Golf courses are man-made ecosystems which include natural habitats, diverse wildlife populations (both permanent and migratory), ground and surface water, managed turf, and provide recreational space for millions of people each year. The grasses found on golf courses clean the environment by absorbing gaseous pollutants and intercepting pesticides, fertilizers, dust, and soil. In addition, grasses release oxygen and reduce glare, noise, and summer temperatures. Irrigation water applied to golf courses remains on site to recharge water supplies.

Construction Phase

- Erosion and Sedimentation
- Wetlands
- Ponds and Lakes
- Turfgrass Selection

Established Turf

- Fertilizers
- Irrigation
- Mowing
- Integrated Pest Management
- Pesticide Selection and Use
- Pesticide Leaching Potential Indices
- Pesticide Storage, Disposal, and Spills
- Storage Tanks

The need to protect surface and groundwater quality is a serious environmental issue. Good design can prevent or minimize erosion and runoff. Good design provides for buffers and natural vegetated areas near streams, wetlands, and other fragile areas. It also minimizes the development of gullies, the redirection of streams, and the unnecessary disruption of the natural landscape, especially around drainage ditches, and stream banks.

Proper management practices need to be developed and followed to protect this environment. The purpose of this publication is to provide golf course superintendents, golf course builders, greens committee members and others concerned with golf courses, with management strategies to preserve and protect water resources.

Best Management Practices (BMPs)

Every turf management decision you make in managing the golf course will have an effect on the golf course ecosystem. Best Management Practices, or BMPs, are a series of cultural practices designed to maximize resources while minimizing risk to the environment. BMPs cover important aspects of golf course management from the original design to the daily
maintenance. This publication provides a discussion of some of the BMPs applicable to the creation, protection, and maintenance of the golf course ecosystem.

**CONSTRUCTION PHASE**

**Erosion and Sedimentation**

Bare soils and steep slopes, without proper turfgrass cover, are highly susceptible to erosion. Sediment resulting from erosion is the leading cause of stream impairment and pollution. Sediment destroys fish spawning beds, reduces useful storage volumes in reservoirs, and results in increased filtration costs for municipal water supplies. Pesticides and nutrients, such as nitrogen and phosphorus, can be moved in water containing sediment. A healthy stand of turf can help to control erosion and reduce runoff, but it must be properly constructed in order to protect water quality.

North Carolina requires that an erosion and sediment control plan be submitted to the Land Quality Section, Division of Land Resources, DEHNR regional office in your area, thirty days prior to the start of clearing or grading, for areas larger than one contiguous acre.

Following are several methods of reducing and managing erosion and sedimentation during construction.

**Erosion and Sedimentation BMPs**

- Plan construction activities to minimize the duration of exposed soil.
- Limit the area of soil disturbance at any one time.
- Construct sediment traps and basins before other land-disturbing activities take place.
- Establish soil stabilization with plant materials as soon as possible after soil disturbance.
- Through controlled irrigation, manage runoff and keep velocities low.
- Break long slopes with diversions.
- Divert storm water runoff from disturbed areas to sedimentation containment systems using dikes, diversions, and waterways.
- Inspect and maintain the erosion and sedimentation control systems frequently.

Further information is found in the *North Carolina Erosion and Sediment Control Planning and Design Manual*. It is available for $30 from the Division of Land Resources, PO Box 27687, Raleigh, NC 27611. The *Field Manual* is a condensed version of the design manual and is available from the same source for $20.00.

**WETLANDS**

Wetlands serve as filters for surface and groundwaters. They provide vital habitat for many species of plants and animals, and serve as recreational areas, and help in natural flood control. The most recent version of the 404 section of the 1979 Clean Water Act defines wetlands as, "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Wetland areas must be defined and delineated at the beginning of the golf course design process. During construction they must be protected from excess water and sedimentation. Once the course is built they should be managed as natural areas which are protected from abnormal volumes of water, nutrients, or pesticides used in the maintenance of the golf course.

Actions you can take to reduce the impact on wetlands include:

**Wetlands BMPs**

- Maintain borders of low maintenance turf or natural vegetation within 50 feet of wetland boundaries.
- Minimize the flow of irrigation water into the wetlands. This will also reduce the possibility of nutrient and pesticide movement into those areas.
- Stabilize and maintain stream banks and ditches to limit erosion.
- Limit the application of fertilizers and pesticides to turf near the wetlands boundary areas.
- Locate pesticide, fuel, fertilizer, and chemical storage, mixing and loading areas away from sites where possible transport from runoff and spills to wetlands could occur.
- Install and maintain wash-down and mixing pads where waters from these operations are contained, and reused or filtered.
- Use a sound IPM program on wetland areas of the golf course.
- Avoid direct runoff from parking lots and drives directly into wetlands.
- Design the course to inhibit intrusion into wetland areas.


**P O N D S  A N D  L A K E S**

Surface water of ponds and lakes must be protected. Effective erosion control and turf management practices can help prevent sediment and nutrients from reaching and contaminating lakes and ponds. Design considerations at pond and lake areas should include a site selection that minimizes the surface runoff and downward seepage through the soil.


**Pond and Lake BMPs**
- Choose a site that minimizes disturbance and can accommodate runoff from the immediate surrounding area.
- Maintain an unfertilized buffer zone at least 50 feet wide (wider if the slope is steep).
- Construct a small sedimentation pond upstream to reduce nutrient and sediment deposits.
- Be careful not to introduce undesirable plant material into the ponds and lakes.

**T U R F G R A S S  S E L E C T I O N**

Turfgrass selection can have a major impact on water quality. Using weed-free planting material can minimize future weed problems and the need for herbicides. Adapted, improved grasses often require less fertilizer, pesticides, and water. Healthy plants are better able to ward off pests and recover from pest injury or environmental stress.

Grasses differ in adaptation, cultural requirements, and performance. Base your selection on existing environmental conditions (soil pH, soil type, level of moisture, degree of sunlight, topography), the purpose for which the grass will be used, and expected management intensity. Check with a turfgrass specialist or Cooperative Extension Center to find out which grasses perform best in your area.

For more information on obtaining permits, following regulatory processes, and using good construction practices in building a golf course, see Cooperative Extension Service publication, *Water Quality and Turfgrass Area Development*, AG-153.

**E s t a b l i s h e d  T u r f**

Fertilizers

The primary objective of a fertility program is to create a soil environment where sufficient nutrients are available for optimal plant health with minimal risk to water quality. Since nutrients are not found in adequate supply in the soil, most turfgrasses require regular fertilization.
Improper fertilization practices can pose a risk to surface or groundwater quality. You must have a working knowledge of how the plant uses nutrients and the fate of nutrients in the soil.

**Nitrogen and Phosphorus**

Nitrogen and phosphorus are the nutrients most likely to affect water quality. Carefully planned applications are critical to the health of the plant and the environment.

Phosphorus is critical in establishing and rooting plants. However, through erosion or sedimentation, an improper application of phosphorus can cause undesirable algal blooms and excessive growth of aquatic plants in lakes and ponds.

Nitrogen is required for plant growth and is often associated with the green color in plants. Nitrogen deficiency results in poor growth and susceptibility to pests and diseases. Excess nitrogen may cause restricted root systems, an overaccumulation of thatch, an increase in the occurrence of disease, a decrease in the tolerance to environmental stress, reduced wear tolerance, and a diminished ability to recover from environmental stress or pest attacks.

**Table 1. Characteristics of Nitrogen Carriers**

<table>
<thead>
<tr>
<th>Fertilizer Source</th>
<th>N % Content</th>
<th>Leaching Potential</th>
<th>Burn Potential</th>
<th>Low Temp. Response</th>
<th>Residual Effect</th>
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<tbody>
<tr>
<td><strong>Quickly Available</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Inorganic</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>33-34</td>
<td>High</td>
<td>High</td>
<td>Rapid</td>
<td>Short</td>
</tr>
<tr>
<td>Calcium Nitrate</td>
<td>16</td>
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<td>High</td>
<td>Moderate</td>
<td>Short</td>
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<tr>
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<td>Rapid</td>
<td>Short</td>
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<tr>
<td><strong>Organic</strong></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Urea</td>
<td>45-46</td>
<td>Moderate</td>
<td>High</td>
<td>Rapid</td>
<td>Short</td>
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<tr>
<td><strong>Slowly Available</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Slowly Soluble</em></td>
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<td></td>
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<tr>
<td>IBDU</td>
<td>31</td>
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<tr>
<td>Ureaformaldehyde</td>
<td>38</td>
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<td>Low</td>
<td>Very Low</td>
<td>Mod. to Long</td>
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<td><em>Slow Release</em></td>
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<td></td>
<td></td>
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<tr>
<td>Sulfur Coated Urea</td>
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<td>Moderate</td>
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<td>Low</td>
<td>Moderate</td>
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<td><strong>Natural Organics</strong></td>
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<td></td>
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<tr>
<td>Sewage Sludge</td>
<td>6</td>
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<td>Very Low</td>
<td>Long</td>
</tr>
<tr>
<td>Other Natural Products</td>
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<td>Very Low</td>
<td>Very Low</td>
<td>Very Low</td>
<td>Long</td>
</tr>
</tbody>
</table>

**Nitrogen Carriers**

The carrier of nitrogen, the form in which it is supplied to the soil, plays an important role in the potential for impact on surface and groundwaters by affecting the degree of runoff or leaching. The nitrate ion (NO₃) has the highest potential to leach or runoff into water sources. Runoff can occur if the nitrogen is applied at high rates to frozen ground, to steep
slopes, or before an excessive rainfall or irrigation. Leaching is likely if the soil is sandy, has insufficient organic matter, or is saturated through intense irrigation.

*Table 1* above outlines the characteristics of many of the nitrogen carriers available on the market today. Generally, nitrogen sources are separated into quickly-available and slowly-available categories.

Quickly-available forms may release large quantities of nitrogen into the soil solution all at once and cause a rapid response by the plant. Inorganic salts, such as ammonium sulfate, dissociate rapidly in the soil water providing large amounts of plant-available nitrogen in a short period of time. Urea is a quickly-available, organic nitrogen source, and is commonly applied in a liquid or a granular form. Upon entering the soil, several reactions take place rapidly to convert the urea to the plant-available nitrate form. However, because of the rapidity of these reactions, leaching potential is high.

Slowly-available products such as IBDU or urea-formaldehyde rely on chemical and/or microbial activity for release of plant-available nitrogen. Some of the ureaformaldehyde products are available as solutions or suspensions and can be applied in liquid form. Coated urea products such as sulfur-coated urea and polymer-coated urea rely on the coating to control the release of plant-available nitrogen into the soil solution.

Natural organic sources are composed of material such as processed municipal sewage sludge, composted plant and animal debris, or various other organic wastes. Plant-available nitrogen is released from these products through chemical and microbial processes in the soil. As a result, temperature and moisture are important factors governing microbial activities and the ultimate release of available nitrogen. Warm, moist conditions favor high levels of microbial activity, and as temperature and moisture levels move toward either extreme, the release of nitrogen will be affected.

Overall, slowly-available nitrogen sources provide a more controlled release of nitrogen resulting in longer residuals and are less likely to impact groundwater through leaching than quickly-available products.

**Fertilizer Management BMPs**

**Base fertilizer applications on a soil test.** A soil test will show the types and levels of nutrients in the soil. Most newly planted areas should be tested during the construction phase and every 1 to 2 years after that, depending on the type of turf being grown. Putting greens are often tested several times a year.

Wait a minimum of 3 to 4 weeks after the last fertilization before sampling.

Be careful to submit a sample for analysis that is truly representative of the area.

Make sure the equipment used to take the sample is clean and free of contaminants. Clean equipment between samples.

Sample to a uniform depth—preferably to 4 inches for roughs and fairways and at 2 inches at greens and tees.

Take 15 to 20 soil cores from each area being tested, using a one inch diameter soil probe and thoroughly mix them in a plastic container or paper bag. Do not use a metal bucket which may affect results.

It may take several weeks before you receive the results of your test, so plan to submit your samples far enough in advance.

Submit samples to a reputable laboratory for testing and interpretation. The North Carolina Department of Agriculture provides soil testing free of charge. Submit samples to the Agronomic Division—NCDA, 4300 Reedy Creek Road, Raleigh, NC 27607-6465, or to the Cooperative Extension Center in your county.

**Supplement the soil test with a plant tissue analysis.** A plant tissue analysis is a diagnostic tool that can be used by a turf manager to identify potential nutrient problems. The analysis measures the concentrations of different nutrients in the tissue and indicates adequacy or deficiency. For more information contact your Cooperative Extension Center.
Core or aerify compacted soil. Coring and aerification at the time of fertilization can aid the fertilizer getting into the soil. This is especially important for phosphorus. Coring compacted, sloped areas will reduce runoff.

Minimize fertilizer rates on slopes. The application of high rates of nitrogen and phosphorus fertilizer on slopes near surface water increases the risk for negatively impacting water quality. Use no more than 0.25 to 0.50 pounds of nitrogen per 1,000 square foot per application.

Do not apply fertilizers directly into lakes, drainage areas, and other bodies of water. Maintain a buffer zone of low-maintenance grasses or natural vegetation between areas of highly maintained turf and water. This prevents erosion and produces a trap or filter for unwanted nutrients.

Consider using iron as a supplement to nitrogen for greening response. Iron can be used alone or in combination with nitrogen to provide a greening response. Reduced nitrogen applications will minimize possible nitrate leaching into groundwater. Rates will vary with grass type and environmental conditions. Follow label directions.

Use a slowly-available carrier on sandy soils. Sandy soils put groundwater at greater risk of contamination. Slowly-available nitrogen fertilizers are less likely to be leached below the root zone than quickly-available sources on highly leachable soil.

If you use quick-release nitrogen on sandy soils with little organic matter, or near shallow water tables, use no more than 0.25 to 0.50 pounds nitrogen per 1,000 square foot per application. Some superintendents use lower rates on putting greens to achieve better control of growth. Plant response is often better under a program of lower levels of nitrogen with more frequent applications.

Time applications carefully. Quickly-available sources should not be applied before a heavy rainfall or irrigation. Nitrogen has the highest chance of leaching under cool and wet weather. Cold temperatures (55 to 60 degrees Fahrenheit) slow microbes and plant uptake, as well as loss through volatilization and denitrification.

Irrigate after each application of quick-release fertilizer. Irrigation of 0.25 to 0.50 inches of water moves the fertilizer off the foliage and into the ground where it can be used by the plants. It decreases loss by runoff and volatilization and minimizes the risk of foliar burn.

Irrigate to replace water that is used up. Provide only enough water to compensate for that lost by evapotranspiration. Overirrigation will produce water movement beyond the rootzone, increasing the potential for leaching.

Recycle grass clippings (grascycling). When practical, clippings should be allowed to remain on the turf area to decompose and recycle nutrients back into the turf. If clippings are removed, they should not be blown into ditches, streams, lakes, or placed in areas such as ditches or concrete areas where they have a high probability of running off into surface water sources.

Use a drop (gravity) spreader near bodies of water or impenetrable areas. Centrifugal (rotary) spreaders should not be used near bodies of water because of the potential of granules entering the water.

Return to Main Index

Irrigation

Determining the appropriate level of irrigation for an area of turfgrass is vital to the health of the plant and the preservation of water quality. Under-irrigating produces wilt and desiccation. Over-irrigating increases the potential for leaching and surface runoff and weakens the turf, making it more prone to pest attacks and environmental stress.

A properly designed and installed irrigation system will apply a uniform level of water at the desired rate and time. The amount and frequency of irrigation should be based on the needs of the grass, soil conditions, and expected weather conditions. The goal is to wet the soil to a depth just below the existing root zone to encourage further rooting. Watering deeper than that does not benefit the plant and, as mentioned above, may leach contaminants into the groundwater.
While it is obvious that a plant needs a certain amount of moisture to function, determining the amount and frequency of water to apply is not that easy. Several programs have been developed to aid irrigation scheduling.

Consumptive use approaches to irrigation are based on the premise that evaporation from water exposed to the atmosphere is proportional to the amount released from the plant. Temperature, wind, relative humidity, and soil moisture are all factors that determine the amount of water available for use by the plant.

**Irrigation BMPs**
- Water to a depth just below the root system. If you observe runoff, shut the system off and wait for the existing water to enter the soil. Go back and rewet until the water reaches the appropriate depth.
- Do not irrigate again until you see visual signs of wilt or footprinting. A soil probe can aid in the visual estimate of moisture content.
- Sloped areas, compacted soils, and sandy soils will need to be irrigated in short, frequent intervals.
- Water in the early morning for best results. If you must water in the evening, allow sufficient time for the leaves to dry before nightfall to lessen the chance of disease. Avoid midafternoon watering to reduce loss from evaporation.
- Do not be alarmed at brown, withered leaves as a result of drought. These are normal signs of dormancy on cool season grasses. Lawns allowed to go dormant should be watered every three weeks in the absence of rainfall to prevent injury to grasses due to heat and drying.
- Do not plan to water a surface before it is used by heavy traffic. Heavy traffic on a wet soil leads to compaction, which may lead to runoff.
- Periodically test the irrigation system to make sure it is producing an acceptable level of uniformity.

**Mowing**

Maintaining the appropriate grass height encourages deeper roots, reduces the potential encroachment of certain weeds that need high light intensity for germination, such as crabgrass, and cools the surface of the grass.

*Thatch* is a layer of partially decomposed organic matter situated above the soil surface. This layer can be effective in capturing and breaking down pesticides, but it can also be damaging when it is too thick (1/2 inch) and creates a favorable environment for insects and plant pathogens. The thickness can be reduced by vertical mowing, coring, and topdressing.

**Mowing BMPs**
- Use the highest acceptable mowing height for the grasses being grown.
- Never remove more than 33 percent of the foliage at one time.
- Do not mow when grass is excessively wet to avoid compacting the soil, clumping of clippings, and spread of disease.
- Practice **grasscycling**. Every 100 pounds of dried grass clippings contains 4 pounds of nitrogen, 1/2 pound of phosphorus, and 2 pounds of potassium. **Grasscycling** may enable you to reduce your fertilization requirements by 25 percent.
- Compost if you collect your clippings. Use the compost as a soil modifier or mulch.

**Integrated Pest Management (IPM) Program**

An Integrated Pest Management (IPM) program is a multidisciplinary, ecologically-based pest management system that uses all available methods to keep pests at acceptable levels while minimizing the effect on people, the environment, and turf. Pesticides are only one of several options available to you for use in pest management. Other options include genetic, regulatory, physical, biological, and cultural solutions.

A sound IPM program is based on the acceptance and tolerance of pests at a damage level which does not significantly reduce the acceptability of the turf. It is this reduced reliance on pesticides which is an important factor in managing golf courses for water quality. A sound IPM program will include:

**A Knowledgeable Superintendent** Knowledge is the cornerstone to any successful IPM program. You should know about the grasses being grown, the pests which are likely to be a problem, and the conditions that may impact the pests and grasses being maintained.
A Written Plan This plan should include objectives for each section of the course and the degree of acceptable injury from pests. It will help define pest threshold levels. Input can be obtained from the greens committee, club manager and club members as to what they expect from the superintendent in terms of proper pest control. Include specific management practices for non-chemical control. They will vary with each section of the course.

Defining Pest Threshold Levels Determine what is acceptable for your course, such as whether weeds should be allowed in roughs or how many insects should be tolerated per square foot. Recommendations are available regarding threshold levels for certain insects.

Implementing Appropriate Cultural Practices Use of agronomically sound cultural practices results in a healthy, dense, vigorous turf that is better able to ward off pests and pest injury.

Monitoring Pest Activity Most pests are easiest to manage when they are immature and few in number. Frequent scouting can help determine the stage of pest activity or injury.

Maintaining Accurate Records Keeping accurate and up-to-date records of pest activity, actions taken, and the results of those actions will assist in future planning.

Pesticide Selection and Use

Pesticides are sometimes necessary to keep pests at tolerable levels. These chemicals will continue to be an integral part of any IPM program. However, sole reliance on chemical control can no longer be justified because of rising chemical costs, increased resistance to pesticides, and environmental concerns. Some pesticides can also enter surface or groundwater either from leaching or runoff. The selection of pesticides to be used on the golf course should be based on many criteria including the pest to be controlled, the turfgrass species the pest is infesting, the season and growth stage of the pest, the level of control desired, the application method required for the pesticide, the duration of control from the pesticide, the possibility of environmental contamination, and the need for frequent rotation of pesticides of different modes of action for the target organism to avoid pesticide-resistant plants, insects, and diseases. After all factors are considered, there may be two or three possible pesticides for control of the pest.

You should then select the pesticide keeping in mind the pesticide leaching potential rating (PLP). See Tables 2, 3, and 4. A pesticide with a low rating would be unlikely to move into groundwater or surface waters. A pesticide with a high ranking may be more easily transported offsite, leach into groundwater, or may persist long enough to allow it to enter surface or groundwaters even though it moves very slowly.

The PLP values given in the following tables are based on the soil retention, persistence of the pesticide, rate of application, and percent pesticide reaching the groundwater. You should be aware that the PLP rating may change from site to site depending on microbial decomposition, soil pH, soil type, photodecomposition (degradation from sunlight), or transformation of chemical properties due to exposure to light, volatilization (changing of solids and liquids into gasses), and water volumes applied after pesticide application.

You should also keep in mind that leaching is only one of many considerations in selecting a pesticide. There will be some instances where a pesticide exhibits low leaching potential but because of its high potential toxicity to wildlife, such as fish, extra precautions may be necessary around water. These precautions should be mentioned on the label.

Pesticides currently available for use on agricultural, turfgrass, horticultural, and residential pests in North Carolina have been thoroughly tested by the pesticide manufacturer and approved by the Environmental Protection Agency (EPA) before registration and release to the public. Pesticide applicators should be aware that the pesticide label is an official and binding contract between the chemical manufacturer, the EPA, and the purchaser of the product. If the label directions are not followed, the applicator may be subject to prosecution resulting in penalties which may include fines and imprisonment.

**Pesticide Selection and Use BMPs**
- Select turfgrasses which are insect and disease resistant.
- Use pesticides which have low pesticide leaching potential (PLP) index, when possible.
- See Tables 2-4 for pesticides labeled for use in North Carolina on turf. Rates of pesticides applied are based on the maximum reported application rates in the Cooperative Extension Service publication, 1994 *North Carolina*
Pest Control Recommendations for Turfgrass Managers, AG-408. The pesticide leaching potential (PLP) value was computed based on formulas defined by R.L. Warren and J.B. Weber in *Evaluating Pesticide Movement in North Carolina Soils*. Trade names listed are examples. Pesticides may be sold under other trade names.

- Develop and implement a quality IPM program.
- Train employees in proper pesticide application techniques.
- Determine the size of the area of application and mix only the quantity of pesticide needed in order to save money, avoid disposal, and protect the plants.
- Spot treat whenever possible.
- Read and follow all label directions. The label is a legal document.
- Only apply pesticides labeled for the turfgrass being grown and for the area being treated.
- Apply the pesticide correctly at the right time.
- Note groundwater advisories on the label.
- Mix the pesticide and load the spreader or sprayer carefully to avoid spills.
- Mix pesticides in areas where spill may be safely contained.
- Do not mix, apply, or dispose of chemicals within 100 feet of your well.
- Consider closed systems for loading and mixing.
- Triple-rinse containers, pour rinsate into tank, and spray excess on turf area. Do not exceed label rates.
- Calibrate your spreader or sprayer. Refer to information provided with your equipment and to Extension Service publication, *Water Quality and Sprayer/Spreader Calibration*, AG-152, for complete calibration instructions.
- Fill the spray tank away from the well or any body of water.
- Prevent back siphoning by keeping the fill hose above the solution level of the spray tank. Use an anti-backflow device or check valve on the fill hose.
- Store all pesticides in properly built and maintained storage facilities.

Return to Main Index

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**Pesticide Leaching Potential Indices**

### Table 2. Herbicides

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade Name</th>
<th>Rate *</th>
<th>Index **</th>
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</thead>
<tbody>
<tr>
<td>Fenoxaprop</td>
<td>Acclaim</td>
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<td>Prodiamine</td>
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* Maximum recommended application rate (lb A.I./Acre)
** Pesticide Leaching Potential Index (0-100) where 0 = very low leaching potential and 100 = very high leaching potential.

### Pesticide Storage and Disposal

The best way to manage pesticide storage and disposal is to reduce the amount of pesticides left over after applications through proper planning and equipment calibration. Faulty or improperly managed storage facilities may result in direct runoff or leaching of pesticides into surface and groundwaters. You and others may be held liable for damages suffered from improperly stored or disposed of pesticides.

A good storage facility should possess the following features:

- A secure area where unauthorized persons are restricted from entering
- Proper labeling, such as *No Smoking* and *Warning Pesticide Storage* signs
- Limited opportunity for water damage
Temperature control
- A location at least 50 feet from any body of water or stream
- Nonporous floors and materials and equipment to contain and cleanup pesticide spills
- Adequate lighting and ventilation.
- Capability of containing runoff from spills
- Source for clean water

Freedom from combustible materials or debris

Pesticide Storage and Disposal BMPs
- Maintain and follow labels on all pesticide containers.
- Store pesticides only in original containers or make sure the new container is properly labeled.
- Store like pesticides together. For example, herbicides with herbicides, and fungicides with fungicides.
- Keep containers closed tightly.
- Watch for damaged containers.
- Store pesticides which may be flammable separately.
- Maintain an up-to-date inventory of pesticides.
- Purchase only the amount you need.
- Comply with Emergency Planning and Right-to-Know regulations.
- Triple-rinse empty containers and puncture, crush, and recycle them. You can also take them to an approved landfill.
- Apply the rinsate to a labeled site at no more than labeled rates or save the rinsate and use it to make up water for similar applications.

Return to Index

Pesticide Spills

Unmanaged spills may quickly move into surface waters and cause injury to plants and animals. It is essential that you be prepared for major or minor spills.

Pesticide Spill BMPs
- Locate and control the source.
- For small spills, use kitty litter, vermiculite, shredded newspaper, adsorbent pillows, clean sand, or pads.
- Direct large spills away from ditches, storm drains, ponds, or wells via dikes.
- Place contaminated material in a plastic container for disposal.
- Encourage employees to report spills as soon as possible.
- Call Chemtrec, a 24-hour emergency service regarding spill management and for specific instructions on site neutralization. (1-800-424-9300).

Return to Main Index

Storage Tanks

Underground storage tanks are frequently used in golf course maintenance for petroleum storage. However, a leaking underground storage tank represents a fire and explosion hazard, as well as a fume hazard, and is a serious threat to groundwater. The safety concern related to environmental contamination of groundwater with hydrocarbons is potential exposure to benzene and ethyl dibromide which are suspected to be cancer-causing agents.

Piping failure, spills and overfills, and tank corrosion are the main causes of leaks from underground storage tanks. The EPA estimated that 80 percent of all spills were the result of failure or fatigue of piping systems. Many of these failures were caused by improper installation and maintenance. The corrosion of tank walls and the failure of fiberglass-reinforced tanks are other leading causes.

An above-ground storage tank with containment walls is the preferred method for storing chemicals. For more information, contact your local fire marshal.
Given the difficulty and the cost of cleanup, you need to monitor any storage tanks at your site closely. Specific preventive measures including installation of double-walled tanks, early detection of leaks, inventory control, monitoring, and tightness testing can avoid leaks.

Water quality should be considered in all stages of golf course design, construction, and maintenance. Some factors to consider have been outlined in this publication. Help to protect one of our most precious resources.

Return to Main Index

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