HGCIA
Houston Gulf Coast Irrigation Association
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Best Management Practices

for

Landscape Irrigation Systems

October 2004

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Forward

The Houston Gulf Coast Irrigation Association (HGCIA) has developed these voluntary landscape irrigation best management practices (BMPs) to benefit Texas and local landscape and irrigation-related business professionals, public agencies and municipalities, and property owners:

- Landscape architects, irrigation designers, irrigation consultants and irrigation contractors can improve their bottom line by adapting and expanding their business and marketing plans with new and innovative value-added water-conscious irrigation services and products that promote higher customer satisfaction through commitment to landscape water conservation and efficiency.

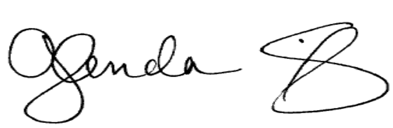
- Municipalities, water utilities, and regulating entities can create or adapt landscape and/or irrigation ordinances, rules or standards pertaining to the design, installation, maintenance and management of landscape irrigation systems, with the goal of decreasing the waste of water in the landscape while allowing for healthy landscapes. Similarly, these BMPs can be used for public and private education outreach programs.

- Private and public property owners and managers can reduce unnecessary expenditures associated with improperly designed, installed and managed irrigation systems. Such unnecessary expenditures include the cost of wasted water, cost to replace plants or trees, and cost to repair damaged sidewalks, parking lots, fountains, etc. Contracts for irrigation services can be awarded based on a ranking of competitive bids that include ways to reduce the waste of irrigation water while maintaining healthy landscapes.

We have tried to create BMPs that are both doable and economically justifiable. We hope that these BMP's will benefit contractors and landscape owners alike, as well as local cities, homeowner associations and municipal utility districts.

I would like to express my sincere gratitude to the following dedicated irrigation professionals for taking the time to draft, revise, draft and revise yet again this very special document. Special thanks to Jim McCabe (Committee Chairman), Dee Cunningham, Doug Goodwin, Richard Granberry, Danny Lenderman, Dave McCullough, Rodney McNabb, David Smith and JT Summarell.

Very truly yours,



Glenda Single, President (2004), Houston Gulf Coast Irrigation Association

Comments and Recommendations

The HGCIA may revise this document from time to time based on comments and recommendations from irrigation and landscape professionals and contractors, irrigation associations, state and local agencies, municipalities, and others. To submit suggestions for improvements or other recommendations or comments, please fill out this sheet (add additional pages as needed) and fax to 713-776-1295 or submit an email to Jim@SensibleTechnologies.com.

Recommendations or Comments: ____

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Follow-up Contact Information:

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Best Management Practices for Landscape Irrigation Systems

1. Introduction

The overall goal of landscape irrigation Best Management Practices (BMPs) is to limit an excessive application of irrigation water while maintaining healthy and functional landscapes. This goal is achievable through proper design, installation, maintenance and management of efficient irrigation systems.

The BMPs defined herein are relevant to the following stakeholders:

1. Private business professionals including landscape architects, irrigation designers, irrigation consultants and irrigation contractors may use these BMPs to:

    a. Develop new business and marketing plans.
    b. Adapt, modify, and expand existing business and marketing plans.
    c. Perform an internal audit of existing processes, methods and procedures.
    d. Develop new and innovative value-added services to enhance competitiveness.
    e. Enhance the professional image of the business and reinforce customer trust.
    f. Identify specific products, services, management strategies, and technologies that meet consumer needs and promote higher customer satisfaction.
    g. Raise the level of professionalism within the industry.
    h. Demonstrate a business' commitment to water conservation and efficiency.

2. Government, municipalities, water utilities, and other regulating entities may use these BMPs to:

    a. Create, modify or amend existing landscape and/or irrigation ordinances, rules or standards pertaining to the design, installation, maintenance and management of landscape irrigation systems.
    b. Develop guidance for contracting entities to comply with state and local regulations.
    c. Rank, distinguish and award competitive contract bids for irrigation design and installation.
    d. Develop internal policy and guidance for employees responsible for designing, installing, maintaining, and managing irrigation systems.
    e. Guide public and private education outreach programs involving landscape water conservation.

3. Private and public property owners and managers may use these BMPs to:

    a. Educate employees responsible for maintaining and managing landscape irrigation systems.
    b. Reduce unnecessary expenditures associated with improperly designed, installed and managed irrigation systems. Such expenditures include the cost of wasted water, cost to replace plants or trees, and cost to repair damaged sidewalks, parking lots, fountains, etc.
    c. Audit existing irrigation systems and landscape management plans.
    d. Rank, distinguish and award competitive bids for irrigation services.
    e. Take a proactive approach to prepare for future local water ordinances and restrictions.

BMPs are presented in sections 2 through 6 in categories of quality, design, installation, maintenance and water management. Many of these BMPs have their roots in the Irrigation Association's "Turf and Landscape Irrigation Best Management Practices" available from the Internet at http://www.irrigation.org. Additionally, many of the BMPs support existing Texas state rules as specified by the Texas Commission on Environmental Quality.

References are provided in Section 7. Terms needing definition are italicized at first use and are provided in the Glossary.

Note: The BMPs defined in this document are voluntary except as otherwise required by Texas state law or local ordinances.

Note: Should a BMP stated herein be in conflict with state or local rules and regulations, then the state or local code shall prevail.

Note: In this document, "qualified" means certified, trained, licensed or other similar qualification that meets state and local requirements.

2. BMPs for a Quality Irrigation System

Quality irrigation systems are those that keep plants healthy and functional but without applying an *excessive amount of irrigation water*. Quality systems rarely happen by chance. They are the product of sound design, installation, maintenance and management.

To assure that a high-quality irrigation system is designed, installed, maintained and managed:

1. A *qualified* landscape architect or licensed irrigation contractor should design the irrigation system to *uniformly distribute* the water without applying an excessive amount of irrigation water. Design-related BMPs identified in Section 3 should be followed.

2. A licensed irrigation contractor should install the irrigation system according to the design specifications. The irrigation contractor should test the completed system to verify that the system operates according to the design criteria. Installation-related BMPs identified in Section 4 should be followed.

3. A qualified landscape architect, irrigation designer, irrigation consultant, irrigation contractor, irrigation professional or local water district representative should perform one or more site observations to check for adherence to the design. The observation should assure that the intent of the design has been preserved.

4. A licensed irrigation contractor should periodically maintain the irrigation system for ongoing efficient performance and to preserve the integrity of the design. Maintenance-related BMPs identified in Section 5 should be followed.

5. The irrigation schedule should be managed to respond to the changing need for water in the landscape, and to maintain a healthy and functional landscape without applying an excessive amount of irrigation water. Scheduling-related BMPs identified in Section 6 should be followed.

3. BMPs for Design of an Irrigation System

A qualified landscape architect or licensed irrigation contractor should design the irrigation system to uniformly distribute the water without applying an excessive amount of irrigation water. This section defines design-related BMPs to help in achieving this goal.

3.1 General Design-Related BMPs

1. The designer should obtain direct knowledge of site conditions and not rely solely on plot plans to generate a design. The design should be based on a thorough evaluation of physical, environmental, and hydraulic site conditions.

2. The design should meet all applicable state and local codes including *backflow* protection, plumbing and electrical codes.

3. The design should specify manufacturer, model, type, and size of components to eliminate ambiguity at construction and to facilitate future maintenance of the system. The selection of pipe, electrical wire and other materials should be based on design parameters, environmental conditions and code requirements.

4. When selecting components, the following rules of maximum safe flow rate should be applied, with the lowest safe flow rate prevailing as the design guideline:

   a. The maximum allowable pressure loss through the meter should be less than 10% of the static pressure at the meter.

b. The maximum flow rate through the meter should not exceed 75% of the maximum safe flow rate through the meter.

c. The velocity of water through the service line supplying the meter should not exceed 7.5 feet per second (fps).

d. The velocity of water moving through the irrigation pipe should not exceed state and local requirements, or the industry standard of 5 fps.

5. The design should specify protection of the water source in accordance with state and local requirements. Where no requirements exist, the designer should assess the degree of hazard and specify the appropriate *backflow prevention device*. For further information related to device selection for protection of potable water supplies, see Reference 3.

6. The design should specify the recommended operating (working) pressure at the maximum design flow rate of the system. For systems on a municipal supply, the design should allow for a reduction in static pressure of up to10 psi to accommodate possible future expansion in the supply network.

7. The design should specify the use of flexible pipe or swing joints to connect sprinkler heads to supply pipe for sprinkler heads that may be damaged by pedestrian, vehicle and/or lawn maintenance equipment.

3.2 Water Use Efficiency and Water Conservation BMPs

1. The design should specify pressure regulation where variable or excessive static pressure exists to keep the operating pressure at the sprinkler head, emitter or watering outlet within the manufacturer's recommended operating pressure range. This reduces misting and subsequent water loss due to spray drift and *evaporation*.

2. Drip/micro-irrigation should be used where appropriate to reduce evaporation losses and surface *runoff*, and to minimize applying water on hardscapes. For zones with drip/micro-irrigation, the design should:

   a. Specify filtration at the control valve to remove particulate matter.

   b. Separate drip/micro-irrigation zones from overhead irrigated zones since drip/micro-irrigation systems are not as susceptible to water loss due to evaporation, wind, or surface runoff. Separate zoning allows the irrigator to adjust water requirements given these differing conditions.

   c. Consider differing plant water requirements and root zone depths and use separate drip/micro-irrigation zones where practical.

d. Specify pressure-compensated devices to improve overall *emission uniformity*.

e. Specify pressure regulation upstream from the drip/micro-irrigation components. Typically, the pressure of city water sources may be increased periodically by the city for flushing or other purposes, and can potentially damage a drip/micro-irrigation system that has no pressure regulator on the zone controls. Pressure-compensated emitters do not serve this function. Pressure regulating devices can be omitted only when the absolute maximum possible pressure is known to be lower than the maximum allowable pressure for all drip/micro-irrigation components.

f. Connect the ends of individual laterals when possible to improve *application uniformity* and limit contamination should drip tubing be damaged. This helps to equalize system pressure and also allows water to flow from both sides of damaged drip tubing, thus flushing out any debris.

g. Follow manufacturer's recommendations for use of air relief valves to minimize ingestion of dirt or other contaminants into the emitters.

h. Follow manufacturer's recommendations for flushing the laterals after completion of the irrigation cycle.

3. The design should specify components and layout of zones in accordance with manufacturer's specifications to achieve a uniform application of water. Sprinkler head spacing should be based on manufacturer's recommendations usually with a minimum of "head-to-head" coverage (i.e., 50% of diameter) unless the coverage is designed for *wind derating* (see next item below). Spray heads and rotors should be selected to meet manufacturer-specified *matched precipitation rate* (MPR) requirements.

4. Wind derating should be based on the average nighttime wind speed for the prevailing wind direction during the normal irrigation season. The layout of spray and rotary zones exposed to the prevailing wind direction should be designed for wind derating according to the manufacturer's wind derating and spacing recommendations. This BMP is optional (unless further restricted by state and local codes) for areas with average nighttime wind speed less than 5 mph (during the normal irrigation season), zones that are sheltered from the wind, zones that are not exposed to the prevailing wind direction, or zones that are irrigated by drip, subsurface, or micro-irrigation methods that are not subject to wind influences.

5. The layout of heads and other emission devices should be designed to minimize *overspray* across or onto a street, public driveway, public sidewalk, parking area, building, fence, or adjoining property. This BMP is optional for narrow foot and cart paths where runoff from the surface does not leave the property. Overspray may occur during operation of the irrigation system due to actual wind conditions that differ from the design criteria.

6. The selection and placement of sprinkler and drip/micro-irrigation components should be guided by the expected size of larger specimen plants through a minimum three-year establishment period for shrubs and ten years for trees.

7. The *precipitation rate* of spray and rotary zones should meet existing state requirements for various precipitation zones in Texas (5 regions of Texas; see Reference 5). For example, Houston is located in precipitation zone #1 which currently requires that the precipitation rate be at least 0.25 inches per hour, for every hour that the landscape irrigation system is in operation. Similarly, El Paso is located in precipitation zone #4 which currently requires a precipitation rate of at least 0.325 inches per hour.

8. Surface *runoff* should be minimized when selecting components to use. Sprinklers at the top of *sloped areas* should be zoned separately from those at the base. Sloped areas should be zoned separately from non-sloped areas. Where practical, the design precipitation rate should be kept below the *intake rate* of the soil. This may not be possible for clay or other heavy soils, or in meeting state requirements for minimum allowed precipitation rates based on various precipitation zones in the state (see item 7 above).

9. Areas of plants with dissimilar water requirements should be zoned on separate valves so they can be scheduled independently of each other. For example, high-water use plants should be zoned separately from native or lower-water use plants.

10. The layout and selection of appropriate heads, nozzles, and other emission devices should be designed to meet the geometric constraints of narrow or irregular landscape areas while meeting applicable BMPs for head spacing, wind derating, runoff and overspray.

11. Where possible and practical, and to minimize the loss of irrigation water to evaporation and the wind, irrigation water should be applied when evaporation and wind are at their lowest; for example, between the hours of 6:00 pm to 10:00 am. (Early morning is best for most plants.) This BMP is optional for drip and micro-irrigation. This BMP does not apply to installation, maintenance testing, and preparation and establishment of new plant material.

12. *Check valves* should be installed to reduce *excessive water loss due to low head drainage* caused by elevation differential between the heads and the zone valve.

13. The following water-conserving concepts and equipment should be recommended where appropriate and economically justified:

    a. A water meter or other metering device that measures the total landscape water use separate from non-landscape use. This allows more effective management of landscape water usage by allowing a comparison of actual usage to planned or budgeted usage.

b. An alternative nonpotable water source (such as gray water or reclaimed water) where allowed by law. Special management practices and components may be required when using alternative water sources.

c. Low-trajectory sprinkler nozzles (with the appropriate modified head spacing) to mitigate the effects of wind.

d. Components to minimize mist when manufacturer's pressure specifications are met.

e. Pressure regulators or pressure compensating screens, stems or nozzles to control high pressure.

f. Rain or moisture sensors to suspend irrigation during weather conditions that are unfavorable for irrigation.

g. A wind shutoff device to suspend irrigation during *high wind speed conditions*. This BMP is optional for zones composed of drip or micro-irrigation and zones that are protected from the wind.

h. Environmental sensors that can actively measure weather conditions to determine daily plant water need.

i. Soil moisture sensors to monitor soil moisture and suspend irrigation if the moisture reserve in the root zone is significantly above the *allowable depletion* limit.

j. A controller that allows for flexible irrigation scheduling and advanced water management features.

3.3 Safety-Related BMPs

1. A minimum of six inches of coverage should be provided over piping except where a different coverage is required by local or state requirements. Effective means should be provided to prevent damage to the pipe due to freezing soil conditions.

2. Wiring that connects zone (section) valves to controllers should be Underwriters Laboratories (UL) listed for direct underground burial and should be sized according to manufacturer's recommendations.

3. Wire splices should be manufacturer-approved water-tight connectors, and should be rated for direct burial when buried.

4. A freeze sensor should be specified to suspend irrigation for those areas of the state that commonly have freezing conditions. Irrigation should not be applied to zones

exposed to freezing temperatures to reduce the potential hazard caused by frozen water on the surface.

3.4 Scheduling and Water Management Design-Related BMPs

1. Specific criteria that should be considered in the schedule for each zone include soil type, slope, root depth, plant materials, *microclimates*, *hydrozones*, precipitation rate, application uniformity, *cycle run time* to minimize runoff, and weather conditions.

2. When the design precipitation rate of the zone exceeds the *intake rate* of the soil based on slope and predominant soil type, then the irrigation water should be applied to the zone in two or more *repeat cycles* to allow the water to soak into the soil between cycles to reduce runoff.

3. Monthly or seasonal *base irrigation schedules* should be provided to the owner (or end user) of the irrigation system for the period of the irrigation season. These schedules should define the frequency of irrigation (when to irrigate) based on replenishing allowable depletion (how much to irrigate; i.e., run time) of the soil moisture between irrigation days.

4. A rain shutoff device, soil moisture sensor or other method should be used to suspend irrigation to those zones exposed to rainfall during and following a *rain event*.

3.5 Documentation

A documentation package should be provided to the owner of the irrigation system that includes the following information at a minimum:

1. A set of design drawings or documents which includes the locations and sizes of the meter, manual shutoff valve, backflow prevention device, mainline pipes and zone valves. The locations of the controller and sensors (rain, freeze, etc.) should also be identified.

2. Design pressure criteria including recommended system static pressure range, recommended system operating pressure range and recommended system operating pressure.

3. Zone-specific design criteria including predominant plant type, soil type, slope, root zone depth, precipitation rate, recommended operating pressure range, recommended operating pressure and wind derating criteria.

4. A base irrigation schedule so that the owner (or end user) can make schedule adjustments for normal monthly or seasonal weather changes. (Also see Section 6, item 3.)

4. BMPs for Installation of an Irrigation System

A licensed irrigation contractor should install the irrigation system according to the design specifications. To conserve and protect water resources, the installation should result in an efficient and uniform distribution of the water:

1. Prior to installation, all appropriate utility companies should be contacted to locate underground utilities including gas lines, electrical, telephone, cable, and so forth. State laws (and some federal laws) require anyone who digs to notify utility companies before starting. The property owner should be contacted to locate, identify and mark all privately-owned underground utilities. Installation should not be started until all underground utilities are located and marked.

2. Prior to beginning installation, the static pressure should be measured and verified that it is within the acceptable range as specified in the design.

3. Prior to installation, planting plans should be reviewed to minimize conflicts between larger plants and layout of irrigation heads. Construction plans should be reviewed for conflicts between hardscape and sprinkler head placement.

4. The property owner and irrigation designer should be informed of unusual or abnormal soil conditions which may impact the installation and schedule of the irrigation system.

5. The irrigation system should be installed according to the design specifications. If a design does not exist, then the property owner should be encouraged to have a qualified irrigation designer develop a design.

6. Where deviations from the design are required (for example, running pipe around a tree or other structure that was unknown during design), the plan drawing should be redlined to note the deviation. The designer should be consulted prior to making the change to ensure that the change is within design performance specifications.

7. The completed irrigation system should be tested to verify that the system meets the design, installation, operation, safety and other requirements. At a minimum, the contractor should:

    a. Measure and record the static pressure at time of installation.

    b. Verify that the precipitation rate meets or exceeds minimum state requirements. At a minimum, the precipitation rate of all turf zones should be measured and recorded.

    c. Verify that the *lower-quarter distribution uniformity (DU)* meets or exceeds the values in the following table. At a minimum, the DU of all turf zones should be measured and recorded.

Operational Lower-Quarter Distribution Uniformity

Type of Zone	Minimum DU
Spray	55%
Rotor	70%

d. Test all sensors (wind, rain, etc.) for proper operation. Record all test results.

e. Test the backflow prevention device and record the test results.

8. The irrigation schedule provided with the design should be reviewed, specifically the rationale and methods for determining irrigation days, zone run times and start times. If no schedule exists, then one should be created (see item 3 of Section 6). The system should be operated and observed, and repeat cycles should be added if needed to reduce runoff.

9. The location and operation of the controller, shutoff and zone valves, pressure regulators, backflow device and sensors (rain, freeze, etc.) should be explained to the owner (or end user). Advanced controller programming features should be discussed, including multi-cycle irrigation to prevent run-off. Features and capabilities of the system including maintenance requirements should be discussed.

10. The irrigation contractor should discuss with the owner (or end user) the following landscape water conservation topics:

    a. Proper operation of system components requires periodic maintenance.

    b. Landscape irrigation is meant to supply water to supplement rainfall.

    c. Plant water requirements may change from day-to-day based on weather conditions; thus the schedule should be changed accordingly.

    d. Importance of hydrozoning according to plant water and scheduling requirements.

    e. Benefits of applying water-conserving landscaping practices such as the use of mulch and soil amendments.

11. A documentation package should be offered to the owner of the system to aid in future maintenance or alteration. This documentation package should include at a minimum:

    a. An *as-built* set of drawings or documents which includes the final locations and sizes of the meter, manual shutoff valve, backflow prevention device, mainline pipes and zone valves. The final locations of the controller and sensors (rain, wind, freeze, soil moisture, etc.) should also be identified.

b. Design criteria including recommended system static pressure range, recommended system operating pressure range and recommended system operating pressure.

c. Actual zone-specific criteria including predominant plant type, soil type, slope, average effective root zone depth, precipitation rate, operating pressure and wind derating criteria. Also include the recommended design operating pressure range for each zone.

d. A base irrigation schedule based on actual zone criteria and typical weather conditions so that the owner (or end user) can make schedule adjustments for normal monthly or seasonal weather changes. Also see Section 6, item 3.

e. Copy of installation test results (from item 7 above).

f. User's manuals for the controller and sensors.

g. Product and irrigation system warranties.

12. The contractor should retain design, installation and test documentation for a minimum of three years.

5. BMPs for Maintenance of an Irrigation System

A licensed irrigation contractor should periodically maintain the irrigation system for ongoing efficient performance and to preserve the integrity of the design. To conserve and protect water resources, the maintenance should result in an efficient and uniform distribution of water:

1. A periodic maintenance schedule should be established for inspection and reporting performance conditions to the owner (or end user) of the irrigation system.

2. System repairs or modifications should be consistent with design specifications and should not cause the landscape water demand to exceed the hydraulic capacity of the system.

3. The backflow prevention device should be tested annually to verify that it is working correctly.

4. The static pressure should be measured to verify it is within the recommended design range. This step should be performed before making any changes to the system. The effect of the planned change on the operating pressure should be considered.

5. Pressure regulators should be adjusted within the design operating pressure range.

6. The controller should be tested and verified that it is working properly. The date/time should be verified and the back-up battery should be tested and replaced if necessary.

7. Each zone should be tested and verified that it is working properly. Heads should be inspected for alignment, arc, radius, level, attitude with respect to slope, and so forth.

8. Environmental sensors (rain, freeze, etc.) should be tested and verified that they are working properly and are within their calibration specifications.

9. Filters should be examined and cleaned, or replaced as required.

10. Zone valves should be adjusted for proper flow and operation. Valve flow regulators should be adjusted for the desired closing speed.

11. Broken hardware and pipe should be replaced as needed with identical products (preferred) or with products that meet or exceed the design specifications of the original product. Aftermarket replacement nozzles may not match original parts well enough to preserve distribution uniformity and the precipitation rate. Any required equipment changes should be specified in a way that meets or exceeds the minimum distribution uniformity, runoff and overspray criteria.

12. As plant material matures, vegetation should be trimmed or removed as required to preserve system performance. Additional sprinklers or other hardware should be added as required to compensate for blocked spray patterns or changes in the irrigation needs of the landscape.

13. The backflow protection should upgraded or improved as needed to reflect any changes to the system.

14. The owner (or end-user) should be notified of any deviations from the original design. Any modifications or additions to the design should be documented, and a copy of the documentation provided to the owner.

15. A “winterization” protocol should be established, if required based on the applicable region of the state. A corresponding process should be established for system activation in the spring.

16. A performance audit should be conducted every three to five years to assure that the system is working efficiently and with the desired distribution uniformity and precipitation rate specifications.

6. BMPs for Scheduling and Water Management

To conserve and protect water resources and the environment, the irrigation schedule should be changed as required to provide supplemental water to maintain a functional and healthy turf and landscape without applying an excessive amount of irrigation water:

1. The manager should understand the expected monthly and seasonal irrigation water usage (budget) and water cost for both typical and drought-weather seasons. The manager should understand how the system should operate; for example, (a) the irrigation system run time per week, normally and in the peak summer months; (b) the expected maximum run time on a day of the warmest month; (c) the maximum duration of the watering window; (d) the expeced water use in typical-weather months; and (e) the expected water use in drought-weather months.

2. If necessary, an irrigation audit should be performed to obtain data for creating the base irrigation schedule:

    a. Plant types and microclimate factors should be identified for each hydrozone. The basic soil texture and root zone depth should be identified from soil cores.

    b. The actual sprinkler performance should be measured for each zone including operating pressure, precipitation rate, distribution uniformity and flow rate.

    c. The time it takes for runoff to occur should be recorded for each zone that has a soil infiltration rate below the applied precipitation rate. The number of cycle starts (repeat cycles) and soak time between cycles should be determined to minimize runoff.

3. If not provided in the design package, the manager should develop monthly or seasonal base irrigation schedules where the frequency of irrigation (when to irrigate) is based on replenishing the allowable depletion (how much to irrigate) of the soil moisture between irrigations. Monthly or seasonal schedules should be based on cool-season reference evapotranspiration data (ETo), plant type, root zone depth, soil type, infiltration rate, slope, measured precipitation rate and distribution uniformity. Where there is a potential for surface runoff, multiple repeat cycle start times should be used to allow the water to infiltrate into the soil. Information on scheduling is available from the Irrigation Association (see Reference 2).

4. The irrigation schedule should be adjusted manually or automatically to avoid applying an *excessive amount of irrigation water*.

5. The effectiveness of system water management should be periodically determined by monitoring and comparing actual landscape water usage to a target budget (see references 1 and 2). For example, at the end of the month compare actual monthly water usage to the budgeted amount. If the budget is exceeded, then try to find out why. Make system repairs or schedule adjustments as needed.

7. References

1. Irrigation Association, Turf and Landscape Irrigation Best Management Practices, February 2004, see http://www.irrigation.org.

2. Irrigation Association, Landscape Irrigation Scheduling and Water Management, September 2004, see http://www.irrigation.org.

3. Manual of Cross-Connection Control, Ninth Edition, December 1993, Foundation of Cross-Connection Control and Hydraulic Research, University of Southern California.

4. Stryker, Jess, "Glossary of Landscape Irrigation Terms," see http://www.irrigationtutorials.com.

5. Texas Administrative Code, Title 30 (Environmental Quality), Part 1 (Texas Commission on Environmental Quality), Chapter 344 (Landscape Irrigation), Subchapter A (General Provisions) and Subchapter D (Standards for Landscape Irrigation).

6. WaterWise Council of Texas, see http://www.waterwisetexas.org.

GLOSSARY

Note: The terms defined below are italicized at their first use within this document.

(1) *Allowable depletion* {inch}: The amount of total plant available water that is to be depleted from the active plant root zone before irrigation is applied.

(2) *Application uniformity* {percent}: See distribution uniformity.

(3) *Area* {square feet}: See *landscape area* and *zone area*.

(4) *As-built drawing, as-built plan*: Set of construction plans including the original design and noting all design deviations. These drawings should also show the location of all major underground components, dimensioned from permanent features. The plans may be generated by computer, by hand, or by a combination of the two. Also referred to as a record drawing.

(5) *Backflow*: Any unwanted flow of used or non-potable water or substance from any domestic, industrial or institutional piping system into the pure, potable water distribution system. The direction of flow under these conditions is in the reverse direction from that intended by the system and normally assumed by the owner of the system. (USC, 1998).

(6) *Backflow prevention device*: Safety device which prevents the flow of water from the water distribution system back to the water source (ASAE, 1998).

(7) *Base irrigation schedule*: An irrigation schedule (typically for each month of the irrigation season) where the frequency of irrigation (when to irrigate) depends on replenishing allowable depletion (how much to irrigate) of the soil moisture between irrigations based on historical or other reference evapotranspiration data. Also see *allowable depletion* and *historical reference evapotranspiration*.

(8) *Check valve*: A device located in a lateral or at the base of a sprinkler head or emission device and that prevents water from draining through the sprinkler lowest in elevation after the irrigation cycle is completed.

(9) *Cycle run time* {typically minutes}: The operating duration of one or more valves for one irrigation start time.

(10) *Distribution uniformity, application uniformity, system uniformity:* The measure of the uniformity of applied irrigation water over an area. (ASAE, 1998)

(11) *Distribution uniformity, lower-quarter* [DU]{percent}: The average of the lowest twenty-five percent of measurements to the overall average measurement and expressed as a percentage. The design DU can be calculated from head spacing and

other information. The measured DU is determined through the use of catch cans, commonly used to evaluate the coverage of one or more zones. DU is a specific method for rating how evenly irrigation water is applied over a zone.

(12) *Effective rainfall* {inches per time period}: The amount of rainfall that is actually stored in the root zone. Some rainwater does not reach the soil profile because it is held in mulch or turf thatch or because it runs off. Some water may percolate below the root zone and be lost, depending upon the intensity and duration of the rain event and the water content of the soil prior to the rain event. (Scheduling, 1999)

(13) *Emission uniformity* [EU]{percent}: An index of the uniformity of emitter discharge rates throughout a micro-irrigation system. EU takes into account variations in a group of like emitters and variations in the pressure under which they operate. (Soil and Water Terminology, ASAE 2000)

(14) *Evaporation* {inches per time period}: Water evaporated from the soil and plant surfaces. Also see *evapotranspiration*.

(15) *Evapotranspiration* [ET] {inches per time period}: Combination of water transpired from vegetation and evaporated from the soil and plant surfaces. Also see *reference evapotranspiration* and *historical reference evapotranspiration*.

(16) *Excessive amount of irrigation water*: An irrigation system of good quality and that has a well-managed schedule should not apply more than 30 to 40% of water above the supplemental water needs (i.e., net plant water requirement) of the landscape to account for nonuniform distribution of the water, uncertainty in the weather and other normal water losses that are inherent in a good, well-managed system. An applied amount of irrigation water more than 40 to 50% above the supplemental water needs of the landscape is considered excessive. Also see *distribution uniformity*, *supplemental water* and *net plant water requirement.* (HGCIA, 2004)

(17) *Excessive water loss due to low head drainage*: An amount of lost water due to low head drainage that exceeds 3% of the total water applied to the zone during a normal (typical) irrigation season is considered to be excessive. (HGCIA, 2004). Also see *head drainage*.

(18) *Head drainage*: Irrigation water loss through the sprinkler head due to elevation differential between the head and the zone valve.

(19) *High wind speed conditions*: Wind speeds that are 10 mph or more above the average wind speed for which the irrigation system is designed are considered high wind speed conditions. For example, a high wind speed condition is one that is 15 mph (or greater) for an irrigation system that is designed to operate under average wind speeds of 5 mph or less. Similarly, a high wind speed condition is one that is 20 mph or higher for an irrigation system that is designed for 10 mph average wind speed. (HGCIA, 2004).

(20) *Historical reference evapotranspiration* [historical reference ET] {inches per time period}: A multiple-year average of recorded historical grass-reference ET (ETo) data from a weather station, evaporative pan or other device in a given geographic location. This value is typically a monthly average of the specific month in a given multi-year time frame. This value, when corrected for plant species characteristics, can be used as a baseline to evaluate the expected water needs of a landscape planting in that geographic area. Also see *evapotranspiration* and *reference evapotranspiration*.

(21) *Hydrozone*: An area of the landscape where all the factors that influence the watering schedule are similar. Typical factors to be considered are the type of plants, type of soil, root zone depth, slope, sun/shade exposure, and wind exposure. Also see *microclimate*. (Weinberg and Roberts, 1988)

(22) *Infiltration rate, soil infiltration rate* {inches per hour}: The dynamic rate at which irrigation water applied to the surface can move into the soil profile. The rate typically declines rapidly after an initial period of surface hydration. This value depends to a great extent on the texture of the soil and whether the soil is overly compacted.

(23) *Intake rate* {inches per hour): See *infiltration rate*.

(24) *Irrigation audit*: Procedure to collect and present information concerning the uniformity of application, precipitation rate, and general condition of an irrigation system and its components.

(25) *Irrigation schedule*: Set of data describing when, duration and amount of irrigation water to be applied to each zone. Also see *base irrigation schedule*.

(26) *Landscape area* {square feet}: Area of the landscape including all zones. Also see *zone area*.

(27) *Lower quarter distribution uniformity* (DU) {percent}: See *distribution uniformity, lower quarter*.

(28) *Matched precipitation rate* (MPR) {inches per hour}: Zone in which all the heads or emission devices have similar precipitation rates is said to have matched precipitation rates. (Monroe, 1993) Also see *precipitation rate*.

(29) *Microclimate*: A subdivision of a landscape characterized by environmental conditions that may differ from the typical site condition to a degree that evapotranspiration will be affected, either higher or lower than expected for the site. Examples of conditions that might create a separate microclimate include reflected heat, breezeways, wind exposure, topography (slope) and shading.

(30) *Net plant water requirement* {inches per time period}: Defined as the plant water requirement less effective rainfall and is the supplemental amount to be provided to

the plants by the irrigation system. Also see *plant water requirement, effective rainfall* and *supplemental irrigation water*.

(31) *Overspray*: Above ground irrigation water that reaches beyond the desired target area (for example, on to hardscapes, fences, buildings, or adjoining property).

(32) *Plant water requirement* {inches per time period): The amount of water required by plants to keep them functional and healthy regardless of the source (e.g., rainfall and as supplied by the irrigation system). Plant species have differing plant water requirements. Also see *net plant water requirement* and *supplemental water*.

(33) *Precipitation rate* {inches per hour}: Rate at which a sprinkler system applies water to a given area. Also see *matched precipitation rate*.

(34) *Qualified*: Certified, trained, licensed or other similar qualification that meets state and local requirements.

(35) *Quality irrigation system*: Irrigation systems that keep plants healthy and functional but without applying an excessive amount of irrigation water. Quality irrigation systems are the result of sound design, installation, maintenance and management. Also see *excessive amount of irrigation water*.

(36) *Rain event* {time duration}: A period of time that begins with the occurrence of a stated amount of rainfall (for example one-fourth inch) and ends when the rainfall has stopped. (HGCIA, 2004)

(37) *Reference evapotranspiration* {inches per time period}: Expressed using one of two reference types: [ETo] representing short clipped cool-season grass or [ETr] representing tall vegetation similar to alfalfa. Landscape irrigation uses short grass reference ETo. Also see *evapotranspiration* and *historical reference evapotranspiration*.

(38) *Repeat cycles*: Two or more activations of a zone valve to dispense irrigation water, and with a delay time in between activations to allow the irrigation water to soak into the soil.

(39) *Runoff:* Portion of irrigation or rain water that leaves the target area, primarily due to slope or the precipitation rate exceeding the soil infiltration rate. Also see *slope*, *precipitation rate* and *infiltration rate*.

(40) *Slope, sloped area* {degrees above horizontal}*:* Ground where grade varies or is not level.

(41) *Soil infiltration rate* {inches per hour}: See *infiltration rate*.

(42) *Supplemental water*: Irrigation water applied to the landscape plants to make up for a rain shortfall. Also see *net plant water requirement*.

(43) *Uniformly distribute*: See *distribution uniformity*.

(44) *Wind derating*: A process of modifying the standard “head-to-head” spacing (50% of diameter) to account for the average wind speed for the prevailing wind direction.

(45) *Zone area* {square feet.}: Area of a zone of the landscape. Also see *landscape area*.

(46) *Zone valve*: An area where the irrigation is controlled by a single control valve. Each zone valve must be within only one hydrozone. Also see *hydrozone*.