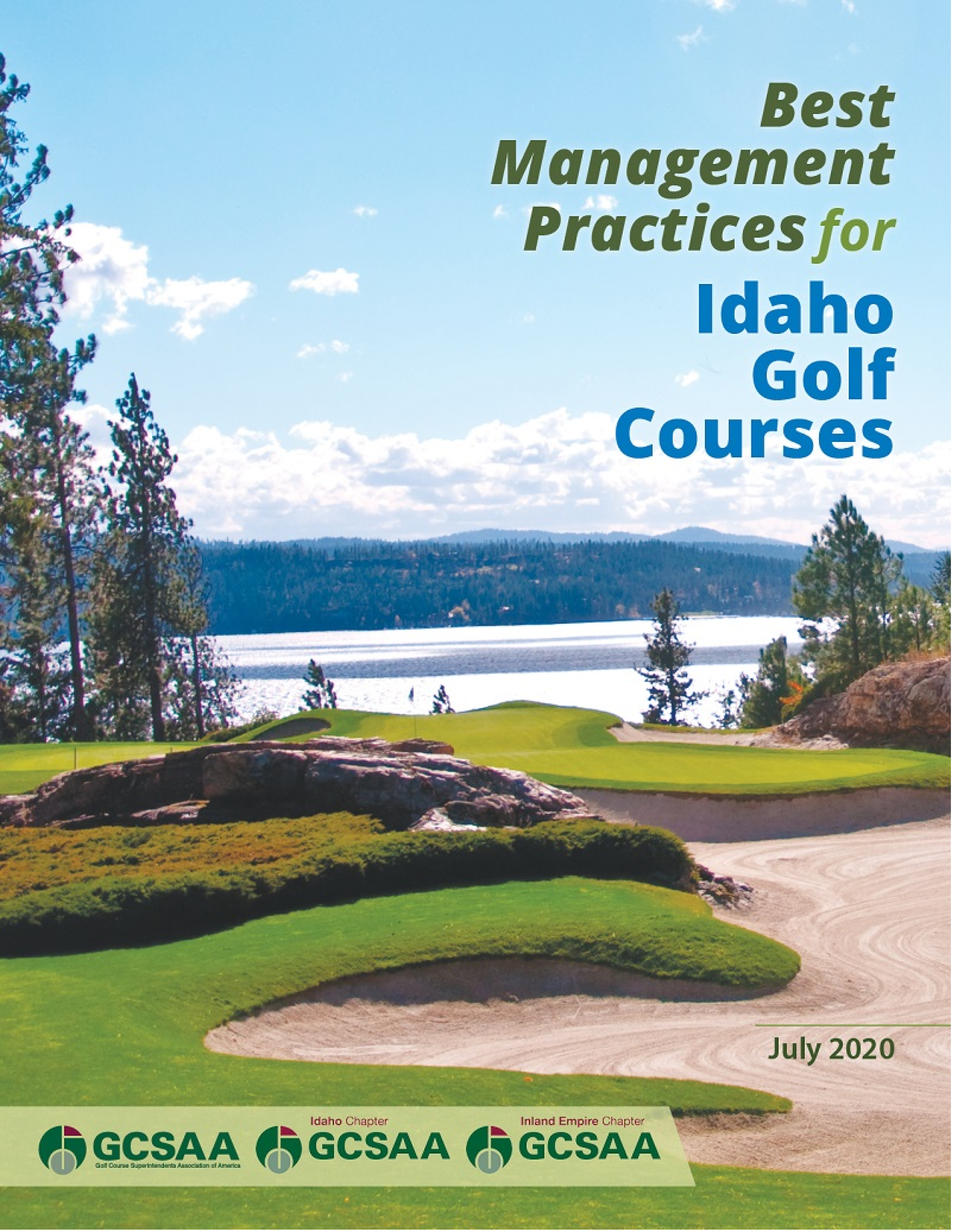

Best Management Practices for Idaho Golf Courses

July 2020

GCSAA
Golf Course Superintendents Association of America

Idaho Chapter GCSAA

Inland Empire Chapter GCSAA

BMP Best Management Practices

Best Management Practices Planning Guide & Template

GCSAA USGA

In partnership with the PGA TOUR

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EIFG *Funded through the Environmental Institute for Golf*

Table of Contents

Acknowledgement

BMP

GCSAA USGA.

Who We Are/ Acknowledgments

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.

Acknowledgments

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 on Florida Golf Courses

Additional Acknowledgement

The development of the Best Management Practices for Idaho Golf Courses was made possible by the Northwest Turfgrass Association and superintendents in the state of Idaho. Representatives from each organization provided their time and expertise to develop and review drafts of best management practices specifically for the state of Idaho designed to protect the state's natural resources.

We would also like to thank the external reviewers of the draft final version of this document, including Utah State University, University of Idaho, Idaho Department of Environmental Quality, Idaho State Department of Agriculture, and Idaho Department of Water Rights. The time and effort taken by individuals and agency representatives strengthened our document and ensured its accuracy.

Funding and support for this project was provided by the Idaho Golf Course Superintendents Association, Inland Empire Golf Course Superintendents Association, Northwest Turfgrass Association, GCSAA, EIFG, and USGA. The GCSAA also provided a Best Management Practices template that served as source material for this project.

The Idaho BMP committee would also like to acknowledge the following associations whose continuing support is vital for the ultimate success of this project: the Idaho Golf Association, Rocky Mountain Golf Association, Inland Empire PGA, and Washington Golf Association.

Idaho Chapter GCSAA

Inland Empire Chapter GCSAA

BMP Index

Introduction

Preface

Idaho's golf course superintendents are dedicated to protecting the state's natural resources. As a demonstration of this commitment, superintendents have partnered with the Idaho Golf Course Superintendents Association and Inland Empire Golf Course Superintendents Association to develop and document best management practices (BMPs) for golf course management. These research-based, voluntary guidelines have been developed specifically for Idaho's golf courses. These guidelines not only protect natural resources, they also afford the opportunity for superintendents to be recognized as environmental stewards by club members, the community at large, and state officials.

Idaho has more than 95,000 miles of rivers and streams and 100 lakes and reservoirs, making water one of the state's most important resources. Three of Idaho's aquifers – the Eastern Snake River Plain Aquifer, Spokane Valley-Rathdrum Prairie Aquifer, and Lewiston Basin Aquifer – are classified as sole source aquifers, making water quality protection especially important to protect drinking water resources.

Throughout this document, golf course superintendents will find recommendations that can help protect and preserve the state's water resources. In the urban areas of the state, golf courses can help mitigate the impacts of pollutants in stormwater, allowing water to infiltrate into the ground naturally instead of flowing into storm sewers or streams and rivers. For golf courses in the drier areas of Idaho that are more prone to drought, superintendents can use these recommendations to use less water while maintaining acceptable qualities of turfgrass. Golf courses provide other environmental benefits as well, such as conserving native grass areas and creating habitat for wildlife.

Best Management Practices

BMPs are methods or techniques found to be the most effective and practical means of achieving an objective, such as preventing water quality impacts or reducing pesticide usage. Because of the efforts aimed at protecting surface and groundwater quality, the majority of BMPs in this document relate to water.

Many BMPs protect water quality by reducing nonpoint source pollution (such as nutrients and pesticides in stormwater runoff), stormwater volume, and peak flow. Through retention, infiltration, filtering, and biological and chemical actions, any negative effects of golf courses on surface and groundwater resources can be prevented or minimized. In fact, several studies have shown that implementing BMPs can improve water quality as it traverses golf course properties. Many BMPs also can be used to conserve water and to prepare for water use restrictions that may be imposed in times of extended drought.

Pollution Prevention

Best management practices reduce the potential for sedimentation, runoff, leaching, and drift – the mechanisms that can transport contaminants and impact water quality. For example, bare ground is much more likely to erode than turfgrass. Therefore, following grow-in BMPs during course construction or renovation to quickly establish dense turfgrass ground cover helps minimize erosion potential. Maintaining vegetated areas, such as filter strips and buffers, to slow down stormwater or excess irrigation, allows infiltration and uptake and is another key BMP. Pesticide BMPs help superintendents follow state and federal regulations related to the storage, handling, transport, and use of pesticides, preventing point source pollution and minimizing the potential for nonpoint source pollution from these chemicals.

Understanding site characteristics is another key to preventing pollution. For example, steep slopes are more prone to runoff, while areas that have a shallow water table are more prone to leaching.

Water Conservation

Water is a fundamental element for physiological processes in turfgrass such as photosynthesis, transpiration, and cooling, as well as for the diffusion and transport of nutrients. Turfgrass quality and performance depend on an adequate supply of water through either precipitation or supplemental irrigation. Too little water induces drought stress and weakens plants, while too much causes anaerobic conditions that stunt plant growth and promote disease. Excessive water can also lead to runoff or leaching of nutrients and pesticides into groundwater and surface water. Proper irrigation scheduling, careful selection of turfgrass species, and incorporation of cultural practices that increase the water holding capacity of soil are addressed through these BMPs, as well as considerations in the design, construction, and maintenance of irrigation systems.

Pollinators

Protecting bees and other pollinators is important to the sustainability of agriculture. Minimizing the impact of pesticides on bees, other pollinators, and beneficial arthropods is addressed in this document in two ways: providing specific guidance for pesticide applicators and promoting the use of integrated pest management (IPM) methods to reduce pesticide usage and minimize the potential of exposure. Superintendents can also directly support healthy pollinator populations by providing and enhancing habitat for pollinator species and by supplying food sources and nesting sites and materials.

Individual Facility BMPs

To adapt BMPs to an individual facility, superintendents should assess their individual site, consider their available resources (such as budget), and understand that implementing BMPs will be an ongoing process that can be undertaken over time.

Besides contributing to natural resources stewardship, incentives for golf courses in Idaho to create a facility BMP plan and to implement BMPs include the following:

- Cost savings associated with applying less fertilizer and pesticides.
- Potential for more efficiently allocating resources by identifying management zones.
- Cost savings associated with more efficient irrigation and other water conservation efforts by reducing electricity needs and equipment usage.
- Recognition by club members and the community at large of environmental stewardship.

Because of limitations, such as budget, staff, clientele expectations, and management decisions, not all golf courses can achieve all of the best practices. Turfgrass managers should understand that implementing BMPs will be a process that can be undertaken over time. In addition, multiple approaches can be adopted to achieve the goals of the BMPs, such as reducing fertilizer usage while maintaining turfgrass health. For example, the following describes an incremental approach to developing a nutrient management program:

- A good practice is to assess the chemical and physical analysis of regularly fertilized soils using a Minimum Levels for Sustainable Nutrition (MLSN) Guideline interpretation. MLSN guidelines use overall turfgrass quality and growth to develop a nutrient management program. Following these guidelines means that supplemental nutrient applications are applied only to targeted areas of established need.

- A better practice is to use the Web Soil Survey as a guide to classify and sample all soils on the property using the MLSN interpretation and performance variables (quality and growth). Supplemental applications of nutrients can be made based on large-scale mapping in targeted areas of well-established needs.

- The best practice is to implement a Web Soil Survey-driven sampling program and use appropriate interpretation and performance variables as layers in a GIS database built from the sampling locations. This GIS database of soil properties for GPS-based variable rate application equipment can be used for precise supplemental nutrient applications to targeted areas of well-established need.

In addition, planning for improvements over time and making even small changes that meet the goals of BMPs can be achieved. For example, while a sophisticated washwater recycling system may be too expensive for many facilities, blowing clippings off mowers before washing markedly reduces the amount of nitrogen and phosphorus in clippings that end up in washwater.

Conclusion

This document was developed using the latest science-based information and sources. This resource is intended to be a living document. The Idaho BMP steering committee intends to review this information periodically. Therefore, the latest version of this document will be posted available through Idaho Golf Course Superintendent associations. At the time of publication, the information was the most recent available. Some sources are updated regularly, and the reader should try to identify the latest version. In addition, regulations may change, and the reader should identify any changes since the publication date.

1 Planning, Design, and Construction

Preface

Building a new golf course or renovating an existing one requires careful protection of natural resources during all phases of planning, design, and construction. Implementing BMPs should result in an environmentally sustainable golf course that operates efficiently and cost effectively.

1.1 Regulatory Considerations

Local, state, and national regulations impact planning, design, and construction activities on Idaho’s golf courses. These laws protect and conserve the environment both during and after the construction process. Before beginning any golf course construction or renovation, consultation with the appropriate regulatory agencies is recommended. Communication between developers, designers, owners, the public, and regulatory agencies should occur early and often. In addition, if new wells must be installed, experts should be consulted about proper siting in the design plan and about all setback and other regulatory requirements.

1.1.1 Stormwater Permits

Stormwater runoff from construction activities can have a significant impact on water quality, as it carries sediment and other pollutants exposed at construction sites to surface waters. The National Pollutant Discharge Elimination System (NPDES) Stormwater Program requires operators of construction sites that disturb one acre or more to obtain authorization to discharge stormwater under an NPDES construction stormwater permit issued by the United States Environmental Protection Agency (USEPA). This permit outlines a set of provisions construction operators must follow to comply with NPDES stormwater regulations.

In order to be covered under the construction general permit, a site-specific stormwater pollution prevention plan must be developed. The construction manager must document the erosion, sediment, and pollution controls to be used, inspect the controls periodically, and maintain the controls throughout the life of the project. More information on developing the plan can be found on the USEPA’s Developing a Stormwater Pollution Prevention Plan (SWPPP) web page. The USEPA has authorized the transfer of permitting authority to the Idaho Pollution Discharge Elimination System (IPDES) Program and the phased transfer of permits will lead to IPDES issuance of all discharge permits by July 1, 2021.

1.1.2 Wetlands

Activities that impact wetlands are regulated under Sections 404 and 401 of the federal Clean Water Act (CWA). The U.S. Army Corps of Engineers regulates dredging and filling of waters in the United States under Section 404 of the CWA. The role of the Idaho Department of Environmental Quality (DEQ) in the Section 404 permitting process entails issuing §401 certifications that the actions authorized by the permits do not violate Idaho water quality standards. DEQ coordinates closely with the Corps during the certification process of Section 404 permits. Consultation with DEQ during the design phase of any construction activities expected to impact wetlands will assist in understanding the permitting process.

1.1.3 Water Usage

The Idaho Department of Water Resources (IDWR) is responsible for regulating water rights in Idaho. New water rights require submission of a permit application to IDWR.

1.1.4 Listed Species

The Idaho Governor's Office of Species Conservation (OSC) plans, coordinates, and implements the state's actions to preserve, protect, and restore species in Idaho listed as candidate, threatened, or endangered under the federal Endangered Species Act. OSC publishes the listed species found in Idaho.

Figure 1. The bald eagle is one protected species that can be found in Idaho.

1.1.5 Invasive Species

The Idaho Invasive Species Act of 2008 prohibits the introduction or transportation of listed invasive species without a permit. While the incidental presence of invasive species at a facility does not require any action upon the part of the facility, it will be helpful to know the listed recognized plant, animal, and invertebrate species in the state (as published in the Rules Governing Invasive Species and Noxious Weeds) and endeavor to prevent their spread.

1.1.6 Noxious Weeds

Idaho has 67 weed species and four genera designated noxious by state law – 51 of these species are terrestrial and 16 species are aquatic. Property owners are required by state statute to control noxious weeds on their property.

1.2 Overview

Proper planning is the first step to any construction or renovation project, minimizing expenses from unforeseen events and maximizing long-term success. Good planning also incorporates conservation of natural resources and economic sustainability while meeting the stakeholder needs. Once a course is designed, construction must be carried out in a way that minimizes environmental impacts. Maintaining a construction progress report, as well as following regulations and coordinating with regulatory agencies as required, helps to ensure compliance. Table 1 summarizes the steps and best practices for each phase of the project.

Table 1. Best practices for golf course planning, design, and construction.

Planning	
Step	**Description**
Assemble Team	The team should include, but not be limited to, a golf course architect, golf course superintendent, clubhouse architect, irrigation engineer, environmental engineer, energy analyst, economic consultant, civil engineer, soil scientist, golf course builder, and a legal team.
Define Objectives	Identify realistic goals, formulate a timeline, etc.
Conduct a Feasibility Study	Evaluate finances, environmental issues, water availability and sources, and energy, materials, and labor needs. Identify applicable government regulations.
Select Site	Site should meet project goals and expectations. Identify all strengths and weakness of each potential site. During site selection, any site constraints, such as the presence of listed species or valuable habitat, should be identified.
Design	
Retain a Project Manager/Superintendent	This person is responsible for integrating sustainable practices in the development, maintenance, and operation of the course.
Retain a Golf Course Architect	An experienced golf course architect is the person primarily responsible for design of the course including preservation of existing native vegetation, design of course features, and selection of appropriate turfgrass species/varieties in conjunction with the superintendent.
	Existing native landscapes should remain intact as much as possible. Should consider adding supplemental native vegetation to enhance existing vegetation alongside lengthy fairways and out-of-play areas. Nuisance, invasive, and exotic plants should be removed and replaced with native species adapted to the area.
	Greens: Should have plenty of sunlight and be well drained. Greens should be big enough to have several hole locations that can handle expected traffic. Native push up green design can provide an adequate playing surface provided there is adequate surface drainage, sun and air movement. United States Golf Association (USGA) putting greens

	should follow specifications in published in *A Guide to Constructing The USGA Putting Green*.
	Grass Selection: Species should be selected based on climate, including winter hardiness, environmental, and site conditions and species adaptability to those conditions, including disease resistance, drought tolerance, spring greenup, and traffic tolerance.
	Bunkers: The number and size of bunkers depends on considerations, such as the resources available for daily maintenance. For each bunker consider: • The need for drainage. • Entry/exit points and how these will affect wear-and-tear patterns. • The proper color, size, and shape of bunker sands to meet needs. New bunker construction techniques can also be researched to see if they satisfy stakeholders' needs.
Design Irrigation System	Hire a professional irrigation consultant/designer (preferably a member of the American Society of Irrigation Consultants), if possible, to design the irrigation system. Keep in mind the different water needs of greens, tees, fairways, roughs, and native areas. Consider the topography, prevalent wind speeds, and wind direction when spacing the heads. Choose the most efficient type of irrigation system considering available resources. The "Irrigation" chapter of this document provides detailed information on irrigation-related BMPs.
Construction	
Select Qualified Contractors	Use only qualified contractors who are experienced in the special requirements of golf course construction. Members of the Golf Course Builders Association of America make great candidates.
Safeguard Environment	Follow all design phase plans and environmental laws. Soil stabilization techniques should be rigorously employed to maximize sediment control and minimize soil erosion. Temporary construction compounds and pathways should be built in a manner that reduces environmental impacts.
Install Irrigation System	Installation should consider the need to move equipment and bury pipe while maintaining the original soil surface grade to minimize the potential for erosion.
Establish Turfgrass	Turfgrass establishment methods and timing should allow for the most efficient progress of work, while optimizing resources and preventing erosion from bare soils before grass is established.

1.3 Wetlands and Floodplains

1.3.1 Wetlands and Riparian Areas

Wetlands are transitional areas between aquatic and dry upland habitats. They are flooded or saturated by surface or groundwater at a frequency and duration long enough during the growing season to support plants and other life adapted to saturated soils where oxygen is limited and unique chemical properties form. Riparian habitats include the dense and diverse vegetation growing along streams, rivers, springs, wetlands, ponds, and lakes. They often support plants adapted to highly fluctuating water availability (from spring flooding to summer drought).

Wetland and riparian habitats are essential for many of Idaho's fish, wildlife, invertebrate, and plant species. Nearly 50% of bird species rely on wetland and riparian habitats. These habitats support numerous game and fish species (from native trout and waterfowl to moose and beaver), as well up to 50% of Idaho's wildlife Species of Greatest Conservation Need and rare plants.

Conserving the state's wetlands and riparian areas protects water quality and biodiversity, while reducing the potential for flooding and soil erosion. To protect these natural resources, wetlands should be identified in the field by qualified wetland specialists during the design phase and before the permitting process is initiated. Course design should minimize any impact to wetlands and streams tied to activities such as filling, dredging, flooding, crossings, or converting areas from one habitat type to another. In addition, natural buffers should be retained around wetlands (as with other waterbodies) to protect water quality and provide habitat.

Idaho Department of Fish and Game publishes an interactive watershed mapping tool, Wetland Data Viewer, that includes various data sets related to wetlands and wetland management in the state of Idaho and can also be used to identify potential wetland mitigation/restoration sites based on characteristics of disturbed wetlands.

Wetland Restoration

In some instances, wetlands and streams can be improved or restored during golf course construction. For example, a highly degraded stream or wetland can sometimes be reshaped, rehabilitated, or replaced entirely to meet project goals and improve ecological function. Qualified environmental consultants can evaluate the overall benefit of stream enhancement or restoration and assist with permitting issues, which may include a federal 404 permit and/or state 401 certification.

1.3.2 Floodplains

Golf course development is often compatible with floodplains, particularly when compared with other uses such as residential or commercial development. Minimizing encroachment into floodplains to the extent possible is prudent.

Any substantial disturbance to a floodplain, including clearing and grading, generally requires an engineering analysis to demonstrate minimal impact on the base flood elevation in accordance with local ordinances. Depending on the complexity of the encroachment, this analysis may be as simple as a comparison of cut and fill quantities within the floodplain or as complex as a detailed floodplain model of the entire watershed. A complex analysis may require a Federal Emergency Management Agency (FEMA) review along with potential revision to the floodplain mapping.

Key course components (such as greens and tees) should be designed above the 100-year flood elevation whenever possible to avoid loss of golf play due to periodic flooding. Any effects on the floodplain and floodway should be considered, and the required offsetting adjustments should be made in grades or vegetative treatment.

1.4 Drainage

Adequate drainage is necessary for healthy turfgrass. When golf courses are designed and built, their drainage capability concept is guided by an average rainfall event of a given frequency. For example, a golf course drainage system is typically designed to retain a two- or five-year rain event, reasonably draining the precipitation in a matter of hours, with excess water that has not infiltrated into the ground retained temporarily until it leaves the property. In some instances, golf courses are mandated to handle a 20-, 50-, or 100-year rain event, which means the golf course must retain more water, potentially for a longer period of time. This ability to retain large amounts of water requires accurate engineering and extensive construction to prevent physical or financial damage to the facility.

Many BMPs prolong the retention process as long as practical, retaining as much of the stormwater in surface or underground storage as is reasonable, and may even improve the quality of water leaving the property. A high-quality BMP plan for drainage addresses runoff containment, adequate buffer zones, and filtration techniques. However, drainage of golf course features is only as good as the system’s integrity. Damaged, improperly installed, or poorly maintained drainage systems negatively impact play and increase risks to water quality.

1.5 Habitat Considerations

In urban and suburban environments, a golf course may provide the best habitat for many species. A number of golf course management activities can maintain and enhance habitat, and provide food and shelter for numerous species, including mammals, birds, fish, amphibians, reptiles, insects, and native plants. Examples of ways to maintain and enhance habitat include:

- Identifying and preserving wildlife and migration corridors.
- Retaining natural buffer areas around wetlands and watercourses to preserve habitat while protecting water quality for aquatic species.
- Planting native species to provide food for animals and insects.
- Retaining dead trees to serve as nesting areas.
- Providing nest boxes for birds, bees, and bats.
- Removing exotic and invasive species to improve habitat.

Figure 2. A well-planned golf course enhances wildlife habitat.

The “Pollinator Protection” and “Landscape” chapters provide additional recommendations and BMPs for enhancing habitat on the golf course.

Superintendents should be aware of the state-listed noxious weeds or invasive species that may be present on their facility and endeavor to control these species.

1.6 Turfgrass Establishment

1.6.1 Species Selection

Idaho's climate is generally favorable to cool season grasses (fine fescue, Kentucky bluegrass, perennial ryegrass, and bentgrass). Site-specific characteristics, such as desired use, site and microclimate conditions, disease resistance, drought tolerance, and spring transition traits, should be considered when selecting species and cultivar. National Turfgrass Evaluation Program (NTEP) trial results from neighboring states may be useful in determining the most suitable selection for an individual site. Additional resources include the Turfgrass Water Conservation Alliance and Alliance for Low Input Sustainable Turf.

1.6.2 Seedbed Preparation and Planting

Proper seedbed site preparation can help avoid long-term problems, such as weed encroachment, diseases, and drought susceptibility. Turfgrass seedlings thrive when proper attention is given to:

- Preparing the site and soil.
- Understanding correct planting techniques for the material being used (seed, sod, or plugs).
- Properly caring for the grass after planting.

Debris should be removed that could hinder root growth and limit access to water and nutrients. Any drainage issues should be corrected through grading and installation of drainage technologies. Pre-plant amendments should be added per soil test recommendations. Additional information on steps for successful establishment of turfgrass that also applies to golf course turfgrass establishment can be found on the Site Preparation for Lawns and Turf web page of the University of Idaho Extension website.

Figure 3. Grading the surface prior to planting.

1.6.3 Erosion and Sediment Control

The loss of topsoil from a site can be a problem for numerous reasons. Soil carried by wind and water transports contaminants with it. For example, erosion can enrich surface waters, where phosphorus and, to a lesser extent, nitrogen can cause eutrophication. When sediments and soils enter water, they can also increase turbidity, which harms aquatic plants and animals. Therefore, control measures should be documented in an erosion and sediment control plan, put in place prior to any soil disturbance, and properly maintained.

Figure 4. Hydroseeding.

1.7 External Certification Programs

Golf-centric environmental management programs or environmental management systems, such as Audubon International's Audubon Cooperative Sanctuary Program for Golf and the Groundwater Foundation's Groundwater Guardian Green Site program, can help golf courses protect natural resources, as well as gain recognition for their environmental education and certification efforts.

1.8 Planning, Design, and Construction Best Management Practices

Planning and Design

- Maintain appropriate erosion controls during construction (e.g. silt fencing, wattles, straw bale checks) to prevent erosion and sedimentation in accordance with the SWPPP.
- Establish a low- to no-maintenance buffer along wetlands; check local ordinances for any buffer requirements.

- Establish and maintain an effective riparian buffer around wetlands, springs, and channels; check local ordinances for any buffer requirements.

Wetlands and Floodplains

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

Drainage

- Evaluate the watershed size to understand drainage needs and appropriate pipe sizing.
- Ensure discharges from pipes do not drain directly to surface water.
- When constructing drainage systems, pay close attention to engineering details such as subsoil preparation and the placement of gravel, slopes, and backfilling.
- Discharge internal golf course drains through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments. Do not discharge directly into an open waterbody.
- Routinely inspect the drainage system to ensure proper function.
- Add tracking wire to all drainage pipes during construction.

Listed Species

- Identify any listed species and critical habitat that may be present on the site and preserve habitat, including feeding and nesting areas.

Habitat Conservation

- Identify the different types of habitat specific to the site.
- Identify habitat requirements (food, water, cover, space) for wildlife species.
- Identify and preserve regional wildlife and migration corridors by avoiding or minimizing crossings. Design unavoidable crossings to accommodate wildlife movement.
- Design and locate cart paths to minimize environmental impacts. Construct the paths with permeable materials, if possible.
- Remove nuisance and invasive plants and replace them with native species that are adapted to the site.
- Maintain clearance between the ground and the lowest portion of any fences or walls to allow wildlife to pass, except in areas where feral animals need to be excluded.
- Retain dead tree snags for nesting and feeding sites, provided they pose no danger to people or property.
- Construct and place birdhouses, bat houses, bee boxes, etc. in out-of-play areas.

- Plant pollinator gardens around the clubhouse and out-of-play areas.
- Retain riparian buffers along waterways to protect water quality and provide food, nesting sites, and cover for wildlife.

Turfgrass Establishment

- Select species and varieties that are adapted to the desired use, taking note of disease resistance, spring transition and greenup, drought tolerance, and other traits such as shade and wear tolerance.
- Prepare seed/sod beds to maximize success.
- Ensure erosion and sediment control devices are in place and properly maintained.
- Plant cool season grasses from seed from mid-August to early September to allow the seed to germinate and develop well before cold temperatures significantly slow growth prior to winter.
- Plant or establish sod when the turfgrass is actively growing so the sod will root or “knit” down into the soil as quickly as possible
- Fill gaps in sod seams with soil or sand to provide a uniform surface.
- Use selective pre-emergence herbicides to reduce weed competitions and improve the chance of success with seeding establishment during the spring.
- Apply a fertilizer containing phosphorus at seeding. An additional application should be applied if turfgrass displays symptoms of phosphorus deficiency.
- Nitrogen and sufficient water are essential during establishment. Light and frequent applications of nutrients are most desirable, unless a slow-release nitrogen source is applied.
- Allow the turfgrass to initially grow one-third to one-half higher than the desired mowing height before beginning to mow and never remove more than one-third of the turfgrass leaf at mowing.
- Because firm soil can better tolerate the weight of a mower, reduce watering prior to mowing.
- Consider mowing with a walk-behind mower rather than a heavier riding mower to avoid making wheel track depressions in the soil.
- Keep mower blades sharp. Dull mower blades may dislodge or damage young grass.

2 Irrigation

Preface

The supplemental use of water in turfgrass management encourages turfgrass and landscape plant health. BMPs related to irrigation conserve and protect water resources. Conservation and efficiency-related efforts consider the strategic use of course and irrigation design, computerized and data-integrated scheduling, and alternative water quality/supply options that maximize plant health and reduce the potential for negative impacts on natural resources.

Irrigation BMPs may also provide an economic, regulatory compliance, and environmental stewardship advantage to those who integrate them into an irrigation management plan. BMPs are not intended to increase labor or create undue burden. If applied appropriately, irrigation-related BMPs can help stabilize labor costs, extend equipment life, reduce repairs, and limit overall personal and public liability while protecting and conserving natural resources.

2.1 Regulatory Considerations

Idaho water law is based on the appropriation doctrine because water rights in Idaho are based upon diversion and beneficial use of water. The appropriation doctrine has also been called "first in time is first in right" because the priority date determines who gets water when there is a shortage. A water right under Idaho law can be established only by appropriation, and once established, it can be lost if it is not used. See Idaho Code §42-1502 and the Idaho Department of Water Resources (IDWR) publication Idaho Water Rights / A Primer for more information on water rights. New water rights require submission of an permit application to IDWR.

IDWR also has statutory authority for the statewide administration of the rules governing well construction and the licensing of drillers in Idaho. Prior to drilling a well, the well owner or well driller must first obtain a drilling permit from IDWR. All wells must be constructed by a well driller with a valid license from IDWR. See the Well Construction and Drilling page on the IDWR website for more information.

Municipal wastewater used as an alternative water source for irrigation requires a permit from DEQ. The wastewater reuse permit application process begins with the applicant scheduling a pre-application meeting with DEQ at which application requirements are discussed. Applicants are then required to submit to DEQ an application including site-specific information, facility and topographic maps, and wastewater reuse-specific information. More information on the permitting process and permit applications can be found on the DEQ web page Wastewater Reuse Permitting in Idaho.

During times of extended drought, water use restrictions may be issued by municipal governments. Superintendents should be aware of water use restrictions and be prepared with a drought management plan.

A typical drought management plan includes the following:

- A list of water use reductions as required by Idaho.
- A list of all water conservation management practices being deployed at the course.
- A list of water conservation performance goals.

2.2 Water Conservation and Efficient Use Planning

Potable water supplies in many areas of the United States are limited, and demand continues to grow. The challenge is to find solutions to maintain the quality of golf play while using less water. Opportunities to conserve water exist during initial course design and renovations, during irrigation system design and use, and by incorporating the use of management zones.

Some courses are designed using a “target golf” concept that minimizes the acreage of irrigated turfgrass. If properly designed, water hazards and stormwater ponds can capture rain and runoff that may provide supplemental water under normal conditions. Backup sources may be needed during severe drought. During times of intense heat stress, syringing, which is the practice of applying a small amount of water to help cool the turfgrasses as it evaporates, may be beneficial under certain conditions. These conditions include turfgrass with a very shallow root system and turf compromised by disease, poor soils, or wet-wilt. Because the cooling effect of syringing is very brief, repeated syringing and/or the use of fans will maximize the cooling effect.

In addition to utilizing well-adapted cultivars for in-play areas, existing golf courses can convert out-of-play area turf to native plants, grasses, or ground covers to reduce water use and augment the site’s aesthetic appeal. Native plant species also provide wildlife with habitat and food sources, such as native flower areas that benefit pollinators. After establishment, site-appropriate plants normally require little to no irrigation. See the “Pollinator Protection” and “Landscape” chapters for more information on native and drought-tolerant plants.

Water conservation plans should be prepared before a drought occurs, especially in the drier parts of the state. These plans should identify ways to achieve a 10% reduction in water use. Communication with golf club members and the public should be maintained to explain water conservation efforts as a proactive approach to addressing water-related issues.

2.3 Irrigation Water Supply

2.3.1 Irrigation Water Sources

Golf course designers and managers should identify and use alternative water supply sources to conserve freshwater drinking supplies whenever possible. The routine use of potable water is not a preferred practice. Municipal drinking water should be considered only when no alternatives exist.

2.3.2 Irrigation Water Quality

Water should be assessed to determine its suitability for irrigation and for plant growth. Non-potable water irrigation sources (such as retention ponds and recycled water) should be regularly tested to ensure that the quality is within acceptable parameters for irrigation. The University of Idaho Analytical Sciences Laboratory and commercial laboratories can analyze water samples and makes recommendations based on the electrical conductivity (EC) and sodium adsorption ratio (SAR) determined on the irrigation water and the soil series present on the land. The assessment identifies the chemical characteristics of the water and can be used to address possible issues with soil salinity and plant health caused by poor water quality.

For more information see:

- Irrigation Water Quality Guidelines for Turfgrass Sites, Penn State University.
- "Understanding Water Quality and Guidelines to Management," USGA Green Section.

2.3.3 Irrigation Water Requirements

An adequate water supply is essential for any planned or proposed golf course irrigation system. Water requirement analyses can be conducted to understand irrigation needs. A seasonal bulk water requirement analysis verifies the suitability of a water source and irrigation system to supply irrigation water under normal conditions. Because of the potential for drought, a maximum seasonal bulk water requirement analysis should be conducted as a worst-case scenario and calculated to not account for rainfall. For more information on calculating water requirements and example calculations, see Chapter 3 of Environmental Best Management Practices for Virginia's Golf Courses.

Record keeping is an important element in determining water requirement. Accurately determining annual baseline water requirements is helped by recording data such as:

- Average daily water consumption.
- Average monthly water consumption.
- Maximum daily water consumption.
- Total yearly water consumption.

It is essential that all delivery systems install and maintain accurate metering devices. Being able to measure water use allows baselines to be established and progress in water conservation efforts to be tracked. Installation of water meters will become more critical as more regulatory and compliance obligations are imposed on water for irrigation.

2.4 Irrigation System Design

2.4.1 Site Assessment

An assessment of the facility should be conducted prior to developing a system design. The site assessment should include site-specific features, such as water sources; soil types (see the Web Soil Survey for identifying site-specific soil types); soil physical properties; microclimates; slopes; sun, wind and shade exposures; and a seasonal and bulk water requirement analysis.

The site assessment should also evaluate the impact of design elements, such as design features and concepts, planned or existing turfgrass varieties, and planned or existing drainage systems. The system design should include a general irrigation schedule with recommendations and instructions on modifying the schedule to meet these site-specific needs.

2.4.2 Design

A well-designed irrigation system should operate at peak efficiency and be designed and installed to optimize water use effectively, focusing on water placement and distribution. The design should maximize water use, reduce operational cost, conserve supply, and protect water resources. Where feasible, variable frequency drive (VFD) pumps and/or pump stations should be used. These systems only expend enough energy to meet the demands of the irrigation pump(s). VFD systems reduce water hammer to fitting, pipe, and sprinklers when systems are pressurized. Detailed BMPs for irrigation system design are published by the Irrigation Association in Landscape Irrigation Best Management Practices.

The irrigation system design should meet the site-specific needs identified by the water quantity analyses and the site assessment. The system's capacity to deliver water should not exceed the infiltration of the soils on site, as that will lead to runoff. Though the design of an irrigation system is complex, some of the most important design decisions that influence the efficiency and effectiveness of water usage include those related to sprinkler and piping placement, sprinkler coverage and spacing, and communication options. In addition, the use of high density polyethylene pipe in the system will increase the ease of installation and reduce the potential for pipe breaks.

Multi-row sprinkler systems provide the most efficient use of water and can respond to specific moisture requirements of selected areas. Newer designs with multiple nozzle configurations provide increased flexibility and improved distribution uniformity. Single row systems do not uniformly distribute water and increases the risk of runoff. Double-row systems offer improved efficiency over single-row coverage, although manual watering or other types of supplemental watering may be needed outside the fairway area and into the extended rough. Sprinkler layouts can be specific to each area. For example, part-circle sprinklers can be arranged to avoid overspray of impervious surfaces and to apply water only to the green surface or in heavy traffic areas. Manual quick-coupler valves can be an important conservation element and should be installed near greens, tees, and bunkers so these can be hand-watered during severe droughts. Irrigation systems strive to provide uniform water distribution and to achieve distribution uniformity (DU) values near 80%. After installation, nozzles and irrigation head runtimes should be optimized to maintain uniform soil moisture distribution. That can be easily monitored with a soil moisture probe.

For precise irrigation control, courses should consider using advanced irrigation control systems that can schedule each green, tee, and fairway separately and allow course managers to adjust for differences in microclimates and root zones. Weather stations that calculate and automatically program water replacement schedules also provide opportunities for more precise irrigation, as do soil moisture sensors placed in multiple locations. Additional water conservation features may include such things as single head control and rain stop safety switches that either shut down the system in the event of rain or adjust schedules based on the amount of precipitation.

2.5 Irrigation System Installation

To ensure maximum efficiency, the irrigation system must be installed per the design and specifications. The installer must ensure that there is qualified supervision of the installation process and that a qualified irrigation specialist inspects and approves the system installation.

2.6 Irrigation System Maintenance and Performance

A properly working irrigation system is critical to ensure optimum operation. System checks and routine maintenance should be done for pumps, valves, programs, fittings, and sprinklers. A schedule of inspections and a plan for record keeping should be completed. Use of photography is especially helpful in recording installations/repairs of underground systems. The publication Landscape Irrigation Best Management Practices can be consulted for devising a schedule and a plan for record keeping.

To ensure that it is performing as intended, an irrigation system should be calibrated regularly by conducting periodic irrigation audits, such as catch-can tests and an annual irrigation audit, to check actual water delivery and nozzle efficiency. Nozzles can wear over time, changing irrigation output and distribution. Therefore, nozzles should be replaced, depending on the manufacturer's recommendation, to ensure proper function. Inspecting and exercising isolation valves ensures their sound operation in the event of an irrigation break.

While routine inspection and audits can be performed by the golf course superintendent, a professional irrigation consultant is required for a detailed irrigation audit, which should be conducted according to the Irrigation Audit Guidelines published by the Irrigation Association. Ideally, this professional audit should be conducted at least once every five years.

Figure 5. Regular auditing of the irrigation system should be performed to check actual water delivery and nozzle efficiency.

2.6.1 Winterization

Winterizing protects irrigation system pipes from damage due to water expanding and rupturing the pipe walls and fittings. Golf courses need to drain or use compressed air to remove water from lateral and mainlines pipes before temperatures drop below freezing, from all sprinkler heads, and quick couplers. Many facilities operate an independent irrigation system below the frost line, allowing the facility to apply water during cold periods to dormant turf in an effort to prevent winter desiccation and winter kill.

2.6.2 Spring Start Up

Spring start-up of the irrigation system is essentially the reverse of the steps taken to winterize the system. At the time of start-up, the system should be inspected for corrective maintenance issues.

2.7 Irrigation Management Decisions

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 and not on a calendar-based schedule. Irrigation scheduling must consider soil infiltration and percolation rates, as well as plant water requirements, to prevent excess water use that could lead to leaching or runoff.

2.7.1 Soil Infiltration Rate and Plant Available Water

The rate of infiltration depends on soil textures. Sandy soils, with their higher porosity, have greater infiltration rates than silty or clay soils. Plant available water (PAW) represents the amount of water (expressed in inches) available per inch of soil depth that a plant can access for transpiration. A soil moisture probe indicates the total volumetric water content, which is greater than the PAW for a soil. The PAW can be estimated with a soil moisture meter by subtracting the current soil moisture content from the moisture content when the turf wilts. Plant available soil moisture and infiltration rates are provided in Table 2.

Table 2. Available soil moisture and infiltration rates for common soil textures.

Soil Texture	**Soil Type**	**Typical plant-available moisture per foot of soil depth (inches)**	**Infiltration rate (inches h^{-1})**
Light, sandy	Coarse sand Fine sand	0.25 – 0.75 0.75 – 1.00	Fast (0.5 – 6+)
Medium, loamy	Loamy sand Sandy loam Fine sandy loam Silt loam	1.10 – 1.20 1.25 – 1.40 1.50 – 2.00 2.00 – 2.50	Moderate (0.25 – 0.5)
Heavy, clay	Silty clay loam Silty clay Clay	1.80 – 2.00 1.50 – 1.70 1.20 – 1.50	Slow (0.1 – 0.25)

2.7.2 Root Zone Depth

The depth of effective turfgrass rooting should be determined with a soil probe or spade. The majority of turfgrass roots in greens and tees reside in the top several inches of soil, whereas turfgrass in fairways and roughs typically have deeper roots. Exact root depths depend on grass species and time of year. The soil infiltration rate and root zone depth should be used together to estimate the amount of water that needs to be available to the root system to avoid wilting. The rooting depth is multiplied by the PAW to estimate the total amount of water available to the turfgrass.

2.7.3 Evapotranspiration

Evapotranspiration (ET) describes the water lost through soil evaporation and plant transpiration and is influenced by the climatic conditions on any given day, in addition to day length and solar intensity. For example, hot, windy days with low relative humidity have higher rates of ET than cooler, calm days with low relative humidity.

Potential ET can be calculated and should be used to help determine irrigation needs. Sources of potential ET data include on-site weather stations, the IDWR Evapotranspiration Viewer, and the University of Idaho Kimberly Research and Extension Center ETIdaho website.

2.7.4 Soil Moisture

Rain gauges, rain shut-off devices, soil moisture sensors, and other irrigation management devices accurately measure local precipitation and should be incorporated into irrigation management decision-making (Figure 6). Soil moisture monitoring, in addition to calculating ET rates and visually observing turfgrass, assists in planning irrigation to meet turfgrass water needs while conserving water resources.

Figure 6. Soil moisture sensors help facilitate irrigation management decision making.

2.7.5 Irrigation Scheduling

Proper irrigation can sustain plant energy reserves, increase root mass and depth, and reduce thatch accumulation. Irrigation should be applied as necessary to prevent wilt without oversaturating the soil/root zone and without compromising playing conditions. Soils do not need to be wetted below the root zone depth, as this could potentially lead to leaching, especially in shallow soils.

The goal of successful irrigation management is to limit excessive soil moisture while preventing wilt. Golf course managers strive to precisely apply water so plant-available water is only slightly greater than predicted ET. For many highly maintained turf areas, like greens, small amounts of water are applied every night to replace what was lost the prior day. Soil moisture probes can help further improve irrigation precision. These technologies can guide irrigation head run times and identify locations that might benefit from additional hand watering.

During periods of sufficient natural precipitation, stress pre-conditioning with deficit irrigation can improve tolerance to future drought, heat, and cold stress. Deficit irrigation is the practice of limiting irrigation to slowly deplete soil PAW until the soil moisture approaches wilt points. Computerized irrigation systems provide many advantages, including allowing a superintendent to remotely cancel the program if the course has received adequate rainfall. Clock-controlled irrigation systems preceded computer-controlled systems, and many are still in use today. Electric/mechanical time clocks cannot automatically adjust for changing ET rates. Therefore, frequent adjustment is necessary to compensate for the needs of individual turfgrass areas.

2.7.6 Hand Watering

Although modern irrigation systems can provide accurate watering applications, additional hand watering to select areas may be required. In some cases, the installation of quick couplers can provide improved capability for turf managers to target isolated turfgrass areas in need of supplementary water due to moisture related stress. As an alternative to plugging hoses directly into irrigation heads, the addition of quick couplers can also reduce wear and tear on irrigation equipment and eliminate the problem of finding heads remaining in the off position after an employee has plugged directly into a head.

2.7.7 Winter Desiccation

Idaho experiences long, cold winters that may require the application of irrigation water during turfgrass dormancy. During the summer, the crowns are 80% to 85% water by weight. After fall cold-acclimation, crown moisture values typically range from 50% to 60% water by weight. This dramatically increases cold tolerance. When crown moisture values drop below 50% in winter, certain turfgrass species, like creeping bentgrass, annual bluegrass, and perennial ryegrass, can suffer from desiccation stress. The lower the water weight, the greater the risk of plant death when temperatures drop well below freezing. Turfgrass grown on sandy soils or having excessive thatch is more likely to have issues with winter desiccation. Therefore, lightly irrigating high-value turfgrass on dry, sunny winter days when the air temperatures are well above freezing is recommended to rehydrate plant crowns back to a survivable level and restore moisture at the surface. Other cultural practices such as sand topdressing, turfgrass covers, snow fences, and anti-desiccants may also help prevent desiccation/winter injury.

2.8 Irrigation Best Management Practices

Water Conservation and Efficient Use Planning

- Minimize acreage of irrigated turfgrass.
- Convert out-of-play area turfgrass to native plants, grasses, or ground covers to reduce water use and augment the site’s aesthetic appeal.
- During times of intense heat stress, syringing, or the practice of applying a small amount of water to help cool the turfgrasses as it evaporates, may be beneficial under certain conditions.
- Create a drought management plan for the facility that identifies steps to be taken to reduce irrigation/water use and to protect critical and valuable areas.

- Restrict water usage in time of drought. Use appropriate turfgrass species adapted to the location of the golf course and use drought-tolerant species whenever possible.

Irrigation Water Supply

- Identify appropriate water supply sources that meet seasonal and bulk water allocations for grow-in and routine maintenance needs.
- Use alternative water supplies/sources that are appropriate and sufficiently available to supplement water needs, if available.
- Reclaimed, effluent, and other non-potable water supply mains must have a thorough cross-connection and backflow prevention device in place and operating correctly.
- Post signs in accordance with local utility and state requirements when reclaimed water is in use.
- Use salt-tolerant varieties of turfgrass and plants to mitigate saline conditions resulting from an alternative water source, if necessary.
- Assess the irrigation water quality.
- Account for the nutrients in irrigation water when making fertilizer calculations.
- Monitor irrigation water regularly for dissolved salt content.
- Conduct a seasonal bulk water requirement analysis and a maximum bulk water requirement analysis.
- Design and/or maintain a system to meet a site's peak water requirements under normal conditions. Be flexible enough to adapt to various water demands and local restrictions.
- Install and maintain accurate metering systems.

Irrigation System Design

- Conduct a thorough site assessment prior to designing the irrigation system.
- Develop a written, site-specific Irrigation Management Plan.
- Seek assistance from irrigation professionals, such as from Certified Golf Course Irrigation System designers and WaterSense-certified irrigation consultants, and follow established BMPs related to system design.
- Sprinkler placement should avoid interfering with the playability of the hole.
- Irrigation pipes should be installed away from the green surface to avoid substantial increases in repairs and damages should pipe failures occur.
- Update multi-head control systems with single-head control systems to conserve water and to enhance efficiency.
- Manual quick-coupler valves should be installed for site specific irrigation, so hand-watering can be used during severe droughts.
- Install part-circle heads along lakes, ponds, wetlands margins, native areas, and tree trunks.
- Use part-circle or adjustable heads to avoid overspray of impervious areas such as roadways, sidewalks, and parking areas.

- Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/distribution.
- When possible, use precise irrigation control technologies.

Irrigation System Installation

- The designer must approve any design changes before construction.
- Prior to construction, all underground cables, pipes, and other obstacles must be identified, and their locations flagged.
- Only qualified specialists should install the irrigation system.
- Construction and materials must meet existing standards and criteria.
- Construction must be consistent with the design.
- Installers must provide an accurate and comprehensive As-Built map.

Irrigation System Maintenance and Performance

- Visual inspections should be conducted to identify necessary repairs or corrective actions, which should be completed before further evaluation of system performance.
- Pressure and flow should be evaluated to determine that the correct nozzles are being used and that the heads are performing according to the manufacturer's specifications.
- Pressure and flow rates should be checked (ideally annually) at each head to determine the average precipitation rates.
- 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.
- Conduct an irrigation audit annually to facilitate a high-quality maintenance and scheduling program for the irrigation system.
- Inspect for water distribution interferences, such as trees and other obstructions.
- Inspect for broken and misaligned heads.
- Check that the rain sensor is present and functioning.
- Inspect the backflow device to determine that it is in place and in good repair.
- Examine turfgrass quality and plant health for indications of irrigation malfunction or a need for scheduling adjustments.
- Periodically conduct a professional irrigation audit that follows established guidelines.
- Record any modifications to the As-Builts, including head and nozzle choices.
- Use photography to record and document any major underground installations/repairs.
- Review efficiency of above-ground electric motors annually.
- Licensed professionals should routinely inspect the well housing.

Irrigation System Winterization

- Flush and drain above-ground irrigation system components that could hold water as part of winter preparation.
- Remove water from all conveyances and supply and distribution devices that may freeze. Use compressed air or open the drain valves at the lowest point on the system.
- Change filters, screens, and housing; remove drain plugs and ensure any water is removed from the system. Secure systems and close and lock covers/compartment doors to protect the system from vandalism and from animals seeking refuge.
- Drain any above-ground pump casings that may have “trapped” water.
- Record metering data before closing the system.
- Secure or lock any remote irrigation components, including satellites.
- Perform pump and engine servicing/repair before winterizing.

Irrigation System Spring Start Up

- Power up the pump station and pump motors before prior to using the system. By completing this task ahead of recharging the system, the coils inside the motors heat up and will therefore remove any moisture that collected during the off season.
- Keep the water pressure at 60 PSI or lower when priming the lines.
- Operate each of the sprinklers until all excess air is flushed from the irrigation system.
- Check the functionality of air pressure relief valves.
- Inspect the entire system for any corrective maintenance issues.

Irrigation Management Decisions

- Evaluate root zone depth on the course and do not irrigate beyond this depth.
- Monitor potential ET and calculate plant available water to improve irrigation precision.
- Utilize soil moisture technologies and techniques consistently.
- Use soil moisture sensors to assist in scheduling or to create on-demand irrigation schedules.
- Use multiple soil moisture sensors to reflect soil moisture levels.
- Place soil moisture sensors in a representative location within an irrigation zone.
- Use predictive models to estimate soil moisture and the best time to irrigate.
- Use a journal to record the “indicator zones” that should be more closely monitored.
- Calibrate older clock-control station timing devices periodically, and at least seasonally.
- Install control devices to allow for maximum system scheduling flexibility.

- Base plant water needs should be determined by ET rates, recent rainfall, recent temperature extremes, and soil moisture.
- Avoid use of a global setting; adjust watering times per head.
- Adjust irrigation run times based on current local meteorological data and computed daily ET rate to meet moisture needs.
- Manually adjust automated ET data to reflect wet and dry areas on the course.
- Irrigation quantities and rates should not exceed the available moisture storage in the root zone.
- Use infrequent, deep irrigation to supply sufficient water for plants and to encourage deep rooting in fairways and roughs.
- To maximize turfgrass health during summer, irrigate to the depth of the turfgrass root in early morning.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.
- Lightly irrigate high-value turfgrass on dry, sunny winter days when the air temperatures are well above freezing to rehydrate plant crowns back to a survivable level and restore moisture at the surface.
- The irrigation schedule should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).
- Generally, granular fertilizer applications should receive 0.25” of irrigation to move the particles off the leaves while minimizing runoff.

3 Water Management

Preface

Whether natural or manmade, surface water in the form of lakes, ponds, and streams has long been associated with golf courses. Natural lakes and ponds are usually associated with existing water sources, such as wetland areas. Irrigation impoundments (lakes, ponds, and constructed wetlands) can be incorporated into the design of a course and used both to manage stormwater and to function as a source for irrigation.

Because groundwater is plentiful, the vast majority of the state's citizens use it as drinking water. However, in some parts of the state, groundwater is contaminated, primarily with nitrates, other nutrients, and agricultural chemicals such as pesticides. Because of the public health concerns related to drinking water, preventing leaching and protecting wellheads are important aspects of golf course management.

Overall, water management incorporates not only the information contained in this chapter, but many of the issues discussed throughout this document, including:

- Design considerations such as the use of vegetated buffers.
- Fertilization strategies near surface waters.
- Pesticide usage.
- Water quality monitoring.

In addition to planning for stormwater issues and protecting groundwater, water management should focus on lakes and ponds. Important parts of aquatic maintenance include managing components of aquatic habitats, such as algae and plant growth; reducing or preventing nutrient and sediment enrichment especially through the use of vegetated buffers; and ensuring that dissolved oxygen levels can sustain aquatic life.

3.1 Regulatory Considerations

3.1.1 Surface Water

The USEPA administers the protection of streams and lakes under the CWA. At the same time, DEQ creates state-specific regulations and water quality standards based on federal recommendations. Surface water quality is regulated under the CWA. DEQ is the state's lead agency with regulatory authority for surface and groundwater quality.

The CWA requires states to prepare a list of impaired surface waters every other year. Impaired waters are those that do not meet the state water quality standards. From this list of impaired waters, states prepare Total Maximum Daily Loads (TMDLs) that include pollution control goals and strategies necessary to improve the quality of impaired waters and remove the identified impairments. TMDLs can include goals for nutrient loading (e.g. nitrogen or phosphorus). DEQ provides information on TMDLs, including a list of finalized TMDLs in the state, on its website.

In addition to developing TMDLs, DEQ is required to provide Congress with surface water quality reports every two years that describe the status and trends of existing quality of all waters in the state. The report also provides information about the extent to which designated uses are supported. DEQ combines this report with the impaired waters report into one integrated report.

3.1.2 Groundwater

Groundwater is protected by federal and state laws regulating activities that either directly or indirectly affect groundwater quality. Important groundwater quality protection legislation in Idaho includes the following:

- Environmental Protection and Health Act (Title 39, Chapter 1, Sections 102, 120, 126).
- Health and Safety: Aquifer Protection Districts (Title 39, Chapter 5).
- Local Land Use Planning Act (Title 67, Chapter 65, Section 37).
- Ground Water Quality Protection Act of 1989 (Title 39, Chapter 1).

A concise description of these laws is available in the DEQ publication Overview of Idaho Ground Water Quality Protection Laws. DEQ is the state regulatory agency responsible for protecting the quality of groundwater in Idaho and relies on a combination of programs to protect groundwater from pollution, clean up degraded groundwater, and monitor and assess groundwater quality.

3.1.3 Dams

Owners who desire to construct, enlarge, alter, or repair a water storage dam or water diversion structure equal to or exceeding 10 feet in height and impounding a reservoir of 50 acre-feet or more must have it designed by an Idaho licensed professional engineer (Idaho Code §42-1712) and must submit an Application for Construction or Enlargement of a New or Existing Dam to IDWR. The design generally will be expected to meet or exceed the prescriptive design and construction requirements enumerated in the IDAPA 37.03.06.

3.1.4 Aquatic Pesticides

Aquatic pesticides that control nuisance aquatic plants like Eurasian milfoil, as well as algaecides that control algae, are available from commercial distributors. Aquatic pesticide applicators must be licensed by the Idaho State Department of Agriculture (ISDA) with the appropriate aquatic license.

As with any pesticide application, the label must be followed. Labels on aquatic herbicides for algae control may specifically state that only a portion of the surface water area can be treated at one time to prevent massive algae and other plant die-offs and to avoid the low dissolved oxygen (DO) conditions that result from decaying organic matter. Some aquatic pesticides may have irrigation restrictions following applications.

3.2 Stormwater Management

Best practices related to protecting the quality of surface waters center on preventing nutrients, chemicals, and sediments from reaching waterbodies and wetlands. Superintendents can effectively protect Idaho's water resources by managing stormwater effectively, maintaining buffers, and considering the special needs of wetlands, floodplains, lakes, and ponds.

The control of stormwater on a golf course is more than just preventing the flooding of the clubhouse, maintenance sites, and play areas. Proper management of stormwater controls the amount and rate of water leaving the course, controls erosion and sedimentation, stores irrigation water, removes waterborne pollutants, enhances wildlife habitat, and addresses aesthetic and playability concerns. Stormwater runoff (also called surface runoff) is the conveying force behind what is called nonpoint source pollution. Nonpoint source pollution is caused by water moving over and through the ground, picking up and carrying away natural and human-made pollutants, and finally depositing them into surface waters (lakes, rivers, wetlands, coastal waters) and groundwater. On golf courses, pollutants that might be found in surface runoff include, but are not limited to, pesticides, fertilizers, sediment, and petroleum.

Treating stormwater to avoid impacts to water quality 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. These treatments include source controls, structural controls, and non-structural controls. Source controls are the first car of the BMP treatment train. They help prevent the generation of stormwater runoff or the introduction of pollutants into stormwater runoff. The most effective method of stormwater treatment is to prevent or preclude the possibility of movement of sediment, nutrients, or pesticides in runoff.

The next car in the treatment system is often structural controls, which are design and engineering features of the course created to remove, filter, detain, or reroute potential contaminants carried in surface runoff. Examples of structural BMPs include ponds, constructed wetlands, and filters to address water quality, water recharge, and stream channel protection. Non-structural controls mimic natural hydrology and minimize the generation of excess stormwater and include vegetated systems. Vegetated systems such as stream buffers act as natural biofilters, reducing stormwater flow, removing sediments from surface water runoff, and preventing nutrient and pesticide discharge in runoff from reaching surface waters. The treatment train approach combines these controls, as in the following example: Stormwater can be directed across vegetated filter strips (such as turfgrass), through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.

During any construction or redesign activity, proper erosion and sedimentation control must be followed (as discussed in the "Planning, Design, and Construction" chapter) to ensure that stormwater runoff does not impact water quality. Properly designed golf courses capture rain and runoff in water hazards and stormwater ponds, providing most or all of the supplemental water necessary under normal conditions, though backup sources may be needed during drought conditions.

3.2.1 Preventing Surface Runoff

Factors that affect nutrient mobility, availability, and accessibility can be evaluated to predict where and when N contamination can potentially occur. BMPs related to this are designed to prevent the transportation of N to surface waters (Table 3). Soils data is needed for this assessment and is available from the Idaho office of the Natural Resources Conservation Service (NRCS). Digital soils data is available from the Web Soil Survey.

Table 3. Criteria for high potential to affect N transport to surface water as related to natural factors.

Natural Factors	Criteria
Surface water proximity	Adjacent land within 500 feet that slopes into the drainage network.
Soil aeration	Excessive, somewhat excessive, and well drained soils
Mobilization in solution	Soil hydrogeologic group C and D
Mobilization with sediment	K factor near 0.69 combined with soils in hydrogeologic groups C and D
Land slope	Slopes > 9%
Flooding frequency	Frequent flooding as defined by NRCS
Source: *How to Assess for Nitrogen Problems in Water Resources*, North Dakota State University (NDSU).	

3.2.2 Buffers

Buffers around the shore of surface waters, wetlands, or other sensitive areas filter runoff as it passes across the buffer. Buffers can be vegetated filter strips, such as those used as part of a stormwater treatment system. When used as a buffer along shorelines, stream banks, and wetland boundaries, filter strips are the last line of defense to keep sediment out of streams and to filter out fertilizers and pesticides that might otherwise reach waterways. Buffers also provide valuable food, cover, and travel corridors for some wildlife. Buffer widths as narrow as 15 feet have been shown to be effective in protecting water quality.

Figure 7. A buffer area allows nutrients in runoff to be taken up before reaching surface waters.

Care needs to be taken when applying pesticides or fertilizers near or in buffer strips to prevent movement into the nearby surface water. A number of turfgrass species should be considered for buffer strips. Table 4 lists the Natural Resources Conservation Service-recommended species for buffer strips in Idaho, by rainfall requirements and seeding rates.

Riparian buffers along streams and rivers can be up to three different plant assemblages, progressing from sedges and rushes along the water's edge to upland species. Riparian buffers of sufficient width intercept sediment, nutrients, and pesticides in surface runoff and reduce nutrients and other contaminants in shallow subsurface water flow. Woody vegetation in buffers provides food and cover for wildlife, stabilizes stream banks, and slows out-of-bank flood flows.

Table 4. Plants recommended for buffer strips in Idaho.

Species	Seeds/Ft^2	Lbs/Acre
20-30" rainfall or irrigation		
Creeping foxtail	90	5
Orchardgrass	96	8

Kentucky bluegrass	100	2
17 - 20+" rainfall or irrigation		
Smooth brome	48	16
Meadow brome	48	24
Tall fescue	50	10
13-16+ rainfall or irrigation		
Intermediate wheatgrass	48	24
Pubescent wheatgrass		24
Tall wheatgrass		24
Western wheatgrass		16
Thickspike wheatgrass		16
Streambank wheatgrass	48	16
<12+" rainfall or irrigation		
Crested wheatgrass	48	12
Siberian wheatgrass	48	12
Source: *Vegetative Filter or Buffer Strips*, NRCS		

3.3 Flood Recovery

When floods occur and turfgrass is submerged for any length of time, the potential for turfgrass death depends upon a number of factors, including the time of year; the length of time the turfgrass is submerged; the depth of submersion; water temperature; and light intensity. Actively growing turfgrass is most vulnerable; substantial loss can be expected after four days of continued submersion whereas dormant turfgrass can be expected to survive longer submersion. If any of the leaf tissue is above the water line, the potential for survival is greater. Cooler temperatures also increase survival rates, due to lower water temperatures and lower light intensity.

Following a flood, turfgrass injury can be evaluated by inspecting the turfgrass crown and cross-sectioning. If the majority of the crown is alive, recovery can be monitored. If the majority of the crowns are dead (brown and mushy), aggressive over-seeding is called for.

3.4 Wetlands

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. Wetlands should be maintained as preserves and separated from managed turfgrass areas by means of native vegetation, structural controls to protect water quality, and low/no maintenance activities to avoid nutrient or pesticide contamination.

3.5 Floodplains

Control structures located near floodplains, such as retention basins, can store water and thereby reduce flooding and protect stream banks. These structures should be regularly inspected and maintained to ensure their proper function. Vegetated buffers along floodplains should be maintained to mitigate flooding, control stormwater, and protect water quality.

3.6 Lakes and Ponds

The management of lakes and ponds should include a clear statement of goals and priorities to guide the development of the BMPs necessary to meet those goals. Some of the particular issues superintendents should address to maintain the water quality of golf course lakes and ponds include:

- Pond design.
- DO levels.
- Aquatic plant management.
- Near-shore management zones.

3.6.1 Pond Location and Design

Designing a new pond requires considerations such as the size of the drainage area, water supply, soil types, and water depth. In addition to potentially serving as an irrigation water source, ponds support aquatic life and the construction of ponds should consider the needs of aquatic ecosystems (such as discouraging excessive growth of aquatic vegetation, DO needs for aquatic species, etc.). Careful design may significantly reduce future operating expenses for pond and aquatic plant management.

3.6.2 Dissolved Oxygen

Dissolved oxygen is the amount of oxygen present in water and is measured in milligrams per liter (mg/L). Adequate DO levels are required to sustain life in aquatic organisms and vary by species, the organism's life stage, and water temperature.

The amount of DO that water can hold depends on the physical conditions of the body of water (water temperature, rate of flow, oxygen mixing, etc.) and photosynthetic activity. Colder water has higher DO levels than warmer water. Dissolved oxygen levels also differ by time of day and by season as water temperatures fluctuate. Similarly, a difference in DO levels may occur at different depths in deeper surface waters if the water stratifies into thermal layers. Fast-flowing streams hold more oxygen than impounded water. Lastly, photosynthetic activity also influences DO levels. As aquatic plants and algae photosynthesize during the day, they release oxygen. At night, photosynthesis slows down considerably or even stops, and algae and plants pull oxygen from the water. In impoundments with excessive plant and algae growth, several cloudy days in a row can increase the potential for fish kills due to low DO during warm weather. Therefore, preventing excessive aquatic growth helps to maintain DO levels. The use of artificial aeration (diffusers) can also be used to maintain adequate DO, especially in small impoundments or ponds.

3.6.3 Aquatic Plants

Aquatic plants include algae and vascular plants. Phytoplankton, or algae, give water its green appearance and provide the base for the food chain in ponds. Tiny animals called zooplankton use phytoplankton as a food source. Large aquatic plants (aquatic macrophytes) can grow rooted to the bottom and supported by the water (submersed plants), rooted to the bottom or shoreline and extended above the water surface (emerged 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).

Aquatic plants are part of aquatic ecosystems. They provide a number of benefits, such as:

- Habitat for aquatic organisms (e.g. food and nesting sites).
- Oxygenation.
- Shoreline stabilization.
- Aesthetic appeal.

Aquatic plants growing on a littoral shelf may help protect receiving waters from the pollutants present in surface water runoff. Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal to provide the best substrate for aquatic plant growth. In open areas, floating-leaved and floating plants suppress phytoplankton because they absorb nutrients from the pond water and create shade.

Particularly in shallow or nutrient-enriched ponds, aquatic plant growth can become excessive. Non-native plants, in particular, can aggressively colonize aquatic environments. Sixteen species of aquatic plants are listed as noxious weeds in Idaho. The excessive growth of any aquatic plant requires management. Following the principles laid out in the “Integrated Pest Management” chapter, a number of controls should be considered to deal with excessive aquatic plant growth, including:

- Prevention, such as reducing nutrient enrichment and avoiding the introduction of invasive species.
- Cultural practices, such as benthic barriers to prevent vascular plant growth.
- Mechanical removal.
- Chemical control.

Triploid grass carp are allowed in Idaho and are sometimes used as a biological control for aquatic plant.

For more on aquatic plant and algae management, see Resolving Common Maintenance Problems / Aquatic Vegetation from the Nebraska Game and Parks Commission.

3.6.4 Shoreline Management

Special management zones should be established around the edges of lakes and ponds. The management specifications should include a setback distance when applying fertilizers, as well as reduced mowing. Grass clippings should be collected near shorelines, as the phosphorus and nitrogen in clippings can impact water quality when transported into waterbodies.

3.6.5 Waterfowl

The deposits of fecal matter by resident and migrating waterfowl (such as Canada geese) can substantially impact water quality through nutrient enrichment. On golf courses, shallow ponds with significant populations of waterfowl are most likely to be affected. In addition, large numbers of Canada geese can erode shorelines and thin the grass cover on greens and fairways, contributing to the potential for erosion. Efforts to control waterfowl have met with mixed success. Loud sounds, dogs, and hunting have been tried in order to deter them. However, many of these efforts do not lend themselves to golf courses, especially in more urban areas. For more information, see Managing Canada Geese from the University of Nebraska-Lincoln Extension.

3.7 Groundwater Management

Establishing protection zones around water supply wells and safe land-use practices that prevent leaching protects aquifers from accidental contamination.

3.7.1 Preventing Leaching

Leaching refers to the loss of water-soluble plant nutrients or chemicals from the soil as water moves through the soil profile and reaches the saturated zone. Some of the factors that can influence leaching potential include the depth to groundwater, soil type and structure, geology, rate of precipitation, and amount of irrigation. When applying fertilizers or pesticides, the rate, timing, and location of applications should be considered to minimize the potential for losses due to leaching. Sandy soils, for example, have a low potential to fix phosphorus and therefore are more likely to leach phosphorus, as well as nitrogen, than other soil types.

Nitrogen, in the form of nitrate (NO_3-N) presents leaching concerns for groundwater quality. In Idaho, nitrate is one of the most widespread groundwater contaminants. Sandy or gravelly textured soils, excessively drained soils, and areas with shallow groundwater tables are most likely to leach nitrogen (Table 5). Fertilizers with a solubility of more than 30 mg/L (or 30 ppm) can pose a risk for leaching.

Table 5. Criteria for high potential to affect N translocation to groundwater as related to natural factors.

Natural Factors	Criteria
Soil aeration	Excessive, somewhat excessive, or well drained soils
Soil texture	Sandy, sandy-skeletal, or fragmental family particle size
Depth to aquifer	Less than 50 feet to the top of the saturated aquifer
Hydrologic recharge area	>20 inches to accumulations of $CaCO_3$
Source: How to Assess for Nitrogen Problems in Water Resources, NDSU.	

3.7.2 Protecting Wellheads

Protecting wellheads from physical impacts and contaminants, keeping them secure, and sampling wells are all best practices for ensuring groundwater supplies of drinking water are adequately protected.

Before installing new wells, the well construction permit should be reviewed to determine any permitting and setback requirements. New wells should be located in areas that will maximize yield but also minimize potential contamination of source water such as being located up-gradient as far as possible from potential pollutant sources, such as petroleum storage tanks, septic tanks, chemical mixing areas, and fertilizer storage facilities. The completion of a preliminary wellhead protection area delineation and source inventory is therefore desirable prior to the installation of new wells. Once installed, activities that could contaminate the well should be prohibited in the protected area. In addition, most pesticide labels now prohibit mixing/loading pesticides within 50 feet (or other specified setback distance) from any well.

3.8 Water Management Best Management Practices

Stormwater Management

- Design stormwater treatment trains.
- Install berms and vegetated swales to capture pollutants and sediments from runoff before they enter irrigation storage ponds or other surface waters.
- Implement no- or low-maintenance vegetated buffer strips around surface waters.
- Utilize vegetated filter strips in conjunction with water filtration basins.
- Eliminate or minimize directly connected impervious areas.
- Use depressed landscape islands in parking lots to catch and filter water and allow for infiltration. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediment, while allowing the overflow to drain away.

- When possible, maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and plants.

Flood Recovery

- After a flood, if turfgrass has been submerged for any length of time inspect the crowns and either monitor recovery or aggressively overseed as needed.

Wetlands

- Maintain appropriate silt fencing on projects upstream to prevent erosion and sedimentation.
- Natural waters cannot be considered treatment systems and must be protected. (Natural waters do not include treatment wetlands).
- Establish a low- to no-maintenance buffer along wetlands, springs, and spring runs.

Floodplains

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

Lakes and Ponds

- Maintain an unmowed, vegetated buffer strip (riparian buffer) to filter the nutrients and sediment in runoff. Leave it unmowed or mow only once or twice a year so that grasses and plants grow knee-high.
- If mowing near a pond or lake, collect clippings or direct them to upland areas so they do not increase nutrient loading to waterbodies.
- Maintain the required setback distance when applying fertilizers near waterways.
- Encourage clumps of native emergent vegetation at the shoreline.
- Maintain water flow through lakes if they are interconnected.
- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate erosion and sedimentation controls on projects upstream to prevent sedimentation and nutrient enrichment to waterbodies.
- Dredge or remove sediment before it becomes a problem.

Dissolved Oxygen

- Establish DO thresholds to prevent fish kills, which occur at levels of 2-3 mg/L.
- Reduce stress on fish by keeping DO levels above 5 mg/L.

- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Use artificial aeration (diffusers), if needed, to maintain adequate DO.

Aquatic Algae and Plants Management

- Develop a comprehensive management plan that includes strategies to prevent and control the growth of nuisance aquatic vegetation.
- Keep phosphorus rich material (e.g. natural or synthetic fertilizers, organic tissues like grass clippings, or unprotected topsoil) from entering surface water.
- Install desirable native plants to naturally buffer DO loss and fluctuation.
- To control excessive aquatic plant growth, use an IPM approach that incorporates prevention, cultural practices, and mechanical removal methods in addition to chemical control.
- To reduce the risk of DO depletion, use an algaecide containing hydrogen peroxide instead of one with copper or endothall.
- Dredge or remove sediment as needed to improve aquatic habitat.
- Reverse-grade around the waterbody perimeters to control surface water runoff and to reduce nutrient loads.
- Discourage large numbers of waterfowl from colonizing golf course waterbodies.

Preventing Leaching

- Identify areas on the course that may be prone to leaching (shallow depth to groundwater, sandy soils, etc.).
- Manage irrigation to avoid over-watering.
- Consider the potential for fertilizers or pesticides to leach before applying.

Wellhead Protection

- Use backflow-prevention devices at the wellhead, on hoses, and at the pesticide mix/load station to prevent contamination of water sources.
- Follow pesticide labels for setback distance requirements (typically a minimum of 50 feet).
- Properly decommission illegal, abandoned, or flowing wells.
- Surround new wells with bollards or a physical barrier to prevent impacts to the wellhead.
- Inspect wellheads and the well casing routinely 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 the well's depth; these factors will have a bearing on how vulnerable the well is to contamination.
- Develop a written Wellhead Protection Plan that minimizes environmental risk and potential contamination.

4 Water Quality Monitoring

Preface

Aligning golf course management practices with BMPs protects water quality on and downstream from the facility. A water quality monitoring program can confirm the effectiveness of a BMP-based program and provide important feedback on areas needing improvement.

Golf course superintendents seeking to develop and implement a monitoring program to document water quality conditions should first review available baseline water quality data. Baseline data can be assessed to determine the likely origin of contaminants, measure the extent of sedimentation and nutrient inputs, and estimate the potential impacts to surface water and groundwater. Following implementation of BMPs, routine monitoring can be used to measure water quality improvements and identify any areas where corrective actions should be taken.

Water quality monitoring on golf courses is voluntary. However, monitoring results demonstrate a commitment to water quality and implementing BMPs that protect water resources downstream. Furthermore, providing monitoring information to local, regional, and state regulatory authorities and watershed groups can help foster positive relationships with these stakeholders.

In addition to monitoring water quality from golf course management operations, superintendents will want to regularly test irrigation water, such as that from retention ponds. Information on irrigation water quality testing is provided in Section 3.3.2 “Irrigation Water Quality.”

4.1 Existing Water Quality Information

Several sources of existing surface water and groundwater monitoring data may be available that can provide baseline information for a course-based water quality monitoring program. These potential data sources include:

- IDWR's Statewide Groundwater Quality Monitoring Program.
- U.S. Geological Survey's Surface Water Data for Idaho.
- USEPA’s How’s My Waterway tool.

4.2 Developing a Water Quality Monitoring Program

A water quality program begins with the development of a monitoring plan. The plan should identify specific conditions such as the presence of a watershed, stream flows, soil type, topography, drainage, and vegetation. In addition, the plan needs to document the hydrologic conditions and drainage, the monitoring objectives, the monitoring locations and frequency, and the monitoring parameters. Baseline reference conditions can be established by collecting upstream water samples and comparing them with collection sites downstream of the areas influenced by golf course management practices.

Surface water collection sites can include streams, rivers, ponds, wetlands, etc., with the number and location of collection sites dependent upon monitoring objectives. For example, a simple monitoring program can consist of the collection of DO data in surface waterbodies to ensure that these waterbodies can support aquatic life. Regardless of the extent of the monitoring program, the location of monitoring sites should remain consistent to establish trends in data.

A more comprehensive monitoring program should expand field measurements and add in analytical testing. Field measurements can include pH, temperature, specific conductance, and DO. Testing should be conducted by a certified laboratory. Typical testing parameters include nutrients (such as nitrates and phosphorus), total dissolved solids (TDS), alkalinity, sediments, and selected pesticides used on the course. For more information on surface water monitoring programs, sampling procedures, and parameters specific to golf turfgrass, Environmental Stewardship Guidelines can provide detailed guidance.

Developing a water quality monitoring program on golf courses is often limited to surface water monitoring. Sampling of benthic macroinvertebrates in streams is a useful addition to a monitoring program, as species composition and diversity can be used as a relative assessment tool for stream health. For more information on sampling, see New Mexico State University's Stream Biomonitoring Using Benthic Macroinvertebrates. Such sampling can often be undertaken by university students in fulfillment of course work, by watershed association volunteer groups, or by other volunteer monitoring efforts.

Figure 8. Drawing a water sample.

In some instances, groundwater monitoring may be desired. Groundwater monitoring from wells located at the hydrologic entrance and exit from the course may be the best way to evaluate a golf course's impact on water quality. If groundwater monitoring data from these locations are not available from existing sources, monitoring wells at the hydrologic entrance and exit from the course can be installed by private installers. Groundwater quality parameters can be limited to test only the ones directly influenced by course management, such as levels of pesticides and organic and inorganic nitrogen.

Water quality monitoring of irrigation sources (particularly water supply wells and storage lakes) provides valuable agronomic information that can influence nutrient programs. Immunoassay analysis may be a possible and cost-effective method for monitoring, depending on the analytical goals and the number of samples. To save money, several golf courses could pool resources and share immunoassay analyzer equipment and kits. See the "Irrigation" chapter for more information on irrigation water quality issues.

4.3 Interpreting Water Quality Testing Results

Interpretation and use of water quality monitoring data depends to a large extent on the goal of the monitoring program. For example, the results may be analyzed to compare:

- Values over time.
- Values following implementation of BMPs, such as IPM measures.
- Monitoring points entering the site and leaving the site.

Results should also be interpreted and compared with the state's water quality standards, if water quality standards have been established for the parameter being evaluated. Data analysis can also be used to identify issues that may need corrective action, based on findings such as a spike in nutrient levels. For example, operator error in nutrient applications, an extreme weather event, or some combination of factors may be responsible. Water quality problems can often be addressed by simple changes to a course's existing nutrient management program.

4.4 Water Quality Best Management Practices

Developing a Water Quality Monitoring Program

- Review existing sources of groundwater and surface water quality information.
- Develop a water quality monitoring program.
- Establish baseline quality levels for water.
- Identify appropriate sampling locations and sample at the same locations in the future.
- Visually monitor/assess any specific changes of surface waterbodies.
- Follow recommended sample collection and analytical procedures.
- Conduct seasonal water quality sampling. The recommendation is four times per year.
- Partner with other groups or volunteer water quality monitoring programs if possible, to share data and monitoring costs.

Interpreting Water Quality Testing Results

- Compare water quality monitoring results to benchmark quality standards.
- Use corrective measures when necessary.

5 Nutrient and Soils Management

Preface

Proper nutrient and soils management play a key role in the reduction of environmental risk while also potentially helping to reduce inputs and overall expenditures. Maintaining appropriate nutrient levels along with managing soil physical and biological health ultimately produce the most efficient turfgrass system possible. This will allow turfgrass to not only survive under stress conditions but be as healthy as possible during the variety of seasonal changes that occur in our climate.

Nutrients may move beyond the turfgrass via leaching or runoff, which may directly impact our environment. The goal of a proper nutrient management plan should be to apply the minimum necessary nutrients to achieve an acceptable playing surface and apply these nutrients in a manner that maximizes their plant uptake.

Soils are a dynamic, living entity which encompass what some refer to as a "three-legged stool." 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 turfgrass management such as thatch breakdown, nutrient cycling, buffering of salts and bicarbonates, and the efficient use of water.

5.1 Regulatory Considerations

Commercial fertilizers and commercial plant and soil amendments must be registered for use in Idaho.

5.2 Soil Health

Healthy soil contains a large and diverse microbial population, a rich and buffered nutrient base, and excellent soil structure resulting in sustainable soil-air exchange, good internal water drainage and water-holding capacity, and sustained nutrient feeding. Soil amendments and sound cultural practices (including mowing, cultivation, irrigation, and seeding/vegetative rejuvenation) all contribute to soil health. Organic options for maintaining a healthy microbial system include biologically friendly inputs such as humic acids and naturally derived N sources, such as kelp, composts, and other organic sources.

5.3 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.

5.3.1 Terminology

Grade or analysis is the percent by weight of N, P, and potash, which contains potassium (K), guaranteed to be in the fertilizer at minimum. Complete fertilizers contain N, P, and K.

5.3.2 Label

The label is intended to inform the user about the contents of the fertilizer. When applied according to the label, the use of fertilizer presents little to no environmental risk. Fertilizer labels generally provide the following information:

- Manufacturer's name and address.
- Brand name.
- Website.
- Nutrient guarantee (i.e. guaranteed minimum amounts of nutrients, given as a ratio).

Additional information that may be found on the label includes characteristics such as size guide number (SGN), water-insoluble nitrogen (WIN), water-soluble nitrogen (WSN), and release characteristics.

5.3.3 Macronutrients

Macronutrients are required in the greatest quantities. N, P, and K are the ones most likely to be deficient in agronomic soils. Secondary macronutrients – calcium (Ca), magnesium (Mg), and sulfur (S) – are also needed in relatively high quantities but are rarely deficient in turfgrass soils. Understanding the role of each macronutrient within the plant provides a greater understanding of why these nutrients play such a key role in proper turfgrass management.

The Role of N

Nitrogen is required by the plant in greater quantities than any other element except carbon, hydrogen, and oxygen. Nitrogen plays a role in numerous plant functions and is 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 below, in addition to the fate and transport mechanisms of runoff and leaching, leads to sound decision making and ultimately leads to an increase in course profitability and a reduction in environmental risk. These nitrogen processes are:

- Mineralization, the microbial mediated conversion of organic N into plant-available NH_4.
- Nitrification, the microbial-mediated conversion of NH_4 to NO_3.
- Denitrification, the microbial mediated conversion of NO_3 to N gas; this primarily occurs in low-oxygen environments and is enhanced by high soil pH.
- Volatilization, the conversion of NH_4 to NH_3 gas.

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 a slow-release form) is unique and therefore should be managed accordingly. For example, applying a polymer-coated urea in the same manner as a sulfur-coated urea greatly reduces the value of the polymer-coated urea. Similarly, applying 2 pounds of N from ammonium sulfate may cause burning, while applying 2 pounds of N from certain polymer-coated ureas may not provide the desired turfgrass response. Rate, application date, location, and turfgrass species all should be included in nutrient application decision-making.

Soluble Nitrogen Sources

Soluble N 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).

Slow-release Nitrogen Sources

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

- Coated urea (sulfur, polymer, or both).
- Urea-formaldehyde/urea-formaldehyde reaction products (methylene urea).
- Isobutylidene diurea (IBDU).
- Natural organic compost (plant material or animal manure and biosolids).

Urease and Nitrification Inhibitors

Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and an increase in plant-available N. Nitrification inhibitors reduce the activity of *Nitrosomonas* bacteria, which converts NH_4 to NO_2. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N. These compounds are best applied to turfgrass sites that are not irrigated.

The Role of Phosphorous

Phosphorus forms high-energy compounds that are used to transfer energy within the plant. Phosphorus may remain in an inorganic form or may become incorporated into organic compounds. Phosphorus can be a growth-limiting factor for many unintended organisms and is a major contributor to eutrophication of waterbodies.

Therefore, the goal of P fertilization is to supply enough to sustain healthy turfgrass growth yet minimize environmental risk. Phosphorous application rates should be based on soil test results. Fortunately, phosphorus binds tightly to native soils and organic matter. The most important way to limit phosphorus movement off-site is to maintain dense and healthy vegetation.

P Fertilizer Sources

Phosphorus sources include:

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

The Role of Potassium

Potassium is of no environmental concern but can be an economic concern, particularly when potassium is overutilized, which can be quite common. Generally, potassium concentrations in turfgrass tissue are about one-third to half that of N. Potassium is not a component of any organic compound and moves readily within the plant. Potassium is a key component of osmoregulation and has been documented to increase stress resistance.

Potassium Fertilizer Sources

Potassium fertilizer sources include:

- Potassium chloride.
- Potassium nitrate.

- Potassium phosphate.
- Potassium sulfate.

5.3.4 Secondary Macronutrients

Fertilization with secondary macronutrients is rarely justified in a turfgrass systems. Calcium (Ca), magnesium (Mg), and sulfur (S) are essential to plant function, but fibrous turfgrass root systems and soils typically satisfy demand for these nutrients. Soil test interpretations for these nutrients are unsubstantiated in turfgrass because deficiencies for these nutrients are exceedingly rare. Therefore, suspected secondary nutrient deficiencies should be confirmed with tissue tests. Also, confirm suspected deficiencies with small-test applications of fertilizer. If there is not a turfgrass response, then a widespread nutrient application is not warranted. Secondary nutrient sources can be found in Table 6.

Table 6. Secondary macronutrients.

Nutrient	Role	Sources
Calcium	Primarily a component of cells walls and structure.	Gypsum Limestone Calcium chloride
Magnesium	Central ion in the chlorophyll molecule and chlorophyll synthesis.	S-Po-Mg Dolomitic limestone Magnesium sulfate
Sulfur	Metabolized into the amino acid cysteine, which is used in various proteins and enzymes.	Ammonium sulfate Elemental sulfur Gypsum Potassium sulfate

5.3.5 Micronutrients

Micronutrients are just as essential for proper turfgrass health as macronutrients but are required in very small quantities compared with macronutrients. Micronutrients include iron (Fe), manganese, boron, copper, zinc, molybdenum, and chlorine. They play a variety of roles in turfgrass biology, including roles in photosynthesis, nitrogen fixation, and protein synthesis. Micronutrient deficiencies can be confirmed by tissue testing or small fertilizer applications to turfgrass to verify fertilizer response. Soil testing for micronutrients is not recommended, and soil interpretations for these nutrients can be ignored.

Iron and manganese deficiency symptoms can be common in bluegrasses and bentgrass during summer. Deficiency symptoms include yellow colored (chlorotic) turfgrass that does not respond to N fertilization. In many instances, N fertilization intensifies the chlorosis. The chlorosis is most severe when soils are warm, wet, and have high pH (>7.3). It is believed that root function is lost under these conditions. As a result, foliar Fe and manganese applications effectively corrects the deficiency. Deficiency symptoms subside as the soil cools in the fall.

5.4 Soil pH

Soil pH influences nutrient availability and microbial communities. Unlike some pH-sensitive plant species, turfgrasses are largely pH-independent. The dense and fibrous root system of turfgrasses allow the plants to thrive across pH ranging from 5.5 to 8.0. The ideal soil pH for managing most turfgrasses is 6.5 because most nutrients are available at this slightly acidic level.

Soils in Idaho vary widely due to topography, climate, and origin. In southern Idaho, most soils have a high pH (alkaline) and contain very little organic matter. At high pH values, iron in the soil is not available to turfgrass roots, resulting in iron chlorosis. This hinders chlorophyll production and turns turfgrass dull green to yellow. Elemental sulfur amounts needed to lower soil pH are provided in Table 7.

Northern Idaho soils can have a relatively low pH (acidic) and contain considerable organic matter. Some of these soils may need the pH adjusted upward with lime. A lime requirement test may be included in the soil test results, which will indicate the total amount of limestone needed to raise the soil pH to the optimum level. In general, fairways should not receive more than 100 pounds of limestone per 1,000 square feet in any single application. Golf course greens should receive no more than 25 pounds per 1,000 square feet per application. If a soil requires more limestone than can be applied in a single application, semiannual applications can be made until the suggested requirement is met.

Table 7. Approximate amounts of elemental sulfur needed to lower pH for various soil textures.

Change in pH Desired	**Pounds sulfur/1,000 feet^2**		
	Sand	**Loam**	**Clay**
8.5 to 6.5	46	57	69
8.0 to 6.5	28	34	46
7.5 to 6.5	11	18	23
7.0 to 6.5	2	4	7

Source: *Interpreting the NDSU Soil Test Analysis for Managing Turfgrass*, NDSU.

5.5 Soil Testing

Soil tests estimate nutrient availability and predict a plant's response to an applied nutrient. Accurate and consistent sampling and analysis provide useful soil test information over time. Soil test sampling and analytical testing recommendations include the following:

- Conduct soil sampling at a 4-6" depth from representative areas of similar management.
- Exclusively use one trusted soil testing laboratory.
- Use the Mehlich-3 pH independent method for soil testing.
- Use paste extract testing and tissue testing for additional information on nutrient availability and uptake, if needed.

Soil testing is best for providing guidance for soil pH, organic matter content, plant available phosphorus and potassium, and salinity and soil sodicity. Soil test result recommendations for other nutrients are not supported by turfgrass science. The best way to utilize soil testing is to monitor changes in the nutrients over time. Declining soil test phosphorus and potassium, for example, indicates that fertilization with P2O5 and K2O should be increased relative to the N fertilization rate, unless the values for those nutrients are deemed to be high. Nitrogen fertilizer drives the uptake of all other nutrients in turfgrass. Therefore, P2O5 and K2O should be looked at relative to the N fertilization rate and not just the total amount applied.

For more information on testing, see the University of Idaho Extension's Soil Testing to Guide Fertilizer Management.

5.6 Managing Soil Salinity

When salts accumulate in soils, problems arise for two main reasons: the soil becomes less permeable, and salt damages or kills the plants. The major source of salinity problems is usually irrigation water, with the effects being seen after time as more salt is added to soil than is removed. Other reasons for accumulated salts in soils include lack of rain and naturally sodic soils.

Salt buildup can result in three types of soils: saline, saline-sodic, and sodic. Saline soils contain enough soluble salts to injure plants. Saline-sodic soils are like saline soils, except that they have significantly higher concentrations of sodium salts relative to calcium and magnesium salts. Sodic soils are low in soluble salts but relatively high in exchangeable sodium. Routine soil testing can identify soil salinity levels and suggest measures to correct any specific salinity problem in the soil.

Salt-affected soils can be corrected by:

- Improving drainage.
- Leaching.

- Reducing evaporation.
- Applying chemical treatments.

More information on managing saline soils, saline-sodic soils, and sodic soils can be found in the NRCS publication Plants for Saline to Sodic Soil Conditions.

5.7 Nutrient Management Planning

Nutrition programs are ultimately designed to supply nutrients to the turfgrass as they diminish over time. For example, nutrients can leave a turfgrass system through soil and water runoff, nutrient leaching, volatilization, and mowing. Nutrients can also be temporally removed from a system through processes of nutrient fixation and immobilization. Nitrogen is particularly difficult to manage because it can be quickly immobilized and then mineralized depending on a soil's physical, chemical, and biological properties. Therefore, the goal of a successful nutrient management program should be to sustain even levels of plant-available nutrients for a uniform growth rate and sustain adequate recuperative potential to meet expectations of quality and turfgrass performance, while minimizing excessive growth and the risk of nutrient loss to the environment. Nutrient management planning uses four management practices:

- Apply the most appropriate type of fertilizer.
- Apply fertilizer at the right rate.
- Apply fertilizer at the right time.
- Apply fertilizer in the right place.

To improve application efficiency, a spatial assessment of nutrient requirements that calibrate nutrient applications to plant growth can be performed. Using Minimal Levels of Sustainable Nutrition (MLSN) soil nutrient interpretation guidelines and the turfgass growth potential (GP) model, nutrient needs can be predicted based on variable plant demand through the growing season. This approach ensures nutrients are applied in amounts and at times when plants are most capable of uptake and utilization and can effectively reduce costs in nutritional programs through reduced applications. For more information on MLSN guidelines, see also the MLSN Cheat Sheet.

5.8 Nitrogen Fertilization

Nitrogen is the most important nutrient managed by golf course superintendents as it drives turfgrass growth rate. During the growing season, slow growth is an indication of low soil N status. Alternatively, excessive amounts of growth typically indicate there is large pool of available N. That fertilizer may have come from fertilizer application or organic N mineralization within the soil. Research on a Kentucky bluegrass lawn shows that only 1 pound of the 3 pounds of N taken up during a year came from synthetic fertilizer. The remainder came from the soil or clippings.

Soil N mineralization is typically greatest right after winter (during spring greenup) and when the soil is warm and wet at mid-summer. During these periods, turfgrass growth rate is accelerated and N fertilization should typically be avoided. Optimum N fertilization times occur when soil nitrogen mineralization is low. To help schedule N application timings, monitor turfgrass performance, including color, growth rate, and traffic recovery. Best cool-season turfgrass application times are in late spring and early fall. Warm season turfgrass should be fertilized after greenup and again in mid- to late summer. Late summer applications can help sustain the green color of warm-season grasses into the fall. Nitrogen fertilizer should not be applied after mid-October because uptake is low and loss to the environment is greatest. Winter has been shown to be the period of greatest nitrogen loss from leaching and runoff when the soil is frozen.

Soils with high levels of organic matter generally have more mineralization than newer turfgrass stands with less organic matter. As a result, N fertilizer requirements are higher in new turfgrass stands than well-established turfgrass stands. Those requirements decline as the turfgrass stand ages. The exact time depends on many management, use, and soil factors.

5.8.1 Nitrogen Application Rates

Turfgrass is extremely responsive to N fertilizer. Highly maintained turfgrass areas (greens and tees) are traditionally fertilized by “spoon-feeding” small amounts of N frequently. This approach has several advantages. First, the small quantity of N (typically sprayed on the turfgrass) presents a smaller risk for a large leaching or other loss event. Light and frequent applications also increase control because managers can vary fertilizer rates and intervals based on turfgrass performance. Highly soluble sources are recommended for these applications because they are fast-acting and short-lived. Application rates when spoon-feeding with soluble N sources typically range from 0.1 to 0.5 lb of N per 1,000 ft^2. Applications at rates above 0.75 lb of N per 1,000 ft^2 increases the risk of fertilizer burn and N loss. In most cases, fertilizer should be watered-in with 0.2” of irrigation or less to minimize the risk of burn or nutrient loss.

Less intensively managed turfgrass areas are traditionally treated with granular products, which can range from 100% water soluble products to 100% controlled-release products. Most application rates range from 0.5 to 2.0 lbs of N per 1,000 ft^2 (Table 8). Lower rates are more common for quick-release fertilizers and fertilizers with a small size guide number (SGN), with the median prill diameter in millimeters x 100. Products with SGN < 100 are best for putting greens, 120-180 for fairways, and >200 for roughs. Higher N rates are most common with large SGN products and products that have very slow-release characteristics. Some slow-release fertilizer products can release fertilizer over a period of 75 days to 120 days after application. An obvious advantage is fewer applications. However, the manager forfeits control and little can be done if the turfgrass grows too rapidly following an application.

Table 8. Annual nitrogen application rates.

Turf managed area and species	Pounds of actual N / 1,000 sq. ft. annually*
Greens	

Bentgrass	1-3
Annual bluegrass	2-5
Tees	
Creeping bentgrass	1-3
Annual bluegrass	2-5
Kentucky bluegrass	2-6
Perennial ryegrass	2-6
Buffalograss	1-3
Fairways	
Creeping bentgrass	1-3
Kentucky bluegrass	2-6
Perennial ryegrass	2-5
Buffalograss	0-3
Roughs	
Kentucky bluegrass	1-4
Perennial ryegrass	0-4
Turf-type tall fescue	0-2
Buffalograss	0-3
** Annual N fertilizer rates will be affected by soil organic matter, climate, length of growing season, cultural practices, traffic, and aesthetic expectations. Mature turfgrass sites with little traffic may require little to zero N. However, new sites that are highly trafficked may require more than the values in this table.*	

5.9 Phosphorus and Potassium Recommendations

The goal of P and K fertilization is to supply enough to sustain healthy turfgrass growth yet minimize unnecessary cost and environmental risk. Soil test calibration and interpretations suggest that soil test P levels should remain above 20 ppm Mehlich-3 P. Potassium levels should be greater than 40 ppm Mehlich-3 K. To ensure a margin of safety, turfgrass managers should strive to keep soil test P levels between 25 ppm and 50 ppm and K between 40 ppm and 80 ppm.

5.10 Fertilizer Applications

Because N and P are two of the major sources contributing to both surface and groundwater pollution, fertilizers must be applied using practices that will prevent runoff and leaching, including removing any that are accidentally applied to impervious surfaces. Sandy soils often have a lower potential to fix P and are more likely to have a leaching problem than other soils. Fertilizer applications should be avoided whenever possible on steep slopes and should not be allowed to be deposited on impervious surfaces, such as paved cart paths and parking areas. To prevent both runoff and leaching, avoid applying fertilizer to soils that are at, or near, field capacity or following rain events that leave the soils wet. In addition, maintaining a vegetated buffer or filter strip around surface waterbodies significantly filters out any nutrients in surface runoff.

The selection and calibration of application equipment is another important aspect of nutrient management. Not all fertilizers can be spread with every spreader. For example, if sulfur-coated urea is spread through a drop spreader, the sulfur coating could be damaged, essentially leading to an application of soluble urea. Therefore, choosing the appropriate spreader for a given material (walk-behind rotary drop spreader, bulk rotary, or spray) is important.

Accurately calibrated sprayers or spreaders are essential for proper application of fertilizers. Incorrectly calibrated equipment can easily apply too little or too much fertilizer, resulting in damaged turfgrass, excess cost, and greater potential of nutrient movement off-site. An excellent resource for spreader care and calibration can be found at Penn State Extension's Calibrating Your Fertilizer Spreader. Spreaders should also be thoroughly cleaned after use due to the high salt content that corrodes metal parts and in keeping with the BMPs for equipment washing.

5.11 Nutrient Management 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.
- Because turfgrass is extremely responsive to soil N status, evaluate changes in clipping yield during the growing season to estimate N availability.
- Reduce N inputs on more mature turfgrass stands.
- Use N fertilizer to produce an even growth rate. This increases golf course playability and minimizes the risk to the environment, while excessive fertilization reduces playability and increases the risk of N leaching.
- Use soluble N sources (0.05-0.50 lb N per 1,000 square feet) to fine-tune clipping yield on highly managed turfgrass surfaces.
- Fertilizer products with a blend of quick- and slow-release fertilizer are often applied to non-intensively managed areas. Optimum timing for cool-season species are late spring/early summer and again in late summer/early fall.
- Summer fertilizer applications can benefit young turfgrass stands or stands growing on poor soils.
- Apply fertilizer when turfgrass is actively growing to minimize loss.
- Light irrigation after P application has been shown to reduce P runoff.
- Maintain dense turfgrass stand through proper nitrogen fertilization to reduce soil runoff.
- Monitor K and P by testing soil regularly.

Fertilizer Applications

- Prevent fertilizers from being deposited onto impervious surfaces.
- Avoid applying fertilizer to soil at or near field capacity or following rain events that leave the soil wet.
- Do not apply fertilizer when heavy rains are likely.
- Do not apply fertilizers to dormant turfgrass or when ground is frozen.
- Maintain buffer areas around waterbodies. The buffer areas should not be fertilized.
- Choose the appropriate type of spreader for a given fertilizer.
- Calibrate application equipment regularly.
- Clean application equipment following use.

6 Cultural Practices

Preface

Cultural practices play a large role in turfgrass quality. Proper cultural management can help produce a dense, healthy turfgrass playing surface. These practices are used on all areas of a golf course and include a variety of methods, such as mowing, cultivation, cultivar selection, and rolling. Cultural practices typically manage the top 3-4” of soil and improve plant nutrient/water uptake and the overall health of the plant.

6.1 Mowing

Mowing is the most commonly used cultural practice on golf courses. Mowing practices impact turfgrass density, texture, color, root development, and wear tolerance. Failure to mow properly results in weakened turfgrass with poor density and quality (Figure 9). Mowing height, frequency, equipment, time of year, abiotic and biotic stress, root growth, and shade can all affect mowing quality. As much as possible, mowing should increase tillering and shoot density while not decreasing root and rhizome growth.

Figure 9. Mowing practices can cause injury to turf.

6.1.1 Height of Cut

Height of cut (HOC) is important for a healthy playing surface. Proper mowing HOC is a function of the species/cultivar being managed and the intended use of the site. While taller grown turfgrass is more likely to withstand pests and stresses, many golfers prefer a well-groomed turfgrass stand for both playability and aesthetic appeal.

Various HOCs are used on different locations on a golf course. The table shown below shows recommended HOC for turfgrass species (Table 9). These HOC ranges maximize turfgrass density, assuming water, nutrient, and cultivation needs are being met. A rule of thumb is that no more than one-third of the plant should be removed at one time to avoid scalping. Removing more than one-third reduces turfgrass density and can result in a dramatic reduction in root growth.

Mowing heights can vary seasonally, due to such factors as sun availability, weather, and drought stress. Throughout the heat of the summer, lower cuts increase stress. Therefore, a higher HOC is recommended to help insulate the crown from heat stress, reduce weed competition, and reduce water needs. During the spring and fall, when exposure to sunlight is reduced, mowing frequency and mowing heights should be adjusted to correlate with decreased turfgrass growth rates. In shaded areas, photosynthetically active radiation is restricted, and turfgrass response is to grow upright in an effort to capture more light to meet photosynthetic needs. To counterbalance this effect, mowing HOC should be increased for turfgrass grown in shaded environments.

Table 9. Mowing HOC recommendations by species and location.

Turf Species	**Greens**	**Tees, Collars, Approaches**	**Fairways**	**Roughs**
	(in inches)			
Creeping bentgrass	0.10 – 0.16	0.20 – 0.60	0.25 – 0.5	-
Kentucky bluegrass	-	0.25 – 0.8	0.25 – 0.8	2 – 4
Annual bluegrass	0.10 – 0.16	0.20 – 0.60	0.25 – 0.5	-
Perennial ryegrass	-	0.40 – 0.6	0.40 – 0.6	2 – 4
Tall fescue	-	-	-	2 – 4
Fineleaf Fescue	-	0.40 – 0.80	0.40 – 0.80	2 – 4
Buffalograss	-	-	0.60 – 0.75	1.5 – 3

6.1.2 Frequency

Mowing frequency should be based on vertical leaf growth to maintain an optimal root-to-shoot ratio. Turfgrass plants mowed too low require a substantial amount of time to provide the food needed to produce shoot tissue for future photosynthesis. If turfgrass 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 slough off the unneeded roots. Conversely, root growth is least affected when following the one-third rule. Under extremes such as heat, drought, heavy traffic or certain cultural practices, such as aeration, decrease mowing frequency.

6.1.3 Patterns

Mowing patterns influence both the aesthetic and functional characteristics of a turfgrass surface. Changing the direction of cut is used to prevent excessive lateral growth and to avoid lay over, providing a cleaner playing surface and an easier maintained HOC (Figure 10). While patterns should be varied regularly throughout the course, the direction of cut should be changed on putting greens every time it is mowed, including changing the direction of cleanup and skipping some cleanup mows. Varying mowing patterns also provides aesthetic value.

6.1.4 Clipping Management

Turfgrass clippings are a source of nutrients, containing 2% to 4% N on a dry-weight basis, as well as significant amounts of P and K. These nutrients can be sources of pollution and should be handled properly to avoid contaminating water resources. Clippings should be returned unless the presence of grass clippings will have a detrimental impact on play, such as on greens, or when the volume of clippings is so large that it could smother the underlying grass. When possible, collecting and measuring clipping yield can assist in determining growth rates, the need for fertilization, and scheduling plant growth regulator (PGR) applications.

Collected clippings should be disposed of properly to prevent undesirable odors near play areas and to prevent a fire hazard due to the heat generated by composting that can occur when clippings accumulate. Consider composting clippings or dispersing them evenly in natural areas where they can decompose naturally without accumulating in piles, though care should be taken to ensure that clippings are free from pesticides.

6.1.5 Mowing Equipment

Different mowing equipment is typically used on different locations of a golf course. For example, reel mowers are ideally suited for maintaining turfgrass stands that require HOC below 1.5” and provide the best quality cut when compared with other types of mowers. Rotary mowers, when sharp and properly adjusted, deliver acceptable cutting quality for turfgrass cut above 1” in height (Figure 11). Flail mowers are most often used to maintain infrequently mowed areas.

Maintaining blades by sharpening and adjusting them regularly provides the best quality cut. Dull blades shred leaf tissue, increase water loss, and increase the potential for disease development.

Figure 10. Rotary mower.

6.2 Aeration

Cultivation practices – aeration practices and surface cultivation practices – disturb the soil or thatch through the use of various implements to achieve important agronomic goals that include relief of soil compaction, increased microbial activity, thatch/organic matter reduction, and improved water and air exchange. Aeration practices consist of core aeration, deep drilling, solid tining, and high-pressure water injection. Light and frequent sand topdressing applications are also beneficial for smoothing the surface, diluting organic matter, and improving playability.

Aeration frequency depends upon traffic intensity, thatch/organic matter buildup, black layer and level of soil compaction. Even though aeration is very beneficial, it disturbs the playing surface and takes some time to heal. Table 10 shows advantages and disadvantages of multiple aeration practices.

Table 10. Aeration practices.

Method	Compaction relief	Surface disruption	Water/air movement	Disruption of play
Hollow-tine aeration	High	Medium	High	Medium to High
Solid-tine aeration	Low	Low	Low to Medium	Low to Medium
Deep-tine aeration	Medium	Medium	High	Low to Medium
Deep drilling	Medium	Medium	High	High
Sand injection	Medium	Low	High	Low
High-pressure water injection	None	Low	Medium	Low

6.2.1 Hollow-tine Aeration

Hollow-tine (or core) aeration is effective at relieving soil compaction, improving internal soil drainage and increasing oxygen in the soil (Figure 12). Aeration involves physically removing cores, varying in depth, diameter, and distance apart. Table 11 shows different core sizes used for aeration.

Table 11. Core size options for aeration.

Tine Size (in.)	Spacing (in.)	Holes/ft²	Surface Area of One Tine (in.)	Percent Surface Area Affected (Outside tine)
¼	1.252	100	0.049	3.4%
¼	2.52	25	0.049	0.9%
½	1.252	100	0.196	13.6%
½	2.52	25	0.196	3.4%
5/8	2.52	25	0.307	5.3%

Figure 11. Hollow-tine aerification of a green.

6.2.2 Deep-tine Aeration

Deep-tine aeration loosens soils and creates aeration channels to a depth well below that of conventional core aerification (Figure 13). It is also used to improve air, water, and nutrient movement through layered, poorly drained soils. Following deep-tine aeration, relatively large amounts of topdressing soil or organic matter can be added to the turfgrass root zone.

Either hollow tines or solid tines may be used in deep-tine aeration; solid tines are often preferred when cultivating heavily compacted clay soils or gravelly soils for the first time. Cultivating with a conventional aerifier before using a deep-tine aerifier with solid tines may prove very beneficial. That's because the aeration channels created by the conventional core aerifier receive some of the soil displaced by deep-tine, solid-tine aerification and lessen the disruption of the turfgrass surface with fewer plants lifted from the soil.

Figure 12. Deep-tine aeration.

6.2.3 Deep Drilling

Deep-drill aeration creates deep holes in the soil surface 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 replacement of heavier soils with sand or other materials in an effort to improve water infiltration into the soil profile.

6.2.4 Sand Injection

Sand injection, which injects small columns of sand into the rootzone without removing cores, has been used recently as a supplement to traditional core aeration. The injection depth should be adjusted so the majority of sand is injected where it is needed most, often in the upper rootzone.

6.2.5 High-Pressure Water Injection

High-pressure water injection promotes water penetration and air exchange. Streams of water are injected at high velocities 4” to 8” into the soil at 1/8” to 1/4” diameter. High-pressure water injection doesn’t disrupt play.

6.3 Surface Cultivation

The goals of surface cultivation are to manage organic matter accumulation above the soil, reduce the formation of leaf grain, improve infiltration, and improve surface consistency (Table 12). These methods are generally less disruptive than traditional aeration practices and can quickly impact a large percentage of the turfgrass canopy. They usually have low to no impact on soil compaction.

Table 12. Surface cultivation practices.

Method	**Compaction relief**	**Surface disruption**	**Water/air movement**	**Disruption of play**
Vertical mowing	Low	Medium to High	Medium	Low to High
Spiking/slicing	None	Low	Low	None

6.3.1 Vertical Mowing

Vertical mowing can be incorporated into a cultural management program to achieve a number of goals. The grain of a putting green can be reduced by setting a verticutter to a depth that just nicks the surface of the turfgrass. Frequent, light vertical mowing minimizes grain formation. Deeper penetration of knives stimulates new growth by cutting through stolons and rhizomes while removing accumulated thatch. A more aggressive, deep vertical mowing can reach a depth of 0.5” to 1” and remove a greater amount of thatch compared with other cultivation practices. Even though it is beneficial, deeper vertical mowing should not be used when the grass is growing slowly because aggressive growth is needed to fill in disturbed areas.

6.3.2 Spiking/Slicing

Spiking/slicing promotes water infiltration with minimal surface damage. Slicing is faster than core aeration but is less effective. Spiking can break up crusts on the soil surface, disrupt algae layers, and improve water infiltration.

6.5 Rolling

Rolling can help smooth the putting surface and maintain speeds at higher HOC. Even with a raised HOC, rolling can increase ball roll by 10 percent. Light-weight rollers typically have little negative impact on soil compaction unless the practice is overutilized or is used on high silt and clay soils when saturated with water. Rolling can also be used to remove dew from the playing surface, reducing the possibility of dollar spot.

6.4 Topdressing

The primary goal for any sand topdressing program is to dilute organic matter and produce smooth, firm putting surfaces while minimizing golfer and mower impact. Sand topdressing improves the soil structure and can relieve surface compaction, improve drainage, increase water and air infiltration, and protect turfgrass crowns. The important considerations for a sand topdressing program include sand type, application rate, and application frequency.

6.4.1 Sand Type

When purchasing sand for topdressing, it is important to consider the source, cost, texture, and overall quality of the sand. For example, angular sand performs better than spherical shaped sand for topdressing. Two or more sand materials can be used for a topdressing program: a coarse type for aeration and topdressing when playability is less important (e.g. as part of winterization preparation) and another less-coarse sand that can be used for routine topdressing to minimize disruptions to play.

Topdressing with sand with greater than 25 percent fine material (0.15- 0.25mm) could potentially lead to problems associated with layering, such as increased moisture at the surface of the greens. Collecting soil cores and analyzing for physical characteristics every few years can be used to monitor putting green performance.

6.4.2 Application Rate and Frequency

Two application rates must be considered in a topdressing program: the rate for each topdressing event and the annual rate achieved from the sum of all topdressing events. An annual rate of 25 to 35 cubic feet of sand per 1,000 ft2 is a typical range for dilution of organic matter. Factors to consider in determining optimal topdressing rates include the length of the growing season, quality of the growing environment, turfgrass species and cultivar, nitrogen fertilization program, and traffic intensity.

Individual application rates must be considered in conjunction with the application frequency, as increasing application frequency decreases the topdressing application rate. Light and frequent topdressing (e.g. on the order of every 1 to 3 weeks) is usually recommended, which reduces the disruption to playing surfaces and is easier to apply and incorporate. Table 13 provides application rates for light and frequent topdressing. When necessary, an accelerated program can be followed to quickly improve rootzone conditions and playability.

For more information on topdressing recommendations, see "Light and Frequent Topdressing Programs" in the USGA Green Section Record.

Table 13. Light and frequent topdressing rates.

Quantity (ft^3/1,000 ft^2)	Quantity (lbs/1,000 ft^2)	Quantity (tons/acre)	Depth of Application (inches)
0.50	50	1.1	0.006
0.75	75	1.7	0.009
1	100	2.2	0.012

6.6 Wetting Agents

Wetting agents can be used for a number of reasons, such as treating dry spots; preventing dry spot development; to move water through the soil; improve irrigation efficiency; or as a spray adjuvant when applying pesticides or PGRs. Wetting agents are especially helpful when applied to sandy soils that can become hydrophobic (water repellent). Turf grown on sand-based root zones can develop severe localized dry spots (LDS) especially when the stand is irrigated deep and infrequently. Surfactants help promote water infiltration into these hydrophobic areas which prevents and alleviates LDS.

Research shows preventative applications can increase soil water uniformity and sustain high visual turfgrass quality at very low levels of irrigation (30% pET). Preventative applications of wetting agents can also increase irrigation precision, which reduces water use while maximizing playing conditions. In addition, their use can reduce the electrical usage and wear and tear on pumps associated with irrigation systems. Late fall applications may reduce water repellency in soils well into the spring, reducing the potential for LDS in the spring. In Idaho, the benefits of a late fall application will typically last until April.

For more information on wetting agents, see the USGA publication Understanding Wetting Agents.

In addition to a variety of chemistries available for wetting agent products, natural options to improve water movement in the soil include yucca extracts and gypsum (calcium sulfate).

6.7 Plant Growth Regulators

Plant growth regulators are frequently used to reduce clipping yield, improve stress tolerance, and improve turfgrass quality and performance. An additional benefit of using PGRs is a reduction in the use of other inputs (e.g. fertilizers). PGRs require frequent reapplication during the growing season to maintain consistent growth suppression, but excessive PGR use can result in a number of undesirable side effects. These side effects might include mild discoloration, stressed turfgrass, and segregation of grasses like creeping bentgrass and annual bluegrass. These effects can be confused with disease and can intensify damage from pests and traffic.

The best approach to planning PGR applications is to use growing degree day (GDD) thresholds instead of a calendar-based schedule. Free tools are available online for assistance in using GDD information to schedule PGR applications, including the web-based app GreenKeeper. For more information on using GDD to schedule PGR applications, see the article "Looking at GDD: The Perils of PGR Over-Regulation."

6.8 Winterization

Because of Idaho's cold winters, a number of measures should be taken to reduce the risk to turfgrass from winterkill, which is caused by a combination of stresses such as desiccation, low temperatures, ice sheets, and snow mold. In addition, temperature fluctuations in the late winter/early spring when warm weather is followed by a rapid decrease in soil temperature can result in lethal freezing temperatures at the crown level.

The first defense against winterkill is appropriate turfgrass selection. Although cool-season turfgrasses are adapted to colder climates, certain species and cultivars may still be susceptible to winter injury. Overall, freezing tolerance is determined by the ability of plants to cold-acclimate in the fall and by the capacity of plants to maintain freezing tolerance throughout the winter and early spring. Both cold acclimation and maintenance of freezing tolerance are influenced by environmental conditions (such as temperature and moisture) and plant genetics (such as the species or cultivar). Some species, such as bentgrass, have generally good winter survival rates, but are susceptible to snow molds and therefore preventative applications of fungicides should be applied in the fall. Turf breeding programs and NTEP trial results from neighboring states with similar climates and Canada can be consulted for evaluation of appropriate cool-season species and cultivars. Minimizing *Poa annua* populations can decrease winterkill, as winter stress tolerance in *Poa* is very poor both in terms of tolerance of ice encasement and susceptibility to pink snow mold.

Measures for preparing turfgrass for dormancy include appropriate nutrient management planning, sand topdressing, pesticide applications to prevent snow mold, and covering the turfgrass surface. For example, turfgrass should not be overfertilized with N in the fall; PGRs should not be used too close to the time of dormancy; and field capacity should be reached before installing covers. The use of antidessicants, permeable or impermeable covers, wood mulch, straw, etc. can help to prevent or minimize winterkill.

Figure 13. In some cases, superintendents may choose to remove accumulated snow from a green.

For more information on winterkill and winter preparation, see the following publications:

- Preparing Golf Course Turf for Winter
- Winterkill of Turfgrass
- Comprehensive Guide to Winter Turf Damage and Recovery in the Northern United States
- Fighting Desiccation: Should We Water Turf in the Winter?

6.9 *Cultural Practices Best Management Practices*

Mowing

- Follow the recommended HOC for different turfgrass species.
- Raise HOC by at least 30% in heavily shaded areas to improve turfgrass health.
- Routinely use plant growth regulators, if needed, to improve overall turfgrass health in shaded environments.
- Increase HOC in times of stress such as heat, drought, or prolonged cloudy weather to increase photosynthetic capacity and rooting depth of plants.
- If turfgrass becomes too tall, it should not be mowed to the desired height all at once. Tall grass should be mowed frequently and HOC gradually decreased until the desired HOC is achieved.
- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods.
- Decrease mowing frequency and increase HOC when the turfgrass is stressed.
- Change mowing patterns on all locations of the golf course.
- Change direction of mow on greens every time they are mowed.
- Rarely use inefficient mowing patterns (e.g. 9-3) on areas other than putting greens to save time, fuel, and labor.
- Return clippings to the canopy whenever possible.
- Use compressed air to blow off clippings from mowing equipment over grassed areas and before washing equipment.
- Collect pesticide-free clippings and compost or distribute in natural areas, away from surface waters.
- Use proper mowing equipment.
- Regularly sharpen and adjust blades.

Aeration

- When thatch levels are excessive, core aeration programs should be designed to remove 15% to 20% of the surface area and to minimize grain formation.
- 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 in the spring and fall to aid in quick recovery of surface density.
- Aeration events should be as deep as practical to prevent development of compacted layers in the soil profile as a result of cultivation.
- Consider timing of core aeration to avoid the period of Poa annua (annual bluegrass) seed head formation.
- Backfill holes with new root-zone materials if a drill-and-fill machine is used.
- High pressure water injection can be applied once every three to four weeks throughout the summer.

Surface Cultivation

- Initiate vertical mowing when thatch level reaches 0.25-0.5" in depth. Shallow vertical mowing should be done at least monthly on putting greens to prevent excessive thatch accumulation.
- 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.
- Aggressive or deep vertical mowing should not be used when the turfgrass is growing slowly.
- Frequent shallow vertical mowing on putting greens prevents excessive thatch buildup and grain formation.

Topdressing

- Assess rootzone physical characteristics regularly by analyzing core samples to determine topdressing needs and evaluate the topdressing program.
- Know the sand source and ensure that sand is weed-free, uniform, and of appropriate quality.
- Use silica sand if possible because of its tolerance to weathering.
- Determine a rate and frequency for each topdressing event based on an annual topdressing goal, adjusting if needed to match growth and organic matter accumulation.
- Use light and frequent topdressing applications with or without aeration, according to Table 13.
- Aeration backfill should closely match the physical characteristics of the sand used at construction, but routine topdressing sand can be somewhat less coarse to ease incorporation and reduce wear on mowers.
- Light sand topdressings can be effectively brushed, rolled, or irrigated into the turfgrass canopy.
- Double-mowing and increasing the frequency of clip should be avoided following topdressing to reduce sand harvesting and wear on mowers.

Rolling

- Roll putting surfaces following mowing to increase putting speeds and allow for improved ball roll without lowering HOC.
- Avoid rolling on saturated soils to avoid compaction.
- Use lightweight rollers to minimize potential compaction.

Wetting Agents

- Preventative applications of wetting agents should be made to high risk (sandy) soils.
- Frequent preventative applications limit development of localized dry spot and increase soil water uniformity.

- Water-in wetting agents sufficiently.
- Apply wetting agents in the late fall to reduce water repellency in soils and reduce the potential for localized dry spot.

PGRs

- Use GDD to plan PGR use; free web-based applications such as GreenKeeper can help plan applications.
- PGRs should not be applied too early or too late in the growing season to avoid stressing turfgrass

Winterization

- Evaluate cold hardiness when selecting turfgrass species and cultivars.
- Minimize Poa, especially on greens, which are more likely to succumb to winterkill than fairways because of the increased stress associated with golf greens.
- Use covers to maintain cold hardiness of turfgrass into the spring when possible.
- Do not overfertilize with N late in the growing season.
- Apply fungicides preventatively for snow mold.
- Topdress with sand in the fall.
- Eliminate the use of PGRs before dormancy.
- Reach field capacity before adding covers (if used).
- If covers are available, use them in the spring on severely damaged greens to increase temperatures, especially on warm, sunny days, and speed up the recovery process.
- Follow turfgrass establishment BMPs when reseeding areas damaged by winterkill.

7 Integrated Pest Management

Preface

IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. IPM utilizes regular monitoring and record keeping to determine if and when treatment is needed. This approach takes the form of a combination of strategies and tactics to prevent unacceptable damage. When warranted and after a considered selection process, pesticides can be used following state and federal regulations.

7.1 Regulatory Considerations

7.1.1 Pesticide Usage

As described in detail in the next chapter ("Pesticide Management"), pesticide usage needs to follow state and federal regulatory requirements. The label is the law and must be followed at all times.

7.1.2 Prescribed Burns

Prescribed burns can be part of an IPM program to control weeds and other growth in Idaho during the closed fire season (typically May 10 to October 20) and require a permit from the Idaho Department of Lands (IDL).

Before burning, the current status of fire restrictions should be reviewed. Fire danger ratings are calculated using grassland fuel moisture, forecast temperature, humidity, and wind speed. During severe, extended dry conditions, or drought, the governor may issue a proclamation mandating restrictions on prescribed burns. Local governments may institute burn bans and reference these restrictions regardless of fire danger and independent of a governor's proclamation. Local bans may be more restrictive but not less than what is identified in the state proclamation for the same area.

Figure 14. Prescribed burns, like the one in the background, help control undesirable plants.

7.1.3 Invasive Species

The Idaho Invasive Species Act of 2008 prohibits the introduction or transportation of listed invasive species without a permit. While the incidental presence of invasive species at a facility does not require any action upon the part of the facility, it will be helpful to know the listed recognized plant, animal and invertebrate species in the state (as published in the Rules Governing Invasive Species and Noxious Weeds) and endeavor to prevent their spread.

7.1.4 Noxious Weeds

Idaho has 67 weed species and 4 genera designated noxious by state law; 51 of these species are terrestrial and 16 species are aquatic. Property owners are required by state statute to control noxious weeds on their property.

7.2 IPM Overview

IPM is comprised of a range of pest control methods or tactics designed to prevent pests (insects, pathogens, nematodes, weeds, etc.) from reaching economically or aesthetically damaging levels while creating the least risk to the environment. IPM programs have basic components that provide the opportunity to make informed decisions on the control of pests at a golf course. Five steps for an effective IPM program for turfgrass are as follows:

Step 1: Monitor pests and their damage and record information.

Step 2: Identify pests and understand their biology.

Step 3: Determine threshold levels.

Step 4: Consider a variety of control methods.

Step 5: Evaluate the IPM program.

IPM is flexible, and superintendents can usually balance course quality and environmental goals through its implementation. Growing healthy turfgrass is the best and first line of defense against pests. For example, cultural conditions that predispose turfgrass to diseases include close mowing, inadequate or excessive nitrogen fertility, frequent or excessive irrigation, inadequate thatch management, poor drainage, and shade. Following cultural and nutrient BMPs can help alleviate these conditions. However, under the right conditions, pests can sometimes cause excessive damage to highly managed turfgrass.

A number of non-chemical and chemical control options are available. When chemicals are needed, selection of an appropriate pesticide should follow an evaluation process that considers potential impacts on beneficial organisms and the environment, as well as the potential for development of pesticide resistance. Pesticide products should be rotated, based on their resistance classification.

7.3 Monitoring Pests and Recording Information

In the IPM plan, pest monitoring or “scouting” efforts should be described for all areas of the course such as putting greens, tees and fairways, roughs, and landscaped areas. Scouting methods include visual inspection, soil sampling, soap flushes, and trapping for insects. Additional monitoring efforts can include weather tracking, which is especially helpful for predicting potential disease outbreaks.

Here is one potential scouting schedule:

- Daily on putting greens.
- At least weekly on tees and fairways.

- Twice a month on roughs.

Scouting efforts should increase when weather conditions are more favorable for increased pest pressure. For example, warmer temperatures combined with high humidity favor the development of diseases such as dollar spot and brown patch.

When pests are discovered during monitoring, the pest pressure should be quantified with measurements such as:

- Number of insects per unit area.
- Disease patch sizes.
- Percent of area affected.

Documentation should include useful information, such as photographs, delineation of pest boundaries on an area map, outbreak date, description of the prevailing weather conditions, and recent management practices. This information can be used to build a database for reference in future seasons and for updating the IPM plan.

7.4 Identifying and Understanding Pests

Once detected, pests must be properly identified. Understanding the biology of pest species and their vulnerable life stages assists in later control efforts. Just as important as identifying pests is recognizing and understanding beneficial organisms and their life cycles so their populations are not unduly negatively affected while managing pests. Superintendents and staff should continually hone their diagnostic skills by attending training seminars and field days, obtaining reference materials, and providing peer-to-peer training.

7.4.1 Diseases

In many cases, diseases develop when conditions are favorable, regardless of management strategies. However, the severity of disease is often greatly reduced by using cultural, biological, and genetic techniques. As a rule, healthy, well-managed turfgrass better withstands disease outbreaks and recovers more rapidly than unhealthy turfgrass. Some common diseases in Idaho include gray and pink snow molds, melting out, powdery mildew, fairy ring, summer patch, necrotic ring spot, and take all patch. For more information on some of these diseases and their control, see the Utah State University presentation Turf Diseases and Other Landscape Problems.

7.4.2 Weeds

High-quality turfgrass outcompetes seedling weeds for light, water, and nutrients, and thus prevents them from establishing large weed stands that decrease turfgrass playability and aesthetics. Weeds can also harm turfgrass by hosting other pests such as plant pathogens, nematodes, and insects.

The potential for invasive weeds can be limited through implementation of the BMPs identified in this document related to turfgrass selection, nutrient management programs, irrigation, and cultural practices. Some common Idaho turfgrass weeds include crabgrass, yellow nutsedge, annual bluegrass, and broadleaf weeds. The Turfgrass Weed Control for Professionals guide provides detailed weed identification and management information. The University of Idaho Extension publication Idaho's Noxious Weeds provides identification and distribution maps of the state-listed noxious weeds.

7.4.3 Nematodes

Plant-parasitic nematodes adversely affect turfgrass health by debilitating the root system of susceptible species, thus decreasing the efficiency of water and nutrient uptake. Turf weakened by nematode infestations favors further pest infestation, especially weeds. Over time, turfgrass in the affected areas thins out and, with severe infestations, may die. Turfgrass often begins showing signs of nematode injury during additional stresses, including drought, high or low temperatures, and wear.

7.4.4 Insects/White Grubs

Insects such as billbugs, chinch bugs, webworms, crane flies, and armyworms and cutworms are common turfgrass pests in Idaho. Armyworm and cutworm larvae feed at night on many varieties of turfgrass on the surface and then rest during the day. They are easier to detect using visual inspection and other methods based on irritating detergent-based solutions (soap flushes) to assess larval numbers.

White grubs are the larval stage of a group of beetles collectively known as scarabs (family Scarabaeidae). Among the white grub species causing turfgrass injury in Idaho are:

- May/June beetles, *Phyllophaga* spp. (three-year grubs).
- Northern masked chafers, *Cyclocephala* spp. (annual grubs).
- Black turfgrass ataenius, *Ataenius spretulus*.
- Japanese beetle, *Popillia japonica*.

White grubs can destroy significant areas of turfgrass, with damage appearing in summer. Summer drought stress and insufficient irrigation may compound the damage to turfgrass by grubs.

7.5 Determining Threshold Levels

A key feature of IPM programs is the identification of tolerance thresholds. Thresholds are based on the pest population, the stage of the pest, and the life stage of the plant. Injury thresholds represent the pest level population that causes unacceptable injury. Treatment thresholds are less than the injury threshold and indicate the number of pests or level of damage that would justify treatment to prevent the pest population from causing unacceptable turfgrass loss.

7.6 Control Methods

Once a pest problem reaches the established treatment threshold, different methods can be used to control the problem, including cultural, mechanical, biological, and chemical. Selecting the most appropriate approach depends on a number of factors, including the site-specific location on the golf course, efficacy of non-chemical controls for the particular situation, economics, and pest populations.

7.6.1 Cultural Controls

Cultural practices, especially irrigation, mowing, topdressing, core cultivation, and venting, greatly affect both short- and long-term plant health. Using and/or altering cultural practices, especially in times of stress, to keep plants and soil healthy helps turfgrass to better withstand pest pressure. It is important to recognize that turfgrass management practices such as core aeration and sand topdressing, while beneficial, can also stress turfgrass.

7.6.2 Mechanical or Physical Controls

Mechanical methods, such as vacuuming, or physical control methods, such as hand pulling weeds, exclude or remove pests, though these methods may be time consuming and work best when pest populations are low.

7.6.3 Prescribed Burns

As many golf courses convert maintained turfgrass areas to native grassed areas, many facilities use prescribed or controlled burns to reduce undesirable plants, including noxious weeds, and to encourage desirable species, enrich wildlife, and remove excessive plant debris. Prescribed burns are especially effective in suppressing cool-season grasses and woody plant materials to create a more desirable stand of a links-style course that resembles a tallgrass prairie. Use of a prescribed burn, along with other control methods, is an IPM approach to effectively manage these eco-sensitive areas. As noted in the “Regulatory Considerations” section of this chapter, any local notification requirements should be followed as required and all fire danger information reviewed before conducting a controlled burn.

7.6.4 Biological Controls

The biological component of IPM involves the release and/or conservation of natural predators, such as parasites and pathogens, and other beneficial organisms. Several organisms known to have some efficacy against turfgrass pests have been marketed as pest control products, such as such as Bacillus licheniformis. Natural enemies (e.g. ladybird beetles, green lacewings, and mantids) of some insect pests may be collected or purchased and released near pest infestations. Areas on the golf course can also be modified to better support natural predators and beneficial organisms, especially in landscaped areas.

7.6.5 Pesticides/Chemical Controls

Chemical control is an acceptable IPM practice when other methods will not alleviate the pest problem. Reduced-risk pesticides and biopesticides provide a number of advantages over conventional pesticides and should be considered if applicable. The selection and use of conventional pesticides should follow a selection process and these criteria:

- The pesticide must be registered for use in Idaho. A database of registered pesticide products is searchable online.
- The pesticide should be effective in treating the pest problem.
- The timing of the pesticide application should be based on growing degree day (GDD) information for the pest to be controlled. GDDTracker is an example of a tool that can assist in timing applications.
- Pesticide rotation, based on resistance classification, as classified by the Fungicide Resistance Action Committee (FRAC), Herbicide Resistance Action Committee (HRAC), and Insecticide Resistance Action Committee (IRAC).
- Costs should be considered.
- Environmental risk and potential for water quality impacts must be evaluated.
- Any restrictions on the pesticide label must be reviewed and rigorously followed.

Evaluating the environmental risk and potential for impact on water quality can include the use of software, such as the Windows Pesticide Screening Tooll (WIN-PST), which was developed by the U.S. Department of Agriculture's Natural Resources Conservation Service to evaluate the potential of pesticides to move with water and eroded soil/organic matter and to affect non-targeted organisms. WIN-PST users can select combinations of active ingredient, soil type, and growing conditions to select an active ingredient that has less potential to leach and/or run off into surface water.

The use of all pesticides should follow the label and adhere to state and federal regulations, as described in the “Pesticide Management” chapter.

Reduced Risk Pesticides and Biopesticides

USEPA's Conventional Reduced Risk Pesticide Program registers reduced-risk pesticides, which are commercially viable alternatives to conventional pesticides. The IDA maintains a database of registered pesticide products that includes reduced risk pesticides.

USEPA characterizes the advantages of reduced-risk pesticides as follows:

- Low impact on human health.

- Lower toxicity to non-target organisms (birds, fish, and plants).
- Low potential for groundwater contamination.
- Low use rates.
- Low pest-resistance potential.
- Compatibility with IPM practices. Biopesticides, which are derived from such natural materials as animals, plants, bacteria, and certain minerals, are classified separately by USEPA.

For more information on biopesticides, see the USEPA's Biopesticide Registration page.

7.7 Evaluation and Record Keeping

It is essential to record the results of IPM-related efforts to develop historical information, document patterns of pest activity, and evaluate successes and failures. Records of pesticide use are required for restricted-use pesticides For IPM purposes, records should be kept for all pesticide applications and should include additional information, such as monitoring records, weather records, cultural management logs, and pest response.

7.8 IPM Best Management Practices

- Develop a facility-specific, written IPM plan. Available resources for writing an IPM plan include the Golf Course Superintendents Association of America's IPM information and online tools.
- Select turfgrass cultivars and species recommended for use in areas with similar climate and best suited for the intended use and environmental conditions of the specific site.
- Correct the soil's physical and chemical properties that may impact turfgrass health and its ability to resist pests.
- Evaluate the potential impact of the timing of cultural practices and nutrient applications on the incidence of pest problems.
- Use a defined pesticide selection process to select the most effective pesticide with the lowest toxicity and least potential for off-target movement.
- Document all IPM-related activities, including non-chemical control methods and pesticide usage.

Monitoring Pests and Recording Information

- Monitor prevailing environmental conditions for their potential impact on pest problems.
- Train personnel how to regularly monitor pests by scouting or trapping.
- Identify alternative hosts and overwintering sites for key pests.
- Assess pest damage when it occurs, noting particular problem areas, such as the edges of fairways, shady areas, or poorly drained areas.

- Document when the damage occurred. Note the time of day, date, and flowering stages of nearby plants.
- Map pest outbreak locations to identify patterns and susceptible areas for future target applications.

Identifying and Understanding Pests

- Identify key pests in the IPM plan.
- Determine the pest's life cycle and know which life stage to target (e.g. for insect pests, whether it is an egg, larva/nymph, pupa, or adult).
- Identify pests accurately. For diseases, correctly identifying the disease pathogen often involves sending samples to a diagnostic laboratory.

Determining Thresholds

- Establish injury and treatment thresholds levels for key pests and document them in the IPM plan.

Control Methods

- Implement proper cultural, irrigation, and turfgrass management practices to reduce stress and pressure of pest establishment.
- Maintain a proper fertilization schedule to improve turfgrass density and quality and reduce pest populations.
- Make sure your materials, such as topdressing, are pest-free.
- Apply a preventative pesticide to susceptible turfgrass when unacceptable levels of disease are likely to occur.
- Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds.
- Divert traffic away from areas that are stressed by insects, nematodes, diseases, or weeds.
- When nematode activity is suspected, an assay of soil and turfgrass roots is recommended to determine the extent of the problem.
- Release insect-parasitic nematodes to naturally suppress insect pests such as white grubs.
- Identify areas on the golf course that can be modified to attract natural predators, provide habitat for them, and protect them from pesticide applications.
- Install flowering plants that can provide parasitoids with nectar or sucking insects (aphids, mealybugs, and soft scales) with a honeydew source.
- Avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- Follow a selection process when conventional pesticide use is warranted.
- Follow guidelines and advice provided by the FRAC, HRAC, and IRAC.
- Evaluate use of reduced-risk pesticides and biopesticides to treat the problem.

Prescribed Burns

- Follow local permitting requirements.
- Notify the following of when/where an open burn will occur: local fire department, municipality nearest the burn, county sheriff's department and any military, commercial, county, municipal or private airport or landing strip that may be affected by the open burn.
- Make sure the burn area is free of any debris.
- Ensure that the prevailing winds during the burn are away from any town/city or any occupied residence likely to be affected by the smoke to the best extent possible.
- Minimize the amount of dirt in the material being burned to reduce smoldering.
- Conduct open burns between three hours after sunrise and three hours before sunset to allow for smoke dispersion and to avoid air inversions that can trap the smoke at breathing level. Additionally, fuel should not be added outside the timelines listed above.
- Extinguish an open burn completely to ensure smoldering of material does not persist.
- Do not create a traffic hazard on any public road or airport right of way or obscure visibility.
- Use common sense precautions, such as having someone watching the fire until it is extinguished and assuring smoke does not impact residences or impair vehicular travel on highways.

Evaluation and Record Keeping

- After treatment, determine whether the corrective actions reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Observe and document turfgrass conditions regularly, noting which pests are present, so that informed decisions can be made regarding the damage the pests are causing and what control strategies are necessary.

8 Pesticide Management

Preface

Pesticide use should be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices. When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, site characteristics, and its solubility and persistence in the environment.

Storage and handling of pesticides in their concentrated form poses the highest potential risk to groundwater and surface water. For this reason, it is essential that facilities for storing and handling pesticides be properly sited, designed, constructed, and operated in accordance with federal and state regulations.

8.1 Pesticide Regulations

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the federal law regulating the manufacture, distribution, sale, and use of pesticides. The Idaho State Department of Agriculture regulates the registration, sale, distribution, use, storage, and disposal of pesticides under the authority of state laws and rules governing pesticides. The USEPA has also delegated to the ISDA primacy in areas relating to pesticide use and distribution.

Commercial pesticide applicators must be certified by the ISDA to apply both general use and restricted-use pesticides in Idaho. Private pesticide applicators must be state certified to apply restricted-use pesticides. Training resources and study materials are available on the ISDA website. Recertification is required for all certified applicators to ensure they maintain competency and keep current with changing technology. Licensed applicators can attend approved seminars to obtain credit in lieu of taking recertification exams.

8.2 Human Health Risks

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. Acute toxicity refers to a single exposure by mouth, skin, or inhalation, or repeated exposures over a short time. Chronic toxicity effects are associated with long-term exposure to lower levels of a toxic substance, such as ingestion in drinking water. Pesticide toxicity and level of exposure can be a risk to human health. This idea is expressed by the risk formula: Risk = Toxicity x Exposure. Therefore, risk can be held to an acceptably low level if the amount of exposure is kept low. A number of measures can be taken to mitigate risk of exposure, including:

- Reading the pesticide product label and complying with all directions.
- Dressing appropriately and using personal protective equipment (PPE).

- Storing, handling, mixing, and applying pesticides with caution and following all safety precautions.

Pesticide labels provide information on PPE and first-aid information specific to the product. Therefore, applicators should always read and follow the label before using a pesticide, in addition to following standard safety practices. Safety Data Sheets (SDS) provide important information on hazardous chemicals. In addition, exposure to pesticides can be mitigated by practicing good work habits and adopting modern pesticide mix/load equipment (e.g. closed loading) that reduce potential exposure. SDS for pesticides can be found in an online database of U.S. registered pesticide labels.

Potential routes of exposure to golfers include ones via shoes, clothing, and equipment. Pesticide labeling addresses re-entry restrictions, and any application should be allowed to thoroughly dry before play resumes.

For more information on human health related pesticide issues, see the University of Nebraska-Lincoln Extension publication Managing Pesticide Poisoning Risk and Understanding the Signs and Symptoms.

8.3 Personal Protective Equipment

PPE protects workers from exposure through one or more pathways: skin, eyes, oral ingestion, or respiratory tract. Pesticide labels list legal requirements for minimum PPE, such as specific types of clothing, goggles, and respirators. The type of PPE needed depends both on the toxicity of the pesticide and the formulation. If a pesticide label does not have specific PPE requirements, the route of entry and other information on the label can be used to determine the type and degree of appropriate protection. To avoid contamination, PPE should not be stored in a pesticide storage area. For more information on PPE, see the Pacific Northwest Pest Management Handbook's Pesticide Safety section.

8.4 Environmental Fate and Transport

Environmental characteristics of a pesticide can often be determined by the environmental hazards statement found on pesticide product labels. The environmental hazards statement (referred to as “Environmental Hazards” on the label and found under the general heading “Precautionary Statements”) advises the user of product specific concerns. Potential environmental impacts include toxicity to non-target organisms (such as pollinators) and contamination of surface water or groundwater. If endangered species are present on or near the course, labeling on applicable pesticide products directs users to the limitations found in the USEPA's Endangered Species Protection Bulletins.

The key to preventing pesticide impacts to water quality is an understanding of the physical and chemical characteristics that determine a pesticide's interaction with the environment: solubility, adsorption, persistence, and volatilization. Pesticide characteristics influence the potential for runoff, leaching, or drift. Once applied, pesticides can move off-site in several ways: in water, in air, attached to soil particles, and on or in objects, plants, or animals.

To prevent pesticides from moving off-site, pesticide characteristics, site-specific characteristics, and prevailing conditions should all be evaluated. Pesticide characteristics, such as solubility, and site-specific characteristics, such as soil type, depth to the water table, geology, and proximity to surface water, should be considered before selecting and applying pesticides. Prevailing weather conditions, such as the chance of precipitation, the prevailing wind, and humidity, should be evaluated with respect to the timing of pesticide applications.

8.4.1 Leaching and Runoff

Most pesticide movement in water is either by surface movement off the treated site (runoff) or by downward movement through the soil (leaching). Runoff and leaching may occur when:

- Too much pesticide is applied or spilled onto a surface.
- Too much rainwater or irrigation water moves pesticide through the soil off-site or into groundwater.
- Highly water-soluble or persistent pesticides are used.

Pesticide movement in soil and water is affected by its water solubility, adsorption by soil, and persistence. Pesticides with greater adsorption by soil are less likely to be moved by leaching or surface runoff but can be carried to surface water with eroding soil. In addition to following the pesticide BMPs to reduce the likelihood of pesticides moving off-site in surface runoff, the use of buffer strips (as discussed in the “Water Management” chapter of this document) slow down runoff and allow pesticides to adhere to soil particles and plant tissue, preventing contamination of surface water.

Pesticides with less adsorption by soil are more likely to leach through the soil and reach groundwater. For example, if rainfall is high and soils are permeable, water that carries dissolved pesticides may take only a few days to percolate down to the groundwater.

8.4.2 Drift

Air movement causing pesticide transfer away from the application site is called drift. Pesticides may be carried off-site in the air as spray droplets, vapors, or even on blowing soil particles, as follows:

> *Spray drift:* Airborne movement of pesticide particles to non-target sites during application.

Vapor drift: Volatilization of particles from plant and other surfaces during and after application and movement as a gas or vapor to a non-target site in sufficient concentrations to affect plant processes.

The potential for spray drift is strongly related to droplet size; smaller droplets have smaller mass and remain airborne and exposed to air movement longer than larger droplets. Equipment selection and operation characteristics, such as nozzle type, spray pressure, nozzle spray angle, and spray volume, impact the potential for spray drift. Weather-related considerations that can influence the potential for spray drift include wind speed, wind direction, air stability, relative humidity, and temperature.

The formulation of combination products as an amine or ester can also impact the potential for drift. Esters have higher vapor pressures than amines, but typically provide better weed control. In cooler weather, ester formulations can often be used safely. In higher temperatures, the risk of volatilization increases and calls for switching to an amine formulation if drift is a concern.

Vapor drift can sometimes be difficult to predict and depends on the factors such as the pesticide's chemical characteristics and weather, even days after the application. Volatility increases as the pesticide's vapor pressure increases and as air temperature and wind speed increase. Irrigating shortly after surface application of volatile pesticides reduces the potential for vapor drift.

Drift management additives can be added to the tank to help reduce the potential for drift. In addition, weather conditions at the time of application should be considered. Wind speeds of 3-10 mph are best for applying pesticides. More than 10 mph indicates an increasing potential for particle drift while less than 3 mph indicates stagnant air and the potential for temperature inversions. Temperature inversions can result in long-distance drift, which occur when lighter warm air rises upward into the atmosphere and heavier cooler air settles near the ground. Under these conditions, air does not mix, and spray droplets do not disperse and any subtle airflow can move this mass of pesticide spray droplets off-target. Temperature inversions typically start at dusk and break up around sunrise as air mixes vertically.

Drift management directions are typically an integral component of product labeling. Therefore, the pesticide label should be reviewed for specific information on drift reduction techniques or requirements. Weather-related instructions on the label must be followed as well.

For more information on preventing drift, see the UNL Extension publication Spray Drift of Pesticides. Some specialty crops are especially sensitive to pesticides. Therefore, pesticide applicators can check the DriftWatch and BeeCheck websites, which are online mapping services from FieldWatch that allow those with commercial specialty crops, organic crops, beehives, and other sensitive crops to report their field locations. All applicators applying pesticides outdoors are encouraged to sign up for free access to the FieldCheck app and/or free email notices.

8.5 Water Quality

Water is the major component of pesticide spray solutions. Research indicates that the quality of the water can impact pesticide performance. Therefore, performing a few water quality tests can indicate whether or not water conditioners may be needed to maximize pesticide effectiveness. For example, water conditioners can be added to the spray solution or tank-mix to eliminate problems associated with water hardness. A pH buffer can be used to raise or lower the pH, depending on the desired range needed for optimum performance. Some pesticide formulations already contain water conditioners that make them compatible within a wide range of water conditions. Other products, however, perform better when adjuvants are added to overcome water quality issues. For more information, see the Purdue Extension publication The Impact of Water Quality on Pesticide Performance.

8.6 Pesticide Equipment and Calibration

Application equipment must apply the pesticide to the intended target at the proper rate. Information on the pesticide label specifies the legal application rate and sometimes suggests the appropriate equipment for use with the product.

8.6.1 Application Equipment

Selection For spray applications, the size of the equipment (tank size, boom width, etc.) should be matched to the scale of the facility. Nozzle selection and coverage, in particular, are important in the control of drift. The type of nozzle, nozzle orifice size, sprayer pressure, and the height or distance of the nozzles from the target affect the potential for off-site movement of pesticides. A nozzle that primarily produces coarse droplets is usually selected to minimize off-target drift. Boom covers can also be incorporated to minimize the potential for drift.

For more information on equipment selection to reduce drift, see the UNL Extension publication Spray Drift of Pesticides.

Superintendents should consider the use of GPS-guided sprayer systems (Figure 15). With individual nozzle control, auto steering, automatic pressure adjusting, auto boom height, these systems have been shown to significantly improve accuracy and consistency of targeted pesticide applications, reduce chemical and labor costs, and, by reducing overall chemical use, improve environmental stewardship efforts.

Figure 15. Foam markers help with spray accuracy.

Figure 16. Due to their accuracy and efficiency, GPS sprayers represent a "Best" management practice.

8.6.2 Equipment Calibration

To apply liquid or granular pesticides at the proper rate, properly calibrated application equipment is essential. Such equipment mitigates environmental and human health concerns, reduces the chances of over- or under-applying pesticides, and optimizes pesticide efficacy. In addition, applicators must be especially careful to avoid exposure through inhalation when applying granular products. Equipment should also be checked frequently for leaks and malfunctions.

For more information on selecting and calibrating application equipment, see the University of Idaho Extension publication Improving Sprayer Accuracy: Simple Methods for Correct Calibration.

8.7 Pesticide Recordkeeping

Maintaining accurate records of pesticide-related activities (e.g. purchasing, storage, inventory, and applications) is essential and required by state law for all pesticide applications applied by certified professional applicators and private applicators.

Certified professional applicators must retain records for a period of three years following the application of the pesticide. The ISDA provides an example pesticide application record that can be used to track all the required details.

Certified private pesticide applicators must maintain records of federally restricted-use pesticide applications pursuant to U.S. Department of Agriculture requirements. These records must be retained for a period of two years following the application of the restricted-use pesticide. The ISDA provides an example restricted-use pesticide application record that can be used for compliant recordkeeping. Applications must be documented within 14 days, and the records must include the following information:

- The brand or product name of the federally restricted-use pesticide and the product's USEPA Registration number.
- The total amount of restricted-use pesticide applied.
- The size of the area treated with the restricted-use pesticide.
- The crop, commodity, stored product, or site treated with the restricted-use pesticide.
- The location of the application of the restricted-use pesticide.
- The month, day, and year of the application.
- The certified applicator's name and certification number.

8.8 Pesticide Storage and Handling

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

General guidelines for storage of bulk pesticides are as follows:

- Avoid the problem of storing pesticides by purchasing only the amount needed for the current season.
- Store pesticides in their original container with the original label attached. Read each label to determine suitable storing conditions.
- Do not store pesticides with food, feed, seed, planting stock, fertilizers, veterinary supplies, or pesticide safety equipment. Also, avoid storing them next to a water supply.
- Date the containers as they are purchased and keep an inventory list so outdated material can be disposed of.
- Designate a building, room, or cabinet specifically for pesticide storage and nothing else. The optimum storage facility should have a concrete floor, which is impermeable and easy to wash; adequate ventilation to avoid extreme heat and to reduce the concentration of toxic or flammable vapors; insulation and supplemental heating if required to meet label specifications; good lighting; and access to water to handle accidental spills.

- Always keep the building, room or cabinet where pesticides are stored locked when the area is unattended. • Post caution signs at all entrances or doors that warn the area is used for pesticide storage.
- Routinely examine pesticide containers for leaks, corrosion, breaks, and tears. Clean up spills immediately and properly dispose of containers and cleaning materials. Sawdust, industrial absorbent, cat litter, or dry soil may be used to soak up liquid spills. Sweeping compound can be used with dry spills. Keep cleaning materials in the storage area for quick access.

Some herbicides may lose their efficacy when exposed to freezing temperatures in storage; therefore, information on storage temperatures for various herbicides should be reviewed.

8.9 Transportation

According to state law, it is a violation to transport pesticides in any manner that will endanger humans, animals, or the environment. Pesticide transport should follow these recommendations:

- Use a ratchet-type tie-down strap or chain binder to secure tanks to the vehicle. Make sure that the strap or chain/chain binder is of sufficient strength to secure the load.
- Inspect all plumbing and secure hoses and other equipment to avoid damage and potential spills.
- Ensure that the transport vehicle is capable of transporting the weight of the container and contents.
- When transporting small containers:
    - Do not transport them inside the passenger compartment.
    - It is suggested that small pesticide containers be placed within a leak-proof container such as a covered plastic container.
    - Never leave pesticides unattended in an unlocked vehicle or an unsecured area where they can be tampered with or stolen.
    - Secure pesticide containers in an area of the vehicle to avoid significant movement or breakage from movement of other items in the vehicle.

8.10 Mixing/Washing Station

Procedures for mixing of pesticides and washing of pesticide application equipment should prevent the transport of pesticides or pesticide residues into surface water, groundwater, or down drains. Loading and mixing of pesticides should be over an impermeable surface, such as a concrete pad. In addition, maintain a downslope distance of at least 150 feet from any well when mixing pesticides.

Some herbicide labels list a specific mixing sequence. In absence of specific directions, the recommended sequence for adding pesticide formulations to a tank partially filled with water follows the A.P.P.L.E.S. method:

- Agitate
- Powders soluble
- Powders dry
- Liquid flowables and suspensions
- Emulsifiable concentrates
- Solutions

Each ingredient must be uniformly mixed before adding the next component, e.g. a soluble powder must be completely dissolved before adding the next component. Adjuvants are added in the same sequence as pesticides, e.g. ammonium sulfate is a soluble powder, oil adjuvants are emulsifiable concentrates, and most surfactants are solutions. Within each group, the pesticide is usually added before the adjuvant, e.g. a soluble-powder pesticide before ammonium sulfate.

For more on cleaning application equipment, the UNL Extension publication Cleaning Pesticide Application Equipment provides detailed information and the University of Missouri Extension publication Cleaning Fields Sprayers to Avoid Crop Injury describes a sprayer cleanout procedure in detail.

8.11 Disposal

The safest way to dispose of leftover pesticide from professional applications is to use all of the chemical according to directions on the label. This includes the washwater from pesticide equipment washing, which must be used in accordance with the label instructions.

Unusable or unwanted pesticides can sometimes accumulate in the pesticide storage area. Simply keeping them in storage eventually becomes problematic when packaging inevitably deteriorates or corrodes and creates a hazard. Yet disposing of these stockpiles properly can be challenging. For more information on proper disposal methods, see the Pacific Northwest Pest Management Handbooks' Pesticide Safety section. In Idaho, the ISDA conducts fall and spring collections of unusable pesticides. This program is free for the first 1,000 pounds of unusable pesticides per participant.

8.12 Pesticide Container Management

Handling of empty pesticide containers must be done in accordance with label directions as well as with all laws and regulations. Under the federal Resource Conservation and Recovery Act, a pesticide container is not empty until it has been properly rinsed. Non-refillable pesticide containers that have been properly rinsed can be handled and disposed of as non-hazardous solid waste; some plastic containers can be recycled. Refillable containers may be returned to the supplier unrinsed.

Procedures for cleaning pesticide containers, such as pressure rinsing and triple rinsing, and storing empty containers are described in the Pacific Northwest Pest Management Handbooks' Pesticide Safety section. Pesticide containers can be either recycled through participation in a container recycling program or disposed of by depositing them in a licensed sanitary landfill after pressure rinsing or triple rinsing. Ways to reduce the amount of waste that requires handling include identifying and implementing waste-reduction practices and purchasing bulk packaging when possible.

8.13 Emergency Preparedness and Spill Response

Pesticide leaks or spills, if contained, will not percolate down through the soil into groundwater or be carried away in runoff. However, if not contained, controlled, and cleaned up properly, pesticide spills can harm human health, the environment, or both through leaching or runoff. For more information on cleanup methods and procedures, see the Pacific Northwest Pest Management Handbooks' Pesticide Safety section.

Minor spills of pesticide or rinsate that have occurred from the handling, loading, or cleansing of bulk containers and that accumulate in the secondary containment area must be disposed of as provided by the pesticide label. In Idaho, all spills, fires, and poisonings should be reported to the EMS dispatcher: 800-632-8000 (in Idaho only). DEQ should also be notified if water resources are impacted.

8.14 Pesticide Management Best Management Practices

Human Health Risks

- Follow the pesticide label for re-entry period requirements or recommendations following application.
- Allow all pesticide applications to dry thoroughly before allowing play to resume.
- Prioritize using lower risk products whenever possible.

Personal Protective Equipment

- Follow pesticide labels for appropriate PPE.
- Provide adequate PPE for all employees who work with pesticides, including equipment technicians who service pesticide application equipment.
- Ensure that PPE is sized appropriately for each person using it.
- Ensure that respirators are seal- and fit-tested properly and that the person is thoroughly trained and has no medical limitations to respirator use.
- Store PPE where it is easily accessible, but not in the pesticide storage area.
- Forbid employees who apply pesticides from wearing facility uniforms home by providing laundering facilities or a uniform service.
- Meet requirements for the OSHA 1910.134 Respiratory Protection Program.

Pesticide Applications

- Consider pesticide characteristics in the chemical selection process.

- Identify any areas on the course prone to leaching losses (e.g. shallow water tables, sand-based putting greens, coarse-textured soils, etc.). Do not use highly soluble pesticides in these areas.
- Select low- or non-volatile pesticides.
- If listed species or species of concern are present, specifically select pesticides that have no known effects on these species.
- Check the forecast before applying pesticide and apply when conditions are favorable.
- Follow the pesticide label to avoid drift.
- Use spray additives (adjuvants, acidifiers, buffers, drift, retardants, compatibility agents, water conditioners, dyes, foamers, etc.) to improve the efficiency of pesticide applications and use within label guidelines.
- Schedule the timing and amount of irrigation needed to water-in products (unless otherwise indicated on label) without over-irrigating.
- If sites adjacent to the application area are planted with susceptible plants or crops, allow a buffer area between the two, or wait until winds are blowing away from the area of concern.

Pesticide Application Equipment

- Use an appropriately sized applicator for the size of area being treated.
- Ensure the spray technician is experienced, certified, and properly trained.
- Properly calibrate all application equipment at the beginning of each season (at a minimum) or after equipment modifications.
- Check equipment daily when in use.
- Use recommended spray volumes for the targeted pest to maximize efficacy.
- Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration walking speed, etc.
- Avoid high spray boom pressures; consider 45 PSI a maximum for conventional broadcast ground spraying.
- Use drift-reduction nozzles that produce larger droplets when operated at low pressures.
- Use wide-angle nozzles and low boom heights and keep boom stable.
- When possible, use lower application speeds to avoid drift.
- Use spray additives within label guidelines to improve effectiveness of pesticide and reduce potential for drift.
- Use shielded booms. When banding, use shroud covers.
- If available, use GPS guided sprayer.

Pesticide Record Keeping

- Use electronic or hard-copy forms and software tools to properly track pesticide inventory.
- Keep and maintain records of all pesticides; records of restricted-use pesticide applications are legally required to be kept for two years.

- Use records to monitor pest control efforts and to plan future management actions.
- Record pesticide application information immediately following application.

Pesticide Storage and Handling

- Routinely undergo a “risk assessment” to identify any potential risks to the applicator or environment.
- Do not transport pesticides in the passenger section of a vehicle.
- Never leave pesticides unattended during transport.
- Maintain an inventory of all pesticides used and the SDS for each chemical.
- Avoid purchasing large quantities of pesticides that require storage for more than six months.
- Adopt the “first in-first out” principle, using the oldest products first to ensure that the product shelf life does not expire.
- Locate pesticide storage facilities away from other structures to allow fire department access.
- Store, mix, and load pesticides away from sites that directly link to surface water or groundwater (e.g. wells).
- Store pesticides in a lockable concrete or metal building separate from other buildings.
- Shelving should be made of sturdy plastic or reinforced metal.
- Metal shelving should be kept painted to avoid corrosion. Wood shelving should never be used because it may absorb spilled pesticides.
- When storing pesticides on shelves, place liquid pesticides on lower shelves and dry formulations above them.
- Store herbicides, insecticides, and fungicides in separate areas within the storage unit.
- Storage facility floors should be impervious and sealed with a chemical-resistant paint.
- Floors should have a continuous sill to retain spilled materials and should not have 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.
- Automatic exhaust fans and an emergency wash area should be provided. Light and fan switches should be located outside the building, so that both can be turned on before employees enter the building and turned off after they leave the building.
- Avoid temperature extremes inside the pesticide storage facility.

Mixing/Washing Station

- Load and mix pesticides over an impermeable surface, such as a concrete pad.
- Mix pesticides at least 150 feet downslope from any well.

- Mix materials according to label directions and in amounts that will be used for the application to avoid excess that will need disposal.
- Either use anti-backflow devices when mixing pesticides or maintain a 6” air gap between mixing container and water source.
- Pump the sump dry and then clean it at the end of each day. Liquids and sediments should also be removed from the sump and the pad whenever pesticide materials are changed to an incompatible product (i.e. one that cannot be legally applied to the same site).

Disposal

- Collect washwater (from both inside and outside the application equipment) and use as a pesticide in accordance with the label instructions.
- Apply rinsates as a pesticide (preferred) or stored for use for the next compatible application.
- Annually review pesticide inventories and properly dispose of unusable and unwanted pesticides.

Pesticide Container Management

- Rinse pesticide containers immediately in order to remove the most residue.
- Rinse containers during the mixing and loading process and add rinsate water to the finished spray mix.
- Rinse emptied pesticide containers by either triple rinsing or pressure rinsing.
- Use refillable pesticide containers only for pesticides.
- Recycle non-refillable containers when possible.
- Puncture empty and rinsed pesticide containers prior to disposal and dispose of them according to the label.

Emergency Preparedness

- Keep a written pesticide handling and discharge response plan as required that outlines the procedures to control, contain, and clean up spilled materials.
- Train all employees on the emergency response plan and emergency procedures.
- Provide a copy of the written handling and discharge response plan to local authorities.
- Keep an appropriate spill containment kit in a readily available space.
- For small liquid spills, use absorbents such as cat litter or sand and apply as a topdressing in accordance with the label rates, or dispose of as a waste.
- For small solid spills, sweep up and use as intended.
- Ensure that SDS documents are present and that all employees have been properly trained on their location and contents.
- Report releases as required.

9 Pollinator Protection

Preface

Pollinators around the world are facing a number of threats that impact their health, abundance, and distribution. Over 400 species of pollinators can be found in Idaho, but pollinator populations are at risk due to declining populations. Some of these species, such as the monarch butterfly (Danaus plexippus) and the western bumble bee (Bombus occidentalis), have been identified as at risk due to declining populations. One such threat is pesticides, which can have negative effects ranging from gene expression within individuals to colony level impacts. In particular, neonicotinoids have been a focus of research with respect to their impact on pollinators and their prevalent use in agricultural and ornamental settings. At this point, the potential connection between increased neonicotinoid use and recent pollinator decline is the subject of scientific research and debate.

Pesticide applicators need to be mindful of the impact that pesticides used on golf courses may have on pollinator species and their habitat. In addition to adhering to best management practices related to pesticide management and application, golf course managers can protect and enhance habitat on the course in a number of ways to help pollinators.

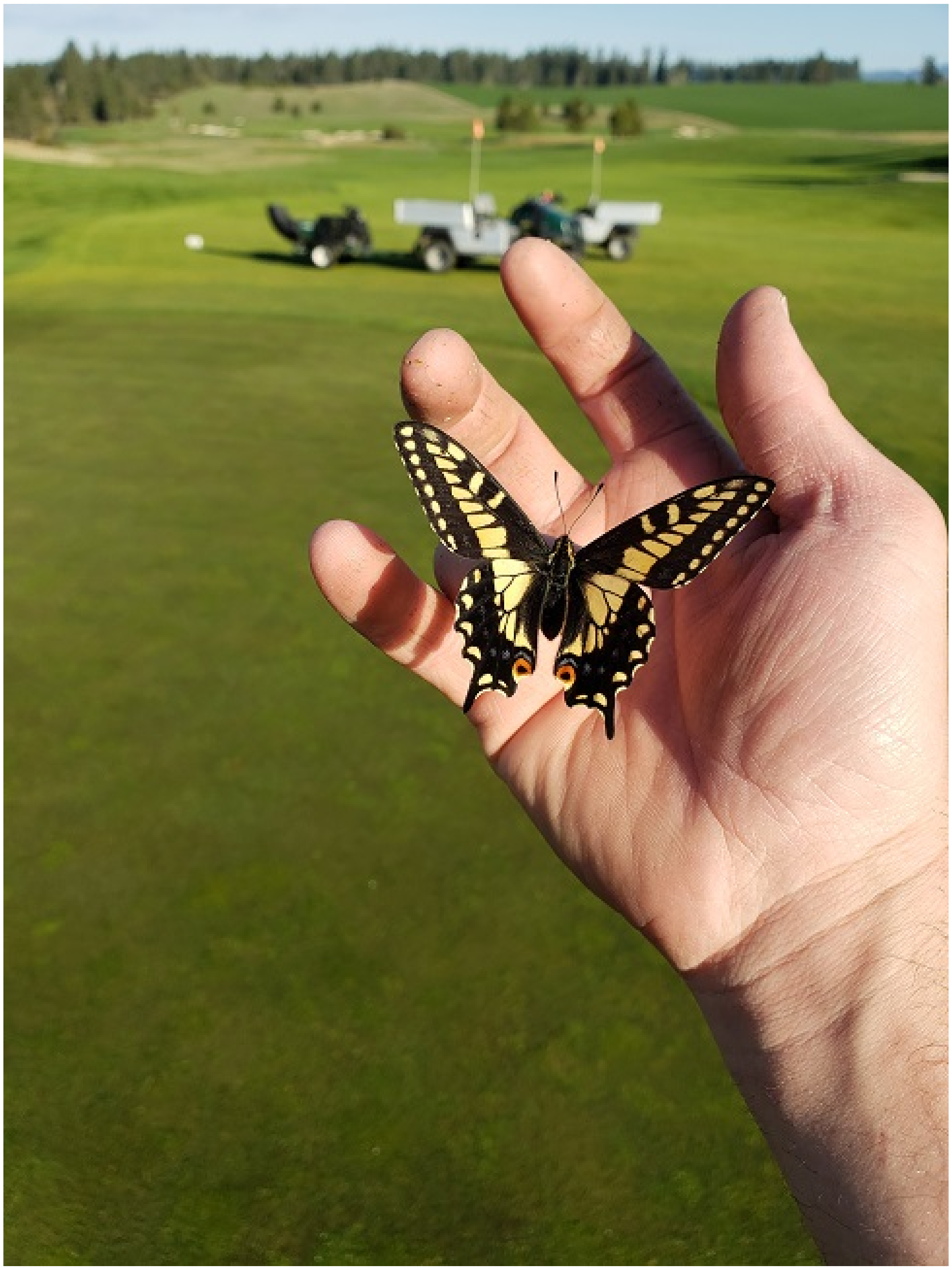

Figure 17. Golf courses can provide high quality butterfly habitat.

9.1 Regulatory Considerations

Pollinator protection language is a requirement for pesticide labels, and following the label is mandatory. Pesticide applicators must be aware of honey bee toxicity groups and be able to understand precautionary statements. In addition to following legal requirements, pesticide applicators should understand the effects of pesticides on bees and other pollinators and the routes of potential exposure.

The USGA publication Making Room for Native Pollinators and the USDA's Forest Service and Pollinator Partnership publication Bee Basics: An Introduction to Our Native Bees provide basic facts about pollinator biology that are useful to pesticide applicators. In addition, recordkeeping may be required by law to use some pesticides. Many of the IPM best management practices, such as record keeping, are valuable tools for protecting pollinators.

Some golf courses maintain beehives on site as a way to increase their environmental stewardship efforts. In Idaho, state law requires that all beekeepers with over 50 hives must register with ISDA's bee inspection program, but beekeepers with fewer hives can register voluntarily. ISDA has also formulated an Idaho Pollinator Protection Plan with voluntary guidance on protecting pollinators in the state.

9.2 Pest Management Practices

Protecting pollinators on the golf course does not preclude the use of pesticides, but instead minimizes any potential impact from these chemicals. Pesticide applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans. Using IPM best management practices is an important key to protecting pollinators because they reduce pesticide usage and minimize the potential of exposure. Superintendents can utilize IPM best management practices for turfgrass that protect pollinators by following these simple steps:

- Identifying what is truly a pest. (For example, solitary ground-nesting bees and wasps might be alarming, but most are harmless.)
- Setting higher weed thresholds in low-use areas.
- Monitoring bee activity to avoid applying pesticides during peak activity times (i.e. apply pesticides in the early morning or evening).

When the use of pesticides is necessary, being mindful of pollinators includes selecting chemicals with low toxicity to bees, short residual toxicity, or properties repellent to bees; using caution when applying near flowering plants, including flowering weeds (mow first whenever possible); and avoiding drift. The Pacific Northwest Extension publication How to Reduce Bee Poisoning From Pesticides includes extensive information on toxicity to bees by pesticide active ingredient.

Pesticide applicators are also encouraged to check the DriftWatch and BeeCheck websites, which are online mapping services from FieldWatch that allow those with commercial specialty crops, organic crops, beehives, and other sensitive crops to report their field locations. All applicators applying pesticides outdoors are encouraged to sign up for free access to the FieldCheck app and/or free email notices.

9.3 Preserving and Enhancing Habitat on the Course

Habitat for pollinators includes foraging habitat, nesting sites, and water sources. Increasing habitat to meet pollinator needs can be accomplished simply by adding to existing plantings or through more intensive efforts to establish a larger native area. Pollinator habitat on the golf course includes existing out-of-play areas (such as buffer strips around water courses and bodies of water) and areas renovated specifically with pollinators in mind that include native plants, wildflowers, flowering trees and shrubs, nesting sites, and water sources. The basics of providing pollinator habitat is covered in the University of Idaho publication Bee Habitat.

To convert an existing out-of-play area to a native area, site preparation is key and may require more than one season of effort to reduce competition from invasive or other undesirable plants prior to planting. For more information on establishing a native area, see Making Room For Native Pollinators. For information on plant selection that specifically includes monarch butterflies, a species in decline, see the Xerces Society's Monarch Nectar Plant Guides (Great Basin, Inland Northwest, and Rocky Mountains) and the Monarchs in the Rough website.

Pollinator-friendly habitat contains a diversity of blooming plants of different colors and heights, with blossoms throughout the entire growing season. An ideal plant mix consists of nine species: three that bloom early in the season, three in mid-season, and three in late season. However in areas of Idaho with less than 16 inches of mean annual precipitation, nine adapted and commercially produced species may not always be available. Native plants are best for providing the most nutritious food source for native pollinators. Though wildflowers are most often thought of as pollinator-friendly plants, grasses, sedges, forbs, shrubs and trees also provide habitat. For example, many sedge species are larval hosts, hollow stem grasses provide nesting habitat, and sturdy grasses shelter insects from harsh weather. Herbs also can be beneficial to bees and other pollinators. For example, borage is an underutilized herb that is extremely attractive to pollinators. Milkweed provides habitat specifically for monarch butterflies.

The NRCS provides information on plants and plant mixes for pollinators appropriate for Idaho:

- Plants for Pollinators in the Inland Northwest
- Plants for Pollinators in the Intermountain West

Providing nesting sites for native species can be accomplished by taking simple steps in out-of-play areas, such as:

- Leaving exposed patches of bare soil.
- Leaving dead trees, stumps, and posts.
- Planting hollow stem grass species.
- Providing stem bundles of hollow plant stems like bamboo.
- Creating bee blocks for solitary nesters such as mason and leafcutter bees.
- Creating artificial boxes for bumble bees.

Bee boxes can be purchased or constructed following simple instructions. The UNL Extension publication Attracting Pollinators to Your Landscape offers instructions for constructing a simple bee box.

A clean, reliable source of water is another essential habitat consideration for pollinators. Pollinators can use natural and human-made water features such as running water, pools, ponds, small containers of water, and mud puddles. Water sources should have a shallow or sloping side so the pollinators can easily approach the water without drowning. In addition, irrigation management practices that preserve ground-nesting pollinators include irrigating at night and avoiding flooding any areas.

9.4 Pollinator Protection Best Management Practices

Pest Management Practices

- Before applying a pesticide, inspect the area for both harmful and beneficial insect populations, and use pesticides only when a threshold of damage has been indicated.
- Consider biological control agents, lures, baits, and pheromones as alternatives to insecticides for pest management.
- When pesticides are needed, select those with a lower impact on pollinators, such as chlorantraniliprole.
- If a granular formulation will control the pest, choose it over liquid. formulations. Granular versions of pesticides are known to be less hazardous to bees.
- Restrict applications to early morning or evening when pollinators are not as active.
- Avoid applying pesticides during bloom season, and mow first to remove blooms, including those of flowering weeds such as white clover.
- Avoid application during unusually low temperatures or when dew is forecast.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site translocation of pesticide.

Habitat Protection and Enhancement

- Follow site preparation guidelines when renovating areas to ensure success.
- Choose south-facing sites whenever possible for establishing native areas.
- Place plants in masses (three or more) to attract pollinators.
- Select plants of different shapes, sizes, and colors and ones that bloom at different times of the year.
- Select native grasses that provide foraging and nesting habitat.
- Use both perennials and annuals.
- Leave stems and coarse, woody debris in native areas for pollinator nesting.
- Leave exposed patches of well-drained soil in native areas for pollinator nesting.
- Provide water sources with shallow sides for pollinators.

10 Maintenance Operations

Preface

It is the objective to manage the potential environmental risks associated with golf course maintenance operations. Our industry has a need and responsibility to implement, manage, measure, and improve all aspects of environmental stewardship. It is imperative that hazardous materials be handled, stored, recycled, and disposed in a safe, healthy, and environmentally sound manner.

Pollution prevention includes the proper delivery, storage, handling, and disposal of all chemicals, washwater, and wastewater. For example, washwater from pesticide application equipment must be managed as a pesticide. Conversely, wastewater not contaminated with harmful chemicals can be reused or discharged to a permitted stormwater treatment system. The “Pesticide Management” chapter discusses many maintenance operations-related BMPs specifically for pesticides.

For unintended releases of any chemicals, an emergency plan, spill kit, and first-aid kit should be readily available.

10.1 Regulatory Considerations

Owners and operators of underground storage tanks (UST) must register tanks. Petroleum tanks greater than 1,100 gallons are regulated and must meet all the UST requirements of Idaho's Underground Storage Tank Rules (IDAPA 58.01.07). Owners of tanks under 1,100 gallons should use good and sound engineering practices and leak detection methods to avoid accidental releases. The UST program should be contacted in case of a leak.

Above ground storage tanks (AST) in Idaho are regulated by the USEPA, under the federal Spill Prevention, Control, and Countermeasure rule. Although DEQ does not regulate ASTs in Idaho, state rules require that the agency be notified within 24 hours if a petroleum release occurs from an AST to the environment.

10.2 Storage and Handling of Fertilizers

Storage facilities that are well designed and well maintained protect people from exposure, reduce the potential of environmental contamination, protect chemicals from extreme temperatures and excess moisture, and, in general, reduce liability concerns and potential environmental risks. The storage area should be secure and provide containment features. In addition, storing and maintaining equipment properly extends its useful life and reduces repairs.

10.3 Equipment Washing

Equipment washing should be conducted under controlled conditions in an appropriate contained area with minimal risk to the environment to prevent adverse washwater runoff impacts whenever possible. Equipment washing guidelines and restrictions should be established that reduce the potential for pollutants to reach stormwater runoff, surface water or groundwater.

Proper cleaning of equipment helps prevent residues from reaching surface waters, groundwater, drainage pipes, or storm sewers (Figure 17). The residues from washing equipment include grass clippings, soil, soaps, oil, fertilizers, and pesticides.

Figure 18. Proper equipment washing technique protects water quality.

A primary concern when washing mowing equipment is the nitrogen and phosphorus nutrients in grass clippings. Using compressed air to blow clippings off mowers before washing can help reduce the amount of nutrients that enter drains via washwater. The best practice is to have a dedicated wash area with a catch basin to collect remaining grass clippings. Clippings can be collected, then composted or removed to a designated debris area. When formal washing areas are not available, a “dog leash” system using a short, portable hose to wash off the grass at random locations, away from surface waters, wells, or storm drains, is an option.

For equipment with possible pesticide residue, BMPs should be followed to ensure that washwater does not become a pollution source. Captured washwater can be used as a dilute pesticide per label, or it may be pumped into a rinsate storage tank for use in the next application and used as a dilute pesticide per the label.

10.4 Equipment Storage and Maintenance

Like chemical storage facilities, equipment storage and maintenance facilities should be designed to prevent the accidental discharge of chemicals, fuels, or contaminated washwater from reaching water sources. Properly storing and maintaining equipment also extends the useful life of machines and reduce repairs.

10.5 Fueling Facilities

Fueling areas should be properly sited, designed, constructed, and maintained to prevent petroleum products from being released into the environment through spills or leaks. Above ground storage tanks are easier to monitor for leakage and are therefore the preferred storage method. Because of the potential for groundwater contamination from leaking USTs, leak detection monitoring is a critical aspect of UST compliance. Any leaks or spills must be contained and cleaned immediately.

Fueling areas should be sited on impervious surfaces, equipped with spill containment and recovery facilities, and located away from surface waters and water wells. Catch basins in fueling areas should be directed toward an oil/water separator or sump to prevent petroleum from moving outside any containment structure. Floor drains in fueling areas should be eliminated unless they drain to containment pits or storage tanks.

10.6 Waste Handling

Facilities need to regularly review how they handle the disposal of unwanted, expired, or accumulated items, including chemicals, paints, pesticides, tires, batteries, used oils, solvents, paper products, plastic or glass containers, and aluminum cans. Developing recycling programs reduces waste and minimizes the quantity of waste reaching landfills. In some cases, recycling of some wastes may be required locally, and superintendents should be aware of these requirements.

All packaging from chemicals, their containers and other wastes should be properly disposed of. Pesticide-specific waste handling requirements are identified on the pesticide label and are discussed in more detail in the “Pesticide Management” chapter.

10.7 Maintenance Operations Best Management Practices

Fertilizer Storage

- Review groundwater sensitivity information before constructing any fertilizer storage facilities or handling areas.
- Storage facilities should not be located in areas with high probability of flooding.
- Locate dry fertilizer storage buildings or liquid fertilizer secondary containment over 500 feet away from a well, water supply or surface water runoff area.
- Construct storage buildings to prevent seepage or spillage of fertilizer under normal conditions.
- Unless stored in a totally enclosed building, all nonliquid fertilizer materials should be covered and stored within an appropriate secondary containment storage structure.
- Construct liquid fertilizer secondary containment capable of holding 125 percent of the volume of the largest container plus the volume of the butts of all other containers inside the liquid containment area.
- Construct dry storage for secondary containment that is of sufficient thickness and strength to withstand loading conditions.
- Design loading areas to prevent spillage onto unprotected areas and create a proper cleanup area by installing curbed containment.
- Post warning signs on chemical storage buildings, especially near entry or exit areas.
- Storage facilities should be secured and allow access only to authorized staff.
- Replace worn or faulty valves, plugs, and threaded fittings in storage containers.
- Install backflow prevention devices or use air gap separation on water supply lines used for fertilizer mixing or equipment rinsing.
- Lock valves and shutoff devices while storage containers and facilities are not in use.
- Follow hazard safety rules, worker protection laws, and fire prevention rules while handling and storing fertilizer.
- Apply appropriate sealant to seams and cracks in all storage facilities and load/wash/rinse pad areas.
- Use approved containers designed for and compatible with the fertilizer being stored.
- Shelves should be made of plastic or reinforced metal. Metal shelving should be coated with paint to avoid corrosion. Wood shelving should not be used due to its ability to absorb spilled chemicals.
- Exhaust fans and an emergency wash station should be provided.
- Light and fan switches should be located on the exterior of the storage facility.
- Store liquid materials below dry materials to prevent contamination from a leak.
- Train staff and other management on how to access and use the facility’s SDS database.
- Maintain accurate inventory lists.

Equipment Washing

- Brush or blow off accumulated grass clippings from equipment using compressed air before washing.
- Wash equipment on a concrete pad or asphalt pad that collects the water. After the collected material dries, collect and dispose of it properly.
- Washing areas for equipment not contaminated with pesticide residues should drain into oil/water separators before draining into sanitary sewers or holding tanks.
- Do not wash pesticide-application equipment on pads with oil/water separators. Do not wash near wells, surface water, or storm drains.
- Use spring-loaded spray nozzles to reduce water usage during washing.
- Minimize the use of detergents. Use only biodegradable, non-phosphate detergents.
- Use non-containment washwater for irrigation.
- Do not discharge non-contaminated wastewater during or immediately after a rainstorm, since the added flow may exceed the permitted storage volume of the stormwater system.
- Do not discharge washwater to surface water, groundwater, or susceptible/leachable soils either directly or indirectly through ditches, storm drains, or canals.
- Never discharge to a sanitary sewer system without written approval from the appropriate entity.
- Never discharge to a septic tank.
- Do not wash equipment on a pesticide mixing and loading pad. This keeps grass clippings and other debris from becoming contaminated with pesticides.
- Solvents and degreasers should be used over a collection basin or pad that collects all used material.

Equipment Storage and Maintenance

- Store equipment in areas protected from rainfall. Rain can wash residues from equipment and potentially contaminate the surrounding soil or water.
- Perform equipment maintenance activities in a completely covered area with sealed impervious surfaces.
- Drains should either be sealed or connected to sanitary sewer systems with the approval of local wastewater treatment plants.
- Solvents and degreasers should be stored in locked metal cabinets away from any sources of open flame.
- Complete a chemical inventory and keep SDS of each on site. A duplicate set of SDS should be kept in locations away from the chemicals, but easily reached in an emergency.
- Use PPE when working with solvents.
- Use containers with dates and contents clearly marked when collecting used solvents and degreasers.

Fueling Facilities

- Above ground storage tanks are preferred as they are more easily monitored for leaks as compared with underground storage tanks.
- Fueling stations should be located under roofed areas with concrete pavement whenever possible.
- Fueling areas should have spill containment and recovery facilities located near the stations.
- Develop a record-keeping process to monitor and detect leakage in USTs and ASTs.
- Visually inspect any AST for leakage and structural integrity.
- Secure fuel storage facilities and allow access only to authorized and properly trained staff.

Waste Handling

- Label containers for collecting used solvents, oils, and degreasers.
- Recycle lead-acid batteries. If not recycled, batteries are classified as hazardous waste.
- Store old batteries on impervious surfaces in areas protected from rainfall.
- Recycle used tires, paper products, plastic or glass containers, aluminum cans, and used solvents, oils, and degreasers.
- Provide a secure and specifically designated storage for the collection of recyclable waste products.
- Recycle or properly dispose of light bulbs and fluorescent tubes.

11 Landscape

Preface

The fundamental principle for the environmentally sound management of landscapes is "choose the right plant, in the right place." Ideal landscape plants are native and adapted specifically to the soil, degree and direction of slopes, precipitation type and amounts, wind direction and speed, light patterns, and microclimate. Susceptibility to major damage by insects and other pests is another selection criterion, as are the nutrient levels of the area. Because native and/or adapted plants can mimic natural ecosystems, their use in the landscape can reduce overall management inputs, attract pollinators, provide multi-season interest, and enhance out-of-play areas.

11.1 Planning and Design

Planning begins with a careful assessment of existing conditions. Slopes and drainage patterns impact not only the playability of the course, but the survival of existing and proposed plants. A majority of the non-play areas on the golf course should remain in natural cover. Supplemental planting of native or adapted trees, shrubs, and herbaceous vegetation can limit soil erosion, protect stream banks, and enhance wildlife habitat, including non-game species, birds, and pollinators, in non-play natural areas. Mimicking natural ecosystems by leaving dead trees (snags), brushy understory plants, and native grasses and forbs in these areas also reduces maintenance work by minimizing or eliminating the need to mow or apply fertilizer or pesticide.

Higher-impact, higher-use landscape areas, such as around the clubhouse, should be designed to utilize natural drainage patterns and channel runoff away from impervious surfaces (e.g. paved areas), conserve water, and lower nutritional input requirements once mature. Installing rain gardens in locations where they catch and temporarily hold water (such as near roofs and other impervious surfaces) helps control stormwater runoff, remove contaminants before releasing water into the surrounding soil or aquifer, and conserve water by reducing supplemental irrigation needs. For more information on rain gardens, see the NRCS publication Rain Gardens.

Golf courses are excellent facilities for zoning the landscape, using designations of high-impact zones, transition zones, and perimeter zones, and matching high-use and high-impact areas to plants that need more water and likely more-intense management. Planning for landscaped areas should take into consideration the lay of the land, including differences in soil and changes in sunlight levels throughout the day, and should include consideration of the water needs in each area. A zoned approach is an efficient way to plan, as follows:

- *High-use and high-impact zones.* Match plants that need the most water to small, highly visible areas that will be watered as needed.

- *Transition zones.* Choose plants that require moderate amounts of water to be applied only when they show signs of moisture stress, such as wilting.

- *Perimeter zones.* Use plants with minimal water requirements. Water during establishment and in periods of extreme drought.

Ideally, 10% or less of the landscaped areas should be zoned for high water use, 30% or less of the area should be zoned for moderate water use, and 60% or more of the landscape should be zoned for low water use.

11.2 Site Inventory and Assessment

Before developing a landscape plan, an inventory should be conducted of existing plants, their condition and quality, their contribution to the overall style of the course, and how they've been managed. For landscaped areas, a soils analysis and a soil test should be conducted. The soils analysis evaluates the structure and texture of the soil. The addition of soil amendments can improve the structure and texture of soil, increase its water-holding capacity, and reduce the leaching of fertilizers. Soil amendments, such as compost from clippings, can contribute to an overall healthier plant environment, allowing easier root development and fewer soil-related problems. The use of peat as an amendment should be very limited (such as in containers), as it is both expensive and originates from peat bogs, which are non-renewable. Fertilizers should be applied on the basis of the results of soil tests that have been conducted to identify plant nutritional needs and pH, as described in the "Nutrient Management" chapter.

11.3 Plant Selection

Selection of specific plants should be based to the extent possible on natural ecosystems in the area. This is particularly true for the perimeter zones and out-of-play areas. Additional considerations for species selection and placement include plant hardiness, design intentions and knowing the ultimate sizes and growth rates of trees, shrubs, and ground covers (Figure 18). This reduces the need for future pruning and debris removal. In addition, the adaptability of plants to a specific site is important. Site-specific characteristics to consider include sun exposure, light intensity, wind conditions, drainage, and temperatures.

With respect specifically to trees, the distance to tees and greens requires additional consideration, as the shade from trees prevents the turfgrasses from growing the best during the summer because of shading and reduced airflow, causes more frost or cold damage on the grasses in winter, and competes with turfgrass for water and nutrients during the growing season. Because trees can impact the health of turfgrass, their careful addition to the landscape when desired and/or selective removal from the landscape when too close to tees and greens should be a component to the landscape management program. See the short USGA article "When Trees and Grass Compete, Trees Win" for a summary of the issues associated with trees near tees and greens. For more information on plant selection in Idaho, see Dr. Love's Favorite Native Plants and Where to Buy Them, a list compiled by Dr. Stephen Love from the University of Idaho.

11.4 Installation

During landscape bed construction, native soil should be used and any hardpan or compaction from construction should be resolved. The beds should be sloped away from buildings, with a minimum percent slope away from buildings of at least 2% for at least 10 feet. Resolve drainage issues and establish clear drainage patterns prior to installing plants. Plants with higher moisture requirements can be planted at lower elevations and drought-tolerant plants at higher elevations.

In general, the best times to plant trees and shrubs in Idaho is late winter after the ground thaws, but these can be planted in the fall as well. A few species (e.g. bur oak and hackberry) prefer planting in the fall. Bare-root trees can be planted only when they are dormant, limiting their planting time to early spring or late fall. These times reduce the stress on the plants by capitalizing on periods of cooler (but not cold) temperatures and more moisture. When planting, the soil ball should be kept together and the fine roots kept moist.

11.5 Irrigation

Regardless of their ability to tolerate drought, all plants require supplemental irrigation during establishment. To increase water-use efficiency and improve plant establishment in landscaping, consider hand-watering individual plants for the first several months of the growing season. If the plants have been selected and placed in zones that match their water requirements, irrigation can be scheduled to help efficiently meet the water needs of the entire landscape, thus eliminating regular hand-watering. When needed, plants should be watered in the early morning to conserve water by avoiding water loss due to evaporation. Careful assessment of landscape watering patterns minimizes spray on impervious surfaces, blockage of spray by plants or other obstructions, and runoff on slopes, clay soils, or compacted sites. Focusing the irrigation of woody plants at or beyond the dripline promotes extensive rooting. Additional water conservation ideas in landscaped areas include using quick couplers in landscaped areas to meet water needs (note: placement is key when using quick couplers) and using planters in areas that need color, as planters require less water than landscaped beds. Self-watering planters can be used to reduce labor requirements as well.

For existing irrigation systems, assess the coverage to determine whether changes should be made to identify areas where efficiency can be improved. Ideally, the irrigation system for the landscape beds should be zoned just like the landscape beds. Periodically throughout the growing season, the performance of the landscape irrigation system should be checked.

11.6 Use of Mulch

Mulch conserves soil moisture, mitigates temperature extremes, and reduces weed competition. In winter, mulch helps prevent soil cracks from forming and exposing roots to cold temperatures and winter desiccation. Organic mulches include herbicide-free grass clippings (though avoid applying too deeply to prevent matting and heating the soil) and wood chips of varying dimensions. Organic mulches are preferred, as non-organic mulches such as stone may add heat stress around annuals and perennials.

Annuals and perennials grow best with no more than 2” of mulch; mulch around trees and shrubs should be no more than 3” to 4” deep. With any planting, mulch should be placed between the plants and not on top of the crown or against tree trunks or shrub canes. In winter after the ground freezes, a deeper layer of coarse mulch (evergreen branches) over bulbs and other perennials can delay or prevent early growth.

11.7 Pruning

Correctly pruning trees, shrubs, and herbaceous perennials has multiple benefits throughout a landscape or golf course. Trees and shrubs are pruned first for safety. Pruning in some cases can increase plant health and result in better growth in future seasons. Typically, the ideal time to prune deciduous shade trees and conifers in Idaho is in late winter/early spring, except in times of drought and except for trees with heavy sap flow (e.g. maples and birches), which can be pruned after fully leafed out. Shrubs should be pruned based on their season of bloom (if the flowers are significant). Plants that bloom on second-year or old wood set their flower buds immediately after flowering and can be pruned for the month following bloom. Plants that bloom on new wood, or current-season wood, can be pruned in early spring prior to dormancy break.

11.8 Pest Management

The same principles and methods identified in the IPM chapter can be applied to landscaped areas. The UNL Extension's Integrated Pest Management for Landscapes provides guidance specifically for these areas.

Additional University of Idaho resources related to pest management of landscaped areas in Idaho include the following:

- Three Categories of Plant Problems
- Common Plant Problems
- Winter Tree Inspection

11.9 Native Areas Establishment and Maintenance

Native areas can serve multiple functions on the golf course such as buffers near surface waters, wildlife habitat that provides forage and nesting sites for game and non-game species; and pollinator habitat (Figure 19). Establishing a native area can include plantings of grasses, forbs, and shrubs. Selection of species to be planted should be based on the site's climate, soils, intended use and planned management. Once established, native areas require little in the way of supplemental irrigation. The NRCS publication Five Keys to Successful Grass Seeding can provide additional information on species selection, seeding rates, and establishment. Figure 19. Native areas provide wildlife habitat and beautiful aesthetics.

Figure 19. Native areas provide wildlife habitat and beautiful aesthetics.

11.9.1 Native Area Establishment

To establish native areas with grasses, transplanting results in much quicker establishment, but is much more expensive than direct seeding. Direct seeding, by contrast, is much less expensive, but requires two to five years to reach maturity, depending upon the species.

Prior to seeding, the area should be prepared. The primary preparation will be related to weed control. Eliminating all existing perennial weeds, especially aggressive and noxious weeds, yields the best results and will require less labor later in managing the native areas. Eliminating weeds may require a full year or possibly longer prior to planting or transplanting natives, depending upon the existing site conditions. Annual and biennial weeds are often a problem in the first two years during establishment as they compete with seedlings for sunlight and/or moisture. Competitive weeds can be controlled either mechanically or chemically, or a combination of the two, and should be performed prior to weed seed maturity.

11.9.2 Native Area Maintenance

Native areas require management that mimics natural disturbance processes (such as grazing and periodic fires) to invigorate and maintain desirable species in an optimum condition. On a golf course, these managed practices can include mowing, haying, or prescribed burns, which reduce unwanted woody vegetation and invasive plant species.

Burning reduces plant litter and stimulates new plant growth. It must be timed to negatively impact the targeted invasive species. For example, burning should be timed in early spring after invasives like smooth bromegrass have greened up but prior to native greenup. Burning to control invasives should be done on a 3 to 5 year rotation. However, annual burning may be needed in the beginning for native grassland heavily invaded by smooth bromegrass or Kentucky bluegrass. For more information on prescribed burns, see the Prescribed Burns subsection of the “Cultural Practices” chapter.

Mowing or haying should be delayed until after the primary nesting season for grassland bird species (mid-spring through early August), and done on a rotational basis, such as once every 3 to 5 years. Haying should be done with a sickle bar mower and rake in order to remove plant litter; swathers or conditioners do not remove plant litter build-up and may shade native plants and inhibit growth. Haying should be done from the center outward or toward undisturbed habitat. Selective use of herbicides may be needed, in conjunction with mowing, to control invasive plants.

11.10 Landscape Best Management Practices

Planning and Design

- Leave the majority of non-play areas in natural vegetation -- the perimeter zone.
- Enhance natural areas with supplemental plantings of native and adapted species.
- In landscaped areas, use natural drainage patterns and directional site grading to channel runoff away from impervious surfaces onto planted areas such as grass swales, filter strips, or rain gardens.
- Install rain gardens in locations where they can catch and temporarily hold runoff.
- Minimize the amount of area covered by paved surfaces. Where feasible, use permeable materials such as bricks laid on sand, interlocking pavers or pervious pavers, porous concrete, mulch, or plants.

- Use a zoned approach to plant management and water needs and minimize the areas zoned for high water use.

Site Inventory and Assessment

- Conduct an inventory of existing plants, their condition and quality, and their contribution to the overall style of the course.
- Conduct a soil analysis before choosing specific plants for landscape areas.
- Conduct a soil test before applying fertilizers. Modify pH if needed, based on soil test results.
- Amend the soil to improve soil texture and increase water infiltration.

Plant Selection

- Select native species whenever possible; use adapted species or cultivars of native plants where appropriate.
- Select trees, plants, and grass species to attract birds seeking wild fruits, herbs, seeds, nesting materials, cover, and insects.
- Know the ultimate sizes and growth rates of trees, shrubs, herbaceous plants, and ground covers.
- Select plants recommended for your specific location.
- Choose the most stress-tolerant species for a particular area.
- Do not introduce invasive species into the landscape.
- Control or remove existing invasive species and noxious weeds.

Irrigation

- Irrigate frequently during establishment.
- Water established plants based on their needs and, when necessary, deeply and infrequently.
- Irrigate in the early morning to conserve water.
- Avoid water runoff onto impervious surfaces or slopes.
- Evaluate landscape irrigation performance periodically.

Use of Mulch

- Use mulch in landscaped beds.
- Use organic mulches whenever possible.
- Use only herbicide-free grass clippings for mulch.
- Protect bulbs and other perennials in winter with a layer of coarse mulch (evergreen branches) to delay or prevent early growth.

Pruning

- Hire a certified arborist to prune trees as the correct pruning cuts are essential to good tree health.
- Maintain pruning equipment to ensure clean cuts and less risk of damage to the plant.
- Prune deciduous shade trees in March and early April, except in times of extreme drought.
- Prune shrubs based on their season of bloom.

Pest Management

- Use IPM for landscaped areas.

Native Areas Establishment and Maintenance

- Eliminate weeds prior to establishment.
- Use native species, and select species based on the site’s climate, soils, intended use, and planned management.
- Seed native areas at the recommended rates for that species.
- Maintain weed control, especially during establishment phase, and time weed-control efforts prior to weed seed maturity.
- Maintain native areas through prescribed burns, mowing, or haying.

12 Energy

Preface

The use of energy for all activities in society is of great interest worldwide. Golf courses use a variety of energy sources, primarily electricity, gasoline, diesel, natural gas, propane, and heating oil. Renewable sources, such as solar, wind, and geothermal, are increasingly being utilized and considered by small business as the return on investment increases. These newer technologies offer opportunities to reduce dependencies on fossil fuels and our carbon footprint.

To establish effective energy BMPs, the facility's existing energy consumption should be evaluated, and improvements should be achieved through energy reduction, conservation, and new technologies. Energy audits allow for identification of deficiencies. A written energy conservation plan is key to ensuring improvement.

Managers should evaluate current conservation practices based on these categories:

- Buildings, infrastructure, and facility amenities such as the clubhouse, restaurant, kitchen, swimming pool, parking lot, offices, maintenance building(s), tennis courts, and restrooms.
- Golf course, surrounding landscapes, and related agronomic operations (playing surfaces, equipment, turfgrass maintenance, etc.).
- Irrigation system and pump station.

The irrigation system and pump station are the largest consumers of energy on the golf course and should be evaluated. Conserving and reducing water through irrigation BMPs also reduces energy consumption.

Some policies, financial incentives, and loan opportunities exist at the state and local level for renewables and energy efficiency measures at commercial enterprises such as golf courses. Energy providers can provide information, expertise, and incentives to help achieve these goals.

12.1 Energy Audits and Evaluations

An energy audit of the facility should be done if one has not been conducted previously. Energy audits identify areas most in need of conservation. Utility providers can be a source of expertise in conducting an audit. An energy audit should include these steps:

- Evaluate insulation in heated buildings.
- Evaluate heating, ventilation, and air conditioning (HVAC) system efficiency.
- Determine annual energy usage. • Itemize usage according to various categories.
- Determine if energy usage during non-peak hours are maximized.

- Compare usage with similar small businesses.
- Identify areas of improvement.

Determining energy conservation goals and establishing an environmental plan is a first step in addressing energy efficiency. An energy management plan sets a baseline related to current energy use and incorporates quality management elements (plan, do, check, and act) for continual improvements. Once goals for energy conservation are established and documented, this policy should be communicated to all staff.

Evaluating the performance of an energy conservation program requires tracking and measuring energy use at the facility based on energy assessment units (e.g. kilowatt hour or BTU). Monitoring energy usage can be accomplished with energy management software or programs such as the USEPA's Portfolio Manager, which also incorporates features such as reporting, savings calculations, and carbon footprint calculations. To benchmark performance, energy consumption can be compared with other local golf facilities of similar size or more generally to buildings of similar size.

12.2 Energy Efficiency Improvements

The audit will identify opportunities to increase energy efficiency in buildings, amenities, and operations. For example, ground-based heat pumps conserve energy as compared with conventional heating sources and could be considered for new building construction or replacement for existing heat sources when the opportunities arise. Developing and implementing a viable energy conservation plan will lead to improvements over time.

12.3 Green and Alternative Energy

Green and alternative energy can be incorporated into golf course operations. Golf courses can become small-scale generators of energy through wind turbines, solar installations, and geothermal heating and pumping. Golf courses normally have the land, space, and natural resources available on the property to lend themselves to energy generation as newer technologies become more affordable. Financial and tax incentives may be available for installing these energy generators.

12.4 Energy Best Management Practices

Energy Audits and Evaluation

- Conduct an energy audit, including lighting, insulation, and HVAC systems.
- Monitor energy use by tracking statistics and "time of use" data.
- Install precision meters, gauges, etc.
- Develop an equipment inventory that documents individual equipment's energy use, traffic patterns, maintenance records, operation hours, etc.
- Benchmark performance against similar-sized facilities.

- Educate, train, and motivate employees on energy efficiency practices pertaining to golf course operations.

Energy Efficiency Improvements

- Evaluate and monitor all energy sources, tracking both costs and any usage trends.
- Add insulation where needed.
- Use non-peak electrical hours for charging golf carts and maintenance equipment.
- Prioritize pump station usage during non-peak hours.
- Limit high-consumption activities when demand is high.
- Install LED lighting and other high-efficiency alternatives.
- Install motion sensors for lights where appropriate.
- Install low-flow faucets.
- Install programmable thermostats.
- Consider energy management software.
- Utilize USEPA's Energy Star and Portfolio Manager programs.
- Utilize USEPA's WaterSense program.
- Maintain good record-keeping practices.
- Prioritize energy consumption as part of decision-making when making purchases concerning all aspects of facility management.
- Evaluate effectiveness of upgrades according to efficiency and conservation goals for energy use.

Green and Alternative Energy

- Consider pursuing the U.S. Green Building Council's LEED certification for new buildings and existing building retrofits.
- Use alternative energy from natural sources, such as solar, geothermal, and wind energy generation when possible.
- Assess the viability of small-scale wind and solar installations.
- Install geothermal heating and cooling systems.

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(Note: URLs are as of September 2016)

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