Best Management Practices for New York State Golf Courses

SECOND EDITION

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Protecting the Environment
NYGCF
New York Golf Course Foundation
BEST MANAGEMENT PRACTICES

GCSAA
Golf Course Superintendents Association of America

Cornell University

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Who We Are/Acknowledgements

New York Golf Course Foundation

The New York Golf Course Foundation (NYGCF) is a nonprofit established in 2018 to promote sustainable golf management efforts in New York State. This nonprofit grew out of the New York State Best Management Practices (BMPs) project, which began in 2012 and established the state's first golf industry BMPs. The foundation's mission is to provide educational opportunities related to BMPs; fund research that furthers the science of golf course management; and maintain outreach efforts to communicate with key audiences.

The current focus of the NYGCF is outreach and education promoting the acceptance and implementation of BMPs by the state's golf course superintendents. As key partners in these efforts, scientists from Cornell University will continue working with NYGCF to accomplish the foundation's mission.

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

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Additional Acknowledgements

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Expert scientific review was provided by Cornell University scientists Dr. Frank Rossi and Dr. Kyle Wickings. Representatives from the New York State Department of Environmental Conservation contributed to the development of these BMPs by providing a detailed and thorough review.

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1 INTRODUCTION

The New York State Best Management Practices (NYS BMP) project is an innovative research and outreach education program that has resulted from a partnership of superintendent leaders in the state and Cornell University. Begun in 2012, this project has codified standards and continues to actively demonstrate the implementation of best management practices for the protection of water quality in the state of New York. The success of this work has led to the commitment of superintendents to continue these efforts in perpetuity as part of a sustainable 501(c)(3) non-profit, the New York Golf Course Foundation (NYGCF).

As the stewards of golf courses in NY, superintendents are dedicated to protecting New York's natural resources and embrace the responsibility to maintain these facilities in harmony with the natural environment. These BMPs are helping those in the golf industry work in concert with policymakers and regulators in a shared commitment to water quality protection. The BMPs integrate the latest research on New York's climate and environment.

The research-based, voluntary BMP guidelines are designed to protect and preserve New York's water resources that enhance open space using current advances in golf turf management. This effort to provide extensive guidance for environmental stewardship is being conducted in the best traditions of golf, as defined by golf's inherent values: honesty, integrity, and fair play (including upholding the rules when no one is watching). These are core values of golf turf professionals and serve as the basis for this innovative environmental effort.

Golf courses, particularly in New York's urban areas, represent some of the largest areas of open space in metropolitan communities. Large expanses of grass allow water to infiltrate into the ground naturally instead of flowing into storm sewers or streams and rivers. Golf courses also provide additional environmental benefits to the public, such as providing habitat, recreational opportunities, and economic benefits.

Since the time of publication of *Best Management Practices for New York State Golf Courses* in 2014, the Golf Course Superintendents Association of America (GCSAA) has begun a nationwide effort to complete golf course BMPs nationwide. As part of this effort, GCSAA is making available state BMPs through their BMP portal for superintendents in each state to use to create their own facility-specific BMP. This version of New York's golf course BMPs serves as that template and includes additional information beyond the 2014 publication, including information on protecting pollinators on golf courses.

1.1 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. Research indicates that successful implementation of BMPs virtually eliminates the golf course risk to water quality. In fact, several studies have shown that implementing BMPs enhances water quality on its journey on and through the golf course property. Besides contributing to natural resources stewardship, additional incentives for golf courses in New York State to create a facility BMP plan and implement BMPs include the following:

- potential for more efficiently allocating resources by identifying management zones
- cost savings associated with applying less fertilizer and pesticide
- cost savings associated with more efficient irrigation and other water conservation efforts
- improved community relations
- recognition by club members and the community at large of golf courses as environmental stewards

Through a cooperative approach between the golf industry and friends and neighbors outside the industry, practices have been developed that benefit all parties. Because of limitations, such as budget, staff, clientele expectations, and management decisions, not all golf courses can achieve all of the best practices. However, planning for improvements over time and making 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 onto a grassed surface is easily achieved and markedly reduces the amount of nitrogen and phosphorus in clippings that end up in washwater. With a bit more of a budget, facilities can utilize the information from the NYS BMP case study on a prototype low-cost wash operation that protects water quality at Locust Hill Golf Club in Rochester. Additional case studies of BMPs implemented on golf courses in the state can be found in the Case Studies section of the NYS BMP website.

1.2 Environmental Concepts

The following environmental concepts provide the basis for understanding the role of BMPs in water quality protection:

- climate and microclimates
- water, including the hydrologic cycle and watersheds
- soils, including soil texture and moisture
- geology, including karst topography

Water, soils, and geology all play a role in environmental fate and transport mechanisms (such as runoff and leaching) that can contribute to water quality. BMPs act on these fate and transport mechanisms to prevent water quality contamination. These basics are covered in detail in Chapter 2 of *Best Management Practices for New York State Golf Courses*.

1.2.1 Climate Change

Projections of a changing climate suggest that rainfall will become less frequent, but more intense. As a result, a greater volume of the precipitation is expected to run off instead of infiltrating into the soil and replenishing groundwater. Consequently, the need for supplemental irrigation may increase, and superintendents will need to take greater care in the applying fertilizer and pesticides to reduce the risk of runoff. Structural BMPs are valuable in managing increased runoff. For more information on available climate data for New York, see the Northeast Regional Climate Center.

1.2.2 Environmental Fate and Transport Mechanisms

Understanding contaminant fate and transport mechanisms helps superintendents to minimize the risk of off-site movement of nutrients and chemical pesticides applied to golf courses. The fate and transport mechanisms of concern to golf course managers are as follows:

- **Runoff** is the movement of water across the turf and soil surface, typically following a storm event or heavy irrigation. The potential for runoff is greatest on steep slopes.

- **Leaching** is the downward movement of water through the soil and potentially into groundwater. Several variables influence the probability and rate of leaching, such as soil type and structure, vegetation, chemical properties, rate of precipitation, and depth to groundwater. When deciding on the rate and timing of fertilizer and pesticide application, it is critical to assess soil moisture status and potential for high infiltration in order to minimize potential losses.

- **Spray drift** is the movement of fine particles, or droplets, through the air while the pesticide is being applied. Droplet size and wind and weather conditions affect the potential for spray drift during pesticide applications.

- **Vapor drift** is the movement of pesticide in the form of a gas or vapor during or after application. Pesticide formulation, wind and atmospheric conditions affect the potential for vapor drift during pesticide applications.

- **Volatilization** occurs when pesticide surface residues change from a solid or liquid to a gas or vapor after a pesticide application. Once airborne, volatile pesticides can come into contact with applicators or move long distances off site.

- **Spills** are the unintended releases of chemicals, such as fertilizers, pesticides, hazardous materials, or petroleum products released during transportation, storage, and routine maintenance and facility operations.

While most of the fate and transport mechanisms of concern can contribute to nonpoint sources of pollution, spills can be a point source of pollution. The legal definition of "point source" is provided in 6 NYCRR Part 050-1.2(65) as follows:

> The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other

floating craft, or landfill leachate collection system from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

On golf courses, point sources of pollution can originate from:

- storage and maintenance facilities
- the unintended release of chemicals, such as pesticides, fertilizers, or fuel, during transportation, storage, or handling
- drainage discharge outlets (e.g. the end of a drainage pipe)

Containment measures can easily prevent chemicals from becoming point sources of pollution during storage and handling. To prevent discharges from contaminating surface water, the discharges must be diverted away from surface water and onto turf areas or other appropriate areas instead. For more information, see the blog post "Stuck in the Shop? Do a Point Source Pollution Assessment" on the NYS BMP website.

1.2.3 Sedimentation

A primary benefit of turfgrass or any perennial vegetation is the reduction in sediment and particulate movement. Precipitation and irrigation can carry soil particles (sediment) in runoff and deposit them into surface water. Too much sediment can cloud surface water, reducing the amount of sunlight that reaches aquatic plants and impairing aquatic species habitat. In addition, sediments can carry fertilizers, pesticides, and other chemicals attached to soil particles and transport them into waterbodies, causing algal blooms that lead to oxygen depletion. Sedimentation is controlled through BMPs that control the volume and flow rate of runoff water, maintain adequate turf density, and reduce soil transport.

1.3 Water Quality

If water quality contaminants reach surface water or groundwater, the potential water quality impacts can include the following:

- drinking water impairment if nitrogen as either nitrate (NO_3) or nitrite (NO_2) are present at levels above health-based risk values in drinking water, which may adversely affect health
- nutrient enrichment of surface water
- sedimentation due to eroding soils
- toxicity to aquatic life

Each potential impact is discussed in more detail on the NYS BMP website Water Quality Protection page.

1.4 Pollution Prevention

Because of the efforts aimed at protecting surface water and groundwater quality, the majority of BMPs addressed in this document relate to water quality. At any golf course, preventive strategies should include combinations of land use controls and source prevention practices. An integrated water quality protection system is based on a tiered concept as follows:

- prevention – prevent problems from occurring
- control – have safeguards in place to control any problems
- detection – consider a monitoring program to detect changes in environmental quality

Preventive measures are categorized as either land use BMPs or source prevention BMPs. Land use BMPs are engineered and incorporated into the course during golf course design and construction. Land use BMPs protect natural resources through primarily mechanical methods, as described in the remainder of this chapter. Source prevention BMPs are implemented during golf course operation to prevent or preclude the possibility of movement of sediment, nutrients, or pesticides from the property or from toxic materials being introduced into ecologically sensitive areas.

BMPs reduce stormwater volume, peak flow, and nonpoint source pollution through evapotranspiration, infiltration, detention, filtering, as well as biological and chemical actions. Implementing BMPs can prevent or minimize the effects of golf course management on surface and groundwater to ensure and enhance public health and environmental quality. Pollution prevention is easier, less expensive, and more effective than addressing problems "downstream." Essentially, BMPs are a sustainable approach to providing environmental, economic, and social benefits to golf and to society.

1.5 Water Conservation

Water is a fundamental element for physiological processes in turf such as photosynthesis, transpiration, and cooling, as well as for the diffusion and transport of nutrients. Turf quality and performance depend on an adequate supply of water through either precipitation or supplemental irrigation. Too little water induces drought stress and weakens the plant, 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.

Many BMPs in this document conserve our water resources and can be used to prepare for water use restrictions that may be imposed in times of extended drought. 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.

The following case studies focusing on water conservation on NYS golf courses have been published by the NYS BMP project:

- *Precision Water Management*, North Hempstead Country Club, Port Washington

- *Conserving Water By Installing Quick Couplers*, GlenArbor Golf Club, Bedford
- *Irrigation System Upgrades for Water Conservation*, Hollow Brook Golf Club, Cortland Manor
- *Opportunities for Improvement of Wash Pad Operations*, Locust Hill Country Club, Rochester

1.6 Pollinators

Protecting bees and other pollinators is important to the sustainability of agriculture. In 2017, the New York State BMP project published pollinator BMPs; updated in the 2019 publication *Best Management Practices for Pollinators on New York State Golf Courses* and incorporated into this document. Minimizing the impacts of pesticides on bees and other pollinators, as well as on beneficial arthropods, is addressed in this document in two ways:

- promoting the use of integrated pest management (IPM) methods to reduce pesticide usage and to minimize the potential of exposure
- providing specific guidance for pesticide applicators

Superintendents can also directly support healthy pollinator populations by providing and/or enhancing habitat for pollinator species and by supplying food sources and nesting sites and materials.

The following case studies focusing on protecting pollinators and IPM use on golf courses have been published by the NYS BMP project:

- *Enhancing Habitat for Native Pollinators with Low-to-No Maintenance Areas*, Rockland Country Club Golf Course, Sparkill
- *Reducing Environmental Impact of Pest Management*, Soaring Eagles Golf Course, Horseheads
- *Integrating BMPs to Increase Sustainability*, Locust Hill Country Club, Rochester
- *Protecting Pollinators on the Golf Course*, Rockville Links Club, Rockville Centre

1.7 Creating a Facility BMP

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. In addition, understand that multiple approaches can successfully protect natural resources when considering the best approach to meeting a BMP objective. For example, the following describes an incremental approach to developing a nutrient management program, as published in the blog post "Assess and Map Your Soils" on the NYS BMP website:

- A **good practice** is to assess the chemical and physical analysis of your regularly fertilized soils using a *Minimum Levels for Sustainable Nutrition (MLSN) Guideline* interpretation, as well as looking at overall turf quality and growth, when developing a nutrient management program. Make accurate supplemental nutrient applications 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). Make supplemental applications of nutrients based on large-scale mapping in targeted areas of well-established needs.

- The **best practice** would be 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. Use this GIS database of soil properties for GPS-based Variable Rate Application equipment for precise supplemental nutrient applications to targeted areas of well-established need.

1.8 Conclusion

This document was developed using the latest research-based information and sources. It will be posted on the NYS BMP website and made available through the GCSAA's online tool (available to GCSAA members only) for development of facility BMPs. At the time of this publication, the information was the latest available. Regulations may change, and superintendents should identify any changes (especially to regulations) since the publication date.

2 SITE ANALYSIS

Site analysis is the first and most important step in aligning golf course management with research-based BMPs designed to protect water quality. A site analysis describes site maintenance areas, chemical storage and handling practices, equipment cleaning, and other priority areas on the golf course associated with topography and environmental sensitivity. Following this thorough assessment, the feasibility of land use and management BMPs should be considered to ensure reasonable water quality protection.

BMPs can be incorporated into the design for a new course or course renovation. For an existing golf course, the golf course superintendent can undertake a site analysis to identify specific areas of interest to focus the implementation of BMPs. For a new golf course development or a renovation project, the New York State requires that a licensed golf course designer guide the site analysis process to ensure compliance with relevant regulations. Designers and others involved in golf course development are encouraged to work closely with local community groups and regulatory bodies during planning and siting and throughout the development process. For every site, local environmental issues and conditions must be addressed.

BMP Principles for Site Analysis

- Properly assess maintenance sites and golf course for priority areas related to water quality protection.
- Determine most effective structural or vegetative BMP strategy, if needed.

2.1 Identify Priority Areas

The site analysis will help to develop a better understanding of how a golf course fits into the landscape, including identifying the facility's location in relation to its watershed. The site assessment then should identify environmentally sensitive areas for protection such as:

- wetlands
- surface waterbodies
- shorelines
- steep slopes to surface water
- areas with shallow depth to ground water
- critical groundwater recharge zones (especially true for Long Island, due to its sandy soils)
- listed species habitat
- areas with unique geological characteristics, such as karst topography, which leave groundwater vulnerable to contamination

On golf courses, areas that could serve as potential point sources of pollution should be identified as priority areas for water quality protection. Specifically, potential point source pollution can originate as the unintended release of chemicals, such as pesticides, fertilizers, or fuel, during transportation, storage, handling, cleaning, or refueling of equipment. Containment measures can easily prevent chemicals from becoming point sources of pollution, as described in the "Maintenance Operations" chapter of this document.

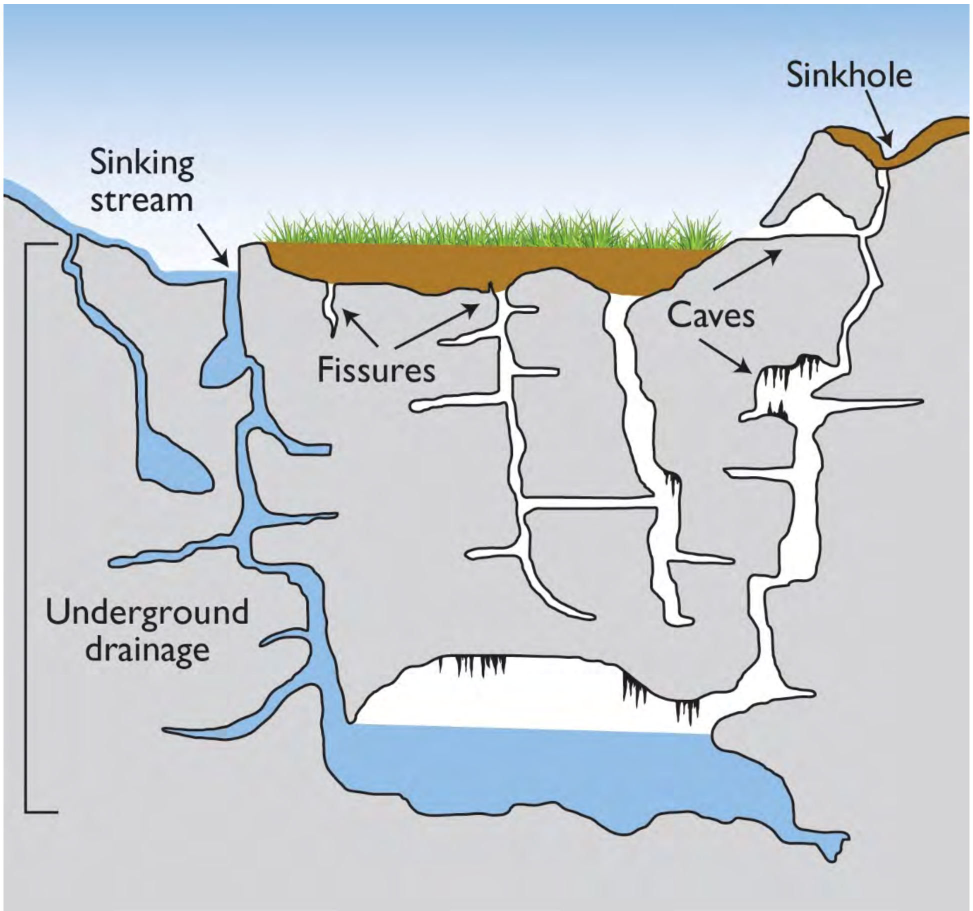

Figure 1. Karst topography.

2.2 Establish Management Zones

In order to manage a golf course in an environmentally sensitive and responsible manner, management zones can be established throughout the course. Management zones are defined as areas that have distinct management practices based on the area's position in the watershed and can be used to protect the priority areas identified in the site analysis. Management zones work hand-in-hand with source prevention BMPs, such as IPM. More information is available on the Management Zones web page on the NYS BMP website.

2.3 Site Analysis Best Management Practices

Identify Priority Areas

- Evaluate the watershed size to understand drainage needs and appropriate pipe sizing.

- ❖ Identify areas on the course that may be prone to leaching (shallow depth to groundwater, sandy soils, etc.) and runoff (steep slopes, etc.)
- ❖ Identify any listed species and critical habitat that may be present on the site and then preserve the habitat, as well as the feeding and nesting areas.
- ❖ Identify and preserve regional wildlife and migration corridors by avoiding or minimizing crossings. Design unavoidable crossings to accommodate wildlife movement.

Management Zones

- ❖ Establish a low- to no-maintenance level within the established buffer along wetlands.
- ❖ Establish and maintain riparian buffers around wetlands, springs, and channels.
- ❖ Leave riparian buffers unfertilized and in a natural state.
- ❖ 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 species.
- ❖ Use turf and native plantings to enhance buffer areas; increase the height of cut if mowing in buffer areas.
- ❖ Separate constructed wetlands from managed turf areas with native vegetation or structural buffers.

3 PLANNING, DESIGN, AND CONSTRUCTION

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.

BMP Principles for Planning, Design, and Construction

- Follow best practices anytime soil is disturbed to avoid erosion and sedimentation.
- Maintain existing habitat to the extent possible during all phases of planning, design, and construction to preserve biodiversity.
- Manage stormwater by implementing a "treatment train" approach to prevent nonpoint source pollution from runoff.

3.1 Regulatory Considerations

Regulations are in place at the local, state, and national levels that impact planning, design, and construction activities on New York's golf courses. Before beginning any golf course construction or renovation work, consultation with the appropriate regulatory agencies is necessary. For a new golf course development or a renovation project, New York State requires that a licensed golf course designer guide the site analysis process to ensure regulatory compliance. If new wells must be installed, experts should be consulted for proper siting in the design plan, and all setback and other regulatory requirements must be followed.

3.1.1 Stormwater Permits

The Environmental Protection Agency (EPA) protects streams, rivers, and lakes from construction pollution under the Clean Water Act (CWA). In concert with federal water quality regulations, the NYS Department of Environmental Conservation (NYSDEC) issues individual and general permits for activities associated with stormwater discharges, including construction activities. Construction projects that will involve soil disturbance of one or more acres must obtain coverage under the State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity from NYSDEC. Permittees are required to develop a Stormwater Pollution Prevention Plan (SWPPP) to prevent discharges of construction-related pollutants to surface water. See the *New York State Stormwater Management Design Manual*, updated in 2015, for more information.

3.1.2 Erosion and Sediment Control

The NYSDEC Division of Water has regulatory oversight of the state's erosion and sediment control program. The 2016 *New York State Standards and Specifications for Erosion and Sediment Control* provides standards and specifications for the selection, design and implementation of erosion and sediment control practices for the development of Erosion and

Sediment Control Plans for the SPDES General Permit for Stormwater Discharges from Construction Activity.

3.1.3 Wetlands

Activities that impact wetlands are regulated under sections 404 and 401 of the CWA. The U.S. Army Corps of Engineers (USACE) regulates dredging and filling of waters in the United States under Section 404 of the CWA. Article 24 of New York Environmental Conservation Law requires permits to conduct activities within a wetland and an adjacent area bordering a wetland. Physical disturbance, as well as application of chemicals (pesticides, herbicides, fungicides, even fertilizer), requires an Article 24 permit if the action is done in a state-regulated wetland or within a regulated adjacent area (typically 100 feet from wetland boundary).

3.1.4 Water Withdrawal

NYSDEC requires water withdrawal permits and annual reporting for any system capable of withdrawing more than 100,000 gallons of groundwater or surface water per day. Any withdrawal must also ensure that the existing best use of the waterbody from which the water is taken, such as protection of aquatic life, is not impaired. For more information on reporting and regulations in New York, see the Water Withdrawal Permits and Reporting web page.

3.1.5 Coastal Areas

Land disturbance activities within a designated coastal area may be regulated at the federal, state, and local levels. NYSDEC has two programs focused on the protection of coastal erosion:

- Coastal Erosion Hazard Area (CEHA) permit program, which provides written approval of regulated activities or land disturbance within the coastal erosion hazards areas under DEC's jurisdiction.
- USACE's Civil Works Program. DEC works with USACE to study erosion problems along coastlines and to develop solutions.

Coastal communities with local CEHA ordinance laws need to complete the Local Coastal Erosion Management Program Annual Assessment Form.

3.1.6 Listed Species

The State Endangered Species Act (ECL § 11-0535) regulations are codified in 6 NYCRR Part 182 and administered by NYSDEC. The NY Natural Heritage Program, a partnership between NYSDEC and the State University of New York College of Environmental Science and Forestry, provides information on listed species and species of special concern and ecological communities in the state. The Natural Heritage Program should be consulted prior to construction activities.

3.1.7 Invasive Species

Invasive species are non-native plants and animals that may negatively affect the environment, human health, and the economy. The transport and fate of invasive species is highly dependent upon the activities at a site. As they may affect areas beyond a project site, their presence should be considered and managed carefully. Furthermore, NYSDEC regulations (6 NYCRR Part 575) require that “no person shall sell, import, purchase, transport, introduce, or propagate any prohibited invasive species”. The prohibited invasive species list is available from NYSDEC. The disposal of invasive species in a manner that prevents their introduction into the environment is exempt from these restrictions.

3.2 Planning, Design, and Construction Overview

Proper planning is the first step to any construction or renovation project. Good planning also incorporates conservation of natural resources into the project. The design should allow for economic sustainability, while meeting stakeholder needs. Once designed, construction must be carried out in a way that minimizes environmental impacts. Maintaining a construction progress report helps to ensure regulatory compliance. Table 1 summarizes the steps and best practices for each phase of the planning, design, and construction process.

3.3 Planning and Design Considerations

3.3.1 Wetlands

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.

3.3.2 Constructed Wetlands

Constructed aquatic ecosystems simulate the role of natural wetlands with respect to water purification. Like natural wetlands, they feature poorly drained soils and rooted emergent hydrophytes. which simulate the role of natural wetlands in water purification. These structures efficiently remove certain pollutants (nitrogen, phosphorus, metals, sediment, and other suspended solids) and can treat wastewater, such as discharges from equipment wash pads before the water enters streams, natural wetlands, or other surface water. Once these areas are constructed, however, they are considered wetlands and regulated as such.

3.3.3 Floodplains

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.

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, biologirst or ecologist, and a legal team. For new golf courses, a licensed golf course designer is required by law to guide the site analysis process.
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 and Analyze 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, valuable habitat, or invasive species should be identified. New York State requires that a licensed golf course designer guide the site analysis process to ensure regulatory compliance.
Design	
Retain a Project Manager/Superintendent	This person is responsible for integrating sustainable practices in the development, maintenance, and operation of the course.
Design the Course	Existing native landscapes should remain intact as much as possible. Consider 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.
	Structural BMPs: Incorporate structural BMPs into the design plan, identifying opportunities to detain stormwater and to improve water quality through stormwater volume reduction, filtering, and biological and chemical processes.
	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. Root zone material should be selected with United States Golf Association (USGA) specifications in mind, as published in *A Guide to Constructing The USGA Putting Green*. Physical testing of these sands by an accredited laboratory prior to use is recommended.
	Grass Selection: Species should be selected based on climate, 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 depend 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
	Vegetative Filters: Vegetative filters (conservation buffers, vegetated filter strips, swales, etc.) can be used throughout the golf course to act as natural biofilters to reduce stormwater flow and pollutant load. Turf areas are also effective filters.

Design Irrigation System	Hire a professional irrigation architect, 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.
Construction	
Select Qualified Contractors	Use only qualified contractors who are experienced in the special requirements of golf course construction, such as members of the Golf Course Builders Association of America.
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. Prevent the spread of invasive species.
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.

See NYSDEC's Floodplain Management web page for more information and links to other sources of information.

3.3.4 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. Therefore, construction of ponds should consider the needs of aquatic ecosystems, such as discouraging excessive growth of aquatic vegetation, supplying sufficient dissolved oxygen (DO) to support aquatic species, etc. Careful design may significantly reduce future operating expenses for pond and aquatic plant management. In addition, water resources should be managed to control or limit the spread of aquatic invasive species, such as submerged plants, fish or invertebrates.

Figure 2. Careful pond design may significantly reduce future operating expenses for pond and aquatic plant management.

3.3.5 Habitat Conservation

In addition to adhering to regulations that protect listed species, maintaining habitat to the extent possible during all phases of planning, design, and construction helps maintain biodiversity. Natural habitats provide food and shelter for numerous species, including mammals, birds, fish, amphibians, reptiles, insects, and native plants. A number of golf course management activities can maintain and enhance habitat, such as the following:

- Retaining natural buffer areas around wetlands and watercourses preserves habitat while protecting water quality for aquatic species.
- Planting native species provides food for animals and insects.
- Retaining dead trees to serve as nesting areas and providing nest boxes for birds, bees, and bats also enhances habitat quality.
- Removing exotic and invasive species improves habitat as well. The New York Invasive Species Information website provides lists of invasive species and species profiles which include control strategies.
- Consider consultation with local Partnerships for Invasive Species Management (PRISMs) for practical advice and region-specific recommendations.
- Creating corridors to connect natural areas (both on and off property).

The "Pollinator Protection" and "Landscape" chapters of this document provide additional recommendations and BMPs for enhancing habitat on the golf course.

Figure 3. Retaining natural buffer areas around wetlands and watercourses preserves habitat while protecting water quality for aquatic species.

3.3.6 Invasive Species

Invasive species should be managed to prevent their spread or where practicable to eradicate them from sites. Areas infested with invasive species should be delineated and monitored whenever construction occurs. Whenever possible, native plants should be used to revegetate disturbed areas.

3.4 Stormwater Management

The movement of water across the land surface (i.e. runoff) from either precipitation or irrigation that does not infiltrate into the ground is the conveying force behind nonpoint source pollution. In this section, stormwater management refers to the management of runoff from precipitation but applies to irrigation runoff as well. Stormwater management is the control and use of stormwater runoff and includes planning for runoff, maintaining stormwater systems, and regulating the collection, storage, and movement of stormwater. Principles of stormwater management on golf courses includes the following:

- Keep stormwater close to where it falls.
- Slow down stormwater runoff.
- Allow stormwater to infiltrate into the soil.

Stormwater management is best accomplished by a "treatment train" approach in which water is moved from one treatment to another by conveyances that themselves contribute to the treatment. These treatments include source controls, structural controls, and non-structural controls. An example of this treatment train approach is as follows: Stormwater is directed across vegetated filter strips, through a swale, into a retention pond, then out through another swale to a constructed wetland system.

Figure 4. Grassed filter strip to infiltration basin.

3.4.1 Source Controls

The first car of the BMP treatment train are source controls to help prevent the generation of stormwater runoff or the introduction of pollutants into stormwater runoff. For example, during construction or redesign activities, strict adherence to erosion and sedimentation controls helps to prevent, or at least minimize, the possibility for sediment and nutrients to impact water quality through runoff. After construction, reduction in the use of pesticides through an IPM program reduces the potential for off-site movement of pesticides.

3.4.2 Structural Controls

Structural controls are often the next car in the treatment train and are design and engineering features on the course created to remove, filter, retain, or reroute potential contaminants (e.g. nutrients, pesticides) carried in surface runoff. Descriptions of structural controls commonly used on golf courses and an evaluation of the effectiveness of each can be found on the NYS BMP Structural Controls web page. Periodic inspection and maintenance of all structural controls are essential to ensure they function as designed; inspection and maintenance guidelines are published on the NYS BMP Maintenance of Structural Controls web page.

In and around the clubhouse and other structures, opportunities to slow down the movement of water from impervious surfaces and allow for infiltration should be identified. For example, runoff from gutters and roof drains should flow into permeable areas. Rain gardens near these areas can be incorporated into the landscape design. Maximizing the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass, allows stormwater to infiltrate into the soil as opposed to running off. Crushed stone and other permeable products are available for cart paths or parking lots.

3.4.3 Non-Structural Controls

Non-structural controls are the last car in the treatment train. Non-structural controls often mimic natural hydrology (e.g. constructed wetlands), hold stormwater (e.g. constructed wetlands and wet retention basins), and filter stormwater via vegetative practices (e.g. filter strips and grassed swales). Turfgrass areas are extremely effective in reducing soil losses compared to other cropping systems, due to the architecture of the turf canopy, the fibrous turf root system, and the development of a vast macropore soil structural system that encourages infiltration rather than runoff. Additionally, turf density, leaf texture, rooting strength, and canopy height physically restrain soil erosion and sediment loss by dissipating impact energy from rain and irrigation water droplets. A description of specific types of vegetative practices that serve as non-structural controls on golf courses is published on the NYS BMP Vegetative Practices web page.

Figure 5. Vegetated buffer areas around surface water provide significant water quality protection.

3.4.4 Drainage

Adequate drainage is necessary for healthy turfgrass. The drainage system should be part of the stormwater management approach, incorporating the containment and treatment features described above.

Subsurface drainage directs stormwater and can reduce runoff and leaching. Subsurface drainage is also installed to control a water table or to interrupt subsurface seepage or flow. Wherever possible, direct this drainage into vegetative areas for biological filtration or into infiltration basins to help control the potential loss of nutrients and pesticides from the golf course.

Drainage 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. The drainage system should be routinely inspected to ensure proper function. Roots and animal activity can easily clog drains and prevent proper functioning.

3.5 External Programs

Golf courses can gain valuable recognition for their environmental education and certification efforts. Examples of external designations include Audubon International's Cooperative Sanctuary Program for Golf and the Groundwater Foundation's Groundwater Guardian Green Site program.

3.6 Planning, Design, and Construction Best Management Practices

Planning, Design, and Construction Activities

- ❖ Retain riparian buffers along waterways to protect water quality and provide food, nesting sites, and cover for wildlife.
- ❖ Rigorously employ soil stabilization techniques to maximize sediment control and minimize soil erosion.
- ❖ Maintain appropriate silt fencing during construction to prevent erosion and sedimentation in accordance with the SWPPP.
- ❖ When constructing drainage systems, pay close attention to engineering details such as subsoil preparation and the placement of gravel, slopes, and backfilling.
- ❖ Identify, delineate, and list aquatic and terrestrial invasive species on the property, and report the presence of any invasive species to iMapInvasives.
- ❖ Wash soils, seeds, and plant propagules off of all construction equipment prior to entering a site and before leaving areas infested with invasive species to prevent the spread beyond a construction zone.

Stormwater Management

- ❖ Install retention basins to store water and reduce flooding at peak flows.
- ❖ Install vegetated swales and slight berms around water edges, including retention basins, to slow water and allow for infiltration.
- ❖ 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.
- ❖ Conduct an initial evaluation of the rate of dewatering of structural controls after large storms and the depth of sediment buildup for each structure.
- ❖ Monitor each control structure regularly, at least once per year.
- ❖ Maintain an inspection log for each control structure.
- ❖ Remove sediment buildup, clean the inlets, and mow as needed to maintain performance of structural controls.
- ❖ Inspect filter strips annually and examine for damage from foot or vehicle traffic, encroachment, gully erosion, or evidence of concentrated flows through or around the strip.
- ❖ Maintain dense grass cover on grassed swales by mowing, spot-seeding, controlling weeds, and watering as needed.
- ❖ Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off.

- Use elevated stormwater drain inlets in parking lots for hard rains. Such inlets can hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Consider using crushed stone or other permeable products for cart paths or parking lots.
- Eliminate or minimize directly connected impervious areas.
- Ensure runoff from gutters and roof drains flows onto permeable areas, allowing the water to infiltrate near the point of generation.

4 IRRIGATION

Water is a fundamental element for physiological processes in turf such as photosynthesis, transpiration, and cooling, as well as for the diffusion and transport of nutrients. Precise water management is arguably the single most important turf practice for maintaining high quality golf turf. When the amount of water lost from the turf system by evapotranspiration (ET) exceeds the amount supplied by rainfall, the turf must be irrigated. Courses should maximize water use efficiency through proper irrigation, as this conserves water and decreases the likelihood of water quality impacts from runoff or leaching. Deliberate use includes having an efficient irrigation system, ensuring the system's proper function, using only the amount of irrigation water needed to maintain healthy turf in playing areas, and incorporating cultural practices that increase the water holding capacity of soil.

BMP Principles for Irrigation

- Design and maintain irrigation systems to uniformly apply water to the intended area of management.
- Determine accurate supplemental water needs based on appropriate climate and soil data.
- Assess irrigation system efficiency through regular audits of application rate and uniformity.

4.1 Regulatory Considerations

NYSDEC requires water withdrawal reporting for any system capable of withdrawing more than 100,000 gallons groundwater or surface water per day. In accordance with the state water quality standards for flow, any withdrawal must also ensure that the existing best use of the waterbody from which the water is taken, such as protection of aquatic life, is not impaired. For more information on water withdrawal reporting and regulations in New York, see the Water Withdrawal Permits and Reporting web page. During times of extended drought, water use restrictions may be issued at the local level.

4.2 Irrigation Water Supply

Irrigation water must be dependable, reliable, and of sufficient quantity and quality to accommodate turf grow-in needs and ongoing maintenance. It must also pose no threat to public health.

4.2.1 Irrigation Water Sources

Irrigation water can come from several sources:

- surface water from ponds, lakes, or stormwater detention ponds
- groundwater from wells

- recycled water sources
- any combined supplemental sources from rainwater and stormwater collection

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 acceptable alternatives exist. In the northeast, irrigating with recycled water may become more common as the cost of water increases and the availability of fresh water decreases, especially in large metropolitan areas. Recycled water is defined as any water that has been treated after human use and is suitable for limited reuse, including irrigation. Such water is also referred to as reclaimed water, wastewater, and effluent water. Using recycled water may also be part of a nutrient reduction strategy to meet the Total Maximum Daily Load (TMDL) in impaired watersheds.

For more information on the use of recycled water on golf courses, see *Guidelines for Using Recycled Wastewater for Golf Course Irrigation in the Northeast*.

4.2.2 Irrigation Water Quality

Nonpotable water irrigation sources (such as recycled water or storage and detention ponds) should be tested regularly to ensure that the quality is within acceptable limits to protect soil quality and turfgrass performance. In addition, wells along the shore that supply potable water might need to be tested for saltwater intrusion.

The Irrigation Water Supply web page of the NYS BMP website provides detailed information on irrigation water quality parameters, including the following tables:

- "Summary of Irrigation Water Quality Guidelines"
- "Relative salt tolerance of turf species in NYS"
- "Irrigation water restrictions related to soil water infiltration"

Additional parameters such as pH and micronutrients may be valuable for detailed evaluations of water quality.

For additional information, see the following:

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

4.2.3 Irrigation Water Requirements

Seasonal and bulk water requirement analysis can be conducted to determine water requirements under normal and worst-case scenario (e.g. extended drought) conditions. For more information on calculating water requirements and example calculations, see Chapter 3 of *Environmental Best Management Practices for Virginia's Golf Courses.* To conduct these analyses, the National Centers for Environmental Information (NCEI) (formerly known as the National Climate Data Center) provides historical climate data and statistics on precipitation across 10 regions in New York.

4.3 Irrigation System Design and Installation

4.3.1 Site Assessment

A site assessment of the entire 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) and soil physical properties; microclimates; slopes; sun, wind and shade exposures; and a seasonal and bulk water requirement analysis. Examples of how site conditions impact irrigation system design include soil properties, which dictate how much water is needed to complete deep and infrequent cycles of replenishing water in the root zone, and wind exposures that increase transpiration losses and create greater water requirements.

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.

4.3.2 Design

Irrigation systems should be designed to meet site requirements, to provide efficient, uniform distribution of water, to conserve and protect water resources, and meet state and local code. Detailed BMPs for irrigation system design are published by the Irrigation Association in *2014 Landscape Irrigation Best Management Practices*.

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 features may include rain stop safety switches that either shut down the system in the event of rain or adjust schedules based on the amount of precipitation.

Figure 6. On-site weather stations provide the data for more precise irrigation control.

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.

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 users of water for irrigation.

4.3.3 Installation

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

4.4 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 *2014 Landscape Irrigation Best Management Practices* can be consulted for devising a schedule and a plan for record keeping.

4.4.1 Seasonal Maintenance

Winterizing protects irrigation system pipes from damage due to water expanding and rupturing the pipe walls and fittings. Most New York golf courses need to drain or used compressed air to remove water from lateral and mainlines pipes before temperatures drop below freezing.

4.4.2 Performance

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. This will change irrigation output and distribution. Nozzles should be replaced, depending on the manufacturer's recommendation, to ensure proper function.

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 7. Soil moisture sensor.

4.5 Irrigation Management Decisions

Irrigation should be scheduled when soils reach 50% of the plant available water point, and the amount of water should replenish the root zone to field capacity. The infiltration rate, effective root zone depth, and estimated ET demand determine irrigation frequency and soak cycle needs. These are explained in the Manage Irrigation web page of the NYS BMP website, which includes information on estimating infiltration rates, calculating and using the potential evapotranspiration (PET), and monitoring soil moisture.

4.5.1 Deep and Infrequent Irrigation

Several studies have compared deep and infrequent irrigation (DI) to light and frequent (LF) schedules. DI was applied at signs of wilting and the soil was wetted to a depth of 9.5 inches. LF treatments watered daily to replace the ET lost and generally wetted the top 1.5-3.0 inches of soil. Both treatments were syringed as required to cool turf on hot days. The turf treated using DI had increased root and leaf carbohydrates, larger and deeper root masses, reduced thatch, and better overall quality throughout the season. This particular study only considered physiological factors and did not assess the risks of leaching.

Wetting soils below the root zone increases the risks of pushing nutrient and pesticide residues closer to groundwater. Other studies have demonstrated that turf pre-conditioned with deficit irrigation for a period of seven to 14 days withstands periods of drought and has a quicker recovery. Pre-conditioning improves stomatal conductance, transpiration rates, and photosynthetic capacity in subsequent periods of stress. However, letting soils dry completely has a negative effect on plants. Creeping bentgrass, perennial ryegrass, and tall fescue can be pre-conditioned replacing 60-80% of the water deficit. Kentucky bluegrass has much higher sensitivity to drought stress and should only be watered at 100% of deficit. Cool season turfgrass should not be watered below 40% of deficit. Even though Kentucky bluegrass has the greatest sensitivity to deficits, it has the highest resiliency to recover.

4.6 Water Conservation

The increasing concentration of the US populations in urban and suburban areas is leading to concentrated demand for water resources. This urbanization has begun to challenge the supply of affordable and plentiful fresh (potable) water for irrigation in New York State. Water suppliers in most of the northeastern US must double the supply capacity to meet demand in the summer, resulting in high infrastructure costs. Therefore, economic, social, environmental, and political pressures dictate that water is used efficiently and conserved on New York's golf courses.

Golf course superintendents can maintain a landscape optimal for play, while conserving water, through effective course design and management. For example, reducing managed turf areas reduces water needs, maximizes rooting in areas that are irrigated, and improves the use of the water applied. In addition, a well-designed, properly maintained, and wisely used irrigation system ensures the uniform application of water and minimizes runoff.

Many irrigation BMPs result in more efficient water usage, such as improving the efficiency of irrigation systems. In addition, superintendents can reduce irrigation requirements through turfgrass management, such as minimizing maintained areas, maximizing rooting potential, reducing water lost through ET, and improving soil water storage where possible on sandy sites.

Figure 8. Individual head control helps to maximize irrigation efficiency and conserve water.

Turfgrass selection can also reduce irrigation requirements. The increased availability of improved turfgrass species and varieties provides an excellent opportunity to select the most well adapted turf to site conditions. If selected for drought tolerance, some turfgrass varieties require less water to survive and maintain playability.

The following NYS BMP case studies illustrate water conservation efforts undertaken at three different golf facilities in the state:

- *Precision Water Management*, North Hempstead Country Club, Port Washington
- *Irrigation Upgrades for Water Conservation*, Hollow Brook Golf Club, Cortland Manor
- *Conserving Water by Installing Quick Couplers*, GlenArbor Golf Club, Bedford Hills

4.6.1 Drought Planning

Extended droughts can occur in New York, and superintendents should be prepared to comply with any applicable local water use restrictions in times of drought and consider voluntarily restricting water use even when not required. NYSDEC publishes current drought conditions in New York and establishes four levels of state drought advisories (in increasing drought severity as follows: "watch," "warning," "emergency," and "disaster").

4.7 Irrigation Best Management Practices

Irrigation Water Supply

- ❖ Conduct a seasonal bulk water requirement analysis and a maximum bulk water requirement analysis.
- ❖ 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.
- ❖ Reclaimed, effluent, and other nonpotable 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 turf and plants to mitigate saline conditions resulting from an alternative water source, if necessary.
- ❖ Assess irrigation water quality.
- ❖ Account for the nutrients in irrigation water when making fertilizer calculations.
- ❖ Monitor irrigation water regularly for dissolved salt content.
- ❖ 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 and Installation

- ❖ 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.
- ❖ When possible, use precise irrigation control technologies.
- ❖ Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/ distribution.
- ❖ Install irrigation pipes away from the green surface to avoid more substantial damages should pipe failures occur.
- ❖ Update multi-head control systems with single-head control systems to conserve water and to enhance efficiency.
- ❖ Install manual quick-coupler valves for site specific irrigation so these areas can be hand-watered 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.

Irrigation System Maintenance and Performance

- Conduct visual inspections regularly to identify necessary repairs or corrective actions, which should be completed before further evaluation of system performance.
- 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.
- Record any modifications to the As-Builts, including head and nozzle choices.
- Use photography to document any major underground installations/repairs.
- As part of winter preparation, flush and drain above-ground irrigation system components that could hold water.
- Remove water from all conveyances and supply and distribution devices that may freeze. 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.
- Recharge irrigation system in the spring with water and inspect for malfunctions.
- Review efficiency of above-ground electric motors annually.
- Evaluate pressure and flow to verify that the correct nozzles are being used and that the heads are performing according to the manufacturer's specifications.
- Run catch-can tests to determine the uniformity of coverage and to accurately determine irrigation run times.
- Conduct an annual irrigation audit to facilitate a high-quality maintenance and scheduling program for the irrigation system.
- At least every five years, conduct a professional irrigation audit that follows established guidelines.

Irrigation Management Decisions

- Base plant water needs should be determined by ET rates, recent rainfall, recent temperature extremes, and soil moisture.
- Evaluate root zone depth on the course and do not irrigate beyond this depth.
- Use infrequent, deep irrigation to supply sufficient water for plants and to encourage deep rooting in fairways and roughs.
- Monitor potential ET and calculate plant available water to improve irrigation precision.
- 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 the 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.
- ❖ Avoid use of a global setting; make adjustments to watering times per head.
- ❖ Adjust irrigation run times based on current local meteorological data.
- ❖ Use a computed daily ET rate to adjust run times to meet the turf's moisture needs.
- ❖ Manually adjust automated ET data to reflect wet and dry areas on the course.
- ❖ Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied at any one time.
- ❖ Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.

Water Conservation

- ❖ Use turf only where actually necessary, such as greens, tees, landing areas, etc.
- ❖ Use native plants in landscaped areas to reduce water consumption.
- ❖ Increase naturalized areas to reduce water consumption.
- ❖ Choose plants for buffer strips that don't require supplemental irrigation.
- ❖ Voluntarily reduce water use during times of drought.
- ❖ Adhere to any local water use restrictions in time of drought.

5 WATER QUALITY MANAGEMENT AND MONITORING

Aligning water quality management programs, such as stormwater management and lake and pond management with established, research-based BMPs is the first step to protecting water quality. Establishing a water quality monitoring program is the next step. Routine monitoring can be used to measure water quality improvements and identify any areas where corrective actions should be taken.

BMP Principles for Water Quality Management and Monitoring

- Manage lakes and ponds to maintain water quality, avoiding nutrient enrichment and maintaining dissolved oxygen levels.
- Assess current surface and groundwater quality.
- Conduct water quality assessments using accepted standards.
- Use an accredited laboratory for water quality assessment.
- Use monitoring results to assess effectiveness of implemented BMP strategies.

5.1 Regulatory Considerations

5.1.1 Surface Water Quality

The goal of all surface water quality protection programs is to ensure that all waters of the state meet water quality standards. The U.S. Clean Water Act requires states to classify all of the waters of the state according to their best uses and to adopt water quality standards in order to protect those best uses. The NYSDEC Division of Water utilizes the best uses and standards so established to regulate surface water, land use associated with tidal and freshwater wetlands, and dams. Specifically, NYSDEC is charged with identifying impaired surface waterbodies (i.e. waters not meeting water quality standards), recommending mitigation, and establishing guidelines for enhanced protection through a variety of regulatory programs.

For surface water in New York not meeting the established state water quality standards, NYSDEC establishes TMDLs for the pollutant of concern causing the impairment (such as nitrogen, phosphorus, or sediments). NYSDEC has completed TMDLs for many waterbodies in New York State, including Long Island Sound, Lake Champlain, waters of the Croton River watershed, and a number of lake watersheds. The EPA may also require localities to develop Comprehensive Nutrient Management Plans (CNMPs) for activities in those impaired watersheds. Currently, CNMPs are focused on agricultural land use specifically related to the New York City Watershed Memorandum of Agreement. Note that state, federal, and local water quality regulations can change. Superintendents must remain informed about local, regional, and national policies and regulations.

5.1.2 Groundwater Quality

NYSDEC regulates groundwater, including setting groundwater quality and effluent standards. For more information, see NYSDEC Division of Water regulations.

5.1.3 Drinking Water

The Safe Drinking Water Act (SDWA), passed in 1974, is the main federal law that ensures the quality of Americans' drinking water. The New York State Department of Health (NYSDOH) established standards for drinking water quality that are more stringent than EPA standards and must be complied with. For more information, see the NYSDOH Drinking Water Protection Program.

5.1.4 Freshwater Wetlands

Article 24 of New York Environmental Conservation Law requires permits to conduct activities within a wetland and an adjacent area bordering the wetland. Physical disturbance, as well as applications of chemicals (pesticides, herbicides, fungicides, even fertilizer), requires an Article 24 permit if the action is done in a state-regulated wetland or within the regulated adjacent area (typically 100 feet from the wetland boundary).

5.1.5 Dams

NYSDEC's Dam Safety Section conducts safety inspection of dams; technical review of proposed dam construction or modification; monitoring of remedial work for compliance with dam safety criteria; and emergency preparedness. Any construction, modifications, or repairs of a dam requires consultation with the Dam Safety Section.

5.1.6 Water Withdrawal

New York State requires annual water usage reports for any system capable of withdrawing more than 100,000 gallons groundwater or surface water per day. In accordance with the water quality standard for flow, any withdrawal must also ensure that the existing best use of the waterbody from which the water is taken, such as protection of aquatic life, is not impaired. Reports for the prior year are due on March 31 of each year. Recycled water is exempted from this reporting requirement. For more information, see Water Withdrawal Permits and Reporting on the NYSDEC website.

5.1.7 Fertilizers

In New York, the Dishwater Detergent and Nutrient Runoff Law became effective in January 2012. See the "Nutrient Management" chapter of this document for more information on fertilizer regulations.

5.1.8 Pesticides

Article 33 and portions of Articles 15 and 71 of the New York State Environmental Conservation Law (ECL) establish the statutory authority to NYSDEC to promulgate regulations concerning pesticides and pesticide use, including the use of aquatic pesticides, through Title 6 of the

Official Compilation of Codes, Rules and Regulations of the State of New York Parts 320-329 See the "Pesticide Management" chapter of this document for more information on pesticide regulations.

5.1.9 Grass Carp

In New York State, stocking of diploid grass carp in ponds for the control of aquatic plants is prohibited, but the stocking of triploid (sterile) grass carp is allowed with a permit from the NYSDEC Division of Fish and Wildlife. For more information, see the Triploid Grass Carp in New York Ponds web page and permit information.

5.2 Stormwater Management

As discussed in Section 3.4 of this document, stormwater management typically refers to the management of runoff from precipitation, though it applies to irrigation runoff as well. Stormwater management includes planning for runoff, maintaining stormwater systems, and regulating the collection, storage, and movement of stormwater. The principles of stormwater management – keeping stormwater close to where it falls, slowing down stormwater runoff, and allowing it to infiltrate into the soil – are the most effective ways to protect surface water quality.

5.3 Lake and Pond Management

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 issues superintendents should address to maintain the water quality of golf course lakes and ponds include:

- low DO levels
- aquatic plant management
- near-shore management zones
- addressing aquatic invasive species

5.3.1 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 water 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.

5.3.2 Aquatic Plants

Aquatic plants include algae and vascular plants and are natural parts of aquatic ecosystems. 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 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 feet 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. The excessive growth of any aquatic plant requires management, and any aquatic invasive plants that are removed should only be disposed of in upland settings to prevent potential reintroduction into waterbodies. Following the principles laid out in the "Integrated Pest Management" chapter of this document, 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

Grass carp are sometimes used as biological control to control aquatic plants. As discussed in the Regulatory Considerations section earlier in this chapter, stocking of triploid grass carp requires a permit issued by NYSDEC.

For more on pond management, see the NYSDEC's *A Primer on Aquatic Plant Management in New York State* and *Diet for a Small Lake: The Expanded Guide to New York State Lake and Watershed Management*.

5.3.3 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 and composted elsewhere at the facility, as the phosphorus and nitrogen in clippings can otherwise impact water quality.

5.3.4 Waterfowl

The deposits of fecal matter by resident and migrating waterfowl (Canada Geese, mute swans, and others) may contribute to water quality impairment through nutrient enrichment. The overall impact of bird feces on water quality, however, depends on numerous factors, such as the size, depth, and natural chemistry of the water body; avian populations and behavior; and the rate at which other nutrient sources enter the water body (Unckless and Makarewicz, 2007).

On golf courses, shallow ponds with significant populations of waterfowl are most likely to be affected. In these cases, annual phosphorus loading by waterfowl can be calculated using the days per year that each species spent on any lake or reservoir. Leaving an unmowed buffer around shorelines has been known to discourage geese from congregating on shorelines. For more information, see *Managing Canada Goose Damage*.

5.4 Water Quality Monitoring

Golf course superintendents wanting to develop and implement a water quality monitoring program 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.

Figure 9. Water quality monitoring at Bedford Golf & Tennis Club.

Water quality monitoring can also demonstrate the presence of issues in water as it enters a golf course property. In Suffolk County, for example, extensive laboratory testing for contaminants has shown that groundwater entering the golf course already has extremely high nitrate levels near or greater than the regulatory limit. The county also collects surface water samples and shares the test reports with superintendents.

5.4.1 Sources of Existing Information

Several sources of existing surface and groundwater monitoring data may be available, including:

- Soil and Water Conservation Districts in NYS – Comprehensive water quality management programs; may be willing to test surface water and assist in installation of groundwater monitoring wells.
- NYSDEC – Conducts a groundwater monitoring program in coordination with United States Geological Survey (USGS).
- New York Water Science Center – USGS program that publishes water quality monitoring information.
- County Water Authorities – Maintain and test community water wells and may have additional test data from other points within the watershed.

5.4.2 Developing a Water Quality Monitoring Program

Developing a water quality monitoring program can include both groundwater and surface water monitoring. The data from this periodic monitoring can be used to identify issues that may need corrective actions. In addition, water quality monitoring of irrigation sources (particularly water supply wells and storage lakes) provides valuable agronomic information that can inform nutrient and liming programs. A water quality monitoring plan should identify appropriate sampling locations, frequency, and monitoring parameters.

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 is not available from existing sources, monitoring wells can be installed by private companies. Installing groundwater monitoring wells can be relatively expensive, but the expense may be justified in certain cases where the origin of contamination can only be determined through comparison of water quality entering and exiting the property. To identify the appropriate site for monitoring wells, groundwater flow is required. In some areas of New York, groundwater flow maps have been developed, but may not be available at a fine enough scale for an individual golf course. Experienced environmental engineering firms or the USGS can assist in determining suitable monitoring well locations.

Testing protocols can be simplified to test only those parameters that are directly influenced by course management, including organic and inorganic levels of nitrogen and phosphorus and a pesticide screen for certain pesticides used on the course. NYSDEC pesticide reports provide the necessary documentation for pesticides used. The USGS also offers contract services to advise on sampling and testing of water samples. County Soil & Water Conservation District (SWCD) offices can also provide guidance on groundwater testing programs.

Surface water monitoring can include the laboratory testing of a number of different physical and chemical parameters to assess water quality. In addition, the sampling of macrobenthic invertebrates can be used as a relative assessment tool for stream health. Sampling of surface water can be conducted by golf course staff or volunteer monitoring groups.

The *Environmental Best Management Practices for Virginia's Golf Courses* includes a detailed chapter on water quality monitoring and an example of a water quality monitoring report.

5.5 Water Quality Management and Monitoring Best Management Practices

Stormwater Management

- ❖ Follow a treatment train approach to manage stormwater, integrating source controls with structural and non-structural controls.

Lake and Pond Management

- ❖ Develop a comprehensive management plan that includes strategies to prevent and control the growth of nuisance aquatic vegetation.
- ❖ Establish minimum DO thresholds to prevent fish kills, which occur at levels of 2-3 mg/L.
- ❖ Reduce stress on fish by keeping DO levels at 5-10 mg/L.
- ❖ Use artificial aeration (diffusers) if needed to maintain adequate DO, especially those waterbodies less than 6 feet in depth, and especially at night during the warmer months.
- ❖ 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.
- ❖ Use a multi-faceted, IPM approach to control nuisance animals.

Water Quality Monitoring

- ❖ 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 in surface waterbodies.
- ❖ Follow recommended sample collection and analytical procedures.
- ❖ Conduct seasonal water quality sampling. The recommendation is four times per year.
- ❖ Use an accredited laboratory for water quality assessment, using accepted standards.
- ❖ Compare water quality monitoring results to benchmark quality standards.
- ❖ Use corrective measures when necessary.

6 NUTRIENT MANAGEMENT

All plants require nutrients to sustain growth and development. Certain essential nutrients are classified as either macro- or micronutrients, based on the amount needed by plants rather than their importance for plant growth. Macronutrients include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), and magnesium (Mg). Micronutrients include iron, zinc, copper, chlorine, nickel, molybdenum, boron, and manganese. Micronutrients are required in significantly lower amounts than macronutrients. However, a deficiency or excess of these micronutrients can have a profound influence on plant growth.

Proper nutrient management usually includes the following steps:

- Determine plant needs (such as light levels, traffic levels, irrigated or not, and expected visual quality).
- Assess the soil reservoir for availability (soil testing).
- Determine nutrient needs and select the proper source of nutrient fertilizer (most are combination products).
- Decide the rate, timing, and frequency of application.

Golf course managers must ensure that all supplemental fertilizer is handled and applied to maximize plant response and minimize off-site movement. N and P re the most important macronutrients to manage correctly because they are critical to both plant health and water quality.

BMP Principles for Nutrient Management

- Determine accurate supplemental nutrient needs based on soil chemical and physical analysis.
- Supplement soil with appropriate rate and source of nutrients to maintain optimum availability and minimize off-site movement.
- Assess application efficiency through regular equipment calibration.

6.1 Regulatory Considerations

The NYS Nutrient Runoff Law (New York State Environmental Conservation Law, article 17, title 21 and Agriculture and Markets Law § 146-g) prohibits and restricts the use of lawn fertilizers as follows:

- Phosphorus-containing fertilizers with a phosphate (P2O5) content greater than 0.67% cannot be used unless soil tests show a phosphorus deficiency or the fertilizer is being used to establish new seeded or sodded turf.

- No lawn fertilizers can be applied between December 1 - April 1.

- If any fertilizer is applied on sidewalks, driveways or other impervious surfaces, it must be swept up to prevent it from washing into drains or waterways. It cannot be hosed off.

- No fertilizer can be applied within 20 feet of any water body unless:
    - There is at least a 10-foot buffer of shrubs, trees or other plants between the area fertilized and the water.
      OR
    - The fertilizer is applied using a spreader guard, deflector shield or drop spreader and applied no closer than 3 feet from water.

Localities may have additional fertilizer use restrictions; for example, Suffolk and Nassau counties have their own fertilizer laws to restrict nitrogen from fertilizer from reaching waterbodies.

6.2 Nutrient Availability and Soil pH

The pH of a soil influences the entire soil chemical environment and fundamentally determines nutrient availability, fertilizer response, and soil biology. In general, a neutral pH is considered adequate for most turfgrass needs; however, slightly more acidic pH can allow for increased levels of metal ions to become soluble and is often favored as a means of increasing the competitiveness of creeping bentgrass and fine fescue over annual bluegrass. More information on soil pH can be found on the Nutrient Availability and pH web page on the NYS BMP website.

6.3 Soil Testing

Soil testing is the beginning of precise nutrient management programs for all nutrients other than nitrogen. Soil testing can be used to determine nutrient levels, make fertilizer recommendations, and in some cases diagnose the cause of poor performing turf. Assessing the existing reservoir of available nutrients in the soil can minimize the need for supplemental applications of fertilizer, which saves money while protecting the environment.

Soil nutrient analysis aids in determining whether nutrient deficiencies exist, as many soils have various levels of nutrient holding capacity, often referred to as cation exchange capacity (CEC). For example, sand-based systems, which have only a limited amount of stored minerals, may demand more mineral additions. Determining supplemental nitrogen needs is typically not based on soil tests as the method of extracting N and the subsequent calibration with plant growth have not been established.

Information on soil sampling, laboratory analysis, interpreting test results, and supplemental plant analysis can be found on the Soil Testing web page on the NYS BMP website.

6.4 Nutrient Management Planning

Fertilizer programs are ultimately designed to supply nutrients to the turf as they become unavailable over time. The goal of a successful nutrient management program should be to sustain even levels of plant available nutrients for a uniform growth rate and to sustain adequate recuperative potential to meet expectations of quality and turf performance, while minimizing excessive growth and the risk of nutrient loss to the environment. One approach to achieving these goals is to utilize the Minimum Level for Sustainable Nutrition (MLSN) Guidelines.

Figure 10. More information on nutrient management planning can be found in this NYGCF publication, on the Publications page of the NYS BMP website./

6.4.1 Nitrogen Fertilization

Using the right product at the right time and at measured rates of application maximizes plant use of the fertilizer and minimizes the risk of nutrient leaching or runoff. However, determining these best practices requires an understanding of other important factors, such as soil issues, plant issues, product characteristics, and application considerations.

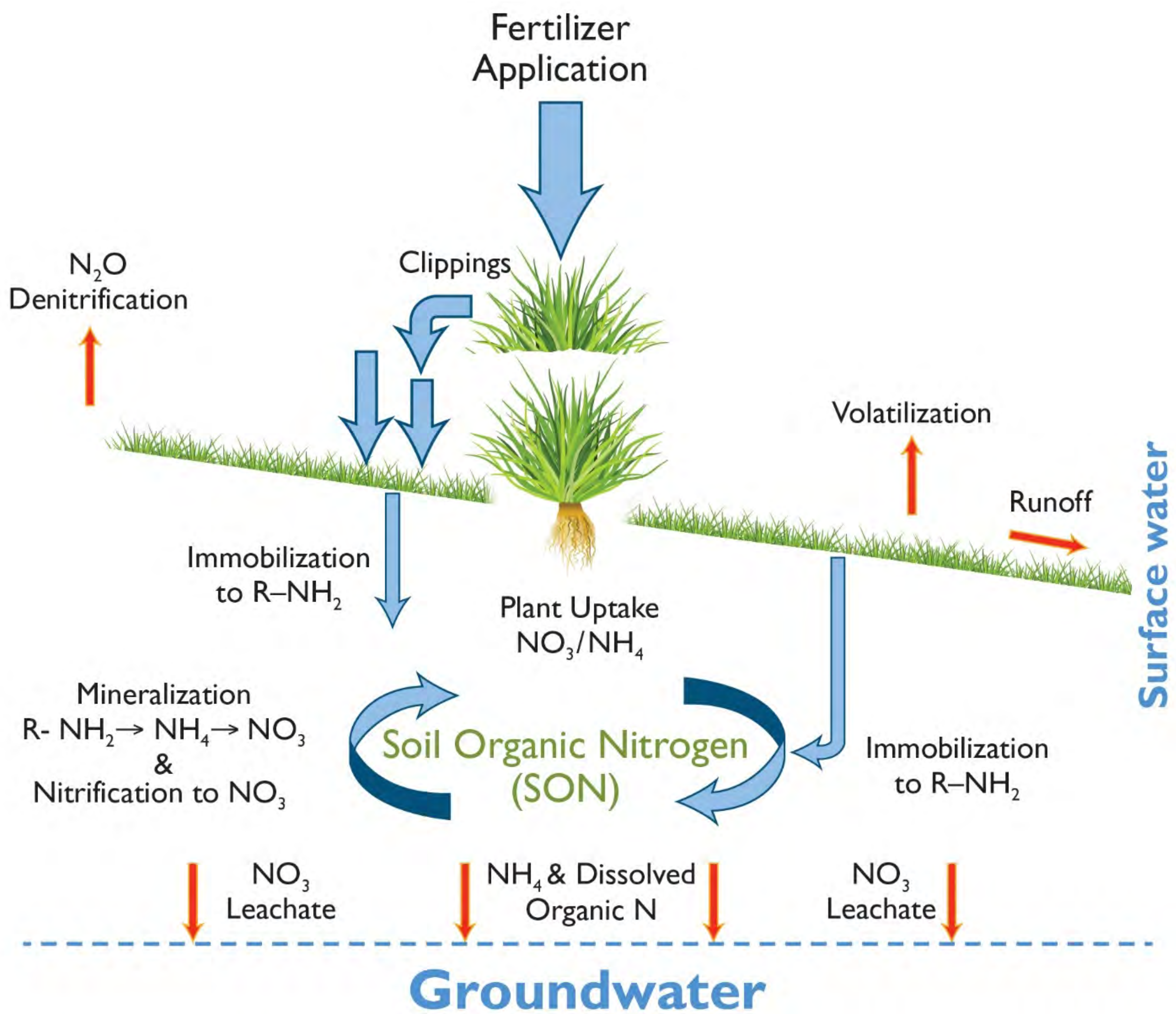

Figure 11. Nitrogen cycle.

Readily available N sources, such as water soluble N (WSN), provide rapid turfgrass growth and color responses, but are more prone to leaching, particularly in sand-based soils. Slow release N sources are more variable in N content and release characteristics. Most N sources can be applied in granular or liquid form. N fertilizer sources are discussed in detail on the Nitrogen Fertilizer Use web page on the NYS BMP website.

Soil Issues

- Soil Type: Well-drained soils with coarse textures and high percolation rates have lower water holding capacity, greater infiltration, and higher risks of leaching.

Organic Matter: Soils with low amounts of organic matter have lower biological capacity to assimilate nitrogen and are more susceptible to leaching.

Plant Issues

- Growth Phase: Newly seeded areas pose higher risks of leaching and runoff than well-established stands of turfgrass. Once established, the increased density of root mass increases nitrogen uptake while reducing the risk of leaching. Turfgrass in early stages of growth (1 to 20 years or more, depending on the organic matter starting point) has increasingly greater capacity to store and release nitrogen, reducing fertilizer requirements. The lower the amount of organic matter present in turfgrass, the longer the period of storage will be. As the site matures and the amount of organic matter accumulates (20 to 50 years), it poses a higher risk of leaching than younger turf.

Product Characteristics and Application

- Product: The best strategy for use of water soluble fertilizers is light rates of 0.5 lbs N/1,000 sq. ft in general; 0.4 lbs N/1,000 sq. ft on sand; and no more than 0.7 lbs N/1,000 sq. ft on other soils (assuming no heavy rain events) and more frequent applications. This practice more closely matches plant uptake and ensures minimal leaching past the turf root zone.

  Water insoluble or slow release products, including organics or stabilized products, used properly, have a lower risk of impairing water quality through leaching and runoff. Release rates of combined fertilizer sources and applications can increase or "stack" the amount of available nitrogen. The combined total nitrogen can possibly leach nitrogen even if individual products would not.

- Fertilizer Rate: Excessive applications of any nitrogen-based fertilizer product can create high soil nitrate levels (>1.0 ppm) susceptible to leaching.

- Timing: Application of any nutrient to saturated soil or prior to heavy rainfall can lead to significant off-site movement. Applications made too early in the spring or too late in the fall result in higher soil nitrate levels, posing a greater risk to groundwater quality. Similarly, applications should be reduced during summer decline when plant uptake decreases. Research has not shown an appreciable difference in turf quality using different schedules of application. Applications made every month compared with split schedules of spring and fall, spring only or fall only show reasonable consistency. Light and frequent applications may provide the most consistent quality and limit the susceptibility of losses to leaching and runoff. Low rates of N associated with light and frequent applications may require that applications be made using spray equipment to uniform coverage and response.

6.4.2 Phosphorus Fertilization

As with nitrogen, using the right phosphorus product at the right time and at measured rates of application maximizes plant use of the fertilizer and minimizes the risk of leaching or runoff. This requires considerations of soil and plant issues, as well as other sources of phosphorus that may need to be considered. Phosphorus can be supplied by a number of sources in fertilizers, biosolids, or as an integral by-product of other soil amendments, natural organic fertilizers, or bio-stimulants. These are discussed in detail on the [Phosphorus Fertilizer Use web page] of the NYS BMP website.

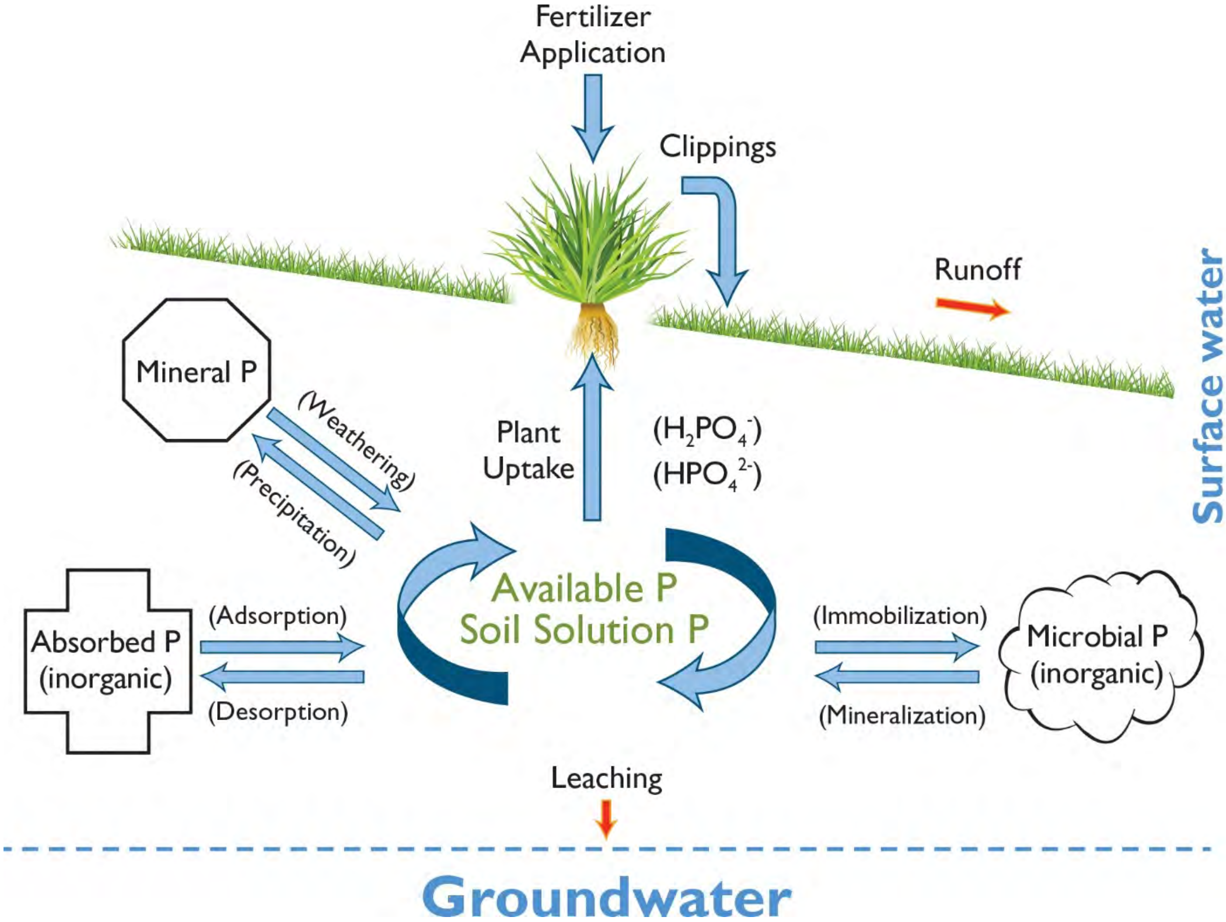

Figure 12. Phosphorus cycle.

Soil Issues

- Phosphorus fixation increases with increasing clay content in the soil. The larger amount of surface area associated with clayey soils and the aluminium-iron minerals in the lattice help adsorb more P than other soils. In calcareous soils, the adsorption is associated with calcium carbonate ($CaCO_3$).
- Larger fertilizer additions are required to maintain a level of plant available P in finer soils compared with that in coarser, sandy soils. The risk of leaching P is highest in sandy soils.
- The rate of biological activity, and therefore P mineralization, increases with increasing temperatures. Fertilizer applications should only be applied to active soils when soil temperatures are above 50° F.
- Applying lime to acid soils increases the P solubility in acid soils, but over-liming can reduce P solubility. Sorption also occurs to calcium cations (Ca^{2+}) but only at pH values up

to 6.5. At higher pH values, Ca-P precipitates form.

- Incorporating P into the soil when possible increases adsorption and reduces the amount of plant available P. Broadcasting P fertilizer on the surface leaves the fertilizer susceptible to runoff.

Plant Issues

- Returning clippings to the turf is a practical method of returning organic P back to the soil. Clippings may account for 0.10 to 0.35 lbs P per 1,000 sq. ft. If clippings are removed, the loss of P depletes available P for plant uptake.

Other Sources Issues

- Foliar applications at light rates may increase plant uptake. Unabsorbed foliar P, however, remains at risk for episodic losses due to runoff caused by heavy precipitation or excessive irrigation. A light irrigation after P fertilizer application has been shown to reduce P runoff.

- Phosphonate fungicides are chemically different from phosphonate fertilizers in that the fungicide provides a phosphite ion (H_2PO^{3-}) having one less oxygen atom. Potassium phosphite, also labeled as mono and di-potassium salts of phosphorus acid (Aliette, and Chipco Signature) are the most common examples of a phosphonate fungicides. No evidence suggests that the phosphite ion is used in the plants metabolism. Regardless, the amount of P supplied in any fungicide application is negligible.

6.5 Fertilizer Applications

Proper application of fertilizers is possible only with accurately calibrated sprayers or spreaders. Incorrectly calibrated equipment can easily apply too little or too much fertilizer, resulting in damaged turf, excess cost, and contamination of the environment. Therefore, sprayers and spreaders should be calibrated at first use and after every fourth application. The time it takes to calibrate application equipment is returned many fold in improved results.

An excellent resource for spreader care and calibration can be found on the Penn State Extension site. Spreaders should also be thoroughly cleaned after use due to the high salt content that corrodes metal parts. However, the washwater will likely contain N or P and should be disposed of properly.

6.6 Nutrient Management Best Management Practices

Soil Testing

❖ Maintain dense turf stand through proper nitrogen fertilization to reduce soil runoff.

- ❖ Because turf is extremely responsive to soil N status, evaluate changes in clipping yield during the growing season to estimate N availability.
- ❖ Monitor K and P by testing soil regularly.
- ❖ Conduct a soil test as required by the NYS Dishwasher Detergent and Fertilizer Law to confirm a need for phosphorus fertilization prior to its application.
- ❖ Sample when soils are biologically active. Fall sampling is most common and allows time to review results and apply lime and nutrients in advance of spring growth and to develop a season-long plan.
- ❖ Do not sample within the two months following heavy fertilizing or liming; sampling around frequent, light applications (spoon feeding) is acceptable.
- ❖ Test soils at the same time of year to allow for comparison of results from year to year.
- ❖ Because soils exhibit significant spatial variability, take a number of samples, combine, and then subsample. As a rule, a minimum of 10 sample locations should be sampled per acre.
- ❖ Sample areas with different soils and drainage separately. For instance, sample sand-based greens and tees separately from fairways and roughs.
- ❖ Take the sample from the root zone (typically 4-6 inches deep) by removing the grass mat from the top of the sample.
- ❖ Used in conjunction with soil tests, analyzing plant tissues over time can be used to observe trends that can be correlated to environmental and management factors.
- ❖ On sand based areas, consider foliar testing as a diagnostic tool.

Nutrient Management Planning

- ❖ Use N fertilizer to produce 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 water soluble fertilizers at light rates of 0.5 lbs N/1,000 sq. ft in general; 0.4 lbs N/1,000 sq. ft on sand; and no more than 0.7 lbs N/1,000 sq. ft on other soils (assuming no heavy rain events) and more frequent applications.
- ❖ Lightly irrigate after P fertilizer application to reduce the potential for P runoff.
- ❖ Do not apply nutrients to saturated soil or prior to heavy rainfall, which can lead to significant off-site movement.
- ❖ Avoid N application too early in the spring or too late in the fall because it can increase soil nitrate levels and can pose a greater risk to groundwater quality.
- ❖ Reduce nutrient applications during summer decline when plant uptake decreases.

Fertilizer Applications

- ❖ Choose the appropriate type of spreader for a given fertilizer.
- ❖ Calibrate application equipment every first use and after every fourth application.

7 CULTURAL PRACTICES

Cultural practices support turfgrass density and therefore play an important role in preserving and protecting water quality. Ensuring that the turf is properly adapted, healthy, and dense and has adequate infiltration protects water quality because of the tendency of healthy turf to hold water and chemicals.

In particular, BMPs for golf course turf to preserve and protect water quality using cultural practices must be designed to sustain high turf shoot density. A dense turf reduces runoff and the negative effect of off-site movement of water and pollutants. A dense turf, however, accumulates surface organic matter that can restrict infiltration and lead to increased runoff. Maintaining the permeability of the turf surface is as important as maintaining turf density. Strategies for preventing excessive organic matter accumulation are important, but management through dilution and cultivation of the soil is key. This practice can include modifications to improve the root zone, balance adequate infiltration as means of reducing runoff, and promote adequate retention to prevent leaching.

BMP Principles for Cultural Practices

- Use and manage turfgrass species and varieties adapted to macro and micro climatic conditions of your location.
- Maintain turf with high shoot density to minimize runoff and maximize infiltration.
- Manage the surface accumulation of organic matter to maintain a permeable system that minimizes runoff and maximizes subsurface retention.

7.1 Turfgrass Species and Variety Selection

The perennial nature of golf turf implies that when establishing or renovating a new turf area, it is critical to choose a well-adapted species and variety. Of course, putting surfaces are unique growing environments, but larger areas such as fairways could have grasses adapted to reduced nutrient levels and increased traffic tolerance, potentially reducing the nutrient loading. This is an important BMP for nutrient management. Additionally, natural areas that serve as landscape BMPs also require careful attention to finding a well-adapted species. Certain grasses adapted to low inputs, reduced mowing, and even submersion tolerance can be part of the selection criteria. Ultimately, it is vital to start out with a well-adapted species that will thrive, meet the functional and visual quality expectations, and be sustained using BMPs.

7.1.1 Species Selection

When selecting species and cultivar, site specific characteristics, such as desired use, site and microclimate conditions, disease resistance, drought tolerance, and spring transition traits, should be considered. To evaluate different species and identify cultivars that perform well in this region, extensive trials are conducted under the National Turfgrass Evaluation Program (NTEP). Results of NTEP trials conducted and evaluated by Cornell are available on the NTEP website.

Figure 13. Bentgrass variety trial plots.

7.1.2 Climate

Highly specific and often less than ideal microclimate conditions challenge many superintendents. A common microclimate is a putting surface location with light deficits and restricted air movement. In these situations, limited options exist for proper turf selection, as these climates simply cannot sustain any turf without significant inputs. Typically, in northern climates, these adverse site conditions lead to increases in weedy species such as annual bluegrass.

7.1.3 Annual Bluegrass Invasion

Over time, annual bluegrass becomes the dominant species in turf. This invasiveness is a result of the highly adaptive and prolific reproductive capacity of annual bluegrass that favors its competitive ability over other cool season turfgrass. Therefore, regular surface disruption when desirable turf is not actively growing selects for the invasive annual bluegrass. Every course that suffers a massive invasion of annual bluegrass must decide whether to renovate or manage typically when there is catastrophic failure. Renovation eradicates and then excludes annual bluegrass, hopefully with proper site modifications to allow perennial species to thrive. Others choose simply to manage the annual bluegrass that has colonized the location. This is a "pay me now or pay me later" situation in which management of the problem is less disruptive, though the inputs required to sustain adequate turf are costly.

Research shows that annual bluegrass requires courses to use significantly more inputs to provide acceptable quality golf turf, especially on putting greens, as compared to more perennial species such as bentgrass or fescues. Therefore, with respect to water quality protection, the less annual bluegrass being managed, the fewer inputs required and the lower the risk to water quality. While this solution may not be as practical on putting surfaces, the putting surfaces comprise less than 10% of the managed turf. It is fairway, rough, and tee areas where annual bluegrass challenges water quality preservation with large tracts of land being treated to sustain a weedy species.

7.2 Turfgrass Establishment

Establishing new turfgrass areas or renovating existing stands can create significant risk to water quality. During establishment, soil is exposed prior to seeding or sodding to ensure effective contact for water transfer from the soil to the plants. Therefore, practices should be implemented that reduce establishment time to full turfgrass cover and protect the soil from being transported in rain events during establishment.

7.2.1 Erosion and Sediment Control During Establishment

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 water, where phosphorus, and to a lesser extent nitrogen, can cause eutrophication. When sediments and soils enter water, they can also increase turbidity, which can have harmful effects on 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.

7.2.2 Nutritional and Irrigation Needs

Minimizing the amount of fertilizer and chemicals used during the establishment phase is critical, as the establishing turf does not provide the needed uptake to prevent runoff and leaching. Newly establishing areas, especially from seed with soil exposed, should be irrigated carefully. Light, frequent amounts of water to keep the seedbed moist will encourage germination and seedling development. Once the turf density reaches 60-70% cover, irrigation can be reduced to more normal levels, as turf will begin to root and extract water and nutrients from the soil.

7.3 Maintaining Turfgrass Density

Turfgrass runoff research consistently concludes that maintaining high shoot density turf is the most effective means of reducing runoff volume. The distance traveled by rainfall or irrigation water increases as the number of shoots per unit area increases. In addition to the reduced runoff, the fibrous root system of turf has been shown to increase infiltration. The longer the water deposited on the turf surface is delayed from becoming runoff, the more likely that proper infiltration will occur. The combination of reduced runoff volume and increased infiltration is a primary aspect of water quality protection, thus maintaining a dense turf is vital. In addition, denser turf also provides a better playing surface.

7.3.1 Mowing

A turf is defined as low growing vegetation maintained under regular mowing and traffic. Conversely, areas not regularly mowed are not considered turf. Mowing is a significant selection tool and one that, when done properly, has a profound influence on turf density. A properly mowed turf maintains a high shoot density that limits surface water movement and sustains an adequate underground biomass to retain additional water and nutrients that infiltrate. Mowing practices require decisions regarding height, frequency, type of mower, and clipping management. When performed properly, these practices maximize turf density.

Mowing Height

Height of cut is often determined by the function of the site, with additional emphasis on visual quality. Mowing height significantly affects rooting depth because the lower the turf is mowed, the shorter the root system, and therefore the greater concentration of surface rooting. Additionally, a lower height of cut requires more frequent mowing as leaf extension accelerates when turf is cut lower and tissue must be removed more frequently.

Ultimately, every turfgrass species has an ideal mowing height range and a mowing range that the species can tolerate. Maintaining turf within the ideal range maximizes density. As long as mowing heights remain within the tolerance range, however, adequate density is possible when other maintenance factors such as water and nutrients are provided in the optimal range.

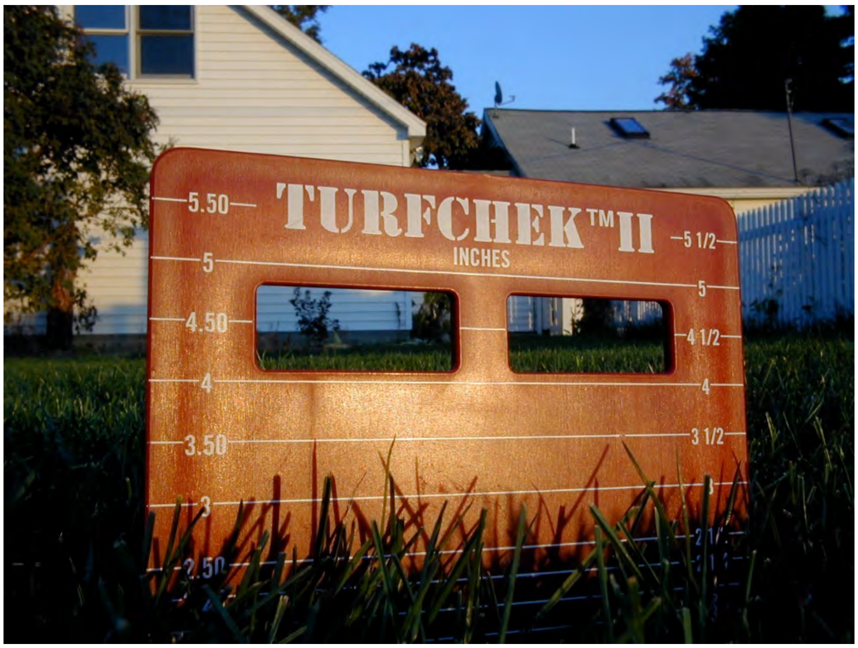

Figure 14. Mowing height significantly impacts turf density.

Mowing Frequency

The turf growth rate and height of cut dictate mowing frequency. In general, increasing mowing frequency increases turf density. Little evidence supports the accepted rule that no more than 30% of the leaf tissue should be removed in a single mow. Instead, significant evidence indicates that some turf species such as tall and fine fescue and perennial ryegrass can have between 50 and 75% of the tissue removed before any turf thinning occurs. Ultimately, increasing mowing frequency positively effects turf density, but will increase the energy consumption of the maintenance program.

Mower Selection

Mower selection is based on the expected height of cut. Mowing heights at or below 1.5 inches are typically best achieved with a reel-type mower. Reel mowers allow for rapid clipping of turfgrass tissue at practical operating speeds with minimal turf damage (when properly adjusted). Mowing heights above 1.5 inches are best achieved with rotary impact mowers, also when blades are sharpened and properly balanced.

Any mistake in mower set up from blade sharpness to bedknife alignment can lead to increased stress from wounding and reduction in turf density. Therefore, the mower must be properly adjusted and set up to minimize leaf shredding and wounding for pathogens.

7.3.2 Clipping Management

From a water quality perspective, grass clippings are a nutrient-rich resource and should be viewed as fertilizer and handled and applied with similar precaution. For example, clippings may account for 0.10 to 0.35 lbs P per 1,000 sq. ft. When managing clippings, consider them a nutritional resource and leave them on-site if possible. However, they must not be allowed to discharge into adjacent waterbodies or to clump on the surface and shade the turf.

Figure 15. Clippings should be removed from impervious surfaces to avoid becoming a surface

Removal of clippings should only be performed if the function of the site dictates removal (such as ball roll on a putting surface). Some courses will remove clippings from fairways, distributing these clippings, such as to driving ranges or clubhouse lawns, or composted. When clippings are distributed, the area should be relatively large, as accumulated clippings distributed over a relatively small area can significantly increase nitrate leaching. If clippings are composted, the compost area should not be located near stormwater treatment structures or wetlands. For further information on composting, see the fact sheets published by the Cornell Waste Management Institute.

7.4 Organic Matter Management

Turf is a perennial plant system that increases biomass as a result of growth and management. Biomass accumulates at the surface from the development and deposition of plant parts such as leaves, stems, and roots. Above-ground plant parts such as leaves and stems are often removed and regrown as a result of frequent mowing. Underground plant parts such as stems (rhizomes) and roots cycle as living, dead, and decomposing organic matter.

The accumulation of organic matter in the top 3 to 6 inches of a turf system provides nutrient and water holding as well as cushioning and insulation. When organic matter accumulates at a rate greater than it degrades, however, it can restrict infiltration of water and gas exchange between the atmosphere and the pore space in soil. Excessive organic matter at the surface can become hydrophobic and increase runoff from the turf surface, which may also reduce the effectiveness of fertilizers and pesticides. Furthermore, excessive surface organic matter can promote surface rooting that interferes with the turf's use of water and mineral nutrients, which leads to increased potential for off-site movement of chemicals applied to turf. Many factors influence the accumulation of organic matter including turfgrass species, fertilization, and soil physical and chemical properties.

Figure 16. Organic matter accumulation.

7.4.1 Grass Type

Creeping bentgrass and annual bluegrass are considered intermediate in their development of organic matter. They accumulate organic matter, but often that matter is not highly lignified tissue and, under warm moist soil conditions, it degrades. Still, these grasses accumulate organic matter at the surface at a rate greater than microorganisms can degrade and thus the accumulation requires dilution or mechanical removal.

7.4.2 Fertilization

Increase in biomass is a normal aspect of plant growth. Supplemental fertilization for functional and aesthetic purposes produces more biomass and more organic matter when compared to an unfertilized turf. The rate of decomposition also increases with supplemental fertilization, up to a point. Therefore, applying enough fertilizer to meet the visual and functional requirements of the turf, but not in excess of these requirements, is critical. Excess fertilization increases biomass production that leads to excess surface organic matter production, reduced infiltration, and increased runoff.

Organic matter is a food source for macro- and microorganisms. The soil food web requires an adequate amount of organic matter and microbial activity to function properly. Degradation of organic matter is maximized in a well-aerated, moist soil with temperatures greater than 65°F. For every ten degree Celsius increase in soil temperature, microbial activity increases tenfold; this principle is referred to as the “Q10”.

7.4.3 Soil Management

Poorly drained soils with high bulk density and predominance of fine particles that restrict soil gas exchange reduce microbial activity. These dense, cool soils also restrict rooting to the surface, which further exacerbates the surface organic matter problem. Maintaining a permeable soil surface sustains adequate microbial activity, good deep root development, and proper infiltration. Taken together, these practices lead to a turf surface less likely to create runoff and more able to retain chemicals applied to turf top prevent leaching.

7.4.4 Cultivation Practices

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, thatch/organic matter reduction, and improved water and air exchange. However, cultivation can require significant time for recovery, thus disrupting play, and should be used judiciously. Cultivation frequency should be based on traffic intensity, level of soil compaction, and the amount of accumulation of excessive thatch and organic matter, which reduces root growth, encourages disease, and creates undesirable playing conditions. Table 2 shows advantages/disadvantages of aeration practices.

Table 2. Aeration practices

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

Surface cultivation manages organic matter accumulation above the soil, reduces the formation of leaf grain, improves infiltration, and improves surface consistency (Table 3). While these methods are generally less disruptive than traditional aeration practices, they usually have a limited to no impact on soil compaction relief.

Figure 17. Aerating at the West Point Golf Course.

Table 3. Surface cultivation practices

Method	Compaction relief	Surface disruption	Water/air movement	Disruption of play
Vertical mowing	Low	Medium – High	Medium	Low - High
Grooming	None	Very low	Very low	None
Spiking/slicing	None	Low	Low	None

7.5 Topdressing

Managing surface organic matter is best accomplished by prevention through proper fertilization and soil management. Many common golf turf grasses, however, under routine maintenance and adequate prevention still produce organic matter that requires some level of management. The most effective means of managing surface organic matter is through regular applications of sand or soil via topdressing. A light (0.1 to 0.2 inches) amount of material applied and integrated into the surface of the turf dilutes the organic matter and creates a physical matrix that functions as a soil.

Topdressing is often performed in conjunction with some form of cultivation that either removes a core or makes a hole. The cultivation not only provides minor removal of the surface material but also creates space for topdressing to serve the purpose of dilution and creation of a pseudo-soil matrix.

Figure 18. Topdressing.

Recent research suggests that under normal golf turf management, creeping bentgrass putting surfaces require 18-22 cubic feet of sand per 1,000 sq. ft per year to properly dilute surface organic matter. This application requires topdressing as frequently as every five days without any cultivation, to as many as 14 to 21 days with more routine cultivation. Ultimately, the goal of proper dilution is to ensure adequate infiltration while preserving sufficient retention of the turf system to prevent leaching.

7.6 Cultural Practices Best Management Practices

Turfgrass Species and Variety Selection

- ❖ Select species and cultivars 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 utilizing NTEP data.

Turfgrass Establishment

- ❖ Ensure erosion and sediment control devices are in place and properly maintained when establishing new turfgrass stands.
- ❖ Use mulch (e.g. hydromulch, loose straw from a clean source, strawmats) for soil stabilization.
- ❖ Prepare seed/sod bed to maximize success.
- ❖ Fill gaps in sod seams with soil or sand to provide a uniform surface.
- ❖ Use selective pre-emergence herbicides to reduce weed competition and improve the chance of success with seeding establishment during the spring.
- ❖ Use light and frequent nutrient applications, unless a slow-release nitrogen source is applied.
- ❖ Mow turf to the desired mowing height as soon as practical to promote density and maturation.

Maintaining Turfgrass Density

- ❖ Raise HOC by at least 30% in heavily shaded areas to improve turf health.
- ❖ Increase HOC in times of stress such as heat, drought, or prolonged cloudy weather to increase photosynthetic capacity and rooting depth of plants.
- ❖ If turf becomes too tall, it should not be mowed down 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.
- ❖ Rarely use inefficient mowing patterns (e.g. 9-3) on areas other than putting greens to save time, fuel, and labor.
- ❖ Use proper mowing equipment.
- ❖ Regularly sharpen and adjust blades.
- ❖ Routinely use plant growth regulators, if needed, to improve overall turf health in shaded environments.

Organic Matter Management

- Incorporate a proper cleaning protocol for cleaning mowing and grounds equipment when working in areas with terrestrial invasive species.
- Return clippings to turf as a practical method of returning organic P and N back to the soil.
- Remove clippings only if the function of the site dictates removal (such as ball roll on a putting surface).
- Accumulated clippings distributed over a relatively small area can significantly increase nitrate leaching, therefore distribute any collected clippings to driving ranges, clubhouse lawns, or compost.
- Clippings can be a significant source of phosphorus and nitrogen movement off-site, and thus should not be placed in or near stormwater treatment structures or wetlands.
- When organic matter levels are excessive, core aeration programs should be designed to remove 15- 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 to aid in quick recovery of surface density; midsummer for buffalograss and spring/fall for cool season grasses.
- 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 time 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 3-4 weeks throughout the summer.
- Initiate vertical mowing when thatch level reaches 0.25-0.5" in depth. Shallow vertical mowing should be completed 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 turf is growing slowly.
- Frequent shallow vertical mowing on putting greens prevents excessive thatch buildup and grain formation.

Topdressing

- Use light and frequent topdressing applications following aeration.
- Creeping bentgrass putting surfaces will typically require 18-22 cubic feet of sand per 1,000 sq. ft per year to properly dilute surface organic matter.
- Use sand particle size distribution similar to the existing soil, to avoid layering.
- Know the sand source and ensure the sand is weed-free, uniform, and of appropriate quality.

8 INTEGRATED PEST MANAGEMENT

Sooner or later, pests can become a problem, especially when turf is stressed, such as when heat, drought, or high humidity conditions persist. Pesticides alone will not control pests; a more effective approach is to develop an Integrated Pest Management (IPM) program to reduce pest damage and reliance on pesticides. 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 and maintains turfgrass quality.

By following the latest research, managers can have high quality playing surfaces with minimal impact on the environment. Research at Bethpage State Park has shown that IPM can result in 33-96% less environmental impact without reducing course quality and does not cost more than conventional management (Rossi and Grant, 2009). The NYS BMP case study *Reducing Environmental Impact of Pest Management* at Soaring Eagles Golf Course shows how IPM methods have reduced pesticide usage.

BMP Principles for IPM

- Conduct thorough assessments of pest pressure and establish appropriate thresholds for managed turf areas.
- Identify and correct growing environments that exacerbate pest pressure.
- Implement sanitation, exclusion, and cultural practices to minimize pest pressure.
- Determine least-toxic pest control programs, including using a selection strategy that includes an evaluation of pesticide characteristics and potential for non-target effects, as well as preventive approaches.
- Assess control program effectiveness using established monitoring practices.

8.1 Regulatory Considerations

As described in detail in the next chapter ("Pesticide Management"), pesticide usage must follow state and federal regulatory requirements.

8.2 IPM Overview

Progressive IPM programs follow seven steps. These steps include the use of pesticides, when needed and used a tool to increase or maintain economic value of the property being managed.

When chemical control is needed, selection and evaluation considerations can be used to help select an appropriate pesticide that can be used safely on the site in question while being protective of the environment.

Although IPM permeates all aspects of course management and planning, it can be thought of in the following steps:

Step 1 – Planning
Step 2 – Identification and Monitoring
Step 3 – Course Management
Step 4 – Evaluation & Analysis
Step 5 – Intervention
Step 6 – Record Keeping
Step 7 – Communication

Each of the seven steps are discussed in detail on the Seven IPM Steps web page of the NYS BMP website. Additional information on IPM can be found in these resources and publications:

- New York State Integrated Pest Management Program
- *Reducing Chemical Use on Golf Course Turf: Redefining IPM*, New York State Integrated Pest Management Program
- *Diagnosis and Decision Making for Sustainable Annual Bluegrass Weevil Management*, Cornell University and New York Golf Course Foundation
- *2017 Cornell Guide for Commercial Turfgrass Management*, Cornell University Cooperative Extension
- *Reducing the Risks of Golf Course Management: The Bethpage Project*, Cornell University Cooperative Extension

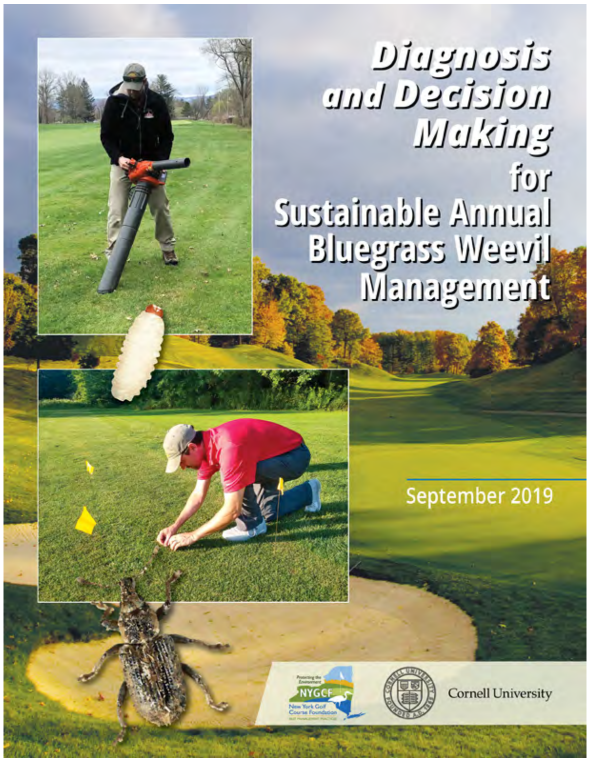

Figure 19. This publication can be downloaded from the Publications page of the NYS BMP website.

Figure 20. Monitoring efforts can include soap flushes for ABW larva.

8.3 Management Options

An IPM manager uses a mix of preventive and reactive strategies to manage pest problems. Course management decisions and cultural practices are ongoing, while reactive measures are decided and implemented in season. Selecting from a number of management options according to incoming information instead of the calendar is a hallmark of an IPM manager.

8.3.1 Diversification

Diversification of management options is key, using a variety of cultural, biological, physical, and possibly chemical strategies. The case against sole reliance on chemical approaches is obvious because it promotes resistance, and frequent use may subject applicators, golfers, and the environment to unnecessary risks. Similarly, reliance on any other single-tactic approach is also not recommended because if it fails, damage or turf loss is likely and that can lead to a negative effect on water quality. IPM's diversification of tactics allows for multiple layers of protection, and therefore better insurance against pests.

8.3.2 Cultural Practices

Turfgrass is a perennial plant system in which cultural practices, especially irrigation, mowing, topdressing, aeration, and venting, greatly affect both short- and long-term plant health. Healthy plants and soil can better withstand pest pressure. Weak turf can be outcompeted by weeds that take advantage of bare ground or thin turf. Pathogens in particular can take advantage of weak, stressed, or otherwise unhealthy plants and cause disease. Unhealthy plants are also less able to fend off, compensate for, mask, or recover from insect damage. Examples of weed, disease, and insect pest issues are provided on the Management Options web page of the NYS BMP website.

8.3.3 Use of Softer and Alternative Pesticides

IPM encourages the use of pesticides as a "last resort" when other methods of pest control prove to be inadequate. However, when pesticides are deemed necessary, an effective product least likely to harm human health or the environment should be selected. Other management options include using an alternative product, such as biological controls or reduced risk pesticides.

Biological Control

Biological control uses other living organisms to suppress or eliminate pests. Several organisms are known to have some efficacy against turfgrass pests and have been marketed as pest control products. These biological controls may act to suppress pest populations alone or work synergistically with other natural, cultural, physical, or chemical management methods. Examples of biological controls that are commercially available in New York State are provided in Table 4 below.

Table 4. Biological controls

Beneficial Bacteria	Action
Bacillus licheniformis	Labeled for dollar spot management
Bacillus subtilis	Labeled for management of brown patch, dollar spot, powdery mildew, rust and anthracnose
Pseudomonas aureofaciens (strain TX-1)	Labeled for management of anthracnose, dollar spot, pink snow mold and Pythium
Bacillus thuringiensis	Labeled for management of caterpillars and white grubs in turf.
Paenibacillus popilliae and *Paenibacillus lentimorbus*	Cause "milky spore disease" and are labeled for management of Japanese beetle grubs in turf. Other strains cause milky spores in other species of grubs but are not commercially available.
Entomopathogenic Nematodes	**Action**
Heterorhabditis bacteriophora and *Steinernema feltiae*	Effective against white grubs
Steinernema carpocapsae	Effective against cutworms and possibly annual bluegrass weevils

Risk Pesticides

The EPA defines conventional "Reduced Risk" pesticides as having one or more of the following advantages over existing products:

- low impact on human health
- low toxicity to non-target organisms (birds, fish, and plants)
- low potential for groundwater contamination
- lower use rates
- compatibility with IPM

A number of reduced risk pesticides can be used on turfgrass in NYS (Table 5). Biological pesticides, which also have many of these desirable characteristics, are classified separately by the EPA.

Table 5. Reduced risk pesticides

Category	Reduced Risk Pesticide
Fungicides	Azoxystrobin
	Boscalid
	Fludioxonil
	Trifloxystrobin
Herbicides	Bispyribac-sodium
	Carfentrazone-ethyl
	Mesotrione
	Penoxsulam
Insecticides	Chlorantraniliprole
	Spinosad

8.4 Pesticide Selection

Pesticides are an integral component of progressive IPM programs. The use of pesticides is regulated by a number of state and federal agencies because of the concerns these compounds pose for human health and the environment. Selection criteria and evaluation tools can assist in selecting an appropriate pesticide when use is warranted while also protecting the environment.

When chemical control is needed, use the following criteria to help select the right pesticide:

- The pesticide must be registered for use in New York State.
- It must be properly transported, handled, and stored.
- It should be effective in treating the pest problem.

- The frequency of pesticide usage should be considered with respect to the possibility of chemical resistance.
- Costs should be considered.
- Environmental risk and potential for water quality impacts must be evaluated.

Each criteria to be considered in the pesticide selection process is explained in detail on the Selection Criteria web page of the NYS BMP website.

8.5 IPM Best Management Practices

IPM Overview

- ❖ 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).
- ❖ Train personnel how to regularly monitor pests by scouting or trapping.
- ❖ Monitor prevailing environmental conditions for their potential impact on pest problems.
- ❖ Observe and document turf 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.
- ❖ 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.
- ❖ Establish injury and treatment thresholds levels for key pests and document them in the IPM plan.
- ❖ Document all pest control efforts, including non-chemical control methods and pesticide usage, to plan future management actions.
- ❖ Map pest outbreak locations to identify patterns and susceptible areas for future target applications.
- ❖ 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.

Management Options

- ❖ Select turfgrass cultivars and species recommended for use in New York State 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.

- ❖ Implement proper cultural, irrigation, and turf management practices to reduce stress and pressure of pest establishment.
- ❖ Maintain a proper fertilization schedule to improve turf density and quality and reduce pest populations.
- ❖ Always use pest-free materials, such as in topdressing.
- ❖ 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.
- ❖ 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.

Pesticide Selection

- ❖ Apply a preventative pesticide to susceptible turfgrass when unacceptable levels of disease are likely to occur.
- ❖ Evaluate use of biological control methods and reduced risk pesticides to treat the pest problem.
- ❖ Use a defined pesticide selection process to select the most effective pesticide with the lowest toxicity and least potential for off-target movement.
- ❖ Prioritize the selection of lower risk products whenever possible.
- ❖ Select low or non-volatile pesticides.
- ❖ Release insect-parasitic nematodes to naturally suppress insect pests such as white grubs.
- ❖ Avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms.
- ❖ Rotate pesticide modes-of-action to reduce the likelihood of resistance, following guidelines and advice provided by the Fungicide Resistance Action Committee (FRAC), Herbicide Resistance Action Committee (HRAC), and Insecticide Resistance Action Committee (IRAC).

9 PESTICIDE MANAGEMENT

The storage and handling of pesticides on golf courses presents the greatest risk to water quality contamination because of the potential for an unintended release of a large volume of pesticide resulting in a point source of pollution to surface and/or groundwater. Therefore, the greatest attention to BMPs should be directed at storage and handling. In addition, the potential for pesticide nonpoint source pollution through runoff, leaching, or drift is minimized through proper handling and application. Adhering to pesticide regulations helps to ensure that all proper procedures are followed.

For more information on the general use and management of pesticides, see:

- Pesticide Safety Education Program, Cornell University's Pesticide Management Education Program
- NYSDEC Bureau of Pesticides Management - Information Portal
- Pesticides overview, Cornell University's College of Agriculture and Life Sciences' Occupational & Environmental Health Program

BMP Principles for Pesticide Management

- Ensure full compliance with existing pesticide regulations, including applicator and technician certification and following all label directions.
- Adapt or implement as many NYS Department of Environmental Conservation pesticide storage guidelines as possible.
- Assess site and weather conditions thoroughly before applying pesticides to avoid the potential for runoff, leaching, or drift.

9.1 Pesticide Regulations

The New York State Environmental Conservation Law Article 33, establishes statutory authority to the New York State Department of Environmental Conservation to regulate pesticides and pesticide use.

9.1.1 Certified Applicators and Technicians

The law requires commercial applicators and technicians applying pesticides to golf course turf to be certified in categories 3A (ornamentals, shade trees, and turf) or 3B (turf only). Commercial applicators must meet requirements in continuing education credits. Special supervisory restrictions apply to technicians and apprentices.

9.1.2 Labels

When chemical controls are to be used, only pesticides registered for use in New York State are permitted. A searchable database of registered pesticides is maintained in the New York State Pesticide Administration Database (NYSPAD).

9.1.3 Pesticide Reporting Law

Applicators are required to file an annual report by February 1 each year summarizing their pesticide applications from the previous calendar year. These applicator reports are compiled each year in a summary report on sales and use around the state. NYSDEC is also monitoring water quality reports to assess pesticide levels in high-risk watersheds, aquifers, and wells across the state.

9.1.4 Neighbor Notification

The Environmental Conservation Law was amended to include the Neighbor Notification Law requiring a 48-hour notice to adjoining property owners prior to pesticide application. However, the requirement is only effective for counties that adopt the requirements into local ordinances; golf courses and sod farms are specifically exempted. Registered businesses should check with county officials or regional NYSDEC offices to see if specific local requirements apply.

9.1.5 Pesticide Transport

Off-property transport of pesticides must comply with New York State Department of Transportation regulations. Regulations require that the driver be trained for hazardous material transport. Drivers are required to carry the pesticide label and SDS sheet, have sufficient knowledge to handle any spills, and communicate with emergency responders in case of spills. Pesticides transported off the property that are not in the manufacturer's original container with the original intact label affixed or stored in a sprayer tank must be labeled with basic pesticide information, as required under the Environmental Conservation Law.

9.1.6 Aquatic Pesticide Applications

The application of any pesticide to water, such as an aquatic herbicide used to control vegetation in golf course ponds, or any mosquito or other insect-related pesticide applied to water, must be covered under a SPDES Pesticide General Permit. In addition, ECL Article 15 states that an Aquatic Pesticide Permit is required for the direct application of an aquatic pesticide to surface waters of the State of an acre or more in size.

9.1.7 Additional Information

For more information on pesticide regulations and guidelines, see:

- NY Pesticide Business Registration
- Pesticides Registered in NY
- NY Pesticide Reporting Law
- NYSDEC Pesticide Storage Guidelines
- NYSDEC Policies on Backflow Prevention Devices

- SPDES General Pesticide Permits
- Clean Sweep NY

9.2 Pesticide Storage

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 facilities for storing and handling these products be properly sited, designed, constructed, and operated. In addition, storing large quantities of pesticides for long periods of time should be avoided. Adopting a "first in-first out" management system for pesticide purchase and storage helps to avoid a buildup of large quantities of chemicals.

All pesticides should be stored according to instructions on their labels. In addition to the label, Part 326.11 of the New York Codes, Rules and Regulations states: "No person shall store any restricted pesticide or empty containers thereof in such a manner as may be injurious to human, plant or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life and property throughout such areas of the State as shall be affected thereby."

Guidelines for chemical storage, including pesticide storage, are listed on the NYS BMP Chemical Storage web page and in the "Maintenance Operations" chapter of this document.

Figure 21. Chemical storage building.

9.3 Mixing and Loading

Mixing should be avoided in areas where a spill, a leak or overflow could allow pesticides to get into water systems, such as near drinking water supplies or near surface water. No pesticide application equipment or mix tank should be filled directly from any source waters unless a back siphon prevention device is present. Mixing should not occur on gravel or other surfaces that allow spills to move quickly through the soil. Personnel should use the appropriate personal protective equipment (PPE) as described on the pesticide label when mixing and loading pesticides.

All transfers of pesticides between containers, including mixing, loading, and equipment cleaning, should be conducted over a spill containment surface designed to intercept, retain, and recover spillage, leakage, and washwater. Containment needs depend on the quantities of pesticides that are being mixed and loaded but should be sufficient to contain any incidental spills.

Figure 22. Equipment mix and load area with recovery lines.

9.4 Washing

Proper cleaning of equipment helps prevent residues from reaching surface water, groundwater, drainage pipes, or storm sewers. For equipment with pesticide residues, washing and rinsing of any equipment with pesticide residues should occur on a pad. 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.

For more information on pesticide equipment cleaning, see the following:

- Cleaning Your Sprayer, Cornell University
- *Maintenance, Cleaning and Storage of Ground Sprayers*, Montana State University

9.5 Pesticide Applications

Golf course monitoring programs conducted in New York and several other states have indicated little to no risk of water contamination from pesticides properly applied to golf turf, as described in Appendix B of *Best Management Practices of New York State Golf Courses*. The application of pesticides is generally made with low concentrations of active ingredients, often between 1% and 5% solutions. Simple attention to proper application procedures, especially avoiding direct discharges into waterbodies or near wellheads, should typically suffice.

In addition to selecting an appropriate pesticide based on the selection criteria and evaluated using available tools, a number of factors should be considered when applying pesticides to avoid water quality impacts. For example, a number of site-specific considerations for the use of pesticides should be evaluated using the results from the site analysis to identify areas where the risks of pesticides reaching surface or groundwater are greater (such as steep slopes, shallow water tables, and areas with frequently wet soils) (Table 6). In addition, pesticides should be applied accurately and with care to avoid conditions that can increase the chances of runoff, leaching, and drift.

Table 6. Factors contributing to greater risk for groundwater and surface water contamination. Source: USGA 1995

Chemical Characteristic	Soil	Site	Management
High solubility	Porous soil (sand)	Shallow water table	Incomplete planning
Low soil adsorption	Low organic matter	Sloping land	Misapplication
Long half-life (persistent)		Near surface water	Poor timing
Low volatility		Frequently wet soils	Over-irrigation

Figure 23. Fairway pesticide application using foam and dye for accuracy.

9.5.1 Preventing Runoff and Leaching

Pesticides can be transported into water by several means:

- surface runoff following precipitation events or irrigation
- leaching through the soil horizon to reach groundwater
- adsorption on eroded soil that reaches surface water
- flowing directly to groundwater through sinkholes and permeable rock

The use of vegetated buffers may be the single most important strategy mitigating the impact of runoff as these buffers can "capture" pesticides and prevent them from reaching waterways. In addition, the timing and location of applications should be thoroughly evaluated. Preventing runoff and leaching of pesticides is heavily influenced by weather and irrigation scheduling. Pesticide applications followed by heavy rain or irrigation can cause the pesticides to leach into groundwater. This leaching can occur even for nonpersistent pesticides (those with a short half-life). Pesticide applications on saturated soils following heavy rain or irrigation can also lead to surface runoff. In addition, avoid applying pesticides in sensitive areas.

9.5.2 Preventing Drift

Drift can potentially cause water quality impacts, damage to susceptible non-target crops, and a lower than intended rate to the turfgrass, thus reducing the effectiveness of the pesticide. Two types of drift occur: airborne (spray) drift and vapor drift. Spray drift is influenced by many interrelated factors including droplet size, nozzle type and size, sprayer design, weather conditions, and the operator. The amount of vapor drift depends upon a pesticide's volatility and atmospheric conditions such as humidity and temperature. Volatile turfgrass pesticides should be avoided. In some cases, the pesticide label may indicate low volatility. Low volatility, however, does not mean that a chemical will not volatilize under conducive conditions, such as high temperatures or low relative humidity. For more information, see Appendix H: Preventing Drift in *Best Management Practices of New York State Golf Courses*.

9.6 Disposal

There is usually no safe and legal way to dispose of pesticide leftover from professional applications. Therefore, all of the chemical must be used according to directions on the label. This includes washwater from pesticide equipment washing, which must be used in accordance with the label instructions.

Often pesticide storage facilities accumulate unusable or unwanted pesticide products. They can accumulate for a variety of reasons, such as mistakes made in calculating the amount of product needed or the launch of new product chemistries that may be more effective at controlling target pests. Disposing of these stockpiles properly may be challenging. Simply keeping them in storage eventually becomes problematic when packaging inevitably deteriorates or corrodes and creates a hazard. CleanSweepNY provides disposal services for unusable pesticides and other chemical wastes. Collection dates are scheduled and organized by NYSDEC with the collaboration of the New York State Department of Transportation.

9.7 Pesticide Container Management

Handling of empty pesticide containers must be done in accordance with label directions as well as with all federal, state, and local laws and regulations. Under the federal Resource Conservation and Recovery Act, a pesticide container is not empty until it has been properly rinsed. However, pesticide containers that have been properly rinsed can be handled and disposed of as non-hazardous solid waste. Federal law (FIFRA) and state law require pesticide applicators to rinse all empty pesticide containers before taking other container disposal steps. For more information on proper pesticide container disposal procedures, see *Pesticide Information Leaflet No. 13: Disposal of Pesticide Containers*, University of Maryland Extension.

After following proper procedures (such as pressure rinsing, triple rinsing, puncturing, etc.), pesticide containers be either recycled through an approved program or disposed of by depositing them in a licensed sanitary landfill. The Ag Container Recycling Council (ACRC), provides an empty pesticide container recycling program in New York.

9.8 Pesticide Management Best Management Practices

Pesticide Storage and Handling

- Use electronic or hard-copy forms and software tools to properly track pesticide inventory.
- Keep and maintain records of all pesticides used in order to meet legal reporting requirements.
- 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 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.
- 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 Safety Data Sheet (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.
- Annually review pesticide inventories and properly dispose of unusable and unwanted pesticides.

Mixing and Loading

- Follow secondary containment requirements as required.
- 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.

Washing

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

Pesticide Applications

- Identify any areas on the course prone to leaching losses (e.g. shallow water tables, sand-based putting greens, coarse-textured soils, etc.) and do not use highly soluble pesticides in these areas.
- 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 pesticides and apply when conditions are favorable, such as minimal wind velocity, temperature inversions not forecast, rain not forecast, etc.
- Follow the pesticide label to avoid drift.
- Use spray additives 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.
- Follow the pesticide label for re-entry period requirements or recommendations following applications.
- Allow all pesticide applications to dry thoroughly before allowing play to resume.

- ❖ 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 pesticide application equipment daily when in use.
- ❖ Use recommended spray volumes for the targeted pest to maximize efficacy.
- ❖ Calibrate walk-behind applicators 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.

Disposal

- ❖ Dispose of unused pesticides properly. See CleanSweepNY for collection days.

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 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.

10 POLLINATOR PROTECTION

Most flowering plants need pollination to reproduce and grow fruit. While some plants are pollinated by wind, many require assistance from insects and other animals. Most people are aware of managed honey bees, but there are also 450 wild pollinator species in New York State, including bees, wasps, beetles, flies, ants, moths, and butterflies. In the absence of these pollinators, many plant species, including the fruits and vegetables we eat, would fail to reproduce. These include economically important crops in the state, such as apples, blueberries, cherries, tomatoes, squash, and peppers, all of which are pollinator-dependent for good yields.

Both wild and managed bees are facing threats that can alter their health, abundance, and distribution. According to the *New York State Pollinator Protection Plan*, "Over the past several years, the loss of managed pollinator colonies in the state has exceeded 50%. This is coupled with losses in the native pollinator community and the habitat that sustains them." Research indicates that some pesticides are harmful to pollinators and can have negative effects at the sub-individual level (such as gene expression or physiology), individual level (such as mortality, foraging, or learning), or even the colony level (such as colony growth, overwintering, or honey production).

Because of the potential for non-target effects of products used in golf course management, pesticide applicators need to be mindful of the impact that pesticides have on pollinator species and their habitat. In addition to adhering to best management practices related to pesticide applications, golf course managers can protect and enhance habitat on the course in a number of ways to help both wild pollinators and managed bees (including hives on the course or in surrounding areas). For more information, see the following: New York State Integrated Pest Management Pollinator web page and the Pollinator Network @ Cornell.

BMP Principles for Pollinator Protection

- Adhere to pest management practices that protect pollinators when selecting and applying chemical control.
- Preserve and enhance habitat on the golf course that provides for pollinator foraging and nesting.

10.1 Regulatory Considerations

Pollinator protection language is a requirement for pesticide labels. Following the label is mandatory. Pesticide applicators must be aware of honey bee toxicity groups and be able to understand precautionary statements. In addition, they should be aware of the behavior of honey bees, wild bees and other pollinators that may visit golf courses and avoid applying pesticides when and where these insects may be present. They should also understand the effects of pesticides on bees and other pollinators, as well as the routes of exposure. The USGA publication *Making Room for Native Pollinators* provides the basics of pollinator biology useful for pesticide applicators. The Pollinator Partnership has visual depictions of honey bee, solitary bee, colony and general pollinator life cycles that are useful as well.

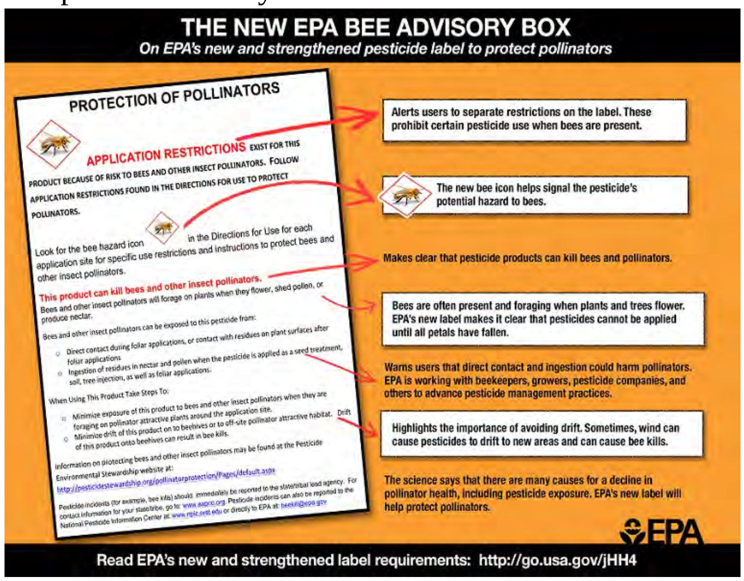

Figure 24. EPA's bee advisory information on pesticide labels.

Recordkeeping may be required by law in order to use some pesticide products. In addition to legal requirements, more detailed records should be kept in accordance with IPM principles. keeping records of both pests and pest control activity provide information on past infestations and control effectiveness that can be referenced to inform future management actions.

10.2 Pest Management Practices that Reduce Impacts on Pollinators

It is important to minimize the impacts of pesticides on bees and beneficial arthropods. Pesticide applicators must use appropriate tools to help manage pests while safeguarding pollinators, the environment, and humans. As detailed in the NYS Pollinator Protection Plan, the state has committed to IPM on state lands "by managing pests on turf and ornamental plants solely through mechanical, sanitary, cultural or biological means to the maximum extent practicable" while recognizing that pesticide use is necessary under certain circumstances.

Superintendents can utilize IPM best management practices for turf that protect pollinators by following these simple steps:

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

When the use of pesticides is necessary, being mindful of pollinators requires focusing on minimizing exposure to non-target pollinators in play and non-play course areas.

Figure 25. Syrphid fly.

10.3 Preserving and Enhancing Habitat on the Course

Habitat for pollinators includes foraging habitat and nesting sites. Pollinator-friendly habitat contains a diversity of blooming plants of different colors and heights, with blossoms throughout the entire growing season. Native plants are best, proving the most nutritious food source for native pollinators. Even plants we consider weeds provide important habitat. For example, red clover offers an important nectar and pollen source. Providing nesting sites for native species can be accomplished by taking simple steps in out-of-play areas, such as leaving stems and coarse woody debris and leaving exposed patches of well-drained soil, or by creating nesting areas such as wooden nesting boxes for hole nesting bees.

Figure 26. Pollinator nest boxes examples.

Figure 27. Establishing a wildflower area for pollinators, first year.

Figure 28. Established wildflower area for pollinators, third year.

Pollinator habitat on the golf course includes both areas renovated specifically with pollinators in mind and existing out-of-play areas. For example, one of the most effective BMPs for protecting water quality also protects pollinator habitat: leaving a low/no management buffer strip around water courses and bodies of water. Opportunities for renovation can be used to enhance the habitat for pollinators with native plants, wildflowers, and flowering trees and shrubs. Part 2 of our video case study describes the process used to establish native areas during renovations at Rockville Links Club in Rockville Centre on Long Island. The NYS BMP case study *Enhancing Habitat for Native Pollinators with Low-to-No Maintenance Areas* at Rockland Country Club provides another example of the establishment process for a native area attractive to pollinators.

For more information see:

- *Making Room For Native Pollinators*, Xerces Society.
- Pollen Specialist Bees of the Eastern United States
- Host plants for specialist bees of the Mid-Atlantic and Northeastern United States
- Monarchs in the Rough, a program sponsored by Audubon International and the Environmental Defense Fund to provide superintendents with regionally appropriate seeds to restore monarch butterfly habitat in out-of-play areas.

10.4 Managed Bee Hives on the Course

Hosting honey bee hives on the golf course provide bees with valuable green space, especially in urban areas, and can be a positive public-relations tool. If embarking on this effort, consider:

- Partnering with an experienced local beekeeper. Proper beekeeping is time and knowledge intensive. A list of beekeeper organizations in New York is available. If not partnering with an experienced beekeeper, superintendents or other responsible staff should attend a beekeeping course.
- Ensuring enough food sources are available for both honey bees and wild pollinator species.
- Placing hives away from areas where golf course workers or golfers are active to avoid stings.
- Facing the hive exit in a direction away from in play areas of the course.
- Educating golfers via explanatory signs, newsletters, and sales of honey and other bee products.
- Calling in an experienced beekeeper if disease or parasites are suspected in order to identify and mitigate any health issues.

For more information on how managed hives have been integrated at a golf course and related communications with club members, see Part 3 of our video case study at Rockville Links Club.

Figure 29. Beehives at Rockville Links Club.

10.5 Pollinator Protection Best Management Practices

Pest Management Practices

- Follow label information directing the application of pesticide when plants may be in bloom and follow all BMPs to avoid impacting pollinators.
- Inform nearby beekeepers in advance of applying pesticides so they have the option of moving their hives.
- Use drift reduction methods to stay on target by using the latest spray technologies, selecting nozzles correctly, using backpack sprayers when possible, and monitoring wind.
- Do not apply pesticides when pollinators are active (spray at night, or in early morning/late evening and when air is calm).
- Before applying a pesticide, scout the area for both harmful and beneficial insect populations, and use pesticides only when populations present exceed a damage threshold.
- Reduce preventive pesticide inputs to only areas with known chronic pest pressure.
- If flowering weeds are prevalent, mow or remove them before applying pesticides.
- Use pesticides that have a lower impact on pollinators.
- Avoid applications during unusually low temperatures or when dew is present or forecast.
- When possible, use spray or granular formulations of pesticides that are known to be less hazardous to bees (e.g. wettable powders).

- Reduce planting dust from treated seeds: use wax treated seeds, use deflectors on machinery, and be aware of dry/windy conditions.
- Follow irrigation instructions carefully to ensure pesticides are washed from foliage into soil. In addition, nonionic surfactant can help reduce the potential for drift.
- Consider the use of biologicals (e.g. entomopathogens) and bio-based lures, baits, and pheromones as alternatives to insecticides for pest management.

Pollinator Habitat Preservation and Enhancement

- Utilize native species when renovating out-of-play areas.
- Choose flowers of different shapes, sizes, and colors.
- Choose species that bloom at different times of the year.
- Include both perennials and annuals in native plant areas.
- Choose south-facing sites whenever possible for establishing native areas.
- 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.
- Consider joining the Monarchs in the Rough project.
- Provide water sources with shallow sides to prevent pollinators from drowning.

11 MAINTENANCE OPERATIONS

New construction designs should consider combining storage, mixing, and washing operations in an integrated chemical management system. For existing facilities, updating these areas does not necessarily require a new building as many changes can be easily made. Information specific to pesticide storage and handling can be found in the "Pesticide Management" chapter of this document.

BMP Principles for Maintenance Operations

- Assess potential point source pollution risk for maintenance operations.
- Ensure compliance with regulatory requirements designed to prevent point source pollution.
- Manage organic and inorganic waste to minimize potential point source pollution.

11.1 Regulatory Considerations

Every golf course has a central area for the maintenance and storage of equipment and supplies. These areas can potentially become point sources of pollution because of unintended releases of chemicals such as pesticides, fertilizers, or fuel during storage or handling of these materials. Containment measures in these areas can easily prevent chemicals from becoming point sources of pollution.

11.1.2 New Maintenance Facilities Siting and Planning

The New York State Department of Health does not allow chemical storage or mixing and loading facilities within 100 feet of a potable well. Other requirements include local zoning for the siting of maintenance facility and operations, which vary by city and county. Requirements often include a minimum distance (set-back) from wetlands, surface wells, and property lines. The state's Freshwater Wetlands Act requires a 100-foot buffer around wetlands. Some townships have even broader requirements.

Local building inspectors should be consulted during planning for new facilities to outline the permitting process and local requirements. Also, consider meeting with a representative from a NYSDEC regional office and the local fire marshal. The NYSDEC requests a State Environmental Quality Review (SEQR) for new construction, which is administered by local governments. NYSDEC comments on SEQR, as do other interested and involved agencies.

11.1.2 Chemical Storage

The NYSDEC currently offers guidelines for chemical storage and mixing and loading operations, as detailed later in this chapter. While there are currently only guidelines, regulations can be drafted in the future.

11.1.3 Backflow Prevention Devices

NYSDEC regulations require the use of Backflow Prevention Devices when public water is used with pesticide application equipment.

11.1.4 Hazardous Wastes

Some of the wastes generated in maintenance facilities must be handled as hazardous wastes. Examples of wastes that may be generated at a golf facility include, but are not limited to, the following:

- parts wash solvents
- waste gasoline
- cleaning materials
- paints
- waste oil
- lead-acid batteries
- aerosol cans
- spent fluorescent bulbs
- unusable pesticides and inner bag liners
- unusable herbicides and inner bag liners
- antifreeze

A waste is a hazardous waste if it exhibits a specific characteristic (ignitability, corrosivity, reactivity, toxicity) or if it is included in any of the four specifically listed categories of hazardous waste. Many waste fluorescent lamps are hazardous wastes due to their mercury content. Other examples of lamps that, when spent, are commonly classified as hazardous waste include: high-intensity discharge (HID), neon, mercury vapor, high pressure sodium, and metal halide lamps.

USEPA issued the Universal Waste Rule in 1995 to streamline compliance with hazardous waste regulations. This rule is designed to reduce the amount of hazardous waste in the municipal solid waste stream, to encourage the recycling and proper disposal of some common hazardous wastes and to reduce the regulatory burden on waste generators. Universal wastes include such items as hazardous batteries, hazardous mercury-containing thermostats, certain pesticides, and hazardous lamps. Although handlers of universal wastes must meet less stringent standards for storing, transporting, and collecting wastes, the wastes must comply with full hazardous waste requirements for final recycling, treatment, or disposal. Therefore, every golf club is responsible (and liable) for the safe handling of the product and for the proper waste disposal by a reputable waste removal service. These services should be certified and bonded for transporting your waste to similarly accredited processing centers.

11.1.5 Petroleum Storage

NYS has regulations for above and below ground storage of fuel and fuel oil in Part 613 of the Environmental Conservation Law. Every facility manager should review this regulation carefully. The regulations require daily inspection logs be kept, as well as annual inspections. Counties and cities may also have their own fuel storage regulations.

11.2 Design and Operation

New construction designs should consider combining storage, mixing, and washing operations in an integrated chemical management system. Buildings and infrastructure should be designed to account for the traffic and usage. The resulting design will provide a much better envelope of the operations compared with separately constructed areas. Integrated designs often include fuel storage and filling stations within the same containment areas. For existing facilities, updating these areas does not necessarily require a new building as many changes can be easily made. Information specific to pesticides storage and handling can be found in the "Pesticide Management" chapter of this document.

11.2.1 Storage

The goal of an ideal storage facility is the safe siting and storage of potential contaminants that ensures a high level of water quality protection. Modular or independent containment units can be installed in many sizes. The units are typically self-contained, fireproof, and secure and can be temperature controlled with ventilation. Options for such units include fire suppression, eye washes, and safety showers. Floor drains should include a sump and a chemical pump to move the chemicals discharged to a waste tank as in the figure below. The material can be reclaimed, diluted to label concentrations, and applied to turf areas or collected for disposal using certified hazmat haulers.

Below are NYSDEC guidelines for pesticide storage which can be applied to the storage of all chemicals. With respect to the storage of pesticides specifically, the pesticide label is the law and all pesticides should be stored according to instructions on their labels. In addition to the label, Part 326.11 of the New York Codes, Rules and Regulations states: "No person shall store any restricted pesticide or empty containers thereof in such a manner as may be injurious to human, plant or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life and property throughout such areas of the State as shall be affected thereby." Pesticide storage areas should be designed and managed in a manner that prevents or minimizes the risk of injury, harm to the environment or any impact on the use or value of property.

Guidelines are as follows:

- Storage facilities should be structurally separate from residential, office and general work areas; livestock quarters, food, feed or seed storage and water supply sources.

- Storage should be in separate buildings and at least 50 feet away from residential or farm property. Fencing is currently not stipulated but could be considered as an added precaution.
- Storage areas should have a raised berm on all sides and an impervious surface for containment.
- Facilities should be equipped with spill containment material and fire extinguishers. Suggested spill containment material includes absorbent spill containment pads, sweeping compound, brushes or brooms, a dust pan, a shovel, and a disposal container or bag.
- PPE should be available near but not within the storage area.
- The storage facility should be locked and properly posted with warnings.
- Annual updates should be provided to the local fire department and include a "Fire and Spill Response Plan." Additional precautions might include provisions of the National Fire Protection Association codes.
- Chemicals should be segregated by function (e.g. fungicide, insecticide, and herbicide) and hazard level. All flammable and "incompatible" materials should be stored separately.
- Mixing areas should be similarly bermed with impervious surfaces.
- Indoor mixing areas should be properly vented.
- Bulk containers, construed to be equal to or greater than 55 gallons, should be locked. Drains should be used to collect any spills into a containment area. The spill containment system should have a capacity equal to or greater than 25% of the volume of pesticides stored.
- A water supply and wash station are required at or adjacent to the facility for emergencies.
- A suitable first aid kit for pesticide poisoning should be nearby.
- Forced air vent systems capable of exchanging the air volume three to four times per hour should be considered, along with temperature control for keeping temperatures under 95° F and above freezing.
- Local fire departments should be made aware of the pesticides and fertilizers stored to help them prepare in the event of a fire.

Very old or inadequate storage areas may or may not be out of compliance, but consider planning for improvements to implement these guidelines over time. Updating chemical storage areas does not necessarily require a new building. Many changes can be made to meet guidelines, such as:

- impervious flooring
- flooring sloped to a drain
- curbing to contain at least 25% of the volume of liquid chemicals and fertilizers stored
- ventilation to exhaust any fumes in the event of a spill
- PPE for workers and emergency wash stations

11.2.2 Mixing and Loading

Mixing, loading, and washing areas should be well ventilated and should take place in contained areas that are bermed, have impervious surfaces, and roofed to prevent rainfall spreading pesticide residue. Pesticide storage and handling require additional considerations and are regulated by NYSDEC. See the Pesticide Use web page on the NYS BMP website for more information specific to mixing and loading of pesticides. In addition, pesticide labels provide information on required PPE that must be used during handling or use of pesticides. See EPA's PPE for Pesticide Handler's web page for more information.

Precautions should be in place to effectively respond to emergencies, such as the availability of proper PPE, spill response kits, and emergency wash stations. When mixing or loading, caution should be used and labels carefully reviewed to ensure that chemicals mixed together are compatible. Water used for mixing should be tested for pH to ensure that tank mixes do not expire prematurely due to alkaline hydrolysis. NYSDEC regulations require the use of Backflow Prevention Devices when public water is used.

11.3 Waste Management

11.3.1 Pesticides

Pesticide containers must be cleaned and disposed of or recycled properly. Procedures typically include triple rinsing nonflammable containers and either returning cleaned empty containers to the vendor or properly sealing and disposing of them in a sanitary landfill. Rinsate may be re-applied to turfgrass consistent with instructions on the label. Unused pesticides must be disposed of in accordance with state regulations, such as by returning to the supplier or disposing at an approved hazardous waste facility.

11.3.2 Lubricants, Greases, Paints, and Solvents

Lubricants, greases, paints, and solvents should be stored appropriately, typically in fireproof enclosures, separately from pesticides and fertilizers. Special cleaning stations are commercially available that contain and recycle solvents and degreasers.

In addition to any handling precautions specified on the product label or SDS sheet, added steps should be taken to prevent and contain any spills. Spills should be cleaned up using approved dry absorbents. Contaminated material should be stored in containers specially marked as hazardous waste and disposed of using licensed waste haulers and hazmat processors.

11.3.3 Organic Waste and Wastewater

The release of organic waste, such as grass clippings, associated with equipment cleaning needs the same level of protection afforded liquid and granular nutrients and pesticides. When debris is removed from equipment, it should not be released into open surface water or in a location near well heads or shallow groundwater. Often, effective equipment cleaning areas can be maintained as mixing and loading areas with impervious flooring and drains that allow for some separation of organic solids and liquids.

When using a simple wash-pad and collection area, the wash-water should be dispersed along the land, preferably along a designed bio-filtration system. Closed system cleaning stations are available that separate clippings/solids and treat the washwater. The recycled water is reused as washwater. Another approach to wastewater treatment uses microbes to break down chemical compounds. Both types of systems may require additional purification steps to remove odors and harmful bacteria. These systems must be carefully sized to process the peak water volume anticipated for contaminant levels expected. The equipment varies in costs but increases with structural requirements and permits. Two NYS BMP case studies provide more information of two types of equipment washing areas: *Wash Load at Bedford Golf and Tennis Club* and *Opportunities for Improvement of Wash Pad Operations*.

Figure 30. Typical equipment wash area.

Clipping Management

Nutrient BMPs recommend that clippings be widely redistributed to turf. Research has shown that nitrate levels in leachate increased to as much as 30 mg/L in areas that received four times the normal clippings return. Some clubs elect to collect clippings from fairways and then dump these clippings as yard waste. The accumulation of clippings and other yard wastes such a leaves, tree limbs, and other plant debris can be a substantial source of contamination to surface water and groundwater if placed close to water courses.

Clippings should be screened and collected when cleaning equipment in the maintenance area. They should not be allowed into the stream of wastewater. The inherent concentration of organic nitrogen and phosphorus, along with any pesticide residues, can contaminate the wastewater or reduce the effectiveness of wastewater treatment equipment. Ideally, clippings should be blown off using compressed air and then collected. If water is being used, sumps should screen and convey clippings and other solids prior to wastewater disposal or treatment. Many clubs have contracted with local composting companies to haul their organic waste. Material is generally accumulated in dumpsters and then frequently removed.

Figure 31. Blowing clippings off equipment prior to washing.

Figure 32. Equipment prewash on clippings collection pad.

Figure 33. Collected clippings from wash area to be composted.

11.4 Emergency Management

Planning and preparations should be made for potential emergencies. Local emergency personnel such as local fire departments should be consulted, be notified about the locations of pesticide and fertilizer storage, and be given regularly updated lists of chemicals stored. Storage areas should be properly placarded. Training and orientation should also be conducted with employees to review plans and preparations.

New York State responds to reports of petroleum and other hazardous material releases through the Spill Response Program maintained by the NYSDEC. Spill response staff throughout the state investigate such spill reports and take action based on the type of material spilled, potential environmental damage, and safety risks to the public. Releases to the environment should be reported to the NYSDEC Spills Management Hotline at 1-800-457-7362. See the Chemical and

Petroleum Spills web page on the NYSDEC website for more information on reporting of spills.

11.4.1 Safety Data Sheets (SDS)

The Hazard Communication Standard (HCS) (29 CFR 1910.1200(g), revised in 2012, requires that the chemical manufacturer, distributor, or importer provide SDS for each hazardous chemical to users to communicate information on these hazards. More information on SDS can be found on the Hazard Communication Standard: Safety Data Sheets web page of the OSHA website.

An up-to-date file should be maintained with copies of all the SDS reports for all chemicals used, stored on the property, and made available to employees. Copies of these files can be provided to local fire departments and hospitals in case of any emergency.

11.4.2 First Aid

Adequate provisions should be provided to immediately treat any person exposed to chemicals. These include eye wash stations and showers. First aid kits should be available to treat skin contact, ingestion, or inhalation.

11.4.3 Spill Management

Cornell's Occupational and Environmental Health Department (OEHD) in the College of Agricultural Sciences has guidelines that can be used a template for spill management:

- Evacuate personnel from the immediate area of the spill.
- Control the spill. Do not endanger yourself. To the extent possible, shut off the source and block the flow.
- Call 911 if:
    - anyone is injured
    - the spill is too large for a local clean up
    - the spill migrates off-site
    - the spill threatens the health and safety of anyone

- Identify the spilled material(s).
- Barricade the area and notify others in surrounding areas not to enter the spill area.
- Wait for help to arrive.

Spill kits can be used for incidental releases. Follow these procedures:

- Consult the appropriate SDS and label (for pesticides).
- Wear the appropriate PPE.
- Contain the spill. Prevent spread or escape from the area by using sorbents.
- Clean up the spill. Never hose down an area until the cleanup is completed.

To clean up pesticides:

- Recover as much product as possible in a reusable form. Store and use as intended. Recover the rest of the product as a waste product by using an absorbent or sweeping compound.
- When all recoverable material is secured, clean contaminated surface residues using triple-rinse technique. For instance, a spill of liquid on the floor requires that the area be damp-mopped three times.

To clean up all other chemicals:

- Small liquid spills can be cleaned up with a commercially available absorbent. Avoid using paper towels; they increase the surface area and the rate of evaporation, increasing the fire hazard.
- For acid or base spills, use a sorbent that will neutralize the liquids (trisodium phosphate, sodium bicarbonate, or other commercially available products).
- Use a dustpan and brush to sweep up the absorbed spill. Wash the contaminated area with soap and water.

11.5 Maintenance Operations Best Management Practices

Storage and Handling of Chemicals

- ❖ Post warning signs on chemical storage buildings, and especially near any entry or exit areas.
- ❖ Storage facilities must be secured and allow only authorized staff to have access.
- ❖ Pesticide and fertilizer storage areas should preferably be located away from other buildings.
- ❖ Floors should be sealed with chemical-resistant paint.
- ❖ Floors should have a continuous sill to help contain any spills.
- ❖ Shelves should be made of plastic or reinforced metal. Metal shelving should be coated with paint to avoid corrosion. Wood 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 exteriorly installed to illuminate and ventilate the building.
- ❖ Store chemicals in original containers.
- ❖ Store chemicals so that the label is clearly visible. Loose labels should be refastened.
- ❖ Store flammable chemicals separately from non-flammable chemicals.
- ❖ Store liquid materials below dry materials to prevent contamination from a leak.
- ❖ Use regulatory agency-approved, licensed contractors for the disposal of chemicals.
- ❖ Provide adequate staff training pertaining to the risks and liabilities of chemical storage and use.
- ❖ 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 mowing 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.
- Do not wash mowing equipment on a pesticide mixing and loading pad. This keeps grass clippings and other debris from becoming contaminated with pesticides.
- 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 field 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.
- 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 (ASTs) for fuel are preferred as they are more easily monitored for leaks as compared with underground storage tanks (USTs).
- Fueling stations should be located under roofed areas with concrete pavement whenever possible.
- Fueling areas should also 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.

Emergency Preparedness

- Develop a facility emergency response plan that outlines the procedures to control, contain, and clean up spilled materials.
- Train all employees on the emergency response plan and emergency procedures.
- 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 to the NYSDEC Spills Management Hotline at 1-800-457-7362 when required.
- For larger spills, follow guidance from the NYSDEC and CHEMTREC for cleanup and disposal.

12 LANDSCAPE

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. By using native or adapted plants that mimic natural ecosystems, landscapes that are designed for the specific location, management capabilities, and desired style can reduce overall management inputs, attract pollinators, provide multi-season interest, and enhance out-of-play areas.

Figure 34. Native areas at Locus Hill Country Club.

12.1 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 enhance the habitat of wildlife, including non-game species, birds, and pollinators, in non-play natural areas. Supplemental planting can also limit soil erosion and protect stream banks. 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.

Designs for higher-impact, higher-use landscape areas, such as around the clubhouse, should utilize natural drainage patterns and channel runoff away from impervious surfaces (e.g. paved areas), conserve water, and lower the 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, see *Rain Gardens*.

Golf courses are excellent facilities for zoning the landscape with designations of high-impact zones, transition zones, and perimeter zones, and for matching high-use and high-impact areas to plants and landscape styles that need more intense management.

12.1.1 High-use and High-impact Zones

In high-use and high-impact zones, the design intent is to create highly ornamental, garden-like landscapes based primarily on visual impact and functionality, not necessarily related to the colors, patterns, and cycles of the native landscape. Regional flora should be given preference. Intervention and maintenance will be required to create and maintain a highly ordered aesthetic attractive on a small to medium scale, and evident even when viewed at close range. Well-defined, small-scale, high-visibility sites such as the clubhouse landscape and parking lot traffic islands are examples of high-use and high-impact zones. In such zones, these steps are recommended:

- Remove existing vegetation completely, expect for desirable plants.
- Correct and maintain environmental conditions to facilitate plant growth. Such changes may include tillage, soil amendment, soil replacement, or modification of topography and drainage.
- Select the plant palette for multiple seasons of interest, resulting in plantings that are neat and attractive on a small scale.
- Select plants based on their ability to survive drought, full sun, wind, salt, or other cultural extremes as much as possible within the design parameters.
- Invest more in plant material to create immediate impact.
- Weed routinely.
- Provide supplemental watering whenever conditions would negatively impact the visual effectiveness of the planting.
- Use mulch as a typical ground layer.

12.1.2 Transition Zones

The design intent in transition zones features ornamental landscapes inspired by the regional colors, patterns, and cycles of the native landscape, but is not necessarily based on plant community dynamics. These areas require a moderate level of intervention, sufficient to create and maintain an aesthetic order that is noticeable and attractive on a medium to large scale. The designs rely on well-defined groupings and masses to create ornamental impact, using regional plant associations when practical to suit this purpose.

This approach is appropriate for medium- to large-scale sites where cultural conditions are suitable, or suitable with moderate modifications, for a mix of regional and North American native species. This approach also works for moderate installation and maintenance budgets. It is appropriate in areas where native flora is a modest to minimal part of the local context. Transition zone landscaping may occur on the course at tees or key junctions of paths. Creating transition zones can include these steps:

- Selectively or completely remove existing vegetation. In some cases, the existing vegetation can be left as the ground layer.
- Correct and maintain environmental conditions to facilitate plant growth, which may include soil modifications (e.g. change pH).
- Select the plant palette for multiple seasons of interest that match regional cycles, organized on a medium to large scale.
- Restrict plants to species that tolerate drought, full sun, wind, salt, or other cultural extremes.
- Spot-control aggressive weeds on a regular basis to supplement plant competition as the primary method of weed control.
- Provide supplemental watering during establishment and only in extreme drought conditions.
- Use mulch around planted specimens as needed, but the long-term ground layer will develop from seeded, planted, or existing vegetation.

12.1.3 Perimeter Zones

The design intent is to develop attractive, naturalistic landscapes based directly on the regional ecology: the dynamics, patterns, colors, and cycles of native plant communities. A minimal level of intervention is required for these areas, just sufficient enough to create and maintain an aesthetic order that can be appreciated on a large scale. Though not intended to fully replicate native plant communities, regional plant associations and dynamics are conserved and enhanced. The low level of intervention allows for considerable natural growth and propagation of native plant species on site.

This approach is appropriate for large-scale sites where cultural conditions are suitable, or suitable with minor modification, for native species, and where the installation and maintenance budget is minimal. It is particularly appropriate in areas where native flora remains a significant part of the local context. This perimeter zone approach should be used in landscaped areas throughout the remainder of the course. Here are key steps to take in perimeter zones:

- Selectively remove existing vegetation to introduce aesthetic order or remove highly undesirable species. The existing vegetation is rarely completely removed.
- Only minimal modifications of environmental conditions are employed. Topography may be modified to provide sites conducive to the growth of regional vegetation.
- Select the plant palette to complement the surrounding vegetation in terms of patterns, color, and cycles. Select plants based in their likelihood to thrive in the existing conditions, with an understanding and awareness of site ecology and opportunities provided by cultural niches.

- Restrict plant selection to species that tolerate drought, full sun, wind, salt, or other cultural extremes.
- Planting desirable species is the primary method of weed control, but spot control of aggressive species that threaten the long-term survival of the site is also practiced.
- Provide supplemental watering during establishment only.
- Use mulch around planted specimens as needed, but the long-term ground layer will develop from seeded, planted, or existing vegetation.

12.2 Site Inventory and Assessment

Before developing a landscape plan, conduct an inventory 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, conduct a soil analysis and a soil test. The soil analysis evaluates the structure and texture of the soil. If needed, soil amendments can improve the structure and texture of soil, increase its water-holding capacity, and reduce nutrient leaching. Soil amendments, such as landscape waste compost, can contribute to an overall healthier plant environment, allowing easier root development and fewer soil-related problems. Do not use peat moss as an amendment as it is both expensive and originates from peat bogs, which are non-renewable. Apply fertilizers based on the results of a soil test as described in the "Nutrient Management" chapter of this document.

12.3 Plant Selection

Select plants for landscape planting that grow in natural ecosystems in the area, especially in the perimeter zones and out-of-play areas. Native plants provide food and cover for native insects, birds, and other game and non-game wildlife. As land becomes developed, it is even more important to provide habitat and other ecosystem services (fresh water, clean air, carbon sequestration, etc.) in open, managed areas like golf courses. Golf courses have the opportunity to teach sustainable landscape design principles to players if responsible landscaping practices are appropriately modeled.

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.

Consider design intentions, ultimate sizes and growth rates of trees, shrubs, and ground covers when selecting and placing landscape plant. 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.

For recommended plant species in New York, see:

- Native Plant List for Pennsylvania, New York, and Northern New Jersey, published by the Plant Native.

- List of native flowers, trees, shrubs and vines, published by NYSDEC.
- Native Plants Suitable for Wildflower Gardens & Meadows or Traditional Gardens in the NY Finger Lakes, published by the Finger Lakes Native Plant Society.
- Woody Plant Database, Cornell University.

The introduction of invasive or potentially invasive plants should be avoided and any existing invasive or noxious weed species should be controlled. Furthermore, intentionally planting or propagating certain invasive plants may be in violation of NYSDEC invasive species regulations. The New York Invasive Species Information website provides lists of invasive species and species profiles which include control strategies.

12.4 Installation

During landscape bed construction, use native soil and break up any remaining hardpan or compaction from construction. Slope beds away from buildings, with a minimum percent slope of 2 percent for at least 10 feet. Resolve drainage issues and establish clear drainage patterns prior to installing plants. Install plants with higher moisture requirements at lower elevations and drought-tolerant plants at higher elevations.
For more information on planting trees and shrubs, see: The Cornell Guide for Planting and Maintaining Trees and Shrubs.

12.5 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. When it's needed, water plants in the early morning to conserve water and avoid water loss due to evaporation. Water new trees and shrubs at least once a week to a depth of one foot and more frequently during dry weather. When using a hose, allow the water to trickle out for at least an hour, and move the hose several times around the base of the tree. Watering bags are effective tools for applying water slowly. Apply at least five gallons when watering from a container, pouring it slowly over the back of a shovel to spread the water. Keep trees well-watered throughout the entire establishment period (one year or more depending on the caliper) with deep, slow watering.

If trees and shrubs are planted in an area with an existing irrigation system, assess the coverage to determine whether changes should be made to identify areas where efficiency can be improved. Carefully assess landscape watering patterns to minimize spray on impervious surfaces, blockage of spray by plants or other obstructions, and runoff on slopes, clay soils, or compacted sites. Focus on the irrigation of woody plants at or beyond the dripline to promote extensive rooting. Periodically throughout the growing season, check the performance of the landscape irrigation system.

12.6 Use of Mulch

Mulch conserves soil moisture, mitigates temperature extremes, and reduces weed competition. During the growing season, mulch also serves as a visual reminder to keep mowers and string trimmers away from shrub stems and tree trunks. 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 avoiding applying too deeply to avoid matting and heating the soil), shredded bark, bark chunks, composted sewage sludge, one-year-old wood chips, pine needles and composted, shredded leaves. 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 inches of mulch. Around trees and shrubs, mulch should be no more than 3 inches deep. With any planting, place mulch between the plants and not on top of the crown or against tree trunks or shrub canes. In the winter after the ground freezes, a deeper layer of coarse mulch (evergreen branches) over bulbs and other perennials can delay or prevent early growth and can be used to protect tender plants. Do not place a new layer of mulch over the old layer each year. Each spring, rake the old mulch to break up any hard crest and add only enough new mulch to maintain a 2-inch to 3-inch layer.

12.7 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 trees in New York is in the late winter/early spring except in times of drought. 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.

For more information on pruning, see: The Cornell Guide for Planting and Maintaining Trees and Shrubs and Pruning: An Illustrated Guide to Pruning Ornamental Trees and Shrubs.

12.8 Pest Management

The same principles and methods identified in the "Integrated Pest Management" chapter of this document can be applied to landscaped areas.

12.9 Landscape Best Management Practices

Planning and Design Best Management Practices

- ❖ Leave the majority of non-play areas – the perimeter zone – in natural vegetation.
- ❖ 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.

Site Inventory and Assessment Best Management Practices

- ❖ 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 Best Management Practices

- ❖ Select native species whenever possible; use adapted species or cultivars of native plants where appropriate.
- ❖ Select trees, plants, and grass species to attract birds and pollinators 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.

Landscape Irrigation Best Management Practices

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

Mulching Best Management Practices

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

Pruning Best Management Practices

- 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 late winter, except in times of extreme drought.
- Prune shrubs based on their season of bloom.

Pest Management Best Management Practices

- Use IPM for landscaped areas.

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