BEST MANAGEMENT PRACTICES FOR MICHIGAN GOLF COURSES

GCSAA
Golf Course Superintendents Association of America

Michigan Chapter
GCSAA
Golf Course Superintendents Association of America

BMP Best Management Practices

Best Management Practices Planning Guide & Template

GCSAA USGA

In partnership with the PGA TOUR

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Introduction

The Michigan Turfgrass Environmental Stewardship Program began as a collaborative project between golf course superintendents, Michigan State University and the Michigan Department of Agriculture and Rural Development (MDARD). The purpose was to protect environmental resources on golf course properties and seek practical solutions to environmental issues facing the golf industry. In order to illustrate how this program evolved, it is vital to understand the social/economic influences present during the time period it was developed and to recognize the leadership, vision and professionalism of individuals in the turfgrass industry in Michigan.

Michigan has a long history of successful golf course businesses and offers diverse options of public and private golf facilities. The golf industry in Michigan enjoyed significant growth for a period of approximately twenty years beginning in the1980's. Golf's appeal was attracting more and more participants and new golf course venues were being built throughout the state to satisfy the demand. Golf course construction was particularly vigorous in northern Michigan thereby taking advantage of the natural splendor that was already known to generations of vacationers. The construction of a few major golf resort facilities in northern Michigan served as attractive destinations for business and family travel. These resort destinations served as hubs for golf enthusiasts and lead to additional golf course construction throughout the region. By the early 2000's, new golf construction vaulted Michigan to be recognized nationally as one of the leading states for total number of golf courses and number of public golf courses per capita.

Public scrutiny of golf course construction and maintenance practices also increased throughout this period. Citizens and advocacy groups raised concern about the degradation of natural resources and the human health hazards associated with golf courses. Opposition to new construction was particularly intense when golf courses were replacing previously undeveloped landscapes and areas containing valuable wildlife habitat. Surface and groundwater degradation, soil disturbance, air quality, loss of habitat, chemical pollution, and increased traffic, noise and light were some of the major concerns. Many considered golf courses to be a poor land use and insisted that long-term effects would perennially insult natural resources. The routine use of pesticides, fertilizers, and petroleum products to maintain golfing conditions were most often the focus of discussions on human health concerns.

The Michigan Turfgrass Foundation (MTF) has been dedicated to supporting research and teaching efforts at MSU for decades. In the early 1990's, they initiated an effort to address the environmental issues facing the golf industry by creating a new faculty position at MSU, the Turfgrass Environmental Education Specialist. The objective of this position was to provide turfgrass professionals a better understanding of environmental issues and promote practices that would advance the environmental stewardship of professionally managed landscapes in Michigan. The collaboration between MTF and MSU was considered a novel approach at the time, considering the objectives of other university turfgrass science positions nationally.

In the mid-1990's, the regulatory framework in Michigan changed regarding the use of pesticides and fertilizers and as a result, more scrutiny was placed on golf course properties. The new regulations imposed additional requirements for applicator training and safety, pesticide handling, mixing, storage and disposal. In addition to the regulatory requirements, new fees associated with the use of these products were imposed upon the industry by the MDARD. The Turfgrass Environmental Education Specialist position was well suited to work together with industry professionals and efficiently transform these new requirements into practice on golf course properties.

During this period, a productive relationship developed between the turfgrass industry, MSU and the MDARD. At the time, the MDARD was working to develop various compliance assistance for Michigan farm operations and these efforts nurtured the concept of a more formal, environmentally focused, compliance assistance program specifically tailored to Michigan golf courses. After a period of development and testing, the Michigan Golf Course Environmental Stewardship Program (MTESP) was launched in the mid-1990's. It was designed to allow golf course superintendents to self-assess potential environmental impacts specific to their property, critically review maintenance operations, seek tools to minimize environmental exposure and gain regulatory compliance for pesticide and fertilizer use. Program participants attended seminars to assist them in assessing their properties, facilities, and maintenance operations. During these educational sessions, improvement plans were initiated to enhance environmental protection and regulatory compliance. As part of the program, participants could receive site visits by MTESP personnel to review improvement plans and verify regulatory compliance. Golf course properties that achieved specific program standards of environmental protection and regulatory compliance were formally recognized by MSU, MDARD and the MTF.

The MTESP was enthusiastically embraced by the golf course industry due to the leadership of many individuals that committed to pro-actively address environmental issues. The program was funded by industry participation and through MDARD grant programs that were generated from pesticide and fertilizer user fees. For over a ten-year period, the program grew in scope and participation. Collaboration from other state regulatory agencies (MI Department of Environment, Great Lakes and Energy, MI Department of Natural Resources) allowed program participants to gain more insight and advice on environmental stewardship. The MTESP was also adapted for use by other turfgrass professionals in the athletic fields, schools, and other ground maintenance sectors.

Data collected by the MTESP provided valuable feedback on productive changes that were made within the turfgrass industry. Upgrades to facilities and advances to maintenance practices were directly linked to the educational effort of MSU and regulatory agency personnel through this program. Additionally, the commitment of turfgrass industry professionals and golf course owners gained the attention of the media, regulatory agencies and citizen advocacy groups in Michigan and beyond. In the late 1990's, the program was recognized with the President's Award for Environmental

Stewardship by the Golf Course Superintendents Association of America.

The experience of the MTESP should provide a positive backdrop as the turfgrass industry in Michigan adopts this Best Management Practices document. Golf Course Superintendents have demonstrated the value of continually improving their practices so they may provide appealing playing conditions while also maximizing the protection of environmental resources.

The success of the MTESP was dependent on the vision and commitment of many individuals. The intention of recognizing their efforts in this document is so they may inspire others with a profound zeal for continual improvement and professionalism. Mr. Gordon LaFontaine served as the Executive Director of the MTF and was instrumental in developing the Turfgrass Environmental Education Specialist position at MSU. He successfully negotiated the commitment of the regulatory agencies in Michigan during the development of the MTESP and inspired industry members to participate. Many MTF members provided the vision of success and leadership that was pivotal to program success. They include: Fritz McMullin, CGCS, Harry Schumann, Jon Maddern, CGCS, Jim Bogart, Bruce Wolfrom, CGCS, Dave Longfield, Kathy Antaya, Paul Muelle, John Johnson, Craig Hoffman, Adam Ikamas, CGCS, Jeff Holmes, CGCS and Steve Hammon just to name a few. Dr. Frank Rossi served as the first Turfgrass Environmental Education Specialist at MSU, I proceeded him in the position and developed the MTESP and Ms. Deborah Swartz served as the liaison for Michigan regulatory agencies and worked tirelessly as the Director of the MTESP for many years.

Greg T. Lyman

Michigan Turfgrass Environmental Stewardship Program

This program is intended to organize efforts of state agencies, Michigan State University (MSU), and environmental advocacy groups to advance the environmental stewardship of the Turfgrass industry and to recognize environmental achievements. The program was developed at MSU with support from the Michigan Turfgrass Foundation (MTF), Michigan Golf Course Superintendents Association (MiGCSA), Golf Association of Michigan (GAM), Michigan Golf Course Owners Association (MGCOA), Michigan PGA Section (PGA), Michigan Sports Turf Managers Association (MiSTMA), Michigan Department of Environmental Quality (DEQ), Michigan Department of Natural Resources (MDNR) and Michigan Department of Agriculture and Rural Development (MDARD). The Michigan Water Stewardship Program provides the base funding to develop and operate the program.

- This program is based around 12 modules that need to be completed for certification.
- Once completed a site visit is conducted to verify all items are completed by a trained MTESP Stewardship Specialist.
- The modules in the program are

    1. Program Overview
    2. Site Evaluation
    3. Wellhead Protection
    4. Pesticide and Fertilizer Storage
    5. Pesticide Mixing and Loading Pad
    6. Pesticide Handling and Application
    7. Fuel Storage
    8. Equipment Wash Pad
    9. Emergency Response
    10. Buffer Strips
    11. Green Purchasing, Conservation, & Waste Reduction
    12. Irrigation

- All of the modules were created with help from the DEQ, MDARD and DNR and are reviewed on a yearly basis to keep them compliant with new laws and regulations.

- This is a voluntary program that covers laws, regulation and best management practices for environmental stewardship.

For more information please visit mtesp.org

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Acknowledgement

Who We Are/
Acknowledgments

Golf Course Superintendents Association of America

The Golf Course Superintendents Association of America (GCSAA) is the professional association for the men and women who manage and maintain the game's most valuable resource — the golf course. Today, GCSAA and its members are recognized by the golf industry as one of the key contributors in elevating the game and business to its current state.

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

Environmental Institute for Golf

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

United States Golf Association

The United States Golf Association (USGA) provides governance for the game of golf, conducts the U.S. Open, U.S. Women's Open and U.S. Senior Open as well as 10 national amateur championships, two state team championships and international

matches, and celebrates the history of the game of golf. The USGA establishes equipment standards, administers the Rules of Golf and Rules of Amateur Status, maintains the USGA Handicap System and Course Rating System, and is one of the world's foremost authorities on research, development and support of sustainable golf course management practices.

Acknowledgments

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

Additional Acknowledgement

Michigan Chapter of GCSAA

The MiGCSA is dedicated to providing value to our members through programs and services that enhance and promote our profession. To join the MiGCSA or for more information on the chapter please visit www.migcsa.org.

Acknowledgments

The Michigan Chapter of the GCSAA would like to thank the Michigan State Turf Team Dr. Thom Nikolai, Dr. Kevin Frank, Dr. John “Trey” Rogers III and Dr. Joseph Vargas. Also our thanks to the GCSAA, EIFG and the USGA for their grant to fund this important project; our volunteers who served on the task group to review BMP and provide technical assistance; and the Michigan Department of Agriculture and Rural Development (MDARD), the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and the Michigan Department of Natural Resources (MDNR) for their review of this document.

Foreword

One of the greatest achievements in the golf industry over the last 30 years has been the implementation and promotion of the positive and caring environmental impact of the golf course superintendent. Here in Michigan this started with the Michigan Turfgrass Environmental Stewardship Program that was started in 1998 in order to work together with the state to provide compliance and guidance on regulations 636 & 637. The MTESP helped many turf managers find areas where they needed to improve their operations specifically for groundwater protection and continues to do so today with the online modules at mtesp.org.

The GCSAA with support from the USGA and PGA Tour has now brought forth a national all-encompassing BMP Program with adoption from all GCSAA Chapters by 2020. This project was a huge undertaking but the ramifications for our members and the entire golf industry are endless.

This project would not exist in any form without the help of Dr. Thom Nikolai from MSU and Shane Conroy our GCSAA Field Staff Representative who did the vast majority of the review and edit work with assistance from the entire MSU Turf Team. Special thanks to the MiGCSA BMP Committee Chaired by Scott Pulaski and included Doug Ware, Skip Connolly, Ryan Moore and Thomas Schall, CGCS.

This tool has the potential to be one of the most important documents at any golf facility as a custom guide to managing that property and as a nationwide tool to utilize as needed to help educate and guide legislation that can impact golf course superintendents. Thank you in advance for utilizing and promoting these best management practices at your facility.

Adam Ikamas, CGCS
Executive Director, MiGCSA

BMP Index

Planning, Design, Construction, and Renovation

Overview

The construction phase of any industry's infrastructure poses the greatest risk of ecosystem alteration. With proper planning and design, golf facilities can be constructed with minimal impact on existing wildlife and can be maintained to enhance wildlife habitat Furthermore, facilities should be designed and constructed to maximize energy efficiency.

Regulatory Issues

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

Planning

Principles

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

Best Management Practices

- Assemble a qualified team
    - Golf course architect
    - Golf course superintendent
    - Clubhouse architect
    - Irrigation engineer
    - Environmental engineer
    - Energy analyst
    - Economic consultant
    - Civil engineer
    - Soil scientist

    - Geologist
    - Golf course builder
    - Legal team
- Determine objectives
- Complete a feasibility study

    - Are needs feasible given existing resources?
    - Financial
    - Environmental
    - Water
    - Energy
    - Labor
    - Materials
    - Governmental regulatory requirement/restrictions

- Select an appropriate site that is capable of achieving the needs of stakeholders.
- Identify strengths and weaknesses of the selected site.
- Identify any rare, protected, endangered or threatened plant/animal species on the site.

Design

Principles

Proper design will meet the needs of the stakeholders, protect the locations environmental resources, and be economically sustainable. Design will also incorporate the compilation of site-appropriate turfgrass cultivars, blends or mixtures which will ideally require less input while maintaining a healthy turf. For more information, see: Turfgrass Species and Cultivar Selection.

Best Management Practices

- Retain a qualified golf course superintendent/project manager at the beginning of the design and construction process to integrate sustainable maintenance practices in the development, maintenance, and operation of the course.
- Design the course to minimize the need to alter or remove existing native landscapes. The routing should identify the areas that provide opportunities for restoration.
- Design the course to retain as much natural vegetation as possible. Where appropriate, consider enhancing existing vegetation through the supplemental planting of native vegetation/materials next to long fairways, out-of-play areas, and along water sources supporting fish and other water-dependent species.
- Design out-of-play areas to retain or restore existing native vegetation where possible. Nuisance, invasive, and exotic plants should be removed and replaced with native species that are adapted to that particular site.
- Greens
    - Select a location that has adequate sunlight to meet plant specific needs and provides sufficient drainage.

    - Choose a green size and sufficient number of hole locations that is large enough to accommodate traffic and play damage, but not so large that it is not sustainable with your resources.
    - Select an appropriate root-zone material as designated by the USGA.
    - Variable depth rootzones should be considered for putting surfaces because research indicates they result in a more volumetric moisture content in the rootzone which can minimize syringing and irrigation inputs while minimizing black layer in low lying areas.
    - Consider the number of bunkers as it relates to resources available for daily maintenance.
    - Greens should be irrigated separately from surrounding turf.
    - Select a turf species/variety that meets the needs of the stakeholders while adhering to the principle of “right plant, right place.”
- Plant only certified turfgrass.
- Decide whether bunkers will contain drainage.
- Consider bunker entry and exit points. Consider wear patterns and create adequate space for ingress/egress points on greens, tees, fairways, and bunkers.
- Select the proper color, size, and shape of bunker sand that meets your needs.
- Define play and non-play maintenance boundaries.

Construction

Principles

Construction should be completed with care to minimize environmental impact and financial ramifications caused by poor construction techniques. Detailed plans will be utilized by a golf course builder to ensure proper methods are followed. Please see An Environmental Approach to Golf Course Development for further information.

Best Management Practices

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

- Determine what sites will be analyzed and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.

Grow-in

Principles

Turfgrass establishment is a unique management phase that requires an increased frequency of irrigation and fertilization due to minimal rooting depth. Additionally, each irrigation event should apply less water compared to a mature turfgrass stand to prevent leaching beyond the rootzone.

Best Management Practices

- The area to be established should be properly prepared and cleared of pests (weeds, pathogens, etc.).
- Ensure erosion and sediment control devices are in place and maintained.
- Use appropriate seeding methods for your conditions. When using sod, nutrient applications should be delayed until sod has sufficiently rooted.
- A granular starter fertilizer should be applied immediately prior to seeding to enhance germination and establishment which in turn minimizes the potential for erosion. Frequent soluble nitrogen applications should be made following seedling germination to enhance said establishment. Slow/control release nitrogen fertilizer should be withheld until plant length and density prevents movement of these forms of particles that can float and be transported off site following a heavy rain on barren soil.
- Nutrients should be applied — in either foliar or granular formulations — to the turf surface. Incorporating nutrients into the root zone does not result in more rapid establishment and increases environmental risk.
- Mow as soon as the sod has knitted-down, and seedlings have reached a height of one-third greater than intended height-of-cut. This will hasten establishment.
- Research proves immature turfgrass putting surfaces are extremely susceptible to injury and indentations from foot traffic that thin out the turf canopy and increase the likelihood of weed seed infestation. For this reason, it is recommended that golfers use cleat less shoes the first year following the opening of golf greens following reconstruction/construction.

Erosion and Sediment Control

Principles

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

- Depending on location of golf course, it may lie in a community with locally specific stormwater requirements. Be sure to verify stormwater requirements with local authorities.

Best Management Practices

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

Wetlands

Principles

Per the Michigan Department of Environment, Great Lakes and Energy, Michigan's wetlands law recognizes the important benefits provided by wetlands and their vital role in recreation, tourism, and the economy. Over thirty years ago, Michigan was the first state, and remains one of only two states, to have received authorization from the federal government to administer the federal wetland program. Because of this approval, wetlands, lakes, and streams permits issued by EGLE under state law also provide federal approval; the permitting process should be an early component of the construction/renovation process if wetlands are involved. This page can be accessed as www.mi.gov/wetlands

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

Best Management Practices

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

- Retain riparian corridors along waterways to protect water quality and provide food, nesting sites, and cover for wildlife.

Drainage

Principles

- Adequate drainage is necessary for growing healthy grass.
- A high-quality BMP plan for drainage addresses the containment of runoff, adequate buffer zones, and filtration techniques in the design and construction process to achieve acceptable water quality.
- Damaged, improperly installed, or poorly maintained drainage systems will result in inferior performance that negatively impacts play and increases risks to water quality.

Best Management Practices

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

Surface Water: Stormwater, Ponds, Lakes

Principles

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

Best Management Practices

- Stormwater treatment is best accomplished by a “treatment train” approach, in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.
- Eliminate or minimize as much directly connected impervious area (DCIA) as possible.
- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.

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

Maintenance Facilities

Principles

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

Best Management Practices

- Design and build pesticide storage structures to keep pesticides secure and isolated from the surrounding environment.
- Store pesticides in a roofed concrete or metal structure with a lockable door.
- Construct floors of seamless metal or concrete sealed with a chemical-resistant paint.
- Ensure that flow from drains does not discharge directly to the ground and that drains are not connected to the sanitary sewer line or septic system.
- Equip the floor with a continuous curb to retain spilled materials.
- Do not store pesticides near burning materials or hot work (welding, grinding), or in shop areas.
- Provide storage for personal protective equipment (PPE) where it is easily accessible in the event of an emergency, but do not store in the pesticide storage area.
- Provide adequate space and shelving to segregate herbicides, insecticides, and fungicides.
- Use shelving made of plastic or reinforced metal. Keep metal shelving painted.
- Provide appropriate exhaust ventilation and an emergency wash area.
- Always place dry materials above liquids, never liquids above dry materials.
- Never place liquids above eye level.
- Locate operations well away from groundwater wells and areas where runoff may carry spilled pesticides into surface waterbodies.
- Do not build new facilities on potentially contaminated sites.
- An open building must have a roof with a substantial overhang (minimum 30° from vertical, 45° recommended) on all sides.
- In constructing a concrete mixing and loading pad, it is critical that the concrete have a water-to-cement ratio no higher than 0.45:1 by weight.
- The sump should be small and easily accessible for cleaning.
- Ensure that workers always use all personal protection equipment as required by the pesticide label and are provided appropriate training.

- Assess the level of training and supervision required by staff.
- Any material that collects on the pad must be applied as a pesticide according to the label or disposed of as a (potentially hazardous) waste according to Michigan laws and regulations.
- Clean up spills immediately!
- Always store nitrogen-based fertilizers separately from solvents, fuels, and pesticides, since many fertilizers are oxidants and can accelerate a fire. Ideally, fertilizer should be stored in a concrete building with a metal or other type of flame-resistant roof.
- Always store fertilizers in an area that is protected from rainfall. The storage of dry bulk materials on a concrete or asphalt pad may be acceptable if the pad is adequately protected from rainfall and from water flowing across the pad.
- Sweep up any spilled fertilizer immediately.
- Do not wash equipment unnecessarily.
- Clean equipment over an impervious area, and keep it swept clean.
- Brush or blow equipment with compressed air before, or instead of, washing.
- Use spring shutoff nozzles.
- Use a closed-loop recycling system for wash water.
- Recycle system filters and sludge should be treated and disposed appropriately.
- Each piece of equipment should have an assigned parking area. This allows oil or other fluid leaks to be easily spotted and attributed to a specific machine so that it can be repaired.
- Use solvent-recycling machines or water-based cleaning machines to cut down on the use of flammable and/or toxic solvents.
- Use a service to remove the old solvents and dispose of them properly.
- Design pesticide storage to keep pesticides secure and isolated from the environment.

External Certification Programs

Principles

Golf-centric environmental management programs or environmental management systems can help golf courses protect the environment and preserve the natural heritage of the game. These programs help superintendents enhance the natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf course operations. Golf courses can gain valuable recognition for their environmental education and certification efforts. The Michigan Turfgrass Environmental Stewardship Program (MTESP) has been a leading program that is intended to organize efforts of state agencies, Michigan State University (MSU) and environmental advocacy groups to advance the environmental stewardship of the turfgrass industry and recognize environmental achievements. The program was developed at MSU with support from the Michigan Turfgrass Foundation (MTF), Michigan Golf Course Superintendents Association (MiGCSA), Golf Association of Michigan (GAM), Michigan Golf Course Association (MGCA), Michigan Section PGA (PGA), Michigan Sports Turf Managers Association (MiSTMA), Michigan Department of Environment, Great Lakes, and Energy (EGLE), Michigan Department of Natural Resources (MDNR) and Michigan Department of Agriculture and Rural Development (MDARD). The Michigan Water Stewardship Program provides the base funding to develop and operate the program.

Best Management Practices

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

Wildlife Considerations

Principles

- Golf courses occupy large land areas, generally in urban areas, providing critical links between urban and rural/natural environments.
- Maintaining wildlife habitat on golf courses maintains biological diversity, which is especially important in the urban environment.
- Most golfers enjoy observing non-threatening wildlife as they play the game.

Best Management Practices

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

Irrigation

Water Management Approaches

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

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

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

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

Several benefits of adopting BMP are:

- Conserving the water supply
- Protecting existing water quality
- Maintaining surface firmness that enhances playing conditions
- Increasing pump and equipment life longevity
- Demonstrating responsible environmental stewardship
- Retaining knowledgeable and effective employees

Conservation and Efficiency

Conservation and efficiency considers the strategic use of appropriate course and irrigation design, plant selection, computerized and data-integrated scheduling, and alternative water

quality/supply options that maximize plant health benefits and reduce the potential for negative impacts on natural resources.

Proper irrigation requires thoughtful decisions based on knowledge. You must first know the site and the system to effectively irrigate the turfgrass and conserve water. It is important to periodically review your reasons for irrigating, factors that influence application rates and timing.

Determining turf irrigation needs

- What is your goal? Turf survival, playability, aesthetic quality? (Each playing surface, turf type, and height of cut may have different goals. These goals may vary from day to day)
- Visually assess turf quality
- Evaluate soil moisture (by feel, or with tools)
- Review evapotranspiration data
- Consider current weather conditions and predictions

Application/run times

- Use hand-held or buried soil moisture sensors to water within the range of plant available water for your soil texture(s). Additionally, evapotranspiration data is useful to calculate the amount of irrigation water to replenish your soil and avoid waste.
- Know sprinkler head precipitation rates and spacing (Use performance data from manufacturer and Perform water audit (catch-can test))
- Monitor depth of rootzone and recognize seasonal variations
- Be aware of soil types and their infiltration rates
- Understand microclimates (tree competition, wind, humidity, etc.)
- Recognize topographic challenges
- Consider the impact of other water inputs (daytime hand-watering, watering-in of fertilizer and topdressing, etc.)
- Utilize “cycle and soak” programming features where water requirements exceed infiltration rates

Establishing irrigation cycle timing

- Determine length of entire cycle (depends on application rates and system capacity)
- Customer considerations (drift onto entry walks and driveways, and gathering places; driving range clean-up, etc.)
- Play considerations (tee times, tournaments, outings, etc.)
- Consider the impact on other maintenance practices (morning mowing, cultivation, spraying, etc.)
- Identify time of day with least wind movement
- Coordinate with time of “off-peak demand” electricity rates
- Recognize that duration of leaf wetness may affect disease development

Special concerns of putting greens

- Surface firmness which may impact ball roll

- Root length
- Poa annua control or management
- flushing a perched water table
- localized dry spot
- moss/algae development
- Daytime/manual hand watering and syringing

Special watering needs

- leaching salts from the root zone
- settling granular fertilizer applications and topdressing
- moving chemicals into the proper zone (depth) for efficacy
- application of bio-controls (e.g. Bioject)
- application of wetting agents, fertigation

Disease management

Research has concluded that irrigating soon after sunset retains moisture in the soil for a longer period of time since evapotranspiration is either not taking place or is minimized when the sun is not driving photosynthesis. This is important because research also indicates dry soil conditions result in increased disease growth. Adequate, not drenched, soil moisture enhances bacterial populations that may enhance nutrient uptake by the turfgrass and may also antagonize or out compete fungal pathogens for food.

Resource Protection

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

Regulatory Considerations

Principles

- Golf course owners are responsible for contacting federal, Michigan, and local water use authorities at the pre-and post-construction phase to determine annual or specific water consumption (water rights), permitting guidelines, and other requirements allowed by regulators.
- Superintendents have a responsibility to adhere to water-quality standard rules regarding groundwater and surface water flows resulting from the removal of water for irrigation use.

Best Management Practices

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

- Develop an annual water budget for the golf course.
- Look for ways to increase efficiency and reduce energy use associated with irrigation systems and practices.
- Demonstrate good stewardship practices by supplementing watering only for the establishment of new planting and new sod, hand watering of critical hot spots, and watering-in of chemicals and fertilizers (if permissible).
- Protect aquatic life and impairment of water systems by adhering to state and local water withdrawal allocations (gallons/day).
- Design an irrigation system that delivers water with maximum efficiency.

Irrigation Water Suitability

Principles

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

Best Management Practices

- Use alternative water supplies/sources that are appropriate and sufficiently available to supplement water needs.
- Use salt-tolerant varieties of turf and plants to mitigate saline conditions resulting from an alternative water supply or source, if necessary.
- Amend sodic water systems appropriately (with gypsum or an appropriate ion) to minimize sodium buildup in soil.
- Flush with freshwater or use amending materials regularly to move salts out of the root zone and/or pump brackish water to keep salts moving out of the root zone.
- Monitor sodium and bicarbonate buildup in the soil using salinity sensors.
- Routinely monitor shallow groundwater table of freshwater for saltwater intrusion or contamination of heavy metals and nutrients.
- Monitor the quantity of water withdrawn to avoid aquatic life impairment.
- Identify appropriate water supply sources that meet seasonal and bulk water allocations for grow-in and routine maintenance needs.

Water Conservation and Efficient Use Planning

Principles

- Document actual watering practices, especially to show savings in water use over averages. Communication should be maintained with water managers, golf course members, and the public to explain what you are doing and why.
- Potable water supplies in many areas of the United States are limited, and demand continues to grow. Our challenge is to find solutions to maintain the quality of golf while using less water.
- BMP and educational programs are necessary to change the public's mind-set toward the inevitable changes in water-related issues.
- Some courses are being designed using a "target golf" concept that minimizes the acreage of irrigated turf. Existing golf courses can make an effort to convert out-of-play areas turf to naturally adapted native plants, grasses, or ground covers to reduce water use and augment the site's aesthetic appeal.

Best Management Practices

- Selecting drought-tolerant varieties of turfgrasses can help maintain an attractive and high-quality playing surface, while minimizing water use.
- Non-play areas may be planted with drought-resistant native or other well-adapted, noninvasive plants that provide an attractive and low-maintenance landscape.
- Native plant species are important in providing wildlife with habitat and food sources. After establishment, site-appropriate plants normally require little to no irrigation.
- The system should be operated to provide only the water that is actually needed by the plants, or to meet occasional special needs such as salt removal.
- If properly designed, rain and runoff captured in water hazards and stormwater ponds may provide supplemental water under normal conditions, though backup sources may be needed during severe drought.
- During a drought, closely monitor soil moisture levels. Whenever practicable, irrigate at times when the least amount of evaporative loss will occur.
- Control invasive plants or plants that use excessive water.

Irrigation System Design

Principles

- An efficient irrigation system maximizes water use, reduces operational cost, and conserves and protects water resources while maximizing playing conditions.

Best Management Practices

- Design should account for optimal distribution efficiency and effective root-zone moisture coverage. Target 80% or better Distribution Uniformity (DU).
- Design should allow the putting surface and slopes and surrounds to be watered independently.
- Recommendations should be based off local knowledge of soil and growing conditions - university extensions are most often the best point of reference here.
- Instructions on modifying is most often best covered by the manufacturer/distributor on how to best use the product. This alludes to the use of a central control system but does

not specifically point out that the use of a central control system can greatly increase your irrigation efficiency by reducing your water window by as much as 30-40%.

- The application rate must not exceed the infiltration rate. To avoid this saturated hydraulic conductivity tests should be performed periodically.
- The design operating pressure must not be greater than the available source pressure.
- The design operating pressure must account for peak-use times and supply line pressures at final buildout for the entire system.
- The system should be flexible enough to meet a site's peak water requirements and allow for operating modifications to meet seasonal irrigation changes or local restrictions.
- Turf and landscape areas should be zoned separately. Specific use areas zoned separately; greens, tees, primary roughs, secondary roughs, fairways, native, trees, shrubs, etc.
- Only qualified specialists should install the irrigation system.
- Construction must be consistent with the design.
- The designer must approve any design changes before construction.
- Construction and materials must meet existing standards and criteria.
- Prior to construction, all underground cables, pipes, and other obstacles must be identified and their locations flagged.
- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Space should be based on average wind conditions during irrigation.
- For variable wind directions, triangular spacing is more uniform than square spacing.
- Distribution devices and pipe sizes should be designed for optimal uniform coverage.
- The first and last distribution device should have no more than a 10% difference in flow rate. This usually corresponds to about a 20% difference in pressure.
- Distribution equipment (such as sprinklers, rotors, and micro-irrigation devices) in a given zone must have the same precipitation rate.
- Heads for turf areas should be spaced for head-to-head coverage.
- Water supply systems (for example, wells, and pipelines) should be designed for varying control devices, rain shutoff devices, and backflow prevention.
- Water conveyance systems should be designed with thrust blocks and air-release valves.
- Velocity must be within 5 feet per second.
- Pipelines should be designed and heads spaced to provide the system with the appropriate pressure required for maximum irrigation uniformity.
- Pressure-regulating or compensating equipment must be used where the system pressure exceeds the manufacturer's recommendations.
- Equipment with check valves must be used in low areas to prevent low head drainage.
- Isolation valves should be installed in a manner that allows critical areas to remain functional.
- Manual quick-coupler valves should be installed near greens, tees, and bunkers so these can be hand-watered during severe droughts.
- Part circle heads should be placed along lakes, ponds, wetlands, and native (no mow) areas to prevent waste of irrigation water and maintain environmental stewardship. Use part-circle or adjustable heads to avoid overspray of impervious areas such as roadways and sidewalks.

- Update multi-row sprinklers with individual head control to conserve water and enhance efficiency.
- Install part-circle heads along lakes, ponds, and wetlands margins.
- Use part-circle or adjustable heads to avoid overspray of impervious areas such as roadways and sidewalks.
- Update multi-row sprinklers with individual head control to conserve water and to enhance efficiency.
- Incorporate multiple nozzle configurations to add flexibility and enhance efficiency/distribution.
- Ensure heads are set level and plumb with the ground and avoid installing on sloped areas whenever possible. Moving a head 4-5 feet to get to level ground is preferred to installing on sloped areas.
- Irrigation systems should be constructed with HDPE pipe or a hybrid of PVC mainlines and HDPE lateral lines.

Irrigation Pumping System

Principles

- Pump stations should be sized to provide adequate flow and pressure. They should be equipped with control systems that protect distribution piping, provide for emergency shutdown necessitated by line breaks, and allow maximum system scheduling flexibility.
- Variable frequency drive (VFD) pumping systems should be used to help minimize pressure surges throughout the piping network and reduce the overall electrical use of the pumping system.
- Design pumping systems for energy conservation.

Best Management Practices

- The design operating pressure must not be greater than the available source pressure.
- The design operating pressure must account for peak-use times and supply-line pressures at final build-out for the entire system.
- Maintain the air-relief and vacuum-breaker valves by using hydraulic-pressure-sustaining values.
- Install VFD pumping system to minimize pressure surges throughout the piping network.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Pumps should be sized to provide adequate flow and pressure.
- Pumps should be equipped with control systems to protect distribution piping.
- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer’s recommendations.
- Monitor pumping station power consumption.
- Monthly bills should be monitored over time to detect a possible increase in power usage.
- Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system.

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

Irrigation System Program and Scheduling

Principles

- Irrigation scheduling must take plant water requirements and soil intake capacity into account to prevent leaching and runoff.
- Plant water needs should be estimated with soil moisture meters and/or evapotranspiration (ET) rates.
- Responsible irrigation management conserves water, reduces nutrient and pesticide movement.
- Time-clock-controlled irrigation systems preceded computer-controlled systems, and many are still in use today. Electric/mechanical time clocks cannot automatically adjust for changing ET rates. Frequent adjustment is necessary to compensate for the needs of individual turfgrass areas.
- Frequent adjustment is necessary to compensate for the needs of individual turfgrass areas.
- Syringing should be performed with the aid of a soil moisture meter to minimize overwatering and runoff and maximize playing conditions.

Best Management Practices

- The reliability of older clock-control station timing depends on the calibration of the timing devices; this should be done periodically, but at least seasonally.
- An irrigation system should have rain sensors to shut off the system after 0.25 to 0.5 inch of rain is received. Computerized systems allow a superintendent to call in and cancel the program if it is determined that the course has received adequate rainfall.
- Install control devices to allow for maximum system scheduling flexibility.
- Generally, granular fertilizer applications should receive 0.25 inch of irrigation to move the particles off the leaves while minimizing runoff.
- Irrigation quantities should not exceed the available moisture storage in the root zone.
- Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied at any one time.
- Irrigation schedule should coincide with other cultural practices (for example, the application of nutrients, herbicides, or other chemicals).
- Account for nutrients in effluent supply when making fertilizer calculations.
- Research results have shown that irrigation daily in the late night reduces disease compared to irrigating with the same amount of water in the early morning hours. Deep infrequent irrigation has led to more irrigation water used and an increase in turfgrass disease such as dollar spot.
- When irrigating with ET as a guide it is imperative that knowledge of the soil texture be taken into consideration. Example: irrigating to an ET of 60% daily on a fine textured soil (predominantly clay) could be sufficient but on a predominantly sand textured soil would most likely be insufficient in the summer heat.

- Use mowing, verticutting, aeration, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.
- Avoid use of a global setting; make adjustments to watering times per head.
- Base water times on actual site conditions for each head and zone.
- Adjust irrigation run times based on current local meteorological data.
- Define specific locations throughout the course that can be used as a baseline for making irrigation management decisions in which to place permanent or portable moisture sensors in the root zone.
- Map locations of permanently buried sensors so they can be easily located and removed for repair or when aerifying to prevent damage.
- Periodically perform catch-can uniformity tests.
- Install emergency shutdown devices to address line breaks.

Turf Drought Response

Principles

- The presence of visual symptoms of moisture stress is a simple way to determine when irrigation is needed.
- Use a soil moisture meter to determine moisture needs of greens and tees.
- Managers of golf greens cannot afford to wait until symptoms occur, because unacceptable turf quality may result.
- Be prepared for extended drought/restrictions by developing a written drought management plan.

Best Management Practices

- Waiting until visual symptoms appear before irrigating is a method best used for low-maintenance areas, such as golf course roughs and, possibly, fairways.
- Use soil moisture meters to determine moisture thresholds and plant needs.
- Data suggests that nightly light frequent irrigation within the depth of the rootzone minimizes certain diseases, saves water, minimizes off target nutrient movement, and leads to improved turfgrass quality.
- For golf greens and tees, the majority of roots are in the top several inches of soil.
- Proper cultural practices such as mowing height, irrigation frequency, and irrigation amounts should be employed to promote healthy, deep root development and reduce irrigation requirements.
- Create a drought management plan for the facility that identifies steps to be taken to reduce irrigation/water use and protects critical areas, etc.
- Use appropriate turfgrass species adapted to the location of the golf course being managed.

Irrigation System Quality

Principles

- Irrigation system maintenance on a golf course involves four major efforts: calibration or auditing, preventive maintenance (PM), corrective maintenance, and record keeping.
- Personnel charged with maintaining any golf course irrigation system face numerous challenges. This is particularly true for courses with older or outdated equipment.
- Good system management starts with good preventive maintenance (PM) procedures and recordkeeping. Maintaining a system is more than just fixing heads.
- Corrective maintenance is simply the act of fixing what is broken. It may be as simple as cleaning a clogged orifice, or as complex as a complete renovation of the irrigation system.
- As maintenance costs increase, the question of whether to renovate arises. Renovating a golf course irrigation system can improve system efficiencies, lower operating costs, maximize playability, and conserve water.

Best Management Practices

- Respond to day-to-day failures in a timely manner, maintain the integrity of the system as designed, and keep good records.
- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.
- The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made.
- Systems need to be observed in operation at least weekly. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation. This process detects controller or communications failures, stuck or misaligned heads, and clogged or broken nozzles.
- Check filter operations frequently. An unusual increase in the amount of debris may indicate problems with the water source.
- Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually for worn components.
- Conduct a periodic professional irrigation audit.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Gather together all of the documentation collected as part of the PM program, along with corrective maintenance records for analysis.
- Correctly identifying problems and their costs helps to determine what renovations are appropriate.
- Collecting information on the cost of maintaining the system as part of system overall evaluation, allows for planning necessary upgrades, replacement etc. and to compare after changes are made.
- Use rain sensors to shut-off aeration equipment during rain events.

Pond Location and Design

Principles

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

Best Management Practices

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

Pond Use and Maintenance

Principles

- Successful pond management should include a clear statement of goals and priorities to guide the development of the BMP necessary to meet those goals. Some of the challenges facing superintendents in maintaining the quality of golf course ponds are as follows:
    - Low DO
    - Sedimentation
    - Changes in plant populations

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

Best Management Practices

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

Pond Water-Level Monitor

Principle

Evaporation losses are higher in some regions than others and vary from year to year and within the year. However, evaporative losses could approach 6 inches per month during the summer. Aquatic plants are more difficult to control in shallow water.

Best Management Practices

- A pond should hold surplus storage of at least 10 percent of full storage.
- Provide an alternative source for ponds that may require supplemental recharge from another water source such as a well during high-demand periods.

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

Metering

Principles

- Rainfall may vary from location to location on a course; the proper use of rain gauges, rain shut-off devices, flow meters, soil moisture sensors, and/or other irrigation management devices should be incorporated into the site's irrigation schedule.
- It is also important to measure the amount of water that is actually delivered through the irrigation system, via a water meter or a calibrated flow-measurement device.
- Knowing the flow or volume will help determine how well the irrigation system and irrigation schedule are working.

Best Management Practices

- Calibrate equipment periodically to compensate for wear in pumps, nozzles, and metering systems.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Flow meters should have a run of pipe that is straight enough — both downstream and upstream — to prevent turbulence and bad readings.
- Flow meters can be used to determine how much water is applied.

Irrigation Leak Detection

Principle

- Irrigation systems are complex systems that should be closely monitored to ensure leaks are quickly detected and corrected.
- Golf courses without hydraulic pressure-sustaining valves are much more prone to irrigation pipe and fitting breaks because of surges in the system, creating more downtime for older systems. A good preventive maintenance program is very important.

Best Management Practices

- Monitor water meters or other measuring devices for unusually high or low readings to detect possible leaks or other problems in the system. Make any needed repairs.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- The system should be monitored daily for malfunctions and breaks. It is also a good practice to log the amount of water pumped each day.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, determine why these failures are occurring. Pipe failures may be caused not only by material failure, but also by problems with the pump station.

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

Sprinkler Maintenance

Principles

- Good system management starts with good preventive maintenance (PM) procedures and record keeping. This can be done during maintenance programs such as fertilizer or chemical applications where irrigation is required, or the heads can be brought on-line for a few seconds and observed for proper operation.
- Maintaining a system is more than just fixing heads. It also includes documenting system- and maintenance-related details so that potential problems can be addressed before expensive repairs are needed. It also provides a basis for evaluating renovation or replacement options.
- Be proactive; if the system requires frequent repairs, it is necessary to determine why these failures are occurring.
    - Pipe failures may be caused not only by material failure, but also by problems with the pump station.
    - Wiring problems could be caused by corrosion, rodent damage, or frequent lightning or power surges.
    - Control tubing problems could result from poor filtration.

Best Management Practices

- System checks and routine maintenance on pumps, valves, programs, fittings, and sprinklers should follow the manufacturer's recommendations.
- The system should be inspected routinely for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads.
- A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots, so that adjustments can be made or replaced.
- Flush irrigation lines regularly to minimize emitter clogging. To reduce sediment buildup, make flushing part of a regular maintenance schedule. If fertigating, prevent microbial growth by flushing all fertilizer from the lateral lines before shutting down the irrigation system.
- Clean and maintain filtration equipment.
- Systems must be observed in operation at least weekly. This process detects controller or communication failures, stuck or misaligned heads, and clogged or broken nozzles.
- Check filter operations frequently. An unusual increase in the amount of debris may indicate problems with the water source.
- Even under routine conditions, keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually. Conduct a periodic professional irrigation audit at least once every five years. Implement a PM program to replace worn components before they waste fertilizer, chemicals, and water.
- Document equipment run-time hours.

- Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor pump station power consumption. Monthly bills should be monitored over time to detect a possible increase in power usage. Compare the power used with the amount of water pumped. Requiring more power to pump the same amount of water may indicate a problem with the pump motor(s), control valves, or distribution system. Quarterly checks of amperage by qualified pump personnel may more accurately indicate increased power usage and thus potential problems.
- Monitor and record the amount of water being applied, including system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance. Not only is this information essential in identifying places that would benefit from a renovation, but it is also needed to compute current operating costs and compare possible future costs after a renovation.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings).

System Maintenance

Principles

- Course owners/superintendents do routine maintenance to ensure water quality and responsible use of the water supply.
- System checks and routine maintenance include: pumps, valves, programs, fittings, and sprinklers.
- To ensure that it is performing as intended, an irrigation system should be calibrated regularly by conducting periodic irrigation audits to check actual water delivery and nozzle efficiency.

Best Management Practices

- Irrigation audits should be performed by trained technicians.
- A visual inspection should first be conducted to identify necessary repairs or corrective actions. It is essential to make repairs before carrying out other levels of evaluation.
- Pressure and flow should be evaluated to determine that the correct nozzles are being used and that the heads are performing according to the manufacturer's specifications.
- Pressure and flow rates should be checked at each head to determine the average application rate in an area.
- Catch-can tests should be run to determine the uniformity of coverage and to accurately determine irrigation run times.
- Catch-can testing should be conducted on the entire golf course to ensure that the system is operating at its highest efficiency.
- Conduct an irrigation audit annually to facilitate a high-quality maintenance and scheduling program for the irrigation system.
- Inspect for interference with water distribution.
- Inspect for broken and misaligned heads.
- Check that the rain sensor is present and functioning.
- Inspect the backflow device to determine that it is in place and in good repair.

- Examine turf quality and plant health for indications of irrigation malfunction or needs for scheduling adjustments.
- Schedule documentation; make adjustments and repairs on items diagnosed during the visual inspection before conducting pressure and flow procedures.

Preventive Maintenance

- In older systems, inspect irrigation pipe and look for fitting breaks caused by surges in the system.
- Install thrust blocks to support conveyances.
- The system should be inspected daily for proper operation by checking computer logs and visually inspecting the pump station, remote controllers, and irrigation heads. A visual inspection should be carried out for leaks, misaligned or inoperable heads, and chronic wet or dry spots so that adjustments can be made.
- Maintain air-relief and vacuum-breaker valves.
- Systems need to be observed in operation at least weekly to detect controller or communication failures, stuck or misaligned heads, and clogged or broken nozzles.
- Check filter operations frequently; keeping filters operating properly prolongs the life of an existing system and reduces pumping costs.
- Keep records of filter changes, as this could be an early sign of system corrosion, well problems, or declining irrigation water quality.
- Application/distribution efficiencies should be checked annually.
- Conduct a periodic professional irrigation audit at least once every five years.
- Document equipment run-time hours. Ensure that all lubrication, overhauls, and other preventive maintenance are completed according to the manufacturer's schedule.
- Monitor the power consumption of pump stations for problems with the pump motors, control valves, or distribution system.
- Qualified pump personnel should perform quarterly checks of amperage to accurately identify increased power usage that indicates potential problems.
- Monitor and record the amount of water being applied, including system usage and rainfall. By tracking this information, you can identify areas where minor adjustments can improve performance.
- Document and periodically review the condition of infrastructure (such as pipes, wires, and fittings). If the system requires frequent repairs, it is necessary to determine why these failures are occurring.
- Increase frequency of routine inspection/calibration of soil moisture sensors that may be operating in high-salinity soils.
- Winterize irrigation system to prevent damage.

Corrective Maintenance

- Replace or repair all broken or worn components before the next scheduled irrigation.
- Replacement parts should have the same characteristics as the original components.
- Record keeping is an essential practice; document all corrective actions.

System Renovation

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

Winterization and Spring

Principle

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

Best Management Practices

- Conduct a visual inspection of the irrigation system: inspect for mainline breaks, low pressure at the pump, and head-to-head spacing.
- Conduct a catch-can test to audit the system.
- Flush and drain above-ground irrigation system components that could hold water.
- Remove water from all conveyances and supply and distribution devices that may freeze with compressed air or open drain plugs at the lowest point on the system.
- Clean filters, screens, and housing; remove drain plug and empty water out of the system.
- Secure systems and close and lock covers/compartment doors to protect the system from potential acts of vandalism and from animals seeking refuge.
- Remove drain plug and drain above-ground pump casings.
- Record metering data before closing the system.
- Secure or lock irrigation components and electrical boxes.
- Perform pump and engine servicing/repair before winterizing.
- Recharge irrigation in the spring with water and inspect for corrective maintenance issues.
- Ensure proper irrigation system drainage design.

Sensor Technology

Principles

- To prevent excess water use, irrigation scheduling should take into account plant water requirements, recent rainfall, recent temperature extremes, and soil characteristics.
- Irrigation management and control devices need to be installed correctly for proper irrigation management.

- Soil moisture sensors and other irrigation management tools should be installed in representative locations and maintained to provide the information necessary for making good irrigation management decisions.
- Rain gauges are necessary measurement tools to track how much rain has fallen at a specific site on the golf course. On some courses, more than one station may be necessary to get a complete measure of rainfall or evaporation loss. The use of soil moisture probes and inspections for visual symptoms such as wilting turf may supplement these measurements. Computerized displays are available to help visualize the system.
- Predictive models based on weather station data and soil types are also available. These are relatively accurate and applicable, especially as long-term predictors of annual turf water requirements.
- Weather data such as rainfall, air and soil temperature, relative humidity, and wind speed are incorporated into certain model formulas, and soil moisture content is estimated. Models, however, are only as effective as the amount of data collected and the number of assumptions made.
- It is best to have an on-site weather station to daily access weather information and ET to determine site specific water needs.

Best Management Practices

- Irrigation controllers/timers should be reset as often as practically possible to account for plant growth requirements and local climatic conditions.
- Properly calibrated flow meters, soil moisture sensors, rain shut-off devices, and/or other automated methods should be used to manage irrigation.
- Irrigation rates should not exceed the maximum ability of the soil to absorb and hold the water applied in any one application.
- Irrigation should not occur on a calendar-based schedule, but should be based on ET rates and soil moisture replacement.
- Computerized control systems should be installed on all new course irrigation systems to help ensure efficient irrigation application. These allow for timing adjustments at every head.
- Rain shut-off devices and rain gauges should be placed in open areas to prevent erroneous readings.
- Use multiple soil moisture sensors/meters for accuracy and to reflect soil moisture levels.

Maintained Turf Areas

Principle

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

Best Management Practices

- The irrigation system should be designed and installed so that the putting surface, slopes, and surrounding areas can be watered independently.
- Install part-circle heads that conserve water and reduce unnecessary stress to greens and surrounds.
- Avoid use of a global setting; make adjustments to watering times per head.
- Base water times on actual site conditions for each head and zone.
- Adjust irrigation run times based on current local meteorological data.
- Install rain switches to shut down the irrigation system if enough rain falls in a zone.
- Use soil moisture sensors to bypass preset or to create on-demand irrigation schedules.
- Permanent irrigation sprinklers and other distribution devices should be spaced according to the manufacturer's recommendations.
- Spacing should be based on average wind conditions during irrigation.
- Triangular spacing is more uniform than square spacing.
- Periodically perform catch-can uniformity tests.
- Reducing dry spots and soil compaction improves water infiltration, which in turn reduces water use and runoff in other areas.
- Research indicates that daily late-night irrigation reduces disease compared with irrigation in the early morning hours and both result in significantly less disease compared to deep infrequent irrigation.
- Use mowing, verticutting, aeriation, wetting agents, nutrition, and other cultural practices to control water loss and to encourage conservation and efficiency.
- Depending on physical soil characteristics and turf type, using solid-tine aeration equipment in place of verticutting is an option.
- Slicing and spiking help relieve surface compaction and promote better water penetration and aeration.
- Visually monitor for localized dry conditions or hot spots to identify poor irrigation efficiency or a failed system device.
- Use predictive models to estimate soil moisture and the best time to irrigate.
- Install in-ground (wireless) soil moisture sensors or use hand-held moisture meters in the root zone for each irrigation zone to enhance scheduled timer-based run times.
- An irrigation system should also have high- and low-pressure sensors that shut down the system in case of breaks and malfunctions.
- Place soil moisture sensors in a representative location of the irrigation zone.
- Install soil moisture sensors in the driest irrigation zone of the irrigation system.
- Wireless soil moisture systems should be installed to prevent damage from aeration.

Non-Play and Landscape Areas

Principles

- Map any environmentally sensitive areas such as sinkholes, wetlands, or flood-prone areas, and identify species classified as endangered or threatened by federal and state governments, and state species of special concern.
- Natural vegetation should be retained and enhanced for non-play areas to conserve water.
- The most efficient and effective watering method for non-turf landscape is micro-irrigation.

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

Best Management Practices

- Designate 50% to 70% of the non-play area to remain in natural cover according to “right-plant, right-place,” a principle of plant selection that favors limited supplemental irrigation and on-site cultural practices.
- Incorporate natural vegetation in non-play areas.
- Use micro-irrigation and low-pressure emitters in non-play areas to supplement irrigation.
- Routinely inspect non-play irrigation systems for problems related to emitter clogging, filter defects, and overall system functionality.

Wellhead Protection

Introduction

Clean drinking water is vital to residents, businesses and industries throughout Michigan. Approximately one half of Michigan's residents depend on groundwater for drinking water purposes. When water wells are improperly constructed or maintained, or if the land surrounding the well is not properly managed, pathogens, pesticides, fertilizers, oil products or other contaminants may impact the groundwater that serves your home or business.

Businesses within the turfgrass industry use different types of wells depending on the amount of water needed and the characteristics of the local geology. To properly protect all wells on the property, it is important to identify the type of well you are using according to guidelines created by the Michigan Safe Drinking Water Act, Act 399, P.A. 1976, as amended. To assist with the identification, a description of each well type is listed below including a reference to its location in Act 399. Also included in this module is information on the well construction and pump installation requirements that are specified in Part 127 of the Groundwater Quality Control Act 368.

Types of Water Supplies

Most wells that supply water to turfgrass-related businesses will be considered a public water supply, which is defined as any water supply serving drinking water to other than a single-family residence. *Act 399, Rule 107*

Public water supplies are classified as Type I, II, or III.

Type I or Community Water Supply

Provides year-round water service to 25 or more residents, or 15 or more living units. A permit for construction is required from the District Engineer at the Michigan Department of Environmental Quality's. Examples of Type I, Community Water Supplies are: cities, villages, townships, condominiums, apartment complexes, mobile home parks. *Rule 103 and Rule 502*

Type II or Non-Community Water Supply

"Non-community supply" means a public water supply which is not a community supply, but which has at least 15 service connections (a direct connection from a water line to a facility for providing water for drinking or household purposes) or which serves 25 or more persons on an average daily basis for at least 60 days of the year. A permit for construction is required from the local health department. Examples of Type II, Non-community water supplies include schools, restaurants, offices, churches and golf courses. *Rule 106, Rule 502*

If your well is Type II, identify whether it is IIa or IIb according to the amount of water produced.

Type IIa Average daily water production for the maximum month greater than or equal to 20,000 gallons per day. Examples are large seasonal resorts (such as those with golf courses) and industries.

Type IIb: All other Type II supplies. Average daily water production for the maximum month is less than 20,000 gallons per day. Examples are food service establishments, campgrounds and many golf courses

Type II wells are further classified as either transient or non-transient depending on whether or not the same people are served regularly by the well.

Type II non-transient: Water supplies routinely serve the same 25 or more people on a daily basis at least six months per year. Examples are schools, daycare centers, offices and other work sites.

Type II transient: Water supplies serve 25 or more different people any 60 days per year. Examples include golf courses, motels/restaurants, churches, and parks. (Transient means a non-community supply that does not meet the definition of non-transient non-community water supply). *Rule 106*

Type III Water Supply

All public water supplies that are not Type I or Type II. The local health department requires a permit for these wells under the sanitary code. Examples include small businesses (lawn care companies with less than 25 employees that are not served by municipal water systems), gas stations and Grade A dairies. *Rule 502*

Irrigation Wells

These wells have no potable (drinkable) water connections: Must be properly constructed in accordance with Part 127 of Act 368. Most local health departments require a permit prior to construction. As with all other wells, irrigation wells should be properly maintained and permanently plugged when no longer in use, to protect groundwater.

Installing New Wells

Your first contact before beginning plans for a new Type I community well, should be the district staff from the Department of Environment Great Lakes and Energy (EGLE) (see the EGLE website for district contacts). District staff will discuss the requirements for a Type I community water supply, inspect and approve all proposed test well locations so that you will meet the set back and monitoring requirements and will issue the production well permit(s).

If you are installing a Type II, non-community well, your first contact should be your local health department (see the EGLE Drinking Water and Environmental Health Division website). The local health department is responsible for issuance of permits for construction of new Type II wells, periodic inspections of the water well and distribution system, and management of required water sampling to monitor water quality. Well owners are required to conduct sampling at prescribed frequencies. Sampling frequency will vary depending upon a number of items examined during the initial site inspection. If sampling identifies a problem, the owner must advise the public and correct the problem.

If you are installing a Type III well, a permit is required from the local health department. Type III wells have to be properly constructed but a specific sampling or inspection program is the

prerogative of the local health department. A listing of local health departments can be found at the website listed above.

A brief summary of selected public water supply rules provided by the DEQ is listed below. Refer to the State of Michigan Safe Drinking Water Act 399 and Part 127 of the Groundwater Quality Control Act 368 for the complete requirements. All deviations from the requirements must be approved by the DEQ or the local health department in writing and must be based on information showing that public health will not be adversely affected or threatened.

Isolation Distances

Well Types I and IIa

These wells cannot be located within 2,000 feet of known major sources of contamination such as: a sanitary landfill, lagoons, chemical or waste chemical storage or disposal areas (fuels, oils, degreasers, fertilizers, pesticides, etc.) unless a written deviation is issued. The standard isolation area of 200 feet must be owned or controlled by Type I water supplies and should not contain sewer lines or septic systems. Type II systems are not required to own or control the 200-foot isolation area.

Well Types IIb and III

The 800-foot isolation area from major contamination sources should not contain lagoons, landfills, groundwater contamination sites or chemical storage. The standard isolation area of 75 feet should not contain sewer lines or septic systems. These distances may not be decreased unless the local health department has approved a written deviation.

The following table indicates specific isolation requirement minimums from various land uses and sources of contamination as required by the Michigan Safe Drinking Water Act, *Act 399, R 325*. The DEQ or local health departments have authority to issue deviations from the required distances on a case by case basis and will consider items such as the well capacity, the hydrogeologic conditions, and the type, volume and containment of the contaminant within the isolation area before making a decision.

Review the following isolation distances and consider whether or not your well(s) meet the minimum requirements and if they are up or down slope from the sources of contamination regardless of the isolation distance.

Required Minimum Isolation Distances

Land Use or Source of Contamination Minimum Isolation Distance (feet):

	Types IIb, III	Types I, IIa
Abandoned well or boring (has not been sealed)	75	75
Agricultural chemical/fertilizer storage or preparation area	800	2,000

Animal/poultry yard	75	200
Brine wells/injection wells	**800	**2,000
Building or projection	3	3
Cemetery or graves	75	200
Cesspool	75	200
Chemical storage	800	2,000
Known Contaminant plumes (Part 201 of Act 451sites, LUST sites, etc.)	**800	**2,000
Drainfield	75	200
Drywell	75	200
Footing drains	10	10
Fuel/chemical storage tanks (above or below ground and associated piping)	800	2,000
Fuel depot/tank farm	800	2,000
Grease trap	75	200
Kennels	75	200
Landfill or dump site (active or inactive)	800	2,000
Liquid petroleum (LP) tanks	see comments following table	see comments following table
Liquid waste draining into the soil	75	200
Metering station for pipelines	300	800
Municipal wastewater effluent or sludge disposal area	800	2,000
Oil or gas wells	300	300
Other wastewater handling or disposal unit	75	200
Petroleum product processing or bulk storage	800	2,000
Pipelines - gas, oil, etc.	300	300
Pipelines - natural gas	see comments following table	see comments following table
Privy or outhouse	75	200
Property lines (no requirements)	10 recommended	10 recommended
Seepage pit	75	200

Septic tank	75	200
Septage waste (land application area)	800	2,000
Sewage holding tank	75	200
Sewage lagoon serving a single family dwelling	75	200
Sewage lagoon effluent land application area	800	2,000
Sewage or liquid waste draining into soil	75	200
Sewage pump chamber transfer station, or lift station	75	200
Sewers - gravity, pressure, sanitary or storm	75	200
Sewer line isolation from water line (plumbing code requirement)	10	10
Sump pit - receiving other than household waste (roof drain, etc.)	10	10
Sump pit - receiving household waste (laundry, softener backwash, etc.)	75	200
Surface water (lakes, streams, ditches)	75	200
Unfilled space below surface - other than approved basement, basement offset, or crawl space beneath as single family dwelling	10	10
Well to well isolation (no requirement)	10 recommended	10 recommended

** These sources of contamination are not specifically named in the rules and the stated isolation distances are recommendations. State or local health department officers may modify this recommended isolation distance, either increasing or decreasing it, on a case-by-case basis.

Additional Specifications

Natural gas and liquid petroleum (LP)

Natural gas and LP are not considered sources of groundwater contamination because of the volatile nature of the fuels. If leaks occur, the gases escape into the atmosphere. Leaked gases do not migrate downward into the soil. Wells should be sufficiently isolated from natural gas lines or LP tanks to minimize the potential for damage to the lines or tanks during well construction or repair, trenching of water lines, etc., and to allow accessibility to the well.

Well Casing termination

For Type I and IIa, the well casing must be a minimum of 12 inches above the ground surface. For Type IIb and III, the well casing must also be12 inches above grade or 12 inches above the floor of approved basement offset (Rule 817).

Pumping equipment

Type I and IIa must have an above-grade structure housing pump control equipment, a flow meter, pump to waste piping and isolation valves, and associated appurtenances (chemical injection tap, energized outlet and sampling taps). For Type IIb and III, the pumping equipment may be in an approved basement offset. Pits of any design are no longer approved (Ground Water Quality Control Act, Part 127).

Grouting

When installing a new well, a steel or plastic pipe called the casing is used to prevent the borehole from collapsing during drilling. The space between the casing and the sides of the hole creates a direct opening for surface water and potential pollutants to reach the water table. To seal off that opening, the space is filled with grout. Grout consists of neat cement (cement & water mixture without sand), bentonite clay or a combination of the two. Well grouting must be within permit specifications and meet the Michigan Water Well Construction and Pump Installation Code. Details of this code are found in Part 127 of the Groundwater Quality Control Act 368 which provides the specific requirements well drillers must follow when installing your well.

Location

Whether a well taps water just below the ground or hundreds of feet deep, its location greatly influences its susceptibility to contamination. A proper location for a well depends on factors such as surface water drainage patterns, groundwater flow direction and the location of sources of potential contamination. A well downhill from a pesticide mix/load area, a leaking tank or a septic system runs a greater risk of contamination than a well on the uphill side of these potential pollution sources.

Once you've determined the surface water drainage patterns on your property, you can examine where chemicals are stored or handled to decide if they should be moved to protect your well(s). Relocating hazardous materials down gradient from your well may be a simple solution to protect your drinking water supply.

The slope of the ground surface does not always indicate the direction a contaminant might flow once it gets into the groundwater. In most cases, groundwater in unconfined, shallow aquifers flows in the same direction as the slope of the land, generally towards a surface water body. In areas where the aquifer is deep or confined, its flow direction may be different from that of the land surface. Determining groundwater flow direction on your property may require the collection of surveyed water level measurements from wells on and around your property.

Once the groundwater flow direction is determined for your property, you have a valuable piece of information to help guide your decisions on where to locate new wells or hazardous materials to minimize the potential for impacts to the groundwater in the event of an accident.

Maintaining Existing Wells

Well inspection and maintenance

Like all mechanical equipment, your well requires periodic upkeep. Good maintenance involves keeping the well area clean and accessible, storing or handling potential contaminants down gradient or as far away from the well as possible, testing the water according to the schedule established by the county health department or EGLE district staff and periodically inspecting the condition of the well and pump. A qualified well driller or pump installer can inspect the well integrity and pump components. You can also routinely inspect the wellhead for any damage. Be sure your well has a physical barrier such as bumper posts to prevent collision from trucks, lawnmowers and other equipment. Also check that the well cap is in place, tightly secured and locked if possible. Wells must have a tight fitting well cap with a screened vent incorporated into it so that air can enter the well.

Consider the location of your well and how many years ago it was installed. If it was installed according to regulations at the time of construction, you should compare how your well conforms to current standards. You may be able to move activities such as pesticide mixing, tank rinsing, or fuel storage farther away from your well or down gradient. You may also want to improve existing wells by getting rid of well pits, installing caps, or extending casings.

Backflow prevention

Backpressure or back-siphoning backflow from pesticide mixing tanks can cause chemicals to flow back into the well through the hose. Use an anti-backflow device when filling pesticide sprayer tanks to prevent the chemical mixture from flowing back into the well and contaminating groundwater. Anti-backflow devices for hoses are available from irrigation or spray equipment suppliers. It is always a good practice to keep the hose out of the tank when filling the pesticide sprayer even if you have an anti-backflow device.

You should also consider installing anti-backflow devices on all faucets with hose connections or maintaining air gaps between hoses or faucets and the water level. Depending on your type of operation, water flowing back through the plumbing may draw water from sinks, washing machines, laundry tubs, outside hydrants, or swimming pools into your water supply and cause contamination. For more information on avoiding chemical backflow, see the Contacts and References Section near the end of this module.

Water testing requirements

The quality and safety of a water supply should be regularly monitored through water testing. Although not feasible to test for every conceivable contaminant, some basic tests can indicate whether or not other problems exist. Consult your local health department to determine an appropriate monitoring routine.

Operator Certification

All community and non-transient, non-community water supply systems must be operated by an individual certified by the DEQ in the appropriate type of water supply. A transient non-community water supply that treats water must also utilize a certified operator.

Type I, community water supplies

Sampling requirements for Community and Non-community Water Supplies are established in Act 399, and modified by EGLE District Staff or local health departments as allowed by Act 399.

Sampling requirements are determined on a case-by-case basis by EGLE, district staff. Water samples are tested for a number of potential contaminants including, but not limited to, nitrate, coliform, organic and inorganic compounds, lead and copper, and disinfection by-products. The specific sampling routine for each water supply system is determined by EGLE, district staff.

Type II, transient non-community public water supplies

Testing of nitrate levels is required annually or more frequently if directed by the local health department. Nitrate can get into water if a well is improperly constructed or located where it is susceptible to contamination sources such as sewage disposal systems, fertilized turfgrass, industrial wastes or even nitrates that are naturally occurring in the soil. Large amounts of nitrate in drinking water can cause a blood disorder primarily affecting infants. Also, since nitrate contamination can be related to human, animal, or industrial waste practices, excessive nitrate levels may indicate that other harmful contaminants are present.

Coliform is a type of bacteria that is used as an indicator of the sanitary quality of drinking water. The presence of coliform in water indicates there is potential for harmful disease-causing organisms to enter the water supply from various sources. Your local health department or the EGLE determines how often you are required to test for coliform.

Type II, non-transient non-community public water supplies

In 1986, amendments to the Federal Safe Drinking Water Act created significant new monitoring requirements for facilities using their own wells and serving the same 25 or more persons a day. In addition to nitrates and coliform, testing is required for lead, copper, cyanide, metals, synthetic organic compounds, volatile organic compounds and other parameters. For the turfgrass industry, this would include only businesses with 25 or more employees (resorts, large companies).

Type III public water supplies

There are no requirements for ongoing testing. Annual coliform and nitrate testing is recommended. Monitoring at prescribed frequencies may be required by EGLE or local health departments, if deemed necessary.

This module does not present all of the testing requirements for various types of water supplies. It is essential that you contact your local health department or EGLE district staff for assistance in understanding and meeting all obligations.

Abandoned Wells

Your property may include abandoned wells. No one knows exactly how many abandoned wells there are in Michigan, although estimates range in the millions. If an unused well is not properly plugged, it provides direct access for contaminants to reach groundwater. State well code requires that abandoned or unused wells be properly plugged.

You may not know the history of your property, so unused well locations may not be obvious. Look for any depressions in the ground that indicate an old well or pipes sticking out of the ground. Wells were often drilled in house basements, under front steps or near old cisterns. If your property was formerly a farmstead, look for wells under old windmills.

To properly plug an abandoned well it generally requires some experience or knowledge of well construction materials, closure methods and the geology of the well site. A state registered water well driller has experience in this area and should be hired to plug abandoned wells. The well driller must meet the minimum well code requirements to plug the well. Special equipment is often required to remove old pumps and piping and to properly plug the well. If inappropriate materials or methods are used, the surrounding area may settle or collapse and continue to be a potential contamination source and make it nearly impossible to repair the defective work.

Plugging requirements vary based on the well type. Contact your local health department for specific requirements.

Costs will vary with the well depth, diameter, and geology of the area. Although, proper well closing takes time and money, ensuring the safety of your operation's drinking water is critical.

State of Michigan Wellhead Protection Program

Municipalities throughout Michigan are protecting their village, city or township drinking water wells by participating in the State of Michigan Wellhead Protection Program. Your property may be up-gradient of municipal water well and within their delineated wellhead protection area. Check with your neighboring municipal water plant superintendent to find out if your property is located in their wellhead protection area and how you can work together to protect groundwater that recharges your wells and the neighboring municipality's.

Contacts and References

Who to call about:

General issues

Contact EGLE at (800) 662-9278 and ask to speak to someone in the appropriate program area.

A copy of your water well record or "well log" (construction report)

Contact the well drilling contractor who drilled the well, your local health department office, or the EGLE offices.

Be prepared to provide the legal description (county, township, range, section, and quarter section) of the well's location. If known, provide the year the well was installed and the owner's name at the time. For wells drilled since 2000, a copy of the "well log" may be obtained from EGLE.

Well construction or inspection

Contact the local health department sanitarian or registered well driller/pump installer.

For Type I well permits contact the EGLE's district staff.

For Type II and III well permits contact your local health department. Website for contact information listed earlier in this document.

Certified well water testing laboratories

Contact EGLE for a list of laboratories. .

Interpreting well water test results

Local Health Department offices or EGLE

Drinking water quality standards

US Environmental Protection Agency's Safe Drinking Water Hotline. Call toll free 1-800-426-4791 from 8:30 a.m. to 5:00 p.m. Eastern time.

EGLE and/or local health departments

Chemical Backflow

Protect Your Water Supply from Agricultural Chemical Backflow. MSU Extension Bulletin E-2349. Call (517) 353-6740 or check with your county Extension Office.

Approved water treatment devices

Use only those devices certified by the National Sanitation Foundation (NSF), an independent testing laboratory.

Requirements for installation of treatment devices

Before installing treatment devices on water supplies contaminated with nitrates, heavy metals, VOC's, pesticides, microorganisms, and other health-related contaminants in excess of health standards, contact your local health department or EGLE.

Locating possible sources of contamination

Well drilling contractors, pump installers, EGLE district office staff, or local health department sanitarians.

Nitrates

Nitrate: A Drinking Water Concern. MSU Extension Bulletin WQ19. Call (517) 353-6740 or check with your county Extension office.

Groundwater, groundwater flow

Introduction to Michigan's Water Resources. MSU Institute of Water Research (517) 353-3742, or E-mail IWR director: Jon Bartholic.

What is Groundwater? MSU Extension Bulletin WQ35. Call (517) 353-6740 or check with your county Extension Office. Groundwater Contamination. MSU Extension Bulletin WQ34. Call (517) 353-6740 or check with your county Extension Office.

Understanding Groundwater: Michigan's Hidden Resource. MSU Extension Bulletin WQ33. Call (517) 353-6740 or check with your county Extension Office.

Well abandonment

Contact your local health department or EGLE.

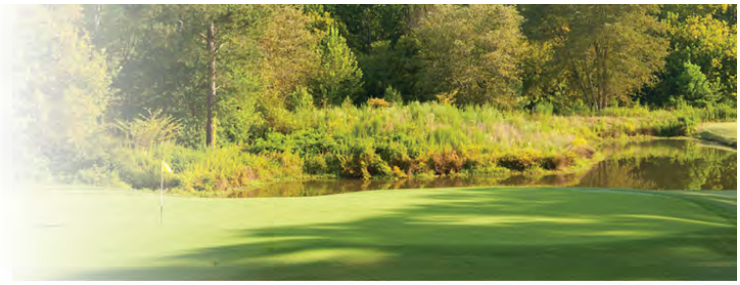
Plugging Abandoned Wells MSU Extension Bulletin WQ40. Call (517) 353-6740 or check with your county Extension office.

Wellhead Protection Worksheets

Work Sheet for Well Types I, IIa and IIb can be found at: https://www.mtesp.org/facilities/169/wellhead_protection/edit#wellhead-protection-worksheets

Water Quality Monitoring and Management

Overview



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

Best Management Practices

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

Site Analysis

Principles

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

Best Management Practices

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

Water Quality Sampling Program

Principles

- Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.
- Monitoring is the method used to determine whether outside events are impacting the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. It also provides a body of evidence on the golf course's environmental impact.
- A water quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction is completed. The same sites should be monitored during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions.

- Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state Total Maximum Daily Load [TMDL] Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation.
- Post-construction surface-water quality sampling should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year.
- Should there be no discharge on the scheduled sample date, samples should be taken during the next discharge event.
- Post-construction surface-water quality sampling should continue through the first three years of operation and during the wet and dry seasons every third year thereafter, provided that all required water quality monitoring has been completed and the development continues to implement all current management plans. It may also be wise to sample if a significant change has been made in course operation or design that could affect nearby water quality.
- Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators).
- Golf courses should also sample for macroinvertebrates as determined useful by water quality specialists.

Sampling Parameters, Collection, and Analysis

Principles

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

Best Management Practices

- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.

- Determine what sites will be analyzed and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.

Buffer Zones

Golf course design concepts have changed dramatically over the years. Modern design practices encourage designers and architects to incorporate the natural features of the landscape into the overall design. This helps to create a more natural appearance and also to protect the surrounding environment from degradation. The use of buffer zones and landscaping with native vegetation is often standard practice on new designs and is being incorporated into existing golf courses & landscapes.

Many Michigan golf courses commonly feature water as an integral part of the design. Water features range from the majestic Great Lakes to inland lakes, ponds, streams and wetlands. Golf course superintendents recognize their role as stewards of the environment and strive to incorporate best management practices in their day-to-day operations.

Definition of Buffers

The Michigan Department of Environmental Quality defines a buffer as a vegetated area adjacent to a waterbody (i.e. river, stream, wetland, lake) that may consist of natural undeveloped land where the existing vegetation is left intact or it may be land planted with vegetation designed to maximize protection. Buffers are often designed to intercept surface runoff and subsurface flow from upland sources in order to filter pollutants before they enter surface waters and groundwater recharge areas.

For use on golf courses & landscapes, we will define buffers as any vegetated areas, natural or planted, that are designed to minimize the effects of human activities on the environment and maximize the protection of natural resources. These areas may be directly adjacent to waterbodies or positioned anywhere within the property where they are deemed to be beneficial for protecting human, plant, animal, air or soil resources. Areas directly adjacent to waterbodies will be referred to as riparian buffers.

Benefits of Buffers

Buffer strips can perform many valuable functions including the following:

- Trap and filter sediment
- Trap and filter nutrients, pesticides and animal waste
- Stabilize eroding banks
- Provide shade to cool the water
- Provide wildlife habitat
- Enhance aquatic habitat
- Can be designed to deter nuisance species like geese

- Reduce or eliminate time- consuming string trimming or walk mowing
- Provide large woody debris for aquatic habitat
- Food source for aquatic habitat

Riparian forests and grass communities have been shown to substantially reduce the amount of nitrogen reaching surface waters. Microbes in organic forest soils and wetlands convert nitrate into nitrogen gas through denitrification. Tree and plant roots help stabilize streambanks and provide protection from erosion.

Shade from riparian forest buffers keep water temperatures cooler and reduce temperature fluctuations. This can be especially important in cold- water trout streams. Streamside forests are also important in the food chain of aquatic systems. Organic compounds such as leaves, fruit, limbs, and insects fall into the stream and decay. These compounds are fed upon by stream bacteria, fungi and invertebrates and provide the foundation of the aquatic food chain. Fallen trees and branches also create favorable habitat areas for fish.

Buffers are also important areas for wildlife and can be designed to attract a variety of wildlife including songbirds, butterflies, and small mammals. Properly designed, they can add interesting and aesthetic viewing opportunities for patrons. The linear nature of many riparian buffers not only provides food and cover for animals, but they also serve as travel corridors between habitat areas. This connection is important in maintaining biological diversity and prevents the fragmentation of habitat. Alternately, buffers can be designed to discourage unwanted species such as geese. When buffers are located directly adjacent to waterbodies, geese are often reluctant to venture through tall vegetation when exiting the water for fear of predators on the other side.

Turfgrass Inputs

The primary pollutants of concern on Turfgrass Systems are nutrients (nitrogen and phosphorus), pesticides, and sediment that could potentially migrate into nearby water. Research conducted to investigate the movement of nutrients and pesticides from golf courses reveals that wise management practices can minimize the potential for these products to contaminate water supplies. Some studies suggest turfgrass areas generally rank second only to undisturbed forests in their ability to prevent pesticides and nutrients from reaching groundwater and surface water. The utilization of buffer strips is an added practice to help safeguard waterbodies from nutrients or pesticides that are not utilized by turfgrass.

Buffer Zone Concepts

Much of the information available on the design of buffer zones is based upon a "Three-zone Buffer Concept" recommended by agencies such as the Natural Resources Conservation Service (NRCS) and the USDA Forest Service. This concept divides the areas directly adjacent to a stream into zones, beginning at the water’s edge and moving outward. These agencies recommend that Zone 1 (next to the water’s edge) should remain an area of undisturbed mature trees. Zone 2 consists of an area of managed forest where plant material may be periodically harvested. Zone 3 is an area of dense grasses and/or forbs (such as wildflowers or broad-leaved herbaceous plants). This zone is periodically mowed or harvested in order to remove nutrients stored in plant materials. Phosphorus becomes physically bound up in plant materials. If it is not removed, the vegetation can reach a saturation point where it is no longer effective in removing nutrients.

Many government agencies use fixed buffer widths in their standards while others recommend a range of widths in order to perform a specific function. For example, the NRCS specifies the following buffer zone widths for various conditions:

- Establishment of riparian forest buffers to reduce pollution by sediment, nutrients, pesticides, or other pollutants and restore overall water quality. The total combined width of all three zones will be not less than 55 feet.
- Establishment of riparian forest buffers to provide wildlife habitat, maintain or restore water temperature, and provide large woody debris. The total combined width of the first two zones will not be less than 100 feet.
- Establishment of riparian forest buffers in areas with existing woody plants that need enhancement and are less than 100 feet wide. The total combined width of the first two zones will not be less than 100 feet.
- Establishment of riparian forest buffers in areas with existing woody plants that exceed 100 feet in width. The total combined width of the first two zones will not be less than 100 feet.

The width of buffer zones can vary depending upon space. Studies have shown that a range of buffer widths from 3m to 200m have been effective, depending upon site specific conditions. In most cases, a buffer of at least 100 feet is necessary to fully protect aquatic resources. Studies have shown that negative impacts to aquatic invertebrates occur on streams with buffer zones less than 100 feet. If 100 feet is not available, smaller buffers still afford some level of protection to the water body and are preferable to no buffer at all.

Using Buffers On Golf Courses

In developing criteria for buffer zones on golf courses, it is necessary to distinguish between in-play and out-of- play areas. For existing golf courses, the use of standard fixed width buffer zones is not practical. Space limitations require more flexibility. Based upon a review of current buffer design concepts, scientific literature and collaboration with governmental agencies in Michigan, a flexible zone system for both in- play and out- of- play areas has been developed for use on golf courses. The specific dimensions of the buffer are adjusted based on the site conditions and available space. The in-play buffer zone system incorporates a series of gradually increasing mowing heights adjacent to the water. Research has shown that even buffer zones of 3-inch tall grass will provide some level of protection for streams, lakes, and ponds from pesticides and nutrient pollution when grown between shorter, high maintenance turf and water bodies. The soils, slope, play of the golf hole and available space will determine the size of each buffer zone. Buffer widths should be maximized to the extent possible to provide the most protection of aquatic resources.

The criteria for in-play areas differs from the traditional three-zone approach in the following manner:

- A management plan for inputs will be implemented for each in-play buffer zone area
- A series of increased mowing heights of turf grass are incorporated into the in-play zones
- The in- play areas require turf grass to be less than 8 inches tall to allow play
- Not all zones must be used in each situation depending upon space limitations

The criteria for the out-of-play areas are similar to the traditional three-zone concept. However, they have been revised to allow more flexibility in areas where either space or other considerations require a different treatment.

Public Education

Public education is an important element in the successful implementation of any buffer zone strategy. Some managers have been forced to remove buffer plantings because of complaints. Many golfers have become accustomed to the manicured look common on older golf courses. Some may view the introduction of buffer plantings as unattractive weeds. Therefore, it is recommended that managers and superintendents educate their clientele before, during and after the implementation of buffer plantings. Newsletters, fact sheets, membership meetings, and interpretive signing are all mechanisms for informing the public about the merits of buffers.

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Michigan State University – Department of Crop and Soil Sciences; Department of Fisheries and Wildlife
Michigan Department of Environmental Quality – Surface Water Quality Division; Land and Water Management Division
Michigan Department of Natural Resources – Wildlife Division; Fisheries Division
U.S. Natural Resources Conservation Service
U.S. Fish and Wildlife Service
Michigan Turfgrass Foundation
Golf Course Owners Association
Golf Course Architects Association

Principles

- Buffers around the shore of a waterbody or other sensitive areas filter and purify runoff as it passes across the buffer. Ideally, plant buffers with native species provide a triple play of water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife. As discussed above, it is important to continue these plantings into the water to provide emergent vegetation for aquatic life, even if the pond is not used for stormwater treatment.
- Effective BMP in these areas include filter and trap sediment, site-specific natural/organic fertilization, and limits on pesticide use, primarily focusing on the control of invasive species.

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

Best Management Practices

- Riparian buffer areas are above the high-water mark and should be unfertilized and left in a natural state.
- Reduce the frequency of mowing at the lake edge and collect or direct clippings to upland areas.
- Institute buffers and special management zones.
- The placement of bunkers and the shaping of contours surrounding a green should allow proper drainage and provide for the treatment and absorption of runoff from the green.
- Use turf and native plantings to enhance buffer areas. Increase height of cut in the riparian zone to filter and buffer nutrient movement to the water.
- Use a deflector shield to prevent fertilizer and pesticide prills from contacting surface waters.
- Apply fertilizer and pesticides based on the effective swath; keep application on target and away from buffers or channel swales.
- Use a swale and berm system to allow for resident time (ponding) for water to infiltrate through the root zone to reduce lateral water movement to the surface water body.
- Maintain a riparian buffer to filter the nutrients in stormwater runoff.
- An appropriate-sized buffer (steeper slope requires great buffer width) of turf mowed at a higher height of cut and minimally fertilized with enhanced-efficiency fertilizers can provide an effective buffer.
- Use plant buffers with native species to provide pleasing aesthetics, habitat, and food sources for wildlife.
- Ideally, littoral zones should have a slope of about 1 foot vertical to 6-10 foot horizontal.
- Encourage clumps of native emergent vegetation at the shoreline.
- Establish special management zones around pond edges.
- Reverse-grade around the perimeter to control surface water runoff into ponds and reduce nutrient loads.
- Planting on slopes with less than a 6-foot horizontal to a 1-foot vertical may not be as successful over the long term.
- Construct random small dips and ridges of a few inches to a foot to promote diversity within the plant community and provide a healthier and more productive littoral zone.
- All or most of the out-of-play water bodies should have shoreline buffers planted with native or well-adapted noninvasive vegetation to provide food and shelter for wildlife.
- Practice good fertilizer management to reduce the nutrient runoff into ponds that causes algae blooms and ultimately reduces DO levels.
- Manipulate water levels to prevent low levels that result in warmer temperatures and lowered DO levels.
- Aerate shallow lakes less than 6 feet in depth to maintain acceptable DO levels.
- Where applicable, aerate at night to control oxygen depletion in any pond.
- Install desirable plants to naturally buffer DO loss and fluctuation.
- Dispose of grass clippings where runoff and wind will not carry them back to the lake.
- Nutrient rich runoff encourages alga blooms and other phytoplankton; apply appropriate fertilizer rates and application setbacks.

- Dredge or remove sediment to protect beneficial organisms that contribute to the lakes food web and overall lake health.

Buffer Zone Techniques

Buffer strategies have been divided into two separate categories for implementation on golf courses: 1) out-of- play areas, and 2) in-play areas. This fact sheet will discuss specific techniques to help golf course managers implement buffer strategies in both areas. In order to gain the most benefit from the implementation of buffers, the buffer zone designer should have an understanding of how water flows through the entire golf course property and determine the most important functions for buffers on their property. In golf situations, nutrient / pesticide filtering is often a primary function. Other valuable functions will include stabilizing eroding banks, providing wildlife habitat, enhancing aquatic habitat, creating aesthetic value and reducing difficult to maintain areas.

If nutrient removal is a goal of the buffer zone strategy, it is important to understand the structure of the landscape and the underlying soils. Studies have shown that buffers implemented for nutrient filtering are most effective when water moves across the surface in sheet flow and/or through shallow subsurface flow of groundwater. Longer water residence times and extensive contact with the root systems of vegetation and organic- rich soils within a buffer zone will promote rapid nitrate removal by plant uptake or microbial processes. A buffer zone will have little to no value for nutrient removal if water flows too rapidly through the area in concentrated flows or avoids the area completely (such as stormwater discharged directly to waterbodies through enclosed pipes). In these cases, the site should be evaluated to see if water can be intercepted at another location (perhaps further inland) in an area where the landscape and soil conditions are more favorable. In some cases, the creation of wetlands and/or detention basins can be used to retain water and allow it to be gradually flow through a buffer area before moving into a water body. Other mechanical structures can also be used to divert water in order to create sheet flow as an alternative to the creation of wetlands or detention areas.

In designing buffers for your area, first analyze the movement of water throughout the property and then complete the following steps to determine a strategy for both out- of- play and in-play areas:

- Determine what functions are needed
    - Nutrient and/or pesticide filtering
    - Bank stabilization
    - Wildlife habitat (do you want to attract songbirds, butterflies, etc?)
    - Aesthetic value (wildflowers, native grasses?)
    - Maintain and enhance aquatic habitat (does a stream run through the property?)
    - Discourage geese in critical play areas
    - Reduce walk mowing and/or string trimming
- Determine the minimum and maximum buffer width available
- Identify the best types of vegetation to provide the needed benefits
- Develop an installation and maintenance plan

Out-of-Play Strategies

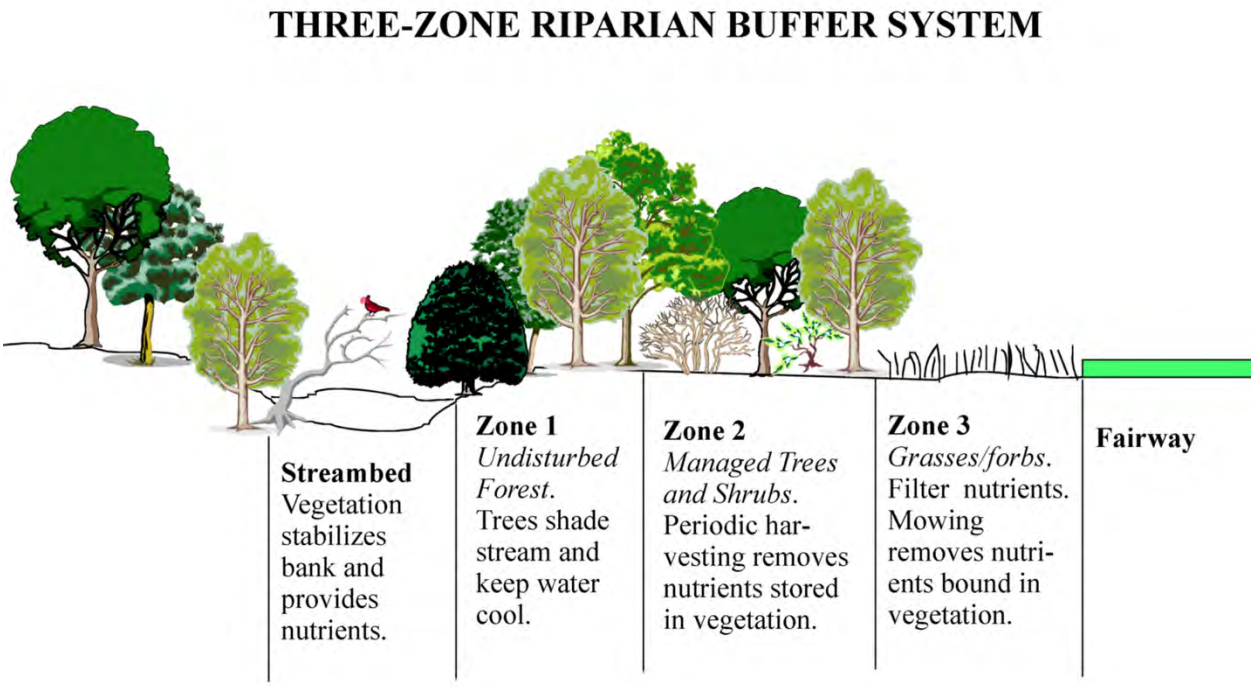
The criterion for out-of- play areas incorporates a zone strategy similar to those used by the Natural Resources Conservation Service (NRCS) and the U.S. Forest Service. The potential for creating wildlife habitat and enhancing aquatic habitat is much greater in these areas as opposed to in-play areas. There is often much more flexibility in the height of vegetation that can be planted in out-of- play areas without affecting the play of golf. When space permits, an ideal riparian buffer zone includes three zones:

- Zone 1 - consisting of mature trees next to a stream, lake, or other waterbody.
- Zone 2 - consisting of managed trees/shrubs
- Zone 3 - consisting of grasses and/or forbs (such as native grasses and wildflowers)

The width of buffer zones may vary according to specific conditions and the objective of the buffer zone. The following are examples of four NRCS buffer zone specifications for various conditions:

- Establishment of riparian forest buffers to reduce pollution by sediment, nutrients, pesticides, or other pollutants and restore overall water quality. The total combined width of all three zones will be not less than 55 feet.
- Establishment of riparian forest buffers to provide wildlife habitat, maintain or restore water temperature, and provide large woody debris. The total combined width of the first two zones will not be less than 100 feet.
- Establishment of riparian forest buffers in areas with existing woody plants that need enhancement and are less than 100 feet wide. The total combined width of the first two zones will not be less than 100 feet.
- Establishment of riparian forest buffers in areas with existing woody plants that exceed 100 feet in width. The total combined width of the first two zones will not be less than 100 feet.

The following diagram depicts a riparian three-zone system:



In general, it is recommended that this 3-zone configuration be used in riparian buffer areas when feasible. Ideally, out-of- play riparian buffer zones should be maintained at a width of 100 feet or more. If space is limited, then the buffer zone should be maximized to the extent possible. In some cases, the inclusion of all three zones is not necessary depending upon the desired functions. Inland buffers, (those not adjacent to waterbodies) may only include one or more of the above zones, depending upon the desired functions. The incorporation of natural areas on golf courses can not only provide added aesthetic value, but also reduce long- term mowing and maintenance costs.

The width of the buffer can vary depending upon space. Studies have shown that a range of buffer widths from 3m to 200m have been effective, depending upon site specific conditions. In most cases, a buffer of at least 100 feet is necessary to fully protect aquatic resources. Studies have shown that negative impacts to aquatic invertebrates occur on streams with buffer zones less than 100 feet. If 100 feet is not available, smaller buffers still afford some level of protection to the water body and are preferable to no buffer at all. Generally, buffer widths toward the lower end of the range may provide for the maintenance of the natural physical and chemical characteristics (such as nutrient filtering) of aquatic resources. Buffer widths toward the upper end of the range are necessary for maintaining the biological components (such as wildlife habitat) of many wetlands and streams.

Obviously, space requirements on existing golf courses may preclude large buffer zones in

some areas. Therefore, it is recommended to use the above information as a guide and maximize riparian buffer areas to the extent possible. As noted earlier, the relocation of fairways and use areas away from sensitive water resources (ponds, streams, wetlands) should be evaluated first before implementing buffer strategies. When relocation is not possible, the installation of any sized buffer zone (even if it is below optimal widths) is preferable to no buffer at all.

In-Play Strategies

A flexible, zone system has also been developed for in-play areas on golf courses. This allows golf course managers to implement buffer strategies based upon site-specific conditions. The following items were considered essential elements in the development of in-play buffer zone criteria:

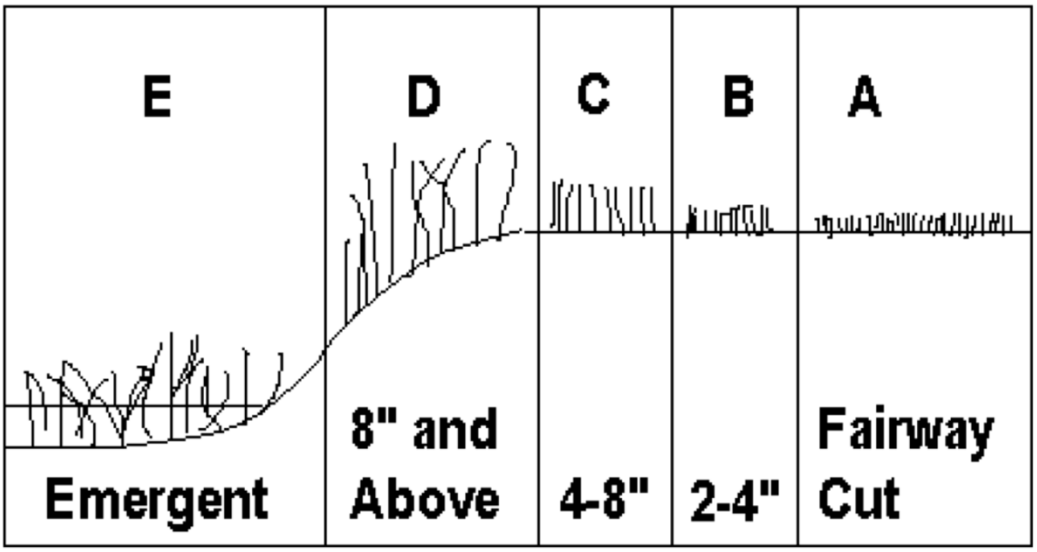
- Relocation of fairways and use areas away from sensitive water resources (ponds, streams, wetlands) should be considered as an option to enhance protection
- Buffer zones can address one or more environmental issues, a few such areas of concern include nutrient/pesticide filtering and bank stabilization on waterways
- Buffer zones may not be able to address all possible resource protection issues
- Buffer zones can be established using various widths, heights and plants
- Buffer zones should not impede the play of golf

Research has shown that even buffer zones of 3-inch tall grass provide some level of protection for streams, lakes, and ponds from pesticide and nutrient pollution when grown between turf and water bodies. Therefore, the In-Play buffer zone system incorporates a series of gradually increasing mowing heights within the fairway. The diagram below depicts Zones A thru E. In general, turf heights up to 4 inches are still considered playable. Therefore, Zones A and B could be used within playable areas. Zones C and D could be installed between the fairway and the water body when space permits. Zone E includes shallow water areas adjacent to lakes or wetlands. Planting of emergent vegetation in Zone E can provide important benefits such as taking up nutrients contained in surface runoff and helping to buffer shorelines from erosion. In areas where there are very small buffer zones and inadequate space to provide buffers in Zones A thru D, Zone E may provide the only feasible location to provide some level of buffering.

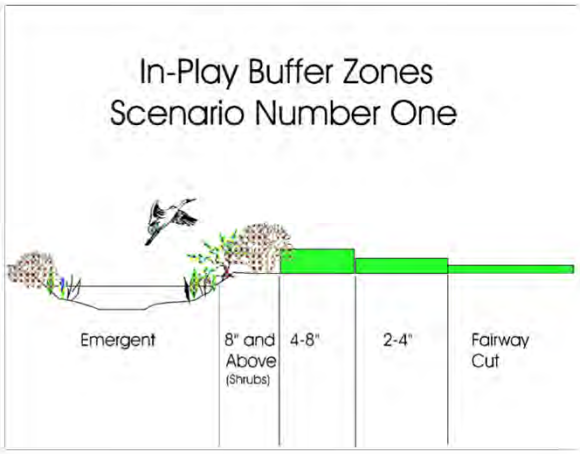
An important element of the buffer zone strategy for In-Play areas includes the implementation of a management plan for inputs. This consists of reducing and/or eliminating fertilizer and pesticide inputs within the In-Play buffer area, particularly in Zones A and B. Grass/vegetation clippings should be removed from the buffer zone periodically in order to remove accumulated nutrients.

The following diagram depicts the In-Play buffer zones described above:

IN-PLAY GOLF ZONES



As noted above, the amount of room available for buffer zones in In-Play areas may vary greatly. The diagrams on the following page depict two possible scenarios for In-Play buffer zones:



Scenarios

In Scenario One, the diagram depicts shrubs adjacent to the water. However, shorter plants could be planted if there is a concern over losing golf balls. For example, some golf courses have found a mix of little bluestem and fine fescues to be aesthetically pleasing while still allowing members to retrieve golf balls. In the second scenario, there is no room for a buffer zone between the water and the fairway, but a series of graduated mowing heights and a management plan for nutrients and pesticides has been implemented. Emergent plantings were

added in the shallow areas along the shoreline for added protection. Taller emergent vegetation may deter geese from using the shoreline.

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U.S.D.A. Natural Resources Conservation Service
U.S. Fish and Wildlife Service
Michigan Turfgrass Foundation
Golf Course Owners Association
Golf Course Architects Association
Regional Golf Course Superintendent Associations – representing 4 regional associations within Michigan: Forest Lake Country Club, Kalamazoo Country Club, Grayling Country Club, and Grossbeck Golf Course

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Buffer Zone Vegetation

The first step in implementing a successful buffer plan is to identify the waterways throughout a golf course along with potential contaminants that could affect these waterways. The earlier section on buffer zones describes the merits of using buffer zones. Buffer Zone Techniques explains the criteria used to identify and implement a comprehensive buffer strategy. This section will address the selection of vegetation for buffer zones. Examples of plant communities for each zone (tree, shrubs, herbaceous, emergent) have been included as well as several seed mixes that have been used in Michigan. A list of references is also included to help identify additional plant material and resources that can be used for creating buffer zones on golf

courses. The vegetation selected for these areas will depend on whether they are located in "in-play" or "out-of-play" areas, the desired functions, and specific environmental conditions.

In-Play Areas

The ability to play and retrieve a golf ball is of primary concern for in- play areas. Therefore, the height of the turf, rough, and surrounding vegetation is important. Once you have determined the amount of space you have to work with and the desired functions of the buffer (nutrient uptake, wildlife habitat, aesthetics), you are ready to begin selecting vegetation that will fulfill the required functions without interfering with the play of golf. Managing turf height might be the only practical option for buffer zones closer to the fairway and areas of highest play. However, in many cases, it may be possible to vary plantings even within in-play areas. Where sight distance and ball retrieval is not as critical to the play of golf (such as in shoot over areas), vegetation that provides color, water quality and wildlife benefits (such as native grasses, wildflowers, shrubs, and emergent vegetation) may be good choices and should be considered. Figures 1 through 3 depict several scenarios for in-play buffer zones.

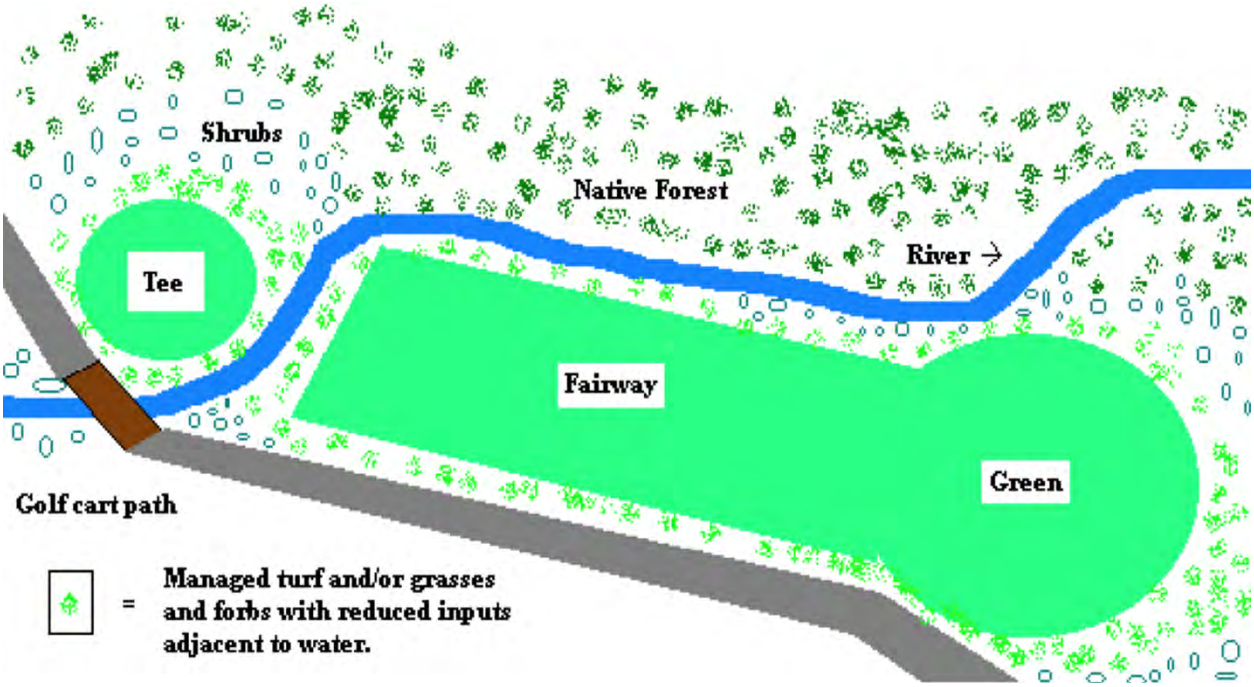

Figure 1: *This diagram depicts a natural river running through a golf course. Areas directly adjacent to the tee, fairway and green contain managed turf and/or grasses and forbs where plant height is of concern. These areas blend into stands of native shrubs and trees in the out-of- play areas.*

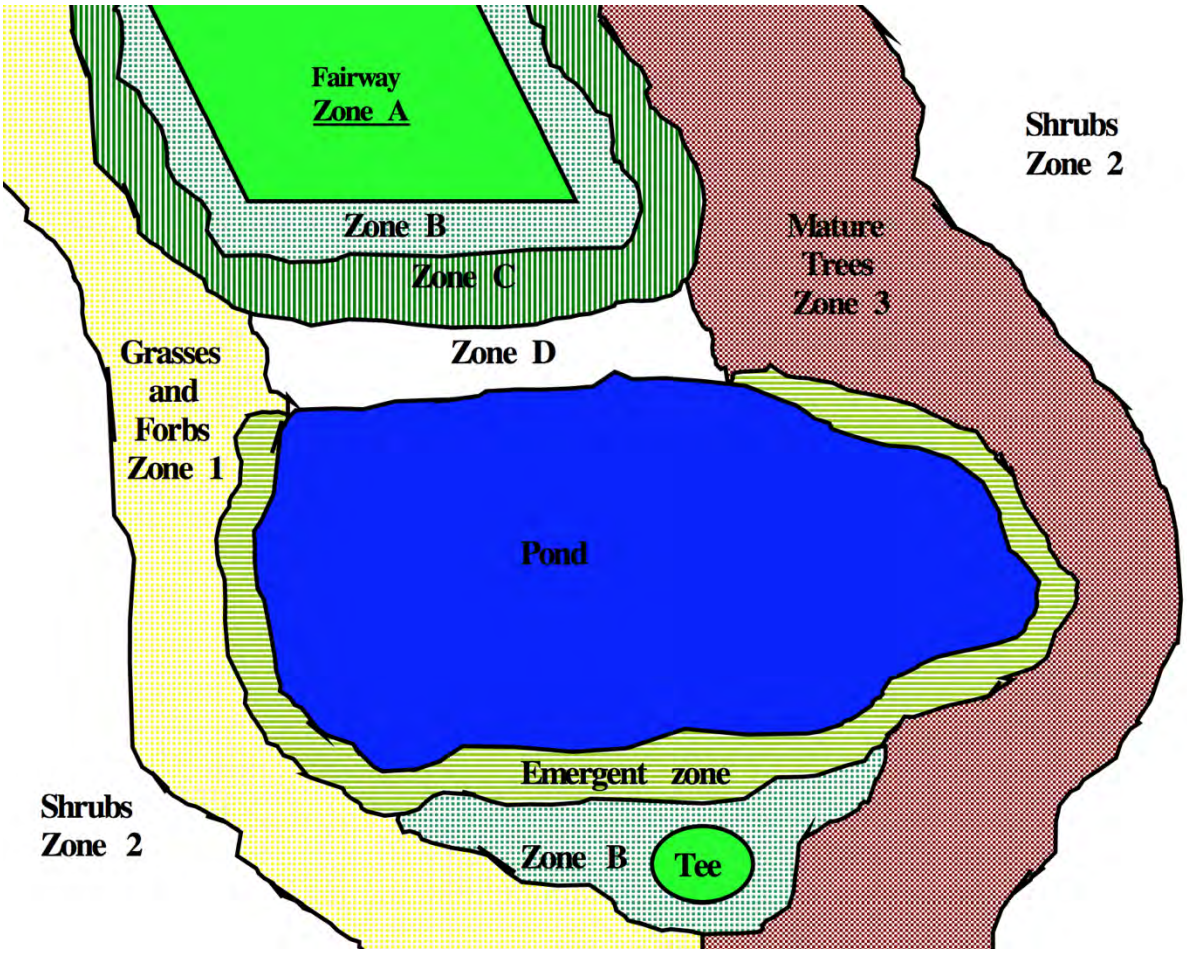

Figure 2: *The above diagram depicts several scenarios for combining buffer zones for both in-play and out-of- play areas. The selection of both the number and width of zones will depend upon site specific conditions.*

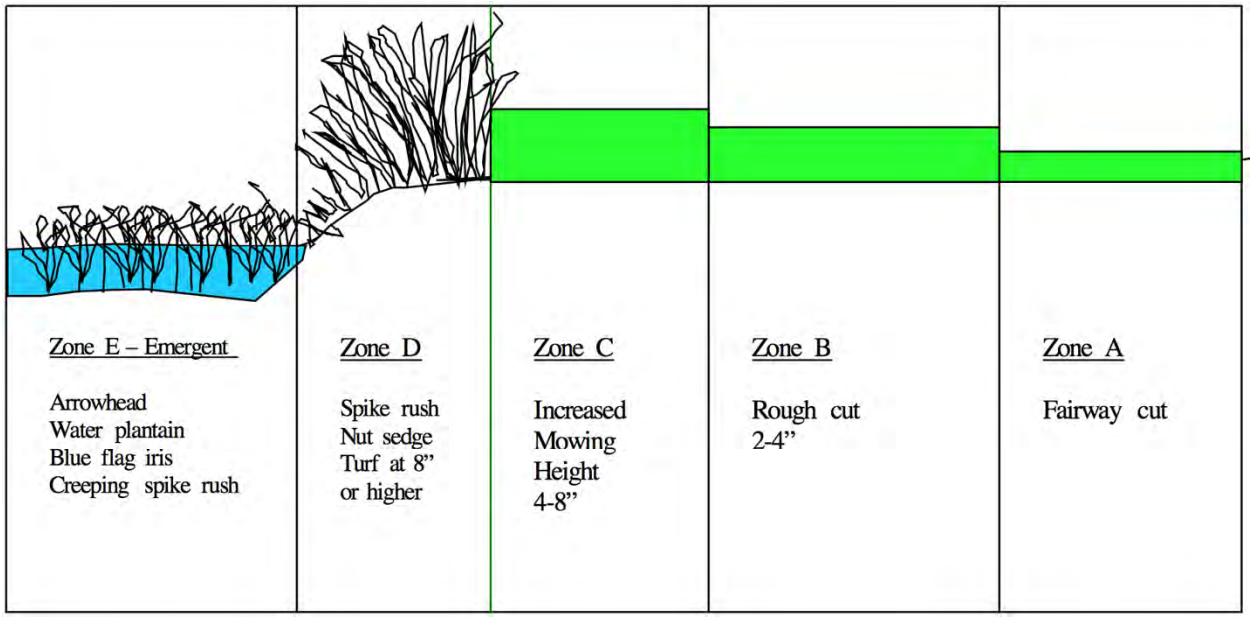

Figure 3: *The above diagram depicts an example cross section of an in-play buffer zone. The selection of vegetation will depend upon desired plant height, soils, light and moisture content.*

Out-of-Play Areas

In general, vegetation options increase dramatically for out-of-play golf areas. Plant height and ball retrieval are usually not as important in these areas. Figures 1 and 2 describe several options for combining out-of-play and in-play buffer zones on a golf course. In choosing plants for these areas, you must first decide whether you plan to use non- native ornamental plantings or native vegetation. It is recommended that native species be used in buffer zone plantings whenever feasible given the invasive nature of many non- native species and their ability to spread into areas where they are not desired. However, there may be cases where non-native plants will be more effective in achieving the desired function of the buffer (such as nutrient filtering or erosion control). This should be determined on a site-specific basis. Care should be taken not to plant aggressive or invasive species adjacent to natural areas where they have the potential to spread and displace native vegetation. The following guidelines may be helpful in determining whether to use native or non-native plants:

1. Is the area in-play or out-of- play? This may affect vegetation choices in terms of height. Are there native plants available that will grow in your specific in-play areas that can be maintained less than 12" and not affect the play of golf? *If not, then you may wish to consider maintaining turfs such as fine fescues at higher mowing heights.*
2. What is the surrounding vegetation? Is it native or non- native? *If your planting area is adjacent to existing natural areas or has the potential to spread to adjacent natural areas use native plants.*
3. What is a the resource value of the area?
    1. Does your golf course contain any woodlots, streams, ponds, rivers or other natural areas? *If yes, then native vegetation should be considered.*
    2. Is your golf course in an urban setting with non- native ornamental landscaping? *If your planting area is in a completely contained urban setting and*

your current landscaping consists of non- native ornamental plants - non- native plants may make sense in this situation.

3. Do any of the water bodies on your course have a connection to the surrounding watershed? In other words, do ponds, lakes or streams discharge off the property? *If yes, you should consider planting native vegetation adjacent to these water bodies. Installing and maintaining buffer zones on your property can also help to improve water quality downstream.*
4. Do any of the natural areas on your golf course connect to natural areas beyond your property boundaries? *If yes, consider planting native vegetation.*

4. What is the slope of the land area you wish to plant? Does the slope create an erosion problem that limits vegetation choices? *Native plants should be considered first. But there may be some cases where non-native plants are more practical for stabilizing the soil. Severe erosion problems might require additional engineering solutions to stabilize the area prior to planting. You may wish to contact a consultant who specializes in erosion control measures.*

Many non-native undesirable plants are now growing throughout Michigan. Some of these plants were brought to the United States by settlers and have escaped into the wild, aggressively displacing our native species. After habitat destruction, invasion of non-native species (also called exotic or alien species) is the greatest threat to rare native species and to the integrity of ecosystems. Some native species can also be highly aggressive and, therefore, are not recommended for golf course settings where they can invade turf areas. Species such as crown vetch, birdsfoot trefoil, reed canary grass and orchardgrass have often been used for erosion control in the past. These species are aggressive and can quickly spread to take over other areas. Therefore, we are not recommending them for inclusion in golf course settings.

Species to Avoid:

Autumn olive	*Elaeagnus umbellata*
Barberry	*Berberris spp.*
Common buckthorn	*Rhamnus cathartica*
Glossy buckthorn	*Rhamnus frangula*
Crown vetch	*Coronilla varia*
European alder	*Alnus glutinosa*
Honeysuckle	*Lonicera tatarica, L. japonica, L. maackii, L. morrowi, L. x-bella & their cultivars*
Multiflora rose	*Rosa multiflora*
Norway maple	*Acer platanoides*
Brome grass	*Bromus spp.*
Oriental bittersweet	*Celastrus orbiculatus*
Privet	*Ligustrum vulgare*
Purple loosestrife	*Lythrum salicaria*
Siberian elm	*Ulmus pumila*
Common mullein	*Verbascum thapsus*
Spotted Knapweed	*Centaurea maculosa*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*

Queen Anne’s lace	*Daucus carota*
Orchard grass	*Dactylis glomerata*
Timothy	*Phleum pratense*
Poison ivy	*Toxicodendron radicans*
Ragweed	*Ambrosia artemisiifolia*
Yarrow	*Achillea millefolium*
Hoary Alyssum	*Berteroa incana*
Common St. John's Wort	*Hypericum perforatum*
Common Motherwort	*Leonurus cardiaca*
Bladder campion	*Silene vulgaris*
Nightshade	*Solanum dulcamara*
Red Clover	*Trifolium pratense*
White Clover	*Trifolium repens*
Reed Canary Grass	*Phalaris arundinacea*
Birdsfoot Trefoil	*Lotus corniculatu*

For more information on whether a plant is considered native to Michigan, refer to the Floristic Quality Assessment for Michigan available from the Michigan Department of Natural Resources, Wildlife Division, Natural Heritage Program, P.O. Box 30444, Lansing, MI 48909-7944.

Because there are so many planting combinations for golf course buffer plantings, this fact sheet cannot address all possible scenarios. Instead, we have included some basic information on native Michigan plants (trees, shrubs, grasses, and wildflowers) along with several example buffer zone plant mixes for the grass/forb zone. At the end of the fact sheet, we have included a list of helpful reference materials that can be used by those interested in devising their own planting schemes, including an interactive native plants CD-ROM available from Springfield Township, Michigan that can be used to identify plants appropriate for specific conditions. Information on how to order this CD- ROM is included in the reference section under native vegetation. In addition, many nurseries now specialize in native plants and have staff capable of assisting you in the development of plant mixtures to meet specific on- site requirements. The lists of plants contained within this fact sheet are not a complete listing of all native Michigan plants. Please refer to the attached reference section if you would like additional information.

Trees

In selecting trees for riparian buffers, several factors should be considered. Trees closest to the waterway are most likely to be flooded during a portion of the year. If this is the case, you should select trees with a greater tolerance for high water tables. If the area has been recently disturbed, trees with a fast growth rate will quickly establish root systems to hold the soil. Fast- growing trees are not necessarily long- lived, therefore you may want to interplant some species with longer life spans. Trees with shallow rooting systems hold surface soils well, but do not provide as much stability to high banks and steep slopes as trees with deeper root systems. Deeper root systems anchor trees better where there are repeated flooding/drying cycles.

Example native trees

Wet to moist conditions:

Ash, Green	*Fraxinus pennsylvanica*
Aspen, Trembling	*Populus tremuloides*
Birch, River	*Betula nigra*
Birch, Yellow	*Betula alleghaniensis*
Blackgum	*Nyssa sylvatica*
Cedar, Northern white	*Thuja occidentalis*
Hemlock, Eastern	*Tsuga canadensis*
Hickory, bitternut	*Carya cordiformis*
Maple, Red	*Acer rubrum*
Maple, Silver	*Acer sacharinum*
Musclewood	*Carpinus caroliniana*
Oak, bur	*Quercus macrocarpa*
Oak, Pin	*Quercus palustris*
Oak, Swamp white	*Quercus bicolor*
Sycamore	*Platanus occidentalis*
Willow, Black	*Salix nigra*

Moist to drier conditions:

Ash, blue	*Fraxinus quadrangulata*
Ash, white	*Fraxinus americana*
Basswood	*Tilia americana*
Beech, American	*Fagus grandifolia*
Birch, Paper	*Betula papyrfiera*
Cedar, eastern red	*Juniperus virginiana*
Cherry, black	*Prunus serotina*
Crab apple, wild	*Malus coronaria*
Dogwood, flowering	*Cornus florida*
Hackberry	*Celtis occidentalis*
Hickory, pignut	*Carya glabra*
Hickory, shagbark	*Carya ovata*
Ironwood	*Ostrya virginiana*
Maple, sugar	*Acer saccharum*
Oak, black	*Quercus velutina*
Oak, chinquapin	*Quercus muehlenbergii*
Oak, red	*Quercus rubra*
Oak, white	*Quercus alba*
Pawpaw	*Asimina triloba*
Redbud	*Cercis canadensis*
Sassafras	*Sassafrass albidum*
Tuliptree	*Liriodendron tilipifera*
Walnut, black	*Juglans nigraz*

Note: Some of the species listed above are not native to the entire state. Species native to southern Michigan may not be considered native in northern Michigan or the Upper Peninsula.

Shrubs may also be incorporated into buffer areas, either alone or in the understory of larger trees. Shrubs often do well at the edge of forested areas, serving as a transition between forested and grassed areas. Planting shrubs increases the diversity of wildlife habitat by providing more layers of vegetation. Many songbirds use shrub species for nesting habitat.

Example Native Shrubs

Wet to moist conditions:

Alder, speckled	*Alnus rugosa*
Bladdernut, American	*Staphylea trifolia*
Buttonbush	*Cephalanthus occidentalis*
Cranberry, highbush	*Viburnum trilobum*
Dogwood, red- osier *	*Cornus stolinifera*
Dogwood, silky	*Cornus amomum*
Elderberry, American	*Sambucus canadensis*
Meadowsweet	*Spirea alba*
Nannyberry	*Viburnum lentago*
Ninebark *	*Physocarpus opulifolius*
Rose, swamp	*Physocarpus opulifolius*
Spicebush	*Lindera benzoin*

*can be aggressive **prefers dry, open environments

Moist to Drier Conditions:

Arrow- wood, downy	*Viburnum rafinesquianum*
Vibernum, mapleleaf	*Viburnum acerifolium*
Chokecherry	*Prunus virginiana*
Dogwood, gray	*Cornus foemina*
Hazelnut, American	*Corylus americana*
New Jersey Tea **	*Ceanothus americanus*
Rose, wild	*Rosa blanda*
Serviceberry, shadblow	*Amelanchier arborea*
Serviceberry, Allegheny	*Amelanchier laevis*
Sumac, Staghorn	*Rhus typhina*

Grasses and Wildflowers

Grassed buffer areas may typically consist of warm or cool season grasses. Warm season grasses include species such as big bluestem, little bluestem, Indiangrass, and switchgrass. Fine fescues are a good cool season choice for golf course buffer areas. When appropriate, wildflowers may also be interspersed into grassed buffer areas for added aesthetic value and attracting butterflies.

In natural areas, native warm season grasses are preferred for wildlife habitat. These grasses provide excellent cover necessary for the mating, nesting, brood- rearing and feeding activities of many small birds and mammals. Most warm season grasses are not shade tolerant and may not do well planted directly adjacent to shady forested areas. A good solution is to plant a shrub transition zone in between the grassed and forested areas.

Example Short Native Grasses and Sedges (up to 4')

Wet to Moist Conditions:

Creeping spike rush	*Eleocharis palustris*
Soft rush	*Juncus effusus*
Lake sedge	*Carex lacustris*
Green bulrush	*Scirpus atrovirens*

Moist to Drier Conditions:

Bluestem, Little	*Schizachyrium scoparium*
Pennsylvania sedge	*Carex pensylvanica*
Purple lovegrass	*Eragrostis spectabilis*
June grass	*Koeleria macrantha*

Example Tall Native Grasses and Sedges

Wet to Moist Conditions:

Hardstem bulrush	*Scirpus acutus*
Prairie cordgrass	*Spartina pectinata*
Wild-rye, Canada	*Elymus canadensis*
Wild- rye, Virginia	*Elymus virginicus*
Wool grass	*Scirpus cyperinus*
Bottlebrush grass	*Hystrix patula*

Moist to Drier Conditions:

Bluestem, big	*Andropogon gerardii*
Switch grass	*Panicum virgatum*
Indian grass	*Sorghastrum nutans*

Example Short Native Wildflowers (up to 3')

Wet to Moist Conditions:

Anemone, Canada	*Anemone canadensis*
Beard-tongue, hairy	*Penstemon hirsutus*

Golden alexanders	*Zizia aurea*
Lobelia, great blue	*Lobelia siphilitica*
Marsh marigold	*Caltha palustris*

Moist to Drier Conditions:

Smooth aster	*Aster laevis*
Butterflyweed	*Asclepias tuberosa*
Black-eyed Susan	*Rudbeckia hirta*
Blazing star, rough	*Liatris aspera*
Blue-eyed grass	*Sisyrinchium angustifolium*
Columbine, wild	*Aquilegia canadensis*
Lupine	*Lupinus perennis*
Onion, nodding wild	*Allium cernuum*
Spiderwort	*Tradescantia*

Example Tall Native Wildflowers (over 3')

Wet to Moist Conditions:

Aster, New England	*Virgulus novae-anglii*
Aster, swamp	*Aster puniceus*
Dotted mint	*Monarda punctata*
Golden alexanders	*Zizia aurea*
Red milkweed	*Asclepias incarnata*
Tall coreopsis	*Coreopsis tripteris*
Ox eye sunflower	*Heliopsis helianthoides*

Moist to Drier Conditions:

Showy goldenrod	Solidago speciosa
Stiff goldenrod	Solidago rigida
Sky blue aster	Aster oolantangiensis
Frost aster	Aster pilosus
Bergamot	Monard fistuloa
Meadow blazingstar	Liatris ligulistylus
Sweet black eyed susan	*Rudbeckia submentosa*

Wetland Vegetation

The following are examples of vegetation adapted to grow in low, wet areas and along the shoreline of ponds and lakes. Wetland areas are particularly useful in buffering nitrates because microbes in the organic soils convert nitrate into nitrogen gas through denitrification and can

substantially reduce the amount of nitrogen reaching surface waters. They can also help to stabilize erosion areas along the shorelines of waterbodies.

Example Wetland Species

Damp to Muddy Soils:

Joe pye weed	*Eupatorium purpureum*
Boneset	*Eupatorium perfoliatum*
Cardinal flower	*Lobelia cardinalis*
Blue vervain	*Verbena hastata*
Lizard's tail	*Saururus cernuus*
Great blue lobelia	*Lobelia siphilitica*
Wool grass	*Scirpus cyperinus*
Sedges	*Carex spp.*
American bulrush	*Scirpus americanus*
Dark green rush	*Scirpus atrovirens*

Moist shoreline to 1 foot of water:

Yellow water iris	*Iris pseudacorus*
Blue flag iris	*Iris versicolor*
Soft-stem bulrush	*Scirpus validus*
Bur reed	*Sparganium eurycarpum*
Arrowhead	*Saggitaria latifolia*
Sweet flag	*Acorus calamus*
Arrow Arum	*Peltandra virginica*
Water plantain	*Alisma plantago-aquatica*

1 to 3 feet of water:

Hardstem bulrush	*Scirpus acutus*
White waterlilly	*Nymphaea odorata*
Yellow waterlilly	*Nuphar advena*
Pickeral plant	*Pontederia cordata*

NRCS Plant Mixtures

The following seed mixtures were developed by the Natural Resources Conservation Service (NRCS) for their Conservation Reserve Enhancement Program (CREP). These particular seed mixtures may not be applicable in all golf course situations due to plant height. However, we have included these mixtures for general reference and as an example of some commonly used buffer species for the grass/forb zone. These mixtures can be altered to meet specific requirements. For instance, if plant height is of major concern, then you might want to consider a mix of little bluestem combined with a short wildflower mix.

NRCS recommended native plant mixtures

(smaller quantities may be suitable when combined with a cover crop)

- Mix 1: Upland Soils
    - Big bluestem @ 2 lbs/acre (pls*)
    - Indiangrass @ 2 lbs/acre (pls) OR Switchgrass @ 5 lbs/acre (pls)
    - Little bluestem @ 2 lbs/acre (pls)
    - Wildflower mixture @ 0.5 lbs/acre
- Mix 2: Wet Soils

    - Big bluestem @ 2 lbs/acre (pls)
    - Switchgrass @ 2 lbs/acre (pls)
    - Little bluestem @ 1 lbs/acre (pls)
    - Lowland wildflower mixture @ 0.5 lb/acre

*(pls = pure live seed)

Turf mixtures

In buffer areas that must be maintained as turf, mixtures containing fine fescue blends may be a good choice. Blends containing species such as Hard, Chewings, Creeping Red, Sheep, and Slender fescues have been used with some success in low maintenance situations. These mixes are available at several professional turf product distributors.

Example Golf Course Seed Mixes

The following seed mixes were developed specifically for the golf courses mentioned and are not intended to serve as recommended plant mixtures. Rather, they have been included as examples of how seed mixes may be tailored for individual golf courses. In addition, these lists are not intended to serve as an endorsement of any particular nursery or firm. These seed mixes were designed for different geographic regions and tailored to meet the specific needs of each site.

It should be pointed out that the cost of native grass and wildflower mixes may vary dramatically from year to year. This is usually because the availability of specific species is variable due to fluctuations in supply and demand. Therefore, the cost of a seed mix may be dramatically increased by only a few species. You may wish to bid species separately or work with your supplier to adjust the amounts of certain species to lower the cost of the seed mix.

Example #1: The following seed mix was developed by Esther Durnwald of the Michigan Wildflower Farm and Mike DeVries of DeVries Designs, Inc. for the Kingsley Club located in Traverse City, Michigan. Approximately 80 acres was the original estimate, with about 100-110 acres ultimately planted with a cover crop of fine fescues combined with the a seed mix of native grasses (primarily little bluestem) and wildflowers. The seeding rates were approximately 17 lbs per acre of fescue, 4 lbs per acre of little bluestem and 1 lb per acre of wildflower mix.

Based upon his experience with this project, Mr. DeVries now recommends that a spraying program to control weed growth be implemented prior to planting the wildflower mix. For the mix used on this project, he indicated he would plant the fescue and little bluestem first, implement a spraying program for 2 to 3 years to control weed growth, and then plant the wildflowers either by drilling in the seeds or broadcasting the seeds after a controlled burn.

Forbs – Mixed and spread together, except for the stiff goldenrod:

Columbine	*Aquilegia canadensis*
Butterflyweed	*Asclepias tuberosa*
New England Aster	*Aster novae-angiae*
Frost Aster	*Aster pilosus*
Sand tickseed	*Coreopsis lanceolata*
Wild lupine	*Lupinus perennis*
Bergamot	*Monarda fistulosa*
Early wild rose	*Rosa blanda*
Blackeyed Susan	*Rudbeckia hirta*
Blackeyed Susan	*Solidago nemoralis*
Stiff goldenrod	*Solidago rigida*

Native Grasses – Distributed Individually:

Little bluestem	*Schizachyrium scoparius*
Big bluestem / Turkeyfoot	*Andropogon gerardii*
Switchgrass	*Panicum virgatum*
Indian grass	*Sorghastrum nutans*
Junegrass	*Koeleria macrantha*

Example #2: The following seed mix was developed by Thomas Smith of Grass Roots Inc. for Groesbeck Golf Course in Lansing, Michigan. This project cost approximately $8,250 per acre and included some live plug plantings along with preparation and labor costs. Approximately 2-1/4 acres were planted on the project.

Native Forbs - Upland:

Columbine	*Aquilegia Canadensis*
Butterflyweed	*Asclepias tuberosa*
Smooth aster	*Aster laevis*
New England aster	*Aster novae-angliae (in selected areas only)*
Sand tickseed	*Coreopsis lanceolata*
Tall coreopsis	*Coreopsis tripteris (in selected areas only)*
Purple coneflower	*Echinacea purpurea*
Western sunflower	*Helianthus occidentalis (in selected areas only)*
Rough blazing star	*Liatrus aspera*
Lupine	*Lupinus perennis*
Bergamot	*Monarda fistulosa*
Horsemint	*Monarda punctata*
Hairy beardstongue	*Penstemon hirsutus*
Grayheaded coneflower	*Ratibida pinnata*
Black-eyed susan	*Rudbeckia hirta*

Prairie dock	*Silphium terebinthinaceum (in selected areas only)*
Cupplant	*Silphium perfoliatum (in selected areas only)*
Stiff goldenrod	*Solidago rigida*
Hoary vervain	*Verbena stricta*

Native Forbs - Wetland Edge:

Joe pye weed	*Eupatorium purpureum*
Boneset	*Eupatorium perfoliatum*
Cardinal flower	*Lobelia cardinalis*
Blue flag	*Iris versicolor*
Great blue lobelia	*Lobelia siphilitica*
Blue vervain	*Verbena hastata*
Lizard's tail	*Saururus cernuus*
Saururus cernuus	*Tradescantia ohiensis*
Prairie blazingstar	*Liatris pycnostachya*

Native Grasses/Sedges/Rushes Mix:

Big bluestem	*Andropogon gerardii (In selected areas only)*
Switch grass	*Ramcum virgatum (In selected areas only)*
Little bluestem	*Schizachyrium scoparium*
Indiangrass	*Sorghastrum nutans (In selected areas only)*
Assorted sedges and rushes	*Carex, Juncus, Scirpus, sp. (In wetland edge)*

Non-native annuals:

Pimpernel	*Anagallis arvensis*
Dwarf godetia	*Clarkia amoena*
Clarkia	*Clarkia unguiculata*
Dwarf plains coreopsis	*Coreopsis tinctoria*
Rocket larkspur	*Delphinium ajacis*
African daisy	*Dimorphotheca aurantiaca*
California poppy	*Eschschoizia californica*
Bird's eyes	*Gilia tricolor*
Candytuft	*Iberis umbellate*
Spurred snapdragon	*Linaria maroccana*
Sweet alyssum	*Lobularia maritime*
Texas bluebonnet	*Lupinus texensis*
Five-Spot	*Nemophila maculata*
Baby blue-eyes	*Nemophila menziesii*
Corn poppy	*Papaver rhoeas*
Dwarf catchfly	*Silene armeria*

Species to Avoid:

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Barberry	*Berberris spp.*
Common buckthorn	*Rhamnus cathartica*
Glossy buckthorn	*Rhamnus frangula*
Crown vetch	*Coronilla varia*
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Multiflora rose	*Rosa multiflora*
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Common mullein	*Verbascum thapsus*
Spotted Knapweed	*Centaurea maculosa*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Queen Anne’s lace	*Daucus carota*
Orchard grass	*Dactylis glomerata*
Timothy	*Phleum pratense*
Poison ivy	*Toxicodendron radicans*
Ragweed	*Ambrosia artemisiifolia*
Yarrow	*Achillea millefolium*
Hoary Alyssum	*Berteroa incana*
Common St. John's Wort	*Hypericum perforatum*
Common Motherwort	*Leonurus cardiaca*
Bladder campion	*Silene vulgaris*
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buffer zone plant mixes for the grass/forb zone. At the end of the fact sheet, we have included a list of helpful reference materials that can be used by those interested in devising their own planting schemes, including an interactive native plants CD-ROM available from Springfield Township, Michigan that can be used to identify plants appropriate for specific conditions. Information on how to order this CD- ROM is included in the reference section under native vegetation. In addition, many nurseries now specialize in native plants and have staff capable of assisting you in the development of plant mixtures to meet specific on- site requirements. The lists of plants contained within this fact sheet are not a complete listing of all native Michigan plants. Please refer to the attached reference section if you would like additional information.

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In selecting trees for riparian buffers, several factors should be considered. Trees closest to the waterway are most likely to be flooded during a portion of the year. If this is the case, you should select trees with a greater tolerance for high water tables. If the area has been recently disturbed, trees with a fast growth rate will quickly establish root systems to hold the soil. Fast- growing trees are not necessarily long- lived, therefore you may want to interplant some species with longer life spans. Trees with shallow rooting systems hold surface soils well, but do not provide as much stability to high banks and steep slopes as trees with deeper root systems. Deeper root systems anchor trees better where there are repeated flooding/drying cycles.

Example native trees

Wet to moist conditions:

Ash, Green	*Fraxinus pennsylvanica*
Aspen, Trembling	*Populus tremuloides*
Birch, River	*Betula nigra*
Birch, Yellow	*Betula alleghaniensis*
Blackgum	*Nyssa sylvatica*
Cedar, Northern white	*Thuja occidentalis*
Hemlock, Eastern	*Tsuga canadensis*
Hickory, bitternut	*Carya cordiformis*
Maple, Red	*Acer rubrum*
Maple, Silver	*Acer sacharinum*
Musclewood	*Carpinus caroliniana*
Oak, bur	*Quercus macrocarpa*
Oak, Pin	*Quercus palustris*
Oak, Swamp white	*Quercus bicolor*
Sycamore	*Platanus occidentalis*
Willow, Black	*Salix nigra*

Moist to drier conditions:

Ash, blue	*Fraxinus quadrangulata*
Ash, white	*Fraxinus americana*
Basswood	*Tilia americana*

Beech, American	*Fagus grandifolia*
Birch, Paper	*Betula papyrfiera*
Cedar, eastern red	*Juniperus virginiana*
Cherry, black	*Prunus serotina*
Crab apple, wild	*Malus coronaria*
Dogwood, flowering	*Cornus florida*
Hackberry	*Celtis occidentalis*
Hickory, pignut	*Carya glabra*
Hickory, shagbark	*Carya ovata*
Ironwood	*Ostrya virginiana*
Maple, sugar	*Acer saccharum*
Oak, black	*Quercus velutina*
Oak, chinquapin	*Quercus muehlenbergii*
Oak, red	*Quercus rubra*
Oak, white	*Quercus alba*
Pawpaw	*Asimina triloba*
Redbud	*Cercis canadensis*
Sassafras	*Sassafrass albidum*
Tuliptree	*Liriodendron tilipifera*
Walnut, black	*Juglans nigraz*

Note: Some of the species listed above are not native to the entire state. Species native to southern Michigan may not be considered native in northern Michigan or the Upper Peninsula.

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Example Native Shrubs

Wet to moist conditions:

Alder, speckled	*Alnus rugosa*
Bladdernut, American	*Staphylea trifolia*
Buttonbush	*Cephalanthus occidentalis*
Cranberry, highbush	*Viburnum trilobum*
Dogwood, red- osier *	*Cornus stolinifera*
Dogwood, silky	*Cornus amomum*
Elderberry, American	*Sambucus canadensis*
Meadowsweet	*Spirea alba*
Nannyberry	*Viburnum lentago*
Ninebark *	*Physocarpus opulifolius*
Rose, swamp	*Physocarpus opulifolius*

Spicebush	*Lindera benzoin*

*can be aggressive ** prefers dry, open environments

Moist to Drier Conditions:

Arrow- wood, downy	*Viburnum rafinesquianum*
Vibernum, mapleleaf	*Viburnum acerifolium*
Chokecherry	*Prunus virginiana*
Dogwood, gray	*Cornus foemina*
Hazelnut, American	*Corylus americana*
New Jersey Tea **	*Ceanothus americanus*
Rose, wild	*Rosa blanda*
Serviceberry, shadblow	*Amelanchier arborea*
Serviceberry, Allegheny	*Amelanchier laevis*
Sumac, Staghorn	*Rhus typhina*

Grasses and Wildflowers

Grassed buffer areas may typically consist of warm or cool season grasses. Warm season grasses include species such as big bluestem, little bluestem, Indiangrass, and switchgrass. Fine fescues are a good cool season choice for golf course buffer areas. When appropriate, wildflowers may also be interspersed into grassed buffer areas for added aesthetic value and attracting butterflies.

In natural areas, native warm season grasses are preferred for wildlife habitat. These grasses provide excellent cover necessary for the mating, nesting, brood- rearing and feeding activities of many small birds and mammals. Most warm season grasses are not shade tolerant and may not do well planted directly adjacent to shady forested areas. A good solution is to plant a shrub transition zone in between the grassed and forested areas.

Example Short Native Grasses and Sedges (up to 4')

Wet to Moist Conditions:

Creeping spike rush	*Eleocharis palustris*
Soft rush	*Juncus effusus*
Lake sedge	*Carex lacustris*
Green bulrush	*Scirpus atrovirens*

Moist to Drier Conditions:

Bluestem, Little	*Schizachyrium scoparium*
Pennsylvania sedge	*Carex pensylvanica*
Purple lovegrass	*Eragrostis spectabilis*
June grass	*Koeleria macrantha*

Example Tall Native Grasses and Sedges

Wet to Moist Conditions:

Hardstem bulrush	*Scirpus acutus*
Prairie cordgrass	*Spartina pectinata*
Wild-rye, Canada	*Elymus canadensis*
Wild- rye, Virginia	*Elymus virginicus*
Wool grass	*Scirpus cyperinus*
Bottlebrush grass	*Hystrix patula*

Moist to Drier Conditions:

Bluestem, big	*Andropogon gerardii*
Switch grass	*Panicum virgatum*
Indian grass	*Sorghastrum nutans*

Example Short Native Wildflowers (up to 3')

Wet to Moist Conditions:

Anemone, Canada	*Anemone canadensis*
Beard-tongue, hairy	*Penstemon hirsutus*
Golden alexanders	*Zizia aurea*
Lobelia, great blue	*Lobelia siphilitica*
Marsh marigold	*Caltha palustris*

Moist to Drier Conditions:

Smooth aster	*Aster laevis*
Butterflyweed	*Asclepias tuberosa*
Black-eyed Susan	*Rudbeckia hirta*
Blazing star, rough	*Liatris aspera*
Blue-eyed grass	*Sisyrinchium angustifolium*
Columbine, wild	*Aquilegia canadensis*
Lupine	*Lupinus perennis*
Onion, nodding wild	*Allium cernuum*
Spiderwort	*Tradescantia*

Example Tall Native Wildflowers (over 3')

Wet to Moist Conditions:

Aster, New England	*Virgulus novae-anglii*
Aster, swamp	*Aster puniceus*
Dotted mint	*Monarda punctata*
Golden alexanders	*Zizia aurea*
Red milkweed	*Asclepias incarnata*
Tall coreopsis	*Coreopsis tripteris*
Ox eye sunflower	*Heliopsis helianthoides*

Moist to Drier Conditions:

Showy goldenrod	*Solidago speciosa*
Stiff goldenrod	*Solidago rigida*
Sky blue aster	*Aster oolantangiensis*
Frost aster	*Aster pilosus*
Bergamot	*Monard fistuloa*
Meadow blazingstar	*Liatris ligulistylus*
Sweet black eyed susan	*Rudbeckia submentosa*

Wetland Vegetation

> The following are examples of vegetation adapted to grow in low, wet areas and along the shoreline of ponds and lakes. Wetland areas are particularly useful in buffering nitrates because microbes in the organic soils convert nitrate into nitrogen gas through denitrification and can substantially reduce the amount of nitrogen reaching surface waters. They can also help to stabilize erosion areas along the shorelines of waterbodies.

Example Wetland Species

Damp to Muddy Soils:

Joe pye weed	*Eupatorium purpureum*
Boneset	*Eupatorium perfoliatum*
Cardinal flower	*Lobelia cardinalis*
Blue vervain	*Verbena hastata*
Lizard’s tail	*Saururus cernuus*
Great blue lobelia	*Lobelia siphilitica*
Wool grass	*Scirpus cyperinus*
Sedges	*Carex spp.*

American bulrush	*Scirpus americanus*
Dark green rush	*Scirpus atrovirens*

Moist shoreline to 1 foot of water:

Yellow water iris	*Iris pseudacorus*
Blue flag iris	*Iris versicolor*
Soft- stem bulrush	*Scirpus validus*
Bur reed	*Sparganium eurycarpum*
Arrowhead	*Saggitaria latifolia*
Sweet flag	*Acorus calamus*
Arrow Arum	*Peltandra virginica*
Water plantain	*Alisma plantago-aquatica*

1 to 3 feet of water:

Hardstem bulrush	*Scirpus acutus*
White waterlilly	*Nymphaea odorata*
Yellow waterlilly	*Nuphar advena*
Pickeral plant	*Pontederia cordata*

NRCS Plant Mixtures

The following seed mixtures were developed by the Natural Resources Conservation Service (NRCS) for their Conservation Reserve Enhancement Program (CREP). These particular seed mixtures may not be applicable in all golf course situations due to plant height. However, we have included these mixtures for general reference and as an example of some commonly used buffer species for the grass/forb zone. These mixtures can be altered to meet specific requirements. For instance, if plant height is of major concern, then you might want to consider a mix of little bluestem combined with a short wildflower mix.

NRCS recommended native plant mixtures

(smaller quantities may be suitable when combined with a cover crop)

- Mix 1: Upland Soils
    - Big bluestem @ 2 lbs/acre (pls*)
    - Indiangrass @ 2 lbs/acre (pls) OR Switchgrass @ 5 lbs/acre (pls)
    - Little bluestem @ 2 lbs/acre (pls)
    - Wildflower mixture @ 0.5 lbs/acre
- Mix 2: Wet Soils

- Big bluestem @ 2 lbs/acre (pls)
- Switchgrass @ 2 lbs/acre (pls)
- Little bluestem @ 1 lbs/acre (pls)
- Lowland wildflower mixture @ 0.5 lb/acre

*(pls = pure live seed)

Turf mixtures

In buffer areas that must be maintained as turf, mixtures containing fine fescue blends may be a good choice. Blends containing species such as Hard, Chewings, Creeping Red, Sheep, and Slender fescues have been used with some success in low maintenance situations. These mixes are available at several professional turf product distributors.

Example Golf Course Seed Mixes

The following seed mixes were developed specifically for the golf courses mentioned and are not intended to serve as recommended plant mixtures. Rather, they have been included as examples of how seed mixes may be tailored for individual golf courses. In addition, these lists are not intended to serve as an endorsement of any particular nursery or firm. These seed mixes were designed for different geographic regions and tailored to meet the specific needs of each site.

It should be pointed out that the cost of native grass and wildflower mixes may vary dramatically from year to year. This is usually because the availability of specific species is variable due to fluctuations in supply and demand. Therefore, the cost of a seed mix may be dramatically increased by only a few species. You may wish to bid species separately or work with your supplier to adjust the amounts of certain species to lower the cost of the seed mix.

Example #1: The following seed mix was developed by Esther Durnwald of the Michigan Wildflower Farm and Mike DeVries of DeVries Designs, Inc. for the Kingsley Club located in Traverse City, Michigan. Approximately 80 acres was the original estimate, with about 100-110 acres ultimately planted with a cover crop of fine fescues combined with the a seed mix of native grasses (primarily little bluestem) and wildflowers. The seeding rates were approximately 17 lbs per acre of fescue, 4 lbs per acre of little bluestem and 1 lb per acre of wildflower mix.

Based upon his experience with this project, Mr. DeVries now recommends that a spraying program to control weed growth be implemented prior to planting the wildflower mix. For the mix used on this project, he indicated he would plant the fescue and little bluestem first, implement a spraying program for 2 to 3 years to control weed

growth, and then plant the wildflowers either by drilling in the seeds or broadcasting the seeds after a controlled burn.

Forbs – Mixed and spread together, except for the stiff goldenrod:

Columbine	*Aquilegia canadensis*
Butterflyweed	*Asclepias tuberosa*
New England Aster	*Aster novae-angiae*
Frost Aster	*Aster pilosus*
Sand tickseed	*Coreopsis lanceolata*
Wild lupine	*Lupinus perennis*
Bergamot	*Monarda fistulosa*
Early wild rose	*Rosa blanda*
Blackeyed Susan	*Rudbeckia hirta*
Blackeyed Susan	*Solidago nemoralis*
Stiff goldenrod	*Solidago rigida*

Native Grasses – Distributed Individually:

Little bluestem	*Schizachyrium scoparius*
Big bluestem / Turkeyfoot	*Andropogon gerardii*
Switchgrass	*Panicum virgatum*
Indian grass	*Sorghastrum nutans*
Junegrass	*Koeleria macrantha*

Example #2: The following seed mix was developed by Thomas Smith of Grass Roots Inc. for Groesbeck Golf Course in Lansing, Michigan. This project cost approximately $8,250 per acre and included some live plug plantings along with preparation and labor costs. Approximately 2-1/4 acres were planted on the project.

Native Forbs - Upland:

Columbine	*Aquilegia Canadensis*
Butterflyweed	*Asclepias tuberosa*
Smooth aster	*Aster laevis*
New England aster	*Aster novae-angliae (in selected areas only)*
Sand tickseed	*Coreopsis lanceolata*
Tall coreopsis	*Coreopsis tripteris (in selected areas only)*
Purple coneflower	*Echinacea purpurea*
Western sunflower	*Helianthus occidentalis (in selected areas only)*
Rough blazing star	*Liatrus aspera*
Lupine	*Lupinus perennis*
Bergamot	*Monarda fistulosa*
Horsemint	*Monarda punctata*

Hairy beardstongue	*Penstemon hirsutus*
Grayheaded coneflower	*Ratibida pinnata*
Black-eyed susan	*Rudbeckia hirta*
Prairie dock	*Silphium terebinthinaceum (in selected areas only)*
Cupplant	*Silphium perfoliatum (in selected areas only)*
Stiff goldenrod	*Solidago rigida*
Hoary vervain	*Verbena stricta*

Native Forbs - Wetland Edge:

Joe pye weed	*Eupatorium purpureum*
Boneset	*Eupatorium perfoliatum*
Cardinal flower	*Lobelia cardinalis*
Blue flag	*Iris versicolor*
Great blue lobelia	*Lobelia siphilitica*
Blue vervain	*Verbena hastata*
Lizard’s tail	*Saururus cernuus*
Saururus cernuus	*Tradescantia ohiensis*
Prairie blazingstar	*Liatris pycnostachya*

Native Grasses/Sedges/Rushes Mix:

Big bluestem	*Andropogon gerardii (In selected areas only)*
Switch grass	*Ramcum virgatum (In selected areas only)*
Little bluestem	*Schizachyrium scoparium*
Indiangrass	*Sorghastrum nutans (In selected areas only)*
Assorted sedges and rushes	*Carex, Juncus, Scirpus, sp. (In wetland edge)*

Non-native annuals:

Pimpernel	*Anagallis arvensis*
Dwarf godetia	*Clarkia amoena*
Clarkia	*Clarkia unguiculata*
Dwarf plains coreopsis	*Coreopsis tinctoria*
Rocket larkspur	*Delphinium ajacis*
African daisy	*Dimorphotheca* aurantiaca
California poppy	*Eschschoizia californica*
Bird’s eyes	*Gilia tricolor*
Candytuft	*Iberis umbellate*
Spurred snapdragon	*Linaria maroccana*
Sweet alyssum	*Lobularia maritime*
Texas bluebonnet	*Lupinus texensis*
Five-Spot	*Nemophila maculata*

Baby blue-eyes	*Nemophila menziesii*
Corn poppy	*Papaver rhoeas*
Dwarf catchfly	*Silene armeria*

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Organizations
Michigan Native Plant Producers Association, Contact: Bill Schneider 517-244-1140

Michigan Wildflower Association, Contact: Marilyn Case 616-781-8470

Wetland Protection

Principles

- Wetlands act both as filters for pollutant removal and as nurseries for many species. Many people do not realize the vital role they play in purifying surface waters.
- The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland is the recycling factory of our ecosystem. While wetlands do pose a special concern, their mere presence is not incompatible with the game of golf. With care, many golf holes have been threaded through sensitive areas, and with proper design and management golf can be an acceptable neighbor.
- When incorporated into a golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers.
- Constructed or disturbed wetlands may be permitted to be an integral part of the stormwater management system.

Best Management Practices

- Establish wetlands where water enters lakes to slow water flow and trap sediments.
- Maintain appropriate silt fencing and BMP on projects upstream to prevent erosion and sedimentation.

- Natural waters cannot be considered treatment systems and must be protected. (Natural waters do not include treatment wetlands.)
- Establish a low- to no-maintenance level within a 75-foot buffer along non-tidal and tidal wetlands.
- Establish and maintain a 100-foot riparian buffer around wetlands, springs, and spring runs.

Stormwater Management

Principle

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

Best Management Practices

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

Sediment

Principle

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

Best Management Practices

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

Sodic/Saline Conditions

Principles

- All natural waters contain soluble salts; however, the amount and type of salts they contain vary greatly.
- Irrigation water can degrade when wells are pumped at high rates or for prolonged periods. Sometimes “up-coning” can occur from pumping, whereby saline water, rather than freshwater, is drawn into the well.
- Saline water typically is unsuitable for irrigation because of its high content of TDS.
- Saltwater intrusion from groundwater pumping near coastal areas can create a problem with some irrigation wells.

Best Management Practices

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

Surface Water Management

Stormwater Capture

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

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

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

Principles

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

Best Management Practices

- Install berms and swells to capture pollutants and sediments from runoff before it enters the irrigation storage pond.
- Monitor pond water level for water loss (seepage) to underground systems. If seepage is occurring, it may be necessary to line or seal the pond or install pumps to relocate water.
- Install water-intake systems that use horizontal wells placed in the subsoil below the storage basin; use a post pump to filter particulate matter.
- A backup source of water should be incorporated into the management plan.
- Inspect irrigation pumps, filtration systems, conveyances and control devices to prevent/correct system issues.

Regulatory Considerations

Principle

Course owners and superintendents should investigate regulatory requirements that apply to the golf facility to protect surface and groundwater quality. Under the Clean Water Act, Michigan is required to adopt water quality standards. Water quality standards are in place to help protect and improve the quality of the nation's surface water. More information on Michigan's water quality standards can be found at the EPA's Water Quality Standards Regulations: Michigan page.

Best Management Practices

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

Water Quality Protection

Principle

- An aquatic plant management strategy should address the intended uses of the waterbody to maintain water quality. Proper documentation of the site's physical attributes and location, the presence of invasive or weedy species, aesthetics, watershed and groundwater assessments, and other environmental considerations.
- Only licensed individuals or contractors should be allowed to select and apply aquatic pesticides.
- Contain sediments from areas under construction.
- Treat stormwater runoff, especially impervious areas with adequate settling.

Best Management Practices

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

Dissolved Oxygen

Principles

- Every golf course should have a plan to monitor the state of the environment and the effects the golf course may be having on the environment.
- Monitoring is used to determine whether outside events are changing the water quality entering the golf course, or whether the golf course is having a positive, neutral, or negative effect on water quality. It also provides a body of evidence on the golf course's environmental impact.
- A water-quality monitoring plan should be prepared to ensure the ongoing protection of groundwater and surface-water quality after construction has been completed. The same sites should be monitored during the preconstruction phase, although the monitoring plan can be modified based on site-specific conditions.
- Sampling parameters are determined based on golf course operation and basin-specific parameters of concern (these may be identified by local/state Total Maximum Daily Load (TMDL) Programs). Typically, samples should be analyzed for nutrients, pH and alkalinity, sediments, and suspended solids, dissolved oxygen (DO), heavy metals, and any pesticides expected to be used on the golf course.
- Ongoing, routine water sampling provides meaningful trends over time. A single sample is rarely meaningful in isolation.
- Post-construction sampling of surface-water quality should begin with the installation and maintenance of golf course turf and landscaping. Samples should be collected a minimum of three times per year.
- If there is no discharge on the scheduled sample date, samples should be taken during the next discharge event.
- Post-construction surface-water quality sampling should continue through the first three years of operation and during the wet and dry seasons every third year thereafter, provided that all required water-quality monitoring has been completed and the development continues to implement all current management plans. It may also be wise to sample if a significant change has been made in course operation or design that could affect nearby water quality.
- Sampling parameters should be determined based on golf course operation and any basin-specific parameters of concern (identified by the TMDL program or local regulators).
- The purpose of quality assurance/quality control (QA/QC) is to ensure that chemical, physical, biological, microbiological, and toxicological data are appropriate and reliable. Data should be collected and analyzed using scientifically sound procedures.
- However, even if the data are only for proprietary use and are not reported to any regulatory agency, it is strongly recommended that a certified laboratory be used and all QA/QC procedures followed.
- Golf course management must have good data to make good decisions. If a golf course should ever want to produce data for an agency or go to court to defend the facility from unwarranted charges, those data must meet QA/QC standards to be defensible as evidence.

Best Management Practices

- Establish DO thresholds to prevent fish kills (occur at levels of 2 ppm), for example, use artificial aeration (diffusers).
- Reduce stress on fish; keep DO levels above 3 ppm.

- Select algaecides containing hydrogen peroxide instead of copper or endothall to treat high populations of phytoplankton.
- Use IPM principles to limit excess use of pesticides.
- Spot-treat filamentous algae or frequently remove algae by hand to prevent lowering oxygen concentrations in water.
- Use dyes and aeration to maintain appropriate light and DO levels.
- Apply algaecides to small areas to prevent fish mortality; do not treat the entire pond at once.
- Coordinate construction/renovation activities to minimize the amount of disturbed area and possible risk of contamination via runoff.
- Plan construction/renovation activities in phases to limit soil disruption and movement.
- Sod, spring, or reseed bare or thinning turf areas.
- Mulch areas under tree canopies to cover bare soil.
- Avoid the use of trimmers along the edge of the water body.
- Mow lake and pond collars at a higher height to slow and filter overland flow to waterbodies.
- Remove excess sediments to reduce irrigation system failures.
- Treat dredged materials as a toxic substance. Avoid contact with turf.
- Locate littoral shelves at the pond's inlets and outlets to reduce problems with the playability and maintainability of a water hazard.
- Seek professional assistance from an environmental specialist to design an appropriate water sample collection strategy.
- Determine which sites will be analyzed, and use reputable equipment and qualified technicians.
- Demonstrate responsible land and water use practices based on water data.
- Define data values appropriately based on the associated BMP used to protect water quality.
- Record observations of fish, wildlife, and general pond conditions.

Aquatic Plants

Principles

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

- Ponds may be constructed on golf courses strictly as water hazards or for landscape purposes, but they often have the primary purpose of drainage and stormwater management, and are also often a source of irrigation water.

Best Management Practices

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

Human Health Concerns

Principles

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

Best Management Practices

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

Floodplain Restoration

Principles

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

Best Management Practices

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

Stormwater, Ponds, and Lakes

Stormwater is the conveying force behind what is called nonpoint source pollution. Nonpoint pollution, which is both natural and caused by humans, comes not from a pipe from a factory or sewage treatment plant, but from daily activity. Pollutants commonly found in stormwater include the microscopic wear products of brake linings and tires; oil; shingle particles washed off roofs; soap, dirt, and worn paint particles from car washing; leaves and grass clippings; pet and wildlife wastes; lawn, commercial, and agricultural fertilizers; and pesticides.

Principles

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

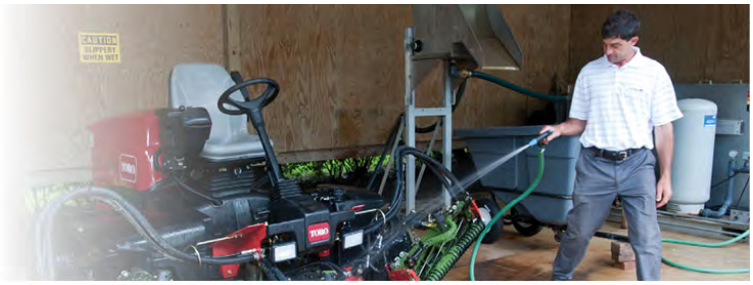
Best Management Practices

- Install swales and slight berms where appropriate around the water’s edge, along with buffer strips, to reduce nutrients and contamination.
- Design stormwater treatment trains to direct stormwater across vegetated filter strips (such as turfgrass), through a swale into a wet detention pond, and then out through another swale to a constructed wetland system.
- Ensure that no discharges from pipes go directly to water.
- Eliminate or minimize directly connected impervious areas.

- Use vegetated swales to slow and infiltrate water and trap pollutants in the soil, where they can be naturally destroyed by soil organisms.
- Use depressed landscape islands in parking lots to catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated stormwater drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.
- Maximize the use of pervious pavements, such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots.
- Disconnect runoff from gutters and roof drains from impervious areas, so that it flows onto permeable areas that allow the water to infiltrate near the point of generation.
- Golf course stormwater management should include “natural systems engineering” or “soft engineering” approaches that maximize the use of natural systems to treat water.
- Ensure that no discharges from pipes go directly to water.
- Use a treatment train approach.
- Institute buffers and special management zones.
- Utilize local or Michigan stormwater manuals.

Maintenance Operations

Regulatory Considerations



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

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

Storage and Handling of Chemicals

Principles

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

Best Management Practices

- Storage buildings should have appropriate warning signs and placards.
- Follow all personal protective equipment (PPE) statements on pesticide labels.
- Store PPE away from pesticide storage areas in an area that is easily accessible.
- Develop an emergency response plan and educate all golf course personnel regarding emergency procedures on a regular basis.
- Individuals conducting emergency chemical cleanups should be properly trained under requirements of federal Occupational Safety and Health Administration (OSHA).
- Store pesticides in a lockable concrete or metal building.
- Locate pesticide storage away from other buildings, especially fertilizer storage facilities.
- Floors of chemical storage buildings should be impervious and sealed with chemical-resistant paint.
- Floors of chemical storage buildings should have a continuous sill to contain spills and should not have a drain. A sump is acceptable.

- Shelving should be fabricated from plastic or reinforced metal. Metal shelving should be painted to avoid corrosion. Wood shelving should never be used because of its ability to absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided
- Explosion-proof lighting may be required. Locate fan and light switches outside the entrance to the building to facilitate ventilation of building before entrance of staff.
- Maintain detailed records of current pesticide inventory in the storage facility. Safety Data Sheets (SDS) for the chemicals stored on-site should be stored separate from the storage room, but readily accessible on-site.
- Do not store large quantities of pesticides or chemicals for long periods of time. Follow a "first in, first out" principle to rotate products into use to ensure products do not expire.
- Store chemicals in original containers. Never store them in containers that might be mistaken as packaging for food or drink.
- Arrange containers so the labels are clearly visible. Securely fasten loose labels to ensure containers and associated labels are kept together.
- Damaged labels should be replaced immediately.
- Store flammable pesticides separate from those that are nonflammable.
- Store liquid materials below dry materials to prevent leaks from contaminating dry products.
- Ensure that oil containers and small fuel containers (service containers) are properly labeled and stored within the facility.
- To recycle pesticide containers, please visit the MDARD Pesticide Container Recycling site for further information

Equipment Storage and Maintenance

Principle

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

Best Management Practices

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

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

Waste Handling

Principles

- Proper disposal of waste materials is critical for protection of water and natural resources. Michigan and/or local laws and regulations related to disposal of hazardous waste products may vary. Be sure to familiarize yourself with all statewide and local laws related to disposal/recycling of these waste materials.
- Identify and implement waste-reduction practices.
- Look for ways to increase recycling efforts and programs.
- Purchase environmentally preferred products in bulk packaging when possible.
- Do not allow mixing of waste and rain runoff; ensure all waste containers are covered if outdoors.

Best Management Practices

- Pesticides that have been mixed for application must be disposed of as waste and may be classified as hazardous waste depending on the materials involved. Contact local authorities for guidance regarding proper disposal.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them as directed by local and Michigan authorities.
- Antifreeze is considered hazardous waste by Michigan and should be handled accordingly. Commercial services are available to collect and recycle antifreeze.
- Lead-acid batteries are classified as hazardous waste unless they are properly recycled.
- Store old batteries on impervious services where they are protected from rainfall and recycle as soon as possible.
- Recycle used tires.
- Recycle or dispose of fluorescent tubes and other lights according to Michigan requirements.

Equipment Washing

Principle

Cleaning mowing equipment after each use is a common practice throughout the turfgrass industry. Wash stations are usually outfitted using water with relatively low pressure (< 100 psi) and high volume (20-80 gallons per minute). Pressure washers that generate a stream of high pressure (>1500 psi) and relatively low volume (< 20 gallons per minute) are not favored because they can be destructive to the bearings and other fittings on the equipment. The simple objective of the operation is to remove the clippings from the equipment so it's clean for the next use. Along with the clippings, dirt collected on the decks, reels, wheels, and carriage of the mowers are also removed in the wash process. Only in those instances where the wastewater is recycled and treated or sent to an appropriate wastewater treatment facility should the facility consider washing engines or other parts that could introduce petroleum products into the discharged wastewater.

Potential Contaminants

It is common to find equipment-washing stations located near surface water bodies. Early designs provided for the wastewater, clippings, and soil to be discharged from the wash area directly into a drainage ditch, stream, pond, or storm water catch basin. The watercourse provided the means to dilute the waste and move it away from the wash area. Grass clippings along with the soil washed from the machinery represent a significant organic load with the potential to contaminate surface water resources. The primary contaminants of issue in grass clippings are the nutrients nitrogen and phosphorous. The percentage of nitrogen and phosphorous in grass clippings are similar to that represented in animal manure as described in the table below.

Nitrogen and phosphorous deposited in natural surface water systems are problematic as they can promote the growth of aquatic vegetation. Phosphorous in particular, is a catalyst for algal growth. Aggressive aquatic plant growth can change other characteristics of the water system that lead to overall degradation for wildlife and recreational uses. Soil carried away in the wash water can be suspended in the water column, deposited on the bottom, and can carry nutrients into the water. All are considered detrimental to aquatic systems.

Therefore, identifying clippings as "green manure" is an appropriate mental image. Everyone knows what happens to a pile of grass clippings that gets hot and wet – it can quickly turn anaerobic, turn into a slimy mess and create a powerful stench. This slurry will release the phosphorous and nitrogen as the clippings degrade and can move downstream if they are not segregated from the water system.

Regulatory Picture

The use of water to clean turf equipment is defined as a "wastewater" because it carries liquid waste resulting from an industrial or commercial process. As such, EGLE regulates the discharge of this water. The technical guts of this regulation are found in Section 3109 of Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451). It states that:

"a person shall not directly or indirectly discharge into the waters of the state a substance that is or may become injurious to any of the following to the public health, safety or welfare."

The "waters of the state" means groundwater, lakes, rivers, streams, wetlands, and all other water courses. Section 3112 of Act 451 also requires that a person shall not discharge waste or waste effluent into the waters of the state unless the person is in possession of a valid permit

from the department.

In August of 1999, the Waste Management Division (WMD) of the EGLE released new rules to regulate the discharge of wastewater to the ground, or more specifically to groundwater since any discharge to the ground surface has the potential to reach groundwater. These rules are referred to as the "Part 22 Rules". This rule making process was a remarkable effort for EGLE and took over 6 years to complete. It involved collaboration with many user groups, public meetings, and legislative oversight. Overall, the rules are preventative in nature and are intended to prevent contamination that could pose an unacceptable environmental or health risk. No discharge can become "injurious" meaning that it cannot cause groundwater to lose its usefulness for drinking, agriculture, recreation, industry, or other uses.

The Part 22 rules group discharges into six categories and define what type of permit is required for each category. The categories range from those that are exempt from a groundwater discharge permit to those requiring highly a detailed groundwater discharge permit involving routine and individualized agency review. Let's examine each of these categories.

- Exemptions - There are approximately 25 types of groundwater discharges listed in the rules that are exempted, or not required to have a permit to discharge. These are discharges that are common and pose little environmental or health threat. They range from household septic systems to the use of portable power washers. By working directly with the Waste Management Division, specific criteria will be established so mowing equipment wash systems in the turfgrass industry are not required to obtain a groundwater discharge permit. Details of how turf systems should operate in order to be exempted are explained below in the "Turf Industry Wash Systems" section.
- Notifications - The discharges in this category must notify the department of their activities through the filing of an application form.
- Certifications - The discharges in this category must file an application form, and wait for department approval before they can begin discharging.
- General Permit - This authorization is for groups of dischargers having the same type of wastewater. Criteria have been developed which if met by a discharger, they file an application form, and if the department concurs they meet the criteria of the general permit, they receive a certificate of coverage.
- Specific Discharges - The department has established specific engineering criteria for treatment systems that the applicant must meet to qualify for this authorization. This category includes sanitary sewage less than 50,000 gallons per day and laundromat wastewater less than 20,000 gallons per day.
- Permits - This category is for all other dischargers not listed elsewhere in the rules, and has very extensive engineering and hydrogeologic requirements.

Turf Industry Wash Systems

There are several options available to discharge wastewater from the wash stations without requiring a permit from EGLE. I have categorized the options into systems where the water is treated or systems where the clippings are separated and the water is discharged on-site. Treatments systems involve on-site equipment that clean the water or where the water is discharged to a local treatment facility via a sanitary sewer connection. A separation system has specific criteria of how the water is handled and discharged. The Water Bureau has identified the basic criteria for use on turf management sites and when used according to these directions, does not require a permit.

Treatment Systems

On-Site Closed Loop Treatment Systems

There are several high-tech machines available on the market that offer a "closed loop" whereby the same water is used over and over and there is no discharge from the system. They offer a variety of filter systems ranging from mechanical screens, chemical filters, and ozone treatment to the use of biological digestion. There are some distinct advantages to this type of system. They are designed to trap or treat variety of wastes including petroleum, pesticides and nutrients. Therefore, they could be used for the everyday washing of equipment, they can handle petroleum products from engine cleaning, and they could also be used as a pesticide mixing and loading pad. The disadvantage is that the initial and maintenance costs are higher than other systems. An example of closed loop treatment system from ESD Waste2Water can be seen in the video below.

Off Site Treatment - Discharge to Sanitary Sewer

Wash systems can be connected directly to a sanitary sewer. Since the waste is being treated by a wastewater treatment facility downstream, the water can contain some clippings, soil or even minor amounts of petroleum products. Before your wash station is hooked into a sanitary sewer system, you must have authorization from the treatment facility. It is optimum to have some type of screening mechanism to separate the clippings from the water stream. This system has been successful at Kalamazoo Country Club.

Separation Systems

These systems are designed to separate the clippings from the water and then discharge the water on site. The primary criteria that must be followed for this use to be allowed without a permit are listed below. A few specific examples of successful systems follow the basic criterion.

- Do not discharge the wash water to a surface water body. This includes wetlands, ponds, lakes, streams and stormwater catch basins.
- The wash water should not contain any additives, including soaps or degreasers.
- Do not wash motors or directly discharge petroleum products into the wash water.

Dog Leash System

This system is simple. Just use a connection to the irrigation system and wash the equipment over a turfed area where the water will infiltrate and will not flow across the surface into a water body. The spot where the equipment is washed should be moved around like a dog on a leash so the area does not become muddy and problematic. The need to move the wash spot will depend on the amount of water used and the percolation rate of the soil. The advantages of this system are low cost and no need to handle the clippings as they can settle into the existing turf. A few golf courses within the Huron-Clinton Metroparks currently use this system.

Catch and Release - Above Ground

In this system, the clippings are captured through some type of screening mechanism and the wash water is released to the ground surface for infiltration. There must be no connection to surface water in this system. The clippings are collected and either returned to a turfed area or composted. The advantage of this system is relatively low cost but it demands handling of the captured clippings. Systems that have been successful are located at the Marysville Golf Course, Gull Lake View and Spring Lake Country Club to name a few.

Catch and Release - Below Ground
This system is similar to the above ground Capture and Release process, but the water is discharged to an underground infiltration network like those used in a septic system. The clippings can be captured via an above ground screening system or a tank containing separation baffles that trap the clippings from the water (septic tank or oil-water separator). If a tank is used, the grass clipping sludge must be removed and disposed of by a licensed Liquid Industrial Waste hauler. This waste is does not meet the definition of "septage" so a conventional septic tank hauler is not authorized to dispose of this material. An above ground clippings screen with an underground discharge field is being used at Gull Lake View - Stonehedge Golf Course. A septic tank and underground discharge field is being used at the Wuskowhan Players Club.

Best Management Practices

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

Fueling Facilities

Principle

Safe storage of fuel, including use of above-ground tanks and containment facilities, is critical to the protection of the environment. Fuel storage has long been recognized as one of the most significant threats to water quality on turfgrass systems. To reduce the potential for groundwater contamination, properties with underground tanks that were installed before December 22, 1988, were required by EGLE, to upgrade or remove them by December 22, 1998. In addition to regulatory guidelines, many operations have replaced underground tanks because of the difficulty in assessing their integrity.

Regulations for above and below ground tanks can be very confusing at times as they involve federal, state and local authorities. This module will offer guidance through the regulatory maze of storage tank requirements and assist you in understanding the potential risk for water contamination. In addition, many practical tips will be discussed that will further your level of water quality protection and personal safety. The worksheet section will help you evaluate your level of compliance, identify the level of protection your operation currently offers and ascertain what fuel storage changes would be most appropriate for your property.

Consequences of a Petroleum Tank Leak

Although underground and aboveground storage tanks can store a variety of materials, most underground tanks in Michigan store petroleum products (gasoline, diesel fuel, and heating oil).

Petroleum leaks and spills create contamination that is especially difficult to clean up. The type and extent of contamination depends on the amount and type of fuel leaked, the permeability of the soil, the depth to the water table and the rate at which groundwater is moving. Fuel is lighter than water and the two do not readily mix. The fuel tends to remain on the top of the water table, moving through the pores between rock and soil particles and leaving behind a residue of fuel.

Fuel that is left behind in the soil pores is gradually flushed downward by the rain and melting snow. Soluble components of the fuel are carried into the groundwater and can continue to contaminate it for many years after the spill or leak occurs. In addition, if the level of the water table drops, a thin coating of oil on the rock and soil particles will be left behind and it is very difficult to flush out. Although some bacteria can break down a significant amount of this oil residue when conditions are favorable, the total effect of a fuel leak or spill is long lasting, complex and expensive.

Fuel leaked into the ground has severe consequences for both public safety and health. In enclosed spaces, such as basements and sewer lines, vapors of a petroleum product from a leak can create hazards ranging from unhealthy odors to disastrous explosions. In addition, contaminated soil and water can harm vegetation, wildlife and humans. Oil and gasoline can be toxic if ingested or if absorbed through the skin, even in extremely low concentrations. Some components of gasoline, such as benzene and ethylene dibromide (EDB) are known carcinogens.

Installing New Aboveground and Underground Tanks

Storage Tank Location Requirements and Recommendations

Whenever you install a fuel storage tank, carefully follow the manufacturer’s recommendations for installation. If a metal tank is scratched during installation, it is considered “defected” and must be repaired as it can increase corrosion and deterioration.

One of the most important aspects of your new tank location is how close it is to drinking water wells. Michigan state well regulations require that petroleum storage tanks be set back from water wells specific minimum distances, depending upon the type of well and the size and use of the tank. Checklists at the end of this module detail the legal requirements for installing a storage tank. For underground storage tanks also see "UST Exclusion Zones / Secondary Containment Zones" in the appendix. Existing tanks are required to meet only the setback requirements that were in effect at the time of their installation. Make every effort, however, to meet new regulations as they are introduced. Along with maintaining adequate setback distances, consider the following characteristics when choosing the location for a new tank.

Soil characteristics: Highly corrosive clays, wet soils, cinders and acidic (low pH) soils can significantly speed up corrosion of underground metal tanks and piping. A minimum of six inches of clean sand, pea gravel, or crushed stone as backfill is required during installation to decrease the negative effects of surrounding soils.

Soil stability: Assess the ability of the underlying soil to support both underground or above-ground tanks. For special tank locations, such as hillsides, be sure to properly anchor tanks in place. Secure pipes so that they cannot twist or break if the tank is disturbed. Tanks that are subject to buoyant forces shall have provisions to prevent them from floating.

Depth to groundwater: Floodways and areas where the water table is close to the surface

(less than 20 feet) are poor locations for storage tanks.

Distance from storage tank to surface water: Identify surface water such as ponds, lakes, ditches, streams and catch basins that are near the area where you want to locate a storage tank. Select a site that does not pose an unacceptable risk to the surface water if a leak or spill should occur. Consider the slope, soil texture, soil type, whether there is secondary containment and whether the tank is above or below ground. For example, the tank should be located down slope from a surface water feature or a dike should be built between the tank and the water feature if it is located up slope to reduce the risk for impact should a leak occur. For aboveground tanks over 1,100 gallons, a tank location map and the distances to wells and receptors (i.e. stream, lake, storm drain, etc.) are required on the plan review.

Traffic: Assess traffic patterns around storage tanks and the dispensing pumps. Determine whether the location of the tank or dispenser will block movement of vehicles during refueling or cause problems if any work needs to be done on the tank. Protect tanks and piping with barriers to prevent collisions with vehicles or equipment.

Ease of monitoring and installation: Be sure the site is accessible for easy installation and locate the tank so that it can be checked easily for leaks. Underground storage tanks must have a state approved leak detection method.

Location with respect to water wells: Observe the required isolation distances as specified in the appropriate worksheet for your tank size and location (above or below ground) and locate the tank down slope of any water wells.

Current and previous land use: Sites that contain abandoned pipes and tanks, agricultural drainage tiles or waste materials pose special installation problems. Any metal already in the ground poses an increased risk for corrosion.

The Regulating Agencies

Petroleum storage tanks in Michigan are regulated by the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division. Regulations for storage tanks differ based on size and location. More restrictive regulations are imposed on larger tanks. Regulations for underground storage tanks are based on whether the tank holds more or less than 110 gallons, while above ground tank regulations are based on whether they hold 61 to 1,110 gallons or more than 1,100 gallons.

Aboveground Storage Tanks

Aboveground Tanks - 1,100 gallons or less

Most golf courses use aboveground storage tanks with a capacity to hold equal to or less than 1,100 gallons. The checklist located in this module outlines the regulatory requirements and additional protective devices for your fuel storage system. Historically, these tanks were regulated by Part 5 of the Storage and Handling of Flammable and Combustible Liquids Rules (FL/CL), National Fire Protection Association (NFPA) 395, as amended but are now covered under Chapter 13 or Part 3 of the FL/CL Rules. This has been the standard for storing flammable and combustible liquids on farms, isolated construction projects and in rural areas for many years.

The Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division can be contacted at:

Michigan Department of Licensing and Regulatory Affairs
Bureau of Fire Services, Storage Tank Division
3101 Technology Boulevard, Suite H
P.O. Box 30033
Lansing, Michigan 48909
P: 517-335-7211

Aboveground Tanks - Greater than 1,100 gallons

If a new aboveground tank over 1,100 gallons is being installed or if an existing tank is over 1,100 gallons, it must comply with Parts 2 and 3 of the Storage and Handling of Flammable and Combustible Liquids Rules, NFPA 30/30A, as amended. New petroleum storage tanks must undergo a plan review before installation and require a permit and annual registration fee. All existing tanks over 1,100 gallons that have not been plan reviewed and inspected need to be permitted and must pay an annual registration fee. For information on the permitting process and plan reviews, contact the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division. All tank installations must have a dispensing area for filling vehicles or equipment with petroleum. This area shall be paved with concrete or similar material to prevent spills from entering groundwater or leaching through soils.

How to Prevent Leaks in Aboveground Tanks

The best way to prevent leaks is to install tanks that meet or exceed state regulations and to follow manufacturer's instructions for installation. For above ground tanks, routinely maintain and inspect them for areas that may be rusting and piping that may be leaking. All tank installations must have a dispensing area for filling vehicles or equipment with petroleum. This area shall be paved with concrete or similar material to prevent spills from entering groundwater or leaching through soils.

Underground Storage Tank Systems

Underground Tank Systems - Less than 110 Gallons

Not Regulated by Michigan Underground Storage Tank Regulations (MUSTR)

There are recommendations based on the Storage and Handling of Flammable and Combustible Liquids Rules for underground storage tanks with a capacity of 110 gallons or less, retail or commercial; 1,100 gallons or less, residential; and all on premise heating oil tanks. Contact the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division to identify the recommendations that apply to your facility.

Underground Tank Systems - Over 110 Gallons

Regulated by the Michigan Underground Storage Tank Regulations

Underground storage tanks with a capacity greater than 110 gallons, retail or commercial;

greater than 1,100 gallons, residential; and all hazardous material storage tanks are regulated under the Michigan Underground Storage Tank Rules administered by the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division.

These petroleum storage tanks must undergo a plan review by the Storage Tank Division before installation. For information on plan reviews, contact the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division, at least 45 days prior to the planned installation. Any deficiencies in the plan will be noted and returned.

Monitoring to Detect Leaks in Underground Tank Systems Greater than 110 Gallons

Regulations for underground tanks require that all tanks greater than 110 gallons retail or commercial or greater than 1,100 gallons, residential, have a method of detecting leaks. Accurate inventory records or a leak detection program shall be maintained on all Class I liquid storage tanks for indication of possible leakage from tanks or associated piping. Two recommended methods for testing a tank's integrity are the volumetric and non-volumetric tank tightness test methods. When you hire a testing firm to perform either method, request a copy of a third party evaluation to serve as verification of compliance with requirements of the state of Michigan and the federal Environmental Protection Agency.

Volumetric Tank Tightness Test Methods: These methods precisely monitor the change in product volume in the tank correcting for the effects of thermal expansion and contraction, vapor pockets and tank deformation. They can determine with 95% probability of detection, and 5% probability of false alarm that the tank is leaking at a rate that exceeds 0.1 gallons per hour.

Non-volumetric Tank Tightness Test Methods: These tests use highly sensitive sound devices to detect either the flow of the product from the storage tank while under pressure; or the flow of air or water into the tank while under vacuum. Leaks may also be detected by inducing a highly volatile substance into the tank and then later checking the surrounding soil for evidence of the substance. Even when a tank system has been tested and proven tight, existing regulations and good practice require that you have a method for regularly detecting leaks. Install internal or external monitoring methods such as groundwater monitoring wells, vapor monitoring, automatic tank gauging and other approved methods. Daily inventory reconciliation is required on all UST systems.

Measuring underground storage tank inventories is an inexpensive and easy way to detect leaks.Leakage is apparent when there is a decrease in the fuel level without any withdrawal, or when there is an increase of water in the tank. Watching inventory will not detect very small leaks, but it will at least warn you to investigate if a discrepancy occurs. The closer the tank is to drinking water wells, the more important it is to ensure you have an adequate leak detection system.

Why Leaks Occur in Underground Tanks

Underground tank leaks are caused by a number of factors including defects in tank materials and improper installation. The most serious problem is corrosion of older tanks. Many gasoline tanks date back to the 1950's and 1960's when gas stations sprang up everywhere in response to the rapid increase in automobiles. The tanks installed during this period were constructed of steel with little or no protection against corrosion.

It is important to determine the age and condition of the tanks on your property since a single

leak of only a few gallons of gasoline can contaminate millions of gallons of groundwater. Approximately 50% of the people in Michigan depend on groundwater for their drinking water.

There are three major reasons why tanks leak:

1. corrosion from exposure to external conditions (primarily steel tanks);
2. corrosion or damage from the inside due to normal use; and
3. improper installation.

External corrosion: External tank corrosion is the major cause of leaks from steel underground storage tanks. Under certain conditions, tanks can begin to leak in less than ten years. Corrosion occurs readily in soils that are acidic, moist, and good conductors of electrical charges. A flaw or nick on the outside of the tank can induce rapid corrosion. As this process continues, the outside of the tank becomes pitted or rusted in one or more places. As of December 22, 1998, all existing and new underground storage tanks are required to have some form of corrosion protection such as impressed current or galvanic.

Internal corrosion: Underground tanks can also wear out from the inside. About 10 percent of all reported tank failures result from internal corrosion. The simple procedure of dipstick testing for fuel content can cause a tank to leak. Each time the stick is lowered into the tank, it hits the bottom at the same point. This repeated action can damage tanks by chipping the protective coating on steel tanks (creating a spot for corrosion) and by cracking Fiberglass Reinforced Plastic (FRP) tanks.

Even filling a tank can cause corrosion. Gasoline is pumped into tanks at speeds up to 200 - 300 gallons per minute. If a steel tank is unlined or the lining is damaged beneath the fill pipe, corrosion will often occur. High velocity filling can also damage FRP tanks. Between filling and refilling a tank, water vapor forms on the inner walls from condensation of moisture in the air that occupies the unfilled portion of the tank. Water in the tank can cause corrosion and can react with sulfur (a constituent of gasoline) to form sulfuric acid. In steel tanks, this acid causes corrosion and pitting as it accumulates on the inside of the tank.

Improper Installation: Weather conditions, such as deep-ground freezing, extreme heat, and heavy rains that cause high water tables and flooding, can cause severe damage to steel and fiberglass tanks and their associated pipes and valves if they have not been installed properly. In addition, the installation process itself can damage tanks. For example, backfill containing large stones or other sharp objects can damage tanks and the tanks may rupture if placed carelessly in the excavation. Fiberglass reinforced plastic tanks can also rupture if backfill material creates uneven external pressure on the tanks. Pipes and valves that are incorrectly fitted or tightened can break or loosen, causing leaks. Piping systems attached to underground storage tanks often corrode and leak. In addition, pipes and fittings are subject to mechanical failure and cracking. Many leaks can be avoided if tanks and pipes are carefully installed according to the manufacturer’s directions.

Over the years, many underground tanks have been abandoned, creating environmental and safety concerns. Although state regulations require removal of unused underground tanks, there are many tanks that have not been closed. These tanks are safety and environmental liabilities.

How to Prevent Leaks in Underground Tanks

The best way to prevent leaks is to install tanks that meet or exceed state regulations and to follow manufacturer's instructions for installation. For underground tanks, test the tank as required and keep a careful inventory to detect any fuel leaks. All tank installations must have a dispensing area for filling vehicles or equipment with petroleum. This area shall be paved with concrete, asphalt or similar material to prevent spills from entering groundwater or leaching through soils.

Steel tanks: Preventing External Leaks

Underground steel tanks corrode because the iron in the steel is inherently unstable. Moisture in the soil around the tank reacts with the iron in the steel and causes corrosion. Under ideal conditions, the reaction will reach equilibrium and stop. However, if another, more stable metal (such as copper pipes attached to the tank) is nearby, and the soil is moist, the reaction will progress because the more stable metal continues to attract electrons (negatively charged particles) from the iron. The moisture in the soil serves as a pathway that conducts the electrons from the iron to the more stable metal. If enough electrons are removed from one place in the tank, a hole is created and the tank leaks.

To prevent steel tanks from corroding, it is necessary to prevent the tank from losing electrons. There are several methods for reducing electron loss. No single method will fully protect a tank, especially if it is located in corrosive soils (acidic, moist soils) but methods can be combined. Even then, corrosion prevention is not guaranteed.

External Coating: The exterior of the tank can be covered with an epoxy or fiberglass coating. The coating prevents corrosion by creating a barrier between the tank and the soil. This method is effective as long as the coating remains intact. However, if the coating is chipped or is not applied carefully to the entire surface of the tank, the exposed metal can corrode. Coated tanks should be inspected carefully before they are installed to be sure the entire surface is covered and they should be handled carefully during installation to avoid chipping of the coating. External coatings are typically applied at the factory by the tank manufacturer. Coatings must be 100 mils thick. Thin coat epoxy alone does not meet these specs; however, it can be used in conjunction with StiP3 tanks. Holiday (scratch) testing of composite tanks shall be performed on-site before installation.

Electrical Isolation: Electrically isolating the tank from the piping and other metals in the tank system is another technique to avoid tank corrosion. This is done by using nonmetallic connectors between the different types of metals, thus preventing a direct flow of electrons between the tank and the pipes.

Cathodic Protection: Cathodic protection that requires installation of anti-corrosion devices is a third way to help prevent corrosion. There are two cathodic protection systems. Both change the tank from an anode that loses electrons, to a cathode that attracts electrons.

One cathodic protection system works by diverting corrosion onto separate bars made of a metal that is more unstable than the iron in the tank (usually zinc or magnesium). The zinc or magnesium bars act as sacrificial anodes, releasing electrons that flow through the soil moisture to the tank. The flow of electrons from the anode to the cathode (the tank) must be strong enough to overcome the tendency of the steel in the tank to release electrons. This system usually can't protect an uncoated tank and must be used in combination with a protective coating.

The other cathodic protection system, called the impressed current system, works by using electrical current to create the circuit between a rectifier (an electrical device) and the tank. This system is used when the tank is poorly coated or bare steel.

Steel Tanks: Preventing Internal Leaks

Lining tanks: To prevent internal leaks, tanks can be lined with interior coating to resist corrosion. Older tanks can also be lined only if the tank wall is structurally sound, and only after the product has been removed and the interior surface has been sandblasted. Lining tanks must be done carefully to achieve effective results.

Striker plates: Special devices are available to cushion the impact of dipsticks or high-velocity filling on tank bottoms. These striker plates (also called deflector or wear plates) absorb shock at the point of impact to avoid damage to the tank.

Fiberglass Reinforced Plastic (FRP) Tanks

Some people prefer fiberglass reinforced plastic tanks because they do not corrode the way steel tanks do. However, FRP tanks can leak from other causes such as incompatibility with stored product or additives, so they still require monitoring.

Ruptures are the major cause of leaks in FRP tanks. Sharp rocks in backfill can puncture the tank; dropping the tank into the excavation pit can rupture it; and a high water table can cause the tank to rise and rupture if it is not anchored properly. These tanks can also rupture if external pressure on them is uneven. To avoid this, homogenous material (such as pea gravel or crushed stone) must be used around the tanks so that uniform pressure is exerted on the tank surface. Do not use sand as it cannot be properly compacted.

If FRP tanks are carefully installed according to the manufacturer’s instructions, these problems can be avoided. Like steel tanks, FRP tanks should be equipped with striker plates to prevent damage from dip sticking and high velocity filling.

Secondary Containment Systems for Underground Tanks

For additional protection, enclose tanks in a containment system that will hold any leaking fuel. There are several types of containment systems. They significantly increase the cost of an underground tank, but may be appropriate especially in sensitive areas such as water supply recharge areas. Secondary containment systems include double- walled tanks and jacketed tanks. These tanks offer excellent protection. The space between the two walls can be a vacuum or be pressurized so that leaks can be detected by loss of vacuum or pressure. Sensors can also be installed between the walls to detect the presence of water or the stored product.

To prevent leaks in piping systems, proper design, handling, and installation are essential. Metal piping systems should be protected against corrosion by electrical isolation and cathodic protection. Periodically, test the system and quickly follow with any repairs or replacement when indicated. Finally, when old metal tanks are replaced with new metal tanks, the old metal piping systems should also be replaced to avoid corrosion caused by a reaction between the new tank and the old pipes.

Tank Closure and Removal Requirements and Recommendations

Tanks that have not been used in twelve months are considered to be permanently out of use and must be properly closed. Tanks no longer in use can cause problems for current and future owners and operators. The tank will continue to corrode and, if it still contains gas or oil, will likely contaminate groundwater. Tanks that are out of use and empty for more than 30 continuous days and intended to be brought back into use within 12 months are considered to be in temporary closure. Under these circumstances, the owner/operator must leave the vent lines open and functioning and must cap and secure all other lines and pumps and monitor the tank corrosion protection system.

Locate unused tanks on your property and try to determine whether they still hold product or have holes. Above ground tanks must be emptied of product, the piping must be blind flanged and the tank secured from tampering. The tank is not required to be removed from the property, however it is recommended. Underground storage tanks must be emptied, purged of all flammable vapors, and removed from the ground. The tank should be removed from the property the same day the vapors and sludge are removed from the tank. If a tank remains at the site overnight or longer, additional vapors may be released from liquid absorbed in the walls or residues in the tank. The vapors and sludge can potentially cause an explosion. It is highly recommended that an experienced professional empty the tank and remove it from the ground. Remember that the law requires a one million dollar, two million dollar aggregate, pollution liability insurance to remove underground storage tanks. Tanks that have been lined internally or coated externally with epoxy- based or similar materials may not be accepted by scrap processors. After removing all vapors from the tank, puncture or otherwise create numerous holes in the tank to ensure it is unsuitable for future use. The tank can be sold for scrap if properly prepared and transported. It must be labeled before disposal as follows:

- Tank has contained (supply the name of what was stored, e.g. diesel, leaded gasoline)
- Not vapor free
- Not suitable for storage of food or liquids intended for human or animal consumption
- Date of removal: month/day/year

If the tank has held leaded motor fuel, or if its past contents are unknown, clearly label the tank with the following information: "Tank has contained leaded gasoline. Lead vapors may be released if heat is applied to the tank shell."

The same label information must be included on a bill of sale to be used to transfer tank ownership. In addition, the bill of sale should include the purchaser’s acknowledgment that he or she will assume all liability related to the tank.

Be sure the buyer understands that tanks that previously contained fuel and must not be used to store food or liquids for animal or human consumption. If you sell the tank to be reused to store petroleum, you must inform the buyer of federal, state and local regulations, as well as the former use and present condition of the tank. Underground tanks cannot be used for aboveground storage and aboveground tanks cannot be used underground. Test the tank for flammable vapors before transporting it to a new site.

Additional Requirements when Removing Underground Storage Tanks

For underground tanks not regulated by MUSTR: Empty and clean the tank by removing all liquids and accumulated sludge, and by purging all vapors. Remove the tank from the ground or, if a structure near the tank prevents removal, fill the tank 100% with an inert solid material

such as sand or concrete. Empty piping of all liquids and sludge. Purge and cap the piping and remove it from the ground. Keep records documenting the removal process including receipts, notes of procedures, estimates, and letters.

For underground tanks regulated by MUSTR: Be sure to follow these legal requirements:

- Check to determine if the tank is registered with the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division.
- Not less than 30 days before removing the tank, the owner must notify the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division. The Storage Tank Division will acknowledge receipt of the notice and establish a starting date for the removal.
- The tank must be removed by a trained company that is insured with $1,000,000 ($2,000,000 aggregate) of pollution liability insurance coverage.
- After removing the tank, if there is evidence of a leak, the owner must report the leak to the BFS, Storage Tank Division within 24 hours.
- After removing the tank, the owner must submit a site assessment report to the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division within 45 days of the removal. If a leak has been confirmed, a further investigation must be performed by a qualified consulting company. If there is no leak, the owner can take the samples and send them to a laboratory.
- Thoroughly document the details of the tank closure such as the time and date the tank was closed, the name of the person or company that completed the closure, and any records and reports related to the closure.
- The owner must file with the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division, an amended tank registration indicating that the tank is no longer in the ground.

Reporting Leaks and Spills

If you find a leak or spill from a 110-gallon or greater underground storage tank, you must call:

Michigan Department of Licensing and Regulatory Affairs
Bureau of Fire Services, Storage Tank Division
P: 517-335-7279

For all other leaks or spills, call:

Your local fire marshal or fire department
Underground Storage Tank Owner/Operator Training and Certification (Class A, B and C Operators)
Underground Storage Tank Owner/Operator Training and Certification

Section 1524 of the Federal Energy Policy Act of 2005 required that the state of Michigan promulgate amendments to the underground storage tank rules (Rules) to require each underground storage tank facility have Class A, Class B, and Class C operators. Candidates will need to pass a written exam in order to be certified as a Class A or Class B operator. A test is not required for the Class C operator, but those persons must be properly trained. The exam assures that underground storage tank system operators possess the necessary knowledge

regarding the proper operation of underground storage tank systems.

Operator Types

Class A Operator: This is the person who has primary responsibility to operate and maintain the underground storage tank system. For a typical gas station, it is the owner of the station or his designee. For large corporations, this is the manager or designee responsible for tank operations. The class A operator can also be designated as a Class B operator as long as he/she has passed the Class B operator exam.

Class B Operator: This designation is for the individual or individuals who implement day-to-day aspects of operating, maintaining, and record keeping for underground storage tank systems at one or more facilities. For a typical gas station, it is the owner or the person/company contracted by the owner to maintain the tanks. For large corporations, it is the employee, or person/company contracted by the corporation to maintain the tanks. A broad knowledge base is required for a Class A operator, but the Class B operator must have in-depth knowledge of tank system operation and maintenance.

Class C Operator: This is an individual who is responsible for responding to alarms or other indications of emergencies caused by spills, releases, or overfills associated with an underground storage tank system. For a typical gas station, this is the cashier. Though an exam is not required, this person must be trained in responding to releases, alarms, and emergency conditions. Training can be performed by the Class A operators, Class B operators, or third-party vendors. Class C operator training is required to be documented.

Go to the Licensing and Regulation Affairs (LARA) website for information on compliance, training and testing (UST Training and Certification).

Resources

Copies of NFPA 30 (2000 ed.) and NFPA 30A (2000 ed.) can be obtained by calling the National Fire Protection Association at 1-800-344-3555. The cost is $35.25 for NFPA 30 and $26.75 for NFPA 30A. The Michigan amendments to NFPA 30, 30A and Parts 2 and 3 of the Flammable and Combustible Liquid Rules can be obtained by contacting the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division.

Michigan Underground Storage Tank Rules can be obtained from the Michigan Department of Licensing and Regulatory Affairs, Bureau of Fire Services, Storage Tank Division.

Underground Storage Tanks and Groundwater Protection, published by the Community Groundwater Protection Project of the Massachusetts Audubon Society. (Sections of this fact sheet were adapted from this Massachusetts Audubon Society publication.)

Handling and Underground Storage of Fuels. 1986. Michigan State University Extension Bulletin WQ 01.

Petroleum Product Storage Glossary

Cathodic protection: One of several techniques to prevent corrosion of a metal surface by reversing the electric current that causes corrosion. A tank system can be protected by

sacrificial anodes or impressed current (see sacrificial anodes and impressed current.)

Corrosion: Deterioration of a metallic material (rust) due to a reaction with its environment. Damage to tanks by corrosion is caused when a metal underground tank and its underground surroundings act like a battery. Part of the tank can become negatively charged, and another part positively charged. Moisture in the soil provides the connecting link and the negatively charged part of the tank (where the current exits from the tank or its piping) begins to deteriorate. As electric current passes through, the metal begins to turn into soft ore, holes form, and leaks begin.

Corrosion protection: Steel tanks can be protected by coating them with a corrosion resistant material combined with cathodic protection. Tanks can also be protected from corrosion if they are bonded to a thick layer of noncorrosive material, such as fiberglass- reinforced plastic. The corrosion problem can be entirely avoided by using tanks and piping made completely of noncorrosive material, such as fiberglass reinforced plastic.

Galvanized: The result of coating an iron or steel structure with zinc. Galvanized materials do not meet corrosion protection requirements.

Impressed current: This protection system introduces an electric current into the ground through a series of anodes that are not attached to the underground tank. Because the electric current flowing from these anodes to the tank system is greater than the corrosive current attempting to flow from it, the underground tank is protected from corrosion.

Interior lining: The lining of petroleum storage tanks with noncorrosive synthetic materials that can be effective in protecting metal tanks.

Inventory control: Measuring and comparing the volume of tank contents regularly with product delivery and withdrawal records to help detect leaks before major problems develop.

Sacrificial anodes: Pieces of metal attached directly to underground tanks that are more electrically active than the steel tank. Because the anodes are more active, electric current runs from the anodes rather than from the tank. The tank becomes the cathode (positive electrode) and is protected from corrosion. The attached anode (negative electrode) is “sacrificed” or consumed in the corrosion process.

Secondary containment: A system such as a sealed basin and dike that will catch and hold the contents of tank if it leaks or ruptures; or a double-walled tank with continuous space between the two walls. A tank may also be in a concrete vault that is liquid tight and will contain the released product.

Soil permeability: The quality that enables soil to transmit water or air. Slowly permeable soils contain fine-textured materials like clays that permit only slow water movement. Moderately or highly permeable soils contain coarse materials like sand and gravel that permit more rapid water movement.

Best Management Practices

- Locate fueling facilities on roofed areas with a concrete (not asphalt) pavement. Areas should be equipped with spill-containment and recovery facilities.

- Use of above ground fuel tanks is preferred.

Pollution Prevention

Principles

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

Best Management Practices

- Pesticides should be stored in a lockable concrete or metal building.

- Pesticide storage and mixing facility floors should be impervious and sealed with a chemical-resistant paint. Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- For valuable information about constructing chemical mixing facilities, reference the Midwest Plan Service book, Designing Facilities for Pesticide and Fertilizer Containment (revised 1995); the Tennessee Valley Authority (TVA) publication, Coating Concrete Secondary Containment Structures Exposed to Agrichemicals (Broder and Nguyen, 1995); and USDA–NRCS Code 703.
- Use a chemical mixing center (CMC) as a place for performing all operations where pesticides are likely to be spilled in concentrated form—or where even dilute formulations may be repeatedly spilled in the same area—over an impermeable surface. (A CMC is a concrete pad treated with a sealant and sloped to a liquid-tight sump where all of the spilled liquids can be recovered.)
- Flush wash pad with clean water after the equipment is washed. Captured wash water can be used as a dilute pesticide per labeled site, or it may be pumped into a rinsate storage tank for use in the next application.
- FIFRA, Section 2(ee), allows the applicator to apply a pesticide at less than the labeled rate.
- The sump should then be cleaned of any sediment before another type of pesticide is handled.
- Discharge to a treatment system that is permitted under industrial wastewater rules.
- Never discharge to a sanitary sewer system without written permission from the utility.
- Never discharge to a septic tank.
- Use a closed-loop wash-water recycling system and follow appropriate BMP.
- Use non-containment wash water for field irrigation.
- Do not discharge non-contaminated wastewater during or immediately after a rainstorm, since the added flow may cause the permitted storage volume of the stormwater system to be exceeded.
- Whenever practical, replace solvent baths with recirculating aqueous washing units (which resemble heavy-duty dishwashers).
- Use soap and water or other aqueous cleaners; these products are often as effective as solvent-based ones.
- Blowing off equipment with compressed air instead of washing with water is often easier on hydraulic seals and can lead to fewer oil leaks.
- Grass-covered equipment should be brushed or blown with compressed air before being washed. Dry material is much easier to handle and store or dispose of than wet clippings.
- It is best to wash equipment with a bucket of water and a rag, using only a minimal amount of water to rinse the machine.
- Clean up spills as soon as possible.
- Keep spill cleanup equipment available when handling pesticides or their containers.
- If a spill occurs of a pesticide covered by certain state and federal laws, you may need to report any accidental release if the spill quantity exceeds the “reportable quantity” of active ingredient specified in the law.
- Large spills or uncontained spills involving hazardous materials may best be remediated by hazardous material cleanup professionals.
- For emergency (only) information on hazards or actions to take in the event of a spill, call CHEMTREC, at (800)424–9300. CHEMTREC is a service of the Chemical

Manufacturers Association. For information on whether a spilled chemical requires reporting, call the CERCLA/RCRA help line at (800) 424–9346.

- Do not allow any wash water to flow directly into surface waters or storm drains.
- Avoid washing equipment in the vicinity of wells or surface water bodies.
- Wash equipment over a concrete or asphalt pad that allows the water to be collected. After the residue dries on the pad, collect, compost, or spread in the field.
- If applicable, allow runoff onto a grassed area to soak into the ground, but never into a surface water body or canal.
- Use compressed air to blow off equipment. This is less harmful to the equipment's hydraulic seals, eliminates wastewater, and produces dry material that is easier to handle.
- Handle clippings and dust separately. After the residue dries on the pad, it can be collected and composted or spread in the field.
- Minimize the use of detergents. Use only biodegradable non-phosphate detergents.
- Minimize the amount of water used to clean equipment. This can be done by using spray nozzles that generate high-pressure streams of water at low volumes.
- Do not discharge wash water to surface water or groundwater either directly or indirectly through ditches, storm drains, or canals.
- Do not conduct equipment wash operations on a pesticide mixing and loading pad. (This keeps grass clippings and other debris from becoming contaminated with pesticide).
- Solvents and degreasers should be used over a collection basin or pad that collects all used material.
- Oil/water separators can be used but must be managed properly to avoid problems. Do not wash equipment used to apply pesticides on pads with oil/water separators
- Collect used solvents and degreasers, place them into containers marked with the contents and the date, and then have them picked up by a service the properly recycles or disposes of them. Never mix used oil or other liquid material with the used solvents.
- Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them. Arrange pickup of used oil, or deliver to a hazardous waste collection site.
- Do not mix used oil with used antifreeze or sludge from used solvents. Antifreeze must be recycled or disposed of as a hazardous waste.
- Store batteries on an impervious surface and preferably under cover. Remember, spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations.
- Lead-acid storage batteries are classified as hazardous wastes unless they are recycled. All lead-acid battery retailers in Florida are required by law to accept returned batteries for recycling.
- Spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations.
- Equipment used to apply pesticides and fertilizers should be stored in areas protected from rainfall.
- Pesticide application equipment can be stored in the chemical mixing center (CMC), but fertilizer application equipment should be stored separately.
- Blow or wash loose debris off equipment to prevent dirt from getting on the CMC pad, where it could become contaminated with pesticides.
- Ensure that all containers are sealed, secured, and properly labeled. Use only regulatory agency-approved, licensed contractors for disposal.

- Rinse pesticide containers as soon as they are empty. Pressure rinse or triple-rinse containers, and add the rinse water to the sprayer.
- Shake or tap non-rinseable containers, such as bags or boxes, so that all dust and material fall into the application equipment.
- After cleaning them, puncture the pesticide containers to prevent reuse (except glass and refillable mini-bulk containers).
- Keep the rinsed containers in a clean area, out of the weather, for disposal or recycling.
- Storing the containers in large plastic bags/tubs to protect the containers from collecting rainwater.
- Recycle rinsed containers in counties where an applicable program is available, or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them. Visit the MDARD Pesticide Container Recycling site for additional information.
- For tire recycling information, please visit the EGLE Making Your Tires Last Longer and Tire Disposal Options site.

Nutrient Management

Regulatory Considerations

Proper nutrient management plays a key role in the reduction of environmental risk and increases course profitability. Among other benefits, applied nutrients inflate the available pool of nutrients and allow turfgrass to recover from damage, increase its resistance to stress, and increase its playability. However, the increase in available nutrients also increases the potential risk of environmental impact. Nutrients may move beyond the turfgrass via leaching or runoff, which may directly impact our environment. Other organisms also respond to increases in nutrients and, in some cases, these organisms may deleteriously alter our ecosystem. The goal of a nutrient management plan should be to apply as little nutrients as possible while providing an enjoyable playing surface and to apply nutrients in a manner that maximizes plant uptake.

The impacts of nitrogen and phosphorus on water quality has been well documented with solutions widely discussed. Michigan State University research has led to programs that reduce/eliminate nutrient pollution in the state's surface and groundwater. The Nutrient Framework to Reduce Phosphorus and Nitrogen Pollution website has been introduced and various entities are addressing water quality issues.

Fertilizer application records should be documented immediately after the initial application. The records should be retained for a minimum of three years and the following information is recommended:

- Name of the applicator
- Date of application (month, day, and year)
- Location of fertilizer application area
- Rate of application (e.g., pounds of fertilizer per acre)
- Analysis of fertilizer applied (e.g., 10-0-10)
- Application method (soil injected, incorporated, surface-applied, etc.)
- Soil conditions at the time of application
- Temperature, precipitation, and other weather conditions at the time of application
- Weather forecast for the day following the application

Principles

- Local and state regulations are in place to better manage nutrient risks based on the unique conditions that exist in your location. Designing a nutrient management plan

within these regulations addresses local concerns and minimizes risk within your unique ecosystem.
- Depending on your location, regulatory agencies may include federal, state, or local policies.
- In general, if your location is regulated by nutrient policies (such as nutrient management plans), all of your nutrient BMP will be designed according to these policies.
- Understand the importance of nutrient licensing.

Best Management Practices

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

Soil Testing

Principles

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

Best Management Practices

- Ten to 15 soil samples should be randomly taken from each section and blended together to provide a representative, uniform soil sample.
- Each soil sample should be taken from the same depth.
- Use an extractant appropriate for your soils.
- The same extractant must be used for each test in order to compare soil test results over time.
- The purpose of a soil test is to provide the grower with a prediction of a plant's response to an applied nutrient.
- If the location has correlation data between a given nutrient applied to soil and a response to that nutrient by turfgrass, then recommendations may provide expected results.
- If your location does not have correlation data, then soil test recommendations may be of little value.
- Keeping soil tests from prior years will allow you to observe changes over time.
- This practice can provide good evidence of the impact of your nutrient management plan.

The Michigan State University Extension maintains guidelines on soil testing.

Plant Tissue Analysis

Principles

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

Best Management Practices

- Tissue samples may be collected during regular mowing.
- Do not collect tissue after any event that may alter the nutrient analysis. Events may include fertilization, topdressing, pesticide applications, etc.
- Place tissue in paper bags, not plastic.
- If possible, allow tissue samples to air-dry at your facility before mailing them.
- Poor-quality turfgrass that is of concern should be sampled separately from higher-quality turfgrass.
- When turfgrass begins to show signs of nutrient stress, a sample should be collected immediately.
- More frequent tissue sampling allows a more accurate assessment of your turfgrass nutrient status changes over time.
- The quantity of tissue analysis you choose to use is entirely up to you and your needs. However, two to four tests per year are common on greens and one to two tests per year are common on tees and fairways.
- Keeping tissue tests from prior years will allow you to observe changes over time.
- Tissue testing can provide good evidence of the impact of your nutrient management plan.

Fertilizers Used in Golf Course Management

Principles

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

Terminology

- Grade or analysis is the percent by weight of Nitrogen (N), Phosphorous fertilizer (P_2O_5) and Potassium fertilizer (K_2O) that is guaranteed to be in the fertilizer.
- A complete fertilizer contains N, P_2O_5, and K_2O.
- Consult the MDARD regarding pesticide labeling laws in Michigan.

Label

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

Macronutrients

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

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

The role of nitrogen (N)

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

- *Fate and transformation of N*
- The goal of all applied nutrients is to maximize plant uptake while minimizing nutrient losses. Understanding each process will increase your ability to make sound management decisions and ultimately leads to an increase in course profitability and a reduction in environmental risk.
- *Nitrogen processes*
    - *Mineralization:* the microbial mediated conversion of organic N into plant-available NH_4
    - *Nitrification:* the microbial-mediated conversion of NH_4 to NO_3
    - *Denitrification:* the microbial mediated conversion of NO_3 to N gas; this primarily occurs in low-oxygen environments and is enhanced by high soil pH
    - *Volatilization:* the conversion of NH_4 to NH_3 gas
    - *Leaching:* the downward movement of an element below the rootzone
    - *Runoff:* the lateral movement of an element beyond the intended turfgrass location
- The release mechanism and factors influencing N release from available N sources

Understanding how certain N sources should be blended and applied is an essential component in an efficient nutrient management plan. In many cases, N sources are applied without regard to their release characteristics. This is an improper practice and increases the risk of negative environmental impact. Each N source (particularly slow-release forms) is unique and therefore should be managed accordingly. Applying a polymer-coated urea in the same manner one would apply a sulfur-coated urea greatly reduces the value of the polymer-coated urea.

Similarly, applying 2 pounds of N from ammonium sulfate may cause burning, while applying 2 pounds of N from certain polymer-coated ureas may not provide the desired turfgrass response. Rate, application date, location, and turfgrass species all should be included in your nutrient application decision.

- *Soluble nitrogen sources*
    - Urea (46-0-0)
    - Ammonium nitrate (34-0-0)
    - Ammonium sulfate (21-0-0)
    - Diammonium phosphate (18-46-0)
    - Monoammonium phosphate (11-52-0)
    - Calcium nitrate (15.5-0-0)
    - Potassium nitrate (13-0-44)
- *Slow-release nitrogen sources*

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

These include:

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

Urease and nitrification inhibitors

- Urease inhibitors reduce the activity of the urease enzyme resulting in a reduction of volatilization and an increase in plant-available N.
- Nitrification inhibitors reduce the activity of *Nitrosomonas* bacteria, which are responsible for the conversion of NH_4 to NO_2. This reduced activity results in a reduction of N lost via denitrification and an increase in plant-available N.

The role of phosphorous (P)

Phosphorous is a limiting nutrient for algae and other aquatic weeds which contribute to eutrophication of water bodies. Thus, proper timing and rates should be implemented to reduce the risk of off-site movement of phosphorus.

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

- *P deficiency symptoms*
    - Initially, reduced shoot growth and dark green color may be observed

    - Eventually, blades will turn a purplish color
- *P sufficiency ranges*

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

- *P fertilizer sources*
    - Diammonium phosphate
    - Concentrated superphosphate
    - Monoammonium phosphate
    - Natural organics

The role of potassium (K)

Potassium is of no environmental concern, but can be an economic concern, particularly when potassium is over-utilized, which can be quite common. Generally, potassium concentrations in turfgrass tissue are about 1/3 to ½ that of nitrogen.

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

- *K deficiency symptoms*

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

- *K sufficiency ranges*

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

- *K fertilizer sources*
    - Potassium sulfate
    - Potassium chloride
    - Potassium nitrate

Secondary Macronutrients

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

The role of calcium (Ca)

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

The role of magnesium (Mg)

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

The role of sulfur (S)

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

Micronutrients

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

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

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

The role of iron (Fe)

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

The role of manganese (Mn)

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

The role of boron (B)

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

The role of copper (Cu)

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

The role of zinc (Zn)

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

The role of molybdenum (Mo)

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

The role of chlorine (Cl)

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

Soil pH

Principle

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

Best Management Practices

- To increase soil pH, apply a liming material (calcium carbonate, calcium oxide, dolomitic limestone) that contains Ca^{2+} and neutralizes acidity.
- To lower soil pH, products containing elemental sulfur should be applied.
- In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial.

Nutrient Management

Principles

- Within Michigan, environmental conditions vary greatly including differences among soils, topography, rainfall, and temperature. These differences require that a nutrient management plan be flexible enough to allow turfgrass managers to address their unique needs.
- Understand the importance of application timing for effective use of applied nutrients.
- Nutrients applied which are carried off by runoff and not utilized by turf contribute to enrichment of downstream water resources and harmful algal blooms.

Best Management Practices

- The objective of all nutrient applications is plant uptake and the corresponding desirable response.
- Apply nutrients when turfgrass is actively growing.

- Apply slow-release N fertilizers at the appropriate time of year to maximize the products' release characteristics. For example, an application of slow-release N to warm-season turfgrasses in fall may not be as effective as the same application applied in early summer because of the prolonged release time in fall.
- Follow N application rate recommendations from your local land-grant university.
- N application rates from slow-release materials should take into consideration the release rate of the chosen material. If insufficient material is applied, the desired response may not be observed.
- Consult your local land-grant university for efficient N:K in your location.
- The reduced height of cut and excessive traffic damage on putting greens results in an increased need for growth leading to an increase in nutrition.
- Tees and landing areas often have higher fertility requirements than fairways and roughs because they suffer constant divot damage.
- Fairways and roughs often require less nutrient inputs than other locations because of their increased height of cut, less damage, and clipping return.
- Exercise caution when applying nutrient applications during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff.
- Provide appropriate rates and products to minimize N loss without reducing turfgrass establishment.
    - Increased water applications
    - Increased nutrients to hasten establishment
    - Reduced root mass
- Be aware of the different types of spreaders and understand the advantages and disadvantages of each.
- Not all fertilizers can be spread with every spreader. For example, if sulfur-coated urea was spread through a drop spreader, the sulfur coating could be damaged, essentially leading to an application of soluble urea.
- Choose the appropriate spreader for a given fertilizer material.

    - Walk-behind rotary
    - Drop spreader
    - Bulk rotary
    - Spray

- Calibration reduces environmental risk and increases profitability.
- Proper fertilizer storage, loading, and clean-up reduce environmental risk.
- Avoid applying fertilizer to soils that are at, or near, field capacity or following rain events that leave the soils wet.
- Do not apply fertilizer when the National Weather Service has issued a flood, tropical storm, or hurricane water or warning, or if heavy rains are likely.

Cultural Practices

Mowing

Cultivation practices are an important part of golf course turf management. Certain cultural practices such as mowing, verticutting, and rolling are necessary to provide a high-quality playing surface, while others such as aerification are performed to enhance plant health.

Heavily trafficked areas, primarily the putting surface, must be proactively managed to minimize thatch accumulation and compaction to enhance playability and turf health by improving nutrient and water uptake.

Turfgrass is a unique plant capable of withstanding traffic more than any other plant. With that said, cultivation of the putting surface is necessary from time to time to enhance soil health and therefore turfgrass recuperative capacity.

Principles

- Mowing is the most common cultural practice because it is necessary to create an acceptable playing surface. The mowing practices implemented on a facility will have an impact on turf density, texture, color, root development, and wear tolerance.
- Mowing practices affect turfgrass growth. Frequent mowing will increase shoot density and tillering. It will also decrease root and rhizome growth as a result of plant stress associated with removal of leaf tissue.
- Infrequent mowing may result in alternating cycles of vegetative growth followed by scalping, which further depletes food reserves of the plants.
- Proper mowing height is a function of the species/cultivar being managed and the intended use of the plant. Other factors influencing mowing height include mowing frequency, shade, mowing equipment, time of year, and abiotic and biotic stress.
- In regard to mowing, root growth is least affected when no more than 30% to 40% of leaf area is removed in a single mowing.
- Failure to mow properly will result in weakened turf with poor density and quality.

Best Management Practices

- Mowing frequency should increase during periods of rapid growth and decrease during dry, stressful periods. During these weather conditions rolling instead of mowing results

in better stress tolerance of the grass on a putting green without decreases in green speed (customer satisfaction).

- If turf becomes too tall, it should not be mowed down to the desired height all at once. Such severe scalping reduces turf density and can result in a dramatic reduction in root growth. Tall grass should be mowed frequently and height gradually decreased until desired height of cut is achieved.
- Shade affects turfgrass growth by filtering out photosynthetically active radiation. As a result, turfgrass plants respond by growing upright in an effort to capture more light to meet their photosynthetic needs. As a result, mowing height should be increased by at least 30% to improve the health of turf grown in a shaded environment.
- The use of the plant growth regulator trinexapac-ethyl has been shown to improve overall turf health when used as a regular management tool for grasses growing in shaded environments.
- Environmental stresses such as prolonged cloudy weather or drought can have a significant impact on turf health. Increase mowing heights as much as use will allow in order to increase photosynthetic capacity and rooting depth of plants.
- Use proper mowing equipment.
- Reel mowers are ideally suited for maintaining turfgrass stands that require a height of cut below 0.75 inches. Below that height reel mowers result in the most uniform and smoothest playing surfaces resulting in a dense canopy that minimizes weed infestation.
- Rotary mowers, when sharp and properly adjusted, deliver acceptable cutting quality for turf that is to be cut above 1 inch in height. Dull blades will result in shredding of leaf tissue, increasing water loss and the potential for disease development.
- Flail mowers are most often used to maintain utility turf areas that are mowed infrequently and do not have a high aesthetic requirement.
- Mowing patterns influence both the aesthetic and functional characteristics of a turf surface.
- Turfgrass clippings are a source of nutrients, containing 2% to 4% nitrogen on a dry-weight basis, as well as significant amounts of phosphorus and potassium.
- Nutrients contained in clippings can be sources of pollution and should be handled properly.
- Clippings should be returned to the site during the mowing process unless the presence of grass clippings will have a detrimental impact on play. Cases when clippings should be removed include times when the amount of clippings is so large that it could smother the underlying grass or on golf greens where clippings affect play.
- Deciduous leaf litter (tree leaves) should be mulched into the rough with rotary mowers each fall. Research indicates that mulching tree leaves into the grass adds nutrients, results in a faster spring green up, holds more moisture which can minimize need for irrigation, and depending upon tree species decreases broadleaf and annual grass weed germination.

Collected clippings should be disposed of properly to prevent undesirable odors near play areas and to prevent fire hazards that can occur when clippings accumulate. Consider composting clippings or dispersing them evenly in natural areas where they can decompose naturally without accumulating in piles.

Cultivation

Principles

- Cultivation involves disturbing the soil or thatch through the use of various implements to achieve important agronomic goals that include relief of soil compaction, thatch/organic matter reduction, and improved water and air exchange.
- Cultivation techniques will result in disturbance of the playing surface that can require significant time for recovery.
- Frequency of cultivation should be based on traffic intensity and level of soil compaction.
- Core aerification is effective at managing soil compaction and aiding in improvement of soil drainage.
- Accumulation of excessive thatch and organic matter will reduce root growth, encourage disease, and create undesirable playing conditions.
- Light and frequent applications of sand will smooth the playing surface, dilute thatch, and potentially change the physical characteristics of the underlying soil when done in conjunction with core aerification.

Best Management Practices

- Core aerification is almost never necessary on seeded sites where the mowing height is 1-inch or greater unless thatch accumulation has an impact on playability of the site. In Michigan heaving, the natural process of freeze/thaws that take place from late fall to early winter, alleviate compaction naturally.
- Core aerification may also not be necessary if other cultural practices, such as frequent sand topdressing, grooming, etc., are implemented on a timely basis that negates thatch accumulation.
- Core aerification involves removal of small cores or plugs from the soil profile. Cores are usually 0.25 to 0.75 inch in diameter. When core aerification is deemed to be necessary, core aerification programs should be designed to remove 15%-20% of the surface area. High-traffic areas may require a minimum of two to four core aerifications annually.
- Core aerification should be conducted only when grasses are actively growing to aid in quick recovery of surface density.
- Solid tines cause less disturbance to the turf surface and can be used to temporarily reduce compaction and soften surface hardness during months when the growth rate of grasses has been reduced.
- As the name implies, deep-drill aerification uses drill bits to creates deep holes in the soil profile with the use of drill bits. Soil is brought to the surface and distributed into the canopy. Holes can be backfilled with new root-zone materials if a drill-and-fill machine is used. These machines allow replacement of heavier soils (clays) with sand or other materials to improve water infiltration.
- Slicing and spiking reduce surface compaction and promote water infiltration with minimal surface damage. However, if done during times of moisture stress and/or high temperatures both practices can result in burn marks at each penetration site.
- Slicing is faster than core aerification but is less effective. Slicing is best accomplished on moist soils.
- A spiker can break up crusts on the soil surface, disrupt algae layers, and improve water infiltration.

- Vertical mowing (verticutting) can be incorporated into a cultural management program to achieve a number of different goals. Deeper penetration of knives will stimulate new growth by cutting through stolons and rhizomes while removing accumulated thatch.
- Verticutting depth for thatch removal should reach the bottom of the thatch layer and extend into the surface of the soil beneath the thatch.
- Dethatching with a verticutter is an aggressive practice that is not recommended on golf putting greens because of the damage that occurs and the extensive recovery time required.
- Initiate vertical mowing when thatch level reaches 0.25 to 0.5 inch in depth. Shallow vertical mowing should be completed at least monthly on putting greens to prevent excessive thatch accumulation.
- Research indicates grooming on a regular basis from 10-20% of the height of cut decreases noticeable foot traffic, possibly resulting in smoother playing surfaces throughout the day and may reduce horizontal runners, leaf blades and other organic matter.
- Groomers, or miniature vertical mowers attached to the front of reels, are effective at improving management of grain and improving plant density through cutting of stolons.
- Topdress the playing surface with sand following core aerification and heavy vertical mowing to aid in recovery of turf. Rates will vary from 0.125 to 0.25 inch in depth and will depend on the capacity of the turf canopy to absorb the material without burying the plants.
- Light, frequent applications of topdressing sand on putting greens smooths minor surface irregularities and aids in the management of thatch accumulation. In fact, if done on a basis that mimics turfgrass growth it can minimize the need for core cultivation.
- Use only weed-free topdressing materials with a particle size similar to the underlying root zone.
- Use of finer materials can result in layering and can have a negative impact on water infiltration.
- Putting surfaces should be rolled from a minimum of every other day to a maximum of 2 times per day to minimize turfgrass pests such as dollar spot and enhance putting green speed.
- Research shows that rolling should take place following core cultivation to smooth the surface to enhance playability and to increase aerification hole closure.
- Research indicates that a light frequent topdressing program in conjunction with rolling decreases anthracnose.
- Rolling should replace mowing when environmental conditions result in the turfgrass growling slowly. This is most important during heat stress which allows the turfgrass relief from the stress and decreases localized dry spot.

Shade and Tree Management

Principles

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

Best Management Practices

- Prune tree limbs and roots as needed to reduce competition for sunlight, water, and nutrients.
- When possible, trees located near closely mowed areas such as tees and greens should be removed or their canopy should be thinned to promote good turf growth.
- Understand the variability in sun angles at different times of the year and how this affects turf health.
- Conduct a shade audit to identify problem areas.
- Conduct a tree survey that identifies each tree's location, species, health, life expectancy, safety concerns, value and special maintenance requirements.

Integrated Pest Management

Philosophy

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

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

Principles

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

Best Management Practices

- Proper records of all pesticide applications should be kept according to local, state, or federal requirements.
- Use records to establish proof of use and follow-up investigation of standard protocols regarding:
    - Date and time of application
    - Name of applicator
    - Person directing or authorizing the application
    - Weather conditions at the time of application
    - Target pest
    - Pesticide used (trade name, active ingredient, amount of formulation, amount of water)
    - Adjuvant/surfactant and amount applied, if used

- Area treated (acres or square feet) and location
- Total amount of pesticide used
- Application equipment
- Additional remarks, such as the severity of the infestation or life stage of the pest
- Follow-up to check the effectiveness of the application

IPM Overview

Principles

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

Best Management Practices

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

Written Plan

Principles

- IPM is an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, other applicable practices, and is a last measure when threshold levels are exceeded.
- A pest-control strategy should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated. A control

strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.
- When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, and site characteristics, as well as its solubility and persistence.

Best Management Practices

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

Pest Thresholds

Principles

- IPM is commonly used in agricultural crop production, where the economic thresholds for key pests have been determined and are easily determined with the law of diminishing returns. Pest levels exceeding the site's threshold warrant treatment.
- Economic thresholds and yield are not a meaningful measure for golf courses since yield is not desired and thresholds are minimal. Fortunately, the law of diminishing returns can be utilized determining the best green speed range for a particular golf course. Once the optimal green speed range is determined all cultural and mechanical inputs can be measured by their significance on greens speed. The result is most often healthy turfgrass with fewer inputs.

Best Management Practices

- Use available pest thresholds to guide pesticide application decisions (see IPM Guide).
- Use preventive chemical applications only when professional judgment indicates that properly timed preventive applications are likely to control the target pest effectively while minimizing the economic and environmental costs.
- Record and use this information when making similar decisions in the future.

Monitoring

Principles

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

Best Management Practices

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

Record Keeping

Principles

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

Best Management Practices

- Document, identify, and record key pest activities on key plants and locations.
- Determine the pest's life cycle, and know which life stage to target (for an insect pest, whether it is an egg, larva/nymph, pupa, or adult).

- Determine whether the corrective actions actually reduced or prevented pest populations, were economical, and minimized risks. Record and use this information when making similar decisions in the future.
- Observe and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), noting which pests are present, so intelligent decisions can be made regarding how damaging they are and what control strategies are necessary.

Turfgrass Selection

Principles

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

Best Management Practices

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

Biological Controls

Principles

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

Best Management Practices

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

Pollinators

Principles

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

Best Management Practices

- When using pesticides, minimize injury and damage by following label directions.
- Follow label information concerning the application of pesticides when plants may be in bloom. Avoid applying pesticides during bloom season.
- Stay on target by using coarse-droplet nozzles and monitor wind to reduce drift.
- Do not apply pesticides when pollinators are active.
- Before applying a pesticide, scout/inspect area for both harmful and beneficial insect populations, and apply only when the indicated threshold of damage has been reached.
- Mow flowering plants (weeds) before insecticide application.
- If flowering weeds are prevalent, control them before applying insecticides.
- Use insecticides that have a lower impact on pollinators.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of pesticide.
- Avoid applications during unusually low temperatures or when dew is forecasted.
- Use granular formulations of pesticides that are known to be less hazardous to bees.
- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.

Conventional Pesticides

Principles

- IPM does not preclude the use of pesticides. However, pesticides should be viewed as one of the many tools used to minimize pest problems.

- IPM involves both prevention — keeping the pest from becoming a problem — and suppression — reducing the pest numbers or damage to an acceptable level.
- A pest-control strategy using pesticides should be used only when the pest is causing or is expected to cause more damage than what can be reasonably and economically tolerated.
- Pesticides are designed to control or alter the behavior of pests. When, where, and how they can be used safely and effectively is a matter of considerable public interest.
- Pesticides should be evaluated on effectiveness against the pest, mode of action, life stage of the pest, personnel hazards, non-target effects, potential off-site movement, and cost.
- A control strategy should be implemented that reduces the pest numbers to an acceptable level while minimizing harm to non-targeted organisms.
- Always follow the directions on the label. These directions have been developed after extensive research and field studies on the chemistry, biological effects, and environmental fate of the pesticide. The label is the single most important document in the use of a pesticide. State and federal pesticide laws require following label directions!

Best Management Practices

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

Disease

Principles

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

Best Management Practices

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

For additional information on turfgrass diseases commonly found in Michigan and management, see: http://www.msuturfdiseases.net/

Weeds

Principles

- Weeds compete with desired plants for space, water, light, and nutrients and can harbor insect pests and diseases.
- Weed management is an integrated process where good cultural practices are employed to encourage desirable turfgrass ground cover, and where herbicides are intelligently selected and judiciously used. A successful weed management program consists of:
    - preventing weeds from being introduced into an area
    - using proper turfgrass management and cultural practices to promote vigorous, competitive turf
    - properly identifying weeds
    - properly selecting and using the appropriate herbicide, if necessary
- Weeds are hosts for other pests such as plant pathogens, nematodes, and insects, and certain weeds can cause allergic reactions in humans.
- Weeds reproduce from seed, root pieces, and special vegetative reproductive organs such as tubers, corms, rhizomes, stolons, or bulbs. People, animals, birds, wind, and water can distribute seeds.
- Weeds complete their life cycles in either one growing season (annuals), two growing seasons (biennials), or three or more years (perennials). Annuals that complete their life cycles from spring to fall are referred to as summer annuals. Those that complete their life cycles from fall to spring are winter annuals.

Best Management Practices

- Proper weed identification is essential for effective management and control.

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

Nematodes

Principles

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

Best Management Practices

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

Pesticide Management

Principles

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

Principle

Pesticides contain active ingredients (the component that targets the pest) and inert ingredients such as solvents, surfactants, and carriers. Both active and inert ingredients may be controlled or regulated by federal, state, and local laws because of environmental and health concerns. The Michigan Department of Agriculture & Rural Development is responsible for licensing pesticide dealers and applicators in addition to ensuring safe use of pesticides and preventing misuse. The section also offers training and testing sessions over the course of the year. Additional information can be found through the MDARD website.

Best Management Practices

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

Human Health Risks

Principle

Pesticides belong to numerous chemical classes that vary greatly in their toxicity. The human health risk associated with pesticide use is related to both pesticide toxicity and the level of exposure. The risk of a very highly toxic pesticide may be very low if the exposure is sufficiently small. Each pesticide label will provide information on personal protective equipment needed (PPE), first aid, as well as include a precautionary statement and pesticide signal word. The label is the law, and each applicator should read the label in its entirety prior to mixing, loading or applying a pesticide. Safety Data Sheets (SDS) also contain relevant information such as

precautionary and first aid treatment. Safety Data Sheets should be used in conjunction with the pesticide label.

Best Management Practices

- Select the least toxic pesticide with the lowest exposure potential.
- Know the emergency response procedure in case excessive exposure occurs.
- Read the pesticide label in its entirety before mixing, loading or applying a pesticide.
- Use the recommended PPE per the pesticide label.
- In case of exposure, refer to the pesticide label for additional information and treatment recommendations

Environmental Fate and Transport

Principle

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

Best Management Practices

- Select pesticides that have a low runoff and leaching potential.
- Before applying a pesticide, evaluate the impact of site-specific characteristics (for example, proximity to surface water, water table, and well-heads; soil type; prevailing wind; etc.) and pesticide-specific characteristics (for example, half-lives and partition coefficients)
- Select pesticides with reduced impact on pollinators.
- Select pesticides that, when applied according to the label, have no known effect on endangered species present on the facility.
- Do not make pesticide applications during adverse weather conditions.
- Implement a drift management plan where applicable (a sample drift management plan can be found here in accordance with Regulation 637 Pesticide Use Rule 10 of the MDARD).

Pesticide Transportation, Storage, and Handling

Principle

The use of pesticides and fertilizers in turf maintenance is one of the most environmentally sensitive activities of the business. The application of pesticides and fertilizers and the potential for environmental impact after application is often the object of public debate. Yet it is the storage of these products on your property and the serious potential for environmental impact that is often overlooked. These products are packaged in concentrated form and thoughtful

consideration is required to ensure protection of natural resources, particularly groundwater, to catastrophic events like a fire or a large spill.

As you evaluate your present storage practices or consider a new design, it is important to understand the framework of current and proposed regulatory guidelines in Michigan. We currently have pesticide and fertilizer regulations written for commercial operations that store "bulk quantities." While these rules are primarily focused on bulk storage situations and will not affect most golf course operations, they do provide clear direction for safe storage of these products regardless of the container size. In addition to regulation, there are solid recommendations for safe storage of these products that have been developed from MSU, the Natural Resource Conservation Service and the Midwest Plan Service that are included within the worksheet section of this module.

It is important to note the manner in which businesses are defined within the existing and proposed pesticide and fertilizer storage rules. Agricultural operations are regarded as those who produce an agricultural commodity and commercial operations are generally defined as those who redistribute the products (fertilizers or pesticides) or offer application services. In some cases, properties do not fall within either category and therefore are not regulated. In these cases it is prudent to comply with the intent and spirit of the regulation because you will provide significant protection toward natural resources.

Pesticide Storage Rules

We currently have pesticide storage regulation dedicated toward the storage of bulk quantities of pesticides at commercial operations (Regulation 640, Act 451 Part 83), which was enacted in 1992 under the definition of Regulation 640. This regulation is strictly intended for commercial operations that store bulk quantities. Golf courses are exempt from these rules because they are not considered a commercial operation. A commercial operation is one that redistributes the pesticide off property or sells a service of application. Pesticides bulk storage is considered to be quantities of liquids over 55 gallons or dry material over 100 pounds in one container.

Michigan's Regulation 640 was reviewed by EPA and it was determined that it was equivalent and in some areas, even more protective than the federal rules. Therefore, Regulation 640 is the primary bulk containment regulation.

Fertilizer Storage Rules

There are two new regulations that are being administered by the Michigan Department of Agriculture and Rural Development dedicated toward bulk quantity fertilizer storage. They are - Commercial Fertilizer Bulk Storage and Regulation 642 On-Farm Fertilizer Bulk Storage. At this time, golf course operations are exempted from these rules because they are not defined as a farm and are not considered a commercial operation since they do not redistribute the product off property. Bulk fertilizer quantities are considered liquid quantities of over 2,500 gallons liquid in one container or a combined total of over 7,500 gallons, or over 2,000 pounds of dry fertilizer product in one container. Generally, the only golf course situations that would be considered bulk storage are those operations that have a fertigation system and have a holding tank over 2,500 gallons or those that receive dry fertilizer in bags containing more than 2,000 pounds per bag.

Applying the Regulations to Your Site

Even though golf courses are exempt from the pesticide and fertilizer storage rules, it's valuable to examine the requirements outlined in the regulations. This will assist you in gauging your level of protection and provide a framework of recommended practices.

Important Requirements from Regulation 640 and 641

- Site map identifying wells, ditches, surface water and storage area
- Maintain a discharge response plan
    - Discharge is considered an uncontained release of over 55 gallons liquid or 650 pounds dry fertilizer
- Prepare a containment design

- Siting requirements for new facilities

    - 200 feet from surface water
    - Out of the 100 year flood plain
    - 2,000 feet form Type I and IIA wells
    - 75 ft or more from Type lIB and III wells-with secondary containment (deviation/rom 800 ft in Rule for fertilizer only)
    - 75 ft or more from all other drinking wells (deviation/rom 150 ft in Rule for fertilizer only)

- Siting requirements for existing facilities

    - 200 feet from Type I and IIA wells
    - 75 feet from Type liB and III wells
    - 50 feet from other drinking wells

- Backflow prevention
- All plumbing above ground - Underground piping is permitted provided the piping is made of stainless steel, enclosed in secondary containment (a pipe within a pipe), or is hydrostatically tested annually.
- Secure tank to prevent floating or tipping
- Mobile containers should be kept 100' from wells or surface water
- Should be able to inspect tank and dike walls
- Have level gauges and shutoff valves
- Tanks should be lockable during off-season
- All loading, mixing and handling conducted on a paved impermeable surface.

Best Management Practices

- Store, mix, and load pesticides away from sites that directly link to surface water or groundwater.
- Store pesticides in a lockable concrete or metal building that is separate from other buildings.
- Locate pesticide storage facilities from other types of structure to allow fire department access.
- Storage facility floors should be impervious and sealed with a chemical-resistant paint.

- Floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included.
- Sloped ramps should be provided at the entrance to allow the use of wheeled handcarts for moving material in and out of the storage area safely.
- Shelving should be made of sturdy plastic or reinforced metal.
- Metal shelving should be kept painted to avoid corrosion. Wood shelving should never be used, because it may absorb spilled pesticides.
- Automatic exhaust fans and an emergency wash area should be provided. Explosion-proof lighting may be required. Light and fan switches should be located outside the building, so that both can be turned on before staff enter the building and turned off after they leave the building.
- Avoid temperature extremes inside the pesticide storage facility.
- Personal protective equipment (PPE) should be easily accessible and stored immediately outside the pesticide storage area.
- Do not transport pesticides in the passenger section of a vehicle.
- Never leave pesticides unattended during transport.
- Place a spill containment kit in the storage area, in the mix/load area and on the spray rig.

Emergency Preparedness and Spill Response

Principle

Accidents happen. Advance preparation on what to do when an accident occurs is essential to mitigate the human health effects and the impact on the environment. MDARD field staff responds to incidents reported to the MDARD Spill Hotline by emergency first responders, responsible parties, or other persons that observe an uncontrolled release. Staff provides direction to the responsible party to contain the spill. Once any immediate environmental concerns are abated, the responsible party is provided with advice on how to clean-up the spilled material. In nearly all situations, the spilled material is land applied at agronomic rates, avoiding costly landfill expenses. Call 1-800-405-0101 to report spills.

Best Management Practices

- Develop a golf course facility emergency response plan which includes procedures to control, contain, collect, and store spilled materials.
- Prominently post “Important Telephone Numbers” including CHEMTREC, for emergency information on hazards or actions to take in the event of a spill.
- Ensure an adequately sized spill containment kit is readily available.
- Designate a spokesperson who will speak on behalf of the facility should an emergency occur.
- Host a tour for local emergency response teams (for example, fire fighters, etc.) to show them the facilities and to discuss the emergency response plan. Seek advice on ways to improve the plan.

Pesticide Record Keeping

Principle

Maintaining accurate records of pesticide-related activities (for example, purchasing, storage, inventory, applications, etc.) is essential. All commercial applicators applying pesticides in Michigan are required to keep verifiable records of those applications. The following present the minimum information required in the records and the situations in which they are required. (Act 451 See 8311 and Regulation 636.15).

Records of the following information for all general-use pesticide applications must be kept for at least one year from the date of the application (636.15.2):

- EPA Registration Number
- Pesticide product name and concentration
- Amount of pesticide applied
- Target pest, purpose, or crop site
- Date of application
- Address or location of application
- Method and rate of application

Records of the following information for all restricted use pesticide (RUP) applications for at least three years from the date of the application? (636.15.1):

- EPA Registration Number
- Pesticide product name and concentration
- Amount of pesticide end dilution applied
- Target pest, purpose, or crop site
- Date of application
- Address or location of application
- Method and rate of application

The above information in the general-use and RUP applications must be made available upon request to an authorized representative of the MDARD during normal business hours.

If the firm employs registered technicians (registered applicators): then the firm must have an approved trainer. This is only required if the firm is conducting training using a firm specific, MDARD approved, registered technician training program. (636.11.1 and Act 451 Sec 8314)

Signage

Ensure there is a general application sign located in the pro shop, men’s and women’s locker room, or registration area that includes a contact person and the statement that from time to time, pesticides are used in the management of turf and ornamental pests. (637.11.3a i-v)

Ensure application signs placed at the first and tenth tees at the time of application until label specific reentry times expire or products are dried and the dust has settled. (637.l1.3b)

Application signs must contain the following information: (637.11.3b)

- Time and date of the application
- Common name of the pesticide
- Area treated
- Label re-entry precautions
- Name of contact person

Best Management Practices

- Keep and maintain records of all pesticides used to meet legal (federal, state, and local) reporting requirements.
- Use records to monitor pest control efforts and to plan future management actions.
- Use electronic or hard-copy forms and software tools to properly track pesticide inventory and use.
- Develop and implement a pesticide drift management plan.
- Keep a backup set of records in a safe, but separate storage area.

Drift Management

If applications are performed where drift may land off property, ensure you have a drift management plan in place. (637.10.3) Maintain records of when and where a drift management plan was used. (637.10.5) Maintain drift management records for one year for general-use and three years for RUP applications. (637.10.5)

Best Management Practices

- Implement a drift management plan where applicable. A sample drift management plan can be found here (https://www.michigan.gov/documents/mda/Drift_Management_Plan_Policy_270250_7.pdf) in accordance with Regulation 637 Pesticide Use Rule 10 of the MDARD.

Sprayer Calibration

Principle

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

Best Management Practices

- Personally ensure spray technician is experienced, licensed, and properly trained.
- Minimize off-target movement by using properly configured application equipment.
- Properly calibrate all application equipment at the beginning of each season (at a minimum) or after equipment modifications.
- Check equipment daily when in use.

- Use recommended spray volumes for the targeted pest to maximize efficacy.

Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration their walking speed, etc.

Types of Sprayers

Principle

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

Best Management Practices

- Use an appropriately sized applicator for the size of area being treated.
- Equipment too large in size requires greater volumes to prime the system. This can result in significant waste that must be properly handled.
- Ensure the application equipment in good mechanical condition. (637.4c)
- Ensure the application equipment free of leaks or malfunctions. (637.4c)
- Routinely calibrate the application equipment. (637.4d) Be able to identify the frequency, method and record keeping of your calibration.
- Ensure there are shut-off valves on the application equipment to prevent off target discharge? (637.4e)
- Keep a spill kit on the application equipment? (637.4m) (Shovel and adsorbent material)

Ensure the application equipment meet the pesticide label requirements? (Act 451, Part 83, Section 8311.7 and Regulation 637.4.a)

Inventory

Principle

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

Best Management Practices

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

Shelf Life

Principle

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

Best Management Practices

- Avoid purchasing large quantities of pesticides that require storage for greater than six months.
- Adopt the “first in–first out” principle, using the oldest products first to ensure that the product shelf life does not expire.
- The MDARD offers the Michigan Clean Sweep Program in order to eliminate potential public health and environmental hazards from cancelled, suspended, and unusable pesticides that are being stored.
- Ensure labels are on every package and container.
- Consult inventory when planning and before making purchases.
- Ensure that labels remain properly affixed to their containers.

Leaching Potentials

Principle

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

Best Management Practices

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

Mixing/Washing Station

Principle

In the early 1990's professionals from Michigan's agricultural industries including turfgrass industry representatives, worked with environmental groups, citizen groups and the Michigan Department of Agriculture to construct a set of rules describing the use of pesticides by commercial applicators. The result of this effort was a package of 16 rules commonly referred to as Regulation 637. It was enacted October 29, 1992 and is currently contained in Public Act 451 Natural Resources and Environmental Protection Act.

Commercial pesticide application is generally recognized as the application of pesticides on the property of another as a routine work assignment or pesticide applications that are hired by the property owner for use on their land. This includes applications on school grounds, golf courses, parks and all applications conducted by lawn care companies.

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

A mixing/loading pad is required to be onsite if the following criteria are met:

- You are considered a commercial applicator by the MDARD.
- You mix, load, or transfer pesticides for more than 10 days in a calendar year (the transfer of pesticides includes transfer from one container to another or transfers between a nurse tank and a sprayer).
- The mixing and loading is conducted on the same site for more than ten days.
- There is use of pesticide application equipment other than hand-held equipment (includes hand can pump sprayers, backpack sprayers, or push spreaders, these devices are exempt from mixing/loading pad requirements).

According to Regulation 637, mixing and loading pads were required to be in place by October 29, 1993. For additional information on Regulation 637 please visit the MDARD website.

Washing, Rinsing & Managing Pesticide Containing Materials

Another rule in Regulation 637 is dedicated toward the washing of pesticide application equipment or where pesticide-containing materials are washed or rinsed. There are clear definitions regarding these materials and activities.

"Wash water" means water that is used to wash exterior surfaces of application, handling, storage or transportation equipment where pesticide residues are likely to occur.

"Pesticide-containing material" means any of the following:

- Any container of a pesticide product that has not been properly rinsed.
- Any rinsate that is derived from a pesticide container, application equipment, or equipment washing.
- Any material that is used to collect or contain excess or spilled pesticide or rinsate.
- Any mixture of pesticide and diluents such as wash water, rinse water or rainwater.
- Material that is generated as a result of contact with a pesticide in an application, containment, recovery, reuse or treatment system. It does not include personal protective equipment that contains pesticide residue.

If you are a commercial applicator by MDARD definition, and your sprayer contains residues on the outside surfaces, and you wash it more than ten days during the calendar year, then you are required to have a wash/rinse pad. This pad has the same specifications as the mixing loading pad and they are considered to be one in the same.

Any materials that contain pesticide residues like wash water, spill recovery materials and rinsates are considered "pesticide containing materials". These materials may be applied onto labeled sites according to label directions.

Best Management Practices

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

Disposal

Principle

Wash water from pesticide application equipment must be managed properly, since it contains pesticide residues. The disposal of pesticide containers or pesticide containing materials (PCM) is an important component of your operation. Examples of PCM's include: unclean pesticide containers, spill cleanup materials, tank rinsates and soil that contacted a pesticide. The Michigan Clean Sweep Program provides free safe pesticide disposal for Michigan residents and businesses and the Michigan Pesticide Container Recycling. Program The Michigan Pesticide Container Recycling Program is a partnership between the Michigan Agriculture Environmental Assurance Program, the Michigan Agri-Business Association, the Ag Container Recycling Council, agri-chemical dealers and pesticide users across Michigan.

The program protects groundwater by promoting the proper rinsing and recycling of pesticide jugs and drums. In addition to protecting our water, recycling empty containers reduces waste entering our landfills.

Best Management Practices

- Collect wash water (from both inside and outside the application equipment) and use it as a pesticide in accordance with the label instructions.
- The rinsate may be applied as a pesticide (preferred) or stored for use as makeup water for the next compatible application.
- Recycle rinsed containers in counties where an applicable program is available or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them. Visit the MDARD Pesticide Container Recycling site for additional information.

Personal Protective Equipment

Principle

Exposure to pesticides can be mitigated by practicing good work habits and adopting modern pesticide mix/load equipment (for example, closed-loading) that reduce potential exposure.

Personal Protective Equipment (PPE) statements on pesticide labels provide the applicator with important information on protecting himself/herself. To avoid contamination, do not store PPE in a pesticide storage area.

Best Management Practices

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

Pesticide Container Management

Principle

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

Best Management Practices

- Rinse 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.
- Puncture empty and rinsed pesticide containers and dispose of according to the label.
- Recycle pesticide containers where applicable.
- Recycle rinsed containers in counties where an applicable program is available, or take them to a landfill for disposal. Check with your local landfill before taking containers for disposal, as not all landfills will accept them. Visit the MDARD Pesticide Container Recycling site for additional information.

Personal Applicator Credentials

Principle

The tasks of handling and applying pesticides have inherent risks and responsibilities. The situations requiring a business license and individual applicator credentials for using pesticides are discussed. Pesticide operations are reviewed from paperwork, a physical, a mechanical, and a practical standpoint.

The three Michigan laws with significant impact on pesticide applicators are:

- The Natural Resources and Environmental Protection Act, Act 451, Part 83
- Regulation 636, as amended, Pesticide Applicators
- Regulation 637, Pesticide Use (Laws and Regulations website)

To obtain a copy of the law(s), contact your regional Michigan Department of Agriculture and Rural Development (MDARD) office or visit the MDARD website.

Personal Applicator Credentials

In Michigan, any person who applies pesticides as a part of their job responsibilities is required to have pesticide applicator credentials, except as indicated below. These credentials include the registered or certified applicators. Applicator credentials are not necessary when persons use general use, ready-to-use pesticides as part of a non-licensed business activity. Ready to use pesticide means that it is applied directly from its original container consistent with label directions and does not require mixing or loading prior to application (Act 451, Part 83, Section 8306.2). All persons using any type of pesticide in a licensed business operation must have an applicator credential. Below are examples of pesticide uses and applicator credentials:

Credentials Required

- Liquid herbicide applications to lawns of others, as a part of a for hire business activity.
- Applying 'weed and feed' products with a granular spreader on the hospital or school grounds as an employee of the hospital or school.
- Treating trees and shrubs that are on the property of another with pesticide, as part of a for hire business activity.
- Treating trees and shrubs that are on the golf course where the applicator is employed, using an insecticide requiring dilution
- Treating an athletic complex for mosquitoes which requires mixing of insecticide
- Treating trees and shrubs that are on the golf course where the applicator is employed, using an insecticide requiring dilution
- Treating an athletic complex for mosquitoes which requires mixing of insecticide solutions, whether employed by the facility to make the application or performing it as a fore hire business activity,
- Making herbicide application to a public lake within a park while employed by the park administration.

No Credentials Required

- Use of a ready-to-use herbicide formulation to treat weeds in sidewalk cracks at the site (non-licensed business) where the applicator is employed.
- Placing self-contained ant baits in the building where the applicator is employed.
- Using an aerosol wasp spray to eradicate a wasp nest at the building where the applicator is employed.
- Spot treating weeds with a ready-to-use herbicide at a golf course where the applicator is employed.

Pollinator Protection

Regulatory Considerations

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

The western honey bee (*Apis mellifera*) is one of the most important pollinators in the United States. Hundreds of other bee species, including the bumble bee (*Bombus* spp.), also serve as important pollinator species. Protecting bees and other pollinators is important to the sustainability of agriculture. The Michigan Pollinator Initiative has information related to pollinators and bees.

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

Principles

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

Best Management Practices

- Proper records of all pesticide applications should be kept according to local, state, or federal requirements.
- Use records to establish proof of use and follow-up investigation of standard protocols regarding:
    - Date and time of application

    - Name of applicator
    - Person directing or authorizing the application
    - Weather conditions at the time of application
    - Target pest
    - Pesticide used (trade name, active ingredient, amount of formulation, amount of water)
    - Adjuvant/surfactant and amount applied, if used
    - Area treated (acres or square feet) and location
    - Total amount of pesticide used
    - Application equipment
    - Additional remarks, such as the severity of the infestation or life stage of the pest
    - Follow-up to check the effectiveness of the application
- Those applying pesticides, and who make decisions regarding their applications should be able to interpret pollinator protection label statements.
- Those applying pesticides should be aware of honey bee biology.
- Those applying pesticides should understand the various routes of exposure (outside the hive and inside the hive).
- Those applying pesticides should understand the effects of pesticides on bees.

Pollinator Habitat Protection

Principles

- 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.
- Be mindful of pollinators; when applying pesticides, focus on minimizing exposure to non-target pollinators in play and non-play course areas.
- Pollinators require a diversity of flowering species to complete their life cycle. Pollinator habitat contains a diversity of wildflower species of different colors and heights, with blossoms throughout the entire growing season

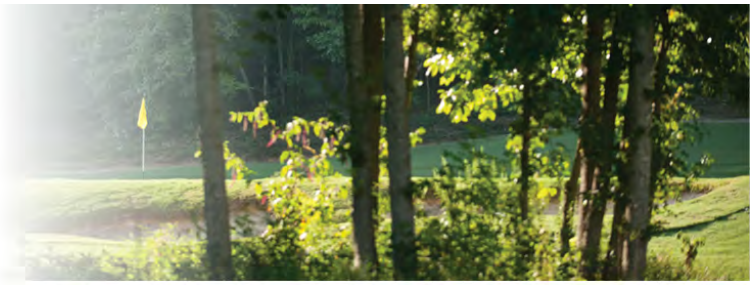
Best Management Practices

- Follow label information directing the application of pesticide when the plant may be in bloom. Avoid applying pesticides during bloom season.
- Stay on target by using coarse-droplet nozzles, and monitoring wind to reduce drift.
- Do not apply pesticides when pollinators are active.
- Before applying a pesticide, scout/inspect the area for both harmful and beneficial insect populations, and use pesticides only when a threshold of damage has been indicated.
- Mow flowering plants (weeds) before insecticide application.
- If flowering weeds are prevalent, control them before applying insecticides.
- Use insecticides that have a lower impact on pollinators.
- Use the latest spray technologies, such as drift-reduction nozzles to prevent off-site (target) translocation of pesticide.
- Avoid applications during unusually low temperatures or when dew is forecast.
- Use granular formulations of pesticides that are known to be less hazardous to bees.

- Consider lures, baits, and pheromones as alternatives to insecticides for pest management.
- Develop new pollinator habitat and/or enhance existing habitat.

Landscape

Species Selection and Size Considerations



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

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

Principles

- The fundamental principle for the environmentally sound management of landscapes is “right plant, right place.” The ideal plant from an environmental standpoint is the one that nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall, and light patterns, insects, and other pests, and endemic nutrient levels over thousands of years.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers. This reduces the need for pruning and debris removal and lowers maintenance costs.
- The addition of proper soil amendments can improve soil’s physical and chemical properties, increase its water-holding capacity, and reduce the leaching of fertilizers. Amendments may be organic or inorganic; however, soil microorganisms rapidly decompose organic amendments such as peat or compost.
- The goal of species-selection BMP is to maintain as close to a natural ecosystem as practical, while meeting the needs of a golf course.
- Landscape areas should be fundamentally designed to facilitate rapid plant establishment to conserve water and lower nutritional input requirements once mature. Plants within areas that are not in play or are not critical to the design of the course may be removed and replanted with native plant material that requires little to no maintenance after establishment. Additionally, 50% to 70% of the non-play areas should remain in natural cover. As much natural vegetation as possible should be retained and enhanced through the supplemental planting of native trees, shrubs, and herbaceous vegetation to provide wildlife habitat in non-play areas, along water sources to support fish and other water-dependent species. By leaving dead trees (snags) where they do not pose a hazard, a well-developed understory (brush and young trees), and native

grasses, the amount of work needed to prepare a course is reduced while habitat for wildlife survival is maintained.

Best Management Practices

- Base plant selection as close to a natural ecosystem as practical, while meeting the needs of the golf course. It has adapted specifically to the soil, microclimate, rainfall, light patterns, insects and other pests, and endemic nutrient levels over many years.
- Select trees, plants, and grass species to attract birds seeking wild fruits, herbs, seeds, and insects.
- Know the ultimate sizes and growth rates of trees, shrubs, and ground covers.
- Use plants that are adapted for the site based on the United States Department of Agriculture (USDA) cold-hardiness map.
- Select stress-tolerant species or cultivars to manage periodic dry/wet conditions.
- Choose the most stress-tolerant species or cultivar for a particular area.
- Selection should keep in mind the environment is ever-changing and selections should reflect environmental adaptations. (ex. Emerald Ash Borer's effect on the use of ash trees in the landscape).

Design and Function

Principles

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

Best Management Practices

- Well-designed forested buffers should contain a mixture of fast- and slow-growing native trees, shrubs, and grasses to provide a diverse habitat for wildlife.
- Use forested buffers to trap and remove upland sources of sediments, nutrients, and chemicals.
- Use forested buffers to protect fish and wildlife by supplying food, cover, and shade.

- Use forested buffers to maintain a healthy riparian ecosystem and stable stream channel.
- Leave dead tree snags whenever possible for nesting and food source to wildlife. However, make sure that these snags are a safe distance away from playing surfaces should they get blown over.
- Use turf as a landscape element where needed.

Planting Methods

Principles

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

Best Management Practices

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

Energy

Energy Conservation

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

The overall conclusion of the study suggests that golf facility managers must take steps toward identifying options for conservation, efficiency, and cost savings.

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

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

Principles

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

Best Management Practices

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

Evaluation

Principles

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

Best Management Practices

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

Efficiency

Principles

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

Best Management Practices

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

Design and Renovation

Principles

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

Best Management Practices

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

Implementation Plan

Principles

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

Best Management Practices

- Evaluate effectiveness of upgrades according to efficiency/conservation goals for energy use.
- Continue to identify future energy needs and maintain good record keeping.
- Prioritize energy consumption as part of purchase/decision-making process for HVAC, food service, laundry, swimming pools, etc.

- Consider other devices as part of the plan; do research on building, pumps, and power generation.

Infrastructure

Principles

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

Best Management Practices

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

Alternative products, operations, and practices

Principles

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

Best Management Practices

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

Course Management Plan

Principles

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

Best Management Practices

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

Irrigation

Principles

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

Best Management Practices

- Audit irrigation system (see Water Conservation BMP).
- Schedule and operate pumps and irrigation in an efficient manner.
- Identify and implement infrastructure and behavioral changes.
- Evaluate technology and upgrades; implement when feasible.

Emergency Response Plans

Introduction

The federal Clean Water Act requires certain facilities to develop a plan that deals with proper storage and containment of oil stored on a property and is titled a Spill Prevention Control and Countermeasures (SPCC) Plan. The plan is only required if the facility meets or exceeds petroleum storage thresholds put forth by this Act. Facilities may also be required by the state to have a Pollution Incident Prevention Plan (PIPP) if the site meets certain conditions under the Part 5 rules of Public Act 451. An emergency response plan should include annual verifiable training tailored for your facility for your employees.

Federal Spill Prevention Control and Countermeasures Plan

Background on the Law

The Oil Pollution Act of 1990 is an amendment of Title 40, Code of Federal Regulations, Part 112 of Section 311 (j)(1)(C) of the Clean Water Act of the Environmental Protection Agencyâ€™s (EPA) Oil Pollution Prevention Regulation that was published in 1973. The United States uses over 250 billion gallons of oil and petroleum products each year. These regulations were issued to prevent oil spills from reaching the countryâ€™s navigable waters. Any spill, no matter how small can have a serious impact on the environment and can cause a threat to human health and wildlife. The remediation required to clean up a spill can go beyond the boundaries of your property and result in costly cleanups. It may take years for an ecosystem to recover from the damage caused by an oil spill. The EPA may levy heavy fines and penalties, especially if you were negligent in your requirement of developing a prevention plan.

What facilities are regulated under the Oil Pollution Regulation?

If a facility meets all of the following criteria, it must comply with the SPCC regulations:

- The facility must be non-transportation related.
- An above ground petroleum storage facility must have the ability to store greater than 1,320 gallons in one or multiple containers that have the storage capacity of 55 gallons or larger or have a total underground storage capacity of greater than 42,000 gallons.
- The facility must have a reasonable expectation for a discharge of oil or petroleum products to reach navigable waters or adjoining shorelines of the United States.

What is the definition of OIL?

Under the SPCC regulations, oil is defined as â€œoil of any kind or in any form, including but not limited to:

- Petroleum
- Fuel Oil
- Sludge
- Oil refuse
- Oil mixed with wastes other than dredged spoils

- Fats, oils or greases of animal, fish, or marine mammal origin
- Vegetable oils, including oil from seeds, nuts, fruits, or kernels
- Other oils and greases including synthetic oils and mineral oils.

What does this mean at golf facilities?

The golf course is considered as one facility, so any oil product that is stored on the property in a container able to store 55 gallons or more is a part of the 1,320 gallon threshold for petroleum storage. The threshold level deals with container storage capacity not with actual amounts stored at that facility. So, if there was a 500 gallon gasoline storage tank, but it was never filled more than halfway, it would still count as 500 gallons rather than 250 gallons toward the total storage threshold of 1,320 gallons.

Storage containers, 55 gallon capacity or larger, that are part of the total storage numbers include:

- Gasoline storage tanks
- Diesel storage tanks
- New oil drums
- Waste oil drums/tanks
- Heating oil tanks
- Gasoline storage tanks for gas carts
- Any petroleum products stored anywhere at the facility
- Any oil, as described above, stored in 55 gallon containers or larger

Under the Oil Pollution Act what requirements do golf courses need to comply with?

- Golf courses fall under the requirements for non-transportation related facilities.
- Golf courses are either exempt from this regulation or required to develop a SPCC plan depending on the size of the petroleum product containers that are stored at the facility. The definition of oil storage containers include, but are not limited to, tanks, containers, pails, drums, transformers, oil-filled equipment, and mobile or portable totes.
- The determination of whether a facility could reasonably discharge oil into or upon navigable waters or adjoining shorelines of the United States is based on geographical aspects and the facility location. The location of a facility must be considered in relation to a water body. The distance to navigable waters, volume of material stored, worse case weather conditions, drainage patterns, land contours, soil conditions and more must be taken into consideration. In most situations if there is any type of water body on or in the area surrounding the facility it will likely be determined that you could reasonably discharge oil into navigable waters of the United States.

Golf Course A
Petroleum Products stored on site:

750 gallon gasoline tank
250 gallon diesel tank
55 gallon drum of S.A.E. 30 Oil
55 gallon drum used oil

TOTAL of 1,110 gallons of petroleum products in storage

In the case of Golf Course A, the total amount of petroleum products stored at this facility (1,110 gallons) is below the threshold for multiple aboveground storage tanks, thus Golf Course A is not required to develop a Spill Prevention Control and Countermeasures plan.

Golf Course B
Petroleum Products stored on site:

1,000 gallon Gasoline tank
500 gallon Diesel tank
55 gallon 10W-30 Oil drum
55 gallon 10W-40 Oil drum
55 gallon Hydraulic Oil drum
55 gallon used oil drum
TOTAL of 1,720 gallons of petroleum products in storage

In this situation, with 1,720 gallons of potential storage, Golf Course B exceeds the threshold (1,320 gallons) for storage of petroleum products in multiple containers. They would be required to develop a Spill Prevention Control and Countermeasures plan for their petroleum storage.

Golf Course C
Petroleum Products stored on site:

500 gallon Gasoline tank
500 gallon Diesel tank
100 gallon Gasoline tank at the Pro Shop
55 gallon drum of 10W-30 oil
55 gallon drum of 10W-40 oil
55 gallon drum of used oil
2 - 30 gallon drums of hydraulic oil
2 - 5 gallon pails of transmission fluid
12 - 1 quart bottles of 10W-40 oil
Total of 1,338 gallons of petroleum product in storage or 1,265 gallons of petroleum product storage toward SPCC threshold.

In this situation the golf course C's total petroleum storage is 1,338 gallons. The amount of storage that goes toward the SPCC threshold is 1,265 gallons because the two 30 gallon drums, the two 5 gallon pails and the twelve 1 quart bottles are smaller than the fifty-five gallon minimum and thus are not part of the reporting threshold. The 1,265 gallons of petroleum products stored is below the threshold for multiple tanks. So, Golf Course C is not required to develop a Spill Prevention Control and Countermeasures plan.

How to Develop a SPCC Plan

If your facility meets the requirements for developing a Spill Prevention Control and Countermeasures Plan (SPCC) the facility owner/operator is required to prepare a SPCC Plan for that facility. The plan must be well thought out and prepared in accordance with good engineering practices. No matter who prepares the SPCC Plan it is the owner/operator who is ultimately responsible for complying with the regulations.

Streamlined Requirements for Tier I and II Qualified Facilities

The SPCC rule has streamlined requirements for facilities with smaller oil storage capacity. The owner or operator of a "qualified facility" can prepare and self-certify an SPCC Plan rather than have a Professional Engineer (PE) review and certify the Plan. Self-certification is an optional alternative to PE certification of the Plan.

Even though each facility is unique there are certain elements that must be included in the SPCC Plan in order for it to comply with the Oil Pollution Act. Those areas that must be addressed in the plan are:

Operating procedures implemented to prevent oil spills at the facility
Control measures installed to prevent a spill from entering the navigable waters or adjoining shorelines
Countermeasures to contain, cleanup, and mitigate the effects of an oil spill
Some of the important elements that must be addressed in the SPCC Plan include but are not limited to the following:

Plan must follow the sequence of Oil Pollution Act as outlined below

Facility Information:

- Name of facility
- Name(s) of the owner or operator of the facility
- Address of the facility
- Date and year of initial facility operation
- Maximum storage or handling capacity of facility & normal daily throughput

Site Map:

- Buildings and storage areas for other oil products
- Wells
- Direction of flow in case of discharge (include an arrow pointing north)
- Distance to surface waters, storm drains, or other conduit to surface waters
- Location of spill cleanup materials
- Location of covered storage for contaminated materials
- Spill exit locations from property

TO-DO:

- Three-year plan review
- Oil spill history and corrective actions
- Spill predictions and potential for equipment failure
- Containment and diversionary structures
- Oil loading and unloading procedures
- Facility inspections

- Facility security
- Training and spill briefings
- Emergency response phone numbers

The SPCC Plan is not required to be filed with the U. S. EPA, but a copy must be available for on-site review by the regional administrator during normal working hours. The SPCC plan must be submitted to the U.S. EPA Region V regional administrator and the appropriate state agency along with the other information specified in Part 112 if either of the following occurs:

- A single discharge of oil to navigable waters or adjoining shorelines exceeding 1,000 gallons, or
- Two discharges of oil to navigable waters or adjoining shorelines each exceeding 42 gallons within any twelve-month period.

Spill information must be reported to your regional U.S. EPA office and state agency within 60 days if either of the above thresholds is reached.

Where do I get more Information?

For questions regarding the SPCC

You may also contact an "Oil Spill Expert" at U.S. EPA at 800-424-9346 or write to the following address for more information:

U.S. EPA - Region 5
77 W. Jackson Boulevard
Chicago, IL 60604-3590
(312) 353-2000
(800) 621-8431 (in Region 5 only)

To Report Oil & Chemical Spills call the National Response Center (NRC) 24 Hour National Spill Reporting Line at 1-800-424-8802.

A template to assist you in creating a Golf Course SPCC is also located in MTESP Appendix.

Pollution Incident Prevention Plans (PIPPs)

A golf course and resort operation would be required to have a Pollution Incident Prevention Plan (PIPP) and meet storage, surveillance, and release reporting requirements under the "Part 5 rules" if the site meets certain conditions:

- Has 5 tons or more of salt (including sand/salt mixtures) or 1,000 gallons brine. Salt includes sodium chloride (also called rock salt), calcium chloride, potassium chloride, and magnesium chloride. Please note the Water Bureau oversees the Part 31 (Water Resource Protection) of Act 451 Part 5 rules and not the Office of Waste Management and Radiological Protection as referenced in the rules. Find the Part 5 rules, PIPP checklist, salt storage and other guidance Emergency Response to Releases to Water.

- Has polluting materials listed in R 324.2009 in aboveground discrete use or storage areas that meet or exceed the listed threshold management quantities Outdoors - 440 pounds / Indoors - 2,200 pounds
- Examples of these materials may be products used in equipment maintenance and building repair (solvents), coolants (ethylene glycol), and sulfuric acid from lead acid batteries.
- Examples of these materials may be products used in equipment maintenance and building repair (solvents), coolants (ethylene glycol), and sulfuric acid from lead acid batteries.
    - Has polluting materials in containers 10 gallons or less, or 100 pounds or less, and stores them indoors so releases canâ€™t get into environment.
    - Only has flammable and combustible materials, hazardous waste, or regulated underground storage tanks that are subject to those applicable regulations overseen by the Office of Waste Management and Radiological Protection.
- EGLE determines a release from the facility could cause substantial harm to the surface or groundwaters of the state.

Polluting materials includes the listed substances, and mixtures of the materials that contain one percent or more by weight of these substances. When determining the threshold management quantity when you have mixtures, include the weight of the whole mixture.

Sites that have oils are not required to prepare a PIPP unless EGLE determines one is necessary. Oils include vegetable oils, animal fats, synthetic oils, petroleum, and refined products like mineral spirits, gasoline, diesel fuel, kerosene, etc. If the oils are subject to the federal Spill Prevention Control and Countermeasure (SPCC) regulations because the site has 1320 gallons or more oil storage capacity, the facility needs to meet those federal requirements along with additional state release reporting requirements.

If the oils are not subject to the federal SPCC regulation and the site has a single aboveground container or tank that has 660 gallon storage capacity or more, under the Part 5 rules you will need to:

- Implement surveillance procedures to detect releases from reaching waters of state
- Have the use and indoor storage designed, constructed, maintained and operated to prevent releases from reaching sewers, drains, or reaching waters of the state, and
- Have procedures to report releases as identified in Rule 324.2002(b) and (g) and in Rule 324.2009.

Reporting releases

The threshold reporting quantity (RQ) for each of the different polluting materials is included in the rules. If there are mixtures, calculate how much polluting material is contained in the mixture. The RQ for releases is based on the weight of polluting material (not the total weight of the mixture).

Call to report releases exceeding threshold reporting quantities or if unsure if a release needs to be reported:

- PEAS at 800-292-4706 or from out of state call 517-373-7660, and

- 911 (or their primary public safety answering point) per Section 3111b of Part 31 of Act 451, effective June 15, 2004

Submit written report within 10 days after the release.

You may use the form **EQP 3465 "Spill or Release Report"**, or submit a written report containing the information identified in Rule 7(2). Including:

- Cause of release
- Discovery of release
- Response measures taken or schedule for when measures will be taken
- Measures taken to prevent recurrence of similar releases

If you are required to submit a written release report to an EGLE Division (for example a permit may require reporting of releases) and are subject to the Part 5 rule reporting requirements, if the other required report contains the information listed, it is not necessary to also submit a separate report to the Water Resources Division.

Releases that go into a public wastewater treatment plant (WWTP) and meet the Part 5 rule conditions are also reportable to the Water Resources Division

PIPP Preparation and Notices

Pollution Incident Prevention Plan Completeness Review Checklist

Get the Checklist here.

Existing facilities subject to these rules were to have a PIPP prepared or updated by August 31, 2003. New, or existing facilities that are changing operations that they now meet threshold management quantities, should have a PIPP completed before beginning those operations. Plans must be reviewed every three years or after any release that required implementation of the plan. Keep a copy of the PIPP onsite. Do not submit a copy to EGLE unless requested.

Notifications that a PIPP was prepared or updated must be sent to the following:

- Local emergency planning committee.
- Local health department.
- EGLE's Water Resource Division district office.

A certification stating the facility is in compliance with all the Part 5 rules must also be submitted to EGLE.

EGLE Notification

When submitting the notice and certification to EGLE, there is not a specific form that is required to be used. Following is optional certification language that may be used, but is not required:

> Under penalty of law, this certifies that (company name) at (site address) is in full compliance with the Part 5 administrative rules pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451). A copy of the Pollution Incident Prevention Plan (PIPP) [or Integrated Contingency Plan (ICP) if prepared] may be requested by [include who and how to contact to request a copy].
>
> The facility has prepared a PIPP/ICP because it has met the threshold management quantities for (identify if salt, polluting materials, or oils if SPCC is included in the ICP) [Note: although not required by the rules, facilities are being asked to identify the category of polluting material that is on-site.]

Include a signature, title, date, and mailing address if different than the site address.

Local agency notifications

For notifying the local entities, check with them how they preferred to be notified. You may:

- Submit a letter explaining you are notifying them as required by the Part 5 administrative rules pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451) that your company has completed a PIPP or ICP.
- Call them, but keep written documentation when you called and who you spoke to. Make sure to provide your companyâ€™s name, site address (and mailing address if different), and who to contact to request a copy of the plan.

Although not required by the rules, check if the local agency would like a copy of the polluting material inventory or the category of polluting material (salt, Rule 9 materials, or oils) that is on-site submitted with the notification. Due to security issues some facilities or local agencies may not want the list included. If the local entities know what material is on- site, it may help them decide if they will request a copy of your plan. A facility must submit a copy of the plan within 30 days of receiving the request.

PIPPs may be combined with other plans as long as the information required to be in the PIPP is in the Integrated Contingency Plan (ICP). For more ICP information, go to Emergency Planning.

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(Note: URLs are as of September 2016)

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