Gypsum Creek Golf Course

Irrigation Best Management Practices

The supplemental use of water for course play and non-play areas is essential to support healthy turfgrass and landscape plant health. It is also necessary for sustaining optimal course playability, aesthetics, marketability, and club membership participation.

The purpose of this document is to identify best management practices related to water use that conserve and protect water resources. It is important to keep in mind that, while new technology makes many tasks easier or less labor-intensive, the principles discussed in this section are important to understand and apply to protect water quality and quantity and surrounding natural resources.

Additionally, irrigation BMP may provide an economic, regulatory compliance, and environmental stewardship advantage to those who consider them part of their irrigation management plan. BMP are not intended to increase labor or place an undue burden on the owner/superintendent. If applied appropriately, BMP can help stabilize labor cost, extend equipment life, and limit repair and overall personal and public liability. The monetary investment in non-structural, BMP costs little to nothing to implement in a daily course water-use plan. Other advantages to using BMP include reduced administrative management stress, improved employee communication and direction, and effective facilities training procedures.

Several benefits of adopting BMP are:

Conserving the water supply

Protecting existing water quality

Maintaining optimal ball roll and playing conditions

Saving water and electricity

Increasing pump and equipment life longevity

Demonstrating responsible environmental stewardship

Retaining knowledgeable and effective employees

Conservation and Efficiency

Conservation and efficiency consider the strategic use of appropriate course and irrigation design, plant selection, computerized and data-integrated scheduling, and alternative water quality/supply options that maximize plant health benefits and reduce the potential for negative impacts on natural resources.

Resource Protection

Resource protection is an integrated approach that includes irrigation practices as part of the course design, pesticide and nutrient practices, and regulatory compliance measures and structural measures as they concern environmental stewardship and policy.

REGULATORY CONSIDERATIONS

PRINCIPLES

Golf course owners are responsible for contacting federal, state, and local water provider authorities at the pre-and post-construction phase to determine annual or specific water consumption (water rights), permitting guidelines, and other requirements.

Superintendents have a responsibility to adhere to water-quality standard rules regarding groundwater and surface water flows resulting from the removal of water for irrigation use.

Superintendents have a responsibility to maintain compliance with regulations pertaining to the use of alternate water supply sources.

► FACILITY BEST MANAGEMENT PRACTICES

Design and/or maintain a system to meet site's peak water requirements under normal conditions and be flexible enough to adapt to various water demands and local restrictions.

Develop an annual water budget for the golf course and drought contingency plan in areas subject to reoccurring water shortages.

Look for ways to increase efficiency and reduce energy use associated with irrigation systems and practices.

Demonstrate good stewardship practices by supplementing watering for the establishment of new planting and new sod, hand watering of critical hot spots, and watering-in of chemicals and fertilizers (if permissible).

Protect aquatic life and impairment of water systems by adhering to state and local water withdrawal allocations (gallons/day).

Design an irrigation system that delivers water with maximum efficiency.

WATER CONSERVATION AND EFFICIENT USE PLANNING

PRINCIPLES

Document actual watering practices, especially to show savings in water use over averages.

Communication should be maintained with water managers, golf course members, and the public to explain what you are doing and why.

Potable water supplies in many areas of the United States are limited, and demand continues to grow. Our challenge is to find solutions to maintain the quality of golf while using less water whether potable or nonpotable supplies are utilized.

BMP and educational programs are necessary to change the public's mind-set toward the inevitable changes in water-related issues.

Some courses are being designed using a "target golf" concept that minimizes the acreage of irrigated turf.

Existing golf courses can try to convert out-of-play areas of turf to naturally adapted native plants, grasses, or ground covers to reduce water use and augment the site's aesthetic appeal.

► FACILITY BEST MANAGEMENT PRACTICES

Selecting drought-tolerant varieties of turfgrasses can help maintain an attractive and high-quality playing surface, while minimizing water use.

Non-play areas may be planted with drought-resistant native or other well-adapted, noninvasive plants that provide an attractive and low-maintenance landscape.

Native plant species are important in providing wildlife with habitat and food sources. After establishment, site-appropriate plants normally require little to no irrigation.

The system should be operated to provide only the water that is actually needed by the plants, or to meet occasional special needs such as salt removal.

If properly designed, rain and runoff captured in water hazards and stormwater ponds may provide supplemental water under normal conditions, though backup sources may be needed during severe drought. Check with local and State water providers/authorities as to whether this is a legal use of stormwater.

In Colorado, most stormwater and runoff containments are not allowed to hold water; stormwater can be detained for 72 hours before leaving the site. It can be diverted to run across areas to infiltrate and remove contaminants. Containments typically have some structure that allows the overflow to flow through the structure and into a drainage.

During a drought, closely monitor soil moisture levels. Whenever practicable, irrigate at times when the least amount of evaporative loss will occur.

Control invasive plants or plants that use excessive water.

IRRIGATION SYSTEM DESIGN

PRINCIPLES

A well-designed irrigation system should operate at peak efficiency to reduce energy, labor and natural resources.

Irrigation systems should be properly designed and installed to improve water use efficiency.

An efficient irrigation system maximizes water use efficiency, reduces operational cost, conserves supply and protects water resources.

► FACILITY BEST MANAGEMENT PRACTICES

Design should account for optimal distribution efficiency and effective root-zone moisture coverage.

Target 80% or better Distribution Uniformity (DU).

Design should allow the putting surface and slopes and surrounding areas to be watered independently.

The design package should include a general irrigation schedule with recommendations and instructions on modifying the schedule for local climatic soil and growing conditions. It should include the base ET rate for the particular location.

The application rate must not exceed the infiltration rate, allowing soil to absorb and retain the water applied during any one application. Conduct saturated hydraulic conductivity tests periodically.

The design operating pressure must not be greater than the available source pressure.

The design operating pressure must account for peak-use times and supply line pressures at final buildout for the entire system.

The system should be flexible enough to meet a site's peak water requirements and allow for operating modifications to meet seasonal irrigation changes or local restrictions (e.g., days of the week rules and/or specific water budget).

Turf and landscape areas should be zoned separately. Specific use areas zoned separately; greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, etc.; consider the agronomic rate of the plant species to be watered. Applying water at agronomic rate is a requirement when using reclaimed water in Colorado.

Design should account for the need to leach out salt buildup from poor-quality water sources by providing access to freshwater.

Only qualified specialists should install the irrigation system.

Construction must be consistent with the design.

The designer must approve any design changes before construction.

Construction and materials must meet existing standards and criteria.

Prior to construction, all underground cables, pipes, and other obstacles must be identified and their locations flagged.

Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.

Space should be based on average wind conditions during irrigation.

For variable wind directions, triangular spacing is more uniform than square spacing.

Distribution devices and pipe sizes should be designed for optimal uniform coverage.

The first and last distribution device should have no more than a 10% difference in flow rate. This usually corresponds to about a 20% difference in pressure.

Distribution equipment (such as sprinklers, rotors, and micro-irrigation devices) in a given zone must have the same precipitation rate.

Heads for turf areas should be spaced for head-to-head coverage.

Water supply systems (for example, wells, and pipelines) should be designed for varying control devices, rain shutoff devices, and backflow prevention.

Water conveyance systems should be designed with thrust blocks and air-release valves.

Flow velocity must be 5 feet per second or less.

Pipelines should be designed to provide the system with the appropriate pressure required for maximum irrigation uniformity.

Pressure-regulating or compensating equipment must be used where the system pressure is less than the manufacturer's recommendations.

Equipment with check valves must be used in low areas to prevent low head drainage.

Isolation valves should be installed in a manner that allows critical areas to remain functional. In conjunction with isolation valves, pipeline drains need to be strategically located on the mainline routing

of the pipe network to allow for as complete a draining of the system as possible, especially in climates where the irrigation systems are winterized. Properly located drains will reduce the time and expense required to complete repairs and "blow-out" of the system.

Manual quick-coupler valves should be installed near greens, tees, and bunkers so these can be hand-watered during severe droughts; quick coupler valves may not be allowed for non-potable water systems. Follow regulations which may require implementing public protection measures including locking hose bibs and segregating equipment.

Install part-circle heads along lakes, ponds, and wetlands margins.

Use part-circle or adjustable heads to avoid overspray of impervious areas such as roadways and sidewalks.

Update multi-row sprinklers with single head control to conserve water and to enhance efficiency.

Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/distribution.

Ensure heads are set at level ground and not on slopes. Maintain 2 degrees of levelness to ensure maximum distribution uniformity.

IRRIGATION PUMPING SYSTEM

PRINCIPLES

Pump stations should be sized to provide adequate flow and pressure. They should be equipped with control systems that protect distribution piping, provide for emergency shutdown necessitated by line breaks, and allow maximum system scheduling flexibility.

Variable frequency drive (VFD) pumping systems should be considered if dramatically variable flow rates are required, if electrical transients (such spikes and surges) are infrequent, and if the superintendent has access to qualified technical support.

Design pumping systems for energy conservation.

► FACILITY BEST MANAGEMENT PRACTICES

The design operating pressure must not be greater than the available source pressure.

The design operating pressure must account for peak-use times and supply-line pressures at final buildout for the entire system.

Maintain the air-relief and vacuum-breaker valves by using hydraulic-pressure-sustaining values. Install VFD systems to lengthen the life of older pipes and fittings until the golf course can afford a new irrigation system.

An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.

Pumps should be sized to provide adequate flow and pressure.

Pumps should be equipped with control systems to protect distribution piping.

System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.

Monitor pumping station power consumption. Enlist help of an irrigation designer to perform a pump station energy audit to reveal ways to increase efficiency and performance and reduce expenses.

Monthly bills should be monitored over time to detect a possible increase in power usage.

Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system.

Quarterly checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus potential problems

IRRIGATION SYSTEM PROGRAM AND SCHEDULING

PRINCIPLES

Irrigation scheduling must take plant water requirements and soil intake capacity into account to prevent excess water use that could lead to leaching and runoff.

Plant water needs are determined by evapotranspiration (ET) rates, recent rainfall, turfgrass types, recent temperature extremes and soil moisture.

Irrigation should not occur on a calendar-based schedule but should be based on ET rates and soil moisture replacement.

An irrigation system should be operated based only on the moisture needs of the turfgrass, or to water-in a fertilizer or chemical application as directed by the label.

Responsible irrigation management conserves water and reduces nutrient and pesticide movement.

Time-clock-controlled irrigation systems preceded computer-controlled systems, and many are still in use today. Electric/mechanical time clocks cannot automatically adjust for changing ET rates. Frequent adjustment is necessary to compensate for the needs of individual turfgrass areas.

► FACILITY BEST MANAGEMENT PRACTICES

An irrigation system should have rain sensors to shut off the system after 0.25 to 0.5 inches of rain is received. Computerized systems allow a superintendent to call in and cancel the program if it is determined that the course has received adequate rainfall.

Install control devices to allow for maximum system scheduling flexibility.

Generally, granular fertilizer applications should receive enough irrigation to move the particles off the leaves while minimizing runoff. This amount should be determined by the superintendent based on soils, topography, weather, micro-climates, turf type.

Irrigation quantities should not exceed the available moisture storage in the root zone.

Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied at any one time.

Irrigation schedule should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).

Account for nutrients in water supply when making fertilizer calculations.

Irrigation should occur in the early morning hours before air temperatures rise and relative humidity drops.

Base plant water needs should be determined by ET rates, recent rainfall, recent temperature extremes, and soil moisture.

Use mowing, verticutting, aeration, nutrition management, and other cultural practices to control water loss and to encourage conservation and efficiency.

Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.

Visually monitor for wet/swampy spots to indicate system problems; a requirement for reclaimed water in Colorado.

Use predictive models to estimate soil moisture and the best time to irrigate.

Avoid use of a global setting; make adjustments to watering times per head.

Base water times on actual site conditions for each head and zone.

Adjust irrigation run times based on current local meteorological data.

Use computed daily ET rate to adjust run times to meet the turf's moisture needs.

Manually adjust automated ET data to reflect wet and dry areas on the course.

Use soil moisture sensors to assist in scheduling or to create on-demand irrigation schedules.

Use multiple soil moisture sensors to reflect soil moisture levels.

Periodically perform catch-can uniformity tests.

Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.

Install emergency shutdown devices to address line breaks.

TURF DROUGHT RESPONSE

PRINCIPLES

The presence of visual symptoms of moisture stress is a simple way to determine when irrigation is needed.

Use a soil moisture meter to determine moisture needs of greens and tees.

Managers of golf greens cannot afford to wait until symptoms occur, because unacceptable turf quality may result.

Be prepared for extended drought/restrictions by developing a written drought management plan.

► FACILITY BEST MANAGEMENT PRACTICES

Waiting until visual symptoms appear before irrigating is a method best used for low-maintenance areas, such as golf course roughs and, possibly, fairways.

Use soil moisture meters to determine moisture thresholds and plant needs.

Irrigating too shallowly encourages shallow rooting, increases soil compaction, and favors pest outbreaks.

For golf greens and tees, the majority of roots are in the top several inches of soil.

For fairways and roughs, use infrequent, deep irrigation to supply sufficient water for plants and to encourage deep rooting.

Proper cultural practices such as mowing height, irrigation frequency, and irrigation amounts should be employed to promote healthy, deep root development and reduce irrigation requirements.

Create a drought management plan for the facility that identifies steps to be taken to reduce irrigation/water use and protects critical areas, etc.

Use appropriate turfgrass species adapted to the location of the golf course being managed.

IRRIGATION SYSTEM QUALITY

PRINCIPLES

Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance (PM), corrective maintenance, and record keeping.

Personnel charged with maintaining any golf course irrigation system face numerous challenges. This is particularly true for courses with older or outdated equipment.

Good system management starts with good preventive maintenance (PM) procedures and recordkeeping.

Maintaining a system is more than just fixing heads.

Corrective maintenance is simply the act of fixing what is broken. It may be as simple as cleaning a clogged orifice, or as complex as a complete renovation of the irrigation system.

As maintenance costs increase, the question of whether to renovate arises. Renovating a golf course irrigation system can improve system efficiencies, conserve water, improve playability, and lower operating costs.

► FACILITY BEST MANAGEMENT PRACTICES

Respond to day-to-day failures in a timely manner, maintain the integrity of the system as designed, and keep good records.

System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.

The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made.

Systems need to be observed in operation at least weekly. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, scheduling during off peak times, or the heads can be brought on-line for a few seconds and observed for proper operation.

This process detects controller or communications failures, stuck or misaligned heads, and clogged or broken nozzles.

Check filter operations frequently. An unusual increase in the amount of debris may indicate problems with the water source.

Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.

Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.

Application/distribution efficiencies should be checked annually. Implement a PM program to replace worn components before wear results in wasted fertilizer, chemicals, and/or water.

Conduct a periodic professional irrigation audit at least once every five years.

Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.

Periodically analyze PM program documentation along with corrective maintenance records to identify equipment wear trends; correctly identifying problems and their costs helps to determine what renovations are appropriate.

Replace nozzles every 10 - 15 years depending on wear; determined by catch can testing results.

Collecting information on the cost of maintaining the system as part of system overall evaluation, allows for planning necessary upgrades, replacement etc. and to compare after changes are made.

METERING

PRINCIPLES

Rainfall may vary from location to location on a course; the proper use of rain gauges, rain shut-off devices, flow meters, soil moisture sensors, and/or other irrigation management devices should be incorporated into the site's irrigation schedule.

It is also important to measure the amount of water that is actually delivered through the irrigation system, via a water meter or a calibrated flow-measurement device.

Knowing the flow or volume will help determine how well the irrigation system and irrigation schedule are working.

► FACILITY BEST MANAGEMENT PRACTICES

Calibrate equipment periodically to compensate for wear in pumps, nozzles, and metering systems.

Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.

Flow meters should have a run of pipe that is straight enough — both downstream and upstream — to prevent turbulence and bad readings.

Flow meters can be used to determine how much water is applied.

If possible, submeter each irrigation zone via submeter or through flow rate to ensure that zones are working properly.

IRRIGATION LEAK DETECTION

PRINCIPLES

Irrigation systems are complex systems that should be closely monitored to ensure leaks are quickly detected and corrected.

Golf courses without hydraulic pressure-sustaining valves are much more prone to irrigation pipe and fitting breaks because of surges in the system, creating more downtime for older systems. A good preventive maintenance program is very important.

► FACILITY BEST MANAGEMENT PRACTICES

Monitor water meters or other measuring devices for unusually high or low readings to detect possible leaks or other problems in the system. Make any needed repairs.

An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.

The system should be monitored daily for malfunctions and breaks. It is also a good practice to log the amount of water pumped each day.

Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, determine why these failures are occurring. Pipe failures may be caused not only by material failure, but also by problems with the pump station.

Ensure that control systems provide for emergency shutdowns caused by line breaks, and allow maximum system scheduling flexibility.

SPRINKLER MAINTENANCE

PRINCIPLES

Good system management starts with good PM procedures and record keeping. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation.

Maintaining a system is more than just fixing heads. It also includes documenting system- and maintenance related details so that potential problems can be addressed before expensive repairs are needed. It also provides a basis for evaluating renovation or replacement options.

Be proactive; if the system requires frequent repairs, it is necessary to determine why these failures occur.

Pipe failures may be caused not only by material failure, but also by problems with the pump station.

Wiring problems could be caused by corrosion, rodent damage, or frequent lightning or power surges.

Control tubing problems could result from poor filtration.

► FACILITY BEST MANAGEMENT PRACTICES

System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.

The system should be inspected routinely for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads.

A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made or appurtenances replaced.

Flush irrigation lines regularly to minimize emitter clogging. To reduce sediment buildup, make flushing part of a regular maintenance schedule. If fertigating, prevent microbial growth by flushing all fertilizer from the lateral lines before shutting down the irrigation system.

Clean and maintain filtration equipment.

Systems must be observed in operation at least weekly. This process detects controller or communication failures, stuck or misaligned heads, and clogged or broken nozzles.

Check filter operations frequently. An unusual increase in the amount of debris may indicate problems with the water source.

Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.

Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.

Application/distribution efficiencies should be checked annually. Conduct a periodic professional irrigation audit at least once every five years. Implement a PM program to replace worn components before they waste fertilizer, chemicals, and water.

Document equipment run-time hours.

Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.

Monitor pump station power consumption. Monthly bills should be monitored over time to detect a possible increase in power usage. Compare the power used with the amount of water pumped.

Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system. Quarterly checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus potential problems.

Monitor and record the amount of water being applied, including system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance. Not only is this information essential in identifying places that would benefit from a renovation, but it is also needed to compute current operating costs and compare possible future costs after a renovation.

Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings).

SYSTEM MAINTENANCE

PRINCIPLES

Course owners/superintendents do routine maintenance to ensure water quality and responsible use of the water supply.

System checks and routine maintenance include: pumps, valves, programs, fittings, and sprinklers.

To ensure optimal performance, an irrigation system should be calibrated regularly by conducting periodic irrigation audits to check actual water delivery and nozzle efficiency.

► FACILITY BEST MANAGEMENT PRACTICES

Irrigation audits should be performed by trained technicians.

A visual inspection should first be conducted to identify necessary repairs or corrective actions. It is essential to make repairs before carrying out other levels of evaluation.

Pressure and flow should be evaluated to determine that the correct nozzles are being used and that the heads are performing according to the manufacturer's specifications.

Pressure and flow rates should be checked at each head to determine the average application rate in an area.

Catch-can tests should be run to determine the uniformity of coverage and to accurately determine irrigation run times.

Catch-can testing should be conducted taking representative samples of several different areas of the golf course, to include greens, tees, fairway/rough to ensure that the system is operating at its highest efficiency.

Conduct an irrigation audit annually to facilitate a high-quality maintenance and scheduling program for the irrigation system.

Inspect for interference with water distribution.

Inspect for broken and misaligned heads.

Check that the rain sensor is present and functioning.

Inspect the backflow prevention device to determine that it is in place and in good repair. Have a certified technician inspect the device at least annually.

Examine turf quality and plant health for indications of irrigation malfunction or needs for scheduling adjustments.

Schedule documentation: make adjustments and repairs on items diagnosed during the visual inspection before conducting pressure and flow procedures.

Preventive Maintenance

In older systems, inspect irrigation pipe and look for fitting breaks caused by surges in the system. Install thrust blocks/joint restraints to support conveyances.

The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots so that adjustments can be made.

Maintain air-relief and vacuum-breaker valves.

Systems need to be observed in operation at least weekly to detect controller or communication failures, stuck or misaligned heads, and clogged or broken nozzles.

Check filter operations frequently; keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.

Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.

Application/distribution efficiencies should be checked annually.

Conduct a periodic professional irrigation audit at least once every five years.

Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.

Monitor the power consumption of pump stations for problems with the pump motors, control valves, or distribution system.

Qualified pump personnel should perform quarterly checks of amperage to accurately identify increased power usage that indicates potential problems.

Monitor and record the amount of water being applied, including system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance.

Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, it is necessary to determine why these failures are occurring.

Increase frequency of routine inspection/calibration of soil moisture sensors that may be operating in high-salinity soils.

Winterize irrigation system to prevent damage.

Corrective Maintenance

Replace or repair all broken or worn components before the next scheduled irrigation.

Replacement parts should have the same characteristics as the original components. When utilizing non-potable water all replacement parts should be appropriately marked/color coded as non-potable water.

Record keeping is an essential practice; document all corrective actions.

WINTERIZATION AND SPRING

PRINCIPLES

Winterization of the irrigation system is important to protect the system and reduce equipment failures resulting from freezing.

► FACILITY BEST MANAGEMENT PRACTICES

Ensure proper irrigation system drainage design.

Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing.

Conduct a catch-can test to audit the system.

Flush and drain above-ground irrigation system components that could hold water.

Remove water from all conveyances and supply and distribution devices that may freeze with compressed air or open drain plugs at the lowest point on the system.

Clean filters, screens, and housing; remove drain plug and empty water out of the system.

Secure systems and close and lock covers/compartment doors to protect the system from potential acts of vandalism and from animals seeking refuge.

Remove drain plug and drain above-ground pump casings.

Record metering data before closing the system.

Secure or lock irrigation components and electrical boxes.

Perform pump and engine servicing/repair before winterizing.

Recharge irrigation in the spring with water and inspect to see if any corrective measures need to be taken.

SENSOR TECHNOLOGY

PRINCIPLES

To prevent excess water use, irrigation scheduling should account for plant water requirements, recent rainfall, recent temperature extremes, and soil characteristics.

Irrigation management and control devices need to be installed correctly for proper irrigation management.

Soil moisture sensors and other irrigation management tools should be installed in representative locations and maintained to provide the information necessary for making good irrigation management decisions.

Rain gauges are necessary measurement tools to track how much rain has fallen at a specific site on the golf course. On some courses, more than one station may be necessary to get a complete measure of rainfall or evaporation loss. The use of soil moisture probes, tensiometers, computer models, and inspections for visual symptoms, such as wilting turf, may provide helpful supplemental measurements.

Computerized displays are available to help visualize the system.

It is best to have an on-site weather station to access weather information daily and ET to determine site specific water needs.

Weather data such as rainfall, air and soil temperature, relative humidity, and wind speed are incorporated into certain model formulas, and soil moisture content is estimated. Models, however, are only as effective as the amount of data collected and the number of assumptions made.

Predictive models based on weather station data and soil types are also available. These are relatively accurate and applicable, especially as long-term predictors of annual turf water requirements.

► FACILITY BEST MANAGEMENT PRACTICES

Irrigation controllers/timers should be reset as often as practically possible to account for plant growth requirements and local climatic conditions.

Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.

Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied in any one application.

Irrigation should be based on ET rates and soil moisture replacement, not on a calendar-based schedule.

Computerized control systems should be installed on all new course irrigation systems to help ensure efficient irrigation application. These allow for timing adjustments at every head.

Rain shut-off devices and rain gauges should be placed in open areas to prevent erroneous readings.

Use multiple soil moisture sensors/meters for accuracy and to reflect soil moisture levels.

MAINTAINED TURF AREAS

PRINCIPLES

Courses should use well-designed irrigation systems with precision scheduling based on soil infiltration rates, soil water-holding capacity, plant water-use requirements, the depth of the root zone, and the desired level of turfgrass appearance and performance in order to maximize efficient watering.

► FACILITY BEST MANAGEMENT PRACTICES

The irrigation system should be designed and installed so that the putting surface, slopes, and surrounding areas can be watered independently.

Account for nutrients in water supply when making fertilizer calculations.

Install part-circle heads that conserve water and reduce unnecessary stress to greens and surrounds.

Adjust water times per head.

Base water times on actual site conditions for each head and zone.

Adjust irrigation run times based on current local meteorological data.

Use computed daily ET rate to adjust run times to meet the turf’s moisture needs.

Manually adjust irrigation output to reflect wet and dry areas on the course.

Install rain switches to shut down the irrigation system if enough rain falls in a zone; an irrigation system should have rain sensors to shut off the system after 0.25 to 0.5 inch of rain is received.

Use soil moisture sensors to bypass preset or to create on-demand irrigation schedules.

Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.

Spacing should be based on average wind conditions during irrigation.

Triangular spacing is more uniform than square spacing.

Periodically perform catch-can uniformity tests.

Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.

Irrigation should occur in the early morning hours before air temperatures rise, and relative humidity drops.

Base plant water needs on evapotranspiration rates, recent rainfall, recent temperature extremes and soil moisture.

Use mowing, verticutting, aeration, wetting agents, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.

Depending on physical soil characteristics and turf type, using solid-tine or core aeration equipment in place of verticutting is an option.

Slicing and spiking help relieve surface compaction and promote better water penetration and aeration.

Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.

Use predictive models to estimate soil moisture and the best time to irrigate.

Install in-ground (wireless) soil moisture sensors or use hand-held moisture meters in the root zone for each irrigation zone to enhance scheduled timer-based run times.

An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.

Place soil moisture sensors in a representative location of the irrigation zone.

Wireless soil moisture systems should be installed to prevent damage from aeration.

NON-PLAY AND LANDSCAPE AREAS

PRINCIPLES

Map any environmentally sensitive areas such as sinkholes, wetlands, or flood-prone areas, and identify species classified as endangered or threatened by federal and state governments, and state species of special concern.

Natural vegetation should be retained and enhanced for non-play areas to conserve water.

The most efficient and effective watering method for non-turf landscape is micro-irrigation.

Older golf courses may have more irrigated and maintained acres than are necessary. With the help of a golf course architect, golf professional, golf course superintendent, and other key personnel, the amount of functional turfgrass can be evaluated and transitioned into non-play areas.

► FACILITY BEST MANAGEMENT PRACTICES

Designate 50% to 70% of the non-play area to remain in natural cover according to "right-plant, rightplace," a principle of plant selection that favors limited supplemental irrigation and on-site cultural practices.

Incorporate natural vegetation in non-play areas.

Use micro-irrigation and low-pressure emitters in non-play areas to supplement irrigation.

Routinely inspect non-play irrigation systems for problems related to emitter clogging, filter defects, and overall system functionality.