Rocky Mountain Golf Course Superintendents Association

COLORADO GOLF INDUSTRY BEST MANAGEMENT PRACTICES GUIDE

INTRODUCTION

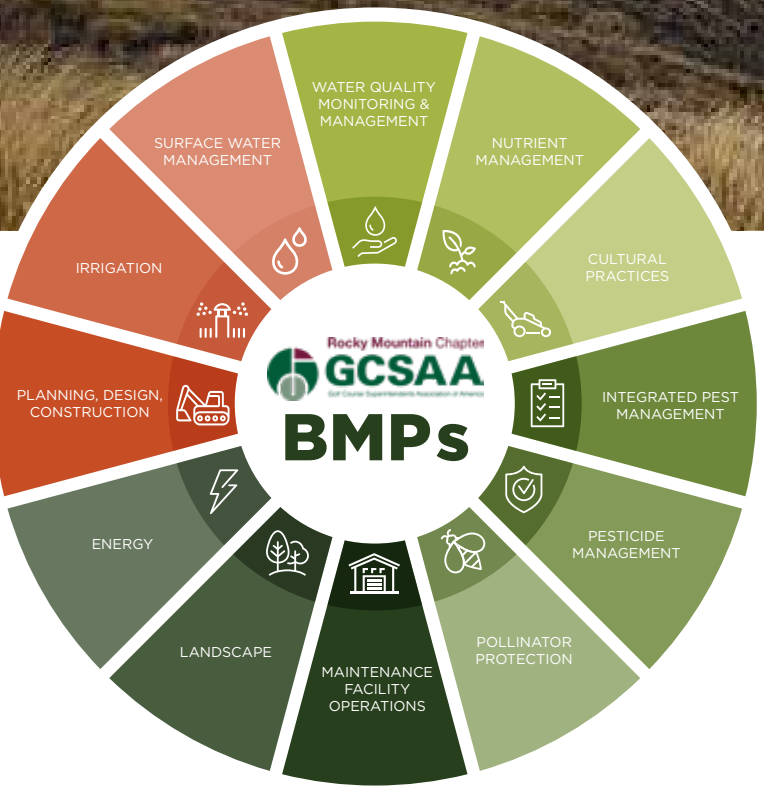
The Colorado golf industry spans four distinct ecosystems from the sand hills and agriculture of the eastern plains, the metropolitan corridor of the Front Range, the majestic expanse of the Rocky Mountains and the orchards and vineyards of the western slope.

The Rocky Mountain Golf Course Superintendents Association and related organizations in Colorado have collaborated to develop and publish the "Colorado Golf Industry Best Management Practices Guide". The Colorado BMPs were developed in part by using the BMP Planning Guide and Template created by the Golf Course Superintendents Association of America (GCSAA) and funded and supported by the United States Golf Association. RMGCSA applied for and received a $10,000 grant from GCSAA funded through the association's Environmental Institute for Golf (EIFG) in part by the PGA Tour.

GCSAA is the professional association for the men and women who manage and maintain the game's most valuable resource — the golf course. Today, GCSAA and its members are recognized by the golf industry as one of the key contributors in elevating the game and business to its current state. Since 1926, GCSAA has been the top professional association for the men and women who manage golf courses in the United States and worldwide. The association provides education, information and representation to more than 17,000 members in more than 72 countries. GCSAA's mission is to serve its members, advance their profession and enhance the enjoyment, growth and vitality of the game of golf.

Golf course superintendents are excellent resource and environmental managers. The diversity of the microclimates throughout the state assures that no two golf courses are alike, nor will they have the same financial resources or manpower. Recognizing these facts, the Colorado BMPs were developed to provide a broad scope of applicable practices to allow each golf course to tailor the use of the BMP document that best fits their operation. Carefully adopted and implemented BMPs can potentially improve long-term environmental sustainability.

The Colorado BMPs are tailored with input from golf course superintendents from biologically diverse areas to provide a common sense approach and general guidelines to assist in development of sustainable resource management practices.



The Colorado BMP document includes information on planning, designing and construction; irrigation; surface-water management; water-quality monitoring and management; nutrient management; cultural practices; integrated pest management; pesticide management; pollinator protection; maintenance operations; landscape; and energy. A particular focus was placed on water management, water conservation and irrigation system design and maintenance. Colorado superintendents are aware of the perception of the golf industry as a large water user and realize that the industry needs to be part of the solution for mandated conservation goals.

The Colorado BMP Committee consisted of 22 members of the Rocky Mountain GCSA and Chapter Executive Director Gary Leeper. Other groups involved in the creation of the BMPs included regulatory authorities and leaders in natural resource management and environmental stewardship. These collective efforts will improve on environmental achievements through the implementation of the Colorado Golf Industry Best Management Practices Guide.

To see the Colorado BMPs and learn more about GCSAA's BMP program, visit www.gcsaa.org/bmp.

COLORADO

COLORADO SUSTAINABILITY PLANNING

Sustainability is integrated throughout our BMPs in order to guide golf courses in balancing performance and economic impact with environmental stewardship and community. Cities, regions, and communities have adopted various levels of sustainability planning; courses are encouraged to collaborate within their communities to make a positive impact today and in the future.

SUSTAINABLE DEVELOPMENT GOALS

SDG INTEGRATION

The Sustainable Development Goals (SDGs) or Global Goals are a universal call to action to end poverty, protect the planet, and promote peace and prosperity. Global goals have been integrated within states, cities, and leading organizations worldwide. The goals are highlighted by section throughout our handbook to show how proper use of BMPs can drive local and global impacts.

For additional information, visit: https://www.un.org/sustainabledevelopment/

ACKNOWLEDGEMENTS

Golf Course Superintendents Association of America

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Since 1926, GCSAA has been the top professional association for the men and women who manage golf courses in the United States and worldwide. From its headquarters in Lawrence, Kansas, the association provides education, information and representation to more than 17,000 members in more than 72 countries. GCSAA's mission is to serve its members, advance their profession and enhance the enjoyment, growth and vitality of the game of golf.

Environmental Institute for Golf

The Environmental Institute for Golf (EIFG) fosters sustainability by providing funding for research grants, education programs, scholarships and awareness of golf's environmental efforts. Founded in 1955 as the GCSAA Scholarship & Research Fund for the Golf Course Superintendents Association of America, the EIFG serves as the association's philanthropic organization. The EIFG relies on the support of many individuals and organizations to fund programs to advance stewardship on golf courses in the areas of research, scholarships, education, and advocacy. The results from these activities, conducted by GCSAA, are used to position golf courses as properly managed landscapes that contribute to the greater good of their communities. Supporters of the EIFG know they are fostering programs and initiatives that will benefit the game and its environment for years to come.

United States Golf Association

The United States Golf Association (USGA) provides governance for the game of golf, conducts the U.S. Open, U.S. Women's Open and U.S. Senior Open as well as 10 national amateur championships, two state team championships and international matches, and celebrates the history of the game of golf. The USGA establishes equipment standards, administers the Rules of Golf and Rules of Amateur Status, maintains the USGA Handicap System and Course Rating System, and is one of the world's foremost authorities on research, development and support of sustainable golf course management practices.

SPECIAL ACKNOWLEDGEMENTS

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The RMGCSA would like to thank the State of Colorado BMP Contributors including superintendents and stakeholders. Thank you to superintendents across the state who provided photo contributions.

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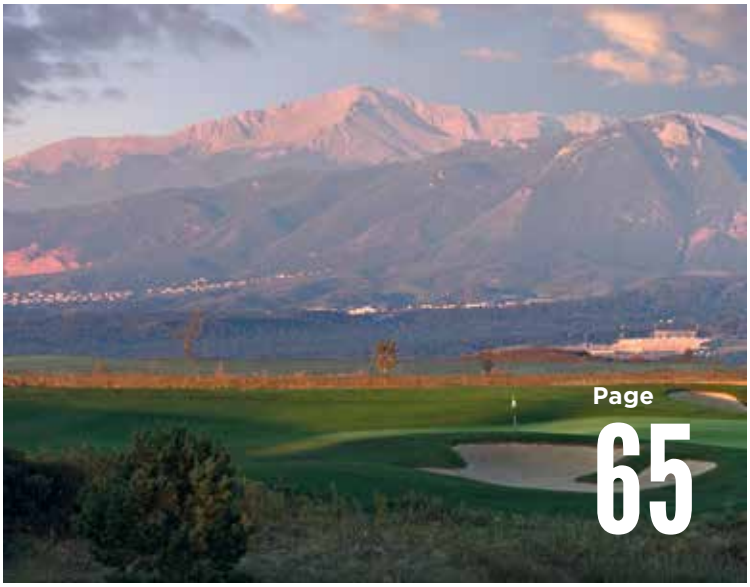
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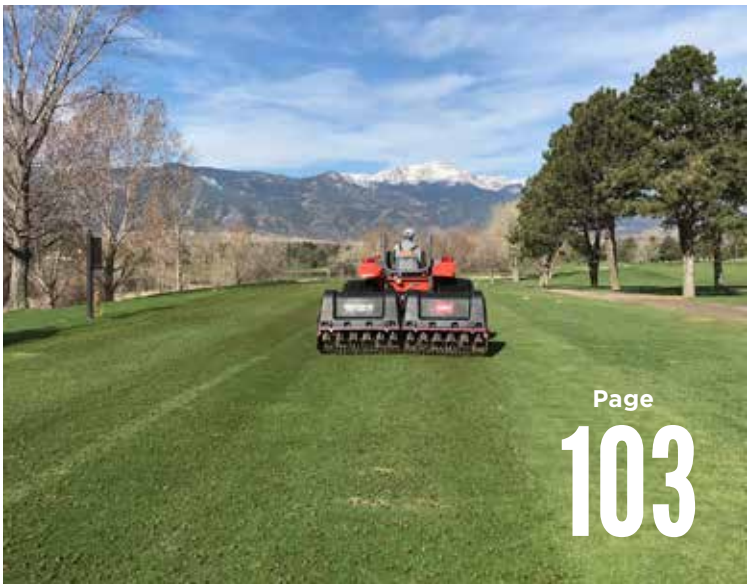
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BMP INDEX

PLANNING, DESIGN AND CONSTRUCTION

REGULATORY ISSUES

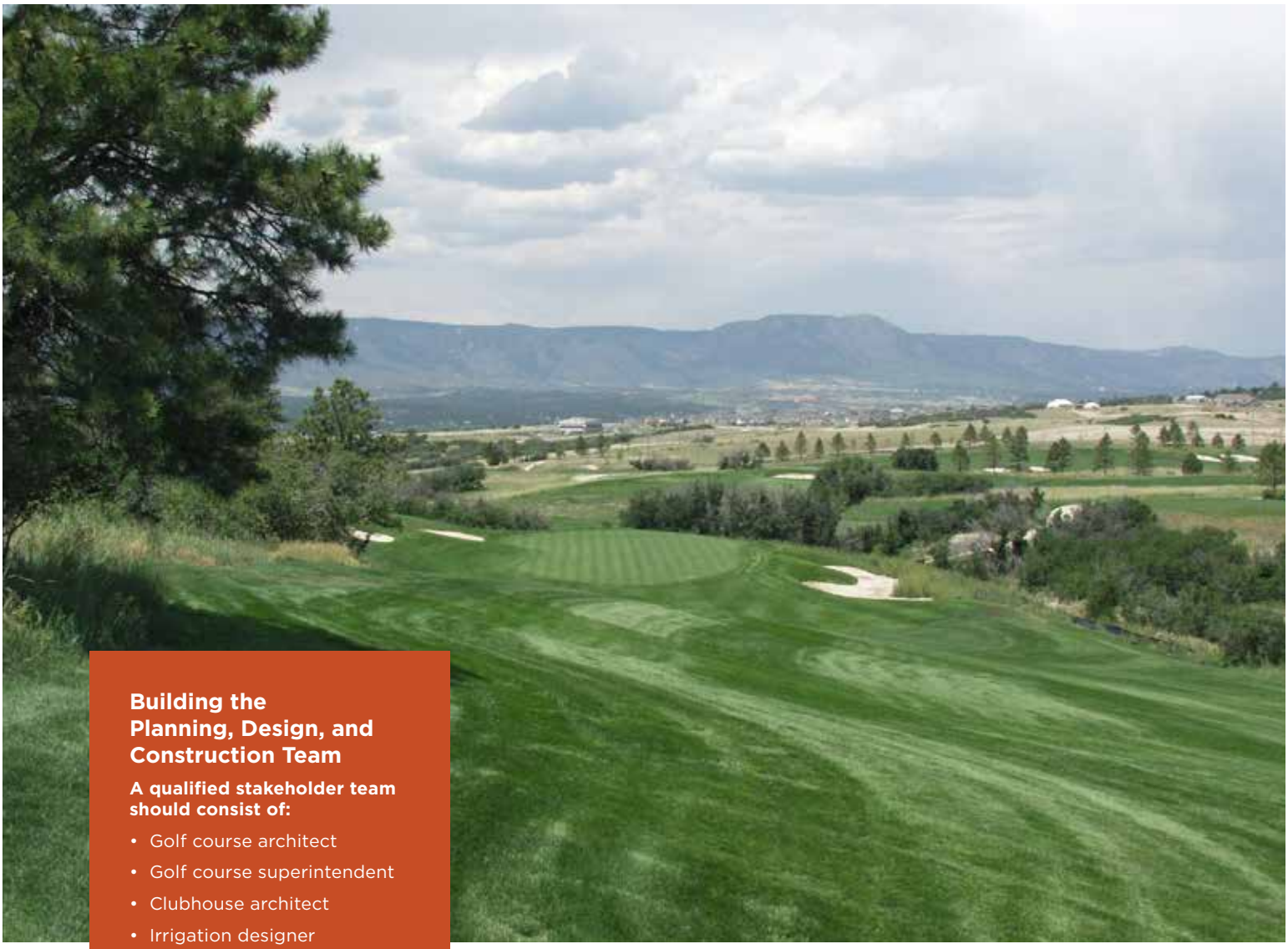
The construction phase of any industry's infrastructure poses the greatest risk of ecosystem alteration. In some cases the golf facility can be designed to improve overall wildlife habitat. In addition, facilities should be designed and constructed to maximize energy efficiency.

Local and state regulations may be in place in your location. Early engagement among developers, designers, local community groups, and permitting agencies minimizes delays in project completion and is essential to designing and constructing a golf facility that minimizes environmental impact and meets the approval process.

> **With proper planning and design, golf facilities can be constructed and maintained with minimal impact to existing wildlife and their habitat.**

Principles

Proper planning will minimize expenses resulting from unforeseen construction requirements. Good planning provides opportunities to maximize/integrate environmentally favorable characteristics into the property. This often requires the involvement of golf course architects, golf course superintendents, civil engineers, soil scientists, agronomists, irrigation designers, ecologists, city agencies, etc.



Building the Planning, Design, and Construction Team

A qualified stakeholder team should consist of:

- Golf course architect
- Golf course superintendent
- Clubhouse architect
- Irrigation designer
- Environmental engineer
- Energy analyst
- Economic consultant
- Civil engineer
- Soil scientist
- Geologist
- Golf course builder
- Legal team

Best Management Practices

- Assemble a qualified team
- Determine objectives
- Complete a feasibility study
  - Are needs feasible given existing resources?
  - Financial
  - Environmental
  - Water
  - Energy
  - Labor
  - Materials
  - Governmental regulatory requirements/restrictions
- Select an appropriate site that is capable of achieving the needs of stakeholders.
- Identify strengths and weakness of the selected site.
- Identify any rare, protected, endangered, or threatened plant or animal species on the site.

DESIGN

Principles

Proper design will meet the needs of the developer, protect the location's environmental resources, and be economically sustainable.

Best Management Practices

- Retain a qualified golf course superintendent/project manager at the beginning of the design and construction process to integrate sustainable maintenance practices in the development, maintenance, and operation of the course.
- Design the course to minimize the need to alter or remove existing drainage-ways and native landscapes. The routing should identify the areas that provide opportunities for restoration.
- Design the course to retain as much natural vegetation as possible. Where appropriate, consider enhancing existing vegetation through the supplemental planting of native vegetation/materials (requiring minimal water) next to long fairways, out-of-play areas, and along water sources supporting fish and other water-dependent species.
- Design out-of-play areas to retain or restore existing native vegetation where possible. Nuisance, invasive, and exotic plants should be removed and replaced with native species that are adapted to that particular site.
- Ensure adequate light for greens, appropriate size, root zone material, and turf.
- Plant only certified turfgrass.
- Decide whether bunkers and/or tees and fairways will contain drainage.
- Consider bunker entry and exit points. Consider wear patterns and create adequate space for ingress/egress points on greens, tees, fairways, and bunkers.
- Select the proper color, size, and shape of bunker sand that meets your needs.
- Define play and non-play maintenance boundaries.
- Have engineering, architect, construction team and golf course superintendent focus a significant amount of time on properly sizing drainage on and around the golf course property.
- When planning golf cart paths or other areas with potentially high vehicle traffic, try to predict the effect the trail's layout could have on vegetation (e.g., running over vegetation due to sharp turns) or the layout of the irrigation system.

Greens! Getting it Right

Numerous factors go into BMPs for constructing greens:

- Select a location that has adequate sunlight to meet plant specific needs and provides sufficient drainage.
- Choose a green size and sufficient number of hole locations that is large enough to accommodate traffic and play damage, but not so large that it is not sustainable with resources.
- Select an appropriate root-zone material as designated by the USGA.
- Consider the number of bunkers as it relates to resources available for daily maintenance.
- Greens should be irrigated separately from surrounding turf.
- Select a turf species/variety that meets the needs of the developer while adhering to the principle of "right plant, right place."

CONSTRUCTION

Principles

Construction should be completed with care to minimize environmental impact and financial ramifications caused by poor construction techniques.

Best Management Practices

- Conduct a pre-construction conference with stakeholders.
- Construction should be scheduled to maximize turfgrass establishment and site drainage.
- Use environmentally sound construction techniques.
- Use soil stabilization techniques to minimize soil erosion and maximize sediment containment.
- Maintain a construction progress report and communicate the report to the proper permitting agencies.
- Use only qualified contractors who are experienced in the special requirements of golf course construction.
- Schedule construction and turf establishment to allow for the most efficient progress of the work, while optimizing environmental conservation and resource management.
- Temporary construction compounds should be built in a way that minimizes environmental impacts.

GROW-IN

Principles

Turfgrass establishment is a unique phase in turfgrass growth, which can require greater quantities of water and nutrients than established turfgrasses. To this end, the establishment phase should be considered carefully to minimize environmental risk.

Best Management Practices

- The area to be established should be properly prepared and cleared of pests (weeds, pathogens, etc.).
- Ensure erosion and sediment control devices are in place and properly maintained.
- Light and frequent irrigation for seeded sites during daytime
- Sod should be topdressed to fill in the gaps between sod pieces. This hastens establishment and provides a smoother surface.
- Use appropriate seeding methods for your conditions. When using sod, nutrient applications should be delayed until sod has sufficiently rooted.
- Slow-release nitrogen or light, frequent soluble-nitrogen sources should be used during grow-in.
- If available, the use of a fertigation system will allow for small amounts of soluble fertilizer to be put down during irrigation cycles thus reducing the need to have equipment on the turf until it matures; use of recycled water potentially having higher nitrogen values than other water sources may negate the need for fertigation systems.
- Allow sufficient time for establishment of new seed so as not to encourage the over application of nitrogen fertility to shorten the grow-in period.

- Nutrients should be applied — in either foliar or granular formulations — to the turf surface. Incorporating nutrients into the root zone does not result in more rapid establishment and increases environmental risk.
- Mow as soon as the sod has knitted-down, and seedlings have reached a height of one-third greater than intended height-of-cut. This will hasten establishment.
- Consider use of hydromulch after seeding to help speed up germination time and alleviate erosion of seed bed.

EROSION & SEDIMENT CONTROL

Principles

- Soil carried by wind and water erosion transports contaminants with it. Contaminants can dislodge, especially on entering water bodies, where they can cause pollution.
- Erosion and sediment control is a critical component of construction and grow-in of a golf course .

Best Management Practices

- Develop a working knowledge of erosion and sediment control management. Each state has its own specifications including types of acceptable structures, materials, and design features.
- Develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species, and designed environmental resource areas.
- Hydro-seeding or hydro-mulching offer soil stabilization.

WETLANDS

Principles

- Most states consider wetlands as “waters of the state and/or U.S.,” a designation that carries significant legal ramifications. Furthermore, permitting requirements for wetlands can have multiple overlapping jurisdictions of federal, state, and local agencies. At the federal level alone, the U.S. Army Corps of Engineers (USACOE), EPA, U.S Fish and Wildlife Service (FWS), National Oceanic and Atmospheric Administration (NOAA), and maritime agencies may all be involved.
- Wetlands act both as filters for pollutant removal and as nurseries for many species of birds, insects, fish, and other aquatic organisms. The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland is the recycling factory of our ecosystem.
- When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers. Constructed or disturbed wetlands may need to be permitted to be an integral part of the stormwater management system.

Best Management Practices

- Ensure that proper permitting has been obtained before working on any wetlands.
- Ensure that wetlands have been properly delineated before working in and around any wetlands.

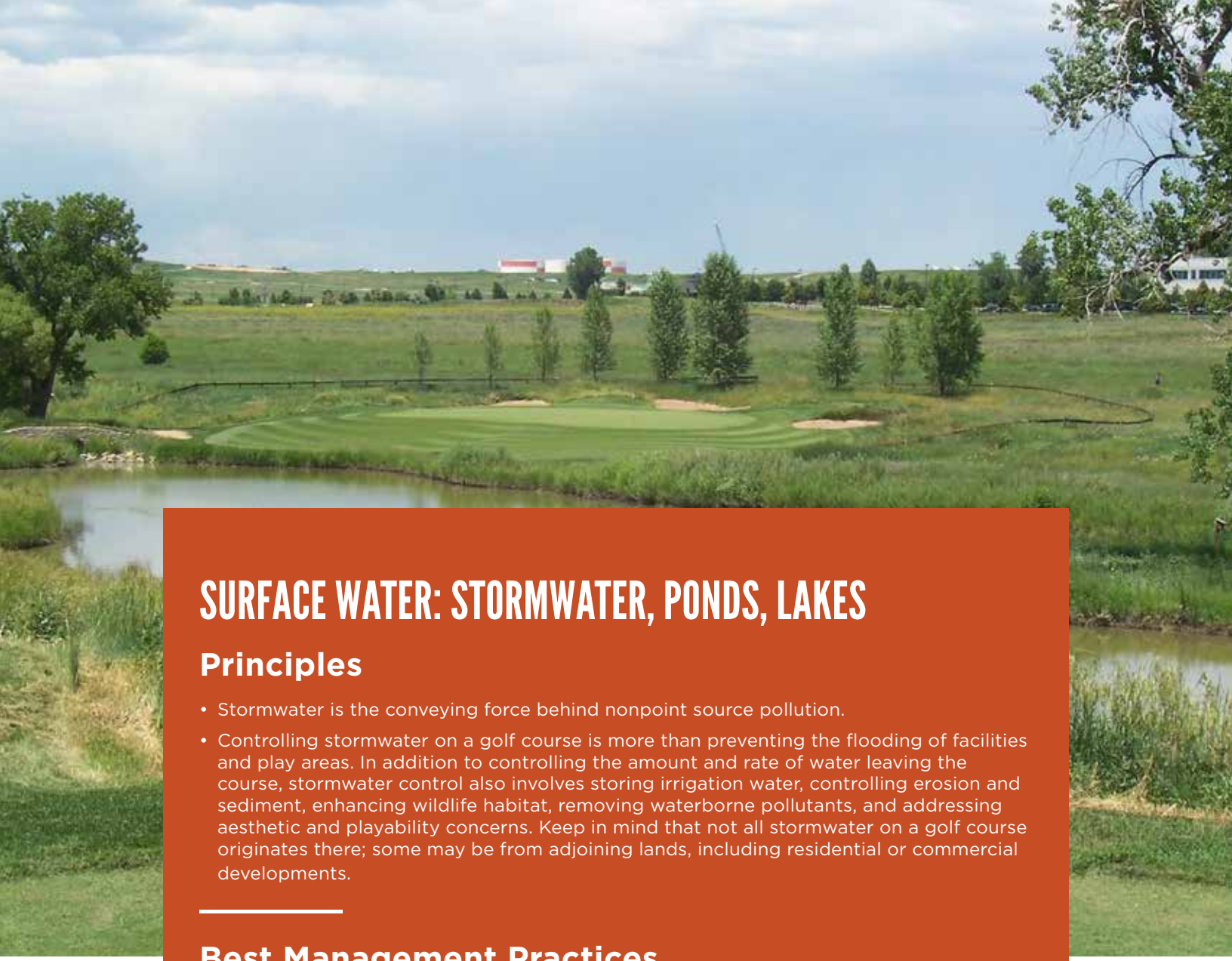
DRAINAGE

Principles

- Adequate drainage is necessary for growing healthy grass.
- A high-quality BMP plan for drainage addresses the containment of runoff, adequate buffer zones, and filtration techniques in the design and construction process to achieve acceptable water quality.
- Drainage of the golf course features is only as good as the system's integrity. Damaged, improperly installed, or poorly maintained drainage systems will result in inferior performance that negatively impacts play and increases risks to water quality.
- The golf course should be designed to minimize the disruption to the existing historical flow of the property's watersheds and drainage-ways.
- Ensure pipe size is adequate based on topography of golf course and surrounding terrain. Enlist the help of a qualified engineer and the construction team to help with determination of proper pipe size.

Best Management Practices

- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Internal golf course drains should not drain directly into an open waterbody, but should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments.
- Drainage should discharge through proper drainage and stormwater management devices, for example, vegetative buffers, swales, etc.
- The drainage system should be routinely inspected to ensure proper function.



SURFACE WATER: STORMWATER, PONDS, LAKES

Principles

- Stormwater is the conveying force behind nonpoint source pollution.
- Controlling stormwater on a golf course is more than preventing the flooding of facilities and play areas. In addition to controlling the amount and rate of water leaving the course, stormwater control also involves storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns. Keep in mind that not all stormwater on a golf course originates there; some may be from adjoining lands, including residential or commercial developments.

Best Management Practices

- Stormwater treatment is best accomplished by a "treatment train" approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.
- Eliminate or minimize as much directly connected impervious area (DCIA) as possible.
- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.

MAINTENANCE FACILITIES

Principles

The maintenance facilities must incorporate BMP to minimize the potential for contamination of soil and water resources. The pesticide mixing and storage facility, the equipment wash pad, and the fuel center are focal points.

Best Management Practices

- Design and build pesticide storage structures to keep pesticides secure and isolated from the surrounding environment.
- Store pesticides in a roofed concrete or metal structure with a lockable door.
- Construct floors of seamless metal or concrete sealed with a chemical-resistant paint.
- Ensure that flow from floor drains does not discharge directly to the ground and that drains are not connected to the sanitary sewer line or septic system.
- Equip the floor with a continuous curb to retain spilled materials.
- Do not store pesticides near burning materials or hot work (welding, grinding), or in shop areas.
- Provide storage for personal protective equipment (PPE) where it is easily accessible in the event of an emergency, but do not store in the pesticide storage area.
- Provide adequate space and shelving to segregate herbicides, insecticides, and fungicides.
- Use shelving made of plastic or reinforced metal. Keep metal shelving painted.
- Provide appropriate exhaust ventilation and an emergency wash area.
- Always place dry materials above liquids, never liquids above dry materials.
- Never place liquids above eye level.
- Locate operations well away from groundwater wells and areas where runoff may carry spilled pesticides into surface waterbodies.
- Do not build new facilities on potentially contaminated sites.
- An open building must have a roof with a substantial overhang (minimum 30° from vertical, 45° recommended) on all sides.
- In constructing a concrete mixing and loading pad, it is critical that the concrete have a water-to-cement ratio no higher than 0.45:1 by weight.
- The sump should be small and easily accessible for cleaning.
- Ensure that workers always use all personal protection equipment as required by the pesticide label and are provided appropriate training.
- Assess the level of training and supervision required by staff.
- Any material that collects on the pad must be applied as a pesticide according to the label or disposed of as a (potentially hazardous) waste according to state laws and regulations.
- Clean up spills immediately!
- Always store nitrogen-based fertilizers separately from solvents, fuels, and pesticides, since many fertilizers are oxidants and can accelerate a fire. Ideally, fertilizer should be stored in a concrete building with a metal or other type of flame-resistant roof.
- Always store fertilizers in an area that is protected from rainfall. The storage of dry bulk materials on a concrete or asphalt pad may be acceptable if the pad is adequately protected from rainfall and from water flowing across the pad.
- Sweep up any spilled fertilizer immediately.
- Do not wash equipment unnecessarily.
- Clean equipment over an impervious area, and keep it swept clean.
- Brush or blow equipment with compressed air before, or instead of, washing.
- Use spring shutoff nozzles.
- Use a closed-loop recycling system for wash water.
- Recycle system filters and sludge should be treated and disposed appropriately.
- Each piece of equipment should have an assigned parking area. This allows oil or other fluid leaks to be easily spotted and attributed to a specific machine so that it can be repaired.
- Use solvent-recycling machines or water-based cleaning machines to cut down on the use of flammable and/or toxic solvents.
- Use a service to remove the old solvents to recycle or dispose of them properly.
- Design pesticide storage to keep pesticides secure and isolated from the environment.

EXTERNAL CERTIFICATION PROGRAMS

Principles

- Golf-centric environmental management programs or environmental management systems can help golf courses protect the environment and preserve the natural heritage of the game.
- These programs help people enhance the natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf course operations.
- Health and wellness frameworks and platforms can increase employee and community relations.
- Golf courses can enhance community support from environmental education and certification efforts.

Best Management Practices

- Obtain and review materials to ascertain whether the facility should seek certification.
- Work with staff to establish facility goals that lead to certification.
- Establish goals to educate members about the certification program.

External Certifications and Frameworks

A qualified stakeholder team should consist of:

- Audubon International Cooperative Sanctuary, Signature, and Sustainable Communities Programs *audubonintenational.org*
- US Green Building Council Leadership in Energy and Environmental Design (LEED) *new.usgbc.org/leed*
- Global Reporting Initiative GRI Standards *globalreporting.org/standards*
- B Corp Certification bcorporation.net/certification
- Sustainable Development Goals *sustainabledevelopment.un.org/sdgs*

WILDLIFE CONSIDERATIONS

Principles

- Maintaining wildlife habitat on golf courses better maintains biological diversity, which is especially important in the urban environment.
- Most golfers enjoy observing non-threatening wildlife as they play the game.

Best Management Practices

- Identify the different types of habitat specific to the site.
- Identify the habitat requirements (food, water, cover, space) for identified wildlife species.
- Identify species on the site that are considered threatened or endangered by the federal or state government, including species the state deems “of special concern.”
- Preserve critical habitat.
- Identify and preserve regional wildlife and migration corridors.
- Design and locate cart paths to minimize environmental impacts. Construct the paths of permeable materials, if possible.
- Avoid or minimize crossings of wildlife corridors. Design unavoidable crossings to accommodate wildlife movement.
- Remove nuisance and exotic/invasive plants and replace them with native species that are adapted to a particular site.
- Maintain clearance between the ground and the lowest portion of a fence or wall to allow wildlife to pass, except in areas where feral animals need to be excluded.
- Retain dead tree snags for nesting and feeding sites, provided they pose no danger to people or property.

- Construct and place birdhouses, bat houses, and nesting sites in out-of-play areas.
- Plant butterfly/pollinator gardens around the clubhouse and out-of-play areas.
- Retain riparian buffers along waterways to protect water quality and provide food, nesting sites, and cover for wildlife.
- Minimize stream or river crossings to protect water quality and preserve stream banks.

Golf courses provide valuable green space, generally in urban areas, supplying critical links between urban and natural environments.

IRRIGATION

WATER MANAGEMENT APPROACHES

The supplemental use of water for course play and non-play areas is essential to supporting 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 section is to identify BMPs 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, along with surrounding natural resources.

Additionally, irrigation BMPs may provide an economic, regulatory compliance, and environmental stewardship advantage to those who consider them part of their irrigation management plan. BMPs are not intended to increase labor or place an undue burden on the owner/superintendent. If applied appropriately, they can help stabilize labor cost, extend equipment life, and limit repair and overall personal and public liability.

The monetary investment in non-structural BMPs costs little-to-nothing to implement in a daily course water-use plan. Other advantages include: reduced administrative management stress, improved employee communication and direction, and effective facilities training procedures.

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.

Embracing Irrigation BMPs

There are several environmental, performance, and employee benefits from adopting BMPs for Irrigation:

- 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

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.

Best Management Practices

- Design and/or maintain a system to meet site's peak water requirements under normal conditions and also 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.

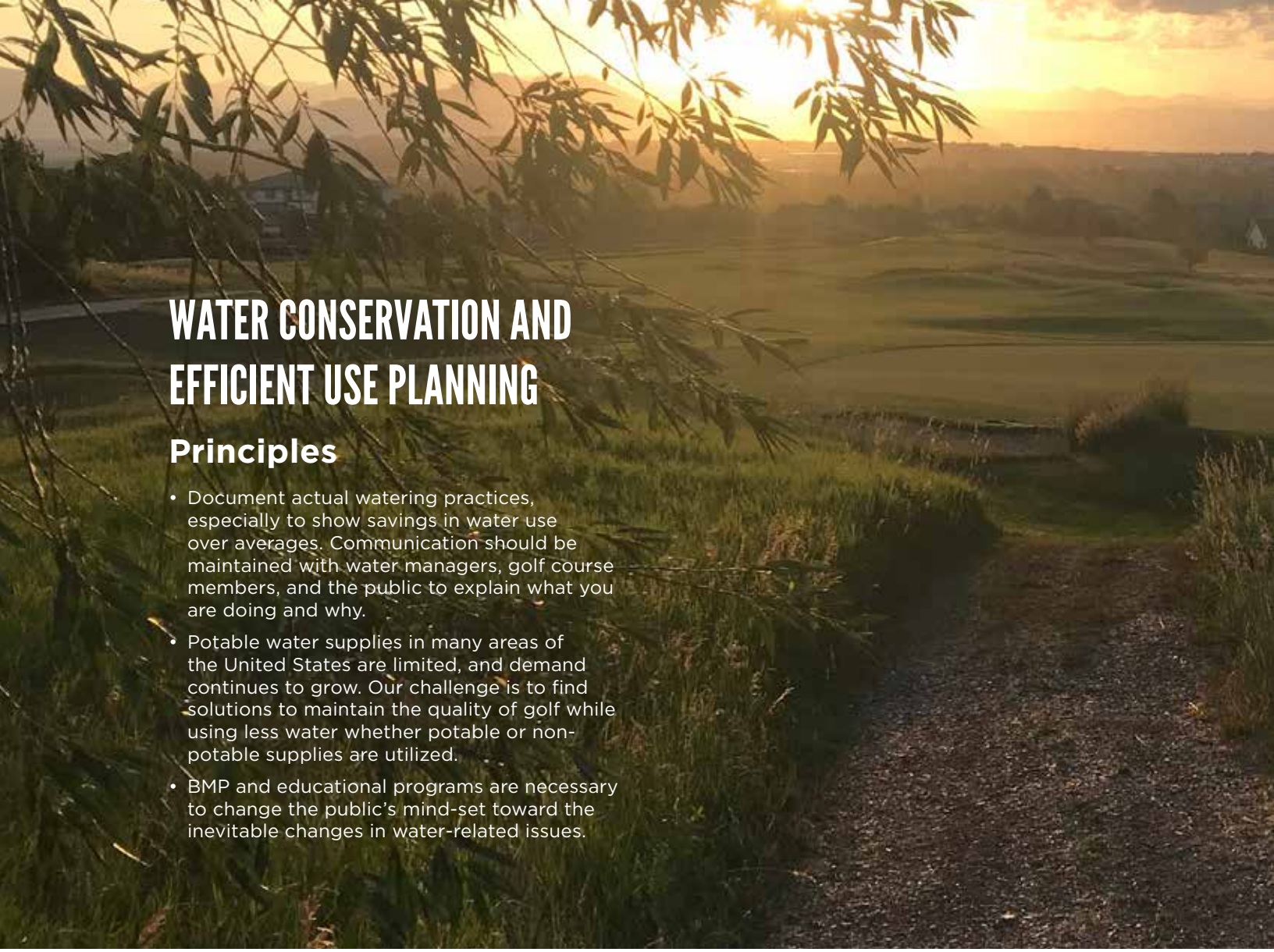
IRRIGATION WATER SUITABILITY

Principles

- Golf course designers and managers should endeavor to identify and use alternative supply sources to conserve freshwater drinking supplies, promote plant health, and protect the environment.
- The routine use of potable water supply is not a preferred practice; therefore, municipal drinking water should be considered only when there is no alternative.
- Studies of water supplies are recommended for irrigation systems, as are studies of waterbodies or flows on, near, and under the property. These maybe helpful to properly design a course's stormwater systems, water features, and to protect water resources.
- When necessary, treatment options for high sodium water concentrations should be included in the budget to address water quality and equipment maintenance.

Best Management Practices

- Use alternative water supplies/sources that are appropriate and sufficiently available for water needs.
- Use salt-tolerant varieties of turf and plants to mitigate saline conditions resulting from an alternative water supply or source, if necessary.
- Amend sodic water systems appropriately (with gypsum or an appropriate ion) to minimize sodium buildup in soil.
- Flush with freshwater or use amending materials regularly to move salts out of the root zone and/or pump brackish water to keep salts moving out of the root zone. Note that reclaimed water cannot be used for this flush. All application of reclaimed water must be at or below the agronomic rate and therefore flushing is not an allowable practice.
- Monitor sodium and bicarbonate buildup in the soil using salinity sensors.
- Reclaimed and other non-potable water supply mains must have a thorough cross-connection and backflow prevention device in place and operating correctly. To include annual testing and certification of backflow equipment.
- Any use of reclaimed water for irrigation must be authorized by, and in compliance with, a Colorado Discharge Permit System permit or an authorization for the use of reclaimed water, issued by the Colorado Water Quality Control Division.
- Post signage in accordance with local utility and state requirements when reclaimed water or other non-potable water is in use.
- Account for the nutrients in reuse/reclaimed water when making fertilizer calculations.
- Monitor reclaimed water tests regularly for dissolved salt content.
- Where practical, use reverse-osmosis filtration systems to reduce soluble salts from saline groundwater.
- Monitor the quantity of water withdrawn to avoid aquatic life impairment.
- Identify appropriate water supply sources that meet seasonal and bulk water allocations for grow-in and routine maintenance needs.
- Ensure that all golf course employees are trained in the appropriate use of reclaimed water, including regulations, policies, and individual authorizations.



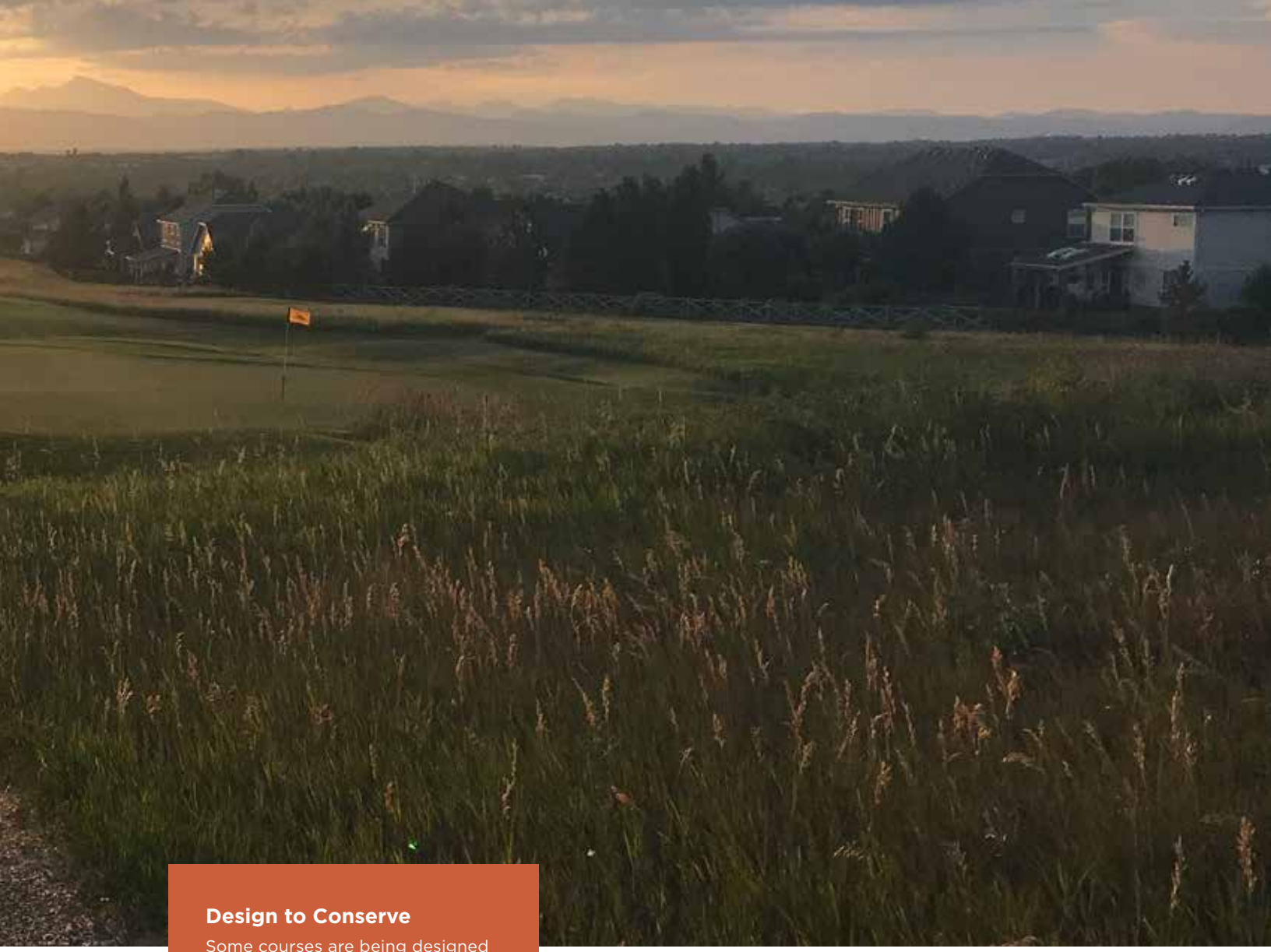
WATER CONSERVATION AND EFFICIENT USE PLANNING

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

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.
- 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.



Design to Conserve

Some courses are being designed using a "target golf" concept that minimizes the acreage of irrigated turf. Existing golf courses can make an effort 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.

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.

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.

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).
- 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.
- 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 Zone BMPs

- Turf and landscape areas should be zoned separately.
- Specific use areas should be zoned separately - including 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.
- 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.

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.

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.

Best Management Practices

- The reliability of older clock-control station timing depends on the calibration of the timing devices; this should be done periodically, but at least seasonally.
- An irrigation system should have rain sensors to shut off the system after 0.25 to 0.5 inch 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 a sufficient amount of 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.
- Install soil moisture sensors in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- Place soil moisture sensors in a representative location within the irrigation zone. Install a soil moisture sensor in the driest irrigation zone of the irrigation system.
- Wired soil moisture systems should be installed to prevent damage from aerification.
- 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.

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.

A Drop of Prevention...

Maintaining a system is more than just fixing heads. Good system management starts with good preventative maintenance (PM) procedures and record keeping.

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.
- 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.

Irrigation System Inspection Checklist

Daily

Visual field inspections for:

_ Leaks (in pipes or heads)
_ Stuck-on heads
_ Flow (actual vs. projected)
_ Meter readings
_ Computer logs
_ Rapid pressure loss at pump stations cycling motors
_ Visually inspect resevoir

Weekly

_ Inspect individual clocks
_ Run the system & watch sprinklers
_ Cleaning filters at the pump station to remove debris
_ Check rotation of heads
_ Make needed adjustments
_ Inspect for proper pressures at sprinklers (visual and measured)

Quarterly

_ Read electrical current drawn by pumps
_ Check voltage at breakers
_ Record run time hours
_ Inspect motors
_ Inspect PRV
_ Pressure adjustments to each zone or sprinkler

Annually

_ Inspect all sprinklers on the course
_ Replace worn parts
_ Record each head
_ Visually inspect reservoir
_ Sprinkler nozzle replacement program by zone or area

Reference: Hawai'i Golf Maintenance BMP Handbook, 2019

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.
- Weekly system operations observation 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.

POND LOCATION AND DESIGN

Principles

- Understanding natural lake processes and accommodating them in the design and management of a pond can create significant aesthetic value and reduce operational costs.
- Lakes and ponds have several distinct defining characteristics. Their size, shape, and depth may all affect how they respond to various environmental inputs.
- Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system. This usually works well for all concerned. However, existing natural waters may not be considered treatment systems and must be protected.
- Lakes and ponds may be used as a source of irrigation water. It is important to consider these functions when designing and constructing the ponds.
- Careful design may significantly reduce future operating expenses for lake and aquatic plant management.
- Depending on irrigation water source additional requirements may be applicable for the design of the lake/pond..

Best Management Practices

- Consult with a qualified golf course architect, working in conjunction with a stormwater engineer, to develop an effective stormwater management system that complies with the requirements of the water management district/department or other permitting agency.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Where practical, internal golf course drains should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments.
- Studies of water supplies are needed for irrigation systems, and studies of waterbodies or flows on, near, and under the property are needed to properly design a course's stormwater systems and water features, and to protect water resources.
- Peninsular projections and long, narrow fingers into ponds may prevent water mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels and promoting algal growth and excess sedimentation.
- In shallow or nutrient-impacted ponds, the use of aeration equipment may be required to maintain acceptable dissolved oxygen (DO) levels in the water.

POND USE AND MAINTENANCE

Principles

- Successful pond management should include a clear statement of goals and priorities to guide the development of the BMP necessary to meet those goals.
- Each pond has regions or zones that significantly influence water quality and are crucial in maintaining the ecological balance of the system. It is important for the manager to understand their function and how good water quality can be maintained if these zones (riparian zone, littoral zone, limnetic zone, and benthic zone) are properly managed.
- Surface water sources can present problems with algal and bacteria growth. Algal cells and organic residues of algae can pass through irrigation system filters and form aggregates that may plug emitters.
- Pond leaks should be controlled and managed properly.
- Use an expert in aquatic management to help develop and monitor pond management programs.

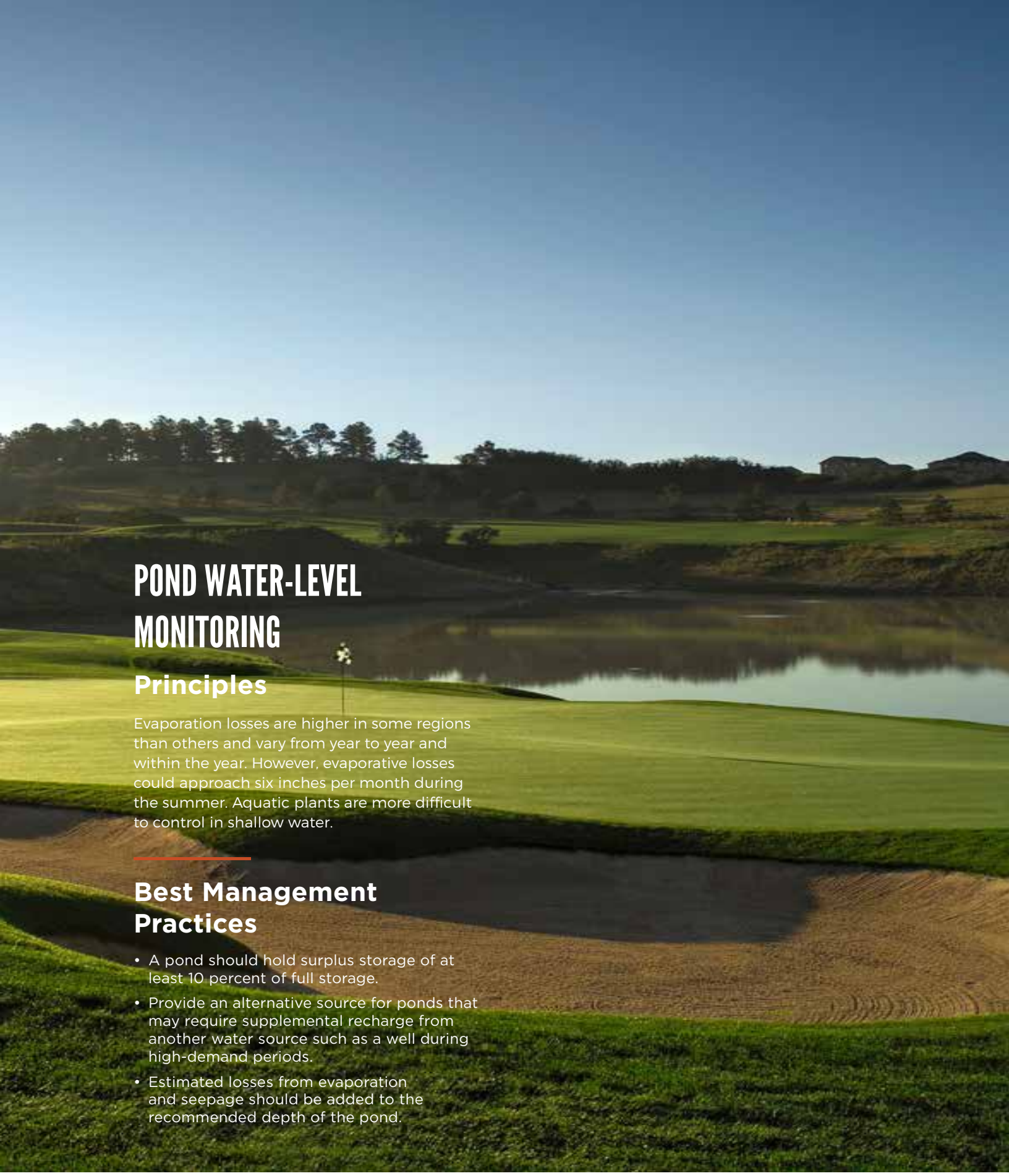
Golf Course Ponds

Maintenance Challenges

- Low DO
- Sedimentation
- Changes in plant populations
- Nuisance vegetation
- Maintenance of littoral shelves
- Vegetation on the lakeshore

Best Management Practices

- Use leak controls in the form of dike compaction, natural-soil liners, soil additives, commercial liners, drain tile, or other approved methods.
- Maintain a riparian buffer to filter the nutrients and sediment in runoff.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Prevent overthrowing fertilizer into ponds. Practice good fertilizer management to reduce nutrient runoff into ponds, which causes algae blooms and ultimately reduces DO levels.
- Establish a special management zone around pond edges.
- Dispose of grass clippings where runoff will not carry them back to the lake.
- Encourage clumps of native emergent vegetation at the shoreline.
- Maintain water flow through lakes, if they are interconnected.
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to reduce erosion and the resulting sedimentation.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate ponds and dredge or remove sediment before it becomes a problem.
- Look into alternative methods of pond maintenance/cleaning such as micro-organisms to help create a healthy pond environment.



POND WATER-LEVEL MONITORING

Principles

Evaporation losses are higher in some regions than others and vary from year to year and within the year. However, evaporative losses could approach six inches per month during the summer. Aquatic plants are more difficult to control in shallow water.

Best Management Practices

- A pond should hold surplus storage of at least 10 percent of full storage.
- Provide an alternative source for ponds that may require supplemental recharge from another water source such as a well during high-demand periods.
- Estimated losses from evaporation and seepage should be added to the recommended depth of the pond.

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.

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.

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.

Potential Sprinkler System Maintenance Solutions

Be proactive. If the system requires frequent repairs, it is necessary to determine why failures are occurring.

- 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.

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.

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.

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.
- Install thrust blocks/ joint restraints to support conveyances.
- Inspect daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. Visually inspect for leaks, misaligned or inoperable heads, and chronic wet or dry spots so adjustments can be made.
- Maintain air-relief and vacuum-breaker valves.
- Observe systems 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 professional irrigation audit at least once every five years.
- Document equipment run-time hours. Ensure all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor power consumption of pump stations for problems with 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. Track to 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.

System Renovation

- Appropriate golf course renovations can improve system efficiencies, conserve water, improve playability, and lower operating costs.
- Correctly identify problems and their cost to determine which renovations are appropriate.
- Determine the age of the system to establish a starting point for renovation.
- Identify ways to improve system performance by maximizing the efficient use of the current system.
- Routinely document system performance to maximize the effectiveness of the renovation.
- Evaluate cost of renovation and its return on benefits both financial and management.

WINTERIZATION AND SPRING

Principles

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

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 daily access weather information 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.

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.

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.

Map 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.

NON-PLAY AND LANDSCAPE AREAS

Principles

- 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.

Best Management Practices

- Designate 50% to 70% of the non-play area to remain in natural cover according to "right-plant, right-place," 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.

WELLHEAD PROTECTION

Principles

- Wellhead protection is the establishment of protection zones and safe land-use practices around water supply wells in order to protect aquifers from accidental contamination. It also includes protecting wellheads from physical impacts, keeping them secure, and sampling wells according to the monitoring schedule required by the regulating authority, which is often a local health department or state department of environmental quality.
- When installing new wells, contact the regulating authority to determine the permitting and construction requirements and the required isolation distances from potential sources of contamination.
- Locate new wells up-gradient as far as possible from likely pollutant sources, such as petroleum storage tanks, septic tanks, chemical mixing areas, or fertilizer storage facilities.
- Licensed water-well contractors may be needed to drill new wells to meet state requirements, local government code, and water management districts' well-construction permit requirements.

Best Management Practices

- Use backflow-prevention devices at the wellhead, on hoses, and at the pesticide mix/load station to prevent contamination of the water source.
- Properly plug abandoned or flowing wells.
- Surround new wells with bollards or a physical barrier to prevent impacts to the wellhead.
- Inspect wellheads and the well casing at least annually for leaks or cracks; make repairs as needed.
- Maintain records of new well construction and modifications to existing wells.
- Obtain a copy of the well log for each well to determine the local geology and how deep the well is; these factors will have a bearing on how vulnerable the well is to contamination.
- Sample wells for contaminants according to the schedule and protocol required by the regulating authority.
- Never apply a fertilizer or pesticide next to a wellhead.
- Never mix and load pesticides next to a wellhead if not on a pesticide mix/load pad.

SURFACE WATER MANAGEMENT

STORMWATER CAPTURE

Although golf courses are typically large properties ranging in size from 60 to 200 acres, they are just one link in a stormwater management chain. Generally, a quantity of stormwater enters the golf course area, supplemented by what falls on the golf course proper, and then the stormwater leaves the golf course. Therefore, golf courses are realistically capable of having only a small impact on major stormwater flow. That impact should be to add only small increments of water over a given period of time. Engineers call this function "detention."

When golf courses are designed and built, their drainage capability concept is guided by an average rainfall event of a given frequency. For example, typically, a golf course drainage system is designed to detain a two- or five-year rain event. In other words, when that rain event happens, the golf course will be able to be reasonably drained in a matter of hours, as excess water not absorbed by the soil flows through the drainage system, is temporarily held, and finally leaves the property. In some instances, golf courses and other recreational facilities are mandated to be designed to handle a 20-, 50- or 100-year rain event, which means the golf course must detain more water for perhaps a longer period of time. This ability to detain large amounts of water requires accurate engineering and extensive construction to prevent physical or financial damage to the facility.and policy

BMPs are intended to prolong the detention process as long as practical, harvest as much of the stormwater in surface or underground storage as reasonable, and to improve the quality of water leaving the property when possible.

Principles

- When the golf course is properly designed, rain and runoff captured in water hazards and stormwater ponds may provide most or all of the supplemental water necessary under normal conditions, though backup sources may be needed during drought conditions.
- Capture systems should be considered part of the overall treatment.
- Stormwater capture is desirable where the lowest quality of water is needed to conserve potable water, maintain hydrologic balance, and improve water treatment.
- This practice uses natural systems to cleanse and improve water treatment.
- A water right is required in Colorado to detain and use stormwater for irrigation.

Best Management Practices

- Install berms and swales to capture pollutants and sediments from runoff before it enters the irrigation storage pond.
- Monitor pond water level for water loss (seepage) to underground systems. If seepage is occurring, it may be necessary to line or seal the pond or install pumps to relocate water.
- Install water-intake systems that use horizontal wells placed in the subsoil below the storage basin; use a post pump to filter particulate matter.
- A backup source of water should be incorporated into the management plan.
- Inspect irrigation pumps, filtration systems, conveyances and control devices to prevent/correct system issues.
- Stormwater detention basins (SW Water Quality Ponds) located on the golf course or properties associated with golf course buildings and parking lots must be maintained in a manner that complies with local regulations and ensures that the basins operate in a manner consistent with their engineered design.
- Use computerized irrigation control systems, associated rain gauges, and moisture sensors in a manner that turns off irrigation during periods of significant precipitation, so that runoff from the golf course is minimized during significant precipitation events.

REGULATORY CONSIDERATIONS

Principles

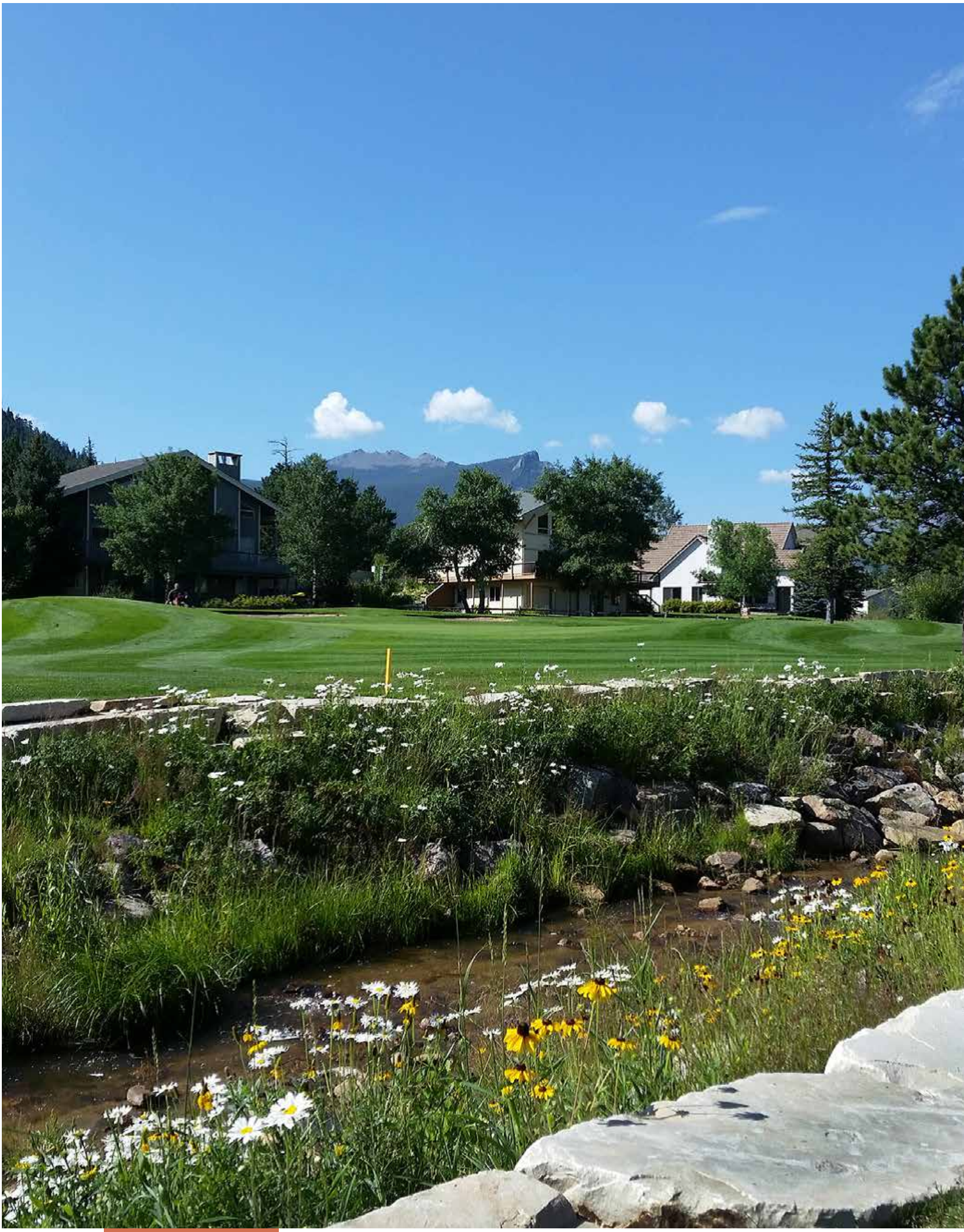
Course owners and superintendents should investigate regulatory requirements that apply to the golf facility to protect surface and groundwater quality. This includes Colorado regulations regarding the capturing, storage and use of stormwater for irrigation, which must be researched to ensure the golf course has the required water right.

Turfgrass Reduces Runoff

Ecosystem services that golf courses provide like stormwater filtration and reducing runoff are especially critical in urban environments like Denver where green space is limited with office buildings, roads, sidewalks, and other impervious surfaces.

Best Management Practices

- Aquatic management of plants may be regulated under construction permitting and regulatory licensing requirements. Consult with federal, state, and local water management agencies before managing golf course lakes and wetland areas.
- Consult with federal, state, and local water management agencies, and/or consult an approved management plan before performing cultural practices: fertilization, installation of plants, hand removal of plants, or mechanical harvesting.
- The introduction of aquatic triploid grass carp, biological controls, aeration, and chemical controls (herbicide/algaecide) must be approved and monitored according to permit and licensing protocols and compliance.
- The disposal of sediments from surface water ponds (stormwater detention) may be subject to regulation.
- Sediment testing will provide the information required to determine the proper disposal method.
- Golf course management may be affected by Total Maximum Daily Loading (TMDL), mitigation, and watershed basin management action plans (BMAP).
- Wetlands are protected areas; consult with federal and state agencies before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property to properly design a course's stormwater system and water features to protect water resources.
- 404 permitting from the Army Corps of Engineers may be required when completing work in wetlands or areas of the golf course that are designated as Waters of the United States.



WATER QUALITY PROTECTION

Principles

- An aquatic plant management strategy should address the intended uses of the waterbody to maintain water quality. Proper documentation of the site's physical attributes and location, the presence of invasive or weedy species, aesthetics, watershed and groundwater assessments, and other environmental considerations should be documented.
- Only licensed individuals or contractors should be allowed to select and apply aquatic pesticides.

Best Management Practices

- Identify position of property in relation to its watershed and understand any concerns.
- Outline goals and priorities to guide the development of the BMP necessary to support the lake/aquatic management plan.
- Identify surface water and flow patterns; indicate stormwater flow as well as existing and potential holding capacity.
- Indicate impervious surfaces, such as buildings, parking lots, or pathways.
- Indicate major drainages and catch basins that connect to local surface water bodies.
- Identify and understand depth to water tables and soil types.
- Accommodate natural lake processes in the construction of lakes and ponds; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs and to provide habitat.
- Use integrated pest management (IPM) strategies and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to prevent turfgrass injury and to protect water quality and wildlife habitat.
- Irrigation should not directly strike or run off to waterbodies, and no-fertilization buffers should be maintained along water edges.
- Superintendents should monitor designated waters in their area for the persistence of toxic herbicides and algaecides in the environment.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Apply fertilizer/fertigation and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface water and groundwater contamination.
- Apply copper products per label instructions to reduce the risk of impairing water quality and causing negative biological impacts.
- Locate and protect wellheads.

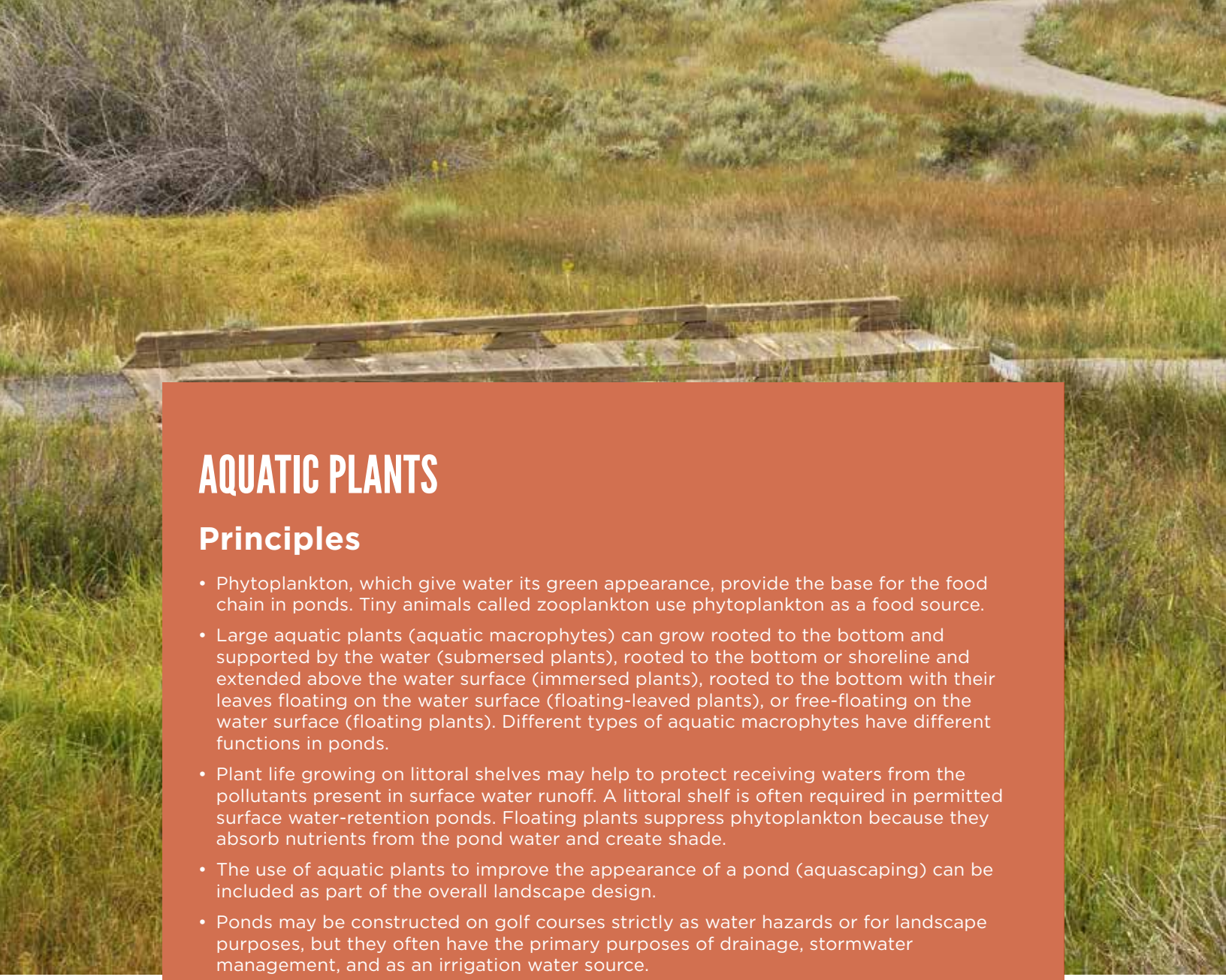
WATER QUALITY CHARACTERISTICS

Principles

- Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.
- Monitoring is used to determine whether outside events are changing the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. It also provides a body of evidence on the golf course's environmental impact.
- Water quality monitoring sites should be identified and sampled during the preconstruction phase. A water-quality monitoring plan, including the identified preconstruction water quality monitoring sites, should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction has been completed. Due to post-construction site conditions the water quality monitoring plan may need to be modified.
- Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state Total Maximum Daily Load (TMDL) Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, and suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation.
- Post-construction sampling of surface-water quality should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year.
- If there is no discharge on the scheduled sample date, samples should be taken during the next discharge event.
- Post-construction surface-water quality sampling should continue through the first three years of operation and during the wet and dry seasons every third year thereafter, provided that all required water-quality monitoring has been completed and the development continues to implement all current management plans. It may also be wise to sample if a significant change has been made in course operation or design that could affect nearby water quality.
- Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators).
- The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable to support sound decision-making. Data should be collected and analyzed using scientifically sound procedures. It is strongly recommended that a certified laboratory be used and all QA/QC procedures are followed, whether for proprietary or regulatory purposes. If a golf course should ever want to produce data for an agency or defend the facility from unwarranted charges, the data must meet QA/QC standards to be defensible as evidence.

Best Management Practices

- Establish a minimum DO limit to prevent fish kills (occur at approximately 2 ppm), for example, use artificial aeration (diffusers).
- Take remedial actions when the minimum DO level is reached, e.g. use artificial aeration (diffusers).
- To reduce stress on fish, keep DO levels above 3 ppm.
- Select algaecides containing hydrogen peroxide instead of copper or endothall to treat high populations of phytoplankton.
- Use IPM principles to limit excess use of pesticides and fertilizers.
- Spot-treat filamentous algae or frequently remove algae to prevent oxygen depletion of the water.
- Use environmentally safe dyes and aeration to maintain appropriate light and DO levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat the entire pond at once.
- Coordinate construction/renovation activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- Sod, sprig, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.
- Avoid the use of trimmers along the edge of the water body.
- Mow lake and pond collars at a higher height to slow and filter overland flow to waterbodies.
- Manage dredged materials in a manner to avoid reentry into the water or contact with turf areas.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.
- Seek professional assistance from an environmental specialist to design an appropriate water sampling plan, including sample sites, sample collection frequency and equipment, and analytical method requirements.
- Determine which sites will be analyzed, and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.



AQUATIC PLANTS

Principles

- Phytoplankton, which give water its green appearance, provide the base for the food chain in ponds. Tiny animals called zooplankton use phytoplankton as a food source.
- Large aquatic plants (aquatic macrophytes) can grow rooted to the bottom and supported by the water (submersed plants), rooted to the bottom or shoreline and extended above the water surface (immersed plants), rooted to the bottom with their leaves floating on the water surface (floating-leaved plants), or free-floating on the water surface (floating plants). Different types of aquatic macrophytes have different functions in ponds.
- Plant life growing on littoral shelves may help to protect receiving waters from the pollutants present in surface water runoff. A littoral shelf is often required in permitted surface water-retention ponds. Floating plants suppress phytoplankton because they absorb nutrients from the pond water and create shade.
- The use of aquatic plants to improve the appearance of a pond (aquascaping) can be included as part of the overall landscape design.
- Ponds may be constructed on golf courses strictly as water hazards or for landscape purposes, but they often have the primary purposes of drainage, stormwater management, and as an irrigation water source.

Best Management Practices

- Properly designed ponds with a narrow fringe of vegetation along the edge are more resistant to problems than those with highly maintained turf.
- In ponds with littoral plantings, problem plants should be selectively controlled without damaging littoral shelves.
- Encourage clumps of native emergent vegetation at the shoreline.
- A comprehensive lake management plan should include strategies to control the growth of nuisance vegetation that can negatively affect a pond's water quality and treatment capacity.
- Frequently remove filamentous algae by hand and/or frequently apply algaecide to small areas of algae (spot treatment).
- To reduce the risk of oxygen depletion, use an algaecide containing hydrogen peroxide instead of one with copper or endothall.

HUMAN HEALTH CONCERNS

Principles

- The use of pesticides should be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices, referred to altogether as IPM.
- Address areas where standing water may provide habitat for nuisance organisms.

Best Management Practices

- Use IPM principles to address insects that may pose a hazard to human health.
- Drain areas of standing water during wet seasons to reduce insect populations.
- Use Bacillus thuringiensis (Bt) products according to label directions to manage waterborne insect larvae.

FLOODPLANE RESTORATION

Principles

- Reestablishment of natural water systems helps mitigate flooding and control stormwater.
- Address high sediment and nutrient loads and vertical and lateral stream migration causing unstable banks, flooding, and reductions in groundwater recharge.
- Land use decisions and engineering standards must be based on the latest research science available.

Best Management Practices

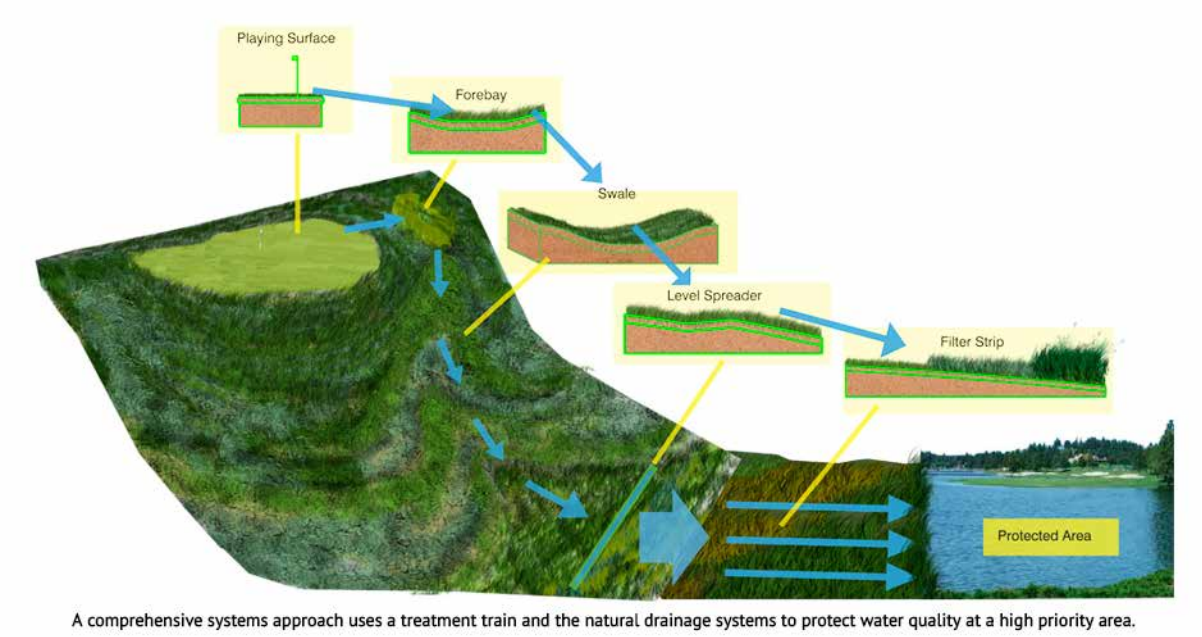
- Install stream buffers to restore natural water flows and flooding controls.
- Install buffers in play areas to stabilize and restore natural areas that will attract wildlife species.
- Install detention basins to store water and reduce flooding at peak flows.

STORMWATER, PONDS, AND LAKES

Stormwater is the conveyance mechanism behind nonpoint source pollution. Nonpoint source pollution contains a collection of pollutants (natural and man-made) from many different sources. Nonpoint source pollutants can include micro or macro solids; oil; soap; dirt; bacteria from animal wastes; dissolved nutrients and metals; fertilizers, pesticides, and other chemicals.

Principles

- The control of stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas. In addition to controlling the amount and rate of water leaving the course, it involves storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns.
- Most golf courses plan their lakes and water hazards to be a part of the stormwater control and treatment system. However, natural waters of the state cannot be considered treatment systems and must be protected.
- Lakes and ponds may also be used as a source of irrigation water if the golf course has the required water right.
- It is important to consider these functions when designing and constructing the ponds. Peninsular projections and long, narrow fingers may prevent mixing. Ponds that are too shallow may reach high temperatures, leading to low oxygen levels and promoting algal growth and excess sedimentation.
- Stormwater treatment is best accomplished by a treatment train approach, in which water is conveyed from one treatment to another by conveyances that contribute to the treatment.
- Source controls are the first step of the BMP treatment train. They help to prevent the generation of stormwater or introduction of pollutants into stormwater. The most effective method of stormwater treatment is not to generate stormwater in the first place, or to remove it as it is generated.



Storm water treatment train | Source: BMPs for NY State Golf Courses

Golf course stormwater management should include "natural systems engineering" or "soft engineering" approaches that maximize the use of natural systems to treat water.

Best Management Practices

- Install swales and slight berms where appropriate around the water's edge, along with buffer strips, to reduce nutrients and contamination.
- Design stormwater treatment trains to direct stormwater across vegetated filter strips (such as turfgrass), through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.
- Ensure that no discharges from pipes go directly to water.
- Eliminate or minimize directly connected impervious areas.
- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Use depressed landscape islands or rain gardens in parking lots to catch, filter, and infiltrate water, to minimize run off amounts. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots.
- Direct gutter and roof drain flows to permeable areas to allow infiltration near the point of generation.
- Use a treatment train approach.
- Institute buffers and special management zones.
- Stormwater detention basins located on the golf course or properties associated with golf course buildings and parking lots must be maintained in a manner that complies with local regulations and ensures that the basins operate in a manner consistent with their engineering design.

WATER QUALITY MONITORING AND MANAGEMENT

REGULATORY CONSIDERATIONS

Principles

Golf course owners and superintendents should investigate regulatory requirements that may exist in their location to protect surface and groundwater quality.

Best Management Practices

- Aquatic management of plants may be regulated under construction permitting and regulatory licensing requirements. Consult with federal, state, and local water management agencies before managing golf course lakes and wetland areas.
- Consult with federal, state, and local water management agencies, and/or consult an approved management plan before performing cultural practices: fertilization; installation of plants; hand removal of plants or mechanical harvesting.
- The introduction of aquatic triploid grass carp, biological controls, aeration, and chemical controls (herbicide/algaecide) must be approved and monitored according to permit and licensing protocols and compliance.
- Removed sediments from surface-water ponds (stormwater detention) may be subject to regulation, test sediment prior to disposal or use.
- Golf course owners are responsible for Total Maximum Daily Loading (TMDLs), mitigation, and watershed basin management action plans (BMAP).
- Wetlands are protected areas; consult with the Army Corps of Engineers and other applicable federal and state agencies before altering natural aquatic areas.

- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Studies of water supplies are needed for irrigation systems, including studies of waterbodies or flows on, near, and under the property are needed to properly design a course's stormwater system and water features to protect water resources.

SITE ANALYSIS

Principle

Design an aquatic plant management strategy that addresses the intended uses of the waterbody to maintain water quality. Identify the site's physical attributes and location, the invasive or weedy species present, aesthetics, watershed and groundwater assessments, and other environmental considerations.

Best Management Practices

- Identify position of property in relation to its watershed and understand any concerns.
- Outline goals and priorities to guide the development of the BMP necessary to support the lake/aquatic management plan.
- Identify surface water and flow patterns; indicate stormwater flow as well as existing and potential holding capacity.
- Indicate impervious surfaces, such as buildings, parking lots, or pathways.
- Indicate major drainages and catch basins that connect to local surface water bodies.
- Identify and understand depth to water tables and soil types.
- Accommodate natural lake processes in the construction of lakes and ponds; include herbaceous and woody vegetation and emergent and submergent shoreline plants to reduce operational costs.
- Use IPM and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides to minimize damage to non-target littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of plants into more desirable littoral plantings.
- Use appropriate aquatic herbicides to avoid turfgrass injury.
- Irrigation should not directly strike or runoff to waterbodies and no-fertilization buffers should be maintained along edges.
- Superintendents should monitor designated waters in their area for the persistence of highly toxic herbicides and algaecides in the environment.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Apply fertilizer/fertigation and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface and groundwater contamination.
- Apply copper products per label instructions to reduce the risk of negative biological impacts and impairing water quality.
- Locate and protect wellheads.

WATER QUALITY SAMPLING PROGRAM

Principle

- Monitoring is the method used to determine whether outside events are impacting the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. It also provides a body of evidence on the golf course's environmental impact.
- A water quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction is completed. The same sites should be monitored during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions.
- Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state Total Maximum Daily Load [TMDL] Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation.
- Post-construction surface-water quality sampling should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year.
- Should there be no discharge on the scheduled sample date, samples should be taken during the next discharge event.
- Post-construction surface-water quality sampling should continue through the first three years of operation and during the wet and dry seasons every third year thereafter, provided that all required water quality monitoring has been completed and the development continues to implement all current management plans. It may also be wise to sample if a significant change has been made in course operation or design that could affect nearby water quality.
- Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators).
- Golf courses should also sample for macroinvertebrates as determined useful by water quality specialists.

Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.

Best Management Practices

- Establish dissolved oxygen (DO) thresholds to prevent fish kills (occur at levels of 2 ppm), for example, use artificial aeration (diffusers).
- Reduce stress on fish; keep DO levels above 3 ppm.
- Select algaecides containing hydrogen peroxide instead of one containing copper or endothall to treat high populations of phytoplankton.
- Use IPM principles to limit excess use of pesticides.
- Spot-treat filamentous algae or frequently remove algae by hand to prevent lowering oxygen concentrations in water.
- Use dyes and aeration to maintain appropriate light and DO levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat the entire pond at once.
- Coordinate construction/renovation activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- Sod, sprig, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.
- Avoid the use of trimmers along the edge of the water body.
- Mow lake and pond collars at 2 inches or higher to slow and filter overland flow to water bodies.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with turf.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.

SAMPLING PARAMETERS, COLLECTION, AND ANALYSIS

Principles

- A water quality monitoring program must include monitoring of surface water, groundwater, and pond sediments. It should be implemented in three phases: background, construction, and long-term management.
- Sampling of all watershed ingress and egress points is important to know what is coming into the property to identify potential impacts and baseline of water quality data.
- The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable, and are collected and analyzed using scientifically sound procedures.
- It is strongly recommended that a certified laboratory be used even if the data are only for proprietary use and are not reported to any regulatory agency
- QA/QC procedures should be followed. Golf course management must have good data to make good decisions, and if a golf course should ever want to produce data for an agency or in court to defend the facility from unwarranted charges, those data must meet QA/QC standards to be defensible as evidence.

Best Management Practices

- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.
- Determine what sites will be analyzed and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.

BUFFER ZONES

Principles

- Buffers around the shore of a waterbody or other sensitive areas filter and purify runoff as it passes across the buffer. As discussed, it is important to continue these plantings into the water to provide emergent vegetation for aquatic life, even if the pond is not used for stormwater treatment.
- Effective BMP in these areas include filter and trap sediment, site-specific natural/organic fertilization, and limits on pesticide use, primarily focusing on the control of invasive species.
- Golf course stormwater management should include "natural systems engineering" or "soft engineering" approaches that maximize the use of natural systems to treat water.

Ideally, buffers should be planted with native species providing a triple play of water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife.

Best Management Practices

- Riparian buffer areas are above the high-water mark and should be unfertilized and left in a natural state.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Institute buffers and special management zones.
- The placement of bunkers and the shaping of contours surrounding a green should allow proper drainage and provide for the treatment and absorption of runoff from the green.
- Use turf and native plantings to enhance buffer areas.
- Use a deflector shield to prevent fertilizer and pesticide prills from contacting surface waters.
- Apply fertilizer and pesticides based on the effective swath; keep application on target and away from buffers or channel swales.
- Use a swale and berm system to allow for resident time (ponding) for water to infiltrate through the root zone to reduce lateral water movement to the surface water body.
- Maintain a riparian buffer to filter the nutrients in stormwater runoff.
- An appropriate-sized buffer (steeper slope requires great buffer width) of turf mowed at a higher height of cut and minimally fertilized with enhanced-efficiency fertilizers can provide an effective buffer. Increase height of cut in the riparian zone to improve filtration and buffer of nutrient movement to the water.
- Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal.
- Encourage clumps of native emergent vegetation at the shoreline.
- Establish special management zones around pond edges.
- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loads.
- Planting on slopes with less than a 6-foot horizontal to a 1-foot vertical may not be as successful over the long term.
- Construct random small dips and ridges of a few inches to a foot to promote diversity within the plant community and provide a healthier and more productive littoral zone.

- All or most of the out-of-play water bodies should have shoreline buffers planted with native or well-adapted noninvasive vegetation to provide food and shelter for wildlife.
- Practice good fertilizer management to reduce nutrient runoff into waterbodies. Nutrient rich runoff encourages alga blooms and other phytoplankton resulting in reduced DO levels; apply appropriate fertilizer rates and application setbacks.
- Nutrient loading of the waterbody can cause algae blooms
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate shallow lakes less than 6 feet in depth to maintain acceptable DO levels.
- Where applicable, aerate at night to control oxygen depletion in any pond.
- Install desirable plants to naturally buffer DO loss and fluctuation.
- Dispose of grass clippings where runoff and wind will not carry them back to the lake.
- Dredge or remove sediment to protect beneficial organisms that contribute to the lake food web and overall lake health.

The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland is the recycling factory of our ecosystem. When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers.

WETLAND PROTECTION

Principles

- Several states protect wetlands as waters of the state by rule of law. Wetlands play a vital environmental role; acting both as filters for pollutant removal from surface waters and as nurseries for many plant and animal species.
- Constructed or disturbed wetlands may be permitted to be an integral part of the stormwater management system.
- Install appropriate signage for protected wetland areas. Encourage play according to ESA rules in the Rules of Golf.

Best Management Practices

- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to prevent erosion and sedimentation.
- Natural waters cannot be considered treatment systems and must be protected. (Natural waters do not include treatment wetlands.)
- Establish a low- to no-maintenance level within a 75-foot buffer along non-tidal and tidal wetlands.
- Establish and maintain a 100-foot riparian buffer around wetlands, springs, and spring runs.

STORMWATER MANAGEMENT

Principle

Controlling stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance, and play areas. In addition to controlling the amount and rate of water leaving the course, stormwater involves storing irrigation water, controlling erosion and sedimentation, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic and playability concerns. Keep in mind that not all stormwater on a golf course originates there; some may be from adjoining lands, including residential or commercial developments.

Best Management Practices

- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms. Use native low water plants that are salt tolerant when possible.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass.
- Special high-permeability concrete is available for cart paths or parking lots.
- Design stormwater control structures to hold stormwater for appropriate residence times in order to remove total suspended solids.
- Use a stormwater treatment train to convey water from one treatment structure to another.
- Eliminate or minimize directly connected impervious areas as much as possible.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Ensure that no discharges from pipes go directly to water.
- Provide staff training to ensure that employees understand the proper procedures that should be used to address a spill or discharge from equipment that could adversely impact water quality.

SEDIMENT

Principle

During construction and/or renovation, temporary barriers and traps must be used to prevent sediments from being washed off-site into water bodies. Wherever possible, keep a vegetative cover on the site until it is actually ready for construction, and then plant, sod, or otherwise cover it as soon as possible to prevent erosion.

Best Management Practices

- Use shoreline grasses to prevent bank erosion.
- Use dry detention basins/catchments to buffer flooding and excessive runoff that may contain sediment.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation, the placement of gravel, slopes, and backfilling.
- Internal golf course drains should not drain directly into an open water body, but should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments.
- Maintain a vegetative cover on construction sites until it is actually ready for construction.
- Follow all local construction regulations associated with sediment management. Permits and approved plans maybe required.
- Proper erosion and sediment control BMPS should be installed during construction activities.

SODIC/SALINE CONDITIONS

Principles

- All natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly.
- Reclaimed water has the potential to contain higher soluble salt concentrations than other water sources.
- Irrigation water can degrade when wells are pumped at high rates or for prolonged periods. Sometimes “up-coning” can occur from pumping, whereby saline water, rather than freshwater, is drawn into the well.
- Saline water typically is unsuitable for irrigation because of its high TDS content.

Best Management Practices

- Use surface water to mix (blend) affected groundwater to lower the total salt concentration.
- Routinely monitor water quality to ensure that salt concentrations are at the acceptable levels.
- Request water quality data from the reclaimed water provider to determine salt concentrations.
- Consider fertilizer that uses soluble nitrogen forms with a relatively low concentration of salts if frequent applications are necessary.
- Consider a controlled-release fertilizer to reduce salt injury.
- Identify salt additions and saline sources that contribute to the total salt concentration.
- Base management plan on routine soil tests to determine sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP), electrical conductivity saturated paste method/unit (ECe), and free calcium carbonate content.
- Select alternative turfgrass and landscape plants that are more salt-tolerant.
- Reduce salt accumulations in the soil by flushing soils as needed with a higher-quality water source.
- Design irrigation systems to account for flushing of salt accumulation from soil.
- Amend soil and water to remove salt ions from affected areas.
- Evaluate BMP to determine effectiveness toward managing sodic/saline conditions.

Ecosystem services that golf courses provide include stormwater management, wildlife habitats, urban green space, and community assets for STEM education.

NUTRIENT MANAGEMENT

REGULATORY CONSIDERATIONS

Proper nutrient management plays a key role in the reduction of environmental risk and increases course profitability. Among other benefits, applied nutrients inflate the available pool of nutrients and allow turfgrass to recover from damage, increase its resistance to stress, and increase its playability. However, the increase in available nutrients also increases the potential risk of environmental impact. Nutrients may move beyond the turfgrass via leaching or runoff, which may impact our environment. Other organisms also respond to increases in nutrients and, in some cases, these organisms may deleteriously alter our ecosystem. It is important to follow proper nutrient management BMPs to minimize environmental impact.

The goal of a proper nutrient management plan should be to apply the minimum necessary nutrients to achieve an acceptable playing surface and apply these nutrients in a manner that maximizes plant uptake.

REGULATORY CONSIDERATIONS

Principles

- Local and state regulations are in place to better manage nutrient risks based on the unique conditions that exist in your location. Designing a nutrient management plan within these regulations addresses local concerns and minimizes risk within your unique ecosystem.
- Depending on your location, regulatory agencies may include federal, state, or local policies.
- In general, if your location is regulated by nutrient policies (such as nutrient management plans), all of your nutrient BMPs will be designed according to these policies.
- Understand the importance of nutrient licensing.

Best Management Practices

- Identify who must be licensed.
- Describe differing licenses, if applicable.
- Provide the minimum requirement.
- Detail the Continued Education Unit required to maintain the license.
- Understand the value of training programs.
- Contact local and state organizations for regulatory restrictions.

SOIL TESTING

Principles

- The purpose of a soil test is to provide a detailed report which includes, among other variables, soil pH, soil organic matter, soil salts, and current nutrient levels. It also offers a prediction of a plant's response to an applied nutrient.

Best Management Practices

- Accurate and consistent sampling is essential to providing useful soil test information over time.
- Divide the course into sections such as greens, fairways, tees, roughs, etc., for each hole.
- Ten to 15 soil samples should be randomly taken from each section consisting of the same volume and taken from the same depth. Within the top 3-4" of soil is recommended. The individual samples should be blended together to provide a representative, uniform section soil sample.
- Use an extractant appropriate for your soils.
- The same extractant must be used for each test in order to compare soil test results over time.
- If the location has correlation data between a given nutrient applied to soil and a response to that nutrient by turfgrass, then recommendations may provide expected results.
- If your location does not have correlation data, then soil test recommendations may be of little value.
- Keeping soil tests from prior years will allow you to observe changes over time.
- This practice can provide good evidence of the impact of your nutrient management plan.
- Consult with your local land grant university to obtain the most current information and better understand which soil test values are relevant in your location.

Soil Testing for Effective Nutrient Management

Through proper sampling, laboratory analysis, interpretation of results, recommendations, and record keeping, soil testing can be used to manage nutrients more efficiently.

PLANT TISSUE ANALYSIS

Principles

- Because of the mobility and conversion of elements within the soil; soil sampling can be less predictable than tissue testing. Tissue testing provides a precise measurement of nutrients within the plant. Tissue test sufficiency ranges are only as good as the correlation data of a given element to an acceptable quality level of a given turfgrass. Typically, tissue correlation data are more prevalent than soil test correlation data and, therefore, programs designed around tissue testing may provide more reliable results.
- Through proper sampling, consistent intervals, and record keeping, tissue sampling may be used to measure existing turf health

Best Management Practices

- Tissue samples may be collected during regular mowing.
- Do not collect tissue after any event that may alter the nutrient analysis. Events may include fertilization, topdressing, pesticide applications, etc.
- Place tissue in paper bags, not plastic.
- If possible, allow tissue samples to air-dry at your facility before mailing them.
- Poor-quality turfgrass that is of concern should be sampled separately from higher-quality turfgrass.
- When turfgrass begins to show signs of nutrient stress, a sample should be collected immediately.
- More frequent tissue sampling allows a more accurate assessment of your turfgrass nutrient status changes over time.

- The quantity of tissue analysis should be based on individual site needs. However, two to four tests per year are common on greens and one to two tests per year are common on tees and fairways.
- Keeping tissue tests from prior years will allow you to observe changes over time.
- Tissue testing can provide good evidence of the impact of your nutrient management plan.

FERTILIZERS USED IN GOLF COURSE MANAGEMENT

Principle

Understanding the components of fertilizers, the fertilizer label, and the function of each element within the plant are all essential in the development of an efficient nutrient management program.

Macronutrients

Macronutrients are required in the greatest quantities and include nitrogen (N), phosphorus (P), and potassium (K).

Understanding the role of each macronutrient within the plant should provide a greater understanding of why these nutrients play such a key role in proper turfgrass management.

The Role of Nitrogen (N)

Nitrogen is required by the plant in greater quantities than any other element except carbon (C), hydrogen (H), and oxygen (O). Nitrogen plays a role in numerous plant functions including an essential component of amino acids, proteins and nucleic acids.

- Fate and transformation of N
- The goal of all applied nutrients is to maximize plant uptake while minimizing nutrient losses. Understanding each process will increase your ability to make sound management decisions and ultimately leads to an increase in course profitability and a reduction in environmental risk.
- The release mechanism and factors influencing N release from available N sources

Nutrient Management Terminology

- Grade or analysis is the percent by weight of Nitrogen (N), Phosphorous fertilizer (P2O5) and Potassium fertilizer (K2O) that is guaranteed to be in the fertilizer.
- A complete fertilizer contains N, P2O5, and K2O.
- The laws governing the labeling of fertilizer vary greatly among states. Consult your land-grant university or the appropriate state agency regarding the laws in your location.

Label

- The label is intended to inform the user about the contents of the fertilizer which, if understood and followed, will result in little to no environmental risk.
- The fertilizer label may contain:
  - Brand
  - Grade
  - Manufacturer's name and address
  - Guaranteed analysis
  - "Derived from" statement
  - Net weight

Nitrogen Processes

Mineralization	microbial mediated conversion of organic N into plant-available NH4
Nutrification	microbial-mediated conversion of NH4 to NO3
Denitrification	microbial mediated conversion of NO3 to N gas; this primarily occurs in low-oxygen environments and is enhanced by high soil pH
Volatization	conversion of NH4 to NH3 gas
Leaching	downward movement of an element below the rootzone
Runoff	lateral movement of an element beyond the intended turfgrass location

Understanding how certain N sources should be blended and applied is an essential component in an efficient nutrient management plan. In many cases, N sources are applied without regard to their release characteristics. This is an improper practice and increases the risk of negative environmental impact. Each N source (particularly slow-release forms) is unique and therefore should be managed accordingly. Applying a polymer-coated urea in the same manner one would apply a sulfur-coated urea greatly reduces the value of the polymer-coated urea. Similarly, applying 2 pounds of N from ammonium sulfate may cause burning, while applying 2 pounds of N from certain polymer-coated ureas may not provide the desired turfgrass response. Rate, application date, location, and turfgrass species all should be included in your nutrient application decision.

Soluble nitrogen sources

- Urea (46-0-0)
- Ammonium sulfate (21-0-0)
- Diammonium phosphate (18-46-0)
- Monoammonium phosphate (11-52-0)
- Calcium nitrate (15.5-0-0)
- Potassium nitrate (13-0-44)

Slow-release nitrogen sources

A slow-release N source is any N-containing fertilizer where the release of N into the soil is delayed either by requiring microbial degradation of the N source, by coating the N substrate which delays the dissolution of N, or by reducing the water solubility of the N source. These include:

- Sulfur-coated urea
- Polymer/resin-coated
- Isobutylidene diurea
- Urea-formaldehyde/ureaformaldehyde reaction products
- Natural organic

Urease and nitrification inhibitors

- Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and an increase in plant-available N.
- Nitrification inhibitors reduce the activity of Nitrosomonas bacteria, which are responsible for the conversion of NH4 to NO2. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N.

The Role of Phosphorous (P)

Phosphorus can be a growth-limiting factor for many unintended organisms and is a major contributor to eutrophication of water bodies. Thus, proper timing and rates should be implemented to reduce the risk of off-site movement of phosphorus.

Phosphorus forms high-energy compounds that are used to transfer energy within the plant. Phosphorus may remain in an inorganic form or may become incorporated into organic compounds. Phosphorous application rates should be based upon soil test results derived from documented correlations demonstrating a turf response to soil test phosphorous levels.

P deficiency symptoms

- Initially, reduced shoot growth and dark green color may be observed
- Later, lower leaves may turn reddish at the tips and then the color may progress down the blade

P sufficiency ranges

Consult your land-grant university for sufficiency ranges in your location.

P fertilizer sources

- Diammonium phosphate
- Concentrated superphosphate
- Monoammonium phosphate
- Natural organics

The Role of Potassium (K)

Potassium is of no environmental concern, but can be an economic concern, particularly when potassium is over-utilized, which can be quite common. Generally, potassium concentrations in turfgrass tissue are about 1/3 to 1/2 that of nitrogen.

Potassium is not a component of any organic compound and moves readily within the plant. Potassium is key component of osmoregulation which has been documented to increase stress resistance.

K deficiency symptoms

Except under severe, documented deficiencies, K may not have an observable influence on turfgrass quality. Yellowing of older leaves followed by tip dieback and scorching of leaf margins have been reported.

K sufficiency ranges

Consult your land-grant university for sufficiency ranges in your location.

K fertilizer sources

- Potassium sulfate
- Potassium chloride
- Potassium nitrate

Secondary Macronutrients

Secondary macronutrients are essential to plant function and are required in quantities less than N, P, and K, but more than micronutrients. These include calcium (Ca), magnesium (Mg), and sulfur (S)

The Role of Calcium (Ca)

- Primarily a component of cell walls and structure
- Consult your land-grant university for sufficiency ranges in your location
- Found in gypsum, limestone, and calcium chloride

The Role of Magnesium (Mg)

- Central ion in the chlorophyll molecule and chlorophyll synthesis
- Consult your land-grant university for sufficiency ranges in your location
- Found in Sul-Po-Mag, dolomitic limestone, and magnesium sulfate

The Role of Sulfur (S)

- Metabolized into the amino acid, cysteine, which is used in various proteins and enzymes
- Consult your land-grant university for sufficiency ranges in your location
- Found in ammonium sulfate, elemental sulfur, gypsum, potassium sulfate

Micronutrients

Understanding the role of each micronutrient within the plant should provide you with a greater understanding of why these nutrients play such a key role in proper turfgrass management.

Micronutrients are just as essential for proper turfgrass health as macronutrients, but they are required in very small quantities compared to macronutrients. Micronutrients include iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), and Chlorine (Cl).

Consult your land-grant university for micronutrient sufficiency ranges in your location.

The Role of Iron (Fe)

- Is part of the catalytic enzymes and is required for chlorophyll synthesis
- Affects photosynthesis, nitrogen fixation, and respiration
- Consult your land-grant university for sufficiency ranges in your location

The Role of Manganese (Mn)

- Involved in photosynthesis
- Required as a cofactor for ~35 enzymes
- Lignin biosynthesis depends on Mn

The Role of Boron (B)

- Found in the cell wall; probably required for the structural integrity of the cell wall

The Role of Copper (Cu)

- Cu-protein plastocyanin is involved in photosynthesis
- Cofactor for a variety of oxidative enzymes

The Role of Zinc (Zn)

- Structural component of enzymes
- Protein synthesis requires Zn
- Carbohydrate metabolism affected by Zn

The Role of Molybdenum (Mo)

- Primarily related to nitrogen metabolism
- Structural and catalytical functions of enzymes

The Role of Chlorine (Cl)

- Required for the oxygen-evolving reactions of photosynthesis
- Also appears to be required for cell division in both leaves and shoots

SOIL PH

Principles

Soil pH is a measure of a soil's acidity or alkalinity. Identifying a soil's pH level is one of the most important aspects of proper turfgrass management, as it affects the availability of nutrients for the turf. In most cases, a pH of 6.3 is ideal because it provides the greatest probability of micronutrient availability. In the Rocky Mountain region, many soils have a pH in the 7.0 - 8.3 range and are considered alkaline. Therefore, most efforts in this part of the country focus on lowering the pH in order to release the nutrients that are bound and unavailable to the grass plant. It is important to keep in mind, however, that long-term soil pH adjustments may occur very slowly and are often temporary.

Best Management Practices

- Test soil pH as part of regular soil testing.
- To increase soil pH, apply a liming material (calcium carbonate, calcium oxide, dolomitic limestone) that contains Ca2+ and neutralizes acidity.
- To lower soil pH, products containing elemental sulfur can be applied.
- Injecting acidic products into irrigation water to lower and/or stabilize pH can be beneficial.

NUTRIENT MANAGEMENT

Principles

- Within each state, environmental conditions vary greatly including differences among soils, topography, rainfall, and temperature. These differences require that a nutrient management plan be flexible enough to allow turfgrass managers to address their unique needs.
- Understand the importance of application timing for effective use of applied nutrients.

Best Management Practices

- The objective of all nutrient applications is plant uptake and the corresponding desirable response.
- Apply nutrients when turfgrass is actively growing.
- Apply slow-release N fertilizers at the appropriate time of year to maximize the products' release characteristics. For example, an application of slow-release N to warm-season turfgrasses in fall may not be as effective as the same application applied in early summer because of the prolonged release time in fall.
- Follow N application rate recommendations from your local land-grant university.
- N application rates from slow-release materials should take into consideration the release rate of the chosen material. If insufficient material is applied, the desired response may not be observed.
- Consult your local land-grant university for efficient N: K in your location.
- The reduced height of cut and excessive traffic damage on putting greens results in an increased need for growth leading to an increase in nutrition requirements.
- Tees and landing areas often have higher fertility requirements than fairways and roughs because they suffer constant divot damage.
- Fairways and roughs often require less nutrient inputs than other locations because of their increased height of cut, less damage, and clipping return.
- Exercise caution when applying nutrient applications during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff.
- Provide appropriate rates and products to minimize N loss without reducing turfgrass establishment.
  - Increased water applications
  - Increased nutrients to hasten establishment
  - Reduced root mass
- Be aware of the different types of spreaders and understand the advantages and disadvantages of each.
- Not all fertilizers can be spread with every spreader. For example, if sulfur-coated urea was spread through a drop spreader, the sulfur coating could be damaged, essentially leading to an application of soluble urea.
- Choose the appropriate spreader for a given fertilizer material.
  - Walk-behind rotary
  - Drop spreader
  - Bulk rotary
  - Spray
- Calibration reduces environmental risk and increases profitability.
- Proper fertilizer storage, loading, and clean-up reduce environmental risk.
- Avoid applying fertilizer to soils that are at, or near, field capacity or following rain events that leave the soils wet.
- Do not apply fertilizer when the National Weather Service has issued a flood, tropical storm, or hurricane water or warning, or if heavy rains are likely.

CULTURAL PRACTICES

MOWING

Certain cultural practices such as mowing, verticutting, and rolling are necessary to provide a high-quality playing surface, while others such as aerification are required to enhance plant health.

Heavily used areas such as putting greens often deteriorate because of compacted soil, thatch accumulation, and excessive use. Soil problems from active use are usually limited to the top three inches of the soil profile and should be actively managed to enhance turf health and improve nutrient and water uptake.

Unlike annual crops, which offer the opportunity for periodic tilling of the soil profile to correct problems like soil compaction that might develop over time, turfgrass does not offer opportunities for significant physical disturbance of the soil without destroying the playing surface. Core aerification is a cultural practice that helps manage soil compaction with less physical disturbance.

Principles

- Mowing is the most basic yet most important cultural practice to consider when developing a management plan.
- The mowing practices implemented on a facility will have an impact on turf density, texture, color, root development, and wear tolerance.
- Mowing practices affect turfgrass growth. Frequent mowing will increase shoot density and tillering. It will also decrease root and rhizome depth as a result of plant stress associated with removal of leaf tissue.
- Infrequent mowing results in alternating cycles of vegetative growth followed by scalping, which further depletes food reserves of the plants.

Cultivation practices are an important part of golf course turf management.

- Proper mowing height is a function of the species/cultivar being managed and the intended use of the site. Other factors influencing mowing height include mowing frequency, shade, mowing equipment, time of year, root growth, and abiotic and biotic stress, weather conditions, tournament conditions, member/guest requirements.
- Maintaining an optimal root-to-shoot ratio is critical. Turfgrass plants that are mowed too low will require a substantial amount of time to provide the food needed to produce shoot tissue for future photosynthesis. If turf is mowed too low in one event, an imbalance occurs between the remaining vegetative tissue and the root system, resulting in more roots being present than the plant needs physiologically. As a result, the plants will slough off the unneeded roots. Root growth is least affected when no more than 30% to 40% of leaf area is removed in a single mowing.
- Failure to mow properly will result in weakened turf with poor density and quality

Best Management Practices

- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods. Rolling Greens with light weight equipment can help maintain green speeds as well as the practice of spot rolling pin locations to reduce wear during stress periods. Dew whipping is also a practice to alleviate any mechanical stress during high stress times while removing dew for play.
- If turf becomes too tall, it should not be mowed down to the desired height all at once. Such severe scalping reduces turf density and can result in a dramatic reduction in root growth. Tall grass should be mowed frequently and height gradually decreased until desired height of cut is achieved.
- Shade affects turfgrass growth by filtering out photosynthetically active radiation. Turfgrass plants respond by growing upright in an effort to capture more light to meet their photosynthetic needs. As a result, mowing height should be increased by

at least 30% to improve the health of turf grown in a shaded environment. This may be an unreasonable goal on highly maintained turf such as greens, tees and fairways. Also the use of separate mowers for certain areas could be costly and inefficient.

- The use of the plant growth regulator trinexapac-ethyl has been shown to improve overall turf health when used as a regular management tool for grasses growing in shaded environments.
- Environmental stresses such as prolonged cloudy weather or drought can have a significant impact on turf health. Increase mowing heights as much as use will allow in order to increase photosynthetic capacity and rooting depth of plants.
- Use proper mowing equipment. A maintained fleet of equipment is essential to the health of all turfgrass stands. It is imperative that equipment be sharpened to perform at its best to help reduce stresses on grass plants that can result in disease, water loss, visually unacceptable grass plants. Sharpened and correctly set blades will ensure quality of cut and plant health.
- Reel mowers are ideally suited for maintaining turfgrass stands that require a height of cut below 1.5 inches. They produce the best quality when compared to other types of mowers.
- Rotary mowers, when sharp and properly adjusted, deliver acceptable cutting quality for turf that is to be cut above 1.5 inch in height. Dull blades will result in shredding of leaf tissue, increasing water loss and the potential for disease development.
- Flail mowers are most often used to maintain utility turf areas that are mowed infrequently and do not have a high aesthetic requirement, i.e. out of play or native areas that are mowed 1-2 times per season.
- Mowing patterns influence both the aesthetic and functional characteristics of a turf surface. As turfgrass managers it's our responsibility to find more efficient avenues to reduce mechanical noise, pollution, wear on turf for health, and damage to the environment. Mowing directions and patterns should be taken into consideration with all of these aspects in mind.
- Turfgrass clippings are a source of nutrients, containing 2% to 4% nitrogen on a dry-weight basis, as well as significant amounts of phosphorus and potassium.
- Nutrients contained in clippings can be sources of pollution and should be handled properly. Clippings from highly maintained areas such as greens and tees, possibly fairways depending on turf variety are often collected to achieve less unsightly and unplayable circumstances. These clippings can be returned to other sites on property such as roughs or native areas more than 200 ft away from water sources. At no time should clippings be returned to water bodies as such that it may present nutrients into water bodies that are less than beneficial to the ecology of that area. Clippings high in nutrients can create eutrophication in water and thus can lead to and produce algal blooms.
- Clippings should be returned to the site during the mowing process unless the presence of grass clippings will have a detrimental impact on play. Cases when clippings should be removed include times when the amount of clippings is so large that it could smother the underlying grass or on golf greens where clippings might affect ball roll.
- Collected clippings should be disposed of properly to prevent undesirable odors near play areas and to prevent fire hazards that can occur when clippings accumulate. Consider composting clippings or dispersing them evenly in natural areas where they can decompose naturally without accumulating in piles.

CULTIVATION

Principles

- Cultivation involves disturbing the soil or thatch through the use of various implements to achieve important agronomic goals that include relief of soil compaction, thatch/organic matter reduction, improved percolation rates and improved water and air exchange.
- Cultivation techniques will result in disturbance of the playing surface that can require significant time for recovery.
- Frequency of cultivation should be based on, but not limited to, traffic intensity, high stress periods, percolation rates and level of soil compaction.
- Core aerification is effective at managing soil compaction and aiding in improvement of soil drainage.
- Accumulation of excessive thatch and organic matter will reduce root growth, encourage disease and insects, and create undesirable playing conditions.
- Light and frequent applications of sand will smooth the playing surface of putting greens, control thatch, and potentially change the physical characteristics of the underlying soil when done in conjunction with core aerification.

Turfgrass Cultivation Methods & Rankings of Agronomic Benefits

Method	Compaction Relief Inches	Thatch Control	Water/air Movement	Disruption of Play
Core aerification	High	Good[1]	High	Medium to high[1]
Deep drilling	Medium	Low	High	High
Verticutting	Low	Best[1]	Medium	Low to high[2]
Grooming	None	Very low	Very low	None
Solid tining	Low[3]	None	High	Medium-low
Spiking/slicing	None	Very low	Low	None
High pressure water injection	Very low	None	Medium-High	Very low

[1] Verticutting removes a greater amount of thatch, but does so only to a maximum of about 0.7"; core aerification is a better approach if excess thatch and organic matter accumulation from 0- 3" must be removed
[2] Use of bigger tines when core aerifying disrupts play for longer; similarly, use of verticutters with wider blades, closer blade spacing, and deeper settings increases length of play disruption.
[3] Compaction relief with solid tining is low except when equipped with a "kicking action" that results in some soil loosening.

Source: "Environmental Best Management Practices for Virginia's Golf Courses" (Virginia Golf Course Superintendents Association, 2012)

Best Management Practices

- Core aerification involves removal of small cores or plugs from the soil profile. Cores are usually 0.25 to 0.75 inch in diameter. Annual core aerification programs should be designed for putting greens/tees to remove 15%-20% of the surface area. High-traffic areas may require a minimum of two to four core aerifications annually.
- Core aerification should be conducted only when grasses are actively growing to aid in quick recovery of surface density. Many Colorado mountain golf courses aerify late in the season before snow cover to help with improved drainage during high snowmelt in the spring. During this time the turf is not actively growing and this should be taken into account.
- Vary depth of aerification events by incorporating varying length tines to prevent development of compacted layers in the soil profile as a result of cultivation.
- Solid tines cause less disturbance to the turf surface and can be used to temporarily reduce compaction and soften surface hardness during months when the growth rate of grasses has been reduced. Benefits of solid-tine aerification are temporary because no soil is removed from the profile. Small solid tine aerification can help with air exchange during stressful periods of high monsoonal moisture, common during the summers of Colorado. This less invasive practice can help alleviate disease pressure as well as increased air exchange in the soil.
- Deep-drill aerification creates deep holes in the soil profile through use of drill bits. Soil is brought to the surface and distributed into the canopy. Holes can be backfilled with new root-zone materials if a drill-and-fill machine is used. These machines allow replacement of heavier soils with sand or other materials in an effort to improve water infiltration into the soil profile.
- Slicing and spiking reduce surface compaction and promote water infiltration with minimal surface damage.

- Slicing is faster than core aerification but is less effective. Slicing is best accomplished on moist soils.
- A spiker can break up crusts on the soil surface, disrupt algae layers, and improve water infiltration.
- Vertical mowing (verticutting) can be incorporated into a cultural management program to achieve a number of different goals. The grain of a putting green can be reduced by setting a verticutter to a depth that just nicks the surface of the turf. Deeper penetration of knives will stimulate new growth by cutting through stolons and rhizomes while removing accumulated thatch.
- Verticutting depth for thatch removal should reach the bottom of the thatch layer and extend into the surface of the soil beneath the thatch.
- Dethatching with a verticutter is an aggressive practice. Extreme caution should be taken if used on golf putting greens because of the damage that occurs and the extensive recovery time required.
- Initiate vertical mowing when thatch level reaches 0.25 to 0.5 inch in depth. Shallow vertical mowing should be completed at least monthly on putting greens to prevent excessive thatch accumulation. Although vertical mowing is extensively used, some newer methods of not using these mowers has proven to be effective on poa annua management on bentgrass greens. Utilizing the bentgrass growth habits for its creeping abilities it has shown to overtake the more bunch type poa annua by not vertically cutting desired bentgrass leaf tissue. This practice can lead to less water and chemical usage on playing surfaces while trying to maintain poa annua in bentgrass greens.
- Groomers, or miniature vertical mowers attached to the front of reels, are effective at improving management of grain and improving plant density through cutting of stolons.
- Topdress the playing surface with sand following core aerification and heavy vertical mowing to aid in recovery of turf. Rates will vary from 0.05 to 0.125 inch in depth and will depend on the capacity of the turf canopy to absorb the material without burying the plants.
- Light, frequent applications of topdressing sand on putting greens can smooth out minor surface irregularities, aiding in the management of thatch accumulation.
- Use only weed-free topdressing materials with a particle size similar to that of the underlying root zone.
- Use of finer materials can result in layering and can have a negative impact on water infiltration.
- Daily rolling of putting surfaces following mowing can increase putting speeds by roughly 10%, allowing for improved ball roll without lowering height of cut.
- To minimize potential for compaction caused by rolling, use light weight rollers.

SHADE AND TREE MANAGEMENT

Principles

- In general, most turfgrasses perform best in full sun.
- Excessive shade reduces photosynthesis and air circulation, thus increasing the susceptibility of the turf to pest and disease problems.
- Competition from tree roots can have negative impacts on turfgrass health and performance.
- Tree planting plans should be thought through with turfgrass health as a key component in new tree locations.

Best Management Practices

- Prune tree limbs and roots as needed to reduce competition for sunlight, water, and nutrients.
- When possible, trees located near closely mowed areas such as tees and greens should be removed or their canopy should be thinned to promote good turf growth.
- When feasible without impacting turf areas and course playability, plant trees to provide shade to waterways, helping to maintain healthy water temperatures for aquatic life
- Understand the variability in sun angles at different times of the year and how this affects turf health.
- Conduct a shade audit to identify problem areas. This would include how shade impacts all aspects of closely mown turf areas throughout the entire year.
- Conduct a tree survey that identifies each tree's location, species, health, life expectancy, safety concerns, value and special maintenance requirements.

INTEGRATED PEST MANAGEMENT

REGULATORY CONSIDERATIONS

The objective of integrated pest management (IPM) is to reduce pesticide use by using a combination of tactics to control pests, including cultural, biological, genetic, and chemical controls.

A successful IPM program on golf courses can help minimize inputs of time, labor, and financial resources. To grow healthy turfgrass, it is important for golf course superintendents to know what IPM is and how to implement it for each pest group (arthropods, nematodes, diseases, and weeds). They must be well-versed in pest identification, understand pest life cycles and/or conditions that favor pests, and know about all possible methods of controlling pests.

Principles

- Some federal or state regulations cover practically anyone who manufactures, formulates, markets, and uses pesticides.
- Record keeping of pesticide use may be required by law. IPM principles suggest that you keep records of all pest control activity so that you may refer to information on past infestations or other problems to select the best course of action in the future.

Best Management Practices

- Proper records of all pesticide applications should be kept according to local, state, or federal requirements.
- Develop a Pesticide Control Plan including:
  - Management of empty containers
  - Management and record keeping for disposal of unused pesticide products

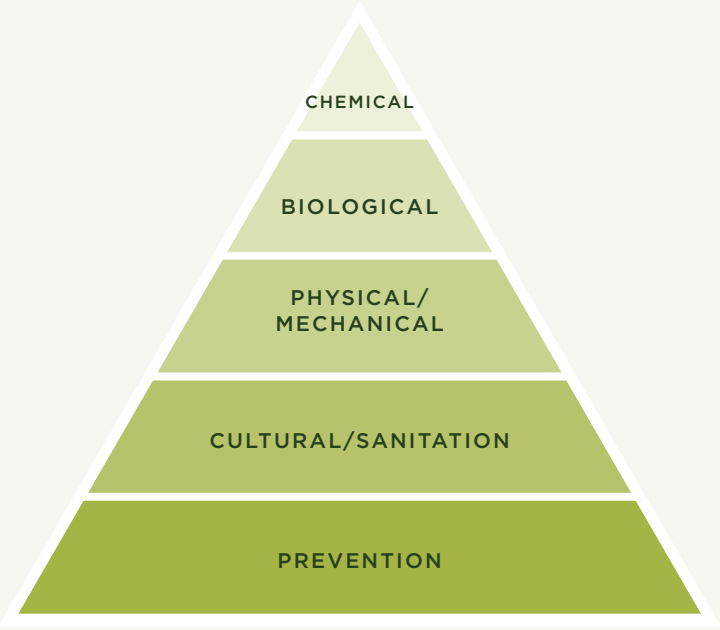
Benefits of IPM include reducing risk of pesticide exposure to people, animals, and the environment, conserving energy, and reducing expenses.

Pesticide Application Record	Details
Date and time of application	
Name of applicator	
Person directing or authorizing application	
Weather conditions at time of application	
Target pest(s)	
Pesticide used (trade name, active ingredient, amount of formulation, amount of water)	
Adjuvant/surfactant and amount applied, if used	
Area treated (acres or square feet) and location	
Total amount of pesticide used	
Application equipment	
Additional remarks (e.g., severity of infestation or life stage of pest)	
Follow-up to check effectiveness of application	

IPM OVERVIEW

Principles

- The fundamental basis of an environmentally sound pest control program is a process called IPM.
- IPM focuses on the basics of identifying the pests, choosing pest-resistant varieties of grasses and other plants, enhancing the habitat for natural pest predators, scouting to determine pest populations and determining acceptable thresholds, and applying biological and other less toxic alternatives to chemical pesticides whenever possible.
- Chemical controls should have minimal effect on beneficial organisms and the environment and minimize the development of pesticide resistance.



IPM Pyramid

Best Management Practices

- Chemical pesticide applications should be carefully chosen for effective and site-specific pest control with minimal environmental impact.
- Identify key pests on key plants.
- Determine the pest's life cycle and know which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Use cultural, mechanical, or physical methods to prevent problems from occurring (for example, prepare the site, select resistant cultivars), reduce pest habitat (for example, practice good sanitation, carry out pruning and dethatching), or to help promote biological control (for example, provide nectar or honeydew sources).
- Decide which pest management practice is appropriate and carry out corrective actions. Direct control where the pest lives or feeds.
- Use preventive chemical applications only when your professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.

WRITTEN PLAN

Principles

- IPM is an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, other applicable practices, and is a last measure when threshold levels are exceeded.
- A pest-control strategy should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated. A control strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.
- When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, and site characteristics, as well as its solubility and persistence.

Best Management Practices

- Decide which pest management practice(s) are appropriate and carry out corrective actions. Direct control where the pest lives or feeds. Use properly timed preventive chemical applications only when your professional judgment indicates they are likely to control the target pest effectively, while minimizing the economic and environmental costs.
- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging the pests are and what control strategies are necessary.

PEST THRESHOLDS

Principles

- IPM is commonly used in agricultural crop production, where the economic thresholds for key pests have been determined. Pest levels exceeding the site's threshold warrant treatment.
- Using IPM is more challenging on golf courses than in an agricultural setting. The golf industry is sensitive to aesthetic damage, and golfers are often intolerant of anything that could affect the appearance of turfgrass and ornamental plants. Increased education of golfers and maintenance personnel could raise tolerance of minor aesthetic damage without compromising plant health, play, and aesthetics.

Best Management Practices

- Use available pest thresholds to guide pesticide application decisions (see IPM Guide).
- Use preventive chemical applications only when professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Record and use this information when making similar decisions in the future.
- Develop a plan/perform routine education of golfers and staff on aesthetic damage tolerance.

MONITORING

Principles

- Monitoring, or scouting, is the most important element of a successful IPM program. Monitoring documents the presence and development of pests, or the conditions that are conducive for pest outbreak throughout the year.
- It is essential to record the results of scouting in order to develop historical information, document patterns of pest activity, and document successes and failures.

Best Management Practices

- Train personnel to observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.
- Train personnel to determine the pest's life cycle and know which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Train personnel to determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Train personnel to document, identify, and record key pest activities on key plants.
- Look for signs of the pest. These may include mushrooms, animal damage, insect frass, or webbing.
- Identify the symptoms of the pest. Look for symptoms such as chlorosis, dieback, growth reduction, defoliation, mounds, or tunnels.
- Determine the damage. Problem areas might include the edges of fairways, shady areas, or poorly drained areas.
- Document when the damage occurred. Note the time of day, year, and flowering stages of nearby plants.
- Map pest outbreaks locations to identify patterns and susceptible areas for future target applications and ultimate pesticide reductions.

RECORD KEEPING

Principles

- It is essential to record the results of scouting in order to develop historical information, document patterns of pest activity, and document successes and failures.
- Pesticide record keeping is required to comply with the federal Superfund Amendments and Reauthorization Act (SARA, Title III), which contains emergency planning and community right-to-know legislation
- Certain pesticides are classified as restricted-use pesticides (RUPs). Very few pesticides in this category are routinely used in turf maintenance, but if you happen to use one of them, certain record-keeping requirements apply.

Best Management Practices

- Document, identify, and record key pest activities on key plants and locations.
- Document the pest's life cycle and document which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Determine and record whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Use this information when making similar decisions in the future.
- Observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.

TURFGRASS SELECTION

Principles

- Selecting pest-resistant cultivars or plant species is a very important part of IPM, and it leads to reduced pesticide usage. Species grown outside of their zone of adaptation are more prone to pest problems.
- Species and cultivars should be managed under conditions similar to their intended use (for example, not exceeding mowing height limitations that a grass was bred for or selected for).
- Educate builders, developers, golf course and landscape architects, sod producers, golfers and others on which plants are best suited to their areas.
- Turfgrasses must be scientifically selected for the eco-region of the golf course, resulting in minimized irrigation requirements, fertilization needs, and pesticide use.

Best Management Practices

- Select the most suitable turfgrass for existing conditions and one that adheres to design specifications.
- Avoid use of turfgrass in heavy shade.
- Select shade-adapted grasses for areas receiving partial sun or shaded areas.
- Reduce pest and disease pressures by correcting dead spots and air-circulation issues by pruning understory and adjusting irrigation scheduling.
- Reduce fertilizer applications in shaded areas.
- Reduce traffic in shaded areas to protect turfgrasses and trees from injury and soil compaction, if practical.

BIOLOGICAL CONTROLS

Principles

- The biological component of IPM involves the release and/or conservation of natural predators, such as parasites and pathogens, and other beneficial organisms (pollinators).
- Natural enemies (including ladybird beetles, green lacewings, and mantids) may be purchased and released near pest infestations.
- Areas on the golf course can also be modified to better support natural predators and beneficial organisms.

Best Management Practices

- Identify areas on the golf course that can be modified to attract natural predators, provide habitat for them, and protect them from pesticide applications.
- Install flowering plants that can provide parasitoids with nectar, or sucking insects (aphids, mealybugs, or soft scales) with a honeydew source.
- Avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- Release insect-parasitic nematodes to naturally suppress mole crickets and white grubs.

POLLINATORS

Principles

- It is important to minimize the impacts on bees and beneficial arthropods. Pesticide applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans.
- Pollinator-protection language is a label requirement found on pesticide labels.
- Be mindful of pollinators; when applying pesticides, focus on minimizing exposure to non-target pollinators in play and non-play course areas.
- Pollinators may be negatively impacted when pesticide applications are made based on insufficient information and/or made without regard to the safety of pollinators.

Best Management Practices

- Develop new pollinator habitat and/or enhance existing habitat. Non-playable areas of golf courses make excellent pollinator habitats.
- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.
- Before applying a pesticide, scout/inspect the area for both harmful and beneficial insect populations. Only use pesticides when a threshold of damage has been indicated.
- Mow flowering plants (weeds) before insecticide application.
- If flowering weeds are prevalent, control them before applying insecticides.
- Consider manual removal of weeds or spot spraying in pollinator habitat areas.
- Follow label information directing the application of pesticide when the plant may be in bloom. Avoid applying pesticides during bloom season.
- Stay on target by using coarse-droplet nozzles, and monitoring wind to reduce drift.
- Do not apply pesticides when pollinators are active. Always consider early a.m. or late p.m. applications when pollinators are less active.
- Use insecticides that have a lower impact on pollinators. Avoid use of any products that contain Chlorothalonil.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of pesticide. Refrain from trunk applied or root injected pesticides on flowering trees.
- Avoid applications during unusually low temperatures or when dew is forecast.
- Limit the use of granular pesticides because they can be mistaken for pollen and can be hazardous to bees.

CONVENTIONAL PESTICIDES

Principles

- IPM does not preclude the use of pesticides. However, pesticides should be viewed as one of the many tools used to minimize pest problems.
- IPM involves both prevention — keeping the pest from becoming a problem — and suppression — reducing the pest numbers or damage to an acceptable level.
- A pest-control strategy using pesticides should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated.
- Pesticides are designed to control or alter the behavior of pests. When, where, and how they can be used safely and effectively is a matter of considerable public interest.
- Pesticides should be evaluated on effectiveness against the pest, mode of action, life stage of the pest, personnel hazards, non-target effects, potential off-site movement, and cost.
- A control strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.
- Always follow the directions on the label. These directions have been developed after extensive research and field studies on the chemistry, biological effects, and environmental fate of the pesticide. The label is the single most important document in the use of a pesticide. State and federal pesticide laws require following label directions!

Best Management Practices

- Train employees in proper pest identification and pesticide selection techniques.
- Choose the product most appropriate for the problem or pest.
- Mix only the quantity of pesticide needed in order to avoid disposal problems, protect non-target organisms, and save money.
- Spot-treat pests whenever appropriate.
- Make note of any environmental hazards and groundwater advisories included on the label.
- Rotate pesticide modes-of-action to reduce the likelihood of resistance.
- Follow guidelines and advice provided by the Fungicide Resistance Action Committee (FRAC), Herbicide Resistance Action Committee (HRAC),and Insecticide Resistance Action Committee (IRAC).

DISEASE

Principles

- In the presence of a susceptible host and a conducive environment, plant pathogens can disrupt play by damaging and destroying intensely managed turf.
- No measure can completely eliminate the threat of turfgrass disease on a golf course. However, turfgrass managers have multiple tactics and tools that can reduce the likelihood of disease.
- Cultural factors that can influence turfgrass stress and the likelihood of disease problems include organic layer management, fertility programs, water management, and mowing height selection. Healthy, well-managed turfgrass is less likely to develop disease problems.
- Disease outbreaks that do occur are less likely to be severe on turf that is healthy because it has better recuperative potential than stressed, unhealthy turf.

Best Management Practices

- Correctly identify the disease pathogen. This often involves sending samples to diagnostic clinics.
- Ensure that proper cultural practices that reduce turfgrass stress are used.
- Correct conditions that produce stressful environments for the turf (for example, improve airflow and drainage, reduce or eliminate shade.)
- Fungicide use should be integrated into an overall management strategy for a golf course.
- The appropriate (most effective) preventive fungicide should be applied to susceptible turfgrasses when conditions favor disease outbreaks or unacceptable levels of disease are likely to occur.
- Record and map disease outbreaks and identify trends that can help guide future treatments and focus on changing conditions in susceptible areas to reduce disease outbreaks.

Weed management is an integrated process where good cultural practices are employed to encourage desirable turfgrass ground cover, and where herbicides are intelligently selected and judiciously used. A successful weed management program consists of:

- Preventing weeds from being introduced into an area
- Using proper turfgrass management and cultural practices to promote vigorous, competitive turf
- Properly identifying weeds
- Properly selecting and using the appropriate herbicide, if necessary

WEEDS

Principles

- Weeds compete with desired plants for space, water, light, and nutrients and can harbor insect pests and diseases.
- Weeds are hosts for other pests such as plant pathogens, nematodes, and insects, and certain weeds can cause allergic reactions in humans.
- Weeds reproduce from seed, root pieces, and special vegetative reproductive organs such as tubers, corms, rhizomes, stolons, or bulbs. People, animals, birds, wind, and water can distribute seeds.
- Weeds complete their life cycles in either one growing season (annuals), two growing seasons (biennials), or three or more years (perennials). Annuals that complete their life cycles from spring to fall are referred to as summer annuals. Those that complete their life cycles from fall to spring are winter annuals. Management strategies for weed should be applied at the appropriate time in their lifecycle.

Best Management Practices

- Proper weed identification is essential for effective management and control.
- Select appropriate turf species or cultivars that are adapted to the prevalent environmental conditions to reduce weed encroachment that may lead to bare soils.
- To prevent weed encroachment, adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures.
- To reduce weed infestation, address improper turf management practices, such as the misuse of fertilizers and chemicals, improper mowing height or mowing frequency, and improper soil aeration, and physical damage and compaction from excessive traffic.
- Proper fertilization is essential for turfgrasses to sustain desirable color, growth density, and vigor and to better resist diseases, weeds, and insects.
- Avoid scalping; it reduces turf density, increasing weed establishment.
- Weed-free materials should be used for topdressing.
- Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds.

- Record and map weed infestations to help identify site specific issues for preventative actions.
- For reference, the State of Colorado maintains a list of noxious weeds and requires property owners to manage noxious weeds. These weeds are classified in different categories and different species warrant different approaches to management.

NEMATODES

Principles

- Plant-parasitic nematodes adversely affect turfgrass health.
- Plant-parasitic nematodes are microscopic roundworms (unsegmented), usually between 0.0156 and 0.125 inch (0.25 and 3 mm) in length, and are difficult to control.
- Nematodes debilitate the root system of susceptible turfgrasses; plant-parasitic nematodes cause turf to be less efficient in water and nutrient uptake from the soil and make it much more susceptible to environmental stresses. Additionally, weakened turf favors pest infestation, especially troublesome weeds that necessitate herbicide applications.
- Over time, turf in the affected areas thins out and, with severe infestations, may die. The roots of turfgrasses under nematode attack may be very short, with few, if any, root hairs, or they may appear dark and rotten.
- Turfgrasses usually begin showing signs of nematode injury as they experience additional stresses, including drought, high temperatures, low temperatures, and wear.

Best Management Practices

- When nematode activity is suspected, an assay of soil and turfgrass roots is recommended to determine the extent of the problem.
- The application of a nematicide on golf course turf should always be based on assay results.
- Divert traffic away from areas that are stressed by insects, nematodes, diseases, or weeds.
- Increase mowing height to reduce plant stress associated with nematodes, root-feeding insects, disease outbreaks, or peak weed-seed germination.
- Reduce/eliminate other biotic/abiotic stresses when nematodes are compromising the root system and plant health.

PESTICIDE MANAGEMENT

REGULATORY CONSIDERATIONS

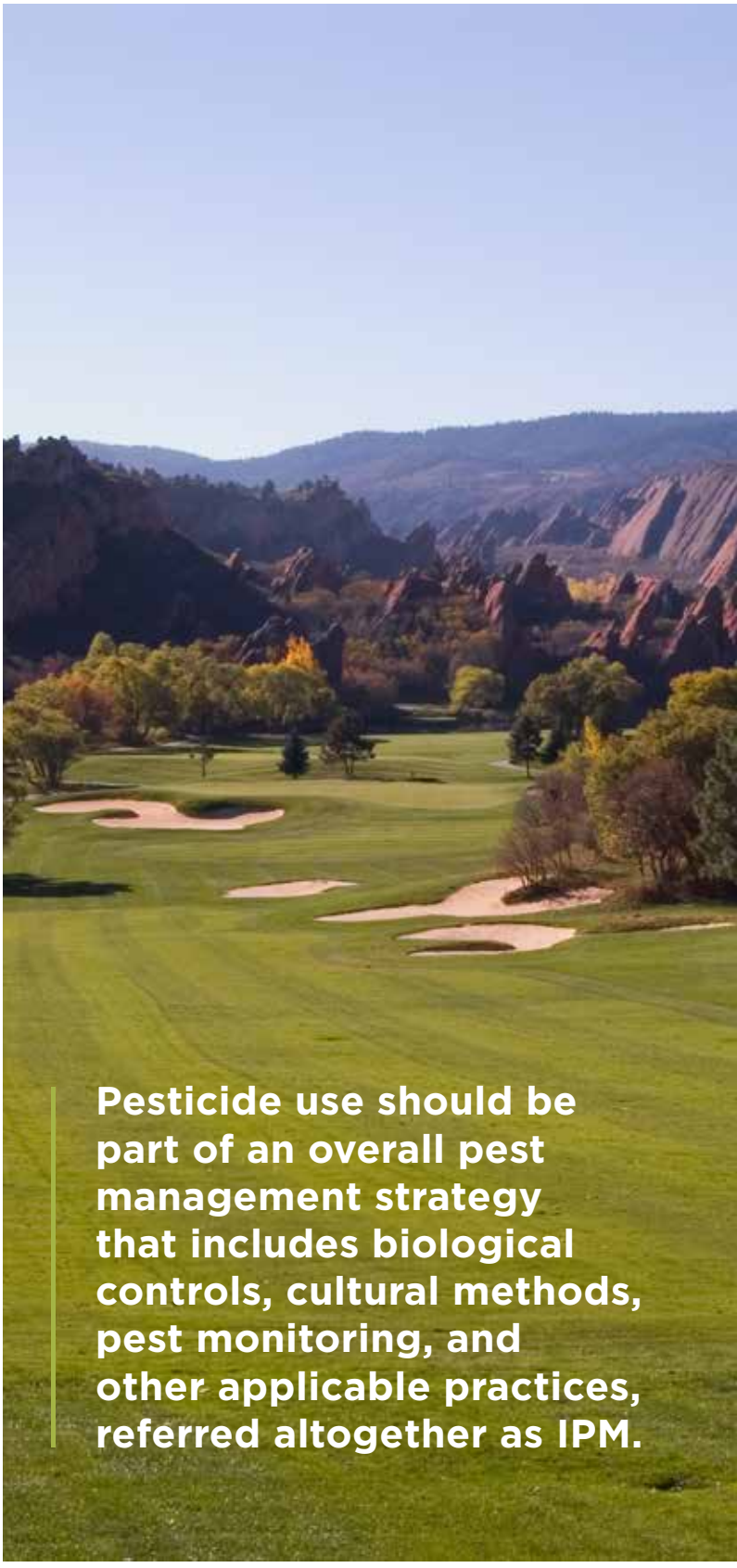
When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, site characteristics, and its solubility and persistence in the environment.

PrincipleS

Pesticides contain active ingredients (the component that targets the pest) and inert ingredients such as solvents, surfactants, and carriers. Both active and inert ingredients may be controlled or regulated by federal, state, and local laws because of environmental and health concerns.

Best Management Practices

- Only apply pesticides that are legally registered at all levels of jurisdiction.
- Only apply pesticides that are legally registered for use on the facility (for example, do not apply pesticides labeled for agricultural uses even though they may have the same active ingredient).
- Apply according to manufacturer recommendations as seen on label.



Pesticide use should be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices, referred altogether as IPM.

HUMAN HEALTH RISKS

Principle

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. The human health risk associated with pesticide use is related to both pesticide toxicity and the level of exposure. The risk of a very highly toxic pesticide may be very low if the exposure is sufficiently small.

Best Management Practices

- Select the least toxic pesticide with the lowest exposure potential.
- Know the emergency response procedure in case excessive exposure occurs.
- Use appropriate personal protective equipment and follow the label safety requirements.

ENVIRONMENTAL FATE AND TRANSPORT

Principle

Environmental characteristics of a pesticide can often be determined by the environmental hazards statement found on pesticide product labels. The environmental hazards statement (referred to as "Environmental Hazards" on the label and found under the general heading "Precautionary Statements") provides the precautionary language advising the user of the potential hazards to the environment from the use of the product. The environmental hazards generally fall into three categories: (1) general environmental hazards, (2) non-target toxicity, and (3) endangered species protection.

Best Management Practices

- Select pesticides that have a low runoff and leaching potential.
- Before applying a pesticide, evaluate the impact of site-specific characteristics (for example, proximity to surface water, water table, and well-heads; soil type; prevailing wind; etc.) and pesticide-specific characteristics (for example, half-lives and partition coefficients)
- Select pesticides with reduced impact on pollinators.
- Select pesticides that, when applied according to the label, have no known effect on endangered species present on the facility.

PESTICIDE TRANSPORTATION, STORAGE, AND HANDLING

Principle

Storage and handling of pesticides in their concentrated form poses the highest potential risk to ground or surface waters. For this reason, it is essential that facilities for storing and handling these products be properly sited, designed, constructed, and operated.

Best Management Practices

- Store, mix, and load pesticides away from sites that directly link to surface water or groundwater.
- Store pesticides in a lockable concrete or metal building that is separate from other buildings.
- Locate pesticide storage facilities from other types of structure to allow fire department access.
- Storage facility floors should be impervious and sealed with a chemical-resistant paint.
- Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- Sloped ramps should be provided at the entrance to allow the use of wheeled handcarts for moving material in and out of the storage area safely.
- Shelving should be made of sturdy plastic or reinforced metal.
- Metal shelving should be kept painted to avoid corrosion. Wood shelving should never be used, because it may absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided. Explosion-proof lighting may be required. Light and fan switches should be located outside the building, so that both can be turned on before staff enter the building and turned off after they leave the building.
- Avoid temperature extremes inside the pesticide storage facility.
- Personal protective equipment (PPE) should be easily accessible and stored immediately outside the pesticide storage area.
- Individuals handling pesticides should utilize appropriate PPE and be trained in proper handling procedures.
- Do not transport pesticides in the passenger section of a vehicle.
- Never leave pesticides unattended during transport.
- Place a spill containment kit in the storage area, in the mix/load area, and on the spray rig.
- Pesticide storage areas should be regularly inspected for improper storage practices, spills, leaks and other items of concern.

Safety First! Through Community Engagement

Host a tour for local emergency response teams (for example, fire fighters, etc.) to show them the facilities and discuss the emergency response plan. Or at a minimum, inform them of bulk storage of pesticides and provide the emergency response plan, including a map of the facility with the storage location noted.

EMERGENCY PREPAREDNESS AND SPILL RESPONSE

Principle

Accidents happen. Advance preparation on what to do when an accident occurs is essential to mitigate the human health effects and the impact on the environment.

Best Management Practices

- Develop a golf course facility emergency response plan which includes procedures to control, contain, collect, and store spilled materials.
- Prominently post “Important Telephone Numbers” including CHEMTREC, for emergency information on hazards or actions to take in the event of a spill; reference pesticide labels for additional emergency numbers.
- Ensure an adequately sized spill containment kit is readily available.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.
- Seek advice on ways to improve the plan.

PESTICIDE RECORD KEEPING

Principle

Maintaining accurate records of pesticide-related activities (for example, purchasing, storage, inventory, applications, disposal, etc.) is essential.

Best Management Practices

- Keep and maintain records of all pesticides used to meet legal (federal, state, and local) reporting requirements.
- Use records to monitor pest control efforts and to plan future management actions. Determine and record whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Use this information when making similar decisions in the future.
- Use electronic or hard-copy forms and software tools to properly track pesticide inventory and use.
- Develop and implement a pesticide drift management plan.
- Keep a backup set of records in a safe, but separate storage area.

SPRAYER CALIBRATION

Principle

Properly calibrated application equipment is paramount to mitigating environmental and human health concerns.

Best Management Practices

- Personally ensure spray technician is experienced, licensed, and properly trained.
- Minimize off-target movement by using properly configured application equipment.
- Properly calibrate all application equipment at the beginning of each season (at a minimum) or after equipment modifications.
- Check equipment daily when in use.
- Use recommended spray volumes for the targeted pest to maximize efficacy.
- Walk-behind applicators should be calibrated for each person making applications to take into consideration individual traits, e.g. walking speed, etc.

TYPES OF SPRAYERS

Principle

Various types and sizes of application equipment are readily available. The size of the equipment (tank size, boom width, etc.) should be matched to the scale of the facility.

Best Management Practices

- Use an appropriately sized applicator for the size of area being treated.
- Equipment too large in size requires greater volumes to prime the system. This can result in significant waste that must be properly handled.

INVENTORY

Principle

Do not store large quantities of pesticides for long periods. Adopt the "first in–first out" principle, using the oldest products first to ensure that the product shelf life does not expire.

Best Management Practices

An inventory of the pesticides kept in the storage building and the Safety Data Sheets (SDS) for the chemicals used in the operation should be accessible on the premises, but not kept in the pesticide storage room itself.

SHELF LIFE

Principles

- Pesticides degrade over time. Do not store large quantities of pesticides for long periods.
- Utilize computer software systems to record inventory and use.

Best Management Practices

- Avoid purchasing large quantities of pesticides that require storage for greater than six months.
- Adopt the "first in–first out" principle, using the oldest products first to ensure that the product shelf life does not expire.
- Many states offer "amnesty" days in order to eliminate potential public health and environmental hazards from cancelled, suspended, and unusable pesticides that are being stored.
- Ensure labels are affixed to every package and container. As per pesticide regulations labels must remain on packages/containers and be in good (readable) condition.
- Consult inventory when planning and before making purchases.

LEACHING POTENTIALS

Principle

Weakly sorbed pesticides (compounds with small Koc values) are more likely to leach through the soil and reach groundwater. Conversely, strongly sorbed pesticides (compounds with large Koc values) are likely to remain near the soil surface, reducing the likelihood of leaching, but increasing the chances of being carried to surface water via runoff or soil erosion.

Best Management Practices

- Understand pesticide sorption principles so that appropriate decisions can be made.
- Understand site characteristics that are prone to leaching losses (for example, sand-based putting greens, coarse-textured soils, shallow water tables).
- Identify label restrictions that may pertain to your facility.
- Avoid using highly water-soluble pesticides.
- Exercise caution when using spray adjuvants that may facilitate off-target movement.

MIXING/WASHING STATION

Principle

Pesticide leaks or spills, if contained, will not percolate down through the soil into groundwater or run off the surface to contaminate streams, ditches, ponds, and other waterbodies. One of the best containment methods is the use of a properly designed and constructed chemical mixing center (CMC).

Best Management Practices

- Loading pesticides and mixing them with water or oil diluents should be done over an impermeable surface (such as lined or sealed concrete), so that spills can be collected and managed.
- Mixing station surface should provide for easy cleaning and the recovery of spilled materials.
- Pump the sump dry and clean it at the end of each day. Liquids and sediments should also be removed from the sump and the pad whenever pesticide materials are changed to an incompatible product (that is, one that cannot be legally applied to the same site).
- Apply liquids and sediments as you would a pesticide, strictly following label instructions.
- Absorbents such as cat litter or sand may be used to clean up small spills and then applied as a topdressing in accordance with the label rates, or disposed of as a hazardous waste.
- Sweep up solid materials and use as intended.

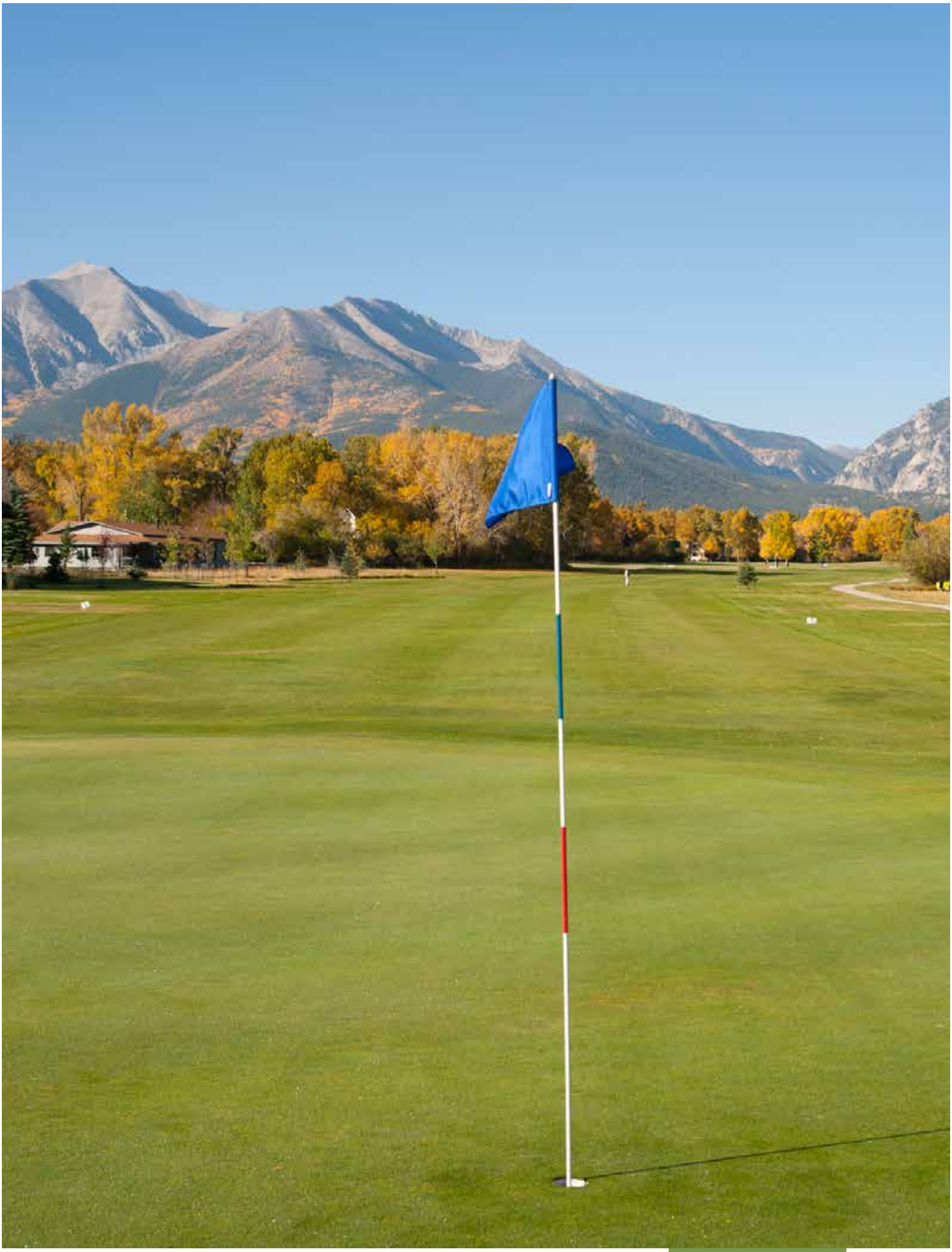
DISPOSAL

Principle

Wash water from pesticide application equipment must be managed properly, since it contains pesticide residues.

Best Management Practices

- Collect wash water (from both inside and outside the application equipment) and use it as a pesticide in accordance with the label instructions.
- The rinsate may be applied as a pesticide (preferred) or stored for use as makeup water for the next compatible application.



PERSONAL PROTECTIVE EQUIPMENT

Principle

Exposure to pesticides can be mitigated by practicing good work habits and adopting modern pesticide mix/load equipment (for example, closed-loading) that reduce potential exposure. Personal Protective Equipment (PPE) statements on pesticide labels provide the applicator with important personal protection information.

Best Management Practices

- Provide adequate PPE for all employees who work with pesticides (including equipment technicians who service pesticide application equipment).
- Ensure that PPE is sized appropriately for each person using it.
- Make certain that PPE is appropriate for the chemicals used.
- Ensure that PPE meets rigorous testing standards and is not just the least expensive.
- Store PPE where it is easily accessible but not in the pesticide storage area.
- To mitigate exposure to the general public, forbid employees who apply pesticides from wearing facility uniforms offsite after pesticide application.
- Provide laundering facilities or uniform service for employee uniforms.
- The federal Occupational Safety and Health Administration (OSHA) requires employers to fit test workers who must wear tight-fitting respirators.
- Meet requirements for OSHA 1910.134 Respiratory Protection Program.

PESTICIDE CONTAINER MANAGEMENT

Principle

Empty pesticide containers are classified as hazardous wastes if not properly rinsed, and as such, are subject to the many rules and regulations governing hazardous waste. The improper disposal of a hazardous waste can result in very high fines and/or criminal penalties. However, pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste. Federal law (FIFRA) and some state laws require pesticide applicators to rinse all empty pesticide containers before taking other container disposal steps. Under federal law (the Resource Conservation and Recovery Act, or RCRA), A PESTICIDE CONTAINER IS NOT EMPTY UNTIL IT HAS BEEN PROPERLY RINSED.

Best Management Practices

- Rinse empty pesticide containers immediately in order to remove the most residue. Rinsate must be used for the pesticides intended use or managed as hazardous waste.
- Rinse containers during the mixing and loading process and add rinsate water to the finished spray mix.
- Rinse emptied pesticide containers by either triple rinsing or pressure rinsing.
- Puncture or crush empty and rinsed pesticide containers and dispose of according to the label. Some labels direct the burying of the empty pesticide container, this is an improper disposal method and the container should be rinsed, rendered unusable and disposed as nonhazardous solid waste.
- Contact the Agriculture Container Recycling Council (ACRC) for pesticide container collection; i.e. G. Phillips and Sons http://www.acrecycle.org/home.
- It is against the law to use empty pesticide containers for another function. Empty containers must be rendered unusable and discarded.

POLLINATOR PROTECTION

REGULATORY CONSIDERATIONS

Most flowering plants need pollination to reproduce and grow fruit. While some plants are pollinated by wind, many require assistance from insects and other animals. In the absence of pollinators, many plant species, including the fruits and vegetables we eat, would fail to survive.

The European honey bee (Apis mellifera) is one of the most important pollinators in the United States. Hundreds of other bee species, including the bumble bee (Bombus spp.), also serve as important pollinator species.

Pesticides are products designed to control pests (for example, insects, diseases, weeds, nematodes, etc.). Pesticides and other plant growth products, including plant growth regulators, surfactants, biostimulants, etc., are used in golf course management. The non-target effect of products used in golf course management is of increasing concern; therefore, pesticide applicators, including those on golf courses, need to be mindful of the impact that pesticides have on pollinator species and their habitat.

Principles

- Pollinator-protection language is a label requirement found on pesticide labels; follow the label, it is the law.
- Pesticide applicators must be aware of honey bee toxicity groups and able to understand precautionary statements.
- Recordkeeping may be required by law in order to use some products. IPM principles suggest that you keep records of all pest control activity so that you may refer to information on past infestations or other problems to select the best course of action in the future.

Best Management Practices

- Proper records of all pesticide applications should be kept according to local, state, and federal requirements.
- Use records to establish proof of use and follow-up investigation of standard protocols – reference BMP IPM Section.
- Those applying pesticides, and who make decisions regarding their applications should be able to interpret pollinator protection label statements.
- Those applying pesticides should be aware of honey bee biology.
- Those applying pesticides should understand the various routes of exposure (outside the hive and inside the hive).
- Those applying pesticides should understand the effects of pesticides on bees.

POLLINATOR HABITAT PROTECTION

Principle

- There are three primary factors adversely impacting honey bee health: varroa mite, pesticides, and forage. Pesticide and forage issues are common to all pollinating insects and are areas where golf courses can truly be impactful.
  - Varroa mites must be managed by beekeepers themselves.
  - It is important to minimize the impacts of pesticides on bees and beneficial arthropods. Pesticide applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans.
  - Pollinators require diverse flowering species to complete their life cycle.

Healthy pollinator habitat contains a myriad of wildflower and plant species of different colors and heights, with blossoms throughout the entire growing season. Non-playable areas of golf courses make excellent pollinator habitats.

Best Management Practices

- Develop new pollinator habitat and/or enhance existing habitat.
- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.
- Before applying a pesticide, scout/inspect the area for both harmful and beneficial insect populations. Use pesticides only when a threshold of damage has been indicated.
- Mow flowering plants (weeds) before insecticide application.
- If flowering weeds are prevalent, control them before applying insecticides.
- Consider manual removal of weeds or spot spraying in pollinator habitat areas.
- Follow label information directing the application of pesticide when the plant may be in bloom. Avoid applying pesticides during bloom season.
- Stay on target by using coarse-droplet nozzles, and monitoring wind to reduce drift.
- Do not apply pesticides when pollinators are active. Always consider early a.m. or late p.m. applications when pollinators are less active.

- Use insecticides that have a lower impact on pollinators. Avoid use of any products that contain Chlorothalonil.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of pesticide.
- Avoid applications during unusually low temperatures or when dew is forecast.
- Limit the use of granular pesticides because they can be mistaken for pollen and can be hazardous to bees.
- Be mindful of pollinators; when applying pesticides, prevent exposure to non-target insects in play and non-play course areas.

Native Plant List

The following plants are recommended for Colorado for pollinators.

Alicella pinnatifida - Sticky Gilia
Agastache foeniculum - Giant Blue Hyssop
Asclepias species - Milkweeds
"Asters"... Now mostly Symphotrichum species, Dieteria species, and Erigeron species
Astragalus crassicarpus - Ground Plum Milkvetch
Amelanchier alnifolia - Western Serviceberry / Saskatoon
Amelanchier utahensis - Utah Serviceberry
Archtostaphylos uva-ursi - Bearberry
Berberis (Mahonia) repens - Creeping Mahonia / Creeping Grape Holly
Chrysothamnus nauseosus - Rabbit Brushes
Cirsium canescens - Prairie Thistle
Cleome serrulata - Rocky Mountain Bee Plant
Dalea candida - White Prairie Clover
Dalea purpurea - Purple Prairie Clover
Epilobum angustifolium - Fireweed
Eriogonum species - Wild Buckwheats
Fendlera rupicola - Cliff Fendler Bush
Frasera speciosa - Green Gentian
Gaillardia aristata - Blanket Flower
Grindelia squarrosa - Curlycup Gum Weed / Rosin Weed
Guttierrezia sarothrae - Broomweed / Snakeweed
Haplopappus species - Goldenweeds
Helianthus species - Sunflowers...annual and perennial species
Lupinus argenteus - Silvery Lupine
Mentzelia multiflora - Adonis Blazing Star
Oreocarya species...probably O. virgata - Miner's Candle
Oenothera suffrutescens - Red Guara / Scarlet Beeblossom
Oxytropis lambertii - Purple Locoweed / Rattle-weed
Prunus americana - Wild Plum
Prunus virginiana - Choke Cherry
Potentilla hippiana - Woolly Cinquefoil
Rhus glabra - Smooth Sumac
Rhus trilobata - Skunkbush
Ribes aureum - Golden Current
Ribes cereum - Wax Current
Rosa woodsii - Wood's Rose
Rubus deliciosa - Boulder Raspberry
Sphaeralcea coccinea - Scarlet Globemallow / Cowboy's Delight
Solidago species - Goldenrods < numerous species native to Colorado
Scrophularia lanceolata - Lanceleaf Figwort
Symphocarpus species...primarily S. alba and S. occidentalis - Snowberry / Buckbrush
Townsendia hookeri - Hooker's Easter Daisy
Thermopsis rhombifolia - Golden Banner

MAINTENANCE OPERATIONS

REGULATORY CONSIDERATIONS

Equipment maintenance, fueling, and chemical storage can have an impact on water quality on-site and off-site both during construction and during the maintenance of existing golf courses.

Local and state regulations may be in place in your location. Early engagement among developers, designers, local community groups and permitting agencies is essential to designing and constructing a golf maintenance and storage facility that minimizes environmental impact and meets the needs for the approval process.

STORAGE AND HANDLING OF CHEMICALS

Principles

- Proper handling and storage of pesticides and petroleum-based products is important to reduce risk of serious injury or death of an operator or bystander. Fires or environmental contamination may result in large fines, cleanup costs, and civil lawsuits if these chemicals are not managed properly.
- Check federal, state, and local regulations for specific requirements related to storage of both pesticides and petroleum-based products.

Working with all stakeholders to design and construct a safe and efficient maintenance facility can minimize environmental impact.

Best Management Practices

- Storage buildings should have appropriate warning signs and placards.
- Follow all personal protective equipment (PPE) statements on pesticide labels.
- Store PPE away from pesticide storage areas in an area that is easily accessible.
- Develop an emergency response plan and educate all golf course personnel regarding emergency procedures on a regular basis.
- Individuals conducting emergency chemical cleanups should be properly trained under requirements of federal Occupational Safety and Health Administration (OSHA).
- Store pesticides in a lockable concrete or metal building.
- Locate pesticide storage away from other buildings, especially fertilizer storage facilities.
- Floors of chemical storage buildings should be impervious and sealed with chemical-resistant paint.
- Floors of chemical storage buildings should have a continuous sill to contain spills and should not have a drain. A sump is acceptable.
- Shelving should be fabricated from plastic or reinforced metal. Metal shelving should be painted to avoid corrosion. Wood shelving should never be used because of its ability to absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided
- Explosion-proof lighting may be required. Locate fan and light switches outside the entrance to the building to facilitate ventilation of building before entrance of staff.
- Maintain detailed records of current pesticide inventory in the storage facility. Safety Data Sheets (SDS) for the chemicals stored on-site should be stored separate from the storage room, but readily accessible on-site.
- Do not store large quantities of pesticides or chemicals for long periods of time. Follow a “first in, first out” principle to rotate products into use to ensure products do not expire.
- Store chemicals in original labeled containers. Never store them in containers that might be mistaken as packaging for food or drink.
- Arrange containers so the labels are clearly visible. Securely fasten loose labels to ensure containers and associated labels are kept together.
- Damaged labels should be replaced immediately.
- Store flammable pesticides separate from those that are nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Ensure that oil containers and small fuel containers (service containers) are properly labeled and stored within the facility.

EQUIPMENT STORAGE AND MAINTENANCE

Principle

Storing and maintaining equipment properly will extend useful life and reduce repairs.

Best Management Practices

- Store and maintain equipment in a covered area complete with a sealed impervious surface to limit risk of fluid leaks contaminating the environment and to facilitate the early detection of small leaks that may require repair before causing significant damage to the turf or the environment.
- Seal floor drains unless they are connected to a holding tank or sanitary sewer with permission from the local wastewater treatment plant.
- Store pesticide and fertilizer application equipment in areas protected from rainfall. Rain can wash pesticide and fertilizer residues from the exterior of the equipment and possibly contaminate soil or water.
- Store solvents and degreasers in lockable metal cabinets away from ignition sources in a well-ventilated area. These products are generally toxic and highly flammable. Never store them with fertilizers or in areas where smoking is permitted.
- Keep an inventory of solvents and SDS for those materials on-site but in a different location where they will be easily accessible in case of an emergency.
- Keep basins of solvent baths covered to reduce emissions of volatile organic compounds (VOC).

- When possible, replace solvent baths with recirculating aqueous washing units. Soap and water or other aqueous cleaners are often as effective as solvent-based products and present a lower risk to the environment.
- Always use appropriate PPE when working with solvents.
- Never allow solvents or degreasers to drain onto pavement or soil, or discharge into waterbodies, wetlands, storm drains, sewers, or septic systems.
- Collect used solvents and degreasers in containers clearly marked with contents and date; schedule collection by a commercial service.
- Blow off all equipment with compressed air to reduce damage to hydraulic seals.

WASTE HANDLING

Principles

- Proper disposal of waste materials is critical for protection of water and natural resources. State or local laws and regulations related to disposal of hazardous waste products may vary. Be sure to familiarize yourself with all state and local laws related to disposal/recycling of these waste materials.
- Identify and implement waste-reduction practices.
- Look for ways to increase recycling efforts and programs.
- Purchase environmentally preferred products when possible.
- Purchase products in quantities that can reasonably be used before the expiration date or within 6-12 months of purchase.

Unused pesticides or pesticides that have been mixed for application must be disposed of as waste and may be classified as hazardous waste depending on the materials involved. Contact local authorities for guidance regarding proper disposal; contact the Agriculture Container Recycling Council (ACRC) for pesticide container collection; i.e. G. Phillips and Sons http://www.acrecycle.org/home.

Best Management Practices

- Never dispose of waste down storm drains.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them as directed by local and state authorities.
- Antifreeze may be considered hazardous waste by state or local laws and should be handled accordingly. Commercial services are available to collect and recycle antifreeze.
- Properly manage used batteries and fluorescent bulbs as Universal Waste and recycle as soon as feasible.
- Recycle used tires.

EQUIPMENT WASHING

Principles

Wash water generated from equipment-washing facilities can be a source of soil, surface-water and groundwater pollution. Steps should be taken to prevent pollution.

Best Management Practices

- Equipment washing areas should drain to an oil/water separator before draining to a sanitary sewer or holding tank.
- Consider the use of a closed-loop wash-water recycling system.
- Grass-covered equipment should be brushed or blown off with compressed air before being washed.
- Wash equipment with a bucket of water and a rag to minimize the amount of water used and use only the minimal amount of water required to rinse the machine.
- Spring-operated shut-off nozzles should be used.
- Do not allow any wastewater to flow directly into surface waters or storm drains.
- If using non-potable water for washing activities comply with applicable state and local regulations.

FUELING FACILITIES

Principles

Safe storage of fuel, including use of above-ground tanks and containment facilities, is critical to the protection of the environment. State or local laws and regulations related to storage of fuel may vary.

Best Management Practices

- Locate fueling facilities on roofed areas with a concrete (not asphalt) pavement. Areas should be equipped with spill-containment and recovery facilities.
- Use of above ground fuel tanks is preferred.

POLLUTION PREVENTION

Principles

- Plan appropriately to minimize the possibility of an elicit discharge and need for disposal. Monitor the water to be discharged for contamination; never discharge to the environment any contaminated water. If the water is not contaminated, it can be reused or discharged to a permitted stormwater treatment system.
- Pesticide leaks or spills, if contained, will not percolate down through the soil into groundwater or run off the surface to contaminate streams, ditches, ponds, and other water bodies.
- Wash water from pesticide application equipment must be managed properly, since it contains pesticide residues. This applies to wash water from both the inside and the outside of the application equipment. Material should be collected and used in accordance with the label instructions for that pesticide.
- The proper handling and storage of pesticides is important. Failure to do so correctly may lead to the serious injury or death of an operator or bystander, fires, environmental contamination that may result in large fines and cleanup costs, civil lawsuits, the destruction of the turf you are trying to protect, and wasted pesticide product.
- Pesticides that have been mixed so they cannot be legally applied to a site in accordance with the label must be disposed of as a waste. Depending on the materials involved, they may be classified as hazardous waste.
- Provide adequate protection from the weather. Rain can wash pesticide and fertilizer residues from the exterior of the equipment, and these residues can contaminate soil or water.
- An equipment-washing facility can be a source of both surface water and groundwater pollution, if the wash water generated is not properly handled. All equipment used in the maintenance of golf courses and associated developments should be designed, used, maintained, and stored in a way that eliminates or minimizes the potential for pollution.
- One of the key principles of pollution prevention is to reduce the unnecessary use of potential pollutants. Over time, the routine discharge of even small amounts of pollutants can result in serious environmental and liability consequences.
- Generating as little as 25 gallons per month of used solvents for disposal can qualify you as a “small-quantity generator” of hazardous waste, triggering EPA and state site management and reporting requirements.
- Never allow solvents to drain onto pavement or soil, or discharge into water bodies, wetlands, storm drains, sewers, or septic systems, even in small amounts.
- Office paper, recyclable plastics, glass, and aluminum should be recycled. Place containers for recycling aluminum cans and glass or plastic soft drink bottles at convenient locations on the golf course.

Best Management Practices

- Pesticides should be stored in a lockable concrete or metal building.
- Pesticide storage and mixing facility floors should be impervious and sealed with a chemical-resistant paint. Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- For valuable information about constructing chemical mixing facilities, reference the Midwest Plan Service book, Designing Facilities for Pesticide and Fertilizer Containment (revised 1995); the Tennessee Valley Authority (TVA) publication, Coating Concrete Secondary Containment Structures Exposed to Agrichemicals (Broder and Nguyen, 1995); and USDA–NRCS Code 703.
- Use a chemical mixing center (CMC) as a place for performing all operations where pesticides are likely to be spilled in concentrated form—or where even dilute formulations may be repeatedly spilled in the same area—over an impermeable surface. (A CMC is a concrete pad treated with a sealant and sloped to a liquid-tight sump where all of the spilled liquids can be recovered.)
- Flush wash pad with clean water after the equipment is washed. Captured wash water can be used as a dilute pesticide per labeled site, or it may be pumped into a rinsate storage tank for use in the next application.
- FIFRA, Section 2(ee), allows the applicator to apply a pesticide at less than the labeled rate.
- The sump should then be cleaned of any sediment before another type of pesticide is handled.
- Discharge to a treatment system that is permitted under industrial wastewater rules.
- Never discharge to a sanitary sewer system without written permission from the utility.
- Never discharge to a septic tank.
- Use a closed-loop wash-water recycling system and follow appropriate BMP.

For emergency (only) information on hazards or actions to take in the event of a spill, call CHEMTREC, at (800)424–9300. CHEMTREC is a service of the Chemical Manufacturers Association. For information on whether a spilled chemical requires reporting, call the CERCLA/RCRA help line at (800) 424–9346.

- Use non-containment wash water for field irrigation.
- Do not discharge non-contaminated wastewater during or immediately after a rainstorm, since the added flow may cause the permitted storage volume of the stormwater system to be exceeded.
- Whenever practical, replace solvent baths with recirculating aqueous washing units (which resemble heavy-duty dishwashers).
- Use soap and water or other aqueous cleaners; these products are often as effective as solvent-based ones.
- Blowing off equipment with compressed air instead of washing with water is often easier on hydraulic seals and can lead to fewer oil leaks.
- Grass-covered equipment should be brushed or blown with compressed air before being washed. Dry material is much easier to handle and store or dispose of than wet clippings.
- It is best to wash equipment with a bucket of water and a rag, using only a minimal amount of water to rinse the machine.
- Clean up spills of hazardous or potential hazardous materials immediately.
- Keep spill cleanup equipment available when handling pesticides or their containers.
- If a spill occurs of a pesticide covered by certain state and federal laws, you may need to report any accidental release if the spill quantity exceeds the “reportable quantity” of active ingredient specified in the law.
- Large spills or uncontained spills involving hazardous materials may best be remediated by hazardous material cleanup professionals.
- Do not allow any wash water to flow directly into surface waters or storm drains.
- Avoid washing equipment in the vicinity of wells or surface water bodies.
- Wash equipment over a concrete or asphalt pad that allows the water to be collected. After the residue dries on the pad, collect, compost, or spread in the field.
- If applicable, allow runoff onto a grassed area to soak into the ground, but never into a surface water body or canal.
- Use compressed air to blow off equipment. This is less harmful to the equipment’s hydraulic seals, eliminates wastewater, and produces dry material that is easier to handle.
- Handle clippings and dust separately. After the residue dries on the pad, it can be collected and composted or spread in the field.

- Minimize the use of detergents. Use only biodegradable non-phosphate detergents. Low foaming detergents are preferable.
- Minimize the amount of water used to clean equipment. This can be done by using spray nozzles that generate high-pressure streams of water at low volumes.
- Do not discharge wash water to surface water or groundwater either directly or indirectly through ditches, storm drains, or canals.
- Do not conduct equipment wash operations on a pesticide mixing and loading pad. (This keeps grass clippings and other debris from becoming contaminated with pesticide).
- Solvents and degreasers should be used over a collection basin or pad that collects all used material.
- Oil/water separators can be used but must be managed properly to avoid problems. Do not wash equipment used to apply pesticides on pads with oil/water separators
- Collect used solvents and degreasers, place them into containers marked with the contents and the date, and then have them picked up by a service that properly recycles or disposes of them. Never mix used oil or other liquid material with the used solvents.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them. Arrange pickup of used oil, or deliver to a hazardous waste collection site.
- Do not mix used oil with used antifreeze or sludge from used solvents. Antifreeze must be recycled or disposed of as a hazardous waste.
- Store batteries on an impervious surface and preferably under cover. Remember, spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations.
- Lead-acid storage batteries are classified as hazardous wastes unless they are recycled. All lead-acid battery retailers in Florida are required by law to accept returned batteries for recycling.
- Equipment used to apply pesticides and fertilizers should be stored in areas protected from rainfall.
- Pesticide application equipment can be stored in the chemical mixing center (CMC), but fertilizer application equipment should be stored separately.
- Blow or wash loose debris off equipment to prevent dirt from getting on the CMC pad, where it could become contaminated with pesticides.
- Ensure that all containers are sealed, secured, and properly labeled. Use only regulatory agency-approved, licensed contractors for disposal.
- Rinse pesticide containers as soon as they are empty. Pressure rinse or triple-rinse containers. Use the rinsate for its intended purpose.
- Shake or tap non-rinseable pesticide containers, such as bags or boxes, so that all dust and material fall into the application equipment; waste needs to be managed as pesticide waste.
- After cleaning them, puncture the pesticide containers to prevent reuse (refillable mini-bulk containers must be returned to the manufacturer for reuse).
- Keep the rinsed containers in a clean area, out of the weather, for disposal or recycling.
- Storing the containers in large plastic bags/tubs to protect the containers from collecting rainwater.
- Recycle rinsed containers in counties where an applicable program is available, or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them.
- Contact the Agriculture Container Recycling Council (ACRC) for pesticide container collection; i.e. G. Phillips and Sons http://www.acrecycle.org/home.

LANDSCAPE

SPECIES SELECTION AND SIZE CONSIDERATIONS

An environmental landscape design approach addresses environmentally safe and energy-saving practices; therefore, environmentally sound landscape management is also economically important. Non-play areas require a mix of sun and shade, optimal soil conditions and adequate canopy air movement to sustain growth and function.

The fundamental principle for the environmentally sound management of landscapes is "right plant, right place." The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall, and light patterns, insects, and other pests, and endemic nutrient levels over thousands of years.

Landscape (non-play) areas are an essential part of the overall course design, providing enhanced course aesthetics, wildlife habitat, external sound/noise abatement, and natural cooling and freeze protection.

POLLUTION PREVENTION

Principles

- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers. This reduces the need for pruning and debris removal and lowers maintenance costs.
- The addition of proper soil amendments can improve soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers. Amendments may be organic or inorganic; however, soil microorganisms rapidly decompose organic amendments such as peat or compost.

- The goal of species-selection BMP is to maintain as close to a natural ecosystem as practical, while meeting the needs of a golf course.
- Landscape areas should be fundamentally designed to facilitate rapid plant establishment to conserve water and lower nutritional input requirements once mature.
- Plants within areas that are not in play or are not critical to the design of the course may be removed and replanted with native plant material that requires little to no maintenance after establishment. Additionally, 50% to 70% of the non-play areas should remain in natural cover.
- As much natural vegetation as possible should be retained and enhanced through the supplemental planting of native trees, shrubs, and herbaceous vegetation to provide wildlife habitat in non-play areas, along water sources to support fish and other water-dependent species. By leaving dead trees (snags) where they do not pose a hazard, a well-developed understory (brush and young trees), and native grasses, the amount of work needed to prepare a course is reduced while habitat for wildlife survival is maintained.

Best Management Practices

- Use of native species will reduce water consumption and improve survival rate.
- Select trees, plants, and grass species to attract birds seeking wild fruits, herbs, seeds, and insects.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers.
- Use plants that are adapted for the site based on the United States Department of Agriculture (USDA) cold-hardiness map.
- Select stress-tolerant species or cultivars to manage periodic dry/wet conditions.
- Choose the most stress-tolerant species or cultivar for a particular area.

DESIGN AND FUNCTION

Principles

- Aesthetic gardens, window boxes, and container gardens should include a variety of plants of different heights that provide nectar for hummingbirds and butterflies. Again, “right plant, right place” is the key to success.
- When integrating turf areas into the landscape around the clubhouse, entries, and other areas, design them for ease of maintenance and keep in mind that turfgrasses grow best in sunny areas. Consider the effect that tree canopy and other design features may have on the health and function of the turf.
- Garden plants, shrubbery, ground covers, or native plants may provide a pleasing view and also provide useful food, cover, or other environmental benefits to wildlife; they may also require reduced maintenance.
- Trees and shrubs along streams provide temperature moderation through shade, which lowers water temperature in summer and increases it in winter.

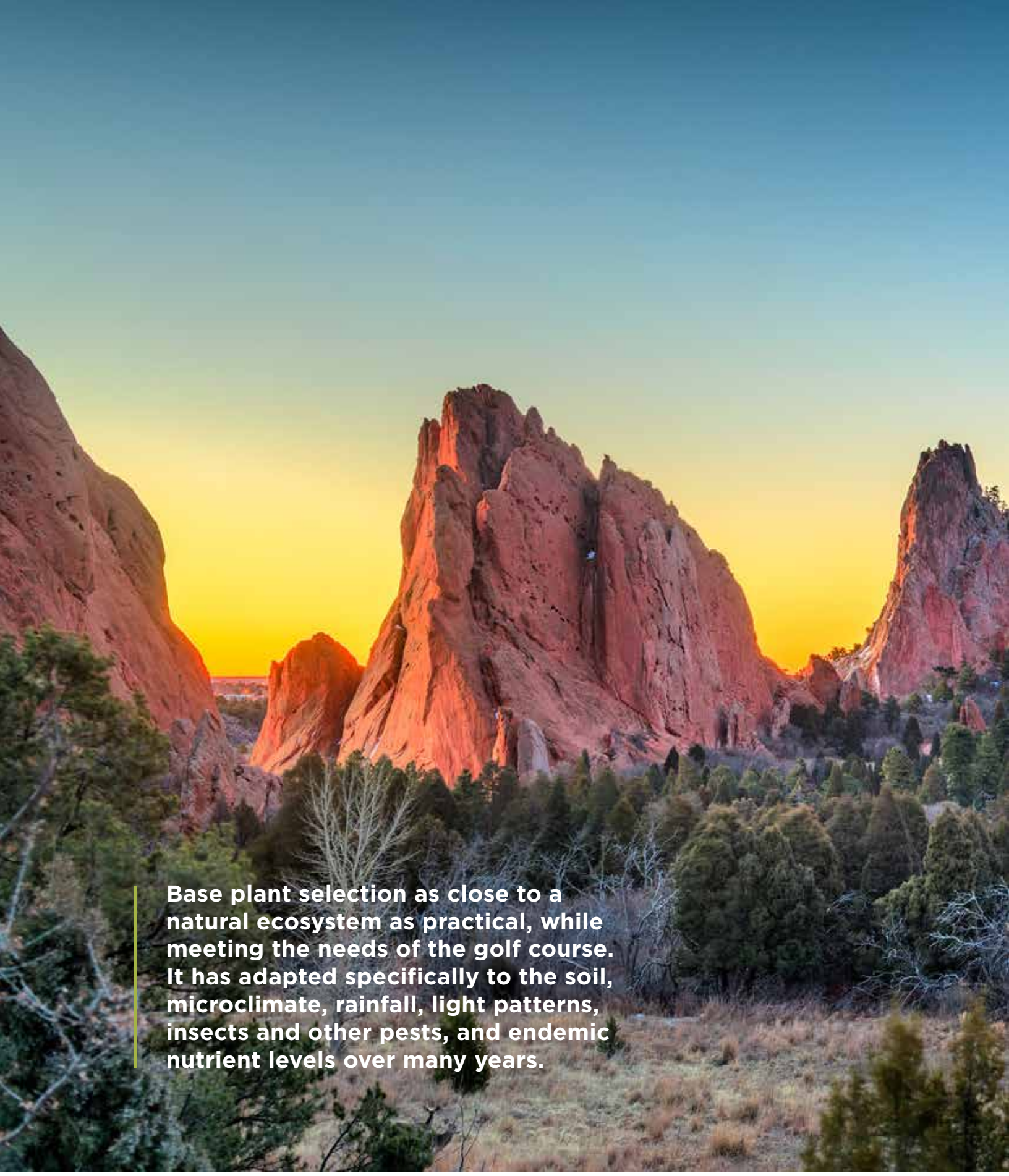
Best Management Practices

- Leave dead tree snags whenever possible for nesting and food source to wildlife. However, make sure that these snags are a safe distance away from playing surfaces should they get blown over.
- Use turf as a landscape element where needed.
- Utilize the contour of the ground which can dictate plant placement. Place xeric plants on higher ground and plants that require more water in low areas.
- Once plants are established, reduce irrigation frequency to an “as needed” basis.
- Use regular observation to determine plant stress levels and when water is needed. This will encourage deeper root growth and development and make the landscape more sustainable.

Benefits of Forested Buffers

Well-designed forested buffers should contain a mixture of fast- and slow-growing native trees, shrubs, and grasses to provide a diverse habitat for wildlife. Other key benefits include:

- Trap and remove upland sources of sediments, nutrients, and chemicals.
- Protect fish and wildlife by supplying food, cover, and shade.
- Maintain a healthy riparian ecosystem and stable stream channel.



Base plant selection as close to a natural ecosystem as practical, while meeting the needs of the golf course. It has adapted specifically to the soil, microclimate, rainfall, light patterns, insects and other pests, and endemic nutrient levels over many years.

PLANTING METHODS

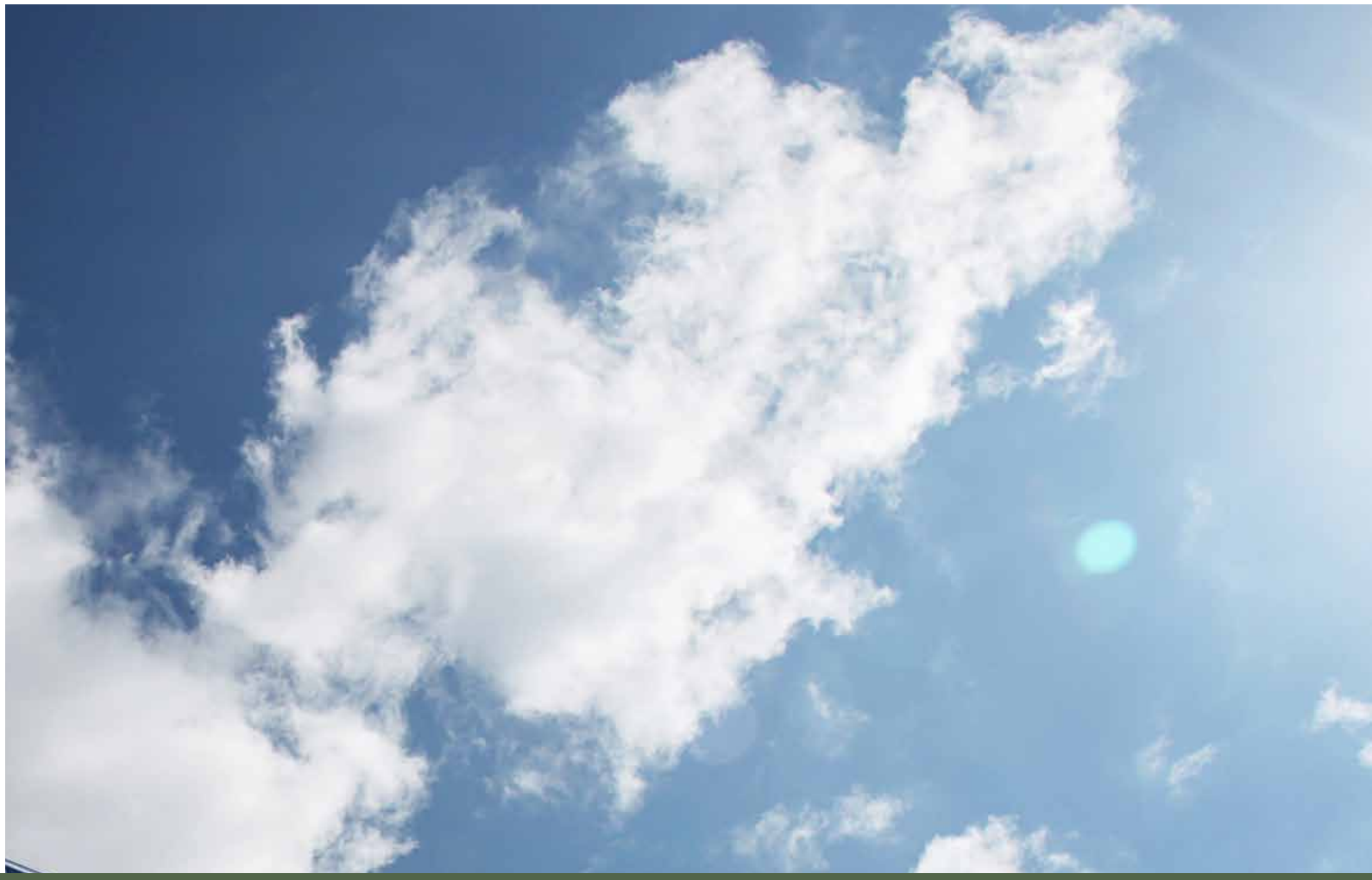
Principles

- The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall, light patterns, insects, and other pests, and endemic nutrient levels over hundreds or thousands of generations. Where these factors have changed, the challenge is finding other suitable plants. A BMP goal is to maintain as close to a natural ecosystem as practical, while meeting the needs of the golf course.
- The use of organic mulches in gardens and aesthetic areas increases the moisture-holding capacity of plantings and prevents weed growth when applied in sufficient depth. Organic amendments are decomposed by soil microorganisms and add to soil tilth.
- Keep mulch 2 to 3 inches away from plants, to prevent fungal growth from excess dampness.
- Excess mulch or compacted mulch may be detrimental, causing water to shed away from the root zone and encourage overwatering. Compaction or excessive mulch buildup should be avoided, especially when annual re-mulching is performed.

Best Management Practices

- The plant palette and irrigation system should be appropriate for site conditions, taking into account that, in some cases, soil improvement can enhance water-use efficiency.
- Plants should be grouped together based on irrigation demand.
- The percentage of landscaped area in irrigated high-water-use hydrozones should be minimized. Local government ordinances should address the percentage of irrigated landscaped area that may be included in high-water-use hydrozones. These high water-use limits should not apply to landscaped areas requiring large amounts of turf for their primary functions (for example, ball fields and playgrounds).
- In most instances, established, drought-tolerant landscape plants have a root system substantial enough to keep them alive with little or no supplemental irrigation.
- Pruning and fertilizing will also benefit landscape plants while they are becoming established.
- Add proper soil amendments in garden areas to improve the soil's physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers.
- Incorporate mycorrhizal fungi into the planting backfill. This will increase root mass, improve nutrient uptake and improve hardiness.


HOMESTEAD



ENERGY

ENERGY CONSERVATION

According to the GCSAA Golf Course Environmental Profile, Vol. IV (GCSAA 2012), six major energy sources were identified for golf course use: electricity, gasoline, diesel, natural gas, propane and heating oil. In addition, operational uses were segmented to meet irrigation, turf maintenance, buildings, clubhouse operations, swimming pools and various amenity needs.

> **Golf facility managers must take steps toward identifying options for conservation, efficiency, and cost savings.**

To address current needs and future energy reduction opportunities, managers should evaluate current energy conservation performance practices based on the following categories:

- General energy conservation position statements on policy and planning
- Buildings and amenities statements – buildings, infrastructure and facility amenities such as the clubhouse, swimming pool, restaurant, parking lot, kitchen, offices, maintenance building(s), tennis courts, etc.
- Golf course statements – the golf course and surrounding landscapes, pump station, irrigation system and related agronomic operations (playing surfaces, equipment, turfgrass maintenance etc.)

Principles

- Determine goals and establish an energy policy that is part of the facility's overall environmental plan.
- Establish an energy management plan for the facility based on current energy use baselines to optimize efficiency.
- Communicate policy to all staff regarding use patterns and management practices to effect change.
- Relate the policy to the entire facility, including the services the facility provides to its customers and community.
- Incorporate quality management elements for continual improvement (plan, do, check, and act) to reduce environmental and economic impacts.
- Understand that the irrigation pump is the largest user of energy relating to turfgrass management. A well-engineered pump station is critical to reducing energy consumption.

Best Management Practices

- Conduct an energy audit.
- Conduct a lighting audit.
- Conduct a carbon footprint analysis.
- Add insulation where needed.
- Use non-demand electrical hour rates: charge golf carts, and use pumps to acquire water, charge maintenance equipment, and other items later in the day or early in the morning.
- Limit high-consumption activities during periods when demand is high.
- Use alternative energy from natural sources, such as solar, geothermal and wind energy generation.
- Upgrade or install National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors.
- Seek output reduction by watering less area, apply target golf goals.
- Install LED lighting and/or retrofit devices.
- Install motion sensors for lights where appropriate.
- Install a programmable thermostat.
- Install solar/Geo Thermal pumps for pools and spa.

EVALUATION

Principles

- Continually track and measure energy use at the facility based on energy assessment units, for example, kilowatt hour.
- Benchmark practices to evaluate existing facility consumption with other local golf facilities of similar size.

Best Management Practices

- Monitor energy use: track data, evaluate billing meters.
- Install adequate meters, gauges, etc.
- Develop an equipment inventory incorporating individual equipment's energy use, use / traffic patterns, etc. (maintenance records, operation hours, etc.).
- Establish a baseline for performance parameters to optimize irrigation pumps.
- Consider benchmarking performance against similar-sized facilities.

EFFICIENCY

Principles

- Evaluate energy efficiency performance.
- Evaluate electric equipment/operations and ensure proper selection, operation, charging, and maintenance.

Best Management Practices

- Evaluate all energy providers (electricity, natural gas and liquid petroleum fuels) for costs, efficiency/assistance programs, and incentives.
- Identify and categorize operations for energy efficiency opportunity and conservation analysis.
- Perform assessments of all the facility's infrastructure and operations.
- Perform appropriate audits throughout the facility depending on operation, infrastructure, and planning stage.
- Track and measure water use of facilities and landscape as a way to monitor energy efficiency and as a way to catch leaks quickly.
- Identify efficiency and conservation elements of infrastructure/hard items and behavioral/ process-oriented items.
- Consider alternative equipment, products, and practices.

DESIGN AND RENOVATION

Principles

- Incorporate an analysis of the assessments, audits, and data.
- Incorporate first cost consideration (initial investment and long-term gain).
- Redesign – evaluate future projects with a priority for energy conservation.
- According to system and compliance standards, communicate with utility provider, insurance company, and any state or local regulatory officials.

Best Management Practices

- Identify buildings, amenities, and operations including existing, new construction, or renovation activities where energy efficiency enhancements are needed.
- Consider using LEED certification guidelines for any new construction or renovation projects
- Identify the golf course, course infrastructure, and related agronomic operations including existing and future developments or renovations that would benefit from energy efficiency improvements.

IMPLEMENTATION PLAN

Principles

- Set goals for buildings/amenities and the golf course operation; develop an implementation plan.
- Set energy-use goals according to efficiency/conservation of the building, infrastructure and equipment efficiency.

Best Management Practices

- Evaluate effectiveness of upgrades according to efficiency/conservation goals for energy use.
- Continue to identify future energy needs and maintain good record keeping.
- Prioritize energy consumption as part of purchase/decision-making process for HVAC, food service, laundry, swimming pools, etc.
- Consider other devices as part of the plan; do research on building, pumps, and power generation.

INFRASTRUCTURE

Principles

- Ensure efficient building/facility/ amenities and related infrastructure.
- Consider the materials: used insulation and color selection.
- Ensure efficient lighting in both interior and exterior areas.

Best Management Practices

- Maximize use of space.
- Inspect and repair leaks/maintenance.
- Monitor temperature/environmental settings (heat loss, etc.).
- Evaluate building automation systems, monitoring systems, etc.
- Incorporate technology and up-to-date equipment (lights, controls, switches, etc.).
- Implement schedules/controlled use.
- Evaluate off-grid pole lighting and similar technology.

ALTERNATIVE PRODUCTS, OPERATIONS, AND PRACTICES

Principles

- Educate and motivate employees, guests, etc.
- Educate, train, and motivate employees on energy efficiency practices pertaining to golf course operations.
- Identify incentives and programs from energy providers.
- Identify state/local programs and certification.
- Consider U.S. Green Building Council's LEED program.
- Consider EPA's EnergyStar, Portfolio Manager, etc.
- Consider energy management software, services, etc.
- Consider national and local programs and programs like the EPA's WaterSense program as it relates to buildings (see Water Conservation BMP).

Best Management Practices

- Evaluate alternative transportation.
- Evaluate cleaning practices (dry vs. wet).
- Consider local vs. distant purchases, product selection, etc.
- Evaluate energy acquisition and energy coming into the facility.
- Evaluate golf car equipment/operations and ensure proper selection, operation, charging, and maintenance.
- Incorporate training for employees.
- Incorporate the use of incentives.

Golf Club Energy Reduction Best Management Practices Behavioral Checklist

Lighting	Y/N	HVAC	Y/N	Irrigation/Water	Y/N	Equipment	Y/N
Conduct a lighting audit		Clean & change air filters regularly		Maintain plumbing fixtures/piping to avoid losses		Check electricity meters at least once per month	
Arrange interior space to optimize natural light & comfort zones		Utilize ceiling fans		Run irrigation early in the morning or late at night		Operate machines according to manufacturers' recommendations for energy efficiency	
Initiate 'lights off' employee awareness campaign		Ensure HVAC units have proper ventilation		Repair leaks		Avoid automatically turning on kitchen equipment when arriving in morning	
Display reminders & visual management signage		Turn off air/set heating at minimum in unoccupied rooms		Check insulation on hot water pipes to reduce heat losses		Consider temperature of kitchen rooms when installing or relocating refrigerators/freezers	
Code light switches (labels or color) to switch on only those needed		Close exterior doors when not in use		Check laundry room equipment regularly for leaks		Turn off food & beverage equipment when not in use	
Reduce general lighting during daytime				Water less area, apply hand watering		Do not exceed oven preheating times	
Turn exterior lighting on only at night; utilize timekeepers				Evaluate cleaning practices (dry vs. wet washing)		Open refrigerators & freezers only when necessary	
Train staff & invite guests/members to get involved						Defrost refrigerators & clean door seals monthly	
Maintain routine preventive maintenance on lighting equipment						Fill dishwashers & washing machines to maximum capacity	
Turn off lights in unoccupied rooms						Use low temperature wash cycles & avoid overloading dryers	
Limit pool lighting that is not required for safety						Conduct regular PM on equipment, vehicles	
						Run washer/dryer during off peak hours	
						Do not leave televisions on standby	
						Switch off equipment (copiers, computers, printers, coffee) when not in use	
						Charge golf carts & equipment during off-peak hours (evening/ early a.m.)	
						Encourage car sharing; designate EV parking & charging stations	
						Source products locally to reduce logistics/transportation fuel consumption	
						Log equipment use including hours operated, length of use, patterns to determine efficiencies (e.g., shift to off-peak hours, minimize use per week, etc.)	

Source: Radius Sports Group, LLC. 2019

Golf Club Energy Reduction Best Management Practices
Product Selection Checklist

Lighting	Y/N	HVAC	Y/N	Irrigation/Water	Y/N	Equipment	Y/N
Install LED lighting and/or retrofit devices		Install energy-efficient air conditioning/chiller equipment		Install shower flow restriction devices to reduce water usage		Choose programmable thermostats	
Replace less efficient T12s with low-wattage T8 & T5 lamps with electronic ballasts		Install HVAC fans & pumps with variable frequency drives (VFDs) that control pump speeds		Install insulation on water heater tanks and pipe		Install onsite photovoltaic solar panels for onsite electricty generation	
Replace incandescent bulbs with CFLs which use less energy & last longer		Install window film to reduce air/heat loss		Install energy efficient water-heating equipment		Install National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors	
Replace fluorescent light exit signs with LEDs		Maximize envelope efficiency; choose high performance insulation systems		Install aerators to reduce demand for hot water		Install solar/geothermal pumps for pools	
Install induction lighting in hard-to-reach places & public facilities		Add insulation for windows & doors, such as weather stripping & thresholds		Install water-saving devices (flow regulators, water flow sensors, self-closing taps, low-flush toilets)		Select a well-engineered pump station with variable frequency drives (VFDs) to minimize water & energy use	
Install pulse-start metal halide & high-pressure sodium lamps in spaces with prolonged use & high ceilings		Utilize energy management systems		Install prescriptive irrigation systems to manage use & detect leaks		Select hybrid equipment including fairway mowers	
Add occupancy sensors or programmable timers		Decrease daytime thermostat setting		Audit irrigation system		Choose electric or battery-powered golf carts	
Install light tubes & natural light maximizers		Install a night setback system to lower room temperature at night		Install localized devices (micro- sprinklers, drip irrigation) for plants & ornamentals		Choose Energy Star rated equipment for clubhouse operations	
		Install an economizer to use outdoor air for cooling		Incorporate native plants to reduce water & energy use			
		Install a timer on supply air fans		Install rooftop solar thermal panels for water heating			
		Install double-glazed windows		Incorporate drought resistant, salt tolerant turf (e.g., paspalum) to lower irrigation needs			
		Shade windows from sun to limit HVAC needs (awnings, automatic louvres, curtains, blinds, screens, heat reflecting sheets, trees)					
		Incorporate a green roof with vegetation or cool roof (white or cool colored)					

Source: Radius Sports Group, LLC. 2019

COURSE MANAGEMENT PLAN

Principles

- Set energy-use goals for efficiency/ conservation including infrastructure, equipment, behavior and agronomic practices.
- Ensure proper selection (type, size, etc.), operation, and equipment maintenance.
- Ensure efficient design, selection, operation, and maintenance of irrigation pumps, irrigation controls and other irrigation components.
- Implement energy source selection, management, and efficiency/conservation practices.

Best Management Practices

- Work with energy providers and evaluate existing programs, resources, etc.
- Consider long-term costs in addition to acquisitions.
- Schedule reviews to evaluate future technology and fuel types.
- Evaluate upgrades.
- Evaluate use of alternative energy/fuels.
- Identify future energy needs.
- Prioritize energy consumption as part of selection.
- Optimize equipment use data including hours operated, use patterns, etc.
- Incorporate new technology and upgrades when feasible.
- Consider alternative equipment, products, and practices.

IRRIGATION

Principles

- Ensure efficient design, selection, operation, and maintenance of irrigation pumps, irrigation controls, and other irrigation components.
- Assess irrigation pump efficiency; consider alternative equipment, products, and practices; use energy efficiently to maximize the output of the pump station.

Best Management Practices

- Audit irrigation system (see Water Conservation BMP).
- Schedule and operate pumps and irrigation in an efficient manner.
- Use premium, high efficiency motors where applicable
- Identify and implement infrastructure and behavioral changes.
- Evaluate technology and upgrades; implement when feasible.

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