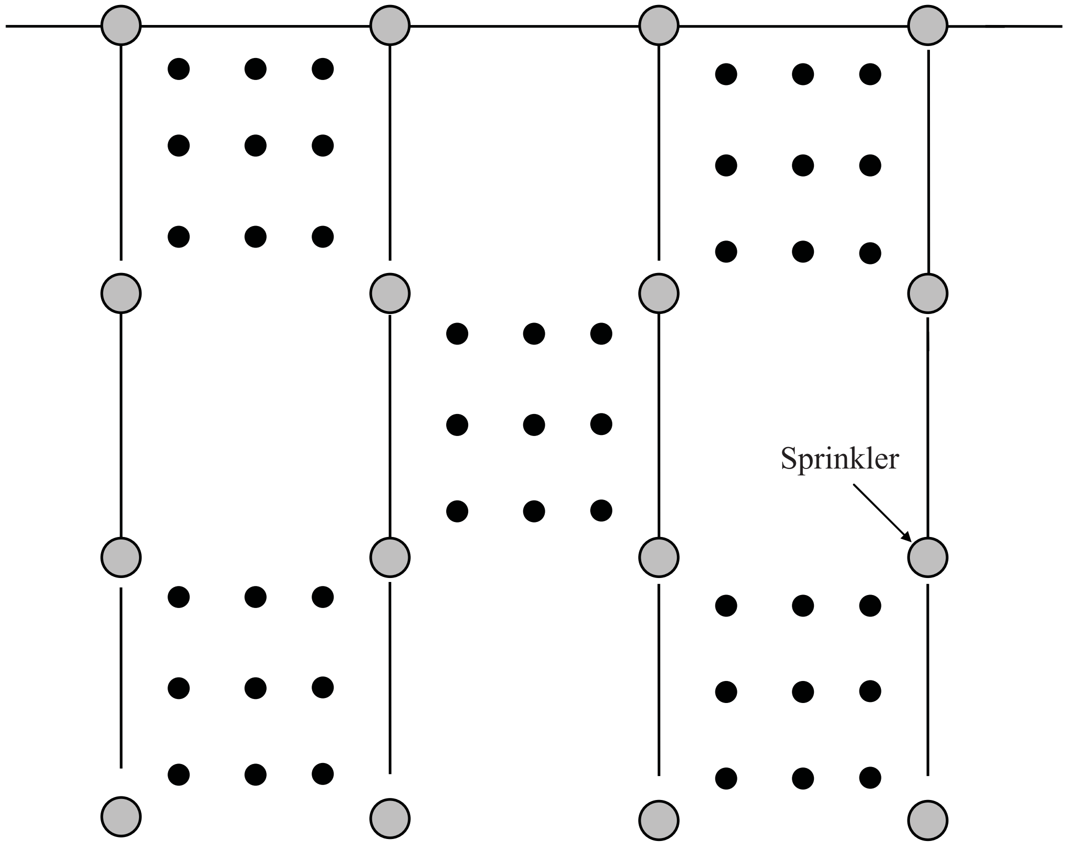


Figure 10. Large turf zone requiring the use of sub zones.

5.5.5 Test duration

The duration of the test will depend on the application rate of the zone being tested. The zone being tested should be operated long enough for each can to catch a measurable amount of water; at least 5 mL. The duration will usually be 20-40 minutes for rotor zones and 7-10 minutes for spray head zones. Visually check cans during the test to see when a measurable amount of water has been collected.

5.5.6 Measuring and Recording Data

Once the test is over, turn the system off and measure the water collected in each of the cans using a graduated cylinder. Record this value on a data sheet in the grid pattern in which the cans were measured. This will point out dry and wet areas, and aid in the report writing process. For example, the data from the catch cans above should be recorded on a table in the following manner:

Table 7. Sample catch can values

58	41	40	21	23	24	34	24	31	18
48	44	41	21	27	29	21	17	20	24
40	39	38	24	XX	17	20	15	18	26
18	26	34	34	23	21	15	18	20	29
27	31	32	17	26	18	19	29	27	18

This table has 49 values because one place in the grid was left open due to sprinkler placement. The DU of this zone can be calculated from the DU formula, where the low quarter is 49/4 = 12.25 ≈ 12. The 12 cans with the least amount of water have been highlighted and were used as the low quarter when calculating DU. From the DU formula

(18+17+17+18+15+19+17+15+18+18+18+18)/12 = 17.33
(58+48+40+18+27+41+44+39+26+31+40+41+38+34+32+21+21+24+34+17+23+27+23+26+24+29+17+21+18+34+21+20+15+19+24+17+15+18+29+31+20+18+20+27+18+24+26+29+18)/49 = 27.04

DU = (17.33/27.04) * 100 = 64.1%. By using the grid system for recording readings, patterns emerge in the landscape. The upper left hand quarter is receiving the highest application rate and the right half of the yard is receiving the lowest application rate.

Application Rate

The **average application rate** is the amount of water that is applied to the irrigated area over a period of time, usually in units of inches per hour (iph). If a sprinkler system applied a layer of water 1 inch deep across an irrigated area in one hour, that system would have an application rate of 1iph. However, sprinkler systems do not apply water in a perfectly uniform pattern over the entire landscape. The **effective application rate** accounts for the uniformity with which water is applied. Average application rates and effective application rates will be calculated from data collected in the field. Depending on the data that is available, there are several ways to calculate these application rates.

The application rate can be determined by either the catch can test or the flow rate method from section 3. Use the following formula to calculate the average application rate from the DU test:

$$Average\ application\ rate = \frac{Volume}{D^2\ \times time} \times 4.66$$

Where *Average application rate*	=	Inches per hour [iph]
Volume	=	Average volume of water collected per catch [mL]
D	=	Diameter of the top of the catch can [in]
time	=	Time of zone operation [min]
4.66	=	Constant which converts mL/in^2 min into iph

The 4.66 constant is derived by the following equation:

$$\frac{mL}{min} \times \frac{60\ min}{1\ hr} \times \frac{1\ in^3}{16.39\ mL} \times \frac{4}{\Pi} = 4.66$$

Use the following formula to calculate the average application rate from the water meter recording water usage in gallons:

$$Average\ application\ rate = \frac{Volume}{Area\ \times time} \times 5775$$

Where *Average application rate*	=	Inches per hour [iph]
Volume	=	Average volume of water collected per catch [mL]
Area	=	Irrigated area [ft^2]

time	=	Time required for needle in water meter to make one complete revolution [sec]
5775	=	Constant which converts gal/ft^2 sec into iph

The 5775 constant is derived by the following equation:

$$\frac{gal}{ft^2 \times sec} \times \frac{3600\ sec}{1\ hr} \times \frac{231\ in^3}{1\ gal} \times \frac{1\ ft^2}{144\ \mathrm{in}^2} = 5775$$

Use the following formula to calculate the average application rate by recording the initial and final meter readings:

$$Average\ application\ rate = \frac{Final\ reading - Intitial\ reading}{Area\ \times Operating\ time} \times 96.25$$

Where *Average application rate*	=	Inches per hour [iph]
Final reading	=	Water meter value after system is turned off [gal]
Initial reading	=	Value at meter before system is turned on [gal]
Area	=	Irrigated area [ft^2]
Operating time	=	Duration that zone was operated [min]
96.25	=	Constant which converts gal/ft^2 min into iph

The 96.25 constant is derived by the following equation:

$$\frac{gal}{ft^2 \times min} \times \frac{60\ min}{1\ hr} \times \frac{231\ in^3}{1\ gal} \times \frac{1\ ft^2}{144\ \mathrm{in}^2} = 96.25$$

The average application rate calculated by either this method or the flow rate method does not take into account that water is not distributed evenly across the landscape. The effective application rate should be used when calculating how long to operate the system. The effective application rate is defined by the following formula:

$$Effective\ application\ rate = Average\ application\ rate * DU$$

Catch Can Test

YES NO

Are dry spots or areas of poor coverage visible? ☐ ☐

Data sheet:

$$Total\ average = \frac{Sum\ of\ all\ catch\ cans}{Total\ number\ of\ catch\ cans}$$

$$Average\ of\ low \frac{1}{4} = \frac{Sum\ of\ low \frac{1}{4}\ catch\ cans}{Number\ of\ catch\ cans}$$

$$DU = \frac{Average\ of\ low \frac{1}{4}}{Total\ Average}$$

$$Average\ application\ rate = \frac{Volume}{D^2 \times time}$$

$$Effective\ application\ rate = Average\ application\ rate \times DU$$

YES NO

Is the DU $\geq$ 70% ☐ ☐

5.6 Plant Watering Requirements and Operating Times

There are various methods to determine plant watering requirements. One method is based on evapotranspiration, where the irrigation time is determined by how much water is actually used by the landscape. Although this method can take into account many factors such as plant type and differing ET rates for different times of year, it is also very time consuming. As a simplification assume that 0.25 or 0.5 inches of water is adequate per application. Most areas of Florida will use the 0.5 inch criteria. In some areas of south Florida, the soil is only a few inches deep until limestone bed rock is reached. In these areas 0.25 inches of water is adequate to fill the soil. This section of the manual outlines how long to recommend operating an irrigation system based on this criteria.

The Net Irrigation Requirement for St Augustine and Bermuda grass in South Florida 30-35 in/yr in North Florida 20-25 in/yr according IFAS documentation.

$$Watering\ time = \frac{0.5\ or\ 0.25\ inches}{Effective\ application\ rate}$$

NOTE: If the DU is less than 50% do not recommend applying excess water to compensate for poor uniformity. If the DU is less than 50%, use 50% to determine the effective application rate and calculate the recommended operating times.

As a general rule for north and central Florida use the following irrigation schedule.

Months	**Turf Zones**	**Non-turf Zones**
April through September	**1 day per week**	**1 day every other week**
October through March	**2 days per week**	**1 day per week**

The five (5) Water Management Districts throughout the various regions of the state may have more frequent irrigation schedules for your area. Contact the local Water Management District for the irrigation schedule that applies to your area.

The tables above take into account lower evapotranspiration rates for the cooler months.
To determine how long to operate one zone using this method:

1. Determine the average application rate from either the flow rate method or catch can method. If no water meter is present then the application rate will have to be measured or estimated.
2. Calculate the effective application rate from the DU. If a DU test was not conducted, estimate DU. Depending on spacing, DU will usually fall between 50-60%.
3. Assume the water requirement is 0.25 or 0.5 inches, depending on the depth of soil.
4. Calculate the irrigation duration by dividing the water requirement (0.25 or 0.5 inches) by the effective application rate.
5. Multiply this number by 60 to determine the number of minutes recommended for an irrigation cycle. If the recommended operating time is longer than the controller will allow, multiple irrigation cycles will be required.
6. Finally, for rotor zones make sure that the average application rate is less than the infiltration rate. If the infiltration rate is less than the application rate then multiple watering cycles will be required to prevent runoff. For example, a steeply sloped front

yard may require 40 minutes of watering from a particular system. If the infiltration rate < average application rate, then water for two twenty minute cycles separated by at least an hour to allow water from the first application time to absorb.

NOTE: Some mechanical controllers have maximum operating times of 30-45 minutes per zone. If a zone requires longer than the controller will allow, multiple cycles are necessary to achieve adequate irrigation.

Example

Given:
A system produces a flow rate of 15 gpm in one zone. This was determined by using a stopwatch and observing the water meter. A 1200 ft^2 area is being watered. Although a catch can test was not conducted, coverage appears to be uniform and no maintenance problems are visible. DU is estimated to be 60%.

Find:
Calculate the appropriate operating time for this zone.

Solution:
From the application rate equation, the average application rate is 1.2 iph.

$[15 \text{ gallons} / (1200 \text{ ft}^2 * 60 \text{ sec})] * 5775 = 1.2 \text{ iph}$

The effective application rate is 0.72 iph.

1.2 iph * 0.60 = 0.72 iph

The appropriate irrigation duration is 0.69 hr.

0.5 inches / 0.72 iph = 0.69 hr

Irrigation time in minutes is 41 min

0.69 hr * 60 min/hr = 41 min

5.7 Water Usage for Urban Irrigation Systems

To determine the current water use per zone, multiply the flow rate per zone by the number of minutes the zone is operated per irrigation cycle. The flow rate from each zone can be determined using the water meter and stopwatch method as discussed in Section 2.2. To use the meter method, turn one zone on and record the time required for the needle on the water meter to make one complete revolution.

If water meter records units of gallons, use the following equation:

$$Flow\ rate = \frac{10\ gallons}{time} \times 60$$

If water meter records units of cubic feet:

$$Flow\ rate = \frac{7.4805\ gallons}{time} \times 60$$

Where *Flow rate* = Flow through a particular zone [gpm]
time = Time required for the needle on the meter to make one complete revolution [sec]

If no water meter is present then the flow rate will have to be measured or estimated. Determine the total flow rate for each zone by measuring or estimating the flow rate from each individual sprinkler and adding them together.

Water used per operating cycle is calculated by the following equation:

$$Current\ usuage = Flow\ rate\ \times time$$

Where *Current usage* = Total water used for a zone per irrigation cycle [gal]
Flow rate = From above equation [gpm]
time = Time each zone is operated during a scheduled irrigation cycle [min]

Potential savings occur by either reducing the flow rate for a given zone and/or by reducing the operating time. Flow rate is reduced by capping sprinklers or changing to low flow systems. Provide the property manager with an estimate of water use from schedule changes alone, as well as system changes. If only the operating time on a given zone is reduced then the new water use can be determined by the following equation:

$$Net\ water\ use = Flow\ rate\ \times Recommended\ time$$

Where *New water use* = Total water used for a zone per irrigation cycle [gal]
Flow rate = From previous page [gpm]
Recommended time = Duration for which a specific zone should operate [min]

If sprinklers are capped or low flow components are installed, then use manufacturers' catalogs to estimate the change in the flow rate.

Recommending operating times for existing systems is a straight forward process. However, if a system is altered by adding sprinklers then the effective precipitation rate may increase and the required operating time may decrease. There is no set rule for determining how to calculate the appropriate irrigation time for proposed system changes. Changing the system invariably alters uniformity, application rate, and pressure.

As an estimation, use the method from section 2.2.1 to determine the application rate. (For example, if a 5 gpm rotor is being added to a zone already delivering 17 gpm then the new average application rate can be determined by dividing the total flow rate by the area irrigated.)

$$New\ average\ application\ rate = \frac{Current\ flow\ rate\ \pm proposed\ changes}{Area\ Irrigated} \times 96.25$$

Where

New average application rate	=	Average applied rate after system is altered [iph]
Current flow rate	=	Flow rate through meter with current system design [gpm]
proposed changes	=	Flow rates added or subtracted depending upon whether or not sprinklers are added to the system or capped [gpm]
Area irrigated	=	Area being watered [ft^2]

Recommend how long to operate the irrigation system based on a 0.5 inch application of water and an estimated improved DU of 60% to 70%. Determine a new effective application rate by multiplying the new average application rate by the estimated DU.

$$New\ effective\ application\ rate = New\ average\ application\ rate\ \times Improved\ DU$$

Calculate the suggested operating times for each zone in the current irrigation system as discussed in section 5.6, and each zone in which system changes have been recommended.

The total water used for each zone before and after recommendations can be determined by multiplying the original operating time by the original flow rate and the new flow rate by the new suggested operating time, respectively.

Example 1

Given: A system is currently delivering 12 gpm at a pressure of 40 psi. The area irrigated is 1500 square feet of medium sand. The current coverage is not very even, so estimate the DU to be 0.50. To improve coverage, you recommend adding a 90^o Hunter G-Type rotor with a #5 nozzle. The new coverage will be improved, so estimate the improved uniformity to be 0.75.

Determine: The current average and effective application rates, recommended irrigation duration using the root zone method, and the water used for one irrigation cycle using the original design. Calculate the new average application rate, the new irrigation duration and the amount of water used for the improved design.

Solution:

Current average application rate:
(12 gpm/1500 ft^2) * 96.25 = 0.77 iph

Current effective application rate:
0.77 iph * 0.50 = 0.385 iph

Recommended irrigation duration:
Water requirement = 0.5 inches
Irrigation duration = 0.5 inches/0.385 iph = 1.3 hr
Time in minutes = 1.3 hr * 60 min/hr = 78 min.

Water used per cycle:
12 gpm * 78 min = 936 gallons

New average application rate:
According to the Hunter catalog the flow rate from a #5 nozzle at 40 psi is 1.8 gpm. The total flow rate for this zone will then be 12 gpm + 1.8 gpm = 13.8 gpm and new water use should be calculated based on this flow rate.

(13.8 gpm/1500 ft^2) * 96.25 = 0.886 iph

New effective application rate:
0.886 iph * 0.75 = 0.664 iph
Recommended irrigation duration:
0.5 inches/0.664 iph = 0.75 hr
0.75 hr * 60 min/hr = 45 min
Water used per cycle:
13.8 gpm * 45 min = 621 gal

Example 2.

Given:
A zone consisting entirely of spray heads is watering turf and Indian Hawthorn shrubs. The zone is currently delivering 15 gpm. Because Indian Hawthorn is natural and does not require supplemental watering, you recommend capping 3 180° Series 12 Rain Bird spray nozzles. Due to difficulty in measuring dynamic system pressure of spray head zones, the operating pressure must be estimated. If the system is operating properly, and pop-up risers are not leaking, assume that system pressure is 30 psi. The zone currently operates for 10 minutes, and will continue to operate for 10 minutes after sprinklers are capped.

Determine:
The water used per irrigation cycle before and after the three sprinklers are capped.

Solution:

Original water use:
15 gpm * 10 min = 150 gal

According to the Rain Bird catalog, 180°, Series 12 Rain Bird spray nozzles deliver 1.3 gpm.

New flow rate:
15 gpm - 3*(1.3 gpm) = 11.1 gpm

New water use:
11.1 gpm * 10 min = 111 gal

5.8 Presentation of Urban Evaluation Results

The manner in which results are reported will vary depending on the goals of the agency conducting the urban irrigation evaluations. Some reports may emphasize system management, while others will more strongly favor system design improvements. In either case there is certain key material which should be included with each type of evaluation.

5.8.1 Visual Inspection
The visual inspection is a basic evaluation and is designed to be a preliminary screening tool to target areas for future evaluations. The report generated from the visual inspection should include the check box evaluation forms.

Fact sheets such as proper mowing height, watering restrictions, and Best Management Practices (BMPs) for turf and landscape should be included with the report.

5.8.2 Pressure and Flow
The report generated from pressure and flow data is more detailed than the visual inspection report. The pressure and flow report will include the average application rate as well as an estimate of the effective application rate. The report will also include recommendations for system improvements on a zone-by-zone basis.

Once the effective application rate is estimated, this report will include a suggested irrigation schedule based on data collected in the field as well as site observation that indicate over watering or under watering.

Finally, this report will include an analysis of current water usage and potential water savings. Water usage should be calculated for recommended operating times alone, as well as recommended operating times combined with system improvements.

5.8.3 Catch Can Test

The report generated from catch can data is also more detailed than the visual inspection report. The catch can test report will include the average application rate as well as the calculated effective application rate for at least one zone. The report will also include recommendations for system improvements on a zone-by-zone basis.

Once the effective application rate is calculated, this report will include a suggested irrigation schedule based on data collected in the field as well as site observation that indicate over watering or under watering.

Finally, this report will include an analysis of current water usage and potential water savings. Water usage should be calculated for recommended operating times alone, as well as recommended operating times combined with system improvements.

5.9 Steps to Conducting an Evaluation

The following is a description of the field procedure for evaluating urban sprinkler irrigation systems.

1. Select a date and time so the landowner will be available to walk through the entire sprinkler system.
2. Locate and determine the water source. (Municipal, well, reclaimed, pond, or lake)
3. Record the irrigation controller settings.
4. Check the irrigation controller for lithium or battery back-up.
5. Run all irrigation zones and flag all sprinklers. If system is too large flag sprinklers in representative zones.
6. While flagging sprinklers determine the best representative zone suited for the catch can test.
7. Locate catch cans and space evenly throughout the test area.
8. Check and record nozzles, makes and models used in test area.
9. Run catch can area. The run time should be so that each catch can has at least 5ml to measure.
10. Record all water caught in catch cans and remove low-quarter mean.
11. Determine (DU) Distribution Uniformity.
12. Once the (DU) Distribution Uniformity is determined run zones and record all data and data sheets (makes, models, pressures and areas.
13. For Municipal systems each zone should be timed for an actual flow rate per zone.
14. For Well and Pump systems count all sprinklers and record all types, makes and models and pressures to determine flow per zone.
15. Determine soil type by referencing the county soil survey or by using the NRCS" feel and appearance" method.

16. Determine the turf root depth.
17. Determine the Net Irrigation requirement for turf (Zoysia, St. Augustine, Bermuda and Bahia). For St Augustine and Bermuda grass in South Florida 30-35 in/yr in North Florida 20-25 in/yr (IFAS).
18. Determine average application rate
19. Determine distribution uniformity
20. Determine effective application rate
21. Calculate operating time
22. Determine water usage
23. Make system recommendations

5.9.1. Determine average application rate

The **average application rate** is the amount of water that is applied to the irrigated area over a period of time, usually in units of inches per hour (iph). If a sprinkler system applied a layer of water 1 inch deep across an irrigated area in one hour, that system would have an application rate of 1iph. However, sprinkler systems do not apply water in a perfectly uniform pattern over the entire landscape. The **effective application rate** accounts for the uniformity with which water is applied. Average application rates and effective application rates will be calculated from data collected in the field. Depending on the data that is available, there are several ways to calculate these application rates.

5.9.2. Meter records water use in gallons

Turn one zone on and use a stop watch to record the time required for the needle on the water meter to make one complete revolution. The average application rate is determined by the following equation:

$$Average\ application\ rate = \frac{Volume}{Area\ \times Time} \times 5775$$

Where *Average application rate* = Inches per hour [iph]

Volume = Volume required for needle in water meter to make one complete revolution [gal]

Area = Irrigated area [ft^2]

Time = Time required for needle in water meter to make one complete revolution [sec]

If a sprinkler system applies 10 gallons of water to 1000 square feet in 30 seconds, that system will have an average application rate of 1.925 iph.

[10 gal/ (1000 ft^2*30 sec)] * 5775 = 1.925 iph

Another method can be used to determine the average application rate. Record the meter reading with the system turned off. Turn one zone on for a specified period of time (1 or 2 minutes) then turn the system off and record the meter reading again. The average application rate can be calculated by the following equation:

$$Average\ application\ rate = \frac{Final\ reading - Intitial\ reading}{Area\ \times Operating\ time} \times 96.25$$

Where *Average application rate* = Inches per hour [iph]
Final reading = Water meter value after system is turned off [gal]
Initial reading = Value taken at meter before system is operated [gal]
Area = Irrigated area [ft^2
Time = Duration that zone was operated [min]

5.9.2. Meter records water use in cubic feet

Some meters will have cubic feet instead of gallons, where one revolution of the water meter is 1 cubic foot. For these systems use the above equations, but multiply your final answer by 7.48. This will convert the volumetric reading in the numerator from cubic feet to gallons.

1 cubic foot = 7.4805 gallons

5.9.3. No meter is present

Some urban irrigation systems may be supplied by a well, and may not have water meters installed. In such a system the flow rate must be determined at each sprinkler, and the entire flow rate for a zone is determined by adding up all the individual flow rates. The total flow rate will then be divided by the area to find the average application rate.

There are two ways to determine the flow rate from a sprinkler. One way is to determine the pressure from a sprinkler, then compare that pressure with the manufacturers catalog to see what flow rate is associated with that pressure.

Pressure on rotor zones is determined by turning the system on holding a pitot tube attached to a pressure gauge in the stream of the rotor, about 1/8 of an inch from the nozzle. Pressure on spray head zones can be determined by installing a pressure gauge in line between the pop-up riser and the nozzle of a spray head sprinkler. There is no tool commercially available to make this measurement, but some NRCS field offices have constructed their own. The pressure should be checked at the first and last spray head in a zone.

Another method used is to measure the flow rate from a sprinkler using a stopwatch and some catchment such as a bucket. Flow rate should be measured on each sprinkler by placing a bucket in front of the rotor stream or spray nozzle for a timed duration using a stop watch. Measure the water collected using a 1000 mL graduated cylinder. Determine the flow rate from the following equation:

$$Flow\ rate = \frac{Volume}{Time} \times 0.01585$$

Where *Flow rate* = Gallons per minute [gpm]
Volume = Volume collected [mL]
Time = Time that water was collected [sec]

The average application rate is then determined using the following equation:

$$Average\ application\ rate = \frac{Total\ flow\ rate}{Area} \times 96.25$$

Only a catch can test is conducted (no pressure and flow)

Use the following formula to calculate the average application rate from the DU test:

$$Average\ application\ rate = \frac{Volume}{D^2\ \times time} \times\ 4.66$$

Where *Average application rate*	=	Inches per hour [iph]
Volume	=	Average volume of water collected per catch [mL]
D	=	Diameter of the top of the catch can [in]
time	=	Time of zone operation [min]

5.9.2. Determine distribution uniformity

$$DU = \frac{Low\frac{1}{4}\ avergae}{Total\ average} \times 100$$

Where *DU*	=	Distribution uniformity in percent
Low quarter average	=	Average volume in the 25% of cans that received the least water [mL]
Total average	=	Average volume of all cans [mL]

If no DU test is conducted, an estimate of 50% to 70% should be assumed based on spacing and system layout.

5.9.3. Determine the effective application rate

$$Effective\ application\ rate = Average\ application\ rate\ \times DU$$

5.9.4. Calculate operating time

$$Watering\ time = \frac{Plant\ water\ requirement}{Effective\ application\ rate} \times 60$$

Where *Watering time*	=	Suggested time that a zone should be operated [min]
Plant watering requirement	=	0.5 or 0.25 depending on location [in]
Effective application rate	=	From Step 3 [iph]

5.9.5. Determine water used per operating cycle

Water used per operating cycle is calculated by the following equation:

$$Current\ usage = Flow\ rate\ \times time$$

Where *Current usage* = Total water used for a given zone per irrigation cycle [gal]
Flow rate = Determined from equations below [gpm]
time = Time a zone is operated during a scheduled irrigation cycle [min]

If water meter records units of gallons, use the following equation:

$$Flow\ rate = \frac{10\ gallons}{time} \times 60$$

If water meter records units of cubic feet:

$$Flow\ rate = \frac{7.48\ gallons}{time} \times 60$$

Where *Flow rate* = Flow through a particular zone [gpm]
time = Time required for the needle on the meter to make one complete revolution [sec]

If no water meter is present, determine the flow rate from each sprinkler within one zone and add them all together.

$$Flow\ rate = \frac{Volume}{time} \times 0.01585$$

Where *Flow rate* = Gallons per minute [gpm]
Volume = Volume collected [mL]
Time = Time that water was collected [sec]

5.9.6. Make system recommendations

Provide the homeowner with an estimate of water use from schedule changes alone, as well as system changes. If only the operating time on a given zone is reduced then the new water use can be determined by the following equation:

$$New\ water\ use = Flow\ rate\ \times Recommended\ time$$

Where *New water use* = Total water used for a given zone per irrigation cycle [gal]
Flow rate = From Step 5 [gpm]
Recommended time = Duration for which a specific zone should operate [min]

If changes are recommended for the system, calculate a new average application rate based on flow changes in the system. Estimate changes in flow from manufacturer's catalogs.

$$New\ average\ application\ rate = \frac{Current\ flow\ rate\ \pm proposed\ changes}{Area\ irrigated} \times 5775$$

Where *New average application rate* = Average applied rate after system is altered [iph]
Current flow rate = Flow rate through meter with current system design [gpm]
proposed changes = Flow rates added or subtracted depending upon whether sprinklers are added or capped [gpm]
Area irrigated = Area being watered [ft^2]

Recommend how long to operate the irrigation system based on a 0.25 or 0.5 inch application of water and an estimated improved DU of 60% to 70%. Determine a new effective application rate by multiplying the new average application rate by the estimated DU, as shown in step 3. Determine a new operating time and calculate water usage as shown in steps 4 and 5 respectively.

5.10 Typical Problems and Recommendations for Urban Irrigation Systems
Problems are irrigation system or management factors that limit irrigation system performance or efficiency. Problems are noted during the site visit, system evaluation, and/or through discussions with the operator.

The following items listed below are recommendations that may be given to the landowner to address the problems identified above:

1. Sprinklers should be spaced according to the manufacturer's specifications.
2. Minimum pressure should be no lower than (25psi).
3. Keep rotary sprinklers separate from spray heads.
4. Rotary sprinklers should have matched nozzles for (MPR) matched precipitation rates.
5. Keep turf separate from landscaped areas.
6. Retrofit low volume alternatives for watering of shrub beds
7. Irrigate in the pre-dawn hours of the day to reduce evaporation.

Automatic rain shut off device should be installed and operating.

5.11 Reporting Results of Urban Irrigation Evaluations
The results for the three types of reports are presented differently. The visual inspection or level one evaluation is presented as a checklist shown in Section 3.1 of the text. The report from a catch can evaluation requires the most time. This report addresses specific recommendations on a zone-by-zone basis.

Pressure and Flow Report

The report generated from the pressure and flow inspection provides the property manager with qualitative information about their system. The pressure and flow report addresses topics of landscape maintenance, irrigation system maintenance, scheduling, material, design and planning. The first example of a pressure and flow report is presented on page A-2 as a series of check boxes to provide general comments about the system as well as a section for zone by zone improvements. Some examples of zone by zone recommendations are as follows.

ZONE 1

- Move the rotor in the southwest corner of the front yard closer to the edge of the sidewalk to improve coverage in this area.

- Replace the #5 nozzle in the center 360° rotor with a #9 nozzle for increased system uniformity.

ZONE 2

- Prune lower branches of the oak tree on the north side of the back yard to reduce excessive blockage of the irrigation stream.

- Cap the 90° rotor in the north east corner of the backyard. This entire area is natural shrubs and trees and does not require supplemental watering.

ZONE 3

- This zone consists of a small strip of turf along the side of the house. Replace the turf in this area with a natural ground cover such as Dwarf Confederate Jasmine. Mulch or stepping stones can be used to provide a walkway from the front yard to the back. Once established, this zone can be turned off completely.

The second example presented on page A-6 is a point system developed by NRCS District Conservationist Jack Creighton, and provides a method for rating the system being tested. It has been a useful tool when conducting residential evaluations.

Urban Irrigation Water Management Report

Customer:____

Note: If there is a recommended correction for your system in the following report, a check will appear in the appropriate box.

Landscape Maintenance

☐ 1. Trim branches or twigs that are blocking emitter streams.

☐ 2. Remove non-functional trees and shrubs that block emitter streams.

☐ 3. Remove grass immediately around sprinklers so the irrigation stream is not blocked.

☐ 4. Remove narrow strips of turf and replace them with mulch or a natural ground cover.

☐ 5. Apply mulch in non-turf areas to a depth of 4 inches to hold moisture, reduce weeds, erosion, and add organic matter to the soil.

☐ 6. When planting trees or shrubs select natural or drought-tolerant plants, adequate mulch and low flow irrigation devices.

Irrigation System Maintenance

☐ 1. Include time to locate and repair clogged or leaking sprinklers and lines.

☐ 2. Monitor pressure reducing and flow restricting devices for proper function.

☐ 3. Low pressure in the system can be corrected by capping unnecessary sprinklers, changing to low volume emitters where possible, and discovering and repairing hidden leaks.

☐ 4. Place protective concrete donuts around sprinklers and show their location to lawn maintenance personnel.

Irrigation System Schedule

☐ 1. A precise irrigation schedule requires observation, a rain gauge and rain sensor. Recommended watering times are based on system examination, soil type, and observations. Skip designated irrigation times when soil has sufficient moisture. Watch turf and shrubs for signs of stress.

☐ 2. Turn off sprinklers on mature natural or drought tolerant trees and shrubs. As sprinklers are capped, visually inspect other sprinklers on the same zone for excessive pressure.

Irrigation System Material

☐ 1. Install a rain-shut-off sensor. They save water by turning the system off after sufficient rainfall.

☐ 2. A rain gauge can provide more useful information than a rain-shut-off sensor. By knowing how much rainfall has occurred, you can decide on how long to wait until your next irrigation cycle.

☐ 3. A well filter will help reduce clogging of sprinklers caused by debris.

☐ 4. Concrete donuts protect sprinklers from damage by vehicles and mowers.

☐ 5. Proper use of risers will reduce stream interference caused by shrubs.

☐ 6. Coring tools aid in determining the soil moisture content when watering on an as-needed basis.

☐ 7. Low volume irrigation devices should be installed in plant beds so that less water is applied to beds than turf.

☐ 8. Update the current controller to one that offers more options for scheduling, such as independent programs for turf and non-turf areas.

☐ 9. Adjust or replace directional spray emitters to avoid watering the driveway or sidewalk.

Irrigation system design and planning

☐ 1. Adjust or relocate sprinklers to achieve head-to-head coverage

☐ 2. Any new zones should be planned as either turf or non-turf zones. One zone should not water both turf and non-turf areas.

☐ 3. Rotors and pop-up spray heads should be placed on separate zones to reduce over watering.

☐ 4. Use the same manufacturer for all rotors and spray heads.

☐ 5. Include drought-tolerant plants in non-turf areas to reduce the water demand of your landscape.

Recommendations:

Zone 1:

Zone 2:

Zone 3:

Zone 4:

Zone 5:

Zone 6:

Irrigation Duration:

Water use per operating cycle.

	Current	Time Changes Only	System and Time Changes
Zone 1			
Zone 2			
Zone 3			
Zone 4			
Zone 5			
Zone 6			
Total			

Urban Irrigation Water Management

Rating System

Evaluator ______________________________ Date ___/___/___.

Site Name ______________________________ Phone (   )_____.

Address ____.

Subject	Point Value (circle)	Total
Devices (65 Points)		
Utilizes coring tool (wetness)	25	
Proper rain or soil moisture sensor	20	
Utilizes rain gauge	15	
Protection for sprinklers (Donuts)	5	☐
Schedule (25 Points)		
Does not exceed 0.5 inches application per watering	25	☐
System (75 Points)		
Filter at well	25	
No system leaks	25	
Minimum pressure at farthest head at least 25 psi	25	☐
Zones (50 Points)		
Plant beds on separate zones from turf	25	
rotors in separate zones from spray heads	25	☐
Drought Tolerant Landscaping (25 Points)		
Uses drought tolerant shrubs and ground covers	25	☐
Turf (30 Points)		
Irrigation stream clear of obstacles	15	
Drought tolerant grass	15	☐
Beds (80 Points)		
Four inches or more of mulch	20	
Low volume emitters	20	
Irrigation stream clear of obstacles	15	
Irrigation heads turned off at mature shrubs	10	
Sufficient use of risers	10	
Proper directional emitters (90°, 180°)	5	☐
Irrigation Heads (75 Points)		
Proper head to head coverage	25	
Matched emitters	25	

Sprinkler position (upright)	10	
All from same manufacturer	5	
Undamaged	5	
Unclogged	5	☐

Operator Knowledge (15 Points)

Understanding of water source (well, pond, municipal)	1	
"As built" orientation	1	
Command of the control box	1	
Understanding pressure	1	
Understanding flow (nozzle sizes)	1	
Sprinkler distribution (degrees)	1	
Sprinkler distribution (distance)	1	
Changing spray nozzles	1	
Rotor sprinkler adjustment	1	
Maintenance for pop-up spray heads	1	
Understanding of rain sensor and gauge	1	
Understanding benefits of drought tolerant landscape	1	
Knowledge of specific drought tolerant plants	1	☐

Operation Summary

Item	**Maximum Value**	**Score**
Devices	65	______
Schedule	25	______
System Water Pressure	75	______
Zones	50	______
Drought Tolerant Landscape	20	______
Turf	30	______
Beds	80	______
Irrigation Heads	75	______
Operator Knowledge	15	______
Possible Score:	440	Total Score: ______

Operation Rating

Total Score (__/440) * 100 = ______% **is your rating**

Catch Can Evaluation Report

The catch can test provides the most detailed information about an irrigation system. The report generated from data collected should provide property managers with precise information about their irrigation system. The report is similar to the report generated from the pressure and flow evaluation with a few pieces of additional information. Include calculations of distribution uniformity, effective application rate, current water used as well as potential savings. Also include zone by zone recommendations of any system or landscape changes.

Irrigation Duration:

Water use per operating cycle.

	Current	Time Changes Only	System and Time Changes
Zone 1			
Zone 2			
Zone 3			
Zone 4			
Zone 5			
Zone 6			
Total			

Distribution uniformity in zone tested: ☐ %

Average application rate in zone tested : ☐ iph

Effective application rate in zone tested: ☐ iph