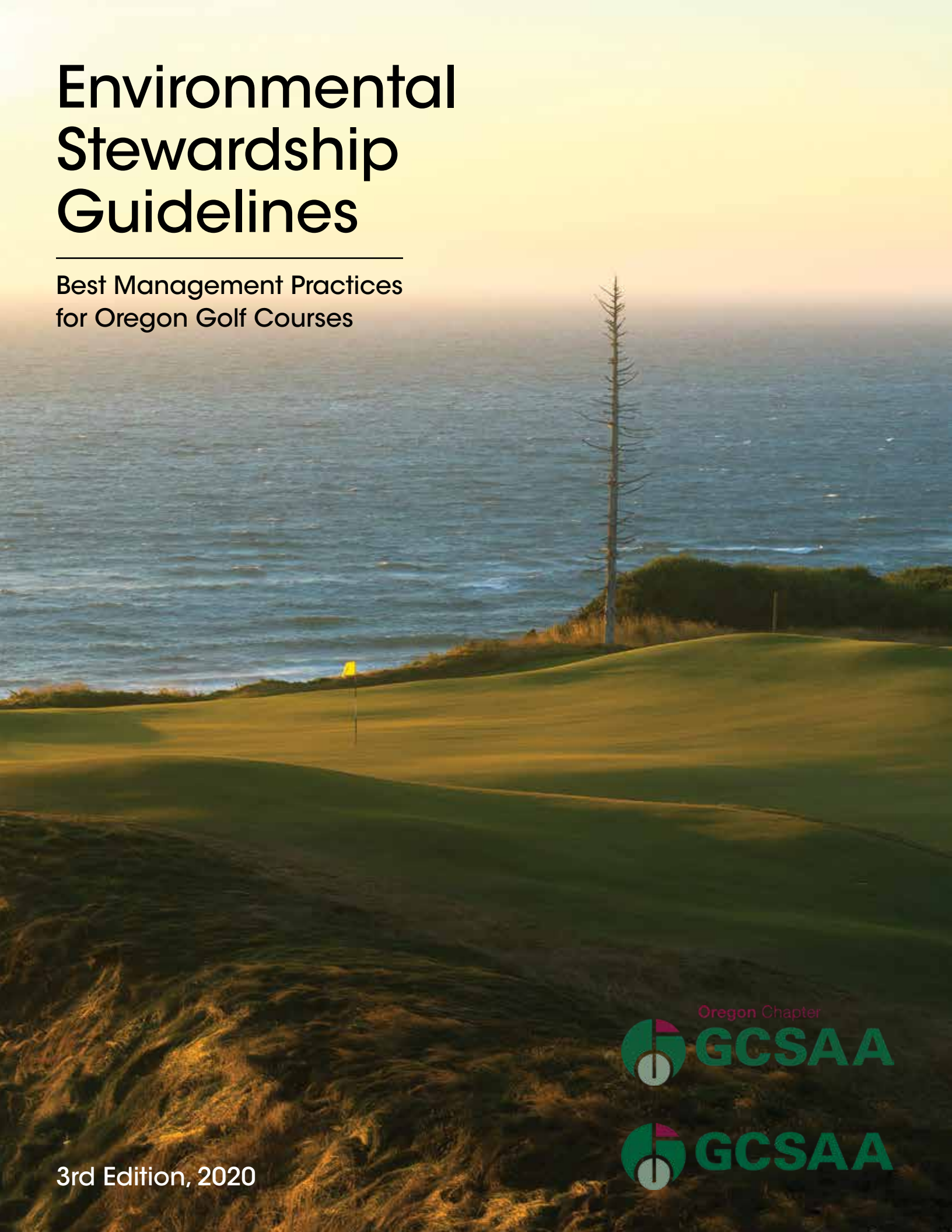
Environmental Stewardship Guidelines

Best Management Practices
for Oregon Golf Courses



Oregon Chapter GCSAA

GCSAA

3rd Edition, 2020

BEST MANAGEMENT PRACTICES PLANNING GUIDE AND TEMPLATE

Best Management Practices for Oregon Golf Courses

Prepared For:

Oregon Golf Course Superintendents Association (OGCSA)

Prepared By:

EnviroLogic Resources, Inc.
P.O. Box 80762
Portland, Oregon 97280-1762

503.768.5121

h2egeo.com

Design and Layout By:

Peggy Price—Price Design

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Navigating the *Guidelines*

All items in the Table of Contents have been hyperlinked to their associated pages. In the main sections (1.0, 2.0, etc.) at the top of each page—except for the chapter head pages—look for **Back to Table of Contents;** that text is also hyperlinked and when clicked on, you will return to this page.

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Who We Are—Acknowledgements

GOLF COURSE SUPERINTENDENTS ASSOCIATION OF AMERICA

The Golf Course Superintendents Association of America (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. 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.

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The GCSAA and EIFG wish to thank the University of Florida, Institute of Food and Agricultural Sciences, faculty, Dr. J. Bryan Unruh, Dr. Travis Shaddox, Dr. Jason Kruse, and Mr. Don Rainey, who worked on this project, providing their knowledge and expertise to help the golf course industry; the USGA for their grant to fund this important project; the volunteers who served on the task group to review BMP and provide technical assistance; and the Florida Department of Environmental Protection for permission to copy its publication, *Best Management Practices for the Enhancement of Environmental Quality.*

Additional Acknowledgements

A MESSAGE FROM SHANE HADWICK, PRESIDENT, OREGON GCSA

The Oregon Golf Course Superintendents Association (OGCSA), partnered with the Western Washington Golf Course Superintendents Association (WWGCSA) and Inland Empire Golf Course Superintendents Association (IEGCSA), are proud to put forth the 3rd Edition of the Environmental Stewardship Guidelines and corresponding Best Management Practices (BMP) Planning Guide and Template on the Golf Course Superintendents Association of America (GCSAA) website. The well-respected Environmental Stewardship Guidelines were created in 2000, updated in 2009, and again with this recent revision. These documents demonstrate the turfgrass industry's commitment to environmental stewardship and sustainability through water conservation, water quality protection, pollution prevention, energy conservation, and pollinator protection. The goal of continuous improvement is evident in the revisions.

With public perception and the ever-changing regulatory environment of today's world, golf course superintendents are at the forefront of sustainable land management. Because maintaining an environmentally sustainable property differs from region to region, the digital platform of the BMP template provides turf managers the ability to edit and generate a site-specific plan for their facility. This plan is a valuable tool for superintendents and represents the benefits a golf course can provide a local environment.

Through the vision of Dr. Michael Hindahl and the first Environmental Committee over 20 years ago, our region has proven its commitment to environmental stewardship. Thank you to all who have been a part of the creation of these documents and again shown how the turf industry is a champion for the environment in which we labor.

Shane Hadwick
President
OGCSA

A MESSAGE FROM TOM CALABRESE, ENVIROLOGIC RESOURCES, INC.

Welcome to the 3rd Edition Environmental Stewardship Guidelines, Best Management Practices for Oregon Golf Courses. The 1st Edition of the Guidelines, prepared by Dr. Michael Hindahl, was an important milestone for the promotion of the environmental stewardship practices at golf courses in the Pacific Northwest. The 2nd Edition of the Guidelines was a comprehensive update to the initial Guidelines, incorporating significant statistical analyses of water quality data collected from Pacific Northwest golf courses.

The 3rd Edition is, again, a comprehensive update. Many people helped in making this edition of the *Guidelines* even better. First, thank you to Alexis Wenker of the Oregon GCSA, Bill Ackerley of the Western Washington GCSA, and Lori Russell of the Inland Empire GCSA. As Executive Directors of their respective organizations, they were responsible for coordination, review, and management of this project on behalf of their members.

Current and former members of the BMP Committees of the Pacific Northwest GCSAs include Sean Reehorn, Ryan Semritc, Justin Otto, Michael Bednar, Chip Caswell, Jesse Goodling, Tod Blankenship, Chuck Wolsborn, Brian Koffler, Shane Hadwick, David Phipps, Eric Langford, Eric Johnson, Scott Phelps, Sean McDonough, Jennifer Camp, Rory Allison, Russ Vandehey, Kathy Hauff, and Gabe

Additional Acknowledgments, cont.

Hughes. Thank you for dedicating your time to review drafts of this document and provide your input.

A draft of the 3rd Edition *Guidelines* was sent out for wider review by the regulatory and golf community. We very much appreciate the time and effort that these people contributed to make the document more complete. The organizations that helped and their reviewers included:

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With so many people involved in this effort, I am sure these acknowledgments are incomplete. Thank you very much to each and every one of you.

Tom Calabrese
EnviroLogic Resources, Inc.
Portland, Oregon

Introduction

These updated *Environmental Stewardship Guidelines* provide a resource to golf course superintendents to help implement Best Management Practices that, overall, are intended to help the environment. The *Guidelines* were produced by updating the 2nd Edition of the *Guidelines* and combining them with the GCSAA BMP template tool. The GCSAA BMP template tool also comes in a facility version that will allow you to customize the *Guidelines* to your facility.

The comprehensive update to the *Guidelines* features some new chapters and provides listings of best management practices for turfgrass management and maintenance operations. Best management practices related to the following topics are covered in the *3rd Edition Guidelines*:

- Golf course planning, design, and construction;
- Water and water quality management;
- Irrigation;
- Plant nutrition;
- Cultural practices;
- Integrated pest management;
- Pollinator protection;
- Landscape;
- Wildlife habitat enhancement;
- Chemical control product management;
- Maintenance operations;
- Energy; and
- Community outreach.

These best management practices are based on the most recent research available, compiled by GCSAA, The Environmental Institute for Golf, USGA, and Oregon State University. Additionally, water quality data collected from Pacific Northwest golf courses over the past 20 years has helped to inform best management practices related to water quality and integrated pest management.

Best management practices should be considered both as documented practices and aspirational. Identifying facility-specific best management practices will help the golf course superintendent prepare a document that can be shared with staff, club managers and owners, golfers, the community at large, and regulators. This facility-specific document is a powerful communication tool that shows how the golf course operations are benefiting the environment.

In reviewing the best management practices contained in the *Guidelines*, the golf course superintendent will also get ideas for areas of improvement to current practices. While not everything in the *Guidelines* is applicable at all golf courses, and some suggestions may be currently cost prohibitive, the concepts presented can be a source for ideas to continually improve environmental performance. In the parlance of environmental management systems, this continuous improvement is—"plan, do, check, act." As such, the *Guidelines*, and the facility-specific documents that are built on the basis of the *Guidelines* should be considered living documents that chart the path for continuous environmental improvement.

PLANNING, DESIGN, AND CONSTRUCTION 1.0

Best management practices related to golf course planning, design, and construction are presented in this chapter. Many of the challenges in developing a new golf course property are encountered during initial golf course siting and achieving approval to build it. In fact, the bulk of the regulatory constraints often relate to the land use review and approval process.

1.1 Planning

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, hydrogeologists, ecologists, and legal counsel.

Best Management Practices

- Comply with Federal and Oregon State laws and regulations
- Assemble a qualified team
  - Golf course architect
  - Golf course superintendent
  - Clubhouse architect
  - Irrigation engineer
  - Environmental engineer/scientist
  - Energy analyst
  - Economic consultant
  - Civil engineer
  - Soil scientist
  - Geologist/Hydrogeologist
  - Water rights expert
  - Fisheries biologist/Wetland Ecologist
  - Golf course builder
  - Legal team
  - Community/civic outreach team
- Determine objectives
- Complete a feasibility study
  - Are needs feasible given existing resources?
  - Financial
  - Environmental
  - Water quality and quantity
  - Energy
  - Labor
  - Materials
  - Governmental regulatory requirements/ restrictions
  - Certification programs
  - Local community/civic relations
- Select an appropriate site capable of meeting stakeholder needs.
- Identify the strengths and weaknesses of the selected site.
- Identify existing water rights and acquire sufficient water rights for development.
- Develop water budget estimates for the land-, surface water-, and groundwater-uses.
- Identify any rare, protected, endangered, or threatened plant or animal species on the site.
- Identify any water quality limited water bodies and/or Total Maximum Daily Loads that may be affected by the site.
- Identify whether the site is within a groundwater management area, coastal management area, or a source water protection area.
- Select grass type(s) suitable for the proposed course's climate, soils, irrigation water quality, and quantity needs.

- Prepare site-specific integrated pest management (IPM) Plan to be included in the land use permit application package to demonstrate responsible land management, including nutrients and pesticide use.
- Integrate sustainable- and adaptive-management practices in the development, maintenance, and operation of the course.
- Within the land use permit application package, prepare a site-specific Best Management Practices document based on the Oregon Environmental Stewardship Guidelines to demonstrate the sustainable practices to be used in the proposed golf course management operations.
- Prepare a proposed routine site-specific water quality monitoring plan to be included in the land use permit application package and Environmental Stewardship Plan documents for the course.
- Prepare the proposed nutrient management plan to be included in the land use permit application package to demonstrate the sustainable fertilization practices proposed on the course.
- Develop a site vegetation management plan for the underutilized facility, out-of-play, and/or natural areas on the proposed course property.
- 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.

1.2 DESIGN

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

Best Management Practices

- Design the course layout, including its water supply, site drainage, stormwater management, and irrigation systems to minimize the need to alter or remove existing native landscapes. The routing should identify the areas that provide opportunities for restoration.
- Design the course to retain as much natural vegetation as possible, and limit habitat fragmentation. Where appropriate, consider enhancing existing vegetation through the supplemental planting of native vegetation/materials 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, and support overall site vegetation management plan implementation. Nuisance, invasive, and exotic plants should be removed and replaced with native species adapted to the particular site.
- Design the course infiltration, drainage, and stormwater management systems to maximize sediment retention along with water features, which reduces the potential for unintended erosional or hydromodification effects on the natural flow channels of water both on- and off-site.
- Consult The Low Impact Development Stormwater Manual for Western Oregon for a collection of proven techniques and instructions

on how to select them, for use in creating Low Impact Development focused stormwater treatment.

- Design longer bridge spans for cart paths, maintenance roads, and footpath crossings of wildlife corridors on the overall site. Minimize the use of cut-/fill-type, or raised, cart paths, maintenance roads, and footpaths in and around stream and wildlife-use corridors.
- Greens:
  - Select locations that have adequate sunlight to meet plant-specific needs, provide sufficient infiltration drainage, and minimizes potential runoff.
  - Choose a green size to include a sufficient number of rotational hole locations to accommodate traffic and damage from play, but not so large it is not sustainable with available operations and maintenance resources.
  - Select an appropriate root-zone material as designated by the USGA.
    - Quality Control Sampling Of Sand And Rootzone Mixture Stockpiles (2015)
    - Putting Green Construction (2018)
  - Consider the number of bunkers as it relates to resources available for daily operations and maintenance.
  - Greens should be designed to be irrigated and maintained separately from surrounding turf.
  - Select a turf species/variety that meets the needs of the stakeholders while adhering to the principle of "right plant, right place."
- Consider overall site infiltration and drainage systems layout and discharge areas in the siting of nutrient, pesticide, and other products storage areas and mixing facilities.
- For valuable information about constructing nutrient, pesticide, and other products 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.
- Consider rotational hole location wear patterns and create adequate space for configurations of ingress/egress points on greens, tees, fairways, and bunkers.
- Plant only certified turfgrass where specified for greens, tees, and fairways.
- Decide whether a bunker or which bunkers will contain drainage systems.
- Consider bunker entry and exit points.
- Select the proper color, size, and shape of bunker sand that meets your needs.
- Minimizing the size of tee complexes can reduce operations and maintenance costs.
- Landing areas should be considered when working with the architect to determine the size and layout of each fairway.
- Work with the architect to define play and non-play maintenance boundaries.

1.3 CONSTRUCTION

C,onstruction should be completed with care to minimize environmental impact and financial or community ramifications caused by poor construction techniques. Oregon has special environmental laws that need to be considered before beginning any construction project.

Best Management Practices

- Hold a pre-construction conference with stakeholders.
- Conduct baseline irrigation and surface water quality monitoring prior to construction to establish initial water quality conditions.
- Conduct baseline groundwater quality monitoring, if appropriate.
- Construction should be scheduled to maximize turfgrass establishment and site drainage.
- Use environmentally sound materials/equipment staging and construction techniques.
- Initiate and site vegetation management plan implementation.
- Demark boundaries of staging activity and construction areas in relation to designed environmental resources or sensitive natural areas where access is to be limited or as specified in the overall site vegetation management plan.
- Use soil stabilization techniques to minimize soil erosion and maximize sediment containment.
- Minimize disruptions to the natural flow channels of water features.
- Maintain a construction progress report and communicate the report to the proper permitting agencies.
- Use 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.

1.4 GROW-IN

Turfgrass establishment is a unique phase in turfgrass growth, which can require greater quantities of water, nutrients, or other products, and/or frequencies versus established turfgrass. The turf establishment phase should be planned carefully to maximize turf establishment and minimize potential impacts to surface water and groundwater from fertilizers or other products.

Best Management Practices

- The area to be established should be adequately prepared and cleared of pests (weeds, pathogens, etc.).
- Ensure erosion and sediment control devices are in place and properly maintained.
- Sprigs should be "knifed-in" and rolled to hasten root establishment.
- Sod should be laid to minimize any gaps between pieces and top-dressed to smooth the surface and fill in the gaps between sod pieces. This hastens establishment and provides a smoother, more uniform surface.
- Use appropriate seeding methods for your conditions. When using sod, nutrient or other product applications should be delayed until the sod has sufficiently rooted.
- When using sprigs, application rates for nitrogen, phosphorous, and potassium, or other products should correspond to percent ground cover (i.e., increasing rate as ground coverage increases.)
- Slow-release nitrogen or light, frequent soluble-nitrogen sources should be used during grow-in.
- Nutrients or other products should be applied—in either foliar or granular formulations—to the turf surface. Incorporating nutrients or other products into the root zone does not result in

more rapid establishment and increases environmental risk.

- Roll the area with a lightweight roller as often as needed prior to the initial mowing and thereafter.
- To hasten establishment, mow as soon as the sod has knitted-down, when sprigs have rooted at the second to third internode, or when seedlings have reached a height of one-third greater than intended height-of-cut.
- Initiate the routine water quality monitoring program as described in the water quality monitoring plan.
- Once grow-in transitions to regular golf course maintenance operations, begin implementation of the nutrient management plan.

1.5 EROSION AND SEDIMENT CONTROL

Soil eroded by wind and water may transport adsorbed contaminants with it. Contaminants can solubilize, especially on entering water bodies, or can accumulate in sediments. Erosion and sediment control is a critical component of the construction and grow-in of a golf course, and also relates to water features and long-term course adaptive management considerations.

Best Management Practices

- A Stormwater Pollution Prevention Plan (SWPPP) should be developed to address erosion control. A Stormwater Pollution Prevention Plan is generally required as part of a county grading or other construction stormwater permit for disturbances greater than one acre or more, including smaller sites in a larger common plan of development or sale.
- Elements of a Stormwater Pollution Prevention Plan include but are not limited to, the use of straw waddles, silt fences, and vegetative cover to reduce or eliminate erosion and resulting offsite sediment movement but may also specify long-term site monitoring, corrective actions, and reporting relating to water features that should be understood early.
- Develop a working knowledge of erosion and sediment control management. Oregon has its own guidance 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 or natural environmental resource areas.
- A vegetative cover like hydro-seeding or hydro-mulching can help soil stabilization efforts.
- Use dry detention basins/catchments to buffer flooding and excessive runoff that may contain sediment.
- The placement of bunkers and the shaping of contours surrounding a green should allow proper infiltration and drainage and provide for capture of runoff from the green.
- Increase the height of turf cut adjacent to surface water or riparian zones to slow runoff flow and direct infiltration of nutrients, pesticides, or other products into surface soil where it will adsorb or degrade.
- Ideally, littoral zones in ponds should have a slope of about 1 foot vertical to 6-10 foot horizontal.
- For the littoral zone in lakes and ponds, consider constructing random small dips and ridges of a few inches to a foot to promote diversity within the biotic community.
- Armor culvert intakes and use energy dissipation structures to limit or prevent erosion during routine storm events and for dampening potential tidal influences.

- Check culverts and remove unintended debris that may deter flow that could cause erosion of the intake area.

1.6 WETLANDS

Most states consider wetlands as either Waters of the United States (WOTUS) or Waters of the State (WOTS), a designation that carries significant legal ramifications. For example, soil disturbance in and around a wetland may constitute a "dredge and fill" activity in which the activity may require a permit or be prohibited. Permitting requirements for wetlands can have multiple overlapping jurisdictions of federal, state, and local agencies. At the federal level alone, the US Army Corps of Engineers (USAC), US Fish and Wildlife Service (FWS), National Oceanic and Atmospheric Administration (NOAA), and/or maritime agencies may all be involved. Wetland soils and vegetation 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, designated 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 course construction or long-term stormwater management systems. Unknowing creation of a wetland may provide habitat for species that require new and special attention, therefore, limit activities in and around the wetland.

Best Management Practices

- No Net Loss of wetlands goals—avoid first, minimize second where possible, or mitigate as necessary.
- Maintain natural ecosystem function to the extent practical to maximize golf course operational and management resources for other areas.
- Ensure proper permitting has been obtained before working on any wetlands.
- Ensure wetlands have been properly delineated before working in and around any wetlands.
- Utilize natural and constructed wetlands to manage stormwater and support functions of natural waterways.

1.7 DRAINAGE

Adequate infiltration and drainage are necessary for growing healthy turfgrass. A 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. Damaged, improperly installed, or poorly maintained infiltration or drainage systems will result in inferior performance that negatively impacts play and increases risks to water quality.

Best Management Practices

- When constructing infiltration and 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.
- Drainage should discharge through proper drainage and stormwater management devices, for example, vegetative buffers, swales, etc.
- The infiltration and drainage systems should be routinely inspected to ensure proper function.

1.8 SURFACE WATER: STORMWATER, PONDS, LAKES

Stormwater is the conveying force behind nonpoint source pollution of surface water bodies. 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 golf course, stormwater control may also involve storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, removing waterborne pollutants, and addressing aesthetic, playability, and community concerns. Not all stormwater infiltrating on or draining from 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 excess drainage water is conveyed from one treatment to another by conveyances that themselves contribute to ecosystem services, or natural filtration benefits, as well as treatment.
- Eliminate or minimize as much directly connected impervious area as possible.
- Use vegetated swales, rain gardens, and constructed wetlands to slow and infiltrate water and trap pollutants in the soil, where they can

be naturally degraded or destroyed by soil organisms.

- Use depressed landscape islands in parking lots to catch, filter, and infiltrate stormwater, instead of letting it runoff. When heavy rains occur, an elevated storm-drain inlet allows the island to hold the treatment volume and settle out sediments while allowing the overflow to drain away.
- Minimize the use of pesticides near water bodies and ensure applications are focused and specific.
- Maximize the use of pervious materials for pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability asphaltic concrete is available for cart paths or parking lots.
- Disconnect gutters and roof drains from draining to impervious areas. Direct runoff so it flows onto permeable areas that allow the water to infiltrate near the point of generation.

1.9 MAINTENANCE FACILITIES

The design and construction of maintenance facilities must incorporate Best Management Practices to minimize the potential for contamination of soil and water resources. The nutrient, pesticide, and other products mixing and storage facility, the equipment wash pad, and the fuel center are focal points.

Best Management Practices

- Design and build nutrient, pesticide, and other product storage structures to keep these materials secure and isolated from the surrounding environment.
- Store nutrients, pesticides, and other products in a roofed concrete or metal structure with a lockable door.
- Construct floors of seamless metal or concrete sealed with chemical-resistant paint.
- Ensure that there are no floor drains inside the pesticide storage building.
- Equip the floor with a continuous curb or other secondary containment to retain spilled materials.
- Do not store nutrients, pesticides, or other products near areas of 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 personal protective equipment in the nutrient, pesticide, and other products material storage area(s).
- Provide adequate space and shelving to segregate herbicides, insecticides, and fungicides, as well as nutrients and other products.
- Use shelving made of plastic or reinforced metal. Keep metal shelving painted.
- Provide appropriate exhaust ventilation and an emergency wash area.
- Always store dry materials above liquids, never store liquids above dry materials.
- Never place liquids above eye level.
- Locate maintenance operations away from groundwater wells and areas where runoff may carry spilled nutrients, pesticides, or other products into surface water bodies.
- Do not build new facilities on potentially contaminated sites unless the nature and degree of contamination have been documented and a remedy can be or has been put in place.
- 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 has a water-to-cement ratio no higher than 0.45:1 by weight.
- The sealed sump should be small and easily accessible for cleaning.

- Ensure that workers always use all personal protective equipment as required by the nutrient, pesticide, or other products label and are provided appropriate training.
- Assess the level of training and supervision required by staff so appropriate programs can be put in place.
- Any material that collects on the mixing and loading 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 and other nutrients separately from solvents, fuels, pesticides, and other products, 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, pesticides, and other dry products in an area that is protected from rainfall or other wetting. 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 dry fertilizer, pesticides, or other products 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-loaded shutoff nozzles.
- Use a closed-loop recycling system for wash water.
- Recycle system filters. Sludge should be treated and disposed of appropriately.
- Each piece of equipment should have an assigned parking area. This allows the oil or other fluid leaks to be easily spotted and attributed to a specific machine so it may be diagnosed and repaired.
- Use solvent-recycling machines or water-based cleaning machines to cut down on the use of flammable and/or toxic solvents.
- Use an appropriate environmental waste management service to recycle or remove the old solvents and dispose of them properly.

1.10 WILDLIFE CONSIDERATIONS IN DESIGN AND CONSTRUCTION

Golf courses occupy large land areas, generally in an urban setting, providing critical linkages between urban/built and rural/natural environments. Maintaining designed or natural wildlife habitat on golf courses better maintains biological value and diversity, which is especially important in the urban and urbanizing environment. Most golfers enjoy observing nonthreatening wildlife as they play the game.

Best Management Practices

- Identify the different types of aquatic and upland habitat specific to designated site species.
- Identify the habitat requirements (food, water, cover, space) for the identified fish and wildlife species.
- Identify species on the site considered threatened or endangered by the federal or state government, including species the state deems "of special concern."
- Preserve critical habitat and provide for the restoration of habitat where necessitated or practical in underutilized and out-of-play areas.
- Identify and preserve regional fish and wildlife and migration corridors.

- Design and locate cart paths, maintenance roads, and footpaths to minimize environmental impacts. Construct the paths and roads of permeable materials, if possible, and minimize the use of cut-/fill-type areas. Ensure that drainage from paths and roads infiltrates into the undisturbed ground and does not drain into storm drains or waterways.
- Avoid or minimize crossings of wildlife corridors. Design unavoidable cart, maintenance road, and footpath crossings to accommodate fish and wildlife movement.
- Remove nuisance and exotic/invasive plants and replace them with native species 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 must be excluded.
- Provided they pose no danger to people or property, retain dead tree snags for nesting and feeding sites.
- Construct and place birdhouses, bat houses, and nesting sites in out-of-play areas.
- Plant butterfly and relevant pollinator gardens around the clubhouse, underutilized, and out-of-play areas.
- Retain riparian buffers along waterways to protect water quality and provide food, nesting sites, and cover for wildlife.
- Take opportunities to expand naturally vegetated riparian buffers to underutilized out-of-play areas (for both new and existing course designs).
- Minimize stream or river crossings to protect water quality and preserve stream banks.
- Construct bridges with longer spans where crossing streams and wildlife corridor crossings are necessary.
- Minimize the use of pesticides near wildlife areas and ensure applications are focused and specific.
- Minimize use of cut-/fill-type, or raised, cart paths, maintenance roads, or footpaths when working in or around stream and wildlife corridors.
- Retain and improve upon riparian buffers along water features to protect water quality, provide food, nesting and pollinator sites, and cover for wildlife.

1.11 EXTERNAL CERTIFICATION PROGRAMS AND STANDARDS

Environmental management programs, health and wellness platforms, and environmentally friendly building design can help courses protect the environment and promote community/civic relations. These programs enhance and communicate the natural areas and wildlife habitats golf courses provide and improve efficiencies, which should be considered during course planning, design, and implementation. Obtaining certifications and adhering to relevant industry standards can enhance the community, member/guest, employee, and civic relations.

Certifications and internationally recognized frameworks that golf courses and clubs can pursue range from environmentally focused programs to certifications related to health and wellness. Establish a communications and outreach plan to educate members/guests and the local or civic community of alignment with these standards or certifications. Some examples of certification programs include:

- Audubon International's Audubon Cooperative Sanctuary Program (ACSP), Signature, and Sustainable Communities Program
- US Green Building Council Leadership in Energy and Environmental Design (LEED)
- Salmon Safe
- Global Reporting Initiative (GRI) Standards
- B Corp Certification
- Sustainable Development Goals

Local governments and/or civic organizations may also provide green business and sustainability reviews and certifications to courses, where applicable.

1.12 REGULATORY CONSIDERATIONS

The construction phase of infrastructure poses the greatest risk of ecosystem alteration. As previously noted, the bulk of the regulatory constraints often relate to the land use review and approval process. Planning and design work should be based on knowledge, evaluation, and application of the rules and regulations in place relating to the golf course property. Long-term golf course operations and management may also present potential or perceived regulatory concerns to local community/civic organization responses. With proper planning, design, monitoring, and adaptive management strategies golf facilities can be constructed and maintained with minimal to beneficial impact to existing wildlife and their habitat. Early engagement between developers, designers, local community/civic groups, and permitting agencies is essential to designing and constructing a golf facility that minimizes or benefits environmental impact and meets the approval process. Furthermore, facilities should be designed and constructed to maximize water conservation and energy efficiency, as well as the use of green building materials, where feasible.

The golf course is generally part of a larger watershed. How the golf course fits in the hydrologic system and wildlife corridors in the larger watershed may help the golf course superintendent to understand how adaptive management activities can most positively affect the surrounding environment. In addition, activities conducted by other landowners on adjoining or upstream properties in the watershed can affect conditions at the golf course. A documented environmental stewardship program provides golf courses with a central repository and means for responding to regulatory issues, as well as local community/civic organizations concerns, both during construction work and long-term operations.

Issues encountered by planners, designers, builders, and superintendents at golf courses include wellhead protection, local watershed, and stormwater management, water supply and quality, green building materials, energy efficiency, and water conservation, effectively using turfgrass and vegetation management products and their potential effects on the environment, threatened and endangered species, and existing, new, and changing rules as applied at the variable discretion of government agencies. Existing, new, and changing rules may fall under multiple regulatory segments. The following is a list of some of the regulatory frameworks that could influence the planning, design, construction, monitoring, operations, and management of a golf course:

- Local Land use approval requirements
- National Environmental Policy Act (NEPA)
- Endangered Species Act (ESA) [Oregon]
- Clean Water Act (CWA) 303(d) Listings [Oregon]
- Total Maximum Daily Loads [Oregon]
- Stormwater Management [Oregon]
- National Pollutant Discharge Elimination System (NPDES) Requirements
- Nearby Contaminated Sites [Oregon]
- Wellhead Protection Ordinances [Oregon]
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
- Waste Management
- Spill Response [Oregon]
- Water Right Permit Regulations [Oregon]
- Local Stream Buffers, and Riparian Setbacks (construction and long-term)
- Climate Initiatives [Oregon]

In addition, other nonregulatory programs can also influence and benefit golf course environmental management and stewardship, including the Oregon Pesticide Stewardship (PSP) Program and various

environmental certification programs. Chapter 13.0 Working With the Community provides more information.

Portions of the environmental stewardship program and plan depend on the initial and ongoing characterization of conditions of the environmental setting locally around the golf course (e.g., wellhead protection, integrated pest management, water quality monitoring, etc). Geographical information and site data are reflected in data management systems and available for evaluation and mapping. For example, a map displaying the percentage of impervious area at the golf course demonstrates that a small percentage of the golf course is impervious. Another example, much of a golf course is suitable for managing stormwater in a variety of ways, and mapping reflects that urban drainage systems are often funneled through golf courses.

Other information to consider showing on maps as part of the documentation of the golf course Environmental Stewardship Program includes:

- Local watershed and land use maps
- USGS topographic maps
- Geologic maps
- Aerial photographs
- Site facilities and course layout survey/CADD/GIS maps
- Hydrologic units, flow/drainage directions, and modeling maps
- 303(d) listings and total maximum daily loads (TMDLs)information
- Wetland inventory data: NWI and SWI map information
- Oregon Biodiversity Information Center (ORBIC) data
- Lidar base elevation and vegetation/canopy data
- FEMA floodplain information
- EPA Watershed and USGS Water data
- Soil survey maps for erosion hazard, road/trail suitability, compaction risk, permeability/chemical transport: NRCS Web Soil Survey
- Monitoring and sampling locations
- Mixing and storage areas

Depending on the amount of information available for a golf course, more than one map describing conditions/features may be useful to the Environmental Stewardship Program and addressing regulatory issues, or other considerations posed by community/civic group responses.

Local and state regulations may be in place, evolve, or become established in the vicinity of your location that must be considered. Regulations may also be interpreted and applied differently over time given policy changes that are within the discretion of relevant governmental agencies. Early engagement among developers, designers, local community groups, and permitting agencies is essential to designing and constructing, or modifying a golf facility that minimizes or benefits environmental impact and meets the approval process. Local requirements during construction may include compliance with county or city ordinances relating to grading requirements, dust control, floodplain and wetland work or course areas, protection of surface and groundwater, wellhead protection, use of green building materials where practical, and stormwater management. For example, if new wells must be installed, experts should be consulted for proper siting in the design plan, and all setback and other regulatory requirements must be followed.

If your project is on or has something to do with Federal government property, you may need to include a National Environmental Policy Act (NEPA) analysis. In Oregon, land use laws provide for analysis for golf course planning acceptance, resulting in potential design and construction prescriptions.

From golf course design, and construction, and through long-term operations, the golf course-specific environmental stewardship program and plan provides

and communicates the strategies and tactics in place to comply with relevant Federal, State, and local laws, and address community/civic group responses. It is a valuable tool for informing course internal and external stakeholders relating to regulations, as needed, including superintendents regarding their long-term adaptive management decision-making process.

WATER AND WATER QUALITY MANAGEMENT 2.0

Water and water quality management at golf courses in the Pacific Northwest comes in many forms. On the west side of the Cascade Mountains, numerous streams and wetlands dot the landscape and/or travel through golf courses. Fewer streams and wetlands are present on the east side of the mountains. Nearly all golf courses have an irrigation pond, or two. Also, stormwater management functions are often delegated to golf courses in urban settings. As a result of these responsibilities for water management, recognition of the water quality issues present in these water bodies and understanding of the effects on water quality caused by golf course management are paramount in any golf course environmental program.

Water is generally considered as one of two types—surface water or groundwater. Surface water issues can be readily evident as the water can be directly inspected. Algal blooms, stormwater flows, and changes in the character of a water body can be viewed in real-time. However, detrimental changes in sedimentation/erosion, nutrient loading from fertilizers, pesticide contamination, temperature changes from loss of vegetation, and changes to biological communities may not be apparent without monitoring. Groundwater occurs beneath the surface of the Earth and we "see" it when we use groundwater for irrigation or water supplies. Otherwise, groundwater exists in the underground aquifers that flow invisibly beneath us. Issues related to groundwater must be ascertained by measuring water levels and collecting and analyzing samples from wells. This section of these *Guidelines* is intended to provide insight into how to manage water and water quality.

The *Guidelines* present Best Management Practices used to reduce or control impacts to water bodies from nonpoint sources of pollution, most commonly by reducing the loading of pollutants from sources into stormwater and waterways. Golf courses provide acres of green space helping to reduce the urban heat island effect, providing surface water filtration, and supporting habitat for wildlife and ecosystem functions, which also includes improving air quality and sequestering carbon. Best Management Practices can be applied before, during, and after pollution-producing activities to reduce or eliminate pollutants to receiving waters.

2.1 SURFACE WATER

Surface water can be observed in lakes and ponds, wetlands, streams, creeks, or rivers, or related to stormwater. Surface water quality protection involves recognizing connections between actions at the golf course and the surface water system. Buffer zones are a key tool for surface water quality protection.

2.1.1 Lakes and Ponds

Understanding natural lake processes and accommodating them in the design and management of a lake or 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.

Many golf courses plan their lakes and water hazards to be a part of the stormwater management, control, and treatment system. This usually works well for all concerned stakeholders. However, 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 ponds. The careful design may significantly reduce future operating expenses for lake and aquatic plant management.

Best Management Practices

- Consult with a golf course architect, working in conjunction with a stormwater professional, to develop an effective stormwater management system that complies with the requirements of the local municipality, 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 possible, internal golf course drains should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments. Incorporate vegetative buffers into the design process.
- Studies of water supplies are needed for irrigation systems, and studies of water bodies or flows on, near, and under the property are needed to properly design golf course stormwater systems and water features and to protect water resources.
- If the irrigation pond holds more than seven days of irrigation supply, a separate storage water right may be needed.
- 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.
- Lakes and ponds should be placed to minimize effects due to invasive plant or aquatic species that may clog intakes. Beaver habitat should be considered in the design and placement of outflows; “beaver deceiver” devices have demonstrated success. Natures architect, beavers may also cause or exacerbate flooding, or damage natural areas and riparian restoration planting sites. If beavers are present, leave wider riparian areas on natural water bodies and protect planting with wire fencing.
- In shallow or nutrient-impacted ponds, the use of aeration equipment may be required to maintain acceptable dissolved oxygen (DO) levels in the water.

Successful pond management should include a clear statement of maintenance goals and priorities to guide the development of the local Best Management Practices necessary to meet those goals. Some of the challenges facing golf course superintendents in maintaining the quality of golf course ponds are as follows:

- Low dissolved oxygen;
- Sedimentation;
- Changes in the plant, avian, and aquatic or semi-aquatic animal populations;
- Nuisance vegetation and other invasives;
- Maintenance of littoral shelves;
- Excess nutrients;
- Algal blooms;
- Erosion control;
- Vegetation on the lakeshore; and
- Depth
- Pesticide loading

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 low dissolved oxygen and algal growth. Overgrowth of aquatic plants may lower oxygen levels in the water. Algal cells and organic residues of algae can pass through irrigation system filters and form aggregates that may plug emitters. Nuisance and invasive species can clog natural flow devices and outlets, or irrigation system inlets and outlets, that necessitate regular monitoring and potential cleanouts. Pond leaks should be controlled and managed properly. Use an expert in aquatic management to help develop and monitor pond management programs.

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, bacteria, and sediment in runoff, stabilize soils and provide shade over surface water. Riparian buffers also aid in the decomposition and reduction of organic wastes related to wildlife or other natural sources (e.g, leaf fall) on the course.
- 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 dissolved oxygen levels. Test soil and/or vegetation nutrient levels periodically and only apply nitrogen or phosphorus fertilizers when testing and/or plant condition indicate fertilizer is necessary.
- Establish a special management zone around pond edges.
- Dispose of grass clippings where runoff will not carry them back to the pond or lake.
- Encourage clumps of native emergent vegetation at the shoreline.
- Maintain water flow through lakes, if they are interconnected.
- Where avian or other relevant animal nuisance activity is detrimental to ponds, place passive (coyote, owl, etc.) decoys, or other hazing devices such as ground-level wind streamers/ flags and beaver deceivers, as appropriate.
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and Best Management Practices on projects upstream to reduce erosion and the resulting sedimentation.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered dissolved oxygen levels.
- Aerate ponds and dredge or remove sediment before it becomes a problem.

Evaporation losses are higher in some regions than others and vary from year to year and within the year. However, evaporative losses could approach 6 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.
- Monitor regularly for obstructions of natural flows inlets and outlets, as well as any irrigation system intakes, particularly during and after periods of heavy rain.

- Estimated losses from evaporation and seepage should be added to the recommended depth of the pond.

A major piece of the lake/pond management plan is the biotic community control plan relating to aquatic plants, as well as avian, and semi-aquatic animals. In order to control these biotic communities appropriately, the intended use of the water body must be known, as well as whether there are any invasive or nuisance species present, the aesthetic purposes of the lake/pond, and any other environmental conditions. The comprehensive lake/pond management plan should include strategies to control the growth of nuisance vegetation, birds, and animals that can negatively impact the water quality and treatment capacity of the ponds.

A biotic community management strategy should address the intended uses of the waterbody to maintain water quality. Proper documentation of the physical attributes and location, the presence of invasive or nuisance species, aesthetics, watershed and groundwater assessments, and other environmental considerations are necessary as part of the lake/pond management plan. Only properly licensed individuals or contractors should be allowed to select and apply aquatic pesticides. The following principles should be applied:

- Proper turfgrass fertilization practices
- Unfertilized buffer strips
- Good pond design
- Hand removal of plants or mechanical harvesting
- Littoral shelf plantings of desirable plants
- Use of nontoxic lake dyes and biological controls
- Physical controls relating to relevant avian and semi-aquatic animals
- Aeration
- Aquatic herbicides

If herbicide or pesticide applications are to be used, they should be used according to the label. Choose the aquatic herbicide according to:

- Target plant or pest
- Waterbody type and uses
- Wind
- Temperature
- Water depth
- Efficiency

It is important to consider the types of chemicals used in an aquatic environment or entering the course at background levels from natural or other activities on adjoining and upstream locations. Often, ambient phosphorus concentrations that are otherwise essential for plant health may also contribute to undesired algal blooms and eutrophication (depletion of dissolved oxygen) at elevated concentrations. Erosion is a major cause of phosphorus inputs to surface waters.

Copper can also be the result of erosion and stormwater runoff. Copper is a concern because of its persistence in the environment and it is highly toxic to fish and other aquatic animals. Copper is in some herbicides but is also a component of vehicular brake-dust that may be contributed to surface water by unfiltered stormwater runoff near and along roadways. If water from the pond is used for irrigation, waiting periods for using the water for irrigation required by the herbicide label must be followed.

The four zones in a lake/pond include:

- Riparian (buffers)
- Littoral (transition between upland and open water)
- Limnetic (open water)
- Benthic (bottom of the pond—sediment)

Properly designed ponds with at least 5-feet or wider fringes of vegetation buffer along the edge are much more resistant to problems than are those with

highly maintained turfgrass. This vegetation along the edge of the pond should be maintained in order to avoid degradation of the pond. Pond edges can often be overtaken by plant growth resulting in reduced water quality or eventual pond extinction. The aquatic plants growing in and around a pond provide many benefits—good water quality; cover for fish; shelter for birds; emergent vegetation serves as egg mass attachment sites for amphibians; cover and food for reptiles, amphibians, and birds; breeding sites for birds; etc. Beavers or other nuisance semi-aquatic animals may find habitat in course lakes/ponds and natural areas, necessitating physical or passive decoys that do not affect course playability and decrease the overall needs for maintenance/cleanup.

Phytoplankton, which gives water its green appearance, provides the base for the food chain in ponds. Tiny animals called zooplankton use phytoplankton (algae) as a food source. Large aquatic plants (aquatic macrophytes) can grow rooted to the bottom and supported by the water (submerged plants), rooted to the bottom or shoreline and extended above the water surface (emersed 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.

Plantlife growing on littoral shelves may help to protect receiving waters from the pollutants present in surface water runoff, and 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 purpose of drainage and stormwater management and are also often a source of irrigation water.

Best Management Practices

- Properly design ponds with a narrow fringe of vegetation along the edge so they are more resistant to problems than those with highly maintained turf to the pond edge.
- In ponds with littoral plantings, problem plants should be selectively controlled without damaging littoral shelves.
- Encourage clumps of native emergent vegetation at the shoreline.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.
- 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.
- 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.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered dissolved oxygen levels.
- Aerate shallow lakes less than 6 feet in depth to maintain acceptable dissolved oxygen levels.
- Where applicable, aerate at night to control oxygen depletion in ponds.
- 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.
- Passive hazing decoys (owls, coyotes), ground-level wind-streaming flags, and beaver deceivers should be used where appropriate to the site fauna using or proximal to surface waters.

- Frequently remove filamentous algae by manual removal methods 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.

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

Best Management Practices

- Confirm aquatic pesticide permit requirements before making applications to water. Prioritize the use of nonpesticide management practices (e.g. hand or machine removal), as pesticides can have difficult to manage effects on the larger food web.
- Maintain dissolved oxygen concentrations to prevent fish kills in ponds and lakes (occur at levels of 2 ppm), for example, use artificial aeration (diffusers) when needed, or certain submerged aquatic plants.
- Select algaecides containing hydrogen peroxide instead of one containing copper or endothall to treat high populations of (algal) phytoplankton.
- Use integrated pest management principles to optimize and focus on the 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 dissolved oxygen levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat an entire pond at once.
- 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 integrated pest management and native or naturalized vegetation wherever practical.
- Apply appropriate herbicides and properly to minimize damage to nontarget littoral plantings.
- Maintain a narrow band of open water at the pond edge to control the expansion of aquatic plants into areas more desirable for littoral plantings.
- Use appropriate aquatic herbicides to avoid turfgrass injury if the pond is used for irrigation water supply.
- Irrigation should not directly strike or runoff to water bodies and wetlands, and no-fertilization buffers should be maintained along edges.
- Outline goals and priorities to guide the development of the Best Management Practices necessary to support the lake/aquatic management plan.
- 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 and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface and groundwater contamination.
- Apply aquatic pesticides per label instructions to reduce the risk of negative biological impacts and impairing water quality.
- Identify the position and environmental setting of property and water body in relation to its watershed.
- Identify overall goals and qualify concerns of the local watershed, habitat, and wildlife.

- Understand surface water and flow patterns.
- Identify major drainages and catch basins that connect to local surface water bodies.
- Identify and understand the depth of water tables and soil types.
- Locate and protect water supply wells, and properly buffer wellhead protection zones. Chemical applications are not allowed within 100 feet of domestic water supply wells. Use careful application practices to ensure that pesticides do not reach groundwater.

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

Best Management Practices

- Use integrated pest management principles to address insects or other vectors 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.
- Obtain a permit if required for aquatic insecticide application.
- Outline goals and priorities to guide the development of the Best Management Practices necessary to support the lake/biotic community management plan.
- Identify the position of property in relation to its watershed.
- Identify overall goals and validate concerns of the local watershed.
- 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 the depth of water tables and soil types.
- Locate and protect domestic water supply wells (wellheads) with a 100ft minimum buffer. Use soil maps from NRCS to identify permeable soils where pesticides will be at risk of reaching the water table.
- 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 integrated pest management strategies and native or naturalized vegetation wherever practical.
- Acquire or file a notice of intent for an aquatic pesticide permit prior to implementing treatment options.
- Apply pesticide products per label instructions to reduce the risk of impairing water quality and causing negative biological impacts.
- Apply appropriate herbicides to minimize damage to nontarget 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 water bodies, and no-fertilization buffers should be maintained along water edges.

- Golf course superintendents should monitor designated waters in their area for the persistence of toxic herbicides and algaecides in the environment.
- Use passive decoys and other hazing devices to minimize issues with avian and semi-aquatic animals.
- Secondary environmental effects on surface water and groundwater from the chemical control of vegetation should be monitored and recorded.
- Apply fertilizer and reclaimed (reuse) irrigation/fertigation appropriately to avoid surface water and groundwater contamination.

2.1.2 Wetlands

Wetlands act both as filters for pollutant removal and as nurseries for many species. Many people do not realize the vital role they play in purifying downstream surface waters. 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. While wetlands do pose a special concern, their mere presence is not incompatible with the game of golf. With care, many golf holes have been threaded through sensitive areas, and with proper design, construction, and management golf courses can be good neighbors and land stewards.

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 be permitted to be an integral part of the stormwater management system.

Best Management Practices

- Preserve wetlands that occur at the golf course.
- Follow the wetland protection "no net loss" principle based on avoidance first, then minimize, or lastly mitigate when wetland disturbances are necessary for golf course planning, design, and construction, as well as for renovation activities.
- Wetland mitigation work, when and where required, may capitalize on and support restoration activities.
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and Best Management Practices on projects upstream to prevent erosion and sedimentation.
- Natural waters generally are not considered treatment systems and must be protected. (Natural waters do not include treatment wetlands).
- Establish a low- to a no-maintenance level of plantings within a buffer along wetlands using native plants.
- Establish and maintain a riparian buffer around springs and spring runs.

2.1.3 Streams, Creeks, and Rivers

Water bodies flowing through golf courses are generally connected to the larger watershed, as opposed to lakes and ponds, which are often discrete features that may or may not connect to a nearby stream. Streams and creeks pose a different set of management issues because of their connectivity. This connectivity usually means that streams and creeks are home to salmonids and similar fish species that may migrate through the golf course at various times of the year. Because of the presence of salmonids, water quality protection in streams and creeks is critically important. Streams may also be part of the drinking water source for private users and public water systems.

Water quality in creeks and streams in and near the golf course should be understood and protected. Many regulatory requirements exist to protect surface water quality. The appropriate regulatory agencies should be consulted. Integrated pest management should be used to establish thresholds and manage pests near-surface water.

Best Management Practices

- Be aware of soil types on the golf course, their ability to infiltrate irrigation and rainwater, and their likelihood of eroding. Erosion can in itself adversely impact surface water quality as turbidity. In some cases, pesticides and nutrients can stick to soil particles and move off-site during erosion events.
- Find out information on the soils on your golf course using the US Department of Agriculture, Natural Resources Conservation Service (NRCS) Soil Web found here.
- Use irrigation practices that do not result in surface runoff that may impact water quality in nearby surface water.
- Identify impervious surfaces, such as building roofs, parking lots, cart paths, and walkways, and assess drainage and erosion, if any, that is created during rain events. Implement mitigation if erosion is occurring (slowing drainage discharge and erosion rates on-site also limits the potential for off-site erosion or hydromodification both upstream and downstream). Ensure drainage infiltrates in rain gardens, vegetated swales, undisturbed soils, or riparian zones to reduce and prevent pollutants from reaching water bodies.
- Identify locations on the golf course that either receive or discharge surface water.
- For locations on the golf course that receive surface water, understand the source of this water and impairments, if any. If this incoming water is impaired, sample, and analyze it as described later in this chapter. Document this impairment so that the course is not potentially implicated in a water quality exceedance. Investigate the source of the impairment and assess options to mitigate the impact.
- For locations on the course that discharge surface water, sample and analyze it as described later in this chapter. Document the quality of this discharged water so the golf course is not potentially implicated in a water quality exceedance by the receiving party. If sampling and analysis of surface water discharged from the course suggest a possible impairment, investigate the source of the impairment, and assess options to mitigate the impact.

Be aware of the possibility of floods on or near your golf course. Work with nature rather than against it through good planning, design, and construction. Reestablishment of natural water systems and flows helps mitigate flooding and control stormwater and erosion. Golf courses should address high sediment, nutrient, bacteria, and thermal loads and vertical and lateral stream migration causing unstable banks, erosion, channel-incision and floodplain disconnection, flooding, and reductions in groundwater recharge. Land use decisions and engineering standards must be based on the latest research science available and demonstrable uses.

Best Management Practices

- Install stream buffers to restore natural water flows and flooding controls, create shade to cool water temperatures, filter nutrients, and bacteria, stabilize soils, minimize erosion, turbidity, and the potential for hydromodification (flow rate) effects upstream and downstream.
- Install buffers in play areas to stabilize and restore natural areas that will attract wildlife species.

- Perform restoration planting within normal floodplain nonplay areas to create additional natural areas, increase natural filtration, and augment other conservation and restoration work. Encourage a variety of native plants within the riparian buffer (trees, shrubs, ground cover). This work generally does not require a permit.
- Complete in-water projects (placement of large woody debris and root wads, boulders, etc.) that slow surface water flows and erosion potential, as well as create riparian and aquatic habitat. Relevant permits should be obtained and followed.
- Install detention basins to store water and reduce flooding to natural surface waters at peak flows.
- Find out if your area is at risk of flooding and have the tools you need in case of an emergency. More information about individual flood preparation in Oregon may be found here.
- Plan, design, and construct the course and drainage systems to support retention of floodwaters to the extent practical within the capacity and means of the overall stormwater systems. Pre-construction permits will apply for certain removal/fill activities.
- Good understanding of the course hydrology through the planning, design, and construction process allows excess floodwaters to be directed to infiltration or storage zones, wetlands, and floodplain areas for the majority of storm events.
- Creation or expansion of lowland areas within the floodplain during planning, design, and construction will add storage capacity during heavy storms. Pre-construction permits will apply for certain removal/fill activities.
- Lowland areas for flood storage, sediment settling, and infiltration should have slight berms with an elevated stormwater drain inlet that allows the depression to hold the treatment volume and settle out sediments while allowing overflows to drain away.
- Existing golf courses can add slight berms to modify the location of the inlet point to a higher elevation along with lowland areas within the floodplain to expand storage and infiltration of floodwaters due to storm events. Post-construction permits will apply for certain removal/fill activities.

2.1.4 Stormwater

Golf courses are typically large properties, ranging in size from 60 to 200 acres, that is often one link in a broader 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. Depending on the golf course design features, golf courses are capable of having an impact on stormwater flow. That impact should be to add only small increments of water over a given period of time. Engineers call this function “detention.” Good golf course design can provide benefits to the overall ecosystem functions within the environmental setting, as well as maximizing playability and water-use efficiency.

When golf courses are designed and built, their drainage capability concept is generally 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. Though soil types may vary on a course, many soils in Oregon are capable of infiltrating up to 90-percent of routine rain events. In other words, when that rain event happens, the golf course playing surfaces and other turfgrass areas 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. Longer stormwater retention times decrease broader risks of flooding that is also beneficial to stream water quality, such as minimizing turbidity and increased filtration within adjoining riparian zones.

Best Management Practices 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.

When the golf course is properly designed, rain and runoff captured in water hazards and stormwater ponds that are part of the irrigation system 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 train. Stormwater capture is desirable where stored water is needed to conserve potable water, maintain hydrologic balance, and/or improve water treatment. This practice uses natural systems to cleanse and improve water quality.

Best Management Practices

- Consult with a golf course architect, working in conjunction with a stormwater professional, to develop an effective stormwater management system that complies with the requirements of the local municipality, water management district/department, or other permitting agency.
- A lake/pond management plan should be prepared to guide management activities.
- Install berms and swales to capture pollutants and sediments from runoff before it enters the stormwater or irrigation storage ponds.
- Plant and maintain riparian vegetation in buffers around the lakes/ponds, streams, creeks, and rivers.
- Monitor pond water level for water loss (seepage) to underground systems. If unintentional seepage is occurring, it may be necessary to line or seal the pond or install pumps to relocate water.
- Stormwater to be used as a backup source of water should be incorporated into the management plan within the requirements of state regulations.
- Inspect irrigation pumps, filtration systems, conveyances, and control devices to prevent/correct system issues.
- Use Low Impact Development (LID) features to capture, filter, and infiltrate stormwater as near as possible to its source (e.g. parking lots and buildings).

Stormwater is the conveying force behind what is called nonpoint source pollution. Nonpoint source pollution, which is both natural and caused by humans, comes not from a pipe from a factory or sewage treatment plant, but from activities conducted over broad areas. Pollutants commonly found in stormwater include the microscopic wear products and toxic metals from brake linings and tires; oil; shingle particles washed off roofs; soap, dirt, and worn paint particles from car washing; leaves and grass clippings; pet and wildlife wastes; lawn, commercial, and agricultural fertilizers; and pesticides. Some legacy pesticides no longer approved or in use or their ultimate residual decomposition products, may remain in soils for decades with corresponding contributions to stormwater quality.

Stormwater management is important at golf courses for many reasons. Stormwater runoff can carry pollution to receiving waters, cause erosion, and cause flooding if not managed properly. 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. Keep in mind that not all stormwater on a golf course originates there; some may be from adjoining lands, including residential or commercial developments.

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. It is important to consider these functions when planning, 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 themselves contribute to the treatment. Source controls are the first car on the Best Management Practice treatment train. They help to minimize the generation of stormwater or the introduction of pollutants into stormwater. The most effective method of stormwater treatment is not to generate stormwater in the first place or to infiltrate it where it is generated.

Best Management Practices

- Install swales and slight berms where appropriate around the water's edge, along with buffer strips, to reduce nutrients, bacteria, erosion and sediment input, and contamination.
- Design stormwater treatment trains to direct stormwater across vegetated filter strips (such as turfgrass and other relevant plants), through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.
- 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.
- Ensure no discharges from pipes go directly to water.
- Eliminate or minimize directly connected impervious areas.
- Use vegetated swales or other Low Impact Development techniques to slow and infiltrate water and trap pollutants in the soil, where they can be naturally consumed by soil organisms.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it runoff. When heavy 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, maintenance roads, or parking lots.
- Disconnect runoff from facility 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.
- Special high-permeability concrete is available for cart paths or parking lots.
- Stormwater management should include "natural systems engineering" or ecosystem services approaches that maximize the use of natural system functions to treat water. Preserve the natural drainage pathways that existed prior to development where possible.
- Control surface runoff quantity and quality in parking lots and from roofs with appropriate infiltration and/or treatment practices such as bioretention facilities (rain gardens), infiltration

planters, grassy swales, filter strips, and constructed wetlands.

- Plan, design, and construct the course to direct runoff from urbanization coming onto the course from storm drain outlets and other drainages of adjoining and upland areas into the course stormwater systems.
- Institute buffers and special management zones.
- Use a treatment train approach.
- Consider the use of eco-roofs for the course and facility infrastructure, where practical and economical. Incentive programs may be available relating to stormwater authority billing discounts or other credits (e.g., leveraging other funding sources for a portion of the construction/installation costs).
- Consider both the quantity and quality of stormwater.
- Stormwater management should slow water velocities and reduce peak discharges, which supports reduced erosion and flooding potential.
- Institute buffers and special management zones.
- Minimize use of curbing—create breaks in curbs where water can flow into appropriate landscaped or natural areas to serve as alternative "irrigation" and be naturally filtered, including in parking lot tree wells and other planters.
- Avoid application of fertilizers and pesticides when rain is imminent or the ground is near saturation to prevent movement of nutrients and pesticides in stormwater.

2.1.5 Sediment

During construction, renovation, and restoration work, 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, renovation, or restoration, and then plant, sod, or otherwise cover it as soon as possible to prevent erosion and limit competition with nuisance, invasive, and weedy species or other natural plants not designed/planned for long-term management.

Best Management Practices

- Use shoreline grasses and native shrubs and/or trees to filter nutrients and bacteria, stabilize soils, and 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.
- Coordinate construction/renovation and restoration activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation and restoration 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.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with the turf. A hazardous waste determination may be needed to appropriately characterize and dispose of the dredged material.
- 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, renovations, and restoration sites until it is actually ready for construction.

2.1.6 Buffer Zones

Buffer zones around water bodies on the golf course can provide important benefits, including temperature modulation, erosion control, sedimentation prevention, filtering instream and riparian habitat, biodiversity, and landscape connectivity for wildlife. A designated buffer zone is defined as the zone between a water body or natural area and where turfgrass management begins (e.g. nutrient or pesticide applications and mowing).

Buffer zone widths may vary in accordance with landscape position, soil characteristics, slope, and the potential pollutants entering the buffer at a specific location. Minimum buffer widths will vary with the intended buffer function and the specific site conditions including hydrogeology, slope, vegetation types, soil type, presence of wetlands, and the type of nutrient or pollutant to be removed.

The US Environmental Protection Agency has developed fact sheets about establishing buffer zones. Buffer zones may also be a requirement of the use instructions found on the product label for certain pesticides, which must be followed.

Fertilizer applications should be eliminated or extremely limited in defined buffer zones. Separate action thresholds must be defined for the application of pesticides within buffer zones. Spot treatments for weeds or invasive species are preferred. The nutrient management plan and vegetation management plan describe Best Management Practices implementation relating to nonplay area operations and management of landscaped, buffer zones, and natural areas.

Buffers around the shore of a waterbody or other sensitive areas filter and purify runoff as it passes across the buffer. Ideally, buffers with native species provide a triple play of water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife. As discussed above, it is important to continue these plantings into the water to provide a diversity of emergent vegetation for healthy aquatic life.

Effective Best Management Practices in these areas include filtering and trapping sediment, nutrients, and bacteria, site-specific natural/organic fertilization, and limits on pesticide use, primarily focusing on the control of nuisance and invasive species when manual removal is not feasible.

Best Management Practices

- Institute buffers and special management zones.
- Establish buffer zones near waterways, where appropriate or as required.
- Riparian buffer areas are above the high-water mark and should be unfertilized and left or maintained in a natural state, preferably with multi-story native vegetation (trees, shrubs, and grass and herbaceous plants).
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- 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. Increase the height of cut in the riparian

zone to filter and buffer nutrient movement to the water.

- Use a deflector shield to prevent fertilizer and pesticide prills from contacting surface waters.
- Apply fertilizer and pesticides based on the effective swath; keep the 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, bacteria, and sediment in stormwater runoff. Riparian buffers also provide shade to cool water temperatures.
- Avoid the use of trimmers along the edge of the water body.
- Establish buffer zones and mow lake and pond collars at 2 inches or higher to slow and filter overland flow to water bodies.
- Transition playable turfgrass and nonplay landscaped areas with buffer zones to natural areas and water features.
- 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 filter for suspended sediments, nutrients, and pesticide residue.
- Use plant buffers with native species to provide pleasing aesthetics, habitat, and food sources for wildlife.
- Establish special management zones around pond edges.
- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loads.
- 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 the nutrient runoff into ponds that cause algae blooms and ultimately reduce dissolved oxygen levels.
- Install desirable plants to naturally buffer dissolved oxygen loss and fluctuation, including certain submerged aquatic plants appropriate for the water feature conditions, where relevant and economical.
- Dispose of grass clippings where runoff and wind will not carry them back to a lake or pond.
- Nutrient-rich runoff encourages algal blooms and other phytoplankton; apply appropriate fertilizer rates and maintain application buffer zones. Test soil and/or vegetation nutrient levels periodically and only apply nitrogen or phosphorus fertilizers when testing and/or plant condition indicate fertilizer is necessary.

Investigate whether waterways on the golf course have additional restrictions for pesticides in buffer zones related to the Endangered Species Act consultations and litigation. Generally, buffer zones of 20 yards are required when making applications of affected active ingredients using ground equipment. Not all pesticide active ingredients have a court defined "buffer zone" requirement—just certain ones that might harm salmonids or other sensitive species. Not all bodies of water have court-defined buffer zones—just ones that have or may have endangered and threatened salmon or other species. Visit www.epa.gov to use the Salmon Mapper, which shows fish distribution and data for streams in the Northwest, to decipher whether the stream on the golf course is a threatened salmon-bearing stream, for example. The Oregon Department of Agriculture website provides information on the court case, the federal rulings to present, and provides links to useful websites such as the one listed above.

2.2 GROUNDWATER

Groundwater is often the water source of choice for irrigation at golf courses in the Pacific Northwest, either as primary or supplemental irrigation. Groundwater occurs in subterranean aquifers that, when penetrated by a water supply well, will yield water of sufficient quantity and quality to meet the irrigation needs. Groundwater is also typically used by nearby municipalities, farmers, and industries to supply water for human consumption, irrigation, and commercial uses.

Groundwater may occur at various depths and its movement is controlled by the geology of the region. In a simplified system, the recharge of an aquifer is the result of precipitation and infiltration in areas that are upgradient of the well. Groundwater discharge occurs to streams, creeks, rivers, lakes, and the Pacific Ocean, downgradient from the well. In a sense, groundwater is surface water waiting to happen.

In Oregon, the right to use water (both surface water and groundwater) for irrigation is granted by the Water Resources Department. Issues related to water rights are discussed in more detail in Section 2.4.3.

2.2.1 Wellhead Protection Program

The objective of a wellhead protection program is to protect groundwater resources primarily for drinking water use by the golf course and the communities in which the golf course is located.

The general principle of a wellhead protection program is to consider capture zones around a municipal water supply well in terms of the travel time for a release of a hazardous substance to reach the well. Often, special ordinances are enacted by municipalities to protect groundwater and limit potential sources of contamination.

A golf course should develop a Wellhead Protection Plan to guide an analog of the municipal wellhead protection process. The groundwater flow direction, the location of nearby water supply wells (municipal and private) or irrigation wells, and how the golf course fits in the watershed need to be determined to develop a Wellhead Protection Plan for the facility.

Best Management Practices in all categories established for the golf course should be evaluated in the context of nearby water supply wells and adjusted, if necessary. Appropriate Best Management Practices implemented upgradient of a water supply well will help to limit the potential for the well to be affected by golf course maintenance activities.

Pesticide and petroleum storage areas may be subject to municipal wellhead protection ordinances. Specific Best Management Practices related to wellhead protection, which could include prohibiting certain activities in the protection area, should be considered and a groundwater sample collected to establish a baseline groundwater quality. It may be useful to perform aquifer tests at golf course wells or review the results of nearby tests to determine aquifer properties or calculate groundwater travel times. Infiltration rates and hazards from the Natural Resources Conservation Service Web Soil survey can assist with understanding the risk to groundwater. Modeling of the groundwater flow system and well mechanics can further inform the Superintendent relating to golf course operations and adaptive management.

The standard of practice for wellhead protection at a golf course developing an Environmental Stewardship Program would be to meet the requirements of the local ordinances. Oregon Health

Authority has rules on allowed activities within wellhead protection zones. For example, these rules prohibit chemical use (including fertilizers and pesticides) within 100 feet of a public water supply well. If no municipal ordinances are applicable to the golf course, concepts enumerated in the City of Portland Groundwater Protection Manual for the Columbia South Shore Wellfield should be considered to the extent practical. For golf courses located in areas subject to regulatory requirements for wellhead protection, permits or land-use restrictions may apply.

Best Management Practices

- Reduce pesticide use in sensitive areas, especially if a pesticide poses a risk to groundwater as stated on a label's groundwater advisory statement.
- Collect samples of groundwater from wells to establish baseline water quality as a point of comparison for future samples.
- Reduce fertilizer use, especially those with ground-water advisory statements on the label, in sensitive areas, including areas such as turfgrass adjacent to waterways, particularly ponds, lakes, wetlands, and rough adjacent to natural areas.
- Create delineation boundaries/buffers.
- Use grasses that have low fertility requirements.
- Maintain natural shore/lawn barriers, which can include using trees, ground cover, and other plants to help minimize runoff and fertilizer loss.
- Store pesticides in restricted access, lockable, dedicated room, or cabinet.
- Mix pesticides in a dedicated area.
- Clean up spills immediately.
- Dispose of pesticide waste in accordance with regulations.
- Manage hazardous materials and petroleum products in accordance with regulations.
- Manage vehicle and equipment maintenance areas to limit the potential for groundwater contamination.
- Store chemicals within containment devices or systems.
- Stormwater systems for facility maintenance and clubhouse areas infrastructure should be designed, constructed, and/or retrofitted to adequately treat or control discharges.
- Perform modeling of the groundwater flow system and well mechanics relating to the fate and transport of relevant chemicals of potential concern or other indicator parameters.
- Check to see which county or municipal wellhead protection, permits, or land-use restrictions apply.
- Review laws and rules pertaining to wellhead protection—federal, state, and local.
- Implement a wellhead protection program.
- Identify public and private sources of drinking water including wells.
- Identify areas of the golf course where groundwater may be most impacted (e.g., shallow water table, sandy soil profile) by golf course management activities or infrastructure. These areas would be considered potentially sensitive areas.
- Select turfgrass varieties that grow much slower and require less fertilizer.
- Maintain buffer zones to help minimize erosion and runoff.

As part of the Wellhead Protection Plan, baseline and future periodic ground-water sampling should be performed at each golf course. In order to establish a baseline of ground-water quality, the water should be sampled and analyzed for all of the chemicals that have been used at the golf course in the last five years. Once the baseline groundwater quality is established, the well water should be sampled at least every five years. If chemicals are detected at levels of poten-

tial concern, then more frequent sampling for those chemicals may be necessary to understand fate and transport characteristics. An environmental risk evaluation should be performed if golf course chemicals are detected.

2.2.2 Sodic/Saline Conditions

All natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly. Saltwater intrusion from groundwater pumping near coastal areas can create a problem with some irrigation wells. 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 content of Total Dissolved Solids (TDS).

Best Management Practices

- Optimize pumping rates. 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 acceptable levels.
- Adjust irrigation water quality for, and consider turfgrass species based on, saline content.
- Consider fertilizer that uses soluble nitrogen forms with a relatively low concentration of salts.
- 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), specific conductivity, and free calcium carbonate content.
- Select alternative turfgrass and landscape plants that are more salt-tolerant where salts are an issue.
- Reduce salt accumulations in the soil by flushing soils as needed with a higher-quality water source.
- Design irrigation systems to account for the flushing of salt accumulation from the soil.
- Understand the groundwater flow system and well mechanics, and mitigate for saltwater intrusion. Install monitoring wells and hydrologic control systems, where practical and economical. Amend soil and water to remove salt ions from affected areas.
- Evaluate Best Management Practices to determine effectiveness of managing sodic/saline conditions.

2.3 WATER QUALITY MONITORING

Water quality monitoring is the foundation for evaluating the effectiveness of Best Management Practices and the environmental impacts of golf course management activities. Water quality monitoring provides a data set that can be developed and evaluated over a long period of record for considering the effects on water quality from the integrated pest management program. By monitoring water quality, problems can be detected early and addressed before they become chronic. The water quality monitoring results provide the feedback loop for adaptive management. Changes in the Best Management Practices, fertilizer/pesticide use patterns, or other course operations can be made based on sound science and hard data.

While the primary objective of a water quality monitoring program is to evaluate whether the golf course is having an effect on the local surface, storm, and/or groundwater, there are numerous other objectives and benefits possible for a water quality monitoring program. The evaluation objectives can focus more specifically on effects on water quality from varying

the frequency and timing of nutrient or pesticide applications and the effectiveness of the integrated pest management program. Potential monitoring objectives might be to monitor golf course impact on sensitive areas, determine the extent and degree of a known problem, or to monitor the effectiveness of renovation or restoration projects, and remediation or mitigation of a known problem. Also, monitoring the quality of water coming onto the golf course can provide important information for turf and soil management programs as well as provide a baseline for evaluating the net effect of the golf course on the water passing through.

Best Management Practices

- Routinely make and document visual observations of the various water bodies entering and present on the golf course.
- Monitor and document water quality of relevant surface and ground waters to assess the impact of golf course management practice.
- Use a certified analytical lab for chemical analysis.
- Use the same laboratory for analysis over time so results are more comparable.
- Use accepted and established sampling protocols to collect samples.
- Use a laboratory capable of detecting contaminant concentrations at or below relevant water quality criteria or EPA benchmarks for pesticides and other parameters (e.g., https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/aquatic-life-benchmarks-and-ecological-risk).
- Consider sensitive environments in the timing and frequency of monitoring.
- Strive for stewardship-related certifications (e.g., Audubon, Salmon-Safe).

2.3.1 Water Quality Monitoring Plan

The water quality monitoring program begins with the development of a water quality monitoring plan for the golf course. Implementation of the water quality monitoring program should be based on site-specific watershed conditions, stream flows, soil type, topography, drainage, and vegetation, as well as minimum needs for healthy ecosystem functions and relevant sensitive natural areas. The water quality monitoring plan documents the hydrologic and drainage conditions, objectives for monitoring, monitoring locations, the field collection, and laboratory analytical program, and quality assurance/control procedures.

There are various objectives a golf course may have for sampling various water bodies. Each water body on every golf course should be reviewed concerning water quality monitoring objectives. Some water bodies may have a big effect on the surrounding environment and/or be more susceptible to contamination from nutrients and pesticides, while others may not.

Water quality monitoring locations at the golf course can include surface water and groundwater. The types of surface water that may be included in the water quality monitoring plan include:

- Ponds—Lined and unlined;
- Wetlands;
- Lakes;
- Streams;
- Rivers;
- Storm Water; or
- Golf Course drainage systems.
- Water quality sampling objectives will vary from golf course to golf course. As part of the water quality monitoring plan, a complete survey of the golf course concerning the surface and groundwater should be performed. During this survey, water bodies that may be affected by golf course maintenance practices should be noted

on a map. The following is a list of details that should be known about the water features:

- Groundwater or surface water;
- Surface water type (pond, stream, etc.);
- Entry point and exit point for surface waters;
- Nearby features that may affect water quality (green, fairway, upstream land use, locations of natural areas and sensitive species habitat, etc.);
- Which of these should be sampled;
- When and at what frequency should sampling occur;
- What should be tested for—nutrients and pesticides or only nutrients;
- Existing monitoring locations and or monitoring data collected near the site; and
- Flow rates for rivers, streams, and creeks; retention times for lakes and ponds.

Ideally, the water quality monitoring plan should designate that samples be collected from all points where surface water enters and exits the course, as well as locations where golf course management practices may locally affect a water body or sensitive natural area.

Samples collected from surface water entry points serve to establish a baseline to determine the influence of golf course management practice on water quality by comparison of testing results with surface water exit point locations. The results from entry point samples also allow for the evaluation of influences from upstream locations (outside sources) on the quality of water entering the golf course. While a single sample or measurement may or may not be meaningful by itself, the results of measurements will be very meaningful if viewed as a trend over time, such as in consideration of state-water quality regulatory program based total maximum daily loads (TMDLs) or state water quality standards that are or may be established for the applicable water bodies.

Many golf courses use groundwater via water supply wells for irrigation purposes. The wells may be deep and completed in bedrock, or they may be shallow wells that are completed in mostly unconsolidated alluvial deposits. The water from these wells should be tested for water quality and irrigation suitability periodically. Baseline testing should include nutrients and pesticides. The monitoring program should include regular nutrient and bacteria analysis of groundwater, and pesticide analyses at least every 5 years depending on the risk factors associated with particular aquifers. Also, monitoring and the testing of groundwater to be used for irrigation will give the golf course superintendent information regarding potential water quality impacts on soil chemistry, nutrient availability, and turfgrass agronomics. From the information, additional adaptive management decisions can be made regarding soil, water quality, and nutrient management programs, and turfgrass cultivation practices.

The laboratory analytical program to be implemented at the golf course should be described in the water quality monitoring plan. The analytical methods and testing program define the chemicals to be tested in water samples collected from the golf course. Suggested approaches for applying analytical programs are presented in Section 2.3.4 Water Quality Sampling Strategies.

Regulatory requirements related to water quality in the watershed in which the golf course is located should be identified in the water quality monitoring plan. These requirements may be included in Oregon State water quality standards, permits issued to the golf course, municipal stormwater permits issued to the city, listing of a nearby water body on the Oregon 303(d) list, or total maximum daily loads that have been applied to discharges in the watershed.

Best Management Practices

- Identify the course environmental setting and explore your watershed.

- Evaluate golf course impact and take steps to reduce pollution.
- Understand water quality-related regulatory requirements in the watershed that may affect the choice of constituents to be analyzed.
- Develop a water quality monitoring plan to monitor surface water, groundwater, and ponds.
- Visually monitor/assess specific changes in surface water bodies.
- Inspect vegetation condition, color and clarity of surface waters, the water quality of ponds, and streams twice annually, in spring and autumn.
- Develop a vegetation management plan relating to nonplay landscaped, buffer zone, and natural areas.
- Educate construction staff, golf course maintenance crews, members/guests, neighboring property owners, and local community groups or other organizations, including preventative outreach communications and procedures to promote water quality.
- Inventory property features concerning habitat and wildlife, water quality, and stormwater management to define a baseline for measuring improvement and enhancements.
- Establish an Aquatic Plant Management Strategy.
- Develop a Storm Water Pollution Prevention Plan.
- Establish source control practices.
- Establish a stormwater capture train.
- Establish erosion and sedimentation control practices.
- Maintain a stormwater treatment train.
- Obtain applicable environmental certifications relating to habitat and wildlife associations with water quality (e.g., Audubon, and Salmon-Safe), where feasible.
- Obtain relevant sustainability certifications relating to the course and facility operations or other continuous improvements programs that may be viewed through a lens of water quality considerations (e.g., Green Business for sustainable operations,
- Leadership in Energy and Environmental Design(LEED) for green buildings, International Organization for Standardization (ISO) for sustainable purchasing and procurement, etc).

2.3.2 Water Quality Sampling Program

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 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 environmental impact. A water quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality during golf course operations.

Sampling parameters are determined based on golf course operation and watershed-specific parameters of concern on which the golf course may have an effect. These watershed-specific may be identified by local/state water quality programs. Typically, samples should be analyzed for nutrients, bacteria, pH and temperature, specific conductance, dissolved oxygen, and any pesticides that may have been used on the golf course. Should deleterious water quality conditions be identified entering or otherwise inexplicably on the golf course, or claims of off-site water quality injuries be presented by others, the analytical monitoring and testing program should be expanded to include relevant additional nongolf course-related pesticides or other chemicals for evaluating water quality entering the golf course that may be due to upstream and/or adjoining land uses. Temperature, pH, specific conductance, and dissolved oxygen are typically measured in the field at the time of sample collection. Ongoing, routine water sampling provides meaningful

trends over time. A single sample is rarely meaningful in isolation.

Should there be no surface water flow on the scheduled sample date, samples should be collected during the next precipitation event. It may also be wise to sample if a significant change has been made in golf course operation or design that could affect nearby water quality.

Best Management Practices

- Review existing sources of water quality data.
- Determine analytical parameters based on known or existing water quality concerns and pesticides needed in golf course operation and watershed in specific parameters the golf course can affect.
- Measure basic water quality characteristics such as pH, temperature, specific conduction, and dissolved oxygen when samples are collected.
- Monitor water quality over time to identify trends, if any.

2.3.3 Sampling Parameters, Collection, and Analysis

A water quality monitoring program should include monitoring and testing of surface water and groundwater and be implemented in three phases: background, construction/renovation or restoration, and long-term management. A 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.

Dissolved oxygen in a lake or pond comes primarily from photosynthesis, wind action, or mechanical aeration devices, and certain aquatic plants. Aquatic organisms require various levels of oxygen to survive—oxygen is important to all forms of life in the pond/lake and supports the food chain. The lack of dissolved oxygen causes a series of chemical reactions that further degrade the pond/lake water quality. For example, sulfide is converted to hydrogen sulfide and insoluble iron is converted to soluble iron.

Natural decomposition processes in the aquatic ecosystem are oxygen-dependent. Improper application of some aquatic herbicides can result in oxygen depletion. Treating aquatic weed infestations with herbicides in hot weather can be risky. Treating only part of the pond at a time can lower the risk of oxygen depletion. The most immediate reactions to oxygen depletion would be fish kills or odors. Long-term reactions include nutrient buildup, sludge accumulation, and chemical imbalance in the lake/pond.

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 for geochemical parameters such as dissolved oxygen 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 environmental impact of the golf course. A water-quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction has been completed. The same sites should be monitored as during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions.

Monitoring and sampling parameters are determined based on golf course operation and basin-specific parameters of concern [these may be identified by water quality standards, the “303(d)” list (list of impaired waters), and state Total Maximum Daily Loads]. Typically, samples should be analyzed for nutrients, ammonia, bacteria, pH, temperature, specific conductance, dissolved oxygen, and pesticides that have been used on the golf course. Ongoing, routine water sampling at the same sample locations provides meaningful trends over time. A 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 two times per year.

Post-construction surface water quality sampling should continue through the first three years of operation and alternating during the wet or dry seasons annually thereafter, provided 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 303d listed waters, state Total Maximum Daily Loads, local regulators, or voluntary-certification programs).

The purpose of quality assurance/quality control is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable. Data should be collected and analyzed using scientifically sound procedures. However, even if the data are only for proprietary use and are not reported to any regulatory agency, it is strongly recommended a certified laboratory be used and all quality assurance/quality control procedures followed. Also, the contract laboratory used for water quality analysis should verify they can detect contaminants at or below relevant water quality criteria or EPA benchmarks. Golf course management must have good data and its validation to make good decisions. If a golf course should ever want to produce data for an agency, voluntary-certification program, or go to court to defend the facility from unwarranted or uninformed charges, those data must meet quality assurance/quality control standards to be defensible as evidence.

Best Management Practices

- Establish dissolved oxygen thresholds to prevent fish kills (hypoxia occurs at levels of 2 ppm), and use artificial aeration (diffusers) if necessary.
- Reduce stress on fish; keep dissolved oxygen levels above 3 ppm (summer concentrations in normal salinity water average 8ppm).
- Select Environmental Protection Agency approved algaecides containing hydrogen peroxide instead of copper or endothall to treat high populations of phytoplankton (algae blooms are also related to phosphorus cycles in the environment).
- Use integrated pest management principles to minimize the use of pesticides and reduce costs.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid removed sediment contact with the turf.
- Locate littoral shelves at pond inlets and outlets to reduce problems with the playability and maintainability of a water hazard.
- Deter golfers with signage limiting access to sensitive natural areas to minimize sediment disturbances and turbidity concerns that can affect dissolved oxygen and other geochemical indicator levels.
- Collect samples using standardized and accepted sampling procedures.
- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.
- Determine which sites will be analyzed and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water quality data.
- Define data values appropriately based on the associated Best Management Practices used to protect water quality.
- Compare water quality monitoring results to state water quality standards
- Record observations of fish, wildlife, and general pond conditions.

The purpose of quality assurance/quality control (QA/QC), procedures described in the water quality monitoring plan, is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable, and are collected and analyzed using scientifically sound procedures. Quality assurance/quality control procedures should be followed for every sampling event, and a determination should be made that a contract laboratory has sufficiently low method reporting and detection limits. Golf course management must have good data to make good adaptive management 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 quality assurance/quality control standards to be defensible as evidence.

2.3.4 Water Quality Sampling Strategies

A water quality sampling strategy should be developed to meet the objectives of the golf course environmental stewardship program. A suggested program that provides important baseline data and results in a data set that can be evaluated to define an on-going monitoring program is broken into three phases:

- Baseline Water Quality Monitoring;
- On-Going Water Quality Monitoring; and
- Targeted Water Quality Monitoring.

2.3.4.1 Baseline Water Quality Monitoring

The monitoring plan at a golf course should begin with Baseline Water Quality Monitoring. The establishment of a baseline for comparing later results allows the golf course to recognize cause and effect between golf course management practices and water quality as well as to identify offsite sources of water quality influences. Offsite sources may include but are not limited to residences and other businesses upstream, upgradient stormwater drainage systems, and other turfgrass/park areas. As adaptive management changes to the Best Management Practices or Integrated Pest Management Plan are identified and implemented, meaningful changes in water quality should be evident.

Baseline Water Quality Monitoring constitutes a rigorous testing program before construction, renovations, or restoration activities, which should include sampling waters from monitoring locations at the golf course defined in the water quality monitoring plan. These water samples should then be analyzed for bacteria, temperature, turbidity, and all of the nutrients and pesticides that have been used on the golf course in the six months before the sampling event. Where contributions from off-site sources are known or anticipated, additional testing parameters should be considered. Sampling should occur in the spring (generally April) and fall (generally October) for each of the first three years. Annual baseline sampling should also include at least one storm event. A list of analytical methods and the chemicals analyzed by each of those methods is provided in Appendix A. Because methods may be modified or added, this list should be regularly updated. In addition to sampling for the pesticides that were used in the previous six months or relating to offsite sources, laboratory analyses should also include those chemicals that were detected in the previous monitoring event(s), bacteria, temperature, turbidity, and nutrients, potentially including those identified by others relating to offsite land uses. The presence of nutrients in water quality samples could be indicators of fertilizer runoff.

In addition to orthophosphates and nitrates, ammonia should also be included in the analytical program for nutrients. If the golf course is working towards certification in the Audubon International's Audubon Cooperative Sanctuary Program, it is recommended that testing be conducted quarterly for one year, generally the first year of the water quality monitoring program, and twice annually after that. To be designated, golf course personnel develop and implement an environmental management plan, document the results, and host a site visit with Audubon International staff. Recertification is required every three years to maintain the Certified Sanctuary designation.

2.3.4.2 On-Going Water Quality Monitoring

Once the baseline water quality has been established, the water quality monitoring program can move toward an On-Going Monitoring program. At this point, water quality monitoring will continue regularly, but now some conditions may influence what chemicals are to be analyzed during a monitoring event as discussed below, potentially including those identified relating to offsite land uses.

Many chemical properties and golf course-specific circumstances will be considered when determining which chemicals need to be analyzed, how often, and from which location(s). These include frequency of detection, persistence, physicochemical properties of pesticides, waterbody types, existing Pacific Northwest-research data, and comparisons of application dates versus detections.

Since the *Guidelines* were first established in 2000, there has been a significant amount of water quality data collected from golf courses in the Pacific Northwest. By studying these data, some changes to the baseline testing program may be justified, which may narrow the number of analyses that need to be run during a given sampling event while retaining a rigorous analytical program.

One important piece of information derived from the historical data is the frequency of detection of golf course chemicals. Each chemical has a different persistence, degradation rate, and half-life relating to detectable residence time in the environment.

Chemicals that have been previously detected at Pacific Northwest golf courses and used during the prior six months should always be included in the analytical program for a water quality monitoring event under these *Guidelines*.

For those chemicals where we have a significant number of samples to provide a reasonable picture of the likelihood of those chemicals entering the hydrologic system, the analytical program included in the ongoing monitoring can be modified to limit analytical costs.

2.3.4.3 Targeted Monitoring

As golf course superintendents perform On-Going Monitoring, they may recognize a need to do more intensive studies on the fate and transport of pesticides considering the specific conditions and management of the golf course, concerning course renovations or natural area restoration projects, or in response to effects relating to offsite land uses. These more intensive studies are termed, "Targeted Monitoring Events," and may include alternative sampling locations, focus on a particular pesticide or nutrient application, or be designed to answer other questions about the fate and transport of pesticides at the golf course, or associated with offsite sources.

The Targeted Monitoring program can be used to supplement or replace an On-Going Monitoring program in a particular year. For example, if propiconazole has been detected periodically at the golf course in an exit sample, additional locations such as drainage systems or other locations in a creek may be sampled to try to pinpoint the source. These Targeted Monitoring events may be performed at times other than the Spring or Fall and may be timed to specific chemical applications. The results may help the golf course Superintendent to make adaptive management changes to Best Management Practices, adjust the Integrated Pest Management Plan for a particular green, or expand buffer zones in an effort to eliminate releases to surface water.

2.3.5 Water Quality Sampling Procedures

The list of analytes to be tested will be determined by the water quality monitoring plan and whether the golf course is in a Baseline Water Quality Monitoring, On-Going Monitoring, or Targeted Monitoring mode. The procedures to be used to collect water samples are described in the following sections.

2.3.5.1 Sample Collection Methods

Proper sample collection methods are important in developing optimal testing information. Less uncertainty about the sample will lead to less uncertainty about the result. The following are the Best Management Practices proper sample collection:

Best Management Practices

- Get detailed sampling procedures from the analytical lab you will use and follow them closely.
- Obtain the proper bottles from the analytical lab.
- Water for nutrient testing should be collected in new, clean plastic bottles supplied by the laboratory.
- Water for pesticide testing should be collected in new, clean amber glass bottles supplied by the laboratory. Currently, these are 1-liter bottles although improvements in analytical techniques may allow for use of different size bottles in the future. Certain chemicals may require alternative bottles depending on the characteristics of the chemical.
- Obtain the samples from the same location at each sampling event. The sample locations should be marked on a map prepared in conjunction with the water quality monitoring plan.
- Label each sample collection bottle with the appropriate sample identifier as well as the date and time of collection.
- Triple rinse the clean sampling device with the subject water. The sampling device should be constructed of materials that will not affect the water sample.
- Lower the sampling device into the water column approximately 6 inches to collect a representative sample. Using the device, fill the bottles. If 2 bottles are necessary for one sample, be sure to fill the 2 bottles almost simultaneously by emptying half of the water from the sampling device into one bottle and the other half of the water sample into the second bottle.
- Once the samples have been collected, cap the sample bottles with clean lids and store them in a cooler with ice. Samples should be kept at 4° Celsius (39° Fahrenheit).
- Deliver samples to the lab within the holding time. For example, samples for nutrient testing have a 48-hour hold time before they must be analyzed.
- As part of the sampling process, field parameters should be measured at the sampling location during sample collection. Four key parameters to measure include pH, temperature, specific conductance, and dissolved oxygen. As mentioned previously, dissolved oxygen is required as part of the Audubon International's Audubon Cooperative Sanctuary Program certification and is an important indicator of stream health.
- Develop and maintain appropriate documentation of the sampling event.

Water quality monitoring samples should be tested using methods approved by the US Environmental Protection Agency, as well as consistent with the most up-to-date, relevant Oregon Department of Environmental Quality issued water quality programs guidance on water quality monitoring and sampling.

2.3.5.2 Field Measurements

Prior to collecting the sample for laboratory analysis, field parameters should be measured and recorded. As mentioned above, these include pH, temperature, specific conductance, and dissolved oxygen, as well as visual and other observations noted at the time of sampling.

pH is a measure of the acidity or alkalinity of a solution in terms of the activity of hydrogen. Solutions with a pH less than 7 are considered acidic, while those with a pH greater than 7 are considered basic. pH 7 is defined as neutral because it

is the pH of pure water at 25 °C. Natural freshwaters can have a pH range from 4.0 to 10.0, but the normal pH for waters in the Pacific Northwest is between 5.5 and 8.5. Knowing the pH of the water body is important for several reasons including but not limited to: 1) high pH values tend to facilitate the solubilization of ammonia, heavy metals, and salts, 2) low pH levels tend to increase carbon dioxide and carbonic acid concentrations, and 3) lethal effects of pH on aquatic life can occur below pH 4.5 and above pH 9.5.

Temperature is a measurement of the intensity (not the amount) of heat or energy stored in a volume of water. Surface water temperatures naturally range from 0º Celsius (C) (32ºF) under ice cover to over 40º C (104ºF) in hot springs. Natural sources of heat include geothermal, solar radiation, transfer from the air, condensation of water vapor at the water surface, sediments, precipitation, surface water runoff, and groundwater discharge. Temperature is the primary influencing factor on water density.

Temperature affects the solubility of many chemical compounds and can therefore influence the effect of pollutants on aquatic life. Increased temperature elevates the metabolic oxygen demand, which in conjunction with reduced oxygen solubility, impacts many species. Coldwater fish, including protected salmon and steelhead, are very sensitive to water temperature and generally need temperatures <18°C. Vertical stratification patterns that naturally occur in lakes affect the distribution of dissolved and suspended compounds. pH is temperature dependent, where incremental changes in temperature result in corresponding pH changes. For all these reasons, it is important to measure the temperature of the water being sampled.

Specific conductance is the measurement of the ability of water to conduct an electric current—the greater the content of ions in the water, the more current the water can carry. Specific conductance may be used to estimate the total ion concentration of the water and is often used as an alternative measure of total dissolved solids. In general, golf course-specific practices do not have an effect on specific conductance general levels, unless using reclaimed water.

Dissolved oxygen is a measure of the amount of oxygen dissolved in water. Typically the concentration of dissolved oxygen in the surface water is less than 10 mg/L but can be higher when the water is colder. The dissolved oxygen concentration is subject to diurnal and seasonal fluctuations that are due, in part, to variations in temperature, photosynthetic activity, and river or stream discharge. Natural sources of dissolved oxygen are derived from the atmosphere, wind, stream riffles, or through photosynthetic production by submerged aquatic plants. Natural re-aeration of streams can take place in areas of waterfalls and rapids. Aeration devices may be used to increase dissolved oxygen in ponds.

These field parameters are measured using instruments designed for the task. The instruments must be calibrated regularly to make sure the data collected are accurate and limit false readings.

2.3.5.3 Monitoring Documentation

Monitoring documentation includes records of field measurements, a chain-of-custody (COC), laboratory reports, interpretations of the laboratory analytical data, and any corrective action that has been taken.

Chain-of-custody forms are a formal means of documenting the handling of a sample from the time of sample collection until the time of sample delivery to the lab. The intention of the chain-of-custody is to establish and maintain a "trail" that defines who was responsible for the possession and maintenance of the samples from start (the sample collection) to the end (delivery to the lab) of the process. The chain-of-custody form contains signatures and the date and time samples were transferred from one person to another. The lab should provide these forms.

Each round of the water quality monitoring program should be documented in a report presenting an interpretation of the results. The report should include a description of the sampling points, who

conducted the sampling, when the sampling was conducted, a comparison of entry point and exit point water quality, a discussion of the field parameter measurements, recent weather conditions, visual changes in surface water conditions, and interpretation of the overall water quality sampled at the golf course. If any chemicals were detected, the concentrations should be discussed in the context of the toxicology of potential ecological receptors and regulatory requirements, as well as turfgrass cultivation and agronomics when and where relevant. The relevant comparison values include Oregon water quality criteria for various parameters, as well as EPA aquatic life and human health benchmarks for current-use pesticides. Humans may also be potential receptors in some watersheds and the effects on human health need to be considered where pathways such as in-water recreation, fish consumption, or drinking water uses are complete. The summary report should be prepared following each round of sampling.

If the results of the sampling event show that golf course operations and management practices may potentially threaten to degrade water quality, it is important to document the best way to change practices through adaptive management to correct the situation. This may include a review of fertilizer and pesticide application records, a review of the Integrated Pest Management Plan, a review of appropriate Best Management Practices documenting results of these reviews, and documenting a corrective action statement. It is important to take and document the corrective action as quickly as possible.

2.3.5.4 Sampling by Golf Course Representative

One way to save costs is for the golf courses to collect their own samples. The regulated industry typically collects samples for compliance with water quality permit conditions. The superintendent and other staff who would be performing the water quality monitoring should receive training in a water quality sampling that demonstrates how to collect representative samples, make the field measurements, and prepare the appropriate documentation.

As part of water quality sampling at their own course, the golf course would need to acquire the proper field sampling equipment such as a pH, temperature, and specific conductance meter and a dissolved oxygen meter. These can be either purchased or rented. Some golf courses may choose to share the equipment purchase with other nearby golf courses. A water-sampling device will also be necessary to perform the sampling and field measuring properly. Sample bottles and a cooler should be supplied by the analytical laboratory.

2.4 REGULATORY CONSIDERATIONS

Golf course owners and superintendents should investigate regulatory requirements that apply to the golf facility to protect surface and groundwater quality and need to be aware of the most current rules governing the application of pesticides to aquatic environments.

2.4.1 Aquatic Pesticide Applications

In Oregon, programs designed to protect surface water quality are administered by the Oregon Department of Environmental Quality. The United States Department of Agriculture (USDA) Forest Service National Best Management Practices Program for water, which was developed to improve management of water quality consistently with the Federal Clean Water Act (CWA) and state water quality programs, also serves as a great resource, in general. The USEPA rule adopted in 2006 to exempt aquatic pesticide applications from permitting requirements under the Clean Water Act's National Pollutant Discharge Elimination System (NPDES) program was invalidated by the U.S. Court of Appeals for the 6th District in January 2009.

Golf courses should be aware of the current legal requirements and know they still may need an Oregon Department of Environmental Quality National

Pollutant Discharge Elimination System Permit if they plan on treating ponds or lakes with pesticides.

Prior to pesticide applications in or over water, the golf course superintendent should contact the state environmental regulatory agency regarding permit requirements. In certain instances, licensing is required for pesticide applications. Information can be found for Oregon licensing here. Staff or contractors applying pesticides in aquatic areas will need relevant licensing, certifications, and training.

Best Management Practices

- Aquatic management of plants and other nuisance species may be regulated under construction permitting and regulatory licensing requirements. Consult with appropriate professionals or state and local water management agencies before managing golf course lakes, wetland, and natural riparian areas and water features.
- Consult with 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.
- Respond to off-site impacts or claims in accordance with any land-use approval conditions, which may require the course to respond to investigate or remedy off-site impacts.
- All nutrients, pesticides, or other products in use on the facility grounds must be used consistently with the manufacturer labeling.
- 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. A hazardous waste determination may be necessary to verify how the sediment waste should be managed and disposed of (i.e., hazardous waste vs. solid waste).
- Wetlands are protected areas; consult with federal and state agencies before altering natural aquatic areas.
- Constructed wetlands may have an impervious bottom to prevent groundwater contamination depending on the objective for their use.
- Local planning codes may necessitate engineering studies relating to the potential for minimizing upstream and downstream hydromodification of natural stream flow rates, and any resulting erosion and sedimentation.
- National Pollutant Discharge Elimination System permit conditions to dictate the golf course use of aquatic pesticides in surface water on the course, as well as nonplay and natural areas. Good planning, design, and construction will support meeting the permit requirements, including relevant use of integrated pest management and Best Management Practices.
- Studies of water supply availability and demand are needed for irrigation systems, including studies of water bodies or flow on, near, and under the property to properly design a course's stormwater system and water features to protect water resources.

The Oregon Watershed Enhancement Board and Portland State University prepared a useful aquatic plant management plan at https://www.anstaskforce.gov/OR_ANS_Plan.pdf titled, "Oregon Aquatic Nuisance Species Management Plan" (Hanson, E., Center for Lakes and Reservoirs, and Sytsma, M.D., 2001). The manual uses an approach based on integrated management of land plants that considers such concerns as:

- How bad is the aquatic plant problem?
- At what level will plants become harmful and when should action be taken to control them?

- When is the best time of year to kill, remove, or suppress the nuisance plant species?
- What methods will best deal with the target species, and for how long?
- How will the treatment affect humans, native plants, and wildlife?
- Are the costs reasonable and affordable?

2.4.2 Water Quality Regulations

Under the federal Clean Water Act and state law, waters of the state must meet water quality standards or be listed as impaired (the 303(d) list). Impaired waters may have a total maximum daily load (TMDL) established for the pollutants in question as a means to restore water quality. Water quality standards and TMDLs are legal requirements subject to enforcement. A total maximum daily load is the amount of a specified pollutant or associated pollutant measurement parameter that is "allowed" to enter the water body and is not expected to result in further degradation of water quality. Total maximum daily loads have been established for some constituents in some basins. Other water bodies have been determined to be water quality limited (i.e., listed on the 303(d) list) and are awaiting the development of total maximum daily loads. These regulatory requirements may lead the golf course superintendent to implement specific water quality sampling strategies to monitor conditions and demonstrate improvements. In order to determine whether a total maximum daily load has been conducted in the watershed where your golf course is located, state websites may be useful. The Oregon Department of Environmental Quality (ODEQ) website contains links to total maximum daily load and Water Quality Management Plan (WQMP) documents prepared for waterbodies in Oregon designated as water quality limited on the 303(d) list: https://www.oregon.gov/deq/wq/tmdls/Pages/default.aspx. The Integrated Report is a searchable database report with data for each water body, pollutant, and location that DEQ has assessed, and the conclusion about water quality in each water body. https://www.oregon.gov/deq/wq/Pages/2012-Integrated-Report.aspx

A municipal wellhead protection program was established under the Federal Safe Drinking Water Act (SDWA) and developed to be an active groundwater contamination prevention program. There are at least six federal laws to help protect groundwater:

- Safe Drinking Water Act (SDWA)
- Set maximum contaminant levels (MCLs) in drinking water and established flexible protection programs.
- Resource Conservation and Recovery Act (RCRA)
- Regulates the storage, transportation, treatment, and disposal of solid and hazardous wastes to prevent contaminants from leaching into groundwater from municipal landfills, underground storage tanks, surface impoundments, and hazardous waste disposal facilities.
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Authorizes the government to clean up contamination caused by chemical spills or hazardous waste sites that could (or already do) pose threats to the environment, and whose 1986 amendments include provisions authorizing citizens to sue violators of the law and establishing "community right-to-know" programs (Title III).
- Federal Insecticide, Fungicide, and Redenticide Act (FIFRA)
- To control the availability of pesticides that have the ability to leach into groundwater.
- Toxic Substances Control Act (TSCA)
- Authorizes EPA to control the manufacture, use, storage, distribution, or disposal of toxic chemicals that have the potential to leach into groundwater.
- Clean Water Act (CWA)

- Sets standards for allowable pollutant discharges to surface water or groundwater.

The Oregon Health Authority and Department of Environmental Quality oversee the public water supply wellhead protection and drinking water source protection programs from the State level. DEQ implemented Oregon's 1989 Groundwater Quality Protection Act, which focuses on statewide prevention of groundwater contamination, conservation of the resource, and maintaining its quality for present and future beneficial uses. The Groundwater Quality Protection Act specifically calls for the Department of Environmental Quality and Oregon Health Authority to implement Wellhead Protection Programs. As with the federal program, the primary goal of the State of Oregon's Wellhead Protection Programs is to be proactive and prevent/reduce the risk of groundwater contamination from potential contaminant sources. Similarly, the Drinking Water Protection program advises on and implements the protection of both surface and groundwater used for public drinking water supplies. Private domestic water users may be downstream on surface waters or downgradient on private wells.

The following information is summarized from the Oregon Department of Environmental Quality Wellhead Protection Program Guidance Manual. There are six general steps in implementing a municipal wellhead protection program at a golf course:

- Prepare wellhead protection plan
- Define staff responsibilities
- Delineate protection area including offsite supply wells
- Inventory potential sources of contamination
- Develop a management approach
- Develop a contingency plan

The golf course should contact the local water department for information on the water source. Source Water Assessments were completed in 2005 for all public water systems in Oregon and were updated recently. Source Water Assessments give information on risks to drinking water sources such as erodible soils. These and other drinking water protection information can be found here: https://www.oregon.gov/deq/wq/programs/Pages/dwp.aspx. Oregon golf courses/golf clubs that have their own drinking water well and are considered a public water supply should have a copy of this assessment or can obtain it by contacting the Oregon Health Authority drinking water program at 971-673-0405. In addition, golf course superintendents can identify if they are located within a source area for a public water system by using the resources on the Oregon Department of Environmental Quality website, https://www.oregon.gov/deq/wq/Pages/default.aspx.

Best Management Practices

- Become familiar with federal, State of Oregon, and local regulations that apply to golf course operations including those related to habitat, surface water, ground-water, and stormwater runoff.
- Implement policies and procedures to achieve compliance with relevant regulations such as water quality standards and total maximum daily loads.
- 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 of Oregon, 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.
- Golf course owners are responsible for water quality standard and Total Maximum Daily Load compliance, and watershed basin management action plans in Oregon.
- Wetlands are protected areas; consult with federal and State of Oregon agencies before altering natural aquatic areas.
- Constructed wetlands should have an impervious bottom to prevent groundwater contamination.
- Perform modeling of the groundwater flow system and well mechanics relating to the fate and transport of relevant chemicals of potential concern or other indicator parameters.
- Studies of water supplies are needed for irrigation systems, including studies of water bodies or flow on, near, and under the property are needed to properly design a course's stormwater system and water features to protect water resources.

2.4.3 Water Rights

Prior to golf course renovation or construction, the availability, quality, and quantity of water must be determined, ideally during the planning and design process. Having the right to use water is critical. The Oregon Department of Water Resources (OWRD) is the state agency authorized to regulate both surface and groundwater usage. Water users must obtain a permit or license from the Water Resources Department to use water from any source - whether it is underground, or from lakes or streams. Below are important elements of Oregon water rights:

Best Management Practices

- Ensure that your golf course has appurtenant rights to the water it uses. Pre-construction permits will apply for certain water rights activities. Changes in places of use or places of diversion will require post-construction permits.
- Determine what Oregon Water Resources Department programs have jurisdiction in the area your golf course is located relating to water quality and quantity.
- Complete a water availability assessment.
- Perform water supply & demand estimates.
- Apply water only to lands defined as the place of use in the water use permit or water right certificate.
- Divert or appropriate water in quantities no longer than specified in the water use permit or water right certificate.
- If additional areas need to be irrigated, apply for new water rights to cover those areas, or transfer water rights from areas that no longer need to be irrigated.
- Irrigate all areas defined in the water rights certificate at least once every five years to assure the noncancellation of the water right.
- Use irrigation practices and other operations that do not result in runoff that may impact water quality in nearby surface water.

IRRIGATION 3.0

Irrigation for golf course maintenance is an integral component of the golf course operation. An adequate system is needed when rainfall is not enough to sustain healthy playable turf, especially during prolonged dry periods. Some facilities may have more than one course or type of irrigation system due to the layout, terrain, or other factors. It is crucial to maintain irrigation system practices that support water conservation while remaining flexible and efficient in meeting maintenance standards.

The purpose of this section is to identify Best Management Practices related to water use that conserves and protects surface water and groundwater resources and ecology. It is important to keep in mind, 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, availability, and surrounding natural resources.

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

The monetary investment in nonstructural irrigation Best Management Practices costs little to nothing to implement in a daily golf course water-use plan. Other advantages to using Best Management Practices include reduced administrative management stress, improved employee and external communications and direction, and effective facilities training procedures.

Several benefits of adopting irrigation related Best Management Practices are:

- Conserving the water supply;
- Protecting existing water quality;
- Providing optimal plant and soil health;
- Maintaining optimal ball roll, playing, and aesthetic conditions;
- Saving water and electricity;
- Increasing pump and equipment life longevity;
- Demonstrating responsible environmental stewardship; and
- Retaining knowledgeable and effective employees.

3.1 IRRIGATION WATER SUITABILITY

Golf course designers and managers should endeavor to identify and use alternative supply sources to conserve freshwater drinking supplies, where feasible, promote plant health and protect the environment. In evaluating the suitability of a water source, consider the turfgrass type(s), soil characteristics including leaching ability or lack thereof, depth to groundwater, and topography as it relates to runoff or low spots where water may drain and pool. Assess characteristics of your irrigation water source(s) to determine compatibility with these golf course characteristics. For example, factors such as salt content, pH, hardness, and in some cases trace metals, can impact turfgrass quality.

The routine use of potable water supply is generally not a preferred practice; municipal drinking water should be considered only when there is no suitable alternative. The capture of stormwater and subsequent reuse as irrigation water can be a viable irrigation water source option to consider.

Studies of water supplies are recommended for irrigation systems, as are studies of water bodies or flows on, near, and under the property, and water budget estimates. These may be helpful to properly design a golf course stormwater system, water features, and to protect water resources. When necessary, sodic water system treatment options should be included in the maintenance budget to address water quality and equipment maintenance.

Reclaimed water from wastewater treatment plants is typically high in salts, including sodium, chloride, and sulfates. Excess salt in irrigation water can adversely impact turfgrass quality and may have long-term impacts to soil and its ability to sustain a viable root zone. Several additional irrigation Best Management Practices may be applicable when reclaimed water is used as a primary water source, particularly on semi-arid lands east of the Cascade Mountains.

Best Management Practices

- Determine that the preferred irrigation source water is suitable for application to turfgrass via water-quality testing.
- Consider long-term implications of irrigation source water quality, such as salt/sodium buildup in soil, or brine management and disposal costs where salt treatment systems operate.
- Treat water as needed to improve suitability for irrigation.
- When possible, use reclaimed water for irrigation.
- Apply water conservation measures even if using reclaimed water.
- The characteristics of reclaimed water vary greatly between sources. Routinely review water quality analytical data or perform water quality testing to determine if any extra management practices are necessary to use the water at the golf course.
- Monitor the quantity of water withdrawn to avoid impairment of aquatic life or other ecosystem function.
- Identify appropriate water supply sources that meet seasonal and bulk water allocations for grow-in and routine maintenance needs.
- Routinely monitor shallow groundwater table of freshwater for saltwater intrusion, or contamination from pesticides, nutrients, or other compounds detrimental to irrigation water quality.
- Use alternative water supplies/sources that are appropriate and sufficiently available to supplement 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 the soil.
- Flush with fresh water or use amending materials regularly to move salts out of the root zone and/or redirect/pump brackish water from the irrigation system to keep salts moving out of the root zone.
- Monitor sodium and bicarbonate buildup in the soil using salinity sensors.
- Reclaimed, effluent and other nonpotable water supply mains must have a cross-connection central/backflow prevention device in place and operating correctly.
- Post signage in accordance with the local utility and state requirements when reclaimed water is in use [OR OAR340-055-0012(5,6,7)(g)].
- Account for the nutrients in effluent (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 detrimental levels of sodium,

chlorides, and sulfates (salts) from saline groundwater.

3.2 WATER CONSERVATION AND EFFICIENT USE PLANNING

An irrigation system that allows for remote control of heads and operates using soil moisture sensors and weather data, including daily measurements of (potential) evapotranspiration, based on a weather station located on the golf course, will provide the most efficient use of water and supports its conservation. This system will have flow meters and totalizers located at key places so water use can be monitored and evaluated.

Preparation of water management and conservation plan is intended to represent a proactive evaluation of the management and conservation measures that suppliers can undertake. The planning program requires that municipal water suppliers consider the water that can be saved through conservation practices as a source of supply to meet growing demands if the saved water is less expensive than developing new supplies. As such, a plan represents an integrated resource management approach to securing a long-term water supply for the community.

The Oregon Municipal Water Management and Conservation Planning (WMCP) program provide a process for municipal water suppliers to develop plans to meet future water needs. Many municipal water suppliers are required to prepare plans for underwater right permit conditions. General information and other resources regarding the Oregon Municipal Water Management and Conservation Planning can be found here.

If a golf course superintendent can document actual watering practices, it is easier to show savings in water use when compared to 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 opportunity is to find solutions to maintain the quality of turfgrass while using less water. Best Management Practices and educational programs are necessary to inform the public about the inevitable changes in water-related issues.

Some golf courses today are designed using a "target golf" concept that minimizes the acreage of irrigated playable turf particularly in areas where there is limited water availability. Existing golf courses can make an effort to convert underutilized facility and course out-of-play turf areas to naturally adapted native plants, grasses, or other ground covers to reduce water use and augment the golf course wildlife and aesthetic appeal.

Best Management Practices

- Select drought-tolerant varieties of turfgrasses to help maintain an attractive and high-quality playing surface, while minimizing water use.
- Nonplay 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 and permitted, rain and runoff captured in water hazards and stormwater ponds may provide supplemental water under normal conditions, though backup sources may be needed during a severe drought.
- During drought conditions, 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.
- If you take areas course out of play and underutilized facility areas to conserve water, communicate this to customers and membership with signage.

3.3 TURF DROUGHT RESPONSE

Drought is a condition of periods of lower than normal natural rainfall for consecutive years or more that creates stress on turfgrass dependent on irrigation to meet quality objectives. This stress may come in the form of reduced rainfall effects that might not be incorporated into the irrigation system design and programming adjustments, or in a reduced availability of water supplies intended for irrigation. The presence of visual symptoms of moisture stress is a simple way to determine when irrigation is needed, however, golf course superintendents generally 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 to lower turfgrass stress.

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 in greens and tees.
- Irrigating too shallowly encourages shallow rooting, increases soil compaction, and favors pest outbreaks.
- For fairways and roughs, use infrequent, deep irrigation to supply sufficient water for plants and to encourage deep rooting.
- During warm weather, water early in the morning and late at night when evapotranspiration rates are lower resulting in an increase of water available for plant uptake.
- 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 and microclimate of the golf course.

3.4 IRRIGATION SYSTEM DESIGN

A well-designed irrigation system should operate at peak efficiency to reduce energy, labor, and protect natural resources. Irrigation systems should be flexible, and properly designed and installed to improve water use efficiency. An efficient irrigation system maximizes water use, turf health, reduces operational cost, conserves supply, and protects water resources. Irrigation systems should be designed and installed by qualified specialists.

Best Management Practices

- The design should account for optimal distribution efficiency and effective root-zone moisture coverage. Target 80% or better Distribution Uniformity.
- Consider the use of soil surfactants to ensure uniform delivery of water and solutes to the root zone.
- The design should allow the putting surface and slopes and surroundings to be irrigated 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 estimated or calculated based evapotranspiration rate for a particular location.

- System elements should employ the use of computerized control systems, weather stations, pump stations, monitoring sensors, and optimum sprinkler heads and nozzles installed at optimum spacing.

- If not already a part of the automated/computerized system/weather station installed at the golf course, install rain gauges/sensors and shutoff switches to avoid over-watering following significant rainfall.
- The application rate must not exceed the infiltration rate, or the ability of the 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 build-out for the entire system.
- The system should be flexible enough to meet peak water requirements and allow for operating modifications to meet seasonal irrigation changes or local restrictions.
- Turf, landscape, and natural areas should be zoned separately, as reflected by the Integrated Pest Management Plan. Specific use areas to be zoned separately include; greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, etc. The site vegetation management plan describes any differing operational approaches not subject to Integrated Pest Management Plans relating to underutilized facility, out-of-play, and natural areas.
- The irrigation system design should account for the need to leach out salt buildup from poor-quality water sources by providing access to freshwater or means of redirecting/pumping brackish water from the irrigation supply, if necessary.
- Only qualified specialists should install the irrigation system.
- Construction must be consistent with the design and specifications.
- The designer must approve any design changes before construction.
- Construction and materials must meet existing standards and design 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 manufacturer recommendations.

- Spacing should be based on average wind conditions during irrigation.
- For variable wind directions, triangular spacing is more uniform than square spacing.
- Distribution devices and pipe sizes should be designed for optimal uniform coverage.
- The first and last distribution device should have no more than a 10% difference in flow rate. This usually corresponds to about a 20% difference in pressure.
- Distribution equipment (such as sprinklers, rotors, and micro-irrigation devices) in a given zone must have the same production rate.
- Sprinkler heads for turf areas should be spaced for head-to-head coverage.
- Water supply systems (for example, wells and pipelines) should be designed for varying control devices, rain shutoff devices, and backflow prevention.
- Backflow prevention devices must be used if there is the possibility of water reentering water supply systems, in accordance with local regulations. This is especially important if the irrigation water is used to convey surfactants or fertilizers.
- 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 and marked with tracing wire for faster locating, excavating work, and repairs when leaks are suspected.
- Pressure-regulating or compensating equipment must be used where the system pressure exceeds 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.
- Manual quick-coupler valves should be installed near greens, tees, and bunkers so these can be hand-watered during severe droughts.
- 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.
- Irrigation of greens and green surrounds should be designed to provide inward and outward sprinkler coverage for maximum efficiency and optimal turfgrass maintenance.
- 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.

3.5 IRRIGATION PUMPING SYSTEM

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 and water conservation by matching the irrigation system supply needs with the demand to the extent practical.

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 build-out for the entire system.
- Maintain the air-relief and vacuum-breaker valves by using hydraulic-pressure-sustaining values.
- Install and program variable frequency drive systems to adjust pumping rates automatically according to weather forecasts, changes in irrigation zonal demands, and to lengthen the life of aging 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.
- 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 operating amperage by qualified pump personnel may more accurately indicate increased power usage and thus potential problems.

3.6 IRRIGATION SYSTEM QUALITY MAINTENANCE

Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance, corrective maintenance, and record-keeping. Personnel charged with maintaining any golf course irrigation system face numerous challenges. This is particularly true for courses with older or outdated equipment. Good system management starts with good preventive maintenance procedures and record keeping. Maintaining a system goes beyond just fixing sprinkler heads. Corrective maintenance is simply the act of fixing what is broken. It may be as simple as cleaning a clogged orifice, or finding and repairing leaks, 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.

3.6.1 Calibration/Auditing

Golf course superintendents perform routine maintenance to ensure water quality and responsible use of the water supply. System checks and routine maintenance targets include pumps/drives, valves, programs, fittings, and sprinklers.

To ensure it is performing as intended, an irrigation system should be calibrated regularly by conducting periodic irrigation audits to check for suspected leaks, actual water delivery, and nozzle efficiency.

Best Management Practices

- Conduct a periodic professional complete irrigation audit at least once every five years.
- 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.
- Electrical control panels should be checked periodically by a license-electrician for proper equipment function and trouble-shooting. Malfunctioning control panels can negatively affect anticipated irrigation rates and duration.
- Pressure and flow should be evaluated to determine the correct nozzles are being used and the heads are performing according to manufacturer 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 on the entire golf course to ensure that the system is operating at its highest efficiency.
- The golf course superintendent should conduct an irrigation audit annually to facilitate a high-quality maintenance and scheduling program for the irrigation system.
- Inspect the system for interference with water distribution.
- Inspect sprinkler heads for broken and misaligned heads.
- Check to ensure the rain gauge or sensor is present and functioning.
- Inspect the backflow prevention device to determine it is in place and in good repair.
- Routinely examine turf quality and plant health for indications of irrigation malfunction or needs for scheduling adjustments.
- Make adjustments and repairs on items diagnosed during the visual inspection before conducting pressure and flow procedures.
- Document the results of calibration/conditioning.

3.6.2 Preventive Maintenance

Good system management starts with good preventive maintenance 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 goes beyond just fixing heads. It also includes documenting system and maintenance related details so potential problems may be identified and addressed before expensive repairs are needed. It also provides a basis for evaluating renovation or comparison of replacement options.

Best Management Practices

- Implement a preventative maintenance program to replace worn components before they waste fertilizer, chemicals, and water.
- In older systems, inspect irrigation pipe and fittings and look for breaks caused by surges in the system, corrosion, exposure to temperature extremes, or other physical failures.
- Install thrust blocks to support conveyances.
- The system components should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, wellhead (if applicable/accessible), remote con-

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

- Maintain air-relief and vacuum-breaker valves.
- System irrigation delivery needs to be observed in operation at least weekly. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation. This process detects locations with controller or communications failures, stuck or misaligned heads, and clogged or broken nozzles.
- Clean and maintain filtration equipment.
- Check filter operations frequently; keeping filters operating properly prolongs the life of an existing system and reduces pumping costs. An unusual increase in the amount of debris may indicate problems with the water source.
- Even under routine or favorable 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 preventative maintenance program to replace worn components before they waste fertilizer, chemicals, and water.
- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow manufacturer recommendations.
- Flush irrigation lines regularly to minimize emitter clogging. To reduce sediment buildup, make flushing part of a regular maintenance schedule. If fertigating with the irrigation system, prevent microbial growth by flushing all fertilizer from the associated lateral lines before shutting down.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to manufacturer recommendations.
- 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.
- 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, fittings, wires, and control panels). If the system requires frequent repairs, it is necessary to determine why these failures are occurring.
- 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.
- Increase the frequency of routine inspection/calibration of soil moisture sensors that may be operating in high-salinity soils.
- Winterize irrigation system components to prevent damage and quicken later startup.

3.6.3 Corrective Maintenance

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

Best Management Practices

- Replace or repair all broken or worn components before the next scheduled irrigation.
- 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, long-term weather and temperature extremes, rodent damage, or frequent lightning or power surges.
- Control tubing problems could result from poor filtration.
- Replacement parts should have the same characteristics and specifications as the original components.
- Record keeping is an essential practice; document all corrective actions.
- 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 and adjustments on pumps, valves, programs, fittings, and sprinklers should follow manufacturer recommendations.
- Use isolation valves before all main lines and major laterals to be able to quickly isolate leaking areas before turfgrass is damaged and water is lost.
- Trim vegetation around and level sprinkler heads and valve boxes as needed.
- Install leak monitoring devices that will automatically disable the pump in the event of a substantial leak.
- Gather all of the documentation collected as part of the preventative maintenance program, along with corrective maintenance records for analysis.
- Correctly identifying problems and their costs helps to determine what renovations are appropriate.

3.7 IRRIGATION SYSTEM PROGRAMMING AND SCHEDULING

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 daily evapotranspiration rates, recent rainfall, recent temperature extremes, and soil moisture. Irrigation should not occur on a calendar-based schedule but should be based on evapotranspiration 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, reduces nutrient and pesticide movement.

Time-clock-controlled irrigation systems preceded programmable computer-controlled systems, and many are still in use today. Electric/mechanical time clocks cannot automatically adjust to changing evapotranspiration 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, and at minimum seasonally.
- An irrigation system should have rain gauges/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 0.25 inches of irrigation to move the particles off the leaves while minimizing runoff.

- 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.
- The irrigation schedule should coincide with other cultural practices (for example, the application of topdressing sand, nutrients, herbicides, or other chemicals).
- Account for nutrients in effluent supply when making fertilizer calculations.
- Irrigation should occur between the early evening and early morning hours when air temperatures are lower and relative humidity drops.
- Base plant water needs should be determined by daily evapotranspiration rates, recent rainfall, recent temperature extremes, and soil moisture.
- Use mowing, verticutting, aeration, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Routinely 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.
- Avoid the 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 evapotranspiration rate to adjust run times to meet turfgrass moisture needs.
- Manually adjust automated evapotranspiration data to reflect wet and dry areas on the golf course.
- Use in-ground or portable 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 in a way that prevents 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.
- Limit irrigation to seasons defined in appurtenant water rights.
- Limit irrigation to quantities defined in appurtenant water rights.
- Monitor soil wettability with the Water Drop Penetration Time (WDPT) Test. If soil resists wetting, use surfactants to restore wettability and avoid the development of soil water repellency.
- Provide adequate drainage to promote healthy root development and help prevent compaction.

3.8 METERING

Rainfall may vary from location to location on a golf 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 irrigation schedule. It is also important to measure the amount of water actually delivered through the irrigation system, via a totalizing

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.
- Automated-data recorders can be used to track the flow rates and production volume from individual pump stations, wells, and mainlines over time, and are useful in identifying leaks or other inefficiencies as they begin to occur.
- Flow meters can be used to determine how much water is applied.

3.9 IRRIGATION LEAK DETECTION

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 total water pumped each day, as well as individual pump stations, wells and mainlines with available metering.
- 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 or well, exposure to the sun and elements, temperature extremes, or corrosion.
- Ensure control systems provide for emergency shutdowns caused by line breaks, and allow maximum system scheduling flexibility.

3.10 SYSTEM RENOVATION

As irrigation systems age to the point where frequent repair becomes a large expense or threatens the health of the turfgrass, renovation of the irrigation system should be considered.

Best Management Practices

- 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 the cost of renovation and its return on benefits both financial and management.

3.11 WINTERIZATION AND SPRING STARTUP

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

Best Management Practices

- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing.
- 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 plugs and empty water out of the system.
- Secure systems and close and lock covers/compartment doors to protect the system from the elements, from potential acts of vandalism, and from animals seeking refuge.
- Remove drain plugs and drain above-ground pump casings.
- Record metering data before closing down the system.
- Secure or lock irrigation components and electrical boxes.
- Perform pump and motor servicing/repair before winterizing.
- Recharge the irrigation system with water in the spring and inspect for corrective maintenance issues.
- Ensure proper irrigation system drainage design.

3.12 SENSOR TECHNOLOGY

To prevent excess water use, irrigation scheduling should take into account plant water requirements, evapotranspiration data, recent rainfall, recent temperature extremes, and soil characteristics. 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 critical measurement tools to track how much rain has fallen at a specific site on the golf course. On some golf courses, more than one station may be necessary to get a complete measure of rainfall or evaporation loss. Microclimates may exist at the golf course scale. The use of soil moisture probes and inspections for visual symptoms such as wilting turf, computer models, and tensiometers may supplement these measurements. Computerized displays are available to help visualize and more efficiently troubleshoot the system. 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. 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. It is best to have an on-site weather station to daily access to weather information and evapotranspiration data to determine site-specific water needs.

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 not occur on a calendar-based schedule but should be based on evapotranspiration rates and soil moisture replacement.
- Computerized control systems should be installed on all new course irrigation systems to help ensure efficient irrigation application. These allow for timing adjustments for zones or at every sprinkler head.
- Rain shut-off devices and rain gauges should be placed in open areas to prevent erroneous readings.
- Use portable devices or multiple soil moisture sensors/meters for accuracy and to reflect soil moisture levels.
- Place soil moisture sensors in a representative location of the irrigation zone.
- Install soil moisture sensors in the driest irrigation zone of the irrigation system.
- Wireless soil moisture systems should be installed to prevent damage from aeration.

3.13 NONPLAY AND LANDSCAPE AREAS

Map environmentally sensitive areas such as natural areas, sinkholes, wetlands, or flood-prone areas, and identify species classified as endangered or threatened by federal and state governments, and state species of special concern. Natural vegetation should be retained and enhanced for nonplay areas to conserve water. Often the most efficient and effective watering method for a nonturf landscape may be micro-irrigation. Older golf courses may have more irrigated nonplay and underutilized facility acres than are necessary for playability. With the help of a golf course architect, golf course superintendent, golf professional, and other key personnel, the amount of functional turfgrass can be evaluated and transitioned into nonplay areas.

Best Management Practices

- Designate 50% to 70% (or more depending on the existing conditions) of the nonplay area to remain in natural cover according to "right-plant, right-place," a principle of plant selection that favors limited to no supplemental irrigation and on-site cultural practices.
- Incorporate natural vegetation in nonplay areas.
- Reduce irrigation in secondary rough areas and, where possible, eliminate irrigation of nonplay areas.
- Irrigate by hand when necessary and practical.

- Use micro-irrigation and low-pressure emitters in nonplay areas to supplement irrigation when necessary.
- Routinely inspect nonplay irrigation systems for problems related to emitter clogging, filter defects, and overall system functionality.

3.14 WELLHEAD PROTECTION

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.

When installing new wells, contact consulting professionals, or 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 are 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 decommission abandoned wells. Flowing wells should be properly shut-in.
- Surround new wells with bollards or a physical barrier to prevent impacts to the wellhead.
- Inspect wellheads and the well casings 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 or the water quality monitoring plan for the golf course.
- Never apply fertilizer or pesticide next to a wellhead.
- Never mix and load pesticides next to a wellhead if not on a pesticide mix/load pad.

3.15 REGULATORY CONSIDERATIONS

Golf course owners are responsible for understanding [Oregon Water Resources Department] requirements at the pre-and post-construction phase to determine annual or specific water consumption (water rights), permitting guidelines, and other regulatory requirements. Golf course 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. Irrigation water is generally infiltrated completely and not considered part of site stormwater drainage, though automated-irrigation systems and controls should be monitored daily and adjusted to minimize potential contributions to stormwater quality during unanticipated rain events.

Best Management Practices

- Design and/or maintain a system to meet peak water requirements under normal conditions and also be flexible enough to adapt to various water demands, weather forecasts, and local restrictions.
- Develop an annual water budget for the golf course land-, surface water-, and groundwa-

ter-use systems, to inform the course adaptive management decision-making process.

- Perform course and facility overall water supply and demand estimate evaluations.
- Look for ways to increase distribution efficiency and reduce energy use associated with irrigation systems and practices.
- Demonstrate good stewardship practices by supplementing watering only for the establishment of new planting and new sod, hand watering of critical hot spots, and watering-in of chemicals and fertilizers (if permissible).
- Complete grass grow-in and other plantings work during times when more natural rainfall occurs to minimize irrigation, when feasible.
- Protect aquatic life and impairment of water systems by adhering to state and local water withdrawal allocations.
- Take advantage of state, local, and private turfgrass removal programs that offering monetary credits or other incentives to reduce irrigation needs for underutilized and out-of-play areas.
- Design an irrigation system that delivers water with maximum efficiency.
- Limit irrigation to seasons defined in appurtenant water rights.
- Limit irrigation to quantities defined in appurtenant water rights.

PLANT NUTRITION 4.0

Appropriate plant nutrition and soil management are essential for turfgrass to sustain desirable color, growth, density, and vigor; to better resist diseases, weeds, and insects; and to provide optimum playability. Nutrient management is most effective when combined with relevant Best Management Practices and integrated pest management. An individual golf course may prepare a nutrient management plan to use as a guide for adjusting management practices to address variability and achieve an acceptable playing surface throughout the golf course. It is a guide for managing the amount, sources, placement, form, and timing of application of nutrients and other soil amendments to efficiently use nutrient resources.

Nutrient management has a significant impact on plant health, soils, and the environment over time; therefore it is important to closely monitor and optimize the nutrient application rate, nutrient form, nutrient application method, and nutrient application timing to maximize plant uptake. Stabilized and controlled-release fertilizers should be used whenever appropriate, with adjustments being made for special needs and conditions. The overall goal of a working nutrient management plan should be to apply the minimum necessary nutrients to achieve an acceptable playing surface.

The major nutrients required for turfgrass health are nitrogen (N), phosphorus (P), and potassium (K). Calcium, magnesium, and sulfur also contribute significantly to turfgrass health. Micronutrients include iron, boron, copper, manganese, and zinc. The availability of nutrients to turfgrass is influenced by the pH of the soil. Consequently, the management of the appropriate pH is an important component of the fertilizer program.

4.1 NUTRIENT MANAGEMENT PLAN

A good nutrient management plan that is followed will reduce fertilizer costs, improve turfgrass quality, protect water resources and natural areas, and lower the environmental risk from reduced inputs and overall expenditures. Three elements of a good nutrient management plan include:

- Use a realistic plan for nitrogen requirements for different management areas of the golf course;
- Adjust the plan based on in-season soil and/or plant testing or monitoring; and
- Manage irrigation efficiently to prevent leaching and runoff.

Appropriate nutrient management plays a key role in the reduction of environmental risk and increases golf course profitability. Among other benefits, applied nutrients inflate the available pool of nutrients and allow turfgrass to recover from damage, increase its stress resistance, 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 directly impact our environment. Other organisms or diseases also respond to increases in nutrients and, in some cases, these may deleteriously

alter playability (e.g, Microdochium patch responses to excess N) or our ecosystem. The goal of an appropriate 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 their plant uptake.

4.1.1 Principles of Fertilizers Used in Golf Course Management

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.

4.1.1.1 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 are administered by the Oregon Department of Agriculture.

4.1.1.2 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

4.1.2 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 you with a greater understanding of why these nutrients play such a key role in optimal turfgrass management.

4.1.2.1 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. 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. Nitrogen fate and transformation processes include:

- Mineralization: the microbial-mediated conversion of organic N into plant-available NH4
- Nitrification: the microbial-mediated conversion of NH4to NO3
- Denitrification: the microbial-mediated conversion of NO3to N gas; this primarily occurs in low-oxygen environments and is enhanced by high soil pH
- Volatilization: the conversion of NH4to NH3gas
- Leaching: the downward movement of an element below the root zone
- Runoff: the 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. For example, applying polymer-coated urea in the same manner one would apply sulfur-coated urea greatly reduces the value of the polymer-coated urea. Similarly, applying two pounds of N from ammonium sulfate may cause burning, while applying two 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 include:

- Urea (46-0-0)
- Ammonium nitrate (34-0-0)
- 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)

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. Slow-release nitrogen sources include:

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

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 NH4to NO2. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N and is known as stabilized nitrogen.

Best Management Practices

- Regulate nitrogen application to optimize turfgrass health and prevent disease development. The goal is to use the least amount of nitrogen needed for healthy functional turf.
- Use slow-release or stabilized nitrogen fertilizers when possible, or low rates of quick-release nitrogen fertilizers to minimize inputs to the environment.
- Adjust nitrogen with consideration to groundwater and surface water vulnerability.
- Consider clipping yield, thatch levels, need for growth, color, growth rate, and tissue testing to determine nitrogen applications.

4.1.2.2 The Role of Phosphorous (P)

Phosphorus can be a growth-limiting factor for many unintended organisms or diseases and is a major contributor to the formation of algal blooms and eutrophication of water bodies. Thus, proper timing and rates should be implemented to reduce the risk of off-site movement of phosphorus. The main goal is to apply the least amount of phosphorus needed for healthy functional turf.

Phosphorus forms high-energy compounds 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 or tissue samples.

- 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 Oregon State Universityfor sufficiency ranges in your location.

Sources of phosphorous in fertilizers include:

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

Best Management Practices

- Use soil test information to determine need.
- Minimize phosphorus applications in areas where phosphorus levels are medium to high based on soil test results, except in the case of establishment operations.
- Be aware of local restrictions on phosphorus use, particularly related to Total Maximum Daily Loads for Oregon water bodies.
- Adjust phosphorus with consideration to groundwater and surface water vulnerability.

4.1.2.3 The Role of Potassium (K)

Turfgrass requirements for potassium are intermediate to nitrogen and phosphorus levels. Potassium is an essential component needed in plant growth. Although applied to maximize the efficiency of uptake, potassium does not pose the extent of environmental risk that excess nitrogen and phosphorus levels represent. Proper levels of potassium are an important component of plant disease resistance and contribute to the ability of turfgrass to withstand wear and traffic stress.

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 ½ that of nitrogen.

Potassium is not a component of any organic compound and moves readily within the plant. Potassium is a 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 Oregon State University for sufficiency ranges in your location.

Sources of potassium in fertilizers include:

- Potassium sulfate
- Potassium chloride
- Potassium nitrate

Best Management Practices

- Use soil test or tissue information to develop target nutrient levels.
- Limit potassium inputs to the amount needed to reach target levels.

4.1.3 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)

4.1.3.1 The role of calcium (Ca)

- Primarily a component of cell walls and structure
- Consult Oregon State University for sufficiency ranges in your location
- Found in gypsum, limestone, and calcium chloride

4.1.3.2 The Role of Magnesium (Mg)

- Central ion in the chlorophyll molecule and chlorophyll synthesis
- Consult Oregon State University for sufficiency ranges in your location
- Found in sulfate of potash magnesia, dolomitic limestone, and magnesium sulfate

4.1.3.3 The role of sulfur (S)

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

4.1.4 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 Oregon State University for micronutrient sufficiency ranges in your location.

4.1.4.1 The Role of Iron (Fe)

- Is part of the catalytic enzymes and is required for chlorophyll synthesis
- Affects photosynthesis, nitrogen fixation, and respiration

4.1.4.2 The Role of Manganese (Mn)

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

4.1.4.3 The Role of Boron (B)

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

4.1.4.4 The Role of Copper (Cu)

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

4.1.4.5 The Role of Zinc (Zn)

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

4.1.4.6 The Role of Molybdenum (Mo)

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

4.1.4.7 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

Best Management Practices

- Apply micronutrients as required to maintain plant health.
- Regularly test soil and plant tissue to avoid micronutrient deficiency problems.

4.2 SOIL HEALTH

Soils are apart of a dynamic, living system that consists of three parts: chemical, physical, and biological. Each part of the system is important and works with others to create a soil system. The chemical leg is addressed thru soil testing and adjusting nutrient levels per the results shown or applying corrective

amendments such as lime or gypsum. The physical leg comprises things like soil amendments and sand topdressing to correct poor physical soil structure. The biological leg addresses the bacterial and fungal populations in the soil that are responsible for many important functions in turf management such as thatch breakdown, nutrient cycling, buffering of salts and bicarbonates, and the efficient use of water. Important ideas to consider may include:

- Understanding that many of the important processes we undertake on a seasonal basis have an impact on the health of the soil microbiology.
- Understanding the dynamic relationships going on in the soil and how we impact them, can make golf courses a haven for a healthy microbial system.
- Ways to maintain a healthy microbial system include using as part of your overall management plan, biologically friendly inputs such as humic acids, and naturally derived nitrogen sources (ex: kelp, composts, other organic sources).

Best Management Practices

- Minimize potentially harmful inputs to the microbial population when possible but if they are necessary, work to rebuild those populations through probiotic efforts.
- One of the best ways to rebuild microbial populations is to boost available carbon content whenever possible, especially during aerification and fertility applications.

4.3 SOIL TESTING

Soil testing provides information about nutrient concentrations in soil. The purpose of a soil test is to provide the turfgrass manager with a prediction of a plant's response to an applied nutrient. These nutrients may be bioavailable to the turfgrass and existing concentrations of nutrients may be sufficient for healthy turfgrass, particularly some micronutrients. In addition, unused nitrogen from prior applications may build up in the soil over time, and adjustments to current application rates may take the ambient or in-situ concentrations into account.

Soil testing may or may not provide the appropriate answers to your nutrient management questions. Consult with Oregon State University to get the most current information and to better understand which soil test values are relevant in your location. Through proper sampling, laboratory analysis, interpretation of results, recommendations, and record-keeping, soil testing can be used to manage nutrients more efficiently.

Best Management Practices

- Perform soil nutrient testing at regular intervals (typically every 1 to 3 years with shorter intervals for sand-based soil profiles). Take samples at the same time of year (i.e. Spring) and the same depth (i.e. 3 inches) to provide a consistent evaluation of soil nutrient levels from year to year. The samples should also be taken at the end of the fertilization application interval before the next application interval.
- Maintain accurate records of soil sample locations, date of sampling, soil conditions, and test results.
- Use the same laboratory for analyses over time so results are more comparable.

- Consider using plant tissue testing to evaluate fertility. This is most valuable for micronutrients. Accurate and consistent sampling is essential to providing useful soil test information over time.
- Divide the course into logical components such as greens, fairways, tees, roughs, etc., for each hole.
- Ten to 15 soil samples should be randomly taken from each section and blended together to provide a representative, uniform soil sample.
- Each soil sample should be taken from the same depth.
- 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 the 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 trends or changes over time.
- This practice can provide good evidence of the impact of your nutrient management plan.

4.4 PLANT TISSUE ANALYSIS

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, or other events that may interrupt constant growing conditions.
- Place tissue in paper bags, not plastic.
- If possible, allow tissue samples to air-dry at your facility before mailing them.
- Poor-quality turfgrass 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 you choose to use is entirely up to you and your 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 trends or changes over time.
- Tissue testing can provide good evidence of the impact of your nutrient management plan.

4.5 SOIL PH

Identifying pH levels may be the most important soil test result for turfgrass managers. In most cases, a pH of 6.3 is ideal because it provides the greatest probability of micronutrient availability. Soil pH adjustments may occur slowly and are generally temporary.

Best Management Practices

- Maintain soil pH appropriate for turfgrass type.
- Adjust soil pH if possible to optimize soil nutrient availability using results from soil tests.
- 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 should be applied.
- In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial.

4.6 NUTRIENT MANAGEMENT

Environmental conditions vary greatly on the east side of the Cascade Mountains from the west side, including differences among soils, topography, rainfall, and temperature. These differences require a nutrient management plan to be flexible enough to allow turfgrass managers to address their unique needs. Understand the importance of application timing for the 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 turfgrass 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 Oregon State 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 Oregon State 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.
- Tees and landing areas often have higher fertility requirements than fairways and roughs because they suffer constant divot damage.
- Fairways and roughs often require fewer 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.
- Anticipate lower periods of foot and cart traffic on the course when nutrient inputs can be reduced while still optimizing turf health and playability.
- Provide appropriate rates and products to minimize N loss without reducing turfgrass establishment.

- Be aware of the different types of spreaders and understand the advantages and limitations 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.
- Review the weather forecast prior to applications. Avoid applications prior to forecasts for heavy rainfall to minimize the potential for runoff.
- Do not apply fertilizer when the National Weather Service has issued a flood warning, or if heavy rains are likely.
- Properly calibrate fertilizer spreaders to ensure accurate application rates.
- Avoid application to impervious surfaces (cart paths, parking lots, etc).
- Avoid applying fertilizer to sand bunkers and water features. Use appropriate application equipment for the area being fertilized.
- Follow appropriate buffer zone practices.
- Limit fertilizer applications to the extent practical in defined buffer zones.
- Record location, date, weather conditions and forecast, and type of fertilizer applied.
- Record rate of nutrient application.
- Record the method of nutrient application.
- Record post-application irrigation practices.
- Maintain a current inventory of fertilizer on hand.
- Avoid long-term storage. Store small quantities and order as needed.
- Maintain fertilizer inventory in a dedicated, dry, well-ventilated, enclosed environment.
- Store fertilizer separately from solvents, fuels, pesticides, and other turfgrass products.
- Sweep up any spilled fertilizer immediately.
- Create a map of fertilizer storage areas and install appropriate placards on the exterior of the storage area.

4.7 REGULATORY CONSIDERATIONS

State regulations are in place to better manage nutrient risks based on the unique conditions that exist in Oregon. 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 or state agencies. In general, if your location is regulated by nutrient policies (such as nutrient management plans), all of your nutrient Best Management Practices will be designed according to the basis of these policies.

Best Management Practices

- Understand the value of training programs.
- Contact state organizations for regulatory restrictions.

In addition to the nutrient management plan, courses located in or around sensitive environmental settings or wellhead protection areas may have bulk

nutrient storage-related requirements incorporated into site stormwater pollution prevention and control permits/plans. Bulk nutrient material storage requirements may also apply at the local, state, or federal level relating to some concentrated forms of nutrients above certain threshold volumes (e.g, that may constitute potential hazardous materials). Similarly, unspent stored nutrient materials may be considered as a hazardous waste generation if not documented in recent or regular use.

CULTURAL PRACTICES 5.0

Turfgrass management cultural practices can vary from one property to the next. Factors such as turfgrass variety, budget, and expectations of the clientele or applicable regulatory programs have an impact on what practices best meet the needs of a facility. Examples of cultural practices that are frequent and have minimal impact on the playing surface include mowing, grooming, and rolling. Other practices such as aeration, spiking, and deep vertical mowing are used to promote healthy turf, but create a temporary disturbance to the playing surface.

Cultural practices on a golf course can have a significant impact on turfgrass health, growth, and playability. Healthy turfgrass is more tolerant of pest pressures. It is important to develop management area-specific cultural practices (i.e., greens, approaches, tees, fairways, rough, out of play surface waters, and naturalized areas). These cultural practices can be modified based upon microclimates (i.e., shade, slope, underlying soil type, or exposure to sun and wind).

5.1 SURFACE AND SOIL PROFILE MANAGEMENT

Golf course playing surfaces perform best when a firm, sandy soil profile is developed for turfgrass growth. 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, and improved water and air exchange. Cultivation techniques will result in disturbance of the playing surface that can require significant time for recovery. The frequency of cultivation should be based on traffic intensity and level of soil compaction. Periodic core aeration is effective at managing soil compaction and aiding in the improvement of soil drainage. Accumulation of excessive thatch and organic matter will reduce root growth, encourage disease, and create undesirable playing conditions. Light and frequent applications of sand will smooth the playing surface, control thatch, and potentially change the physical characteristics of the underlying soil when done in conjunction with core aeration.

Cultivation practices are an important part of golf course turf management. Certain cultural practices such as mowing, vertical mowing, and rolling are necessary to provide a high-quality playing surface, while others such as aeration 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 temporarily destroying the playing surface.

Best Management Practices

- Adjust aeration type and frequency to be appropriate for turfgrass location, conditions, and weather.
- Perform routine vertical mowing to stimulate lateral growth, promote an upright growth habit, and smoother putting surface.
- Core aeration involves the removal of small cores or plugs from the soil profile. Cores are usually 0.25- to 0.75-inch diameter. Annual core aeration programs should be designed to remove 15%-20% of the surface area. High-traffic areas may require a minimum of two to four core aerations annually.
- Core aeration should be conducted only when grasses are actively growing to aid in quick recovery of surface density.
- Vary depth of aeration events by incorporating varying length tines to prevent the 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 reduce compaction and soften surface hardness during months when the growth rate of grasses has been reduced.
- Deep-drill aeration creates deep holes in the soil profile through the 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 the replacement of heavier soils with sand or other materials 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 aeration 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 can be incorporated into a cultural management program to achieve many 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.
- Vertical mowing 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 when performed on golf putting greens and they may require extensive recovery time.
- Initiate vertical mowing when the thatch level reaches 0.25- to 0.5-inch thickness. Shallow vertical mowing should be completed at least monthly on putting greens to prevent excessive thatch accumulation.
- Groomers, or miniature vertical mowers attached to the front of reels, are effective at improving the management of grain and improving plant density through the cutting of stolons.
- Apply light topdressing for preventing excess thatch accumulation at the soil surface and to maintain a uniform soil profile.
- For greens, use topdressing sand that meets the United States Golf Association (USGA) specifications when available to maintain consistent root zone content. Try to use the same source of sand over time to maintain soil profile consistency.
- Apply topdressing following core aeration. Topdressing should be applied before solid tine aeration.
- Apply light frequent topdressing following vertical mowing.

- Topdress the playing surface with sand following core aeration and heavy vertical mowing to aid in the recovery of turf. Rates will vary from 0.125- to 0.25-inch 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.
- The use of finer materials can result in layering and can negatively impact water infiltration.
- Roll greens to provide a smoother playing surface and increased ball roll distance.
- Roll greens to provide a consistent ball roll distance at a higher cutting height.
- Daily rolling of putting surfaces following mowing can increase ball roll distances by roughly 10%, allowing for improved ball roll without lowering the height of cut.
- To minimize the potential for compaction caused by rolling, use lightweight rollers.
- Routinely move cup locations on the greens.
- Vary the points where golf carts enter turfgrass play areas from cart paths to reduce localized wear.

5.2 MOWING

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 growth as a result of plant stress associated with the removal of leaf tissue. Infrequent mowing results in alternating cycles of vegetative growth followed by scalping, which further depletes the food reserves of the plants. 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, abiotic, and biotic stress.

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 and without a sharp cutting unit will result in weakened turf with poor density and quality. Dull mower blades result in the shredding of leaf tissue; decreasing root growth while increasing water loss and the potential for disease development.

Best Management Practices

- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods.

- 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 the desired height of cut is achieved.
- Shade affects turfgrass growth by filtering out photosynthetically active radiation. As a result, 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.
- 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.
- Reel mowers are ideally suited for maintaining turfgrass stands that require a height of cut below 1.5 inches. When cutting units are maintained and sharp, they produce a superior quality of cut 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 inch in height.
- Flail mowers are most often used to maintain utility turf areas that are mowed infrequently and do not have a high aesthetic requirement.
- Mowing patterns influence both the aesthetic and functional characteristics of a turf surface.
- 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, pesticides, or other products contained in or on clippings can be sources of pollution and should be handled properly.
- Remove clippings from greens. Leave clippings on tees, fairways, and rough, where feasible. Unless a controlled composting program is in place, dispose of collected clippings by scattering them in the rough, as opposed to stockpiling them. Do not stockpile within 25 feet of surface waters.
- 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 clean clippings or dispersing them evenly in natural areas where they can decompose naturally without accumulating in piles, where feasible.

5.3 *POA ANNUA* DISCOURAGEMENT

On many golf courses, poa annua in greens is considered a weed. These golf courses typically have bentgrass greens. Other golf courses have embraced the poa annua invasion and manage it for high-quality turfgrass. Poa annua typically requires more nutrients and water for healthy stands. Poa annua is also susceptible to more disease than bentgrass. Certain practices can be used to discourage the growth of poa annua and maintain bentgrass. These practices include managing the chemistry of the growing medium and managing soil disturbances.

Best Management Practices

- Maintain a low soil pH by using high levels of ferrous sulfate with high rates of water frequently.
- Apply minimal phosphorous to limit seed head production.
- Apply low rates of nitrogen.
- Apply low rates of paclobutrazol at times indicated by a growing degree calculator.
- Perform regular deep needle tine aeration(monthly).
- Use smooth rollers on greens mowers.
- Aerate only at the start of the growing season unless needed to improve drainage locally.

5.4 SHADE AND TREE MANAGEMENT

In general, most turfgrass performs best in full sun. Excessive shade reduces photosynthesis and air circulation, thus increasing the susceptibility of the turf to pest and disease problems.

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 the canopy should be thinned to allow more (morning) sunlight and promote good turf growth.
- 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.
- Minimize the extent of maintained turfgrass areas within proximity of large shade trees in and along with natural areas, where practical and not affecting playability (good course planning, design, and maintenance).
- Conduct a tree survey that identifies each tree's location, species, health, life expectancy, safety concerns, value, and special maintenance requirements.

5.5 HYDROPHOBICITY OR WATER REPELLANCY

Hydrophobic soils are soils that repel water as opposed to wetting easily under irrigation or rainfall conditions. Soil hydrophobicity commonly referred to as soil water repellency, is generally caused by a coating of long-chained hydrophobic organic molecules that accumulates on individual soil particles. Soil water repellency can be pronounced, with the soil obviously repelling the water, or slight where infiltration is disrupted but not prevented altogether. In either case, soil water repellency can lead to runoff, nonuniform wetting of soils, poor delivery of fertilizers and pesticides, lowered natural airflow potential, plant stress and reduced quality, increased need for irrigation and water use, and increased risk of environmental contamination. The sources of the hydrophobic organic compounds have been found to include microbes, root exudates, fungi, and decomposing organic matter among other things. Wetting agents used in turf care are nonionic substances that reduce the surface tension of water, and in many cases restore the wettability of the soil. Surfactants can improve the ability of the water and solutes to penetrate the soil surface and more uniformly wet the entire root zone. Soil wetting agents will improve infiltration rates and water distribution only in soils that have some level of water-repellency present, regardless of their texture, tilth, and aggregation (University of Georgia Extension Service). Additional information can be found in the 2010 Soil Science Society of America publication Soil Science: Step-by-Step Field Analysis (S. Logsdon, D. Clay, D. Moore, and T. Tsegaye, 2010) and at the soils.org website.

Best Management Practices

- To counteract hydrophobicity in soil, soil surfactants, a.k.a. soil wetting agents should be used.
- Apply to water-repellent (hydrophobic) soils at rates recommended by manufacturers.
- Before using a wetting agent, be sure that slow infiltration is being caused by water repellency, not some other factor.
- Pull a core sample after a few dry days, lay it on its side, and beginning from the turfgrass at the top, place small drops of water at ½-inch intervals down the side of the column. If there is any delay at all in the penetration of the drop, there is some level of water-repellency present.

5.6 ECO-LAWN

One option for turfgrass in buffer zones where nutrients and pesticides are restricted or limited, or in out-of-play areas, may be low input, low-maintenance Eco-Lawn. As stated on the WSU Clark County Extension website, "an Eco-Lawn is an extensive use of ground cover plants (e.g. specialized blend of fine fescue grasses) to replace the traditional grass lawn… Once established, the Eco-Lawn is drought tolerant, self-fertilizing, and requires no pesticides." An Eco-Lawn also fixes soil nitrogen (N), is self-feeding, improves soil structure, and stabilizes soil erosion potential. Commercially packaged grass and other seed mixtures are blended with varieties well adapted to specific regions. Choose seed mixtures carefully as some packets contain seeds for noxious or nuisance weeds. It takes approximately 1-2 years for an Eco-Lawn to be fully established. Some alternative Eco-Lawn mixes contain lower amounts of grass seed, if any, and may support the health of native butterflies, pollinators, birds, or other habitats.

5.7 REGULATORY CONSIDERATIONS

Cultural practices protect the quality of water and golf course turf to provide good-quality of play. Cultural practices are highly dependent on turf type and local conditions such as course traffic, soil, weather, and quality and quantity of irrigation water. Adhering to the regulations in previous chapters will allow golfers to enjoy a high-quality of playability while playing on a healthy turf.

Best Management Practices

- Nutrients, pesticides, or other products contained in or on clippings can be sources of pollution and should be handled properly and consistent with product labeling.
- Components of site-specific nutrient management plans, vegetation management plans, environmental stewardship plans, and storm management plans developed during course planning, design, and permits may apply.
- Consider locations of open burning relative to clippings management and local fire authority prescriptions, or municipal or other ordinances relating to odors and noise.
- Natural area ecosystem functions in nonplay, nonturf areas should be optimized to adequately address reviews of regulatory agencies and certification organizations, and for responding to concerns of the local community or other groups. The best way to support healthy natural area ecosystem functions is through cultural practices that avoid or minimize impacts beyond playable turfgrass areas.

INTEGRATED PEST MANAGEMENT 6.0

The broad objective of an integrated pest management strategy is to optimize turfgrass, ornamental, and tree health through the adaptive use of cultural, mechanical, physical, or other methods of cultivation and pest management, and biological control methods as a means of minimizing or avoiding the need to control pests with chemical control products. Additionally, a set of example forms for use in documenting fertilizer applications, pesticide applications, IPM scouting, and staff training can be found in Appendix B.

The state of Oregon defines integrated pest management as "a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet institution programmatic pest management objectives" [Oregon Revised Statute 634.650]. The legal definition of integrated pest management in Oregon is located at www.oregon.gov/ODA/PEST/integrated pest management.shtml.

The main goal of an integrated pest management program is to protect the environment and maximize the quality of turfgrass health and usability by using a combination of tactics to control pests, weeds, and diseases, including cultural, biological, genetic, and chemical controls. Many pest management practices do not involve the use of chemical control products. By keeping the turfgrass healthy, the need for chemical treatment will be reduced. Other times, preventative chemical control product applications can reduce the total amount of products used in a given area over a given time. Many times chemical control product applications are used after other integrated pest management strategies have been either employed or considered.

Chemical control products can be applied as preventative or curative maintenance. Whether the chemical control products application should occur before the pest becoming apparent or after the pest has begun to establish itself may depend on the type of pest/disease and its characteristics, the action threshold set for the pest at the golf course, time of year, observed pest history, and the schedule of maintenance activities.

Chemical control product resistance should also be considered when deciding on a course of action for a particular pest. The Insecticide Resistance Action Committee (IRAC), Herbicide Resistance Action Committee (HRAC), and the Fungicide Resistance Action Committee (FRAC) are technical groups of Croplife International designed "to provide pesticide resistance management guidelines to prolong the effectiveness of "at-risk" fungicides and to limit crop losses should resistance occur. The main aims of IRAC, HRAC, and FRAC are to:

- Identify existing and potential resistance problems.
- Collect information and distribute it to those involved with fungicide, herbicide, and insecticide research, distribution, registration, and use.
- Provide strategies, guidelines, and advice on the use of chemical control products to reduce the risk of resistance developing, and to manage it should it occur.
- Recommend procedures for use in product resistance studies.
- Facilitate communication and education on chemical control product resistance.
- Stimulate open discussions and collaboration with universities, government agencies, advisors, extension workers, distribution, and farmers.

The approved IRAC, HRAC, and FRAC monitoring methods are located on their websites.

6.1 INTEGRATED PEST MANAGEMENT OVERVIEW

The following are the basic steps for an integrated pest management program start with identifying the key pests and determining the life cycle of the pest so that a vulnerable life stage can be targeted.

- Cultural, mechanical, physical, or other methods of cultivation and pest management practices help to prevent problems from occurring, reduce pest habitat, and/or promote biological control.
- Directly control where the pest lives or feeds. Properly timed preventive or curative chemical applications to help minimize the economic and environmental costs. Finally, document if the "corrective actions" to act, reduce, or prevent pest populations were successful, economical, and minimized risks.
- A critical component of a successful integrated pest management program is monitoring and early detection. Turfgrass conditions need to be observed regularly. To track the effectiveness of the treatments, results should be documented.

Integrated pest management focuses on the basics of identifying the pests or potential pest conditions, choosing pest-resistant varieties of grasses and other plants, enhancing the habitat for natural pest predators, using cultural practices to promote healthy turfgrass, scouting to determine pest populations, and determining acceptable thresholds, and applying biological and other less toxic alternatives to chemical control products whenever possible. Preventative and curative chemical controls should have minimal effect on beneficial organisms and the environment and minimize the development of pesticide resistance.

Best Management Practices

- Identify key pests on key plants as well as pest weeds.
- Determine the life cycle of the pest and know which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).
- Use cultural, mechanical, physical, or other methods of cultivation and pest management practices 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 to where the pest lives or feeds.
- Establish action thresholds for pests based on maintenance standards for the various management areas of the golf course.
- Chemical control product applications should be carefully chosen for effective and site-specific pest control with minimal environmental impact.
- With good cultural, mechanical, physical, or other pest management practices and biological controls, the preventative chemical application can be avoided for certain pests or conditions, and curative chemical applications minimized based on action threshold decisions while optimizing turf health, playability, and operation and management costs, with limited to no effects on the environment.
- Use preventive or curative chemical applications only when action thresholds informed by professional judgment indicate 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.

6.2 WRITTEN INTEGRATED PEST MANAGEMENT PLAN

Integrated pest management is an overall pest management strategy that includes biological controls, and cultural, mechanical, physical, or other methods, pest monitoring, and early detection, other applicable practices, and where preventative or curative chemical control product application is the last measure when action threshold levels are exceeded. A chemical control product application 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 nontargeted organisms. When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to nontarget species, cost, and site characteristics, as well as its solubility and persistence.

Documented Integrated Pest Management Plans have become important golf course assets and provide a cornerstone for environmental stewardship programs. Pest management decisions and methodology are based on sound scientific information. An Integrated Pest Management Plan can be viewed as the incorporation of the general policies and procedures of best management practices into a written description of integrated pest management-driven management practices.

Although the primary purpose of an Integrated Pest Management Plan is to provide the golf course superintendent and staff with a working reference document, the Integrated Pest Management Plan has a variety of additional beneficial uses. The Integrated Pest Management Plan can be used to inform greens committees, owners, regulatory agencies, and the public regarding the integrated pest management strategies, monitoring data, and operations and adaptive management practices at the golf course. A significant challenge is to develop a documented Integrated Pest Management Plan that is understandable to a wide variety of readers. The plan should contain sufficient detail to define all aspects of integrated pest management practices, yet should also be written so readers with a variety of comprehension levels can easily understand the specifics of the plan. Ideally, the plan should be written in outline form that has short, clear descriptions under each outline heading. In certain instances, the use of tables is recommended to provide a concise presentation of certain aspects of the plan.

The organization of the Integrated Pest Management Plan has been synthesized from a variety of sources, which include the Portland Parks and Recreation Pest Management Policy (Portland Parks and Recreation, 2009); the Audubon International's Audubon Cooperative Sanctuary Program for Golf Courses; and a collection of contemporary, turfgrass management references.

The Portland Parks and Recreation Pest Management Policy is in compliance with the 4(d) Rule under the Endangered Species Act. There have been updates to this policy, which also applies to city golf courses. Alternative weed management treatments are currently being studied. By keeping up to date with the results of these studies, golf course superintendents will be able to develop the best practices to use at the golf course. Another part of the current Pest Management Policy is to stem the invasion of nuisance and nonnative invasive weeds that displace the natural plant communities. This is necessary to restore natural areas, in creating healthy habitats needed to support wildlife, and in enhancing stormwater quality.

The Integrated Pest Management Plan should include a description of the facility. More specifically, the individual management areas and the respective maintenance requirements should be defined. For example, the golf course may include 20 acres of fairways that have a medium level of irrigation requirement, a medium level of mowing frequency, and a low fertilizer requirement. These 20 acres would

be also managed similarly from a pest management standpoint.

The following is a table of contents for a typical Integrated Pest Management Plan. Because Integrated Pest Management Plans are specific to each golf course, your Integrated Pest Management Plan may vary from this example. The contents are described in more detail in later sections.

- Introduction
- Integrated Pest Management Definition, Objectives, Structure
- Area Definition
  - Management Areas
  - Non-Turfgrass Areas
- Turfgrass Cultural Practice
  - Cultural Practice
  - Pest Management
  - Nutrient Management
  - Irrigation
- Tree and (Natural Area) Vegetation Management
- Composting and Organic Materials Management
- Pest Population Definition
- Pest Action Threshold Levels
- Pest Monitoring and Pest Control
- Pesticide Specifications
- Facilities Description
- References

Best Management Practices

- Develop a written Integrated Pest Management Plan.
- Use the Integrated Pest Management Plan as an operational reference for all golf course operations.
- Educate staff on the contents and utility of the Integrated Pest Management Plan.
- Revise/update the Integrated Pest Management Plan over time so that it remains a contemporary document reflecting the state of golf course management and the evolution of the local pest populations or potential pest conditions.
- Document which pest management practice(s) are appropriate to carry out as corrective actions. Document where each pest lives, feeds, and nature and history of its occurrence.
- Document whether past corrective actions actually reduced or prevented pest populations were economical, and minimized risks. Use this information when making similar decisions when updating the Integrated Pest Management Plan.
- Present a plan to observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present. Include a scouting form in the Integrated Pest Management Plan.

6.3 PEST ACTION THRESHOLDS

Integrated pest management is commonly used in agricultural crop production, where the economic thresholds for key pests have been determined. Pest levels exceeding the threshold warrant treatment. Using integrated pest management can be somewhat more challenging on golf courses. 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 outreach to and education of golfers and maintenance personnel could raise their tolerance of minor aesthetic damage without compromising plant health, play, and aesthetics.

An action threshold in a golf course pest management strategy is defined as the point where cultural, mechanical, physical, or other practices or biological controls are no longer sufficient to control a pest below populations that can cause “unacceptable damage” to turfgrass. At this point, a curative chemical control product application is required to control the pest population.

"Unacceptable damage" can vary from facility to facility. For example, fairways at many public golf courses have populations of broadleaf weeds that might be considered unacceptable at resort or private golf courses. The action threshold for broadleaf weeds would be different for each of these types of facilities and need to be determined by the golf course superintendent on the basis of the level required to maximize rounds while minimizing costs. In essence, action thresholds for pest management at golf courses are economic thresholds.

Action thresholds can be related to pest populations, growing degree days, combinations of temperature and humidity, or "when the forsythia blooms," provided the cultural practices are unsuccessful at controlling the pest organism or weed population. Pest populations can be expressed as percentage cover, plants per 1,000 ft2, or any convenient measurement that reflects the population. Local growing degree calculators exist for several common golf course pests (e.g. poa annua seedhead formation).

Best Management Practices

- Define the property by management area—areas that are treated similarly. Typical management areas include greens and approaches, tees, fairways, rough, ornamental areas, natural areas, and water bodies.
- Establish action thresholds that trigger chemical control product applications for each pest observed in each management area. The action threshold should be based on the following:
  - How well can various cultural practices control pest populations; and
  - How much degradation of turfgrass quality can be tolerated in each management area.
- Use curative and preventive chemical applications only when action thresholds informed by professional judgment indicate that properly timed preventive application is 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.

6.4 MONITORING & SCOUTING

Monitoring and scouting is the most important element of a successful integrated pest management program. Monitoring and early detection documents the presence and development of pests, or if the conditions 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 or potential pest conditions, 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 pest organisms or weeds are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.
- Train personnel to determine the life cycle of the pest 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 mini-

mized risks. Record and use this information when making similar decisions in the future.

- Train personnel to document, identify and record key weed or pest organism activities on key plants. Use a scouting form to standardize information recorded during scouting.
- 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, more highly trafficked greens, tees, and landing or drop zones, 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.

6.5 RECORD KEEPING

It is essential to record the results of scouting and early detection in order to develop historical information, document patterns of pest activity, and document successes and failures. 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 chemical control products are classified as restricted-use pesticides (RUPs). Very few chemical control products 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 weed or pest activities on key plants and locations.
- 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.
- Document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pest organisms or weeds are present, on the scouting form.
- Maintain chemical control products application records required by the state.

6.6 TURFGRASS SELECTION

Selecting pest-resistant cultivars or plant species is a very important part of integrated pest management, and it leads to reduced chemical control product usage. Species grown outside of their zone of adaptation are more prone to pest problems. Turfgrass species and cultivars should be managed under conditions similar to their intended use (for example, not exceeding mowing height limitations 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. Turfgrass must be scientifically selected for the eco-region of the golf course, resulting in minimized irrigation requirements, fertilization needs, and chemical control products use.

Best Management Practices

- Select the most suitable turfgrass for existing conditions and one that adheres to design specifications.
- Avoid the use of turfgrass in heavy shade.

- Minimize the use of turfgrass in close proximity to water features and natural areas in nonplay areas to the extent that is practical and economical.
- Maintain or plant low-maintenance, noninvasive, native plant species in buffer zones between managed turfgrass and designated natural areas.
- 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.

6.7 BIOLOGICAL CONTROLS

The biological component of integrated pest management involves the release and/or conservation of natural predators, such as parasites and pathogens, and other beneficial organisms. 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, such as bats or birds.

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.
- 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 white grubs.
- Provide native flowering plants that can be nectar food sources for parasitic insects and pollinators.
- Encourage beneficial organisms in out-of-play areas.

6.8 POLLINATORS

It is important to minimize the impacts of pesticides on bees, beneficial arthropods (e.g, butterflies), and other insects. Feeding activities of some bats and smaller bird species also support pollination. 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 chemical control products, focus on minimizing exposure to nontarget pollinators in play and nonplay course areas. Pollinators may be negatively impacted when chemical control product applications are made based on insufficient information and/or made without regard to the safety of pollinators.

Best Management Practices

- Minimize injury and damage by following label directions when using chemical control products.
- Follow label information concerning the application of chemical control products when plants may be in bloom. Avoid applying chemical control products during bloom season.

- Stay on target by using coarse-droplet nozzles and monitor wind to reduce drift.
- Do not apply pesticides when pollinators are active. If a pesticide spray is needed then spray late in the evening or early in the morning when bees are not foraging.
- Before applying a chemical control product, scout/inspect the area for both harmful and beneficial insect populations and apply only when the indicated action threshold of damage has been reached.
- Mow flowering plants (weeds) before insecticide application.
- If flowering weeds are prevalent, control them before determining whether to apply insecticides.
- Use insecticides that have lower toxicity to pollinators.
- 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 forecasted.
- Use granular formulations of chemical control products considered to pose less hazard to bees.
- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.

6.9 CONVENTIONAL CHEMICAL CONTROL PRODUCTS

Integrated pest management does not preclude the use of chemical control products. However, these should be viewed as one of the many tools used to minimize pest problems. Integrated pest management 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 chemical control products should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated in the action threshold.

Chemical control products 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. These products should be evaluated on the basis of effectiveness against the pest, mode of action, life stage of the pest, personnel hazards, nontarget 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 nontargeted 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 and transformation of the pesticide. The label is the single most important document in the use of a chemical control product. State and federal pesticide laws require following label directions.

Best Management Practices

- Train employees in proper pest identification and chemical control product selection techniques.
- Ensure pesticide applications are performed by appropriately-licensed persons, where required.
- Choose the product most appropriate for the problem or pest.
- Mix only the quantity of product needed in order to avoid disposal problems, protect nontarget organisms, and save money.
- Choose reduced-risk products as defined by the US Environmental Protection Agency when available.
- Test new chemical control products on a small area on the golf course before widespread use.
- Consider the weather conditions and forecasts prior to the application of products.

- Avoid applying herbicides at times when they could contribute to plant stress and result in greater plant damage by a secondary pest problem.
- Honor buffer zones when applying pesticides.
- Spot-treat pests whenever appropriate.
- Make note of any environmental hazards and aquatic area or groundwater advisories included on the label.
- Rotate chemical control product 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).

6.10 DISEASE

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 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, mower sharpness, 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 may involve sending samples to diagnostic laboratories.
- Define action thresholds.
- Understand disease symptoms and disease life cycle.
- Ensure proper cultural cultivation 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.
- Monitor turfgrass regularly enough for early detection of disease symptoms.
- Monitor conditions (temperature, humidity, moisture, etc.) that favor disease development, in particular those conditions that may define an action threshold.
- The appropriate (most effective) preventive fungicide should be applied to susceptible turfgrasses when action thresholds indicate conditions where unacceptable levels of disease are likely to occur.
- Rotate the chemical family of fungicides applied to prevent the development of fungal resistance.
- 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.

6.11 ANTHRACNOSE MANAGEMENT ON BLUEGRASS PUTTING GREENS

Rutgers University developed a set of Best Management Practices for anthracnose on annual bluegrass putting greens, most recently updated in gcmonline.com, 2020. Anthracnose can be a foliar disease or a basal rot of the lower turfgrass stem. The pathogen may cause blight or rot of crowns, stolons, or stems that may cause bluegrass turf reddening, thinning, and death. Nutrient deficiencies, low mowing, and overly wet or dry soil moisture are factors influencing anthracnose development. As a result, best management practices for control of this disease include practices that mitigate these risks.

Increased mowing frequency, lightweight rolling, and abrasive grooming practices such as sand topdressing have long been thought to increase anthracnose severity. Recent research at Rutgers University has challenged these long-held assumptions. The research suggests that frequent, light sand topdressing has a cumulative, beneficial effect, although this practice initially enhances anthracnose. Such topdressing appears to protect the crown from the stress of low mowing heights.

While previous research has primarily focused on individual cultural management factors (see comprehensive list below), recent studies examined combinations of anthracnose BMPs to understand their relative importance in reducing the disease. In a study comparing the BMPs of increasing N fertilization, higher mowing, and greater topdressing, increasing N fertilization was most important for suppressing anthracnose. Combining increased nitrogen, higher mowing, and greater topdressing provided acceptable disease control without fungicides during two of three years of study; however, green speed was often unacceptable. Lowering the mowing height from 0.125 to 0.090" provided acceptable green speeds without greatly increasing disease severity, as long as greater N and greater topdressing were employed.

An additional trial showed that greater N fertilization allowed for fungicide rates to be lowered to 25% of label rates (a 75% reduction) and still provide acceptable anthracnose control. Threshold-based management also produced acceptable disease control and reduced fungicide inputs by 80% compared with a calendar-based approach when greater N was combined with higher mowing.

Best Management Practices

- Nitrogen should be applied to maintain the vigor of the annual bluegrass putting green turf without overfertilizing. Annual "summer" soluble-N rates of approximately 2.4 to 3.6 lb N 1,000 ft2should be applied to reduce anthracnose incidence and severity. A rate at the higher end of the range will be needed if N rates have been low historically.
- Beginning soluble-N programs earlier (April or May) in the year at 0.4 to 0.8 lb of N per 1,000 ft2per month can build up nitrogen in the turf heading into summer, which can result in decreased anthracnose severity.
- Any granular-N fertilization should be emphasized in the "spring" at rates of 1 to 3 lb per 1,000 ft2to reduce disease severity. A rate at the higher end of the range will be needed if N rates have been low historically.
- Potassium should be applied to maintain moderate to high levels of soil K (> 100 lb per acre Mehlich III; > 50 ppm). Soluble-K applications should be made at 1:1 or 2:1 N:K molar adjusted-ratio every 14 days to reduce anthracnose severity.
- Fertilize with complete fertilizers, avoiding deficiencies of potassium and phosphorous.
- Mowing below 0.125 inches should be avoided when using fixed head mowers—a slightly lower bench setting is okay for flex units. If feasible, raise the cutting height as high as 0.140-in for greater suppression of anthracnose. Slight increases in mowing height can significantly reduce the severity of the disease. Thus, the use

of solid rollers versus grooved rollers, at the same bench height setting, may also be helpful.

- Roll and/or increase mowing frequency to maintain ball roll distances at higher mowing heights. Rolling and double-cutting increase ball roll but will not enhance disease severity.
- Double-cutting and lightweight rolling are other practices that are useful to maintain acceptable playability (green speed).
- Rolling every other day can result in slightly decreased anthracnose severity, regardless of roller type.
- Soil pH: Annually test the turfgrass root zone to ensure soil pH does not become too acidic.
- If limestone is required, base the quantity of limestone to be applied on a target pH of 6.0 and the buffering capacity of the soil (check the lime requirement index).
- Routine trinexapac-ethyl use even at high rates and short intervals will not increase and may reduce anthracnose severity by improving turf tolerance to low mowing and enhancing plant health.
- Ethephon can be used to suppress seedhead formation in annual bluegrass turf without increasing anthracnose.
- Ethephon applied in March or April at label rates with subsequent applications of trinexapac-ethyl at 0.1 to 0.2 fl oz/1,000 ft2every 7 to 14 days will provide the best turf quality and may reduce anthracnose.
- Increased anthracnose can result when annual bluegrass is consistently subjected to wilt stress or excessively wet conditions.
- Irrigating to replace 60 – 80% of potential evapotranspiration and hand watering as needed to avoid wilt stress will provide a quality playing surface and reduce conditions favorable for anthracnose.
- Biweekly sand topdressing in the “summer” with up to 100 lb per 1,000 ft2provides a protective layer of sand around the crown, which slightly raises the effective height of cut thus reducing anthracnose.
- Topdressing in the spring at 400 to 800 lb per 1,000-ft2is more effective than fall applications in reducing anthracnose severity. Note these rates do not include the quantity of sand needed to fill aerification holes; more sand will be needed if coring is done at the same time as topdressing. The amount of sand needed will depend on the diameter and spacing of cores.
- Topdressing with sand throughout the growing season is a very effective practice for maintaining a firm and fast playing surface, and, fortunately, is also effective at reducing anthracnose severity.
- Heavy fall topdressings are less effective than summer and spring topdressing at suppressing anthracnose
- Routine topdressing is most beneficial under lower mowing and lower nitrogen fertilization.
- Reduce soil compaction by core aeration in spring and fall.
- Minimize leaf wetness by improving air circulation (pruning of trees and shrubs) and/or early mowing or dew removal.
- Wash mowers when moving from infected areas.
- If renovating greens, consider bentgrass cultivars with moderate resistance to anthracnose.
- Anthracnose does not appear to be affected by different sand incorporation techniques, so methods which best incorporate sand should be selected to minimize turf injury and wear on mowing equipment.
- Foot traffic (similar to rolling) appears to reduce anthracnose, regardless of sand topdressing. The benefits of sand topdressing (better wear tolerance and decreased disease) are also seen in areas that receive daily foot traffic.

- Do not avoid the use of vertical mowing or other abrasive cultivation practices (e.g., aerification, scarification, grooming) if needed when disease is present since wounding from these practices has not been shown to increase anthracnose severity. However, make sure fungicides have recently been applied before utilizing any cultivation practice when anthracnose is active.
- Avoid the sequential use of fungicide chemistry, and tank-mix or alternate fungicides with different modes of action to enhance efficacy and reduce the potential for resistant strains of the anthracnose pathogen from developing.
- Develop fungicide programs that focus on the strengths (efficacy) of fungicide chemistries and time their application to optimize the control of all major diseases on the site.
- Preventive fungicide applications are more effective than curative applications. For basal rot, a systemic fungicide should be applied and watered in to reach the crown area. Follow with a separate application of chlorothalonil at a high rate. Repeated use of Group 3 fungicides should be avoided during the summer stress period to avoid growth regulator effects.
- Rotating use of as many different fungicide chemistries as practical for proven efficacy against anthracnose—i.e., the QoI, DMI, nitrile (chlorothalonil), benzimidazole, dicarboximide (iprodione), phosphonate, antibiotic (polyoxin-D), and phenylpyrrole fungicides—as practical during the growing season to enhance anthracnose control and reduce the potential for fungicide resistance.

6.12 WEEDS

Weeds compete with desired plants for space, water, light, and nutrients and can harbor insect pests and diseases. Weed management is an integrated process where sound 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 and other nuisance plants from being introduced into an area;
- Using proper turfgrass management and cultural practices to promote vigorous, competitive turf;
- Proper management of buffer zones and natural areas;
- Properly identifying weeds and early detection;
- Communicating and coordinating with the neighboring property owner, where practical; and,
- Properly selecting and using the appropriate herbicide, if necessary.

Weeds are hosts for other pests such as plant pathogens, nematodes, and insects, and certain weeds can cause allergic reactions in humans. Weeds and other nuisance plants 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.

Best Management Practices

- Define action thresholds.
- Proper weed identification and early detection are essential for effective management and control.
- Select appropriate turf species or cultivars adapted to the prevalent environmental conditions to reduce weed or other nuisance or invasive plant encroachment that may lead to bare soils.

- To prevent weed or other nuisance or invasive plants encroachment, adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures.
- To reduce turfgrass weed infestation, address improper turf management practices, such as the misuse of fertilizers and chemicals, mowing with dull cutting units, improper mowing height or mowing frequency, and improper soil aeration, and physical damage and compaction from excessive traffic.
- Appropriate 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 the potential for 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.
- Monitor turfgrass regularly for the presence of weeds.
- Optimize turfgrass vigor by mowing at the appropriate height with sharp cutting units and through the appropriate application of fertilizer and water to prevent weed colonization and establishment.
- When possible, use mechanical means (i.e., hand pulling) to remove weeds.
- Monitor, scout, and control out-of-play, buffer zones, and natural areas for weeds or other nuisance or invasive plants consistent with good economics, turf and ecosystem health, and playability.
- Property line areas with observable adjoining properties should also be regularly monitored as part of early detection efforts.
- Communicate and coordinate weed or other nuisance or invasive plant monitoring data, early detection, and controls with neighboring property owners, where practical.
- Use selective herbicides only when thresholds have been exceeded and, when appropriate, limit applications to spot treatments.

6.13 INSECTS

In the presence of a susceptible host and a conducive environment, certain insects can disrupt play by damaging and destroying turf, or by being a nuisance to golfers. Golf course managers have multiple tactics and tools that can be used to control turf insect pests, including cultural, biological, and chemical practices.

Best Management Practices

- Define action thresholds.
- Understand relevant insect life cycles and symptoms of infestation.
- Provide habitat for native insect predators where possible.
- Install bat and bird boxes near areas where insect infestations could be food sources for these animals.
- Encourage beneficial insects and consider impacts to beneficial insects prior to application of pesticides.
- Monitor turfgrass regularly for early detection, and identifying symptoms of infestation.
- Calculate growing degree days to estimate certain insect activity.
- If infestation is detected, correctly identify the insect.
- Use target-specific insecticides.

- When possible, use targeted, spot applications of insecticides.
- For insecticides aimed at soil insects, irrigate turfgrass before and/or after an application, in accordance with the label.

6.14 NEMATODES

Plant-parasitic nematodes can adversely affect turfgrass health. Plant-parasitic nematodes are microscopic roundworms (unsegmented), usually between 0.0156- and 0.125-inch in length, and are difficult to control. Nematodes debilitate the root system of susceptible turfgrasses; plant-parasitic nematodes cause turf to be less efficient at 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, blade density and turf root thickness in the affected areas thins out and, with severe nematode 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 potential, 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 stressed by insects, nematodes, diseases, or weeds.
- Increase mowing height and ensure sharp cutting units 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.

6.15 RODENTS

Certain rodents can disrupt play by damaging and destroying turf, or by being a nuisance to golfers. Several approaches can be utilized to control problem rodents.

Best Management Practices

- Define action thresholds.
- Use mechanical traps when possible and local laws allow.
- Study the habits of the target rodent to enhance trap efficiency.
- Provide habitat for native rodent predators where possible.
- Install nesting or perching features, including snags, nesting boxes, and platforms for raptors (eagles, hawks, kites, falcons, owls, etc) that use rodents as a food source.
- Use rodenticides as a last resort.
- If possible, eliminate food sources or habitat.

6.16 INVASIVE SPECIES

Noxious, nuisance and invasive weeds need to be controlled. These types of plants are a threat to the function, composition, and structure of native ecosystems. The US Environmental Protection Agency states noxious weeds and invasive exotic (nonnative) plants are a serious biodiversity issue of great significance to human and natural resource conditions. Not all nonnative species are invasive in nature. Certain invasive plant species spread quickly and can displace native plants, prevent native plant growth, and create monocultures. Invasive plants cause reductions in biodiversity, and the quality and quantity, of habitat.

Best Management Practices

- Properly identify nonnative species with early detection and determine their ability to be invasive.
- Prevent the continued spread of aggressive, nonnative plant species.
- Prevent the spread of established nonnative noxious and invasive plants into uninfested or lightly infested areas.
- Eradicate new invaders before they become established.
- Eradicate or control known and potential nonnative noxious and invasive plant infestations.
- Monitor, scout, and control out-of-play, buffer zones, and natural areas for noxious, nuisance, or invasive plants consistent with good economics, turf and ecosystem health, and playability.
- Property line areas with observable adjoining properties should also be regularly monitored as part of early detection efforts.
- Communicate and coordinate noxious or other nuisance or invasive plant monitoring data, early detection, and controls with neighboring property owners, where practical.

6.17 LAKE AND AQUATIC PLANT MANAGEMENT

If lakes and/or ponds exist at a golf course, a comprehensive written lake/pond management plan should also exist for that golf course and a section of the written Integrated Pest Management Plan should be devoted to lake and aquatic plant management. Water and water quality management is discussed in Section 3.0.

Best Management Practices

- Define action thresholds.
- Consider pond function (habitat or irrigation) when defining damage/action thresholds.
- Keep ponds/lakes as deep as practical to minimize undesirable aquatic plant growth.
- Where possible, use mechanical means to remove undesirable aquatic plants.
- Where possible, use nontoxic blue or black dye to block sunlight from growing undesirable aquatic plants or algae.
- Use beneficial aquatic plants to out-compete undesirable plants and/or to remove nitrate from the water.
- Some types of submerged aquatic plants may be used to increase dissolved oxygen levels, where desired and practical.
- Use aerators to agitate water; this practice increases oxygen content and reduces the growth of bacteria and algae.
- Before using aquatic herbicides, obtain appropriate permits, if necessary.

6.18 TURFGRASS CULTURAL PRACTICE

Turfgrass cultivation area maintenance is often the most labor-intensive element of the integrated pest management program, requiring greater than 95 percent of resource allocation. The primary intent of the integrated pest management program is to optimize turfgrass vigor utilizing sound cultural practices as a means of preventing and/or minimizing pest infestation. The primary practices of turfgrass cultivation area maintenance include mowing, fertilization, and irrigation. Cultural practices also include aeration, topdressing, thatch removal, and overseeding to promote a healthy turfgrass environment.

Best Management Practices

- Use certified pest-free plant material, if available.
- Use appropriate turfgrasses for cultivation areas being planted.
- Increase mowing height and ensure a sharp cutting unit to reduce plant stress associated with

nematodes, root-feeding insects, disease outbreaks, or peak weed seed germination.

- Stimulate or increase root growth if root-feeding pests are detected. Increase irrigation frequency (with smaller quantities) until roots recover.
- Manage irrigation to avoid excess moisture or drought stress. (See Irrigation Section of the *Guidelines)*.
- Wash mowers to avoid spreading pathogens and weeds.
- Manage thatch by adjusting fertility levels, mechanical removal, top dressing, or other means.
- Divert traffic away from areas that are stressed.

6.19 PLANT NUTRITION

Nutrient management is most effective when combined with integrated pest management practices. The nutrient management plan is a guide for adjusting management practices to address variability throughout the golf course. It is a guide for managing the amount, sources, placement, form, and timing of application of nutrients and other soil amendments and should be applied as part of a conservation management system to efficiently use nutrient resources. Nutrient management has a significant impact on plant health, soils, and the environment over time; therefore it is important to closely monitor the nutrient application rate, nutrient form, nutrient application method, and nutrient application timing. Plant nutrition is discussed extensively in Section 4.0. A vegetation management plan may also be used to plan, inform, and adjust course nutrient operations and management as it relates to the potential for unintended effects to buffer zones or natural features in nonplay areas.

6.20 PLANT GROWTH REGULATORS

Plant growth regulators are chemicals that regulate plant growth. The objective of plant growth regulators is to increase turfgrass quality and reduce maintenance costs. Plant growth regulators provide economical growth regulation of turfgrass. Because the vertical growth of the turfgrass is reduced, the frequency of mowing, fertilization, and irrigation may also be reduced. The use of plant growth regulators may also limit seedhead development, as well as disease or infection potential.

6.21 REGULATORY CONSIDERATIONS

The philosophy of integrated pest management as a strategy was developed in the 1950s because of concerns over increased pesticide use, environmental contamination, and the development of pesticide resistance. The objectives of integrated pest management include reducing pest management expenses, conserving energy, and reducing the risk of pesticide exposure to people, animals, and the environment. Its main goal, however, is to reduce pesticide use by using a combination of adaptive management tactics to control pests, including cultural, biological, genetic, and chemical controls.

Pest management on golf courses results in significant inputs of time, labor, and financial resources. To grow healthy turfgrass, it is important for golf course superintendents to know what integrated pest management is and how to implement it for each pest group (arthropods, nematodes, other insects, diseases, weeds, or other pests). They must be well-versed in pest identification, understanding pest life cycles and/

or conditions that favor pests, and know about all possible methods of controlling pests.

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

Best Management Practices

- Conduct thorough assessments of pest pressure and establish appropriate thresholds for managed turf areas.
- Identify and correct growing environments that exacerbate pest pressure.
- Implement sanitation, exclusion, and cultural practices to minimize pest pressure.
- Determine least-toxic pest control programs, including using a selection strategy that includes an evaluation of pesticide characteristics and potential for nontarget effects, as well as preventive approaches.
- Good planning and design. A vegetation management plan may also be used to plan, inform, and adjust course nutrient operations and management as it relates to unintended effects to buffer zones or natural features in nonplay areas.
- Assess control program effectiveness using established monitoring and early detection practices.
- Routine observations of nonplay areas that may host plant, insect, or animal pests should be made that are in relative proximity to the turfgrass cultivation areas.
- Monitor, scout, and control out-of-play, buffer zones, and natural areas for noxious, nuisance, or invasive plants consistent with good economics, turf and ecosystem health, and playability.
- Property line areas with observable adjoining properties should also be regularly monitored as part of early detection efforts.
- Communicate and coordinate noxious or other nuisance or invasive plant monitoring data, early detection, and controls with neighboring property owners, where practical.

POLLINATOR PROTECTION 7.0

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

The western honey bee (Apis mellifera) is one of the most important pollinators in the United States. Hundreds of other bee species, including the bumblebee (Bombus spp.), also serve as important pollinator species. Protecting bees and other pollinators are important to the sustainability of agriculture.

It is important to minimize the impacts of chemical control products on bees and beneficial arthropods. Chemical control product applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans. Be mindful of pollinators; when applying control products, focus on minimizing exposure to nontarget pollinators in play and nonplay course areas. Pollinators require a diversity of nesting sites as well as flowering species to complete their life cycle. Pollinator habitat contains a diversity of wildflower species of different colors and heights, with blossoms throughout the entire growing season.

7.1 POLLINATOR HABITAT PROTECTION

Identify plant varieties that encourage pollinator populations. This includes color, shape, odor, and native species. Aesthetic gardens, window boxes, and container gardens should contain a variety of plants of different heights that provide attractive color and nectar for bees and butterflies. Resources for plant varieties that attract pollinators specific to the State of Oregon are generally maintained by the Oregon Bee Project, the Xerces Society for Invertebrate Conservation, and the Natural Resources Conservation Service (NRCS). The North American Pollinator Protection Campaign (NAPPC) compiled guidelines, Pollinator Friendly Practices (PFP), to be used by organizations in support of land management practices in schools, private industry, public spaces, agriculture, forests, and homes.

Best Management Practices

- Follow label information and precautions directing the application of chemical control products when the plant may be in bloom. Avoid applying chemical control products during bloom season.

- Stay on target by using coarse-droplet nozzles, and monitoring wind to reduce drift.
- Do not apply chemical control products when pollinators are active. If a chemical control product spray is needed, then spray late in the evening or early in the morning when bees are not foraging.
- Before applying a chemical control product, scout/inspect the area for both harmful and beneficial insect populations and use chemical control products only when a threshold of damage has been indicated.
- Mow flowering plants (weeds) before insecticide application.
- Monitor wind and active pollinator periods; utilize targeted applicators to prevent drift
- If flowering weeds are prevalent, control them before applying insecticides. Apply only when the indicated action threshold of damage is reached.
- Use insecticides that have lower toxicity to pollinators.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of chemical control products.
- Avoid applications during unusually low temperatures or when dew is forecast.
- Use granular formulations of chemical control products considered to pose less hazard to bees.
- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.
- Develop new pollinator habitat and/or enhance existing habitat by planting ornamentals and butterfly gardens.

7.2 REGULATORY CONSIDERATIONS

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

Pollinator-protection language is a label requirement found on chemical control product labels; follow the label, it is the law [Requirements for pesticide labels are found in the Code of Federal Regulations (40 CFR Part 156)]. Chemical control product 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 in the State of Oregon. Integrated pest management principles suggest you keep records of all pest control activity so you may refer to information on past infestations, potential pest conditions, or other problems to select the best course of action in the future.

Best Management Practices

- Proper records of all chemical control product applications should be kept according to local, state, or federal requirements.
- Use records to establish proof of use and follow-up investigation of standard protocols regarding:
  - Date and time of application
  - Name of applicator
  - Person directing or authorizing the application
  - Weather conditions and forecast at the time of application
  - Target pest
  - Chemical control product used (trade name, the 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 chemical control product used
  - Application equipment
  - Additional remarks, such as the severity of the infestation or life stage of the pest
  - Follow-up to check the effectiveness of the application

- Those applying chemical control products, and who make decisions regarding their applications should be able to interpret pollinator protection label statements.
- Those applying chemical control products should be aware of the biology of honey bees and other native bees.
- Those applying chemical control products should understand the various routes of exposure (by foraging or through direct contact).
- Those applying chemical control products should understand the effects of chemical control products on bees.
- Communicate and coordinate pollinator and habitat protection outreach and education with neighboring property owners or local community groups or other organizations, where required, practical, and economical.

LANDSCAPE 8.0

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

An environmental landscape design approach addresses environmentally safe and energy-saving practices; therefore, environmentally sound landscape management is quite 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 planting plan informs the golf course planning, design, and construction, or renovation phases relating to play and nonplay areas. A vegetation management plan provides more specific guidance on the management of nonplay designed landscapes, as well as a buffer and natural cover areas where necessary or practical and economical.

8.1 SPECIES SELECTION AND SIZE CONSIDERATIONS

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.

It is important to know the ultimate sizes and growth rates of trees, shrubs, and ground covers, as well as in relation to the golf course planning, design, and construction visions. This reduces the need for pruning and debris removal and lowers maintenance costs. The addition of proper soil amendments can improve the physical and chemical properties of the soil, 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.

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 nonplay areas should remain in natural cover to support optimal ecosystem functions, where practical and economical. 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 nonplay areas and along water bodies 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 golf course is reduced while habitat for wildlife survival is maintained.

Stream restoration within riparian zones to maintain natural flows may be appropriate in golf course planning, design, and construction, or during renovations to minimize flooding and erosion potential. An environmental design-build firm may be consulted to complete nature-scape and sustainable landscape assessment, design, permitting, and construction. Prior to re-planting the project area landscape, buffer, and riparian areas, large woody debris (large anchored root wads and logs), and boulders may be placed in-water to positively influence channel morphology, stability, and sediment dynamics.

Planting plans for original golf course design and construction, and renovations should be implemented. Where practical and economical, vegetation management plans should also be implemented for nonplay landscape, buffer, and natural cover areas.

The goal of species-selection Best Management Practices is to maintain as close to a natural ecosystem as practical while meeting the needs of a golf course.

Best Management Practices

- Base plant selection as close to a natural ecosystem as practical, while meeting the needs of the golf course. The natural ecosystem has adapted specifically to the soil, microclimate, rainfall, light patterns, insects and other pests; and endemic nutrient levels at that location.
- 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 adapted for the site based on the United States Department of Agriculture (USDA) cold-hardiness map.
- Develop planting plans for original course construction and renovations to provide guidance for establishing the fabric of landscape and natural cover.
- Create a vegetation management plan to focus on the establishment and management of nonplay landscape, buffer, and natural cover areas.
- Select stress-tolerant species or cultivars to manage periodic dry/wet conditions.
- Choose the most stress-tolerant species or cultivar for a particular area.

8.2 TREE MANAGEMENT

Tree management includes inventorying the trees at the golf course and general tree planting, management, and removal practices.

Trees considered for planting are selected based on ultimate size and type of growth appropriate for the planting location, compatibility with soil conditions and climate, and pest resistance properties. Select native species as appropriate. If nonnative tree species are selected, select those that are not invasive in nature. Select a diversity of native tree species—a variety of species is better for wildlife (insects through mammals).

Tree planting locations should be carefully evaluated prior to planting to anticipate the effect of mature trees on surrounding turfgrass and ornamental areas. Architectural features, engineering, aesthetics, and influence on playing characteristics of the golf course are important landscape functional considerations. Water requirements, debris management, shading, and influence on air circulation are the primary determinants of planting locations.

Trees should be planted in planting holes appropriate for the root ball/root mass; and planting holes should be backfilled with native material, except in certain situations where the existing soil is contaminated or filled with rubble. It is important to make sure the planting area is mulched and receives irrigation as required through the first three growing seasons. Planting should occur during the Fall. However, certain tree species, such as conifers, should be planted in the Spring.

Trees should be routinely monitored for overall health, influence on playing characteristics, the

presence of insects and diseases, influence on surrounding turfgrass and ornamentals, and hazard potential. In general, insect and disease pests can be tolerated. High-value specimen trees may require more consideration for integrated pest management strategies. Most established trees do not require supplemental watering except in situations of extreme drought. Trees should be pruned to optimize health, allow passage of light and wind, minimize hazards, and manage pests. A certified arborist should be consulted regarding trees that have a disease and/or pest problems beyond the normal scope of golf course management practices.

Tree removal may be required because of disease, age, wind or lightning damage, or hazard potential. At other times, trees may be removed to increase sunlight and air circulation to specific turfgrass areas to create better-growing conditions for healthy turfgrass. Consider impacts to wildlife habitat and shading properties before trees are removed. The golf course superintendent will be responsible for determining if tree removal is necessary, and will consult with a professional tree service regarding tree removal that is beyond the scope of routine golf course management practices.

Consider removing only a portion of a tree and leaving the rest as a snag to eliminate the hazard but to provide some value on-site such as wildlife habitat. If possible, place cut/pruned material on-site when possible and where appropriate to provide value to wildlife.

Some communities have enacted ordinances requiring planting or protection of trees in riparian zones or forested groves, along public streets and rights-of-way, parking areas, along property lines, or for specified large-diameter trees depending on the jurisdiction. Re-planting is often required relating to course construction or renovations work areas; nearby trees may also need to be protected during such work. Check with your city's arborist or urban forestry program for ordinances affecting your location and for guidance.

Best Management Practices

- Select trees to be planted based on mature size and type of growth suitable for the planting location, compatibility with soil conditions, other associated plants, climate, and pest resistance properties.
- Where appropriate select native trees.
- Carefully evaluate locations prior to planting:
  - Consider water requirements and influence on shading and air circulation for the surrounding turfgrass;
  - Consider wildlife habitat;
  - Consider the influence of the tree on the playing characteristics of the golf course; and
  - Add tree canopy over surface water to help reduce water temperatures and increase dissolved oxygen.
- Complete a tree inventory on the entire property including the natural areas.
- Consider wildlife habitat.
- Consider aesthetics.
- Routinely monitor trees:
  - Monitor overall health;
  - Prune when appropriate to maintain tree health;
  - Consider influence on playing characteristics;
  - Monitor for the presence of insects and diseases;
  - Consider influence on surrounding turfgrass and ornamentals; and
  - Consider the hazard potential.
- Trees may be removed because of disease, age, wind, lightning damage, or hazard potential.
- Trees may also be removed to increase sunlight and air circulation to specific turfgrass areas.
- Consult a certified arborist regarding removal beyond the scope of routine golf course management practices, or where otherwise required by the jurisdiction.

- Consider the impact removal of the tree will have on surface water shading before removing the tree.
- Optimize air circulation.
- Optimize morning sun for turfgrass areas impacted by tree(s).
- Minimize shade for turfgrass areas. Whenever possible, retain shade over waterways to preserve habitat and help control the temperature.
- Minimize traffic in shaded areas.
- When mulching on-site is not a viable option, remove leaves, fallen limbs, and other debris from turfgrass areas to the controlled composting area or an area staged for disposal. Whenever possible, do not disturb this material in waterways or natural areas to preserve habitat.
- Develop planting plans for original golf course construction and renovations to provide guidance for establishing the fabric of landscape, buffer, and natural cover areas.
- Create a vegetation management plan to focus on the establishment and management of non-play landscape, buffer, and natural cover areas.

8.3 ORNAMENTAL LANDSCAPE MANAGEMENT

Ornamental plants should be properly selected, planted, and maintained for increased survival, water conservation, and performance in the landscape. Where practical and economical, vegetation management plans should also be implemented for nonplay landscape, buffer, and natural cover areas.

Best Management Practices

- Develop planting plans for original golf course construction and renovations to provide guidance for establishing the fabric of landscape, buffer, and natural cover areas.
- Create a vegetation management plan to focus on the establishment and management of non-play landscape, buffer, and natural cover areas.
- Plant woody ornamentals and herbaceous perennials in the fall and winter. There is less demand for water and nutrients by the top and more energy and food for root growth. With the proper care, ornamentals may also be planted during the spring in the Pacific Northwest.
- Prepare the planting bed properly:
  - Deep till to a depth of 8 to 12 inches; and
  - When planting individual plants, dig a wide planting hole to provide a favorable rooting environment.
- Add appropriate amendments to the planting bed (when necessary) to improve the physical properties of the soil—water retention, water infiltration, and drainage—or to enhance its mineral and microbial content.
- Irrigate at night or early in the morning to conserve moisture and avoid evaporative loss of water.
- Practice deep watering in order to encourage strong healthy root systems that are water efficient. Avoid light, frequent irrigation that encourages shallow rooting.
- Avoid over-fertilization and avoid fertilizing during periods of limited rainfall or high temperatures.

8.4 DESIGN AND FUNCTION

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 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 the shade, which lowers water temperature in summer and increases it in winter.

Best Management Practices

- 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.
- Use forested buffers to create shade that cools water temperature and filter upland sources of sediments, nutrients, and chemicals.
- Use forested buffers to protect fish and wildlife by supplying food, cover, and shade.
- Use forested buffers to maintain a healthy riparian ecosystem and stable stream channel.
- 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 and high traffic areas should they get blown over.
- Use turf as a landscape element where needed, or when practical and economical.

8.5 PLANTING METHODS

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 primary 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. 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 soil improvement can enhance water-use efficiency.
- Plants should be grouped together based on irrigation demand.
- The percentage of landscaped areas in irrigated high-water-use hydro zones should be minimized.
- 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 appropriate soil amendments in garden areas to improve the soil's physical and chemical properties, increase its water-holding capacity, and reduce the movement of nutrients.
- Keep mulch 2 to 3 inches away from plants, to prevent fungal growth from excess dampness.

8.6 REGULATORY CONSIDERATIONS

Trees and nonplay landscape, buffer, and natural cover areas may be subject to permitting regulations during the golf course planning, design, and construction, or renovation, phases. Local city or county tree care and tree protection ordinances or Urban Forestry

Management Programs guidance and rules may apply relating to landscape maintenance.

The city or county for the golf course location may have an urban forestry management program that provides guidance and rules that apply relating to tree care, tree preservation, and tree planting. Some jurisdictions may require the involvement of city or appropriately certified arborists for certain landscape maintenance, on a case-by-case basis.

Communicating and coordinating landscape, buffer, natural cover areas maintenance approaches, and tree care, tree preservation, and tree planting outreach and education with neighboring property owners and local community groups or other organizations may be a necessary ongoing commitment to course land use or other approvals. General golf course renovation techniques and information can be found at the ASGCA website here.

WILDLIFE HABITAT ENHANCEMENT 9.0

Implementation of the Best Management Practices is intended to promote enhancement of wildlife and wildlife habitat. Golf courses are a good source of open green space in urban areas and often function as the only sanctuary for wildlife in nearby urban areas. Golf courses provide significant habitat to a diverse population of birds, mammals, plants, insects, and other wildlife. Insect diversity is generally the basis of wildlife diversity. Because of their scale, golf course grounds provide excellent opportunities to improve landscape-scale connectivity in a watershed.

As part of the environmental stewardship program developed and demonstrated at a golf course, a Wildlife Habitat Enhancement Plan should be prepared. The plan starts with documentation of current conditions and defining the various habitats that occur on the golf course property.

9.1 "THE FRONT 9"

The USGA and the National Fish and Wildlife Foundation created a list of steps that can be followed when implementing wildlife enhancement and conservation. This list is referred to as "The Front 9" and was documented in "Wildlife Links, Improving Golf's Environmental Game." The following are "The Front 9":

- Take stock;
- Develop a game plan;
- Save what's left;
- Use what you have;
- Protect endangered species (and species of concern);
- Establish corridors;
- Naturalize out-of-play areas;
- Start an integrated pest management program; and
- Engage golfers.

Areas of the golf course that are currently in a natural cover state or planted with native plants should be identified, evaluated for quality, and considered for the kinds of habitat (aquatic or terrestrial) they provide. Areas that are out-of-play or under-developed should be delineated to identify those areas that have the potential to be restored as habitat. Each golf course must be managed with consideration for the unique conditions of its ecosystem functions and place in the watershed.

Inventories of species present at the golf course will help to identify what biota would benefit from an expanded or improved habitat. Golf course maintenance staff can conduct an informal inventory simply by having each person record sightings of birds, reptiles, amphibians, fish, mammals, or insects each day, as they might be recording diseases observed in turfgrass. Special note should be made of species of special management concern. These could be species that require extra management effort to control, such as Canada geese or Japanese knotweed. The inventory can be extended to include players and visitors, for

example, by establishing a board for them to record wildlife observed that day. An inventory is required for certification in the Audubon International's Audubon Cooperative Sanctuary Program.

One of the best and easiest ways to upgrade the environmental quality of a golf course is simply to expand or enhance the existing natural amenities. Information from the City of Portland Terrestrial Environmental Ecology Strategy (TEES) committee was used as a basis for this form. The terrestrial habitat form includes a list of questions to ask when restoring/improving the habitat at a site such as a golf course. Some of the questions include the characteristics of the site, the status of the habitat, what species are involved in the habitat, etc. The document also includes general guidelines for "adding value" during project planning and implementation such as using natural processes to achieve ecological functions and project goals to the extent possible. Site considerations listed in the terrestrial guidelines include food, cover, water, disturbance, and other considerations such as creating urban habitat features (e.g. nest boxes and platforms). State Wildlife Action Plans (e.g. Oregon Conservation Strategy) can help golf courses identify priority habitats and priority species, plus recommended conservation actions for priority habitats and species. The list of Oregon species is available here.

Best Management Practices

- Develop an inventory of birds, reptiles, fish, mammals, or insects at the golf course.
- Define the various habitats present on the golf course property using established procedures.
- Prepare a written Wildlife Habitat Enhancement Plan.
- Protect threatened, endangered, or species of concern.
- Establish or preserve wildlife corridors.
- Define areas on the golf course that can be restored to native habitat.
- Implement a turfgrass removal program (for existing course designs) for significant turfgrass coverage areas in underutilized and out-of-play areas.
- Dedicate turfgrass removal program areas (for existing course designs) as wildlife-use or riparian habitat.
- Use a written Integrated Pest Management Plan to protect nontarget species.
- Include golfers, visitors, and other stakeholders in the wildlife inventory program.
- Communicate and coordinate outreach and education with neighboring property owners and local community organizations or other groups relating to the course's ongoing and future wildlife enhancements and conservation.

9.2 WILDLIFE HABITAT ENHANCEMENT PLAN

The Wildlife Habitat Enhancement Plan provides documentation of the current habitat at the golf course and plans for improvement. Enhancing wildlife habitat at golf courses can be accomplished in numerous ways. The following are some best management practices:

Best Management Practices

- Maintain most nonplay areas in varied types of native vegetation.
- Leave dead trees, or snags, if they are not a hazard to property or people; leave downed logs/woody debris/brush piles on the ground.
- When possible, remove only a portion of a tree and leave the rest as a snag, or high stump.
- Protect stream channels. No need to straighten, line, construct unnecessary bridges, remove down trees, or disconnect from wetlands or ponds.
- Where necessary for playability and economics, construct taller, longer span bridges in, along, or

over wildlife crossings, natural areas, and water features.

- Avoid cut- (incised) and/or fill-type (raised) cart paths, footpaths, or maintenance roadways within proximity to or within natural areas, to the extent practical and economical or allowed by site land use and other permits or approvals.
- Wind natural areas through the golf course to provide movement corridors for wildlife with shelter, concealment, and food.
- Restore natural areas.
- Use sound integrated pest management, fertilization, and cultural maintenance practices.
- Maintain buffer zones surrounding all bodies of water where possible, and to transition landscape and natural areas, where practical and economical.
- Control golf cart traffic to avoid highly sensitive or erodible areas, to minimize turfgrass wear, and to minimize soil compaction.
- Know what species exist and can exist in the area.
- Monitor and document habitat improvements and related wildlife response (e.g., installation of bird boxes leading to increased bird population).
- Provide nesting boxes and/or platforms for birds and bats. Refer to the Audubon International Fact Sheets on bat conservation and the Nest Box Project. Maintain boxes, observe that the correct species are using the boxes;
- Note ground nests during breeding season so they can be avoided by maintenance staff and golfers.
- Provide a suitable habitat for wildlife species to use the golf course.
- Create additional habitats for priority species.
- Communicate to and educate golfers and visitors about wildlife conservation opportunities and initiatives.
- Conduct amphibian egg mass surveys;
- Conduct turtle surveys (visual)—easy when there is basking habitat present. This is a good way to figure out if native turtles are present versus nonnative invasive turtles such as the red-eared sliders; and
- The wildlife habitat enhancement plan supports vegetation management plan prescriptions and approaches to nonplay landscape, buffer, and natural cover or riparian zones.

Another consideration in implementing the Wildlife Habitat Enhancement Plan is to engage the community, such as local watershed groups and schools, in restoration activities. The following section of these *Guidelines* discusses community involvement in more detail. The golf course resides within a watershed, which is usually defined by natural hydrologic characteristics and may overlap municipal jurisdictions. A watershed is an area of land that drains into a given river, lake, or other water body.

At some scale, each watershed likely has a plan associated with it to provide direction and target resources for better management of both point- and nonpoint sources of pollution and restoration of the watershed and water quality. The local watershed and land use maps should also be included as part of your environmental stewardship program. Watershed plans include wildlife habitat enhancement in that they serve as a direction to improve water quality, reduce flood damage, and protect natural resources. Watershed plans aim to prevent existing watershed problems from worsening in the future as a result of pressures from land development. Additionally, watershed planning offers an opportunity for multiple parties to coordinate their efforts in watershed improvement. Wildlife habitat enhancement plans provide a means for the golf course to demonstrate good present and future land and environmental stewardship to the stakeholders as well as neighbors and local community organizations or other groups.

9.3 MACROINVERTEBRATES

Observing the changes in macroinvertebrate populations with time as restoration activities are implemented is one metric that can be used to measure ecosystem health and improvements. One type of study that can be performed by an individual golf course and potentially combined with community watershed stewards is macroinvertebrate observation. Macroinvertebrates provide a food source to aquatic and terrestrial organisms. They are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate). Examples of macroinvertebrates include crayfish, snails, and worms. Observing whether macroinvertebrates are present and of sufficient diversity at the golf course can be used as a good survey tool and can be as simple as comparing numbers on and off the property, and before and after course construction, renovation, and restoration work. As stated by the U.S. Environmental Protection Agency (www.epa.gov/owow/monitoring/volunteer/stream/vms40.html), aquatic macroinvertebrates are good indicators of stream quality because:

- They are affected by the physical, chemical, and biological conditions of the stream.
- They can't escape pollution and show the effects of short- and long term pollution effects.
- They may show the impacts of distribution and diversity from habitat loss or changes not detected by traditional water quality assessments.
- They are a critical part of the stream food web.
- They are relatively easy to sample and identify.
- The basic principle behind the study of macroinvertebrates is that some are more sensitive to pollution than others.

As stated in the 2002 Tualatin Basin Macroinvertebrate Assessment (ABR, Inc., 2002) (www.trwc.org), macroinvertebrate communities are strongly influenced by physical differences among habitats, both naturally occurring and human-induced. A macroinvertebrate study evaluates the sampled community expected to occur in the absence of disturbance and describes its diversity. Information to know when studying macroinvertebrates includes but is not limited to:

- The physical conditions;
- Human influence;
- Maps of riparian zone conditions if available;
- Maps of dominant stream substrate if available;
- Streamflow; and
- Water chemistry.

Macroinvertebrate studies can be incorporated into a watershed characterization plan. A 2002 guidance document from the Oregon Department of Fish and Wildlife titled "Methods for Stream Habitat Surveys" provides more information on this subject. Two examples of studies include the Tualatin Basin, Oregon, and the City of Lake Oswego, Oregon. The Tualatin Basin study examined high-gradient and low-gradient stream reaches independently and included physical habitat assessments. The study identified relationships between environmental conditions and macroinvertebrate conditions. The second study investigated physical conditions and macroinvertebrate communities in representative stream reaches as indicators of water quality and stream health throughout the City of Lake Oswego. Biological monitoring with fish and macroinvertebrate communities is widely used to determine the ecological integrity of surface waters (ABR, Inc., 2006).

9.4 POLLINATORS

As discussed in Chapter 7 and in "Making More Room" by the Xerces Society for Invertebrate Conservation (M. Shepherd, et al, 2006), pollinator conservation is another enhancement tool that is perfectly suited for golf courses. "The basic habitat needs for pollinator insects are simple to provide and can be integrated into current maintenance of

any course, from expansive rural courses to compact urban sites." Examples of pollinators include butterflies, hummingbirds, flies, and bees. "Pollinators are a fundamental component of a healthy environment and keeps plant communities healthy and able to reproduce." A variety of areas exist or have the potential to exist at golf courses such as out-of-play landscaped, buffer, and natural areas, banks surrounding stormwater basins and rain gardens, or wood snags. Both this document and the document titled "Making Room for Native Pollinators" by the United States Golf Association and the Xerces Society (M. Shepherd, 2002) are excellent references for information on pollinator basics. The contents include everything from the history of bees to guidance on creating foraging habitat.

9.5 CERTIFICATION PROGRAMS

The requirements of certification programs can be used to focus the wildlife habitat enhancement efforts and further engage the community. The Audubon International's Audubon Cooperative Sanctuary Program promotes wildlife habitat enhancement as one of its cornerstone principles. These *Guidelines* and the Audubon International's Audubon Cooperative Sanctuary Program complement each other. The preparation and implementation of a Wildlife Habitat Enhancement Plan under these *Guidelines* would generally allow golf courses to achieve basic and recurring requirements for Audubon Cooperative Sanctuary certification.

Another certification that the *Guidelines* generally allow golf courses to achieve is the basic requirements for Salmon-Safe. "In a general sense, compliance with Salmon-Safe certification standards is intended to promote landscape-level conservation and protection of biological diversity. Salmon are a key species and an indicator species within the Pacific Northwest and their conservation is tightly intertwined with the health of the larger ecosystem" (Salmon-Safe Certification Standards for Golf Courses, Draft 1.3 (2018)). Salmon-Safe addresses the overall land management and operations that directly and indirectly affect water quality and fish habitat with standards focusing on many of the key areas that these *Guidelines* also focus on:

- Water Quality;
- Water Quantity;
- In-stream Habitat; and
- Riparian Habitat.

Integrated pest management is also an important factor in the Salmon-Safe standards, which guide clients to develop an acceptable method of application through a comprehensive management program, such as under an Integrated Pest Management Plan. There are six habitat management categories listed in the Salmon-Safe standards:

- In-stream habitat protection and restoration;
- Riparian and wetland protection and restoration;
- Stormwater management;
- Water use management (irrigation activities);
- Erosion and sediment control; and
- Chemical and nutrient containment.

When protecting and/or restoring the in-stream habitat, the stream channels should be in good condition for providing salmonids habitat, should have naturally protected stream banks, a meandering

channel, and some woody structures present. Stream channels should remain or be connected to their historical floodplains, and not incised, to optimize natural hydrology and streamflow, and minimize erosion potential and related hydromodification affects upstream and downstream.

Riparian and wetland protection/restoration involves protecting areas in closest proximity to in-stream habitat, which is referred to as the riparian vegetation zones and any associated wetlands and water feature buffers. As listed in the Salmon-Safe standards, it is important to make sure the riparian areas are in good condition, functioning to maintain and restore ecosystem health, and provide stream shade, wood recruitment, leaf litter supply, stream bank stability, and cover, and filtration of sediment. Natural vegetation should dominate these areas.

9.6 REGULATORY ISSUES

Federal and local municipalities/counties may have different invasive species in their surrounding areas. It is important to follow any relevant jurisdictional guidelines or rules to control the spread of invasive species. Oregon invasive species lists and general information can be found here. Oregon noxious weed laws and general information can be found from the Oregon Weed Board here.

"Sensitive Species" are defined as having small or declining populations, are at-risk, and/or are of management concern under the Endangered Species Act, the Oregon Sensitive Species Rule (OAR 635-100-0040 & OAR 635-100-0040(2)), and the Oregon List of Threatened and Endangered Species (OAR 635-100-0125). Implementation of appropriate conservation measures to address existing or potential threats may prevent them from declining to the point of qualifying for threatened or endangered status. Specifically, species considered as special-status include those which are:

- Federal Endangered
- Federal Threatened
- Federal Proposed
- State Endangered
- State Threatened
- State Candidate
- State Species of Special Concern
- State Fully Protected

Local cities, counties, soil and water conservation districts, and community groups or other organizations may also provide information, rules, and/or guidance on managing natural, nuisance, noxious, and invasive plant and animal species.

Wildlife conservation-related regulations should be identified, understood, and provided for through the initial golf course planning, design, and construction activities, as well as such obligations during routine maintenance, golf course renovation, and restoration work.

The wildlife habitat enhancements on the golf course may be relied upon by other parties involving broader watershed management issues, such as with total maximum daily loads. It is important to understand the context that course wildlife habitat enhancement plans support the work of others and to complement those efforts to support or address healthy ecosystem functions.

CHEMICAL CONTROL PRODUCT (PESTICIDE) MANAGEMENT

10.0

Chemical control product use should be part of an overall pest management strategy that includes biological controls, cultural, mechanical, and physical methods, pest monitoring, and other applicable practices, referred to altogether as integrated pest management. When using control products on golf courses, there are many important factors that come into play. These include minimizing potential hazards to human health and the environment, optimizing playing conditions at the golf course, utilizing effective monitoring to enable selective control of pest populations, minimizing control product use through the targeted application while optimizing product efficacy, sustaining high turfgrass quality, controlling operating costs, and maintaining the health of the landscape elements such as trees, shrubs, flower beds, buffer zones, and natural areas.

Best Management Practices

- Confirm the identity of pests requiring chemical control product treatment.
- Select control products based on efficacy, target specificity, the potential effect on nontarget species, cost, site characteristics, and environmental compatibility.
- Rotate the chemical "family" of chemical control products used for a specific pest to prevent the development of product resistance.
- When possible, use chemical control products labeled by the U.S. Environmental Protection Agency as reduced-risk pesticides.

10.1 HUMAN HEALTH RISKS

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

Best Management Practices

- Select the least toxic control product with the lowest exposure potential.
- Know the emergency response procedure in case excessive exposure occurs.
- Use the proper personal protective equipment while mixing chemical control products and making applications.

10.2 ENVIRONMENTAL FATE AND TRANSPORT

Environmental characteristics of a chemical control product can often be determined by the environmental hazards statement found on 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) nontarget toxicity, and (3) endangered species protection. Stream no-spray or vegetated buffer requirements can also be found in other sections of the product label outside of the Environmental Hazards statement. These other sections of the label can be titled as "Buffers", "Endangered Species", or "Spray Drift."

Best Management Practices

- When possible, use chemical control products labeled by the U.S. Environmental Protection Agency as reduced ecological risk pesticides.
- Select products that have low runoff and leaching potential.
- Select products based on efficacy, target specificity, the potential effect on nontarget species, cost, site characteristics, and environmental compatibility.
- Select products with reduced impact on pollinators and beneficial insects.
- Select products that, when applied according to the label, have no known effect on endangered species present on the facility.
- Rotate the chemical "family" of chemical control products used for a specific pest to prevent the development of chemical control product resistance.
- Before applying a control product, evaluate the impact of site-specific characteristics (for example, proximity to surface water, water table, and wellheads; soil type; prevailing wind; etc.) and chemical control product-specific characteristics (for example, half-lives and partition coefficients)

10.3 CHEMICAL CONTROL PRODUCT TRANSPORTATION, STORAGE, AND HANDLING

Proper transportation, storage, and handling are important to avoid serious injury or death, fires, environmental contamination, cleanup costs, civil lawsuits, destruction of turfgrass, and wasted chemical control product. Storage and handling of products in their concentrated form also pose 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 control products away from sites that directly link to surface water or groundwater. Read labels for specific storage requirements.
- Store chemical control products in restricted access, lockable concrete or metal building, dedicated room or cabinet that is separate from other buildings.
- Organize the products: liquid or dry, flammable or nonflammable, fungicides/herbicides/insecticides.
- Segregate storage of incompatible products.

- Locate chemical control products storage facilities separate from other types of structures to allow fire department access.
- Storage facility floors should be impervious and sealed with 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 products.
- 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 chemical control product storage facility.
- Ensure the chemical control product storage area meets Occupational Safety and Health Administration (OSHA) requirements (i.e., dry, ventilated, temperature control, etc.).
- Personal protective equipment should be easily accessible and stored immediately outside the chemical control product storage area.
- Store liquid products below dry products.
- Do not store incompatible products above/below each other.
- Avoid placing liquids above eye level.
- Store all products; especially dry bags, up off the floor (i.e. on pallets or shelves).
- Store chemical control products in original containers with original labels.
- Label chemical waste containers (with the unusable or damaged product) as such to distinguish them from usable chemical products.
- Dispose of chemical wastes designated as hazardous waste under federal and state rules through a hazardous waste management service provider or a state-sponsored pesticide waste collection event.
- Do not transport chemical control products in the passenger section of a vehicle.
- Never leave chemical control products unattended during transport.
- Place a spill containment kit in the storage area, in the mix/load area, and on the spray rig.
- Create a map showing chemical control product storage areas.

10.4 EMERGENCY PREPAREDNESS AND SPILL RESPONSE

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, or set of standard operating procedures, which includes procedures to control, contain, collect, temporarily store, and dispose of, spilled materials.
- Prominently post "Important Telephone Numbers" including CHEMTREC (1-800-262-8200), for emergency information on hazards or actions to take in the event of a spill.
- Ensure an adequately sized spill containment kit is maintained and readily available at likely potential spill locations.
- Train staff on the proper use of spill response equipment.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.
- Host a tour for local emergency response teams (for example, firefighters, etc.) to show them the facilities and to discuss the emergency response plan. Seek advice on ways to improve the plan.
- Train staff on the procedure for containing spills and avoiding injury.
- Communicate and coordinate emergency response and spill preparedness outreach and education with neighboring property owners or local community groups or other organizations, where required, practical, and economical.
- Site land-use authorizations and permitting requirements must also be followed, including any relevant notifications.
- Large spills or uncontained spills involving hazardous materials may best be remedied by hazardous material cleanup professionals.
- Use proper personal protective equipment during spill response.
- Follow the 4 steps: control, contain, collect, and store.
- Comply with all applicable federal, State of Oregon, and local regulations on spill response training, spill reporting requirements, spill containment, and cleanup.
- Dispose of waste in accordance with regulations.
- Determine the conditions that define whether a spill must be reported (i.e., what quantity of chemical spilled requires reporting) to the applicable regulatory agencies.
- If a spill occurs, contact the Oregon Emergency Response System (OERS) at 800-452-0311. When in doubt about reportable quantities, always report.

10.5 APPLICATION

Chemical control product applications should be based on a documented action threshold exceedance and follow standardized procedures to ensure the effective, consistent, and safe use of the product.

Best Management Practices

- Follow appropriate Oregon regulations regarding the licensing of personnel who handle chemical control products.
- Read and understand the product label before use.
- Use products for labeled use only.
- Use the products that have been stored at the golf course for the greatest length of time first—the "first in—first out" principle.
- Mix chemical control products for target pests at rates specified on the label.
- Mix chemical control products in a dedicated area.
- Have a properly designed and constructed area where the operator can perform all mixing operations and spills can be collected and managed.
- Locate operations well away from groundwater wells and areas where runoff may carry spilled products into surface water bodies.

- Clean up spills immediately and report to the Oregon Emergency Response System if there's a release to the environment over reportable quantities.
- Properly rinse product containers and put rinsate into the spray tank whenever possible.
- Wear appropriate personal protective equipment during product mixing and application.
- Properly calibrate the sprayer or spreader before use.
- Apply products to target areas only. Do not apply chemical control products in buffer zones. Follow application setbacks when specified on the label.
- Observe weather conditions and forecasts and make necessary changes to avoid heavy rains, winds, or other storm event phenomena.
- Minimize chemical control product drift by applying when winds are 5 mph or less or use hooded booms.
- Select appropriate nozzles and use drift reduction technologies.
- Use curative applications only when pest action threshold levels have been reached.
- Use preventative applications only when conditions favoring outbreaks occur (e.g., summer stress favoring anthracnose, cool conditions favoring Microdochium patch (fusarium)). An action threshold should be defined on the basis of these conditions.
- Use check plots to determine product effectiveness (i.e., 2-foot x 2 foot square of plywood laid on turfgrass to block application and serve as an untreated control area.)
- Follow posting requirements according to state law.

10.6 CHEMICAL CONTROL PRODUCT RECORD KEEPING

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

Best Management Practices

- Keep and maintain records of all chemical control products used to meet legal (federal, the State of Oregon, and local) reporting requirements.
- Use records to monitor pest control efforts and to plan future management actions.
- Use electronic or hard-copy forms and software tools to properly track chemical control product inventory and use.
- Develop and implement a product drift management plan.
- Keep a backup set of records in a safe, but separate storage area.
- Follow state regulations for proper documentation and reporting procedures.
- Record target of product application.
- Record location, date, and type of product applied.
- Record weather conditions.
- Record rate of application.
- Record method of application.
- Maintain a current inventory of control products on hand.

10.7 SPRAYER CALIBRATION

Properly calibrated application equipment is paramount to mitigating environmental and human health concerns. 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. Calibrations and equipment checks should be documented.

Best Management Practices

- Personally ensure the 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. Document equipment calibrations.
- Check equipment daily when in use. Document equipment checks.
- Use recommended spray volumes for the targeted pest to maximize efficacy.
- Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration their walking speed, etc.
- Use an appropriately sized applicator for the size of the area being treated.
- Select applicator equipment sizes that optimize operating volumes and droplet size for its intended uses. Equipment too large in size requires greater volumes to prime the system. This can result in significant waste that must be properly handled.

10.8 INVENTORY

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

Best Management Practices

Maintain inventory of the products kept in the storage building.

Keep copies of the Safety Data Sheets (SDS) for the chemicals used in the operation accessible and on the premises.

- Do not keep safety data sheets in the chemical control product storage room itself.
- Utilize computer software systems to record inventory and use.
- Avoid purchasing large quantities of products that require storage for greater than six months.
- Adopt the "first in–first out" principle, using the oldest products first to ensure the product shelf life does not expire.
- Many states or counties offer "amnesty" waste disposal days to eliminate potential public health and environmental hazards from canceled, suspended, and unusable or spent chemical control products being stored.
- Ensure labels are on every package and container and remain properly affixed.
- Consult inventory when planning and before making purchases.

10.9 LEACHING POTENTIAL

Weakly sorbed chemical control products (compounds with small Koc values) are more likely to leach through the soil and reach groundwater. Conversely, strongly sorbed products(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 soil and product absorption principles so appropriate decisions can be made.
- Understand site characteristics prone to leaching losses (for example, sand-based putting greens, coarse-textured underlying soils, shallow water tables, drainage system discharge points).
- Identify label restrictions that may pertain to your facility.
- Avoid using highly water-soluble products.
- Exercise caution when using spray adjuvants that may facilitate off-target movement.

10.10 MIXING/WASHING STATION

Chemical control product 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. One of the best containment methods is the use of a properly planned, designed, and constructed chemical mixing center.

Best Management Practices

- Loading chemical control products and mixing them with water or oil diluents should be done over an impermeable surface (such as lined or sealed concrete) so spills can be collected and managed.
- Mixing station surface should provide for easy cleaning and the recovery of spilled materials.
- Pump the mixing station sump dry and clean it at the end of each day, where evident. Liquids and sediments should also be removed from the sump and the pad whenever chemical control product 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 chemical control product, strictly following label instructions.
- Absorbents such as cat litter, vermiculite, 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 waste.
- Sweep up solid materials and use as intended.

10.11 CHEMICAL CONTROL PRODUCT DISPOSAL AND CONTAINER MANAGEMENT

Wash water from chemical control product application equipment must be managed properly since it contains chemical control product residues. The containers of some commonly used products 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 hazardous waste can result in very high fines and/or criminal penalties. However, chemical control product containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and some state laws require pesticide applicators to rinse all empty chemical control product containers before taking other container disposal steps. Under the Resource Conservation and Recovery Act (RCRA), a chemical control product container is not empty until it has been properly rinsed.

Best Management Practices

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

- Rinse product containers as soon as they are empty in order to remove the most residue. Triple rinse or pressure rinse containers prior to disposal. Mix rinsate into a batch for application according to label directions.
- Consult with the local fire department for storage, control, and reporting requirements.
- Inspect rinsed containers to confirm all visible residues have been removed prior to disposal.
- If chemical control product containers are not properly rinsed they could be classified as hazardous waste.
- Under the RCRA, a container is not empty until it has been properly rinsed.
- After cleaning, puncture the product containers to prevent reuse and dispose of according to the label.
- Contact a local product distributor for container recycling instructions.
- If there is any question about the contents of a container, set it aside for proper disposal.
- Properly dispose of old or unusable chemical control products.

10.12 PERSONAL PROTECTIVE EQUIPMENT (PPE)

Exposure to chemical control products can be mitigated by practicing good work habits and adopting modern product mix/load equipment (for example, closed-loading) that reduce potential exposure. Personal protective equipment statements on pesticide labels provide the applicator with important information on protecting himself/herself.

Best Management Practices

- Provide adequate personal protective equipment for all employees who work with chemical control products (including equipment technicians who service chemical control product application equipment).
- Ensure personal protective equipment is sized appropriately for each person using it.
- Make certain personal protective equipment is appropriate for the chemicals used.
- Ensure personal protective equipment meets rigorous testing standards and is not just the least expensive.
- Store personal protective equipment where it is easily accessible but not in the chemical control product storage area.
- Forbid employees who apply chemical control products from wearing facility uniforms home where they may come into contact with children, the infirm, or the elderly.
- Provide laundering facilities or uniform service for employee uniforms.
- The federal Occupational Safety and Health Administration requires employers to fit test workers who must wear tight-fitting air-purifying respirators.
- Meet requirements for OSHA 1910.134 Respiratory Protection Program.

10.13 REGULATORY ISSUES

Pesticides contain active ingredients (the component that targets the pest) and inert ingredients such as solvents, surfactants, and carrier fluids. Both active and inert ingredients may be controlled or regulated by federal, state, and local laws because of environmental and health concerns. Specific storage and disposal guidelines/requirements for Oregon can be found here.

Federal regulations are in place for the safe use and application of pesticides. The U.S. Environmental Protection Agency's website has information on the pesticide registration process, laws, labeling, and enforcement. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) require all pesticides sold or distributed in the United States (including imported pesticides) to be registered by the U.S. Environmental

Protection Agency. The Endangered Species Act (ESA) requires federal agencies to ensure that any action they authorize, fund, or carry out, will not likely jeopardize the continued existence of any listed threatened or endangered species, or destroy or adversely modify any critical habitat for those species.

Oregon State regulations are in place for the safe use and application of pesticides. The Oregon Department of Agriculture Pesticides and Fertilizer programs are charged with enforcing state and federal regulations regarding the licensing, distribution, and use of pesticide and fertilizer products. The list of resources can be found here. There are also stewardship programs/partnerships aimed at reducing the impact of pesticide use on the surrounding environment.

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 unspecified generic or agricultural uses even though they may have the same active ingredient).
- Determine whether Worker Protection Standards related to pesticides and training apply at your facility, principally because a nursery is maintained on the property.
- Apply according to manufacturer recommendations as seen on the label.
- Assess site and weather conditions and forecast thoroughly before applying pesticides to avoid the potential for runoff, leaching, or drift.
- Follow local fire and stormwater authority rules and site-specific permitting conditions.


RESTROOM
TANK
water

MAINTENANCE OPERATIONS 11.0

The golf course maintenance facility is one of the most important components of any golf course maintenance operation. It is not only the working heart of the property, but also the place for employee training, equipment maintenance, storage and handling of chemicals, fertilizers, fuel, and many other maintenance items. The facility should be designed by an experienced designer and qualified golf course superintendent. It would be beneficial to visit other state-of-the-art facilities to gather ideas for design efficiency.

11.1 STORAGE AND HANDLING OF CHEMICALS

Proper handling and storage of turf or pest control products and petroleum-based products are important to reduce the 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 of Oregon, and local regulations for specific requirements related to the storage of chemical products. Many of the following Best Management Practices have been presented in previous sections.

Best Management Practices

- Storage buildings should have appropriate warning signs and placards.
- Follow all personal protective equipment (PPE) statements on chemical control product labels.
- Store personal protective equipment away from chemical control product 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 the requirements of the Federal Occupational Safety and Health Administration.
- Store chemical control products in a lockable concrete or metal building.
- Locate chemical control product 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 chemical control products.
- 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 the building before the entrance of staff.

- Maintain detailed records of current product inventory in the storage facility. Safety Data Sheets (SDS) for the chemicals stored on-site should be stored separately from the storage room, but readily accessible on-site.
- Do not store large quantities of chemical control products 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 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.
- Segregate storage of incompatible products.
- Store flammable chemical control products separate from those that are nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Do not store incompatible products above/below each other.
- Avoid placing liquids above eye level.
- Store all products; especially dry bags, up off the floor (i.e. on pallets or shelves).
- Avoid long-term storage. Store small quantities and order as needed.
- Maintain chemicals and products inventory in a dedicated, dry, well-ventilated, enclosed environment.
- Store fertilizer separately from solvents, fuels, pesticides, and other turfgrass products.
- Sweep up any spilled materials immediately.
- Create a map of chemical storage areas and install appropriate placards on the exterior of the storage area.
- Ensure oil containers and small fuel containers (service containers) are properly labeled and stored within the facility.

11.2 EQUIPMENT STORAGE AND MAINTENANCE

Equipment used to apply control products and fertilizers should be stored in areas protected from rainfall. Rain can wash control product and fertilizer residues from the exterior of the equipment, and runoff of these residues can contaminate soil or water. Chemical control product application equipment can be stored in the chemical mixing center, but fertilizer application equipment should be stored separately. Blow or wash loose debris off the equipment to prevent dirt from getting on the chemical mixing center pad, where it could become contaminated with control products potentially leaving the pad area.

Other equipment should be stored in a clean, safe, and protected area when not in use. Every piece of equipment should have a designated spot, delineated by yellow or white lines, with its name or a number, and should be parked in the same spot every day. This allows for immediate identification of equipment if it develops a leak (oil, hydraulics, etc.) and increases accountability for maintaining premium operating conditions. Use solvent-recycling machines or water-based cleaning machines, and nontoxic cleaners to cut down on the use of flammable and/or toxic solvents. Use a service to remove old solvents and dispose of them properly. Storing and maintaining equipment properly will extend the useful life and reduce repairs.

Best Management Practices

- Store and maintain equipment in a covered area complete with a sealed impervious surface to limit the 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 for the discharge from the local wastewater treatment plant.
- Store control product and fertilizer application equipment in areas protected from rainfall.

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 Safety Data Sheets 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 to acceptable levels.
- Placement of solvent baths should consider the potential for fire hazards, as well as occupational exposures relating to fugitive emissions. Solvent baths should not be placed near any HVAC system components, air returns, or ductwork where fugitive emissions would be problematic.
- Follow solvent-recycling machine directions provided by the manufacturer, as well as any provided by recycling servicers.
- 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 personal protective equipment when working with solvents.
- Never allow solvents or degreasers to drain onto pavement or soil, or discharge into water bodies, 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 waste service as soon as routinely practical and economical, or register to bring the waste to a local facility or event through a Conditionally Exempt Generator program if available and if qualification criteria are met.
- Blow off all equipment with compressed air to reduce damage to hydraulic seals.

11.3 WASTE HANDLING

Waste management is the collection, transport, processing, recycling, or disposal of waste materials, usually ones produced by human activity. Proper disposal of waste materials is critical for the protection of workers and golfers, as well as water and natural resources. By managing wastes, golf courses can reduce their effect on human or ecological health or local aesthetics or amenities. Managing wastes allows golf courses to reduce the effects on the environment.

This area should be located away from normal employee activity, but close enough to be reasonably functional. Proper access for waste pick-up vehicles should be incorporated in the design and location of this zone.

Best Management Practices

- State or local laws and regulations related to the disposal of hazardous waste products may vary. Be sure to familiarize yourself with all state and local laws related to the disposal/recycling of these waste materials.
- Work with local or state jurisdictions (e.g. fire department) that offer voluntary pollution/spill prevention programs to optimize the development of relevant standard operating procedures for spill monitoring and response.
- Complete waste characterizations and testing to determine if collected used solvents and degreasers, and other chemicals, products, or residues constitute or are comprised of hazardous waste.
- Prior waste characterizations and testing may be relied upon to demonstrate the generator's knowledge but should be reviewed periodically, including for any process changes that could affect the waste composition.
- Temporary waste storage must be consistent with allotted local, state, and/or federal timeframes; temporary storage is only allowed for many spent chemicals or other products and residues that constitute or are comprised of hazardous waste.
- Identify and implement waste-reduction practices.
- Look for ways to increase reuse and recycling efforts and programs.
- Purchase environmentally preferred products in bulk packaging when possible.
- Compost as much biomass as possible and reuse it on the golf course.
- Site compost areas away from surface waters or where groundwater may be impacted.
- Do not wash equipment unnecessarily. Equipment should be brushed or blown with compressed air before, or instead of, washing.
- Do not discharge wash water directly to natural surface water or groundwater.
- Wash water should be discharged into a sanitary sewer system or use a closed-loop recycling system. If this is not possible, contact the state environmental regulatory agency to determine if discharge permits are required.
- A few options and alternatives for equipment wash stations include:
  - "Dog leash" system—Wash over grass and move around to prevent discharge to groundwater or runoff to surface water.
  - Separation system—Intercept clippings and compost, return water to a bioswale that does not discharge to groundwater or runoff to surface water.
  - Onsite—Drain directly to a closed-loop recycling system (recycle systems typically require discharge to a sanitary system for maintenance purposes).

  Offsite—Drain directly to a sanitary system. Contact sewer authority to obtain authorization to discharge wash water.
- Residue from rinsing of mowing equipment that is collected at the prescreening to the wash water disposal system can be collected and composted or spread on the golf course.
- Recycle system filters and sludge should be treated and disposed of as hazardous waste unless they have been tested to determine they are not hazardous.
- Minimize the use of detergents.
- Minimize the amount of water used to clean equipment. For example, use a hose with a shutoff nozzle if washing all equipment and machinery with water.
- Do not conduct equipment wash operations on a pesticide mixing and loading pad.
- Do not wash equipment used to apply chemical control products on pads or impervious areas with oil/water separators; preferably wash at the chemical mixing center. Chemical control

product residues will contaminate the oil that is salvaged.

- Protect equipment maintenance areas from rainfall.
- 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.
- Contact the state environmental agency [Oregon: http://www.deq.state.or.us/lq/hw] to perform a nonregulatory hazardous waste audit through the agency waste reduction assistance program.
- Understand the layouts of the facility stormwater and sanitary sewer systems, and local and/or state permitting and/or other requirements for regulated discharges.
- Ensure all waste containers are sealed, secured, and properly labeled.
- Use only approved, licensed waste contractors for disposal.
- Chemical control product mixtures that cannot legally be applied to a site must be disposed of as hazardous waste.
- Used and expired lead-acid battery storage is classified as hazardous waste unless they are recycled.
- Implement a recycling program (cardboard, recyclable plastics, aluminum cans, etc.).
- Store all used, expired, and cracked batteries on an impervious surface in a nonleaking secondary container to retain acid leaks and recycle them. Store batteries inside a covered area.
- Recycle used materials such as degreasers, used oil, oil filters, antifreeze, cleaning solutions, automotive batteries, used rags, and hydraulic fluid in properly marked containers.
- Chemical control products that have been mixed for an 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.
- The Federal Insecticide, Fungicide, and Rodenticide Act(FIFRA) require chemical control product applicators to appropriately rinse all empty pesticide containers before taking other container disposal steps.
- The improper disposal of hazardous waste can result in fines and/or criminal penalties.
- Chemical control product containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste. If rinsed containers are plastic, they can be recycled through a designated regional service provider (https://acrecycle.org/)
- 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.
- Spills and leaks of hazardous chemicals or other products to the surface should be cleaned up and handled for waste characterization and testing, temporary storage, and transport to and ultimate waste disposition at an appropriate facility. Commercial waste contractors are available to perform spill response, waste characterization and testing, transportation, and disposal.
- Recycle used tires.
- Recycle or dispose of fluorescent tubes and other lights according to state requirements.
- Maintain appropriate spill response equipment.
- Train staff on the proper use of spill response equipment.
- Train staff on procedures for containing spills and avoiding injury.
- Where appropriate, file a spill response report.

- Maintain and post information for appropriate responders based on the nature of the spill.
- Determine the conditions that define whether a spill must be reported (i.e. what quantity of chemical spilled requires reporting).
- If required, report spills to the National Spill Response Center (1-800-424-8802) or to the local state regulatory agency such as the Oregon Emergency Response System (OERS) (1-800-452-0311) as required. When in doubt about quantities released to the environment, always report. If there are other public or private agencies in the area that deal with a spill response, have their number in a location visible for all staff. Be ready to answer questions such as:
  - Who spilled the material?
  - What spilled?
  - Where is the spill?
  - When did the spill occur, or best estimation of when?
  - How much spilled?
  - How concentrated is the spilled material?
  - Is anyone cleaning up the spill?
  - Are there resource damages?
  - Who is reporting the spill?
  - How can they get back to you about the spill?

11.4 EQUIPMENT WASHING

Depending on current regulations, and the size of the operation, a dedicated equipment wash-down area may be most productive and cost-effective to manage wash-down wastes. Wash water generated from equipment-washing facilities can be a source of both surface-water and groundwater pollution. Steps should be taken to reduce and prevent pollution.

Best Management Practices

- Washing areas for equipment not involved in the application of chemical control products should drain to an oil/water separator before draining to a sanitary sewer or holding tank. The other relevant acceptable wash stations waste handling options or alternatives mentioned above may also be used.
- 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.

Chemical control product equipment should not be washed off in this area; it should be washed at the chemical mixing center.

11.5 FUELING FACILITIES

Petroleum products can be harmful when introduced to the environment including surface waters. These products can float on the water surface, sink to the bottom, evaporate into the air, or remain suspended in the soil and groundwater. Petroleum products have low solubility and can be toxic to plants, animals, and people. Safe storage of fuel, including the use of aboveground tanks and contain-

ment facilities, is critical to the protection of the environment.

Best Management Practices

- Locate fueling facilities under covered areas with a concrete (not asphalt) pavement. Areas should be equipped with spill-containment and recovery facilities.
- Use of aboveground fuel tanks is preferred.
- Store bulk fuel in certified, double-walled, self-contained steel tanks.
- Keep gas cans in a separate metal cabinet from other chemical control or other plant growth-related products.
- Label fuel storage containers clearly and accurately.
- Store solvents and degreasers in lockable metal cabinets in an area away from ignition sources.
- Create a map of fuel and chemical storage areas.
- Store used fluids in separate containers appropriate for the specific fluid type.
- Maintain used fluid containers in easy access, safe area that is out of the weather.
- Store used fluid containers on a noncorrosive secondary containment deck.
- Label used fluid containers clearly with fluid contents.
- Contact local petroleum recycling company to arrange pick up of used fluid containers for disposal.
- Minimize the possibility of a discharge and the need for disposal.
- Cover fueling areas to minimize contact with stormwater.
- Direct catch basins in fueling areas to an oil/water separator or a dead-end sump that is tested and managed.
- Educate employees on the importance of handling petroleum products properly.
- Comply with regulatory requirements for aboveground and underground storage tanks.
- Refer to fire authority, environmental agency, or stormwater permits and conditions that may apply.
- A spill kit should be located in the fueling area.
- Choose fuel-efficient equipment.
- Reduce the number of two-cycle engines used.
- Develop mowing, spraying, bunker raking, and other maintenance activity routes that optimize the activity and reduce fuel use.
- Limit engine idling.
- Repair fuel, oil, and hydraulic leaks immediately, and notify relevant fire authority, environmental, or stormwater permitting agencies if a reportable quantity of spill occurs or other reporting requirements apply. For example, a transportation-related spill of greater than 100-lbs of flammable liquid, or roughly 17-gallons of gasoline must be reported.

11.6 POLLUTION PREVENTION

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 solvents can result in serious environmental and liability consequences, because of the accumulation or transformation of contaminants in soil or groundwater. Plan appropriately to minimize the possibility of an unintended discharge and the need for disposal.

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.

Best Management Practices

- Use a chemical mixing center as a place for performing all operations where chemical control products and fertilizers 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 chemical mixing center 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 chemical control product per labeled site, or it may be pumped into a rinsate storage tank for use in the next application. The Federal Insecticide, Fungicide, and Rodenticide Act [FIFRA, Section 2(ee)], allows the applicator to apply a chemical control product at less than the labeled rate.
- Discharge to a treatment system permitted under industrial wastewater rules or contact the sewer authority to receive authorization to discharge.
- 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 when possible.
- Use noncontainment wash water for irrigation.
- Do not discharge noncontaminated 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 nontoxic 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 immediately.
- Keep spill cleanup equipment available when handling chemical control products or their containers.
- 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 it is determined that contaminants in the residue do not pose risks to the environment.
- If applicable, direct runoff onto a grassed area to soak into the ground, but never allow into a surface water body or canal.
- Handle clippings and dust separately. After the residue dries on the pad, it can be collected and composted or spread on the golf course.
- Minimize the use of detergents. Use only biodegradable nonphosphate detergents.
- 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.
- 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.
- 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 liquids or waste materials with the used solvents.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them. Arrange the pick up of used oil, or deliver to a hazardous waste collection site.
- Store batteries on an impervious surface and preferably under a cover. Spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations.
- Shake or tap nonrinseable containers, such as bags or boxes, so all dust and material fall into the application equipment.
- Keep the rinsed containers in a clean area, out of the weather, for disposal or recycling.
- Store the containers in large plastic bags/tubs to protect the containers from collecting rainwater.
- Recycle rinsed containers in counties where a recycling program is available (https://acrecycle.org/), 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.
- 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.
- Compost food scraps from maintenance, clubhouse, and golfer area designated waste receptacles where practical and economical for reuse onsite, or coordinate with local solid waste programs for its inclusion in available food scrap collection and renewable energy programs.
- Irrigation and potable supply well sites shall be setback per relevant local and state regulations or otherwise evaluate for potential risks of contamination due to the proximity of facility and equipment maintenance areas.

11.7 REGULATORY CONSIDERATIONS

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.

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. Stormwater and sanitary sewer systems will likely have local or state permitting and/or other requirements that must be followed for regulated discharges. The storage and use of fuel, oil, and chemicals used for golf course equipment operation and maintenance requires compliance with a variety of state and federal regulations to protect worker and golfer health and safety, and the environment.

Local and state regulations related to worker safety are likely applicable to your operation [Oregon OSHA]. The Hazard Communication Standard (HCS) (29 CFR 1910.1200(g), revised in 2012, requires that the chemical manufacturer, distributor, or importer provide SDS for each hazardous chemical to users to communicate information on these hazards. More information on Safety Data Sheets can be found on the Hazard Communication Standard: Safety Data Sheets web page of the OSHA website. An up-to-date file should be maintained with copies of all the Safety Data Sheets reports for all chemicals used, stored on the property, and made available to employees. Copies of these files can be provided to local fire departments and hospitals in case of any emergency.

Oregon OSHA maintains jurisdiction over the rules and enforcement of the Oregon Safe Employment Act for the health and safety of agriculture workers who may be exposed to pesticides as part of their job duties.

Local and state wellhead protection regulations may apply to the locating of facility and equipment maintenance areas, as well as placement of irrigation or potable supply wells onsite. Fire control or drinking water system requirements also may apply to facility and equipment maintenance areas, depending on the course design and layout, and availability or lack of utilities. Solar power generating systems may best be suited to facility and equipment maintenance areas for practicality and given aesthetic concerns.

Best Management Practices

- Assess potential point source pollution risk for facility and equipment maintenance operations.
- Comply with fire marshal and environmental authority regulatory requirements for aboveground and underground storage tanks.
- Good planning, design, and construction, per the applicable building and industry codes, ensure the permitted facility and equipment maintenance areas utilities are available in sufficient quality and quantity, safe, and efficient.
- Evaluate job tasks periodically to ensure worker health and safety requirements are met relating to physical, chemical, or other hazards that may be present, including after job task process changes where personal protective equipment or other controls are involved.
- Ensure compliance with regulatory requirements designed to prevent point source pollution. This may include any monitoring and inspection activities or controls mandated by local environmental or stormwater authority permits and conditions.
- Manage organic and inorganic waste to minimize potential point source pollution.
- Follow local and state wellhead protection area requirements that may apply.
- Irrigation or potable supply well sites shall be setback per relevant local and state regulations or otherwise evaluate for potentially unacceptable risks of contamination due to the proximity of facility and equipment maintenance areas.
- Resource Conservation & Recovery Act (RCRA)
- Regulates transport, storage, treatment, and disposal of hazardous and solid wastes
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
  - Regulates cleanup of contamination from hazardous wastes
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
- Regulates pesticide use
- Toxic Substances Control Act (TSCA)
  - Regulates manufactured chemicals

ENERGY 12.0

According to the GCSAA Golf Course Environmental Profile, Vol. V (GCSAA, 2017), six major energy sources were identified for golf course use: electricity, gasoline, diesel, natural gas, propane, and heating oil. Also, operational uses were segmented to meet irrigation, turf maintenance, buildings, clubhouse operations, swimming pools, and various amenity needs. The overall conclusion of the study suggests that golf facility managers must take steps toward identifying options for conservation, efficiency, and cost savings.

12.1 ENERGY CONSERVATION

To address current needs and future energy reduction opportunities, golf course 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.; and
- Golf course statements—the golf course and surrounding landscapes, pump station, irrigation system, and related agronomic operations (playing surfaces, equipment, turfgrass maintenance, etc.).

Determine goals and establish an energy policy that is part of the overall environmental plan for the facility. From that policy, an energy management plan for the facility based on current energy use baselines to optimize efficiency can be developed and progress measured towards benchmarks evaluated over time.

Communicate the energy 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. Quality management elements for continual improvement (plan, do, check, and act) to reduce environmental and economic impacts should be included in the energy management plan.

The irrigation pump is usually the largest user of energy. A well-engineered pump station is critical to reducing energy consumption.

Best Management Practices

- Set a baseline year to track improvements and future reductions.
- Measure annual energy use for electricity, natural gas, gasoline, diesel, propane, and heating oil (if applicable); track the data using monthly utility statements.
- Add insulation where needed.
- Use nondemand 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, hydro, and wind energy generation when economical.
- Ensure efficient operation and maintenance of the pump station, irrigation pumps, controls, and components.
- Upgrade or install the National Electrical Manufacturers Association (NEMA) premium efficiency-rated pump motors.

- Seek output reduction by watering less area.
- Participate in turf removal programs where playability and economics are minimally affected to lower irrigation pumping costs.
- Install LED (Light Emitting Diodes) lighting and/or retrofit devices, including along course parking lot and roadway areas.
- Install motion sensors for lights where appropriate.
- Install a programmable thermostat.
- Install solar/geothermal pumps for pools and spas.
- Educate, train, and motivate employees on energy efficiency practices.

12.2 EVALUATION

Continually track and measure energy use at the facility based on energy assessment units, for example, kilowatt-hours, to facilitate comparisons in the future. Use the information collected on energy use to evaluate existing facility consumption with other local golf facilities of similar size.

Best Management Practices

- Monitor energy use: track data evaluate quantities billed.
- Install adequate meters, gauges, etc.
- Develop an equipment inventory incorporating energy use of the individual pieces of equipment 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.

12.3 EFFICIENCY

Evaluate the energy efficiency performance of the various energy-using systems at the golf course. 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 efficiency assessments of the infrastructure and operations at the facility.
- Perform appropriate audits throughout the facility depending on the operation, infrastructure, and planning stage.
- Identify efficiency and conservation elements of infrastructure/hard items and behavioral/process-oriented items.
- Replace less efficient electrical-demand maintenance facility and clubhouse equipment (e.g, HVAC units, refrigerators, monitors, ovens, wash machines and dryers, etc.) or phase-out, whenever practical and economical.
- Consider alternative equipment, products, and practices that provide increased efficiency.

12.4 DESIGN AND RENOVATION

When undertaking a renovation, incorporate an analysis of the energy assessments, audits, and data. New components should be considered with respect to initial capital investment and long-term gain realized by using more efficient systems. Future projects should be evaluated with consideration for energy conservation. According to system and compliance standards, communicate with your utility provider, the insurance company, and any state or local regulatory officials during the planning process.

Best Management Practices

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

12.5 IMPLEMENTATION PLAN

Set goals for energy efficiency of 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. The energy efficiency implementation plan can be used to support documentation for capital expenditure budgets.

Best Management Practices

- Evaluate the 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 the 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.

12.6 INFRASTRUCTURE

Ensure energy-efficient building/facility/amenities and related infrastructure by using completed efficiency evaluations to target various aspects of the infrastructure for improvement. Consider the materials used in insulation and make color selections based on the potential for better efficiency. Use energy-efficient lighting in both interior and exterior areas.

Best Management Practices

- Maximize the 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.
- Educate and motivate employees, guests, and others to save energy or increase efficiency.
- 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 the U.S. Green Building Council LEED program when constructing new structures.
- Consider the U.S. EPA EnergyStar, Portfolio Manager, and others when making purchases of equipment that have ratings.
- Consider energy management software or services to help improve efficiency.
- Consider national and local programs and programs like the U.S. EPA WaterSense program as it relates to buildings when making improvements to fixtures.
- Evaluate alternative transportation.
- Evaluate cleaning practices (dry vs. wet) for efficiency and infrastructure footprint.
- Consider local vs. distant purchases and product selection.
- 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.
- Work with energy providers and evaluate existing programs and resources.
- Consider long-term costs in addition to acquisitions.
- Schedule reviews to evaluate future technology and fuel types.
- Evaluate upgrades that may help increase energy efficiency.
- Evaluate the use of alternative energy/fuels.
- Identify future energy needs when evaluating the capacity of infrastructure.
- Prioritize energy consumption as part of the selection.
- Optimize equipment use data including hours operated and use patterns.
- Incorporate new technology and upgrades when feasible.
- Consider alternative equipment, products, and practices.

12.7 IRRIGATION

The irrigation pumping system is typically the largest user of energy at the golf course. Ensure efficient design, selection, operation, and maintenance of irrigation pumps, irrigation controls, and other irrigation components by conducting or updating energy efficiency audits. Assess the irrigation pump efficiency. Consider using alternative equipment, products, and practices to use energy efficiently and maximize the output of the pump station for the least energy expenditure.

Best Management Practices

- Audit the irrigation system often.
- Schedule and operate pumps and irrigation in an efficient manner concerning energy costs.
- Identify and implement infrastructure and behavioral changes.
- Evaluate technology and upgrades; implement when feasible.

12.8 REGULATORY CONSIDERATIONS

Energy efficiency and conservation requires behavioral changes and is important for golf courses and their shareholders. Federal, state, local regulations may be in place in your area. Energy efficiency certifications like LEED (Leadership in Energy and Environmental Design)are important for the health, safety, and sustainability of your community. Recertifications like LEED is an important step in protecting your building assets. Recertification helps you maintain and improve your buildings while keeping your sustainability investment in place. This applies to all occupied and in-use projects that have previously achieved certification under LEED—including BD+C and ID+C, regardless of their initial rating system or version.

Best Management Practices

- Stay informed of new local, state, and federal laws and regulations related to energy consumption. Oregon is implementing Cap and Trade Policies that could have significant effects on energy prices.

- Understand local and/or state land-use permitting or other requirements as may apply to energy conservation.
- Engage energy management team weekly and/or monthly to review progress.
- Engage leadership team regularly to provide updates to support investment decisions and show progress.
- Communicate with all staff regularly, including updates to employees within stakeholders' departments
- Share energy-saving and conservation highlights and achievements with members and guests.

COMMUNITY OUTREACH 13.0

One of the primary purposes of preparing these updated *Environmental Stewardship Guidelines*/BMPs is to provide a framework for communicating the environmental successes of the golf industry to the public. The community outreach section is intended to provide resources for the golf course superintendent to use to, "tell the story."

Golf courses are often significant features in local watersheds and play a leadership role in water quality. Golf courses are also often targets of citizen groups for the elimination/reduction of pesticide usage. Each community has several organizations or groups interested in improving the environment. These can include watershed councils, tribes, "Friends" groups, schools, business organizations, and activist groups. Municipalities and soil and water conservation districts often solicit ideas and opinions from citizen advisory committees and may provide a source of habitat enhancement project grant funding along with state/federal programs. Golf course superintendents can play an important role by demonstrating and communicating environmental stewardship programs and offering to be a technical resource to the community, and in the process, help shape the way golf is thought of by the community. Participating in local watershed councils, advisory committees, or other interest groups helps a superintendent "tie-in" to current activities in the environmental arena. These types of activities will also help you become certified through the Audubon International's Audubon Cooperative Sanctuary Program for Golf Courses. A few sources of information about community involvement include:

- First Green—www.thefirstgreen.com;
- Network of Oregon Watershed Councils—www.oregonwatersheds.org;
- Oregon Department of Agriculture, Soil and Water Conservation Districts www.oregon.gov/ODA/SWCD/index.shtml;
- Audubon International's Audubon Cooperative Sanctuary Program for Golf Courses—https://auduboninternational.org/wp-content/uploads/2019/03/ACSP-Golf-Fact-Sheet-2018.pdf; and
- Salmon-Safe.

13.1 WORKING WITH THE COMMUNITY

A Community Involvement Plan that identifies the groups active locally and how the golf course staff may interact should be prepared. Staff members, from maintenance technicians to club managers, can be canvassed for their interest in participating in community functions that may be beneficial to the golf course and the environment. The golf course should play an active part in the watershed planning and actions taken, including coordinated outreach and education with stakeholders, neighboring property owners, and local community groups or other organizations.

A local watershed council may be able to provide assistance with funding and volunteers for habitat enhancement or water quality improvements to a golf course. The watershed council may also be able to provide helpful suggestions and expertise on topics

such as wetland restoration, wildlife habitat, and other environmentally related topics.

Best Management Practices

- The term "Community Outreach" is used to refer to efforts to make contact and engage the community on environmental stewardship and education at the golf course. Some ideas for community outreach and education activities include:
- Install signs around the golf course that explain the naturalized areas, turfgrass selection, and habitat preservation goals on the course.
- Conduct educational tours of the environmentally preserved and/or enhanced areas on the golf course to school classes, interested golfers, homeowners, and members of the surrounding community.
- Use wildlife web cameras that can be viewed by the public.
- Host a golf and bird day with possible assistance from the Oregon Department of Fish and Wildlife (ODFW) and/or the local Audubon chapter.
- First Green has developed an educational program that encourages the use of the golf course as a laboratory for environmental education classes at local schools.
- Check the daily weather forecast or your local air quality index to find out if it is a Clean Air Action Day. If it is, reduce activities that add to air pollution. For example, limit the amount of motorized equipment use that day.
- Communicate and coordinate outreach and education with neighboring property owners and local community organizations or other groups of the values provided by wildlife habitat enhancement plans.
- Encourage volunteers to become involved with the environmental stewardship aspects of the golf course.
- Write articles for club newsletters or local publications on the progress of environmental stewardship at the golf course.
- Host a discussion forum for the community about the importance of managing an environmentally friendly golf course and progress in implementing these *Guidelines*.
- Develop a fact sheet for general distribution that describes the environmental accomplishments of the golf course.
- Provide eco-tours to public groups.
- Prepare a Corporate Social Responsibility Report.
- Provide water quality and other ecosystem health monitoring updates to stakeholders, neighboring property owners, and local community groups or other organizations.
- Develop environmental stewardship case studies for distribution via blog or community webpages, including outreach relating to demonstration sites on the course.
- Provide email, social media, newsletter updates to the players, and the public.
- Develop a chef's garden to provide herbs and produce for the kitchen.
- Post an Environmental Stewardship Case Study on the GCSAA website.

- Host a fundraising tournament to help support the local watershed council or charitable organizations working with the course.
- Find out if a voluntary, watershed-based Pesticide Stewardship Partnership is operating in the area, and reach out to the project team (Soil and Water Conservation District, watershed council, Department of Environmental Quality, and/or Oregon Department of Agriculture representatives) about possible participation.

13.2 CERTIFICATION PROGRAMS

Golf-centric environmental management programs or environmental management systems like e-Par can help golf superintendents/courses protect the environment, communicate their efforts to the public, comply with regulations, 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. Golf courses can gain valuable recognition for their environmental education and certification efforts. Certain golf tournament sponsors may only rely on host courses that have obtained a level of certification deemed by their organizations.

Golf courses that implement these *Guidelines* may be eligible for certain certification programs. For instance, designation as a Certified Audubon Cooperative Sanctuary should be achievable for golf courses that have implemented the *Guidelines*. "The Audubon Cooperative Sanctuary Program for Golf is an award-winning education and certification program that helps golf courses protect our environment and preserve the natural heritage of the game of golf. By helping people enhance the valuable natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf course operations, the program serves an important environmental role worldwide. Audubon International has developed Standard Environmental Management Practices that are generally applicable to all golf courses. These standards form the basis for ACSP for Golf certification guidelines," (Audubon International, 2020). In order to become certified, there are specific water monitoring requirements that must be followed. These include analyzing for nutrients including ammonia, and measuring pH, temperature, specific conductance, and dissolved oxygen on a quarterly basis. The water quality monitoring program suggested under these *Guidelines* is currently a semiannual program, therefore each course that is working towards Certified Audubon Cooperative Sanctuary status must include at least one year of quarterly monitoring as a part of their water quality monitoring plan.

In addition, Salmon-Safe administers a certification program. Salmon-Safe promotes ecologically sustainable practices that promote water quality and aquatic biodiversity throughout the Pacific Northwest. The Salmon-Safe standards state that certain pesticides are a serious threat to salmon and other aquatic life—chemicals can potentially kill fish, stress juveniles, alter swimming ability, interrupt behaviors, inhibit migration, and delay spawning. A list from the Salmon-Safe standards of commonly used pesticides that are considered to pose risk to salmon and aquatic life in urban streams is included in Appendix C. Certification of a golf course superintendent's effort to improve the environment in the watershed can be useful. The environmental stewardship program and subsequent certifications can be communicated to the club membership, management, and community, or used in club marketing programs or other educational outreach. However, certification comes with responsibility. A demonstrated record of proactive adaptive management (adjusting Best Management Practices and the Integrated Pest Management Plan to alleviate environmental effects of golf course management) should be maintained.

Best Management Practices

- Obtain and review materials to ascertain whether the facility should seek certification.

- Assess the cost/benefit of certification. What value does it bring?
- Work with staff to establish facility goals that lead to certification.
- Verify periodically the terms of certification, as well as any changes to the program or course.
- Establish goals to educate members about the certification program. This could include signage on the course and in the clubhouse, webpage postings, and school field trips.
- Conduct water quality monitoring to demonstrate environmental performance.

13.3 REGULATORY ISSUES

Certain boards or committees may require golf courses to monitor, protect, and report restoration and/or conservation actions being used as part of the land use approval process. Visit the Oregon Watershed Enhancement Board (OWEB) to see which laws and regulations may apply.

Community engagement is viewed through a lens of good data collection, and outreach and education with course stakeholders, neighboring property owners, and local community groups or other organizations. The conditions of golf course initial planning, design, and construction, renovations, and restoration work permitting and land use authorizations often necessitate data collection, and its outreach and education. Established golf courses tend to be good land and environmental stewards, community engagement helps mold and change the perceptions of others that may have misconceptions of the golf course data, strategic vision, or management. A good outreach and education program can help investigate challenges or claims by external parties.

APPENDIX A

Analytical Methods

Method	Method	Trade Name
Modified EPA 608/Modified EPA 8081B	bifenthrin	Allectus
	chloroneb	Terraneb
	chlorothalonil	Daconil
	chlorpyrifos	Dursban
	cyfluthrin	Baythroid
	DCPA	dacthal
	deltramethrin	
	dichlobenil	Casoron
	dithiopyr	Dimension
	endosulfan	Thiodan
	etridazole	Terrazole
	fenarimol	Rubigan
	flutolanil	Prostar
	iprodione	Chipco 26019, 26GT
	oxadiazon	Ronstar
	oxyfluorfen	Goal

Method	Method	Trade Name
	PCNB	FFII, Terrachlor
	pendimethalin	Pendulum, Prowl
	prodiamine	Barricade
	pronamide	Kerb
	propiconazole	Banner, Tilt
	tetramethrin	neo-pynamin
	trifloxystrobin	Compass
	trifluralin	Treflan
	vinclozalin	Curalan
Modified EPA 625/Modified EPA 8270D	ethofumesate	Prograss
	fluazifop-p-butyl	Fusilade II
	flutolanil	Prostar
	metalaxyl	Subdue
	metalaxyl-M	Apron-XL
	myclobutanil	Eagle
	paclobutrazol	Bonzi
	propamocarb	Banol
	triadimefon	Bayleton
Modified EPA 8321B	azoxystrobin	Heritage

Method	Method	Trade Name
	bendiocarb	Turcam
	carbaryl	Sevin
	carfentrazone-ethyl	Speedzone
	clothianadin	Arena
	fludioxonil	Medallion
	imidacloprid	Merit
	isoxaben	Gallery
	oryzalin	Surflan, Snapshot
	pyraclostrobin	Insignia
	sulfentrazone	Quicksilver
	thiamethoxam	Meridian
	triticonazole	Trinity
Modified EPA 8321A	ethephon	Proxy
	fluridone	Sonar Q
	vinclozalin	Curalan
Modified EPA 8081	tetramethrin	
	deltamethrin	
	cyfluthrin	Tempo
Modified EPA 615/EPA 8321B ACIDS	2,4-D	Trimec, Millenium, Crossbow

Method	Method	Trade Name
	clopyralid	Confront, Stinger, Millenium
	dicamba	Trimec, Banvel, Clarity, Millenium, Powerzone
	MCPA	Trimec, Powerzone
	MCPP	Trimec, Powerzone
	picloram	Tordon
	quinclorac	Drive
	triclopyr	Confront, Garlon, Crossbow
EPA 8141B	ethoprop	Mocap
	fenamiphos	Nemacur
Modified EPA 630.1	mancozeb	Fore, Dithane
	maneb	
	nabam	
	thiram	
	vapam	
	zineb	
	ziram	
Modified EPA 547	glyphosate	Roundup
Laboratory In-House Method	thiophanate-methyl	Cleary 3336
EPA 549.1	diquat	Reward

Method	Method	Trade Name
Manufacturer's Method	trinexapac-ethyl	Primo Maxx

Forms

BIRD OBSERVATION FORM

Facility Name _____

Date _____ **Time** _____

Species _____

Observer's Name _____

Phone/Email _____

Location/Hole _____

Type of Habitat the Bird was Found Occupying _____

_____

_____

_____

Describe the characteristics of the bird you found. Record relevant information such as size, color, shape/length of bill, legs, tail, voice, behavior, number of individuals, observed, sex, and how you eliminated look-alike species _____

_____

_____

_____

_____

_____

_____

Type of Plumage/Age _____

_____

Weather Conditions: Sunny _____ **Stormy** _____ **Overcast** _____

Optics used: Unaided Eye _____ **Binoculars** _____

Spotting Scope _____ **Other** _____

Number of Years Previous Experience with this Species _____

DAILY ENVIRONMENTAL ACCOMPLISHMENTS

Facility Name _____

Project/Activity/Event _____

Location _____

_____

Meeting Date _____ Time _____

Individuals Present _____

Meeting Coordinator(s) _____

Objectives of Project/Event/Activity _____

_____

_____

_____

_____

_____

Event Coordinator's Comments _____

_____

_____

_____

Individual Attendee Comments _____

_____

_____

_____

DAILY ENVIRONMENTAL ACCOMPLISHMENTS

(Continued)

Photos from Project/Event/Activity

(Place photos on this page with caption)

FERTILIZER APPLICATION RECORD

Facility Name _____

Date _____ **Time** _____

Applicator(s) Name & License _____

Area(s) To Be Treated _____ **Time Applied** _____

Square Footage/Acreage _____ **Temp & Conditions** _____

Wind Speed & Direction _____ **Precipitation** _____

Fertilizers/Amendments

Common Name _____

Analysis _____

Other _____

Rate Per 1000 ft^2 N_____P_____K_____ Other _____

Total Product Used _____

Additives & Others

Name _____

Rate _____

Total Product Used _____

Calibrations

Equipment Used _____ Nozzles _____

Total Gallons _____ Gallons Per 1000 ft^2 _____

Speed, RPM & PSI _____ Setting (Spreader _____

Disposal Of Rinsate _____ Overlap (Spreader) _____

Comments _____

_____

_____

_____

IPM SCOUTING FORM

Facility Name _____

Date _____ Time _____

Observer's Name _____

Location/Hole _____

Symptoms observed at the plant _____

_____

_____

Signs of pest observed _____

Weather Conditions: Sun _____ Rain _____ Overcast _____

Other conditional factors _____

IPM SCOUTING FORM

Facility Name _____

Date _____ Time _____

Observer's Name _____

Location/Hole _____

Symptoms observed at the plant _____

_____

_____

Signs of pest observed _____

Weather Conditions: Sun _____ Rain _____ Overcast _____

Other conditional factors _____

IRRIGATION SYSTEM TESTING AND MAINTENANCE

Monthly checklist:

- ❑ Check for leaks. Inspect water lines, sprinklers, emitters, and other components.
- ❑ Replace broken parts.
- ❑ Locate and clean and dirty sprinkler heads, drip emitters, clogged tubing, etc.
- ❑ Use water/flow meter to help reveal the presence of hidden leaks.

NOTES:

IRRIGATION SYSTEM TESTING AND MAINTENANCE

Spring checklist:

- ❑ Set controller for watering times and durations.
- ❑ Replace back-up battery in controller.
- ❑ Test manual shut-off/isolation valve.
- ❑ Check the water pressure in each irrigation zone.
- ❑ Check and clean filters.
- ❑ Check and clean screen in sprinkler heads. Adjust pattern to eliminate water waste due to overspray.
- ❑ Test sprinkler heads to make sure they are delivering consistent amounts of water over the entire area.
- ❑ Inspect all drip emitters.

NOTES:

IRRIGATION SYSTEM TESTING AND MAINTENANCE

Summer checklist:

- ❑ Adjust controller for watering times and durations during the hottest months.
- ❑ Check and clean filters.
- ❑ Inspect all drip emitters and clean if clogged.

NOTES:

IRRIGATION SYSTEM TESTING AND MAINTENANCE

Fall checklist:

- ❑ Adjust controller to shorten watering times and durations as the weather cools.
- ❑ Test manual shutoff/isolation valve.
- ❑ Check and clean filters.
- ❑ Inspect all drip emitters and clean or replace if necessary.

NOTES:

IRRIGATION SYSTEM TESTING AND MAINTENANCE

Winter checklist:

- ❑ Adjust controller to further shorten or stop watering times and durations.

NOTES:

PESTICIDE APPLICATION RECORD

Facility Name _____

Date _____ **Time** _____

Applicator(s) Name & License _____

Area(s) To Be Treated _____ **Time Applied** _____

Square Footage/Acreage _____ **Temp & Conditions** _____

Wind Speed & Direction _____ **Precipitation** _____

Pesticides
Name & EPA Number _____

Active Ingredient & Percentage _____

Rate Per 1000 ft^2 _____

Total Product Used _____

Additives & Others
Name _____

Rate _____

Total Product Used _____

Calibrations
Equipment Used _____ Nozzles _____

Total Gallons _____ Gallons Per 1000 ft^2 _____

Speed, RPM & PSI _____ Setting (Spreader) _____

Disposal of Rinsate _____ Overlap (Spreader) _____

Comments _____

_____

_____

STAFF TRAINING

Facility Name:_____

Golf Course: _____

Address: _____

_____

Meeting Date: _____ Time: _____

Number of Employees Present: _____

Training Topic: _____

Meeting Coordinator(s): _____

What Specifics were Covered? _____

_____

_____

_____

_____

_____

_____

_____

Supervisor or Meeting Coordinator's Comments _____

_____

_____

_____

Employee's Comments _____

_____

_____

_____

Meeting Attendees

Name

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Minutes taken by _____

ENVIRONMENTAL STEWARDSHIP PLAN ADDENDUM

Facility Name_____

Date _____ **Time** _____

Describe the proposed modification: _____

_____

_____

_____

_____

Describe the reason for the modification: _____

_____

_____

_____

_____

Describe the actions to be taken as part of the modification: _____

_____

_____

_____

_____

Provide an implementation schedule for modifying existing procedures/conditions or implementing new procedures/conditions: _____

_____

_____

_____

_____

TERRESTRIAL ECOLOGY SITE ASSESSMENT FORM

PART 1: BACKGROUND INFORMATION

Golf Course Name	
Address	
Total acreage/size of project area	
Watershed/Subwatershed	
Person(s) Conducting Site Visit	
Date and Time of Site Visit	

PART 2: PHYSICAL PARAMETERS

General Topography of Area	Flat Other:	Rolling	Steep	Ravine	Bluff
General Topography of Course	Flat Other:	Rolling	Steep	Ravine	Bluff
General Climate	Average Rainfall: Average High Temp:			Average Snowfall: Average Low Temp:	
Elevation (feet above sea level)	Highest:			Lowest:	

PART 3: SITE VISIT CONDITIONS

Wind	None	Light	Medium	Strong	Direction:	
Precipitation	None Other:	Mist	Lt. Rain	Med. Rain	Hard Rain	Snow
Cloud Cover	0%	33%	66%	100%		
Temperature		_____ °F.	_____ °C.			

PART 4: PROPERTY FEATURES—WATER

Water Features On Site	**Type** (e.g., pond, lake, river, stream, wetland, spring, seep)	**Number, size or extent**	**Condition** (e.g., pristine, degraded, water color, suspended solids)	**Isolated or connected to natural stream?**

PART 5: PROPERTY FEATURES—VEGETATION AND HABITAT TYPES

Percent Cover (General Estimate)		< 5%	5 – 25%	26 – 50%	51 – 75%	76 – 100%
Cover Type	Turf					
	Native Grass					
	Shrub					
	Canopy (Trees)					
	Buffer					

	Habitat Types Present On Site	Approximate Size (acres)	Condition			
Special Status Habitats and Their Condition	Any wetland type		Poor	Fair	Good	Excellent
	Upland prairie;grassland		Poor	Fair	Good	Excellent
	Interior conifer-hardwood forest		Poor	Fair	Good	Excellent
	Late successional conifer forest		Poor	Fair	Good	Excellent
	Oak woodland		Poor	Fair	Good	Excellent
	Bottomland hardwood forest		Poor	Fair	Good	Excellent
	Open water—lakes, rivers and streams		Poor	Fair	Good	Excellent
	Riparian/floodplain habitat		Poor	Fair	Good	Excellent
Other Habitat Types	Mixed deciduous/conifer forest		Poor	Fair	Good	Excellent
	Other:		Poor	Fair	Good	Excellent
			Poor	Fair	Good	Excellent
			Poor	Fair	Good	Excellent
			Poor	Fair	Good	Excellent
			Poor	Fair	Good	Excellent

Large Individual Live Trees	Species:	Height:	DBH*:	Comments

Attach Separate Sheet if Necessary
* Diameter at Breast Height

Snags and Downed Materials	**Abundance of Snags**	Absent Low Med. High	**Comments**
	Snag Size	Small dbh (< 10") Medium dbh (10" – 24") Large dbh (> 24")	
	Bark on Snag(s)?	Y N	
	Downed Wood Present?	Y N	
	Rootwads Attached to Downed Wood?	Y N	

		Present on Site (check all that are observed, and mark locations on maps and/or aerial photographs)	**Percent Covering Site**	**Present on Adjacent Areas** (check all that are observed)
Invasive Plant Species	**English Ivy**			
	Himalayan Blackberry			
	Reed Canarygrass			
	Japanese Knotweed			
	Diffuse Knapweed			
	Spotted Knapweed			
	Garlic Mustard			
	English Holly			
	Butterfly Bush			
	Morning Glory			
	English Laurel			
	Scot's Broom			
	Tree of Heaven			
	Robert's Geranium			
	Shiny Geranium			
	Giant Hogweed			
	Clematis (Traveler's Joy)			
	English Hawthorn			
	Canadian Thistle			
	Purple Loosestrife			
	False Brome			
	Daphne Laurel			
	Iris pseudocaris			
	Parrot Feather			
	Norway Maple			
	Money Plant			
	Other:			

PART 6: OTHER NATURAL FEATURES (NON-VEGETATION-BASED)

	Feature	Present on Site	Used by Wildlife Species Using Feature	Feature
KEY NON-Veg-based Features—Natural	**Beach/mudflat habitat** (seasonally-flooded shallow areas)	Y N	Y N Unknown	
	Rock outcrop	Y N	Y N Unknown	
	Butte	Y N	Y N Unknown	
	Riverine island	Y N	Y N Unknown	
	Waterfall	Y N	Y N Unknown	
	Other:	Y N	Y N Unknown	

PART 7: OTHER WILDLIFE STRUCTURES AND FEATURES—HUMAN-MADE OR PLANTED

Feature	Present on Site	Check if adjacent to, or within ¼ mile	Used by Wildlife	Species Using Feature
Bridge	Y N		Y N Unknown	
Chimney	Y N		Y N Unknown	
Channel marker	Y N		Y N Unknown	
Utility pole/tower	Y N		Y N Unknown	
Stormwater facility (e.g., ecoroof, planter, swale)	Y N		Y N Unknown	
Planted trees ⊙ **Native species** ⊙ **Non-native species** ⊙ **Large canopy** ⊙ **Small canopy**	 Y N Y N Y N Y N		 Y N Unknown Y N Unknown Y N Unknown Y N Unknown	
Semi-natural or cultivated landscapes (e.g., tree stands, vegetated areas or corridors, water features)	Y N		Y N Unknown	
Nest box, platform, bat boxes	Y N		Y N Unknown	
Wildlife crossing/corridor (e.g., between golf course and off site property, between holes, unused natural areas)	Y N		Y N Unknown	
Other:	Y N		Y N Unknown	

PART 8: WILDLIFE SPECIES AND ASSEMBLAGES

Wildlife Species	Species	Observed or Known to be Present on Site	Vegetation or features they are using	Other Evidence	Potentially Present on Site?	Known to be Adjacent to Site	Special Status or Focal Species (check all that apply)
	Invertebrates						
	Amphibians						
	Reptiles						
	Birds						
	Mammals						

Species Groups Observed or Known to be Present	Species Group	Species Group Observed	Species Group Known To Use Site	What Are they Using?
	Migratory waterfowl	Y N	Y N Unknown	
	Shorebirds	Y N	Y N Unknown	
	Neotropical migratory songbirds (e.g. Barn Swallow, Ruby Throated Hummingbird)	Y N	Y N Unknown	
	Cavity-nesting birds (e.g., woodpeckers, owls)	Y N	Y N Unknown	
	Colonial-nesting birds (e.g., great blue heron)	Y N	Y N Unknown	
	"Iconic" species (species of cultural interest; e.g., great blue heron, Vaux's swift, osprey)	Y N	Y N Unknown	
	Other (specify):	Y N	Y N Unknown	
	Other (specify):	Y N	Y N Unknown	
	Other (specify):	Y N	Y N Unknown	

Species of Management Concern (check all that apply)						
	Bullfrog		**House sparrow**		**Black bear**	
	Snapping turtle		**Virginia opossum**		**Common raccoon**	
	Red-eared slider		**Eastern cottontail**		**Striped skunk**	
	Canada goose		**Eastern fox squirrel**		**Western spotted skunk**	
	Domestic goose species		**Eastern gray squirrel**		**Cougar**	
	Mute swan		**American beaver**		**Domestic cat (feral)**	
	Domestic duck species		**Black rat**		**Roosevelt elk**	
	Rock pigeon		**Norway rat**		**Black-tailed deer**	
	European starling		**Nutria**		**Other:**	
	Brown-headed cowbird		**Coyote**		**Other:**	

PART 9: HUMAN DISTURBANCE

	Description, including Intensity (i.e., High, Medium, Low)	**Impacts on Wildlife and/or Wildlife Habitat**
Physical Disturbance (e.g., parking lots, development)		
Human Disturbance on Site (e.g., greens, tees, fairways, nonnatural areas)		
Barriers to Migration or Movement (e.g., fences, buildings, roads, significant vegetation gaps)		
Barriers, or Other Things Preventing or Inhibiting Safe Access to, Water or Other Important Habitat Features (e.g., paved pathways)		
Disturbance from Domestic Animals (e.g., dogs off leash)		
Proximity to Residential or Other Developed Areas (e.g., distances in all directions)		
Type and Intensity of Nearby Developments/Land Uses		
Trails (e.g., formal, informal, trails in floodplains)		
Other Management Issues (e.g., erosion, bridges, events, concerts)		

PART 10: CONSIDERATIONS FOR WILDLIFE

Functional Category		Current Conditions	Potential for providing or establishing (if conditions are poor of nonexistent)
Food Availability (A)	**1 Variety**—Diversity of food sources (e.g., native trees and shrubs), (as opposed to non-native species or maintained turf)	Excellent Good Poor Non-existent	High Medium Low None
	2 Quantity and Seasonality—Abundance of food sources (native trees, shrubs, wetlands) at the desirable season	Excellent Good Poor Non-existent	High Medium Low None
	3 Proximity to Cover—Proximity of cover to food sources identified above	Excellent Good Poor Non-existent	High Medium Low None
Cover (B)	**1 Structural Diversity**—Structural elements such as snags, live trees, downed trees of various sizes and types	Excellent Good Poor Non-existent	High Medium Low None
	2 Variety of cover—Diversity of cover (e.g., trees, shrubs)	Excellent Good Poor Non-existent	High Medium Low None
	3 Nesting—Presence of nesting habitat for desirable species	Excellent Good Poor Non-existent	High Medium Low None
	4 Escape—Quantity of avenues of escape including lack of structures (e.g., fences) that might prevent escape or movement	Excellent Good Poor Non-existent	High Medium Low None
	5 Seasonality—Availability of cover throughout the year	Excellent Good Poor Non-existent	High Medium Low None
	6 Roosting—Presence of roost sites for desirable species	Excellent Good Poor Non-existent	High Medium Low None
	7 Presence of large trees	Excellent Good Poor Non-existent	High Medium Low None
Water (C)	**1 Safe access to clean water**—Lack of barriers (e.g., fences)	Excellent Good Poor Non-existent	High Medium Low None
	2 Good water quality on site—Presence of streams, wetlands, ponds, or other water bodies	Excellent Good Poor Non-existent	High Medium Low None
Disturbance (D)	**1 Lack of habitat modification**—Minimal development, structures and other habitat modification	Excellent Good Poor Non-existent	High Medium Low None
	2 Lack of direct disturbance—Lack of paved trails, road noise	Excellent Good Poor Non-existent	High Medium Low None
Habitat Features (E)	**1 Downed wood, snags and old stumps**	Excellent Good Poor Non-existent	High Medium Low None
	2 Low percentage of nonnative plants	Excellent Good Poor Non-existent	High Medium Low None
	3 Mix of habitats	Excellent Good Poor Non-existent	High Medium Low None
	4 Other	Excellent Good Poor Non-existent	High Medium Low None

PART 11: RESTORATION AND ENHANCEMENT EFFORTS AND OPPORTUNITIES

Possible Future Restoration or Enhancement Efforts	Possible Actions	Check all that apply, and note location on maps and/or aerial photographs	Function(s) Addressed (refer to categories from Part 10—e.g., A1, B2)
	Remove non-native plants/trees or natives suppressing other sensitive species		
	Remove native competing trees (e.g., firs encroaching on oaks)		
	Diversify tree/shrub/plant species and age class		
	Upland (non-streambank) native species plantings		
	Streambank native species plantings		
	Create snags		
	Increase amount of downed wood/large woody debris		
	Create brush piles		
	Conduct controlled burn		
	Slope stabilization		
	Trash or other cleanup		
	Remove fill from wetland		
	Land acquisition or easement		
	Daylight stream		
	Re-establish hydrologic conditions (e.g., flow, stream connectivity)		
	Culvert upgrade or conversion to bridge		
	Remove barriers or human site constraints (e.g., fences)		
	Establish wildlife corridor (e.g., vegetated area between habitat patches)		
	Establish wildlife crossing (e.g., between holes)		
	Reduce/remove human disturbance in natural areas		
	Erect nest box, platform, bat box or other structure		
	Maintain former restoration efforts (e.g., remove rodent barriers that are girdling trees)		
	Protect mature trees from beaver damage		
	Modify stormwater project (e.g., ecoroof, planter, swale) **to benefit wildlife**		
	Plant trees useful to wildlife		
	Other:		

PART 12: OPPORTUNITIES TO CONNECT PEOPLE WITH NATURE

Describe current or past restoration and/or enhancement efforts and apparent success or failure	

Opportunities	Location (note on maps)	Comments
Interpretive signs		
Viewing blind		
Trail		
On-site education		
Other:		

WATER SAMPLE LOG

Facility Name	
Date	
Sampled by	Locator ID
Time Sample Collected	Sample ID
Static Water Level	Time
Amount Purged	Weather
Sample Collection Method	
Discharge rate during sampling	
Color	Odor
Temperature	pH
ORP	Dissolved Oxygen
Specific Conductance	Other
Analyses Requested	
Comments	

WILDLIFE OBSERVATION FORM

Facility Name _____

Species _____

Date _____ Time _____

Observer's Name _____

Location/Hole _____

Habitat Type _____

Behavior _____

Total Number of Species _____

Number of: Males _____ Females _____ Unknown _____

Adults _____ Sub-adults _____ Juveniles (young of year) _____ Unknown _____

Observation Type: Sight _____ Track _____ Other _____

Confidence in ID: Definitely _____ Probably _____ Not Sure _____

Comments _____

_____

WILDLIFE OBSERVATION FORM

Facility Name _____

Species _____

Date _____ Time _____

Observer's Name _____

Location/Hole _____

Habitat Type _____

Behavior _____

Total Number of Species _____

Number of: Males _____ Females _____ Unknown _____

Adults _____ Sub-adults _____ Juveniles (young of year) _____ Unknown _____

Observation Type: Sight _____ Track _____ Other _____

Confidence in ID: Definitely _____ Probably _____ Not Sure _____

Comments _____

_____

APPENDIX C

List Of Chemicals Not To Use Under Salmon Safe

Commonly Used Pesticides That Pose High Risk To Salmon, Other Fish, And Aquatic Life In Urban Stream		
1,3-dichloropropene	2,4-D	Abamectin
Acephate	Altacor	Atrazine
Bensulide	Bentazon	Bifenazate
Bifenthrin	Bromoxynil	Carbaryl
Carbofuran	Carfentrazone-ethyl	Chlorothalonil
Chlorpyrifos	Copper Sulfate[1]	Cyhalothrin
Cypermethrin	Diazinon	Dicamba
Dichlobenil	Diclofop-methyl	Diflubenzuron
Dimethoate	Disulfoton	Diuron
Esfenvalerate	Ethoprop	Extoxazole Technical
Fenamiphos	Fenpyroximate	Fenbutatin-Oxide
Folpet	Imidacloprid	Iprodione
Linuron	Malathion	Mancozeb
Maneb	Metolachlor	Metribuzin
Naled	Norflurazon	Oryzalin
Oxyfluorfen	Paraquat Dichloride	Pendimethalin
Permethrin	Phosmet	

Commonly Used Pesticides That Pose High Risk To Salmon, Other Fish, And Aquatic Life In Urban Stream		
Prometryn	Propargite	Propiconazole
Rimon	Quintozene	Rimon
Simazine	Spinosyn	Triclopyr
Trifluralin	Tebuthiuron	Thiram

[1]Salmon-Safe restrictions apply to any copper-containing pesticide including copper hydroxide, copper ammonium hydroxide, copper carbonate, and copper oxide, and others.

Chlorpyrifos is no longer labeled for use in Oregon.
This list is based on EPA hazard levels for fish and fish habitat. It is revised as pesticide registrations are updated and as more environmental data becomes available.

https://extension.oregonstate.edu/sites/default/files/documents/1/salmonsafe-residential.pdf

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