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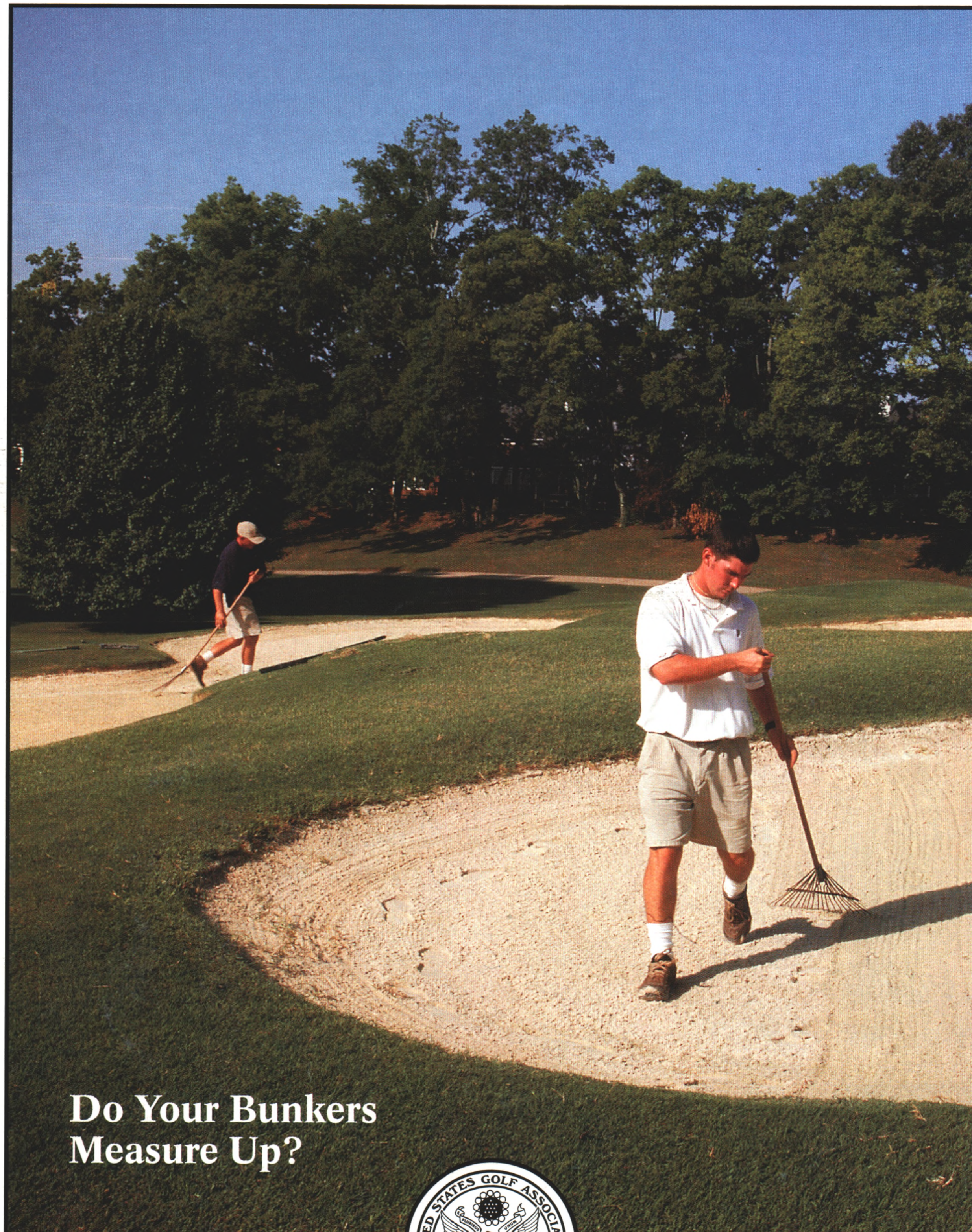

Do Your Bunkers Measure Up?

A PUBLICATION ON TURFGRASS MANAGEMENT BY THE UNITED STATES GOLF ASSOCIATION®

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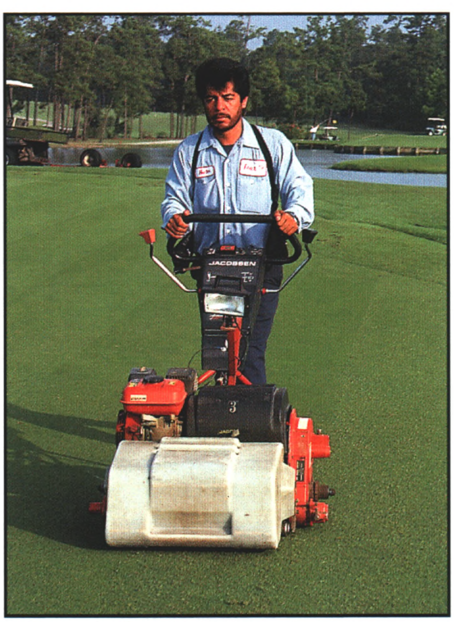
Cover Photo: Despite being classified as hazards, bunkers are expected by today's golfers to be as well constructed and maintained as the other parts of the course.

USGA® GREEN SECTION
Record

The USGA-funded breeding projects are directed at developing grasses with reduced water and pesticide requirements. See page 8.



An annual equipment replacement program is critical to have the necessary tools to meet golfers' expectations. See page 15.

HELP YOUR BUNKERS MAKE THE GRADE

A guide to help you evaluate the factors affecting bunker performance.

by CHRIS HARTWIGER

"OUR BUNKERS are too soft! . . . Our bunkers are too hard! . . . Our bunkers are terrible!" These are comments typically heard at golf courses throughout the country. Whether or not you like the bunkers on your course, you can be sure there is at least one golfer who thinks the bunkers fail to make the grade. Bunkers by definition are hazards, and maybe this is why bunker conditions elicit so many strong opinions. After all, playing a recovery shot from a hazard usually is not a pleasurable experience.

Ask a golfer what he or she thinks about the bunkers on a golf course and you are likely to get an earful. Ask a golfer why the bunkers perform the way they do and you are likely to get a blank stare. Oh, they may be quick to tell you the bunkers need to be rebuilt, but they really do not understand bunker performance.

The first step in improving the condition of the bunkers on a golf course is to understand the factors that influence bunker performance. People have a tendency to look at a problem on a golf course and assign a single reason to why the problem occurred. After all, they reason, if one factor is identified for the poor performance, then one solution can be implemented to resolve the problem. In reality, bunker performance is related to a number of factors.

To develop a plan for improving the bunkers at your course, take the time to complete the Report Card for Bunkers. The Report Card discussed in this article will enable the decision makers at a golf course to understand bunker performance and develop a plan to improve many or all of these factors. It may not be possible to raise all the grades to an A, but raising the ratings one or more letter grades can make a difference.

Bunkers at thousands of golf courses throughout the country have been rebuilt because they were performing below expectations. In many cases, the factors that caused the bunkers to perform poorly were not remedied during reconstruction and, within a few years, the new bunkers were in the same unsatisfactory condition again. Taking the time to understand the factors that influence bunker performance and assessing those factors at your course will enhance the chances for a successful bunker program.

PHOTO BY ROBERT WALKER

Golfers desire a consistent bunker sand with no contaminants, such as clay or rocks.

Using The Report Card for Bunkers

Are your bunkers measuring up? If not, completing the Report Card for bunkers is an ideal first step in improving the bunker performance at your course. To achieve the best results, a rating team that includes the golf course superintendent, the golf professional, and key personnel within the club (e.g., Green Commitee, general manager, etc.) should be assembled.

Step 1: Assign an overall historical performance grade to the bunkers on each hole. Before heading out onto the course, the rating team should discuss the historical performance of the bunkers on each hole and assign a single letter grade from A to F. Make the decision whether or not to include fairway bunkers in this Report Card. Do not rate each bunker individually, but treat all the bunkers on one hole as a unit. This will simplify the process and will eliminate the cumbersome record keeping involved with rating each bunker individually. The historical performance grade represents an average over the last three or four years

At times, water accumulates in a bunker faster than the subsoil can absorb it. In sandy soils, no drainage system may be necessary, but in clay soils a properly functioning drainage system is a must.

and will provide a reference point for the other ratings on each hole. A grade of A reflects superior performance over this period, while an F reflects failure.

Step 2: Visit each hole to complete the Report Card and identify where changes should be made. Listed on the accompanying table are a variety of factors that should be rated. There is room on the Report Card to add additional factors at your discretion. The Rating Team should assign one letter grade from A to F for the bunkers on each hole. After 18 holes, the rating team should have a total of 18 ratings for each factor. The rating process is subjective and it is important for each individual to be consistent throughout the entire process. The rating process should take approximately three hours and should be completed in one day.

Step 3: Implement the changes. Implement as many of the changes as possible. Improving the factors that limit the success of the bunkers will make a difference in how they perform and play.

Factors Influencing Bunker Performance

The factors discussed below have a tremendous influence on how a bunker performs. Sample criteria for determining a grade are included with each factor. These criteria are not meant to be set in stone, but are a starting point for the rating team. It is quite possible the rating team will want to modify the criteria or add additional factors to meet the needs of their course.

Historical Quality: This category provides an overall assessment regarding the quality of the bunkers over the past several years. Has there been a uniform depth of sand in all parts of the bunkers? Are the bunkers properly raked each day? Is the sand quality satisfactory?

- A = Bunker conditions meet or exceed expectations all the time.
- B = Bunker conditions usually meet expectations most of the time.
- C = Bunker conditions meet expectations some of the time.
- D = Bunker conditions consistently fall below expectations.
- F = Bunker conditions never meet expectations.

Intensity of Daily Maintenance: The intensity of daily maintenance is one of the most important factors that influence bunker quality. The bunkers can be constructed according to the latest standards, but if routine maintenance is neglected, unsatisfactory conditions will be the norm.

Few people realize that when viewed on a per-square-foot basis, bunkers are the most labor-intensive part of the golf course. Routine bunker grooming provides a smooth, uniform playing surface for golfers. While routine grooming is time consuming enough, a heavy rain can wash the sand off a bunker face down to the low point in a bunker. Shoveling the sand back on the face is the only way to restore the face of the bunkers following a heavy rain. Another storm a day later will wash the sand off the face again and the repair process must be repeated.

Decision makers at every golf course must decide how intensively the bunkers will be maintained. The number of bunkers, the size of the bunkers, and design features such as flashed faces are all factors that must be considered when developing a daily maintenance program. How the bunkers are groomed and how frequently they are groomed will have a major impact on bunker quality regardless of the changes made to the bunkers themselves.

Some golf courses prefer to use a mechanical bunker rake, while others prefer to hand rake the bunkers. Hand raking is performed if the highest level of surface grooming is desired. Even if the sand in the bunkers is not the best quality or purity, hand raking is the method that provides the best day-to-day playing conditions.

The mechanical bunker rake was developed to allow the bunkers to be raked more efficiently, but there is a reduction in grooming quality with a mechanical rake. It can cause damage to the edges of the bunker and contributes to contaminating the sand. In all likelihood, this factor will be graded the same on every hole since it reflects the overall intensity of the bunker maintenance program.

- A = Bunkers hand raked daily; washouts repaired promptly.
- B = Bunkers mechanically raked daily; washouts repaired promptly.
- C = Bunkers hand raked daily; washouts repaired sporadically.
- D = Bunkers mechanically raked when time allows; washouts repaired sporadically.
- F = Bunkers raked when time allows; no consistent program for washout repair.

Steps to improve the grade in this category involve changing the grooming techniques and adding more man-hours to bunker maintenance. Some courses find an immediate improvement in the playability of the sand by changing from mechanical raking to hand raking. Hand raking generally produces firmer playing conditions. Some superintendents retrofit their mechanical rakes with leaf rake attachments to simulate hand raking. This modification reduces the tilling of the sand and helps to firm the bunkers.

If the bunkers are not raked daily, implementing a daily raking program is another way to improve the grade this category receives. The sight of freshly groomed bunkers each day makes a strong impression on the golfers. Raking daily eliminates unsightly footprints and other disruptions in sand.

Surface Drainage: The frequency and severity of washouts is directly related to the amount of water that runs into a bunker from the surrounding area. If the bunker has flashed faces, the washout problem will be even more severe. Repairing washouts is hard work and time consuming. Sand must be physically shoveled from the low points back up onto the faces *every time a heavy rain occurs.* Bunkers with flat bottoms have fewer problems with washouts, even though surface runoff from surrounding areas can create problems. Failing to repair bunkers properly after washouts creates inconsistent sand depths throughout the bunker. Washouts also contribute to sand contamination problems, shortening the life of the sand.

There are several ways to improve the surface drainage in and around bunkers. Consider installing interceptor drains at the base of a hill or slope that normally channels water into a bunker. Picking up water before it enters the bunker greatly reduces labor time needed to shovel sand back onto the faces.

Proper internal drainage is a must for a bunker to be successful in the long run.

If the bunkers are going to be rebuilt, consider building them with flatter bottoms and fewer flashed faces. Be forewarned that eliminating high sand faces will change the architectural integrity of the bunker. Nevertheless, if the course does not have the budget to properly maintain the high sand faces, then this may be an option to help improve the playability of the bunkers. Extending turf down steep bunker faces reduces the potential for washouts and improves the bunker quality.

Flashed sand faces are dramatic architecturally, but when surface water is allowed to run into a bunker with a flashed sand face, washouts are inevitable.

- A = None of the bunkers on the hole have flashed faces; no surface water from surrounding areas flows into the bunkers.
- B = Fewer than 50% of the bunkers have flashed faces; no surface water from surrounding areas flows into the bunkers.
- C = More than 50% of the bunkers have flashed faces; only a few bunkers wash out severely from surface water flowing into the bunkers.
- D = More than 50% of the bunkers have flashed faces; surface water runs into many of the bunkers.
- F = Most bunkers have flashed sand faces; severe washouts occur in many of the bunkers from surface water running into the bunkers.

Internal Drainage: From a maintenance perspective, overhead rain and irrigation water is the only water that should enter a well-built bunker. At times, water accumulates in a bunker faster than the subsoil can absorb it. As a result, many bunkers have an internal drainage system to drain away excess water. In sandy soils, no drainage system or a poorly functioning system may be sufficient most of the time. In clay soils, a properly functioning drainage system is a must or the bunkers will look like swimming pools every time it rains.

The first step to improve drainage is to determine if the existing drainage system is functioning properly. If a drainage system exists, observe how well the bunker drains or does not drain following a significant rainfall. How long does the water remain in the bunker following the rain?

Poor drainage may be due to heavily contaminated sands or a drainage system that no longer functions efficiently. The rate of internal drainage affects the sand contamination rate. Puddling leaves contaminants on the surface as the water recedes. A properly functioning drainage system with clean sand in the bunkers reduces puddling and contamination. If no drainage system exists at all, it will be necessary to install a new drainage system in the bunker.

- A = Functional internal drainage in all of the bunkers on the hole.
- B = Functional internal drainage in 75% of the bunkers on the hole.
- C = Functional drainage in 50% or more of the bunkers on the hole.
- D = Functional drainage in less than 50% of the bunkers on the hole.
- F = Functional drainage in none of the bunkers on the hole.

Sand Purity: This factor measures the level of contamination in the bunkers. The presence of silt, clay, and organic debris in the sand can act as an impediment to drainage by reducing the infiltration rate of the bunker sand. Contaminated sand is often hard. The appearance of rocks in the bunkers is distracting and disruptive to play.

Little can be done to improve the purity of sand without taking out the old sand and replacing it with new sand. It is tempting to *top off* the bunkers with a few inches of new sand, but this process will not remedy the underlying problems. Within a short period of time, these new bunkers will look just like the old ones.

- A = Sand purity and contamination levels are acceptable.
- B = Sand purity and contamination levels are acceptable on 75% or more of all the bunkers on the hole.
- C = Sand purity and contamination levels are acceptable on 50% to 75% or more of all the bunkers on the hole.
- D = Sand purity and contamination levels are acceptable on 25% to 50% of all the bunkers on the hole.
- F = Sand purity and contamination levels are acceptable on none of the bunkers on the hole.

Sand Quality

The relative firmness of a bunker plays a key role in the playability of the bunker. Some players prefer firm sand, while others would opt for softer sand. Developing a grading scale for sand quality is difficult because it is such a subjective factor. The Report Card is a valuable tool to evaluate how bunkers are performing on the course. If the rating team decides that the sand in an ideally constructed and functioning bunker is undesirable, new sands should be evaluated. To learn more about how to select bunker sands, please refer to "How to Select the Best Sand for Your Bunkers" by James F. Moore in the January/February 1998 issue of the *Green Section Record*.

Conclusion

The performance of bunkers on a golf course is largely a function of architectural design, the physical properties of the sand, and the intensity of bunker maintenance. Although bunkers are classified as hazards and fall below greens, fairways, and tees in terms of maintenance priority, the topic of bunker performance is discussed frequently at courses everywhere. Before making a quick decision that the only way to improve the bunkers is to rebuild them, complete the Report Card for bunkers. Evaluate the factors that influence bunker performance at your golf course and implement programs to improve them. After six months, repeat the Report Card program and compare the results. The time invested in completing the Report Card for bunkers and learning what factors influence bunker performance will pay big dividends as a club makes a decision about upgrading the quality of its bunkers.

CHRIS HARTWIGER *makes the grade as an agronomist in the Southeast Region of the USGA Green Section.*

Report Card for Bunkers

Report Card for ______________________ Date Completed ______________

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Historical Performance																		
Intensity of Daily Maintenance																		
Surface Drainage																		
Internal Drainage																		
Sand Purity																		
Overall Quality (average of factors above)																		
Historical Performance																		

The filtration vessels are at the heart of the reverse osmosis water treatment process. For every four gallons of brackish water treated, three gallons of usable water is produced.

USING REVERSE OSMOSIS TO MAKE IRRIGATION WATER

The reverse osmosis water treatment process can turn brackish water into a valuable resource for golf courses.

by GLEN A. MILLER

WATER is perhaps the most precious resource for any golf course, and a reliable, economical supply of good quality irrigation water should be a priority for every course. What is the water situation at your course? Are you buying your irrigation water, and is the cost of water becoming a real budget issue? Do you have to curtail watering due to water restrictions? Are you located in an area where there is not sufficient fresh water to supply your irrigation needs?

Even if you are surrounded on all sides by brackish or salt water, there is an option available that can provide plenty of fresh irrigation water and save money. For golf courses in coastal areas or other areas with only brackish water available, this water can be effectively purified using the *reverse osmosis* (or "RO") water treatment process.

What is Reverse Osmosis?

To understand reverse osmosis, one must first understand osmosis. Osmosis is a naturally occurring phenomenon that is all around us. The cells in your body get water via osmosis. Osmosis is the process by which water passes from a dilute (or fresh) solution to a more concentrated solution across a semipermeable membrane. The membrane is a barrier that allows the passage of water molecules, but not the passage of dissolved solids in the water.

Let's say there are two containers, one with fresh water and the second with salty water filled to the same level and connected to the first container by a semi-permeable membrane. The natural tendency is for the two solutions to achieve the same concentration. To do this, water from the fresh side would pass to the salty side and this would continue until they reached an equilibrium. At the end, the water level on the original salty side will be higher (and now less salty), and this water height difference is called the *osmotic pressure*.

If we put some pressure on the salty side, it will slow down or prevent osmosis from occurring. If we put more pressure on the salty side, we will not only prevent osmosis, but we will cause water to flow in the other direction, and this is called reverse osmosis.

The reverse osmosis water treatment process applies enough pressure to a salty water supply to make pure water flow through a membrane. The saltier the supply water, the higher the pressure needed to produce the water. All reverse osmosis process systems have some degree of pre-treatment needed to condition the water to minimize plugging or fouling of the membranes. Most membrane elements today can remove up to 99.5 percent of the salt from the water.

In this article, we will look at two golf courses that have built treatment systems and now make their irrigation water. We also will discuss how you can evaluate whether this option is right for your course.

The Everglades Club: Making Water and Saving 75 Percent

Located on the Barrier Island of Palm Beach on the lower southeast coast of Florida, a beautiful golf course has been maintained at the Everglades Club since the early 1920s. Surrounded by the Atlantic Ocean and the Intracoastal Waterway, the course has no fresh water and has to purchase potable water to irrigate the course. With the cost of water rising and no end in sight, the club wanted to do something to lower its water bills. In addition, the club recognized that it was using pristine drinking water for irrigation, and for environmental reasons wanted to help preserve the limited fresh groundwater. Peter Brooks, golf course superintendent for the Everglades Club, was placed in charge of finding a solution. Brooks said, "Our water bills were going through the roof. We knew we had to do something. When water restrictions came out, we knew the time to act was now."

Miller Engineering was brought in to evaluate the situation and recommend a solution. The solution was for the club to start making its own water. Although there was no fresh water around, there was plenty of salt or brackish water. Miller Engineering designed a water plant that would use the reverse osmosis treatment process to remove the salt from the brackish groundwater and produce water fresher than they were currently buying.

The treatment plant was designed to produce 600,000 gallons of fresh water per day. On-site shallow wells were installed to supply brackish groundwater to the plant. For every four gallons of brackish well water, the plant produces three gallons of fresh water. The treatment system is computer controlled and is designed to operate automatically. All of the equipment is housed in a building constructed on the eastern edge of the property. The only noise is the feed pump humming away on the RO system. Operators do not need to be present during plant operation, and they only need to make periodic checks to monitor the system. In fact, to save on power, which is the single largest operating cost, the system was designed to operate at night to take advantage of lower, off-peak power rates from the electric utility.

Peter Brooks has been operating the system for more than two years. Using 100 percent treated water on the golf course, operating costs to produce water are now averaging about 40¢ to 45¢ per 1,000 gallons. This cost compares to $3.18 per 1,000 gallons for potable water. With the RO system producing fresh irrigation water, the club is saving more than 75 percent of the cost previously paid to purchase water from the town. The expected payback for the irrigation water treatment system is about five years.

Jupiter Island Club: Going Deep for Savings

Located about 20 miles north of Palm Beach, the Jupiter Island Club was faced with similar, but more severe water problems. While they have a large freshwater reservoir for storage of irrigation water, the only source for the fresh water is limited stormwater runoff and a water pipe from the local water utility located on the other side of the Intracoastal Waterway. Not only were water rates going up, but availability of water also was an issue. Rob Kloska, golf course superintendent, recalls, "We were starting to see days when the utility company shut us down during drought conditions when we needed water the most. With more than 100 acres of golf course and landscape to irrigate, water is critical. We have a lot invested in plant material. We wanted to save money on water, which was getting expensive, but we also wanted to control our water supply and protect our investment."

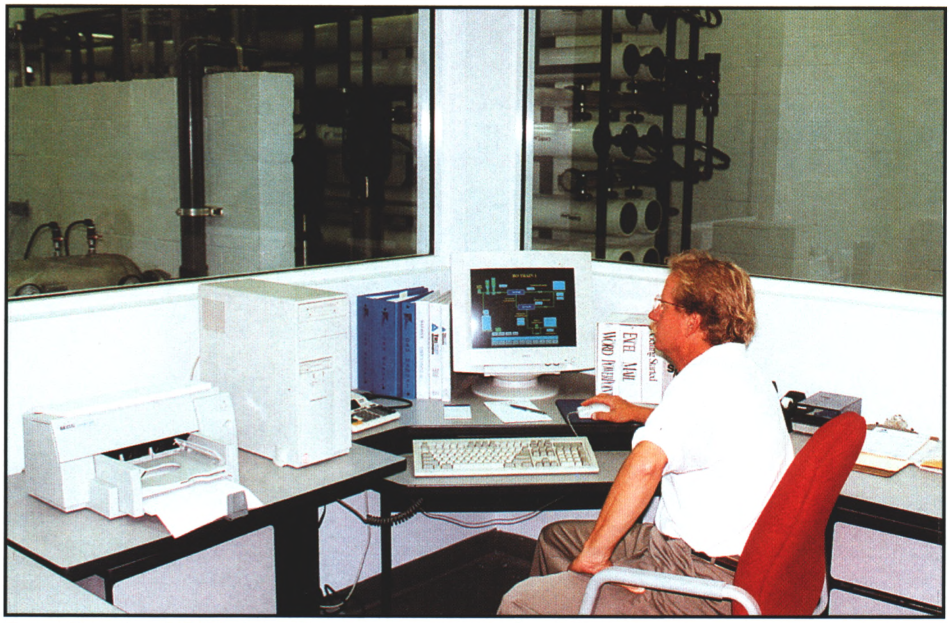
Miller Engineering evaluated the situation and recommended the most cost-effective solution. In this case, there was no shallow brackish groundwater, but there was brackish groundwater 1,500 feet down. A deep well was constructed to supply the brackish groundwater to a new 200,000-gallon-per-day RO treatment plant (expandable to 400,000 gpd). The well was under pressure ("artesian"), which meant that a pump did not have to be placed down the well. To save payroll costs, the plant was designed to operate 24 hours per day and limited computerized operations were incorporated.

The plant has been in operation since April 1998. The treatment building was designed to be unobtrusive and is located directly on the golf course. Jim St. John, managing director, notes, "Putting the building in the middle of the course, next to the irrigation lake, made a lot of sense. We had to make sure we could hide it from view, which was not a problem." Operating costs to produce water are comparable to the Everglades Club, and the savings are substantial. Moreover, the club now has control over the supply and quality of its irrigation water.

Is Reverse Osmosis Right for Your Course?

As cited above, you do not have to be a water treatment utility with experienced operators to consider using reverse osmosis treatment to produce irrigation water. Most systems operate automatically so that constant attention and maintenance are not required. However, several issues are important

A 1,500-foot-deep artesian well supplies brackish water to the reverse osmosis plant at the Jupiter Island Club (Jupiter, Florida).



Peter Brooks, CGCS, is at the computer controls of the reverse osmosis plant at the Everglades Club on the Island of Palm Beach (Florida). While the system is fully automated, Mr. Brooks has found that additional savings in production costs can be achieved with fine-tuning of the system.

to consider in evaluating whether it will make sense to make your own water.

Water Supply

The most important thing to look at is your available water. If you have adequate fresh water from wells or other sources, treatment is not needed, and future use of this supply is not threatened, you probably don't need to consider RO for your course. However, if you have water that is unusable because of high hardness or alkalinity, a special type of RO system termed *membrane softening* may be appropriate.

Reverse osmosis treatment can be performed on water with any salinity, from brackish to straight seawater. Operating costs will increase as the water salinity increases, due to the higher pressures that need to be pumped to achieve the treatment. In addition, seawater systems generally produce only 1.5 to 2.0 gallons of fresh water for every 4 gallons of feed water. Sea water generally will cost 4 to 7 times more to treat than lower-salt, brackish water. Therefore, you want to select a water supply that is plentiful and has the lowest salinity.

Permitting

RO treatment plants in Florida that are used to produce irrigation water do not require a special permit to construct. However, special permits are required to withdraw groundwater (water use permit) and to properly dispose of the unused, concentrated brine water from the system (industrial discharge permit). The water use permit is a straightforward process that normally takes three to five months to obtain.

The industrial discharge permit may take from three to nine months to obtain, depending on the individual site circumstances. It is therefore important that during the initial feasibility period, the most cost-effective brine disposal method is selected. The brine waste from the RO plant is crystal clear and poses no health threat, but environmental regulatory agencies want the disposal process permitted.

Financial Evaluation

Evaluation of the financial aspects of the RO treatment system involves an analysis of the capital costs and the operating costs. Capital costs involve the cost incurred to construct the system. These include *soft* costs (mainly engineering fees and permit fees) and *hard* costs. For an RO plant, the major hard costs are the supply wells, treatment building, brine disposal system, treatment equipment, pumps, and piping. For a typical RO plant to supply irrigation water for a golf course, capital costs will run about $1.50 to $3.00 per gallon. For a 500,000-gallon-per-day brackish water system, total capital costs will be in the $1.0 million to $1.4 million range.

Operating costs include the ongoing expenses to produce the water. These expenses include electricity, treatment chemicals, prefilter cartridges, and periodic cleaning chemicals. Normally, additional staff is not added strictly for the plant, so labor is not an operating expense. Operating expenses for brackish water systems will run 30¢ to 50¢ per 1,000 gallons produced. Electricity for a brackish plant will be about 50 percent of the total operating cost. Another recurring expense is replacement of the membrane elements in the treatment system. Elements cost about $500 to $700 each and are guaranteed for three years, but most installations can and do achieve element lives of more than 10 years. Setting aside funds for 6-year membrane replacement life will add about 8¢ per 1,000 gallons.

A payback analysis is normally performed to estimate how long it will take to repay the capital costs from the savings achieved in operating expenses versus water bills. Most brackish water irrigation plants in Florida will pay themselves back in seven to nine years.

Making irrigation water with an RO system has some substantial financial benefits for most golf courses that currently purchase irrigation water. These benefits can be more accurately estimated by performing a financial feasibility analysis during the preliminary phase of the project.

In Closing

We have presented examples of golf courses that are achieving substantial benefits by making their own irrigation water. These and other benefits can help solve your water problems. However, it is important that any golf course hire professionals experienced in completing these unique projects from start to finish. The entire process will take from 12 to 24 months from concept to producing water, and a committed team of professionals is important.

The author wishes to acknowledge Peter Brooks, golf course superintendent at The Everglades Club, Jim St. John, managing director at the Jupiter Island Club, and Rob Kloska, golf course superintendent at Jupiter Island Club, for their contributions to this article.

GLEN A. MILLER, PE, *is a senior professional engineer and President of Miller Engineering, a company specializing in the planning, permitting, design, and construction of reverse osmosis water treatment plants. Mr. Miller has been involved with the design of water treatment projects for more than 20 years.*

USGA-SPONSORED RESEARCH

Highlights of the USGA-sponsored Research Program.

by DR. MIKE KENNA

IN 1982 the United States Golf Association set out on a historic course when it decided to significantly increase the funding for research to improve the grasses and the maintenance programs used to benefit the game of golf. This article highlights some of the accomplishments of projects completed through January 1998. The overarching goals of the Research Program are to: 1) Reduce turfgrass water requirements, pesticide use, and maintenance costs; 2) Protect the environment while providing good quality playing surfaces; and 3) Encourage young scientists to become leaders in turfgrass research. The specific areas within these overarching goals covered in this article include Turfgrass Breeding, Cultural Practices, Alternative Pest Management, and Pesticide and Nutrient Fate.

USGA Research Project Categories

Turfgrass Breeding: Plant breeding projects intended to develop turfgrasses with better resistance to stress and pest problems.

Cultural Practices: Projects that evaluate cultural practices that have the potential to improve the ability of golf course turf to tolerate stress.

Alternative Pest Management: Evaluation of alternative pest control methods for use in integrated turf management systems.

Pesticide and Nutrient Fate: Projects that determine how pesticides and fertilizers can be applied to golf courses while protecting environmental quality.

Construction and Maintenance of Greens: Identification of the best combinations of putting green construction, grow-in procedures, and post-construction maintenance practices.

Turfgrass Breeding

The turfgrass breeding projects are directed at reducing water and pesticide use through the development of resistance to several stress and pest problems. The programs have focused on the improvement of bentgrass, bermudagrass, buffalograss, *Poa annua*, seashore paspalum, and zoysiagrass. The turfgrasses resulting from the sponsored research will help meet the future needs of golf courses. Table 1 was prepared to summarize the accomplishments of USGA-sponsored breeding projects from 1983 through 1997.

Breeding and Development of Bentgrass, Texas A&M University

After 13 years of improving bentgrass, six varieties with improved heat tolerance and disease resistance were released, and three advanced lines are ready for release (see Table 1). It is important to note that several young scientists were trained and are becoming leaders in the turfgrass industry. New, innovative screening techniques were developed throughout the course of the project. For example, methods to evaluate heat tolerance (heat bench), rooting depth (slant tube), linear gradient irrigation system (LGIS), insect and disease resistance, and salinity tolerance were developed and used.

Breeding Seed- and Vegetatively-Propagated Turf Bermudagrasses, Oklahoma State University

Two seeded, fine-textured, cold-hardy bermudagrasses were released that allow greater ease in establishment versus vegetative establishment (see Table 1). This program developed a reproducible technique for evaluating cold tolerance of bermudagrass plants that shortens cultivar development time and incorporated the use of molecular tools to identify cold-hardy genes. In addition, bermudagrasses from throughout the world were collected to add greater genetic diversity for cold hardiness, seed yield, and acceptable turf quality. The project reached out to other scientists in the southern Great Plains region to aid in the development of bermudagrasses with better spring-dead-spot and insect resistance. Five graduate students and two postdoctoral students have been trained on the project.

Breeding, Evaluation, and Culture of Buffalograss, University of Nebraska

This comprehensive program increased the awareness and interest in buffalograss as a turfgrass species because of its inherent drought resistance and low maintenance. The project developed six vegetative buffalograss cultivars with better turf quality, tolerance to lower cutting heights, and extended range of adaptation (see Table 1). Improved sod production techniques and sod quality of the new cultivars was achieved. Two seeded varieties were developed in cooperation with the Native Turfgrass Development Group. Through a team research approach, the project successfully developed management and establishment studies to coincide with the release of the cultivars. Finally, more than 10 graduate students received M.S. or Ph.D. degrees during the project.

Development of Multiple Stress-Tolerant Seashore Paspalums, University of Georgia

Seashore paspalum offers an alternative to bermudagrass with its greater salinity tolerance and lower nitrogen requirement (i.e., approximately half that of bermudagrass). In just five years, three cultivars were selected for commercialization (see Table 1). The program also has directed efforts toward developing management programs for the new cultivars — specifically, extensive field testing for weed and insect control. In addition, the extensive worldwide collection assembled (germplasm) is very diverse and has great potential to produce outstanding varieties for golf courses in the future.

Breeding and Development of Zoysiagrass, Texas A&M University

Zoysiagrass fairways can produce a high quality golf surface in the transition zone and southern United States. Some of the cultivars developed offer an alternative for partly shaded tees and surrounds and can help prevent bermudagrass encroachment into bentgrass greens. Four new vegetative cultivars were developed with improvements made for fine texture, salinity tolerance, shade tolerance, and color retention (see Table 1). Improvements also were made in sod production quality (i.e., establishment rate and recoverability after harvest). Unfortunately, the cold hardiness of these varieties is inadequate for use in the upper transition zone of the United States. The project cooperated with other scientists throughout the United States to investigate adaptation and resistance to insects. Seven postdoctoral students worked on the project over the last 14 years.

Improvement of *Poa annua* for Golf Courses, University of Minnesota

After years of industry efforts to eradicate annual bluegrass from golf course putting greens, this project took a new approach. Thousands of annual bluegrasses from throughout the United States were collected and evaluated in order to develop an improved variety. After nearly 15 years of work, the first commercially available creeping bluegrass (*Poa annua var. reptans*) variety was released for use on putting greens (see Table 1). A great deal was learned about the growth, seeding habit, genetics and population dynamics of *Poa annua*. In addition, three Ph.D. students received their degrees while working on the project.

Cultural Practices

A series of research projects with the aim to reduce water use, pesticide use, and maintenance costs were conducted in different regions of the United States. This was necessary because of regional differences in climate, soil, and stress conditions. The studies have led to new screening techniques, maintenance programs that conserve water, and management programs for new varieties.

Interseeding New Bentgrasses, Irrigation Management, and Selection of Bentgrasses with Superior Drought Resistance, Texas A&M University

This project addressed interseeding new bentgrass varieties into an older variety, blending bentgrass varieties, and comparing irrigation frequency and amounts. First, interseeding a new bentgrass cultivar into Penncross was somewhat successful. A population shift of 5 to 30 percent was observed following a single interseeding in conjunction with minimal cultivation followed by topdressing. Second, when establishing new greens, blending dif-

Developing herbicide-, disease-, and stress-resistant turfgrasses using genetic engineering has a promising future. Dr. Lisa Lee, while at Rutgers University, worked on developing herbicide-resistant bentgrasses. Michigan State University also has an active program that is developing genetically engineered bentgrasses under the direction of Drs. Mariam Sticklen and Joe Vargas.

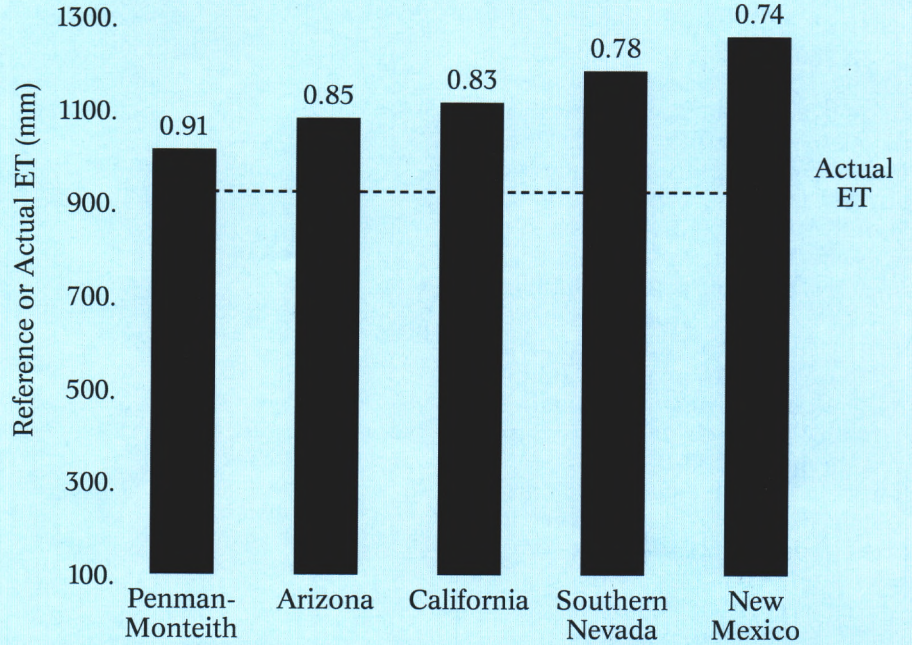
Table 1
Summary of USGA Turfgrass Breeding Projects — 1983 to 1997

Turfgrass	*University*	*Status of Varieties*
Creeping Bentgrass		
Agrostis stolonifera var. *palustris*	Texas A&M University	Crenshaw (Syn3-88), Cato (Syn4-88) and Mariner (Syn1-88), Century (Syn92-1), Imperial (Syn92-5), Backspin (92-2) were released. All are entered in 1993 NTEP trials (National Turfgrass Evaluation Program, Beltsville Agricultural Research Center, Beltsville, MD 20705).
	University of Rhode Island	Providence was released.
	Pennsylvania State University	Pennlinks was released.
Colonial Bentgrass		
Agrostis tenuis	DSIR-New Zealand and University of Rhode Island	A preliminary line, BR-1518, was entered in the NTEP trials. This line was not developed any further.
Bermudagrass		
Cynodon dactylon	New Mexico State University	NuMex Sahara, Sonesta, Primavera, and other seed-propagated varieties were developed from this program.
	Oklahoma State University	Two seeded types, OKS 91-11 and OKS 91-1, were entered in the 1992 NTEP trials. OKS 91-11 was released.
C. transvaalensis	Oklahoma State University	A release of germplasm for university and industry use is under consideration. New triploid ($2n = 3x = 27$) and hexaploid ($2n = 6x = 54$) F_1 hybrids are under evaluation.
C. dactylon X C. transvaalensis	University of Georgia	Tifton 10 and Tifton 94 (MI-40) were released; a Tifway mutant, Tifeagle (TW-72), was released for vegetative production.
Buffalograss		
Buchloe dactyloides	University of Nebraska	Vegetative varieties 609, 315, and 378 were released. Seeded varieties Cody and Tatanka were released. Three new vegetative selections, NE 86-61, NE 86-120, and NE 91-118, are currently being processed for release.
Alkaligrass		
Puccinellia sp.	Colorado State University	Ten improved families were developed; nothing released.
Blue grama		
Bouteloua gracilis	Colorado State University	Elite, Nice, Plus, and Narrow populations were developed; nothing released.
Fairway Crested Wheatgrass		
Agropyron cristatum	Colorado State University	Narrow leafed and rhizomatous populations were developed; nothing released.
Curly Mesquitegrass		
Hilaria belangeri	University of Arizona	Seed increases of *fine* and *roadside* populations are available for germplasm release and further improvement.
Annual Bluegrass		
Poa annua var. *reptans*	University of Minnesota	Selections #42, #117, #184, #208, and #234 were released. Small amounts of MN #184 are commercially available.
Zoysiagrass		
Zoysia japonica and *Z. matrella*	Texas A&M University	Ten vegetative selections were entered in the 1991 NTEP trials. Diamond (DALZ8502), Cavalier (DALZ8507), Crowne (DALZ-8512), and Palisades (DALZ8514) were released in 1996.
Seashore Paspalum		
Paspalum vaginatum	University of Georgia	Germplasm has been assembled and is under evaluation. Two green types (AP 10, AP 14) and one fairway type (PI 509018-1) are being evaluated on golf courses.

ferent bentgrass varieties had distinct effects on turf quality. Superior varieties had a positive impact on the stand, while lesser varieties had a negative impact on the quality. Lastly, frequent irrigation caused a decrease in turf quality and an increase in algae. However, some varieties proved to be more tolerant of frequent irrigation. Less frequent irrigation allowed a favorable water balance in specific cultivars without sacrificing putting green quality. Greenhouse and field drought resistance results were correlated, indicating that plant-water-status measurements (i.e., water potential at zero turgor, osmotic potential at full turgor, relative water content, apoplastic water fraction, bulk modulus of tissue elasticity, and turgid weight to dry weight ratios) could be used as a screening technique in breeding programs.

Figure 1

Total ET — Bermudagrass



Evapotranspiration (ET) estimation methods may differ by as much as 30 percent, which demonstrates the importance of matching crop coefficients (Kc) with the method used to estimate ET. The summer ET_0 was obtained from five Penman Equations under investigation (vertical bars). Actual ET is presented as the dashed line. The number above each bar represents the appropriate seasonal crop coefficient.

Methods to Convert a Putting Green from Penncross to a New Variety, North Carolina State University

A molecular method for measuring change in bentgrass populations over time was developed. The greatest conversion from Penncross putting greens plot to A4 bentgrass occurred with JobSaver® aerification tines plus Primo®, resulting in a conversion of 20 percent. The least effective treatments were verticutting and verticutting plus Primo®. Results indicated that conversion from Penncross is probably feasible, but it will take a number of years. Complete conversion from Penncross to another variety will require fumigation or total renovation.

Growth and Performance Differences Among New Bermudagrass Cultivars and Ecotypes, Auburn University

Off-types, or ecotypes, often appear in hybrid-bermudagrass putting greens over time. Some of the off-types have shown potential suitability as putting green turfgrasses in the southeastern United States. However, proper thatch management of ultra-dwarf cultivars and off-types was possible only with intensive management (i.e., aerification, topdressing, grooming procedures, etc.). Newly released TifEagle and the ecotype Mobile 9 performed well and showed promise in this study.

Biochemical and Molecular Analyses of Cold Acclimation in Bermudagrass, Clemson University

Differences in cell membrane composition between cold-hardy and cold-sensitive bermudagrass cultivars were identified during cold acclimation. Biochemical analyses of total cell membrane lipids identified important differences in the fatty acid chains of phospholipids (see Figures 1 and 2). Bermudagrasses with 18 carbon fatty acid chains and three double bonds were better able to acclimate to cold temperatures. This was quantified by calculating the double bond index (DBI). Considerable genetic variability among bermudagrasses and seashore paspalums was documented and should help turfgrass breeders develop cold-hardy, warm-season grasses.

Turfgrass Irrigation with Municipal Effluent: Nitrogen Fate, Turf Crop Coefficients, and Water Requirements, University of Arizona

The five popular methods of estimating evapotranspiration (ET) differ by as much as 30 percent, demonstrating the importance of matching crop coefficient (Kc) with the method used to estimate ET (see Figure 1). Estimated winter crop coefficients for bermudagrass fairways overseeded with ryegrass were more variable than summer crop coefficients. Turf irrigated with effluent water generated higher growth rates and raised seasonal Kc by three percent. Water that moved through the ten-foot-deep lysimeter had negligible amounts of fertilizer nitrogen. Tissue analysis revealed that 30 percent of the applied nitrogen was in clippings.

Putting Green Characteristics Associated with Surface Depressions Caused by Selected Forms of Traffic, Rutgers University

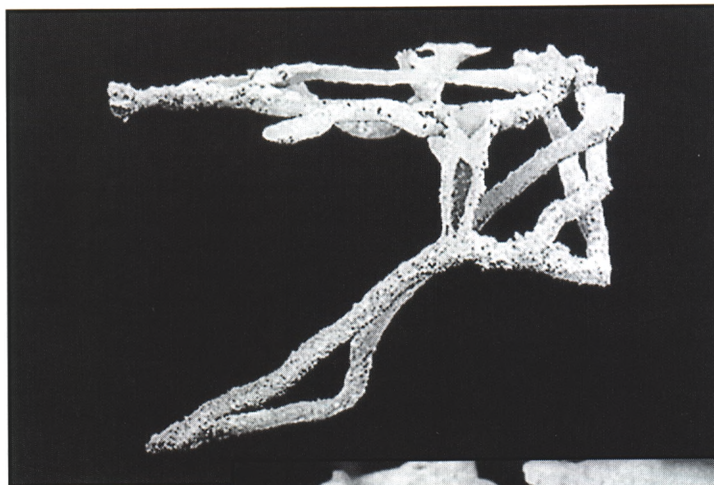
When tested on amended-sand and soil-base putting greens, rigid wheel chair tire (2.5 cm) traffic caused greater depressions than pneumatic tires (3.5 cm) on the putting green surface. A relatively inexpensive penetrometer was used to predict the damage caused by assistive equipment. Some assistive devices can be used by handicapped golfers on putting greens without reducing putting quality. However, the impact of these assistive devices varies, depending on green construction materials, management practices, and environmental conditions. Wheel traffic caused greater ball roll deflection than foot traffic, and pneumatic tires caused less damage than rigid tires. As one would expect, moist soils resulted in more damage than dry soils.

Alternative Pest Management

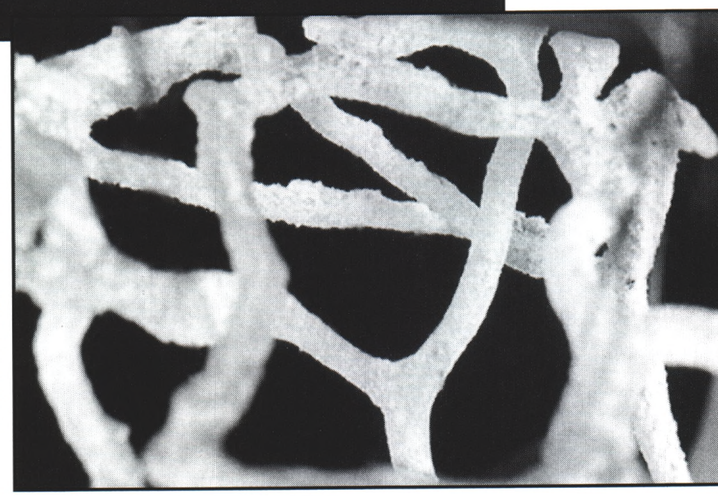
The purpose of these research projects was to evaluate alternative methods of pest control for use in integrated turf management systems. Alternative pest management methods are intended to reduce the amount of pesticide needed to maintain golf course turfgrasses. An alternative method of pest control needs to be highly effective and must be field-tested under realistic golf course conditions in order to receive widespread acceptance by golf course superintendents.

The USGA has provided funding for the development and evaluation of alternative methods of pest control. Even though a great deal of time and effort have been devoted to the area of biological control, there are very few scientifically documented cases where these alternative controls perform as well as their pesticide counterparts.

In addition to new biological controls, more information is needed on the life cycle and behavior of common turfgrass pests. The correct treatment thresholds, cultural practices, use of resistant grasses, proper pesticide timing, and placement all need to be considered carefully in all turfgrass management programs, especially in the case of soil-borne insect or disease problems.



Examples of the use of wax castings to capture the burrowing of mole crickets in large soil areas.



The tawny mole cricket has a unique Y-shaped tunneling behavior which allows for easy feeding, escape from predators, and selection of comfortable temperature and soil moisture conditions.

Development of Improved Turfgrass with Herbicide Resistance and Enhanced Disease Resistance through Transformation, Rutgers University

Creeping bentgrass is one of the more disease-susceptible grasses maintained for turf purposes. This project has produced genetically engineered (transgenic) plants with disease resistance, salinity tolerance, and herbicide resistance genes. There are several herbicide- and pest-resistant plants showing promise in the field that are ready to be integrated into the breeding program for cultivar development.

Genetic Engineering of Creeping Bentgrass with a Disease Resistance (Chitinase) Gene and the Bialaphos-Herbicide Resistance Gene, Michigan State University

This project has genetically engineered plants under evaluation in the field that are ready to be integrated into a breeding program for cultivar development. Researchers were able to incorporate the chitinase gene into bentgrass plants. This gene has the potential to aid in bentgrass disease resistance because chitinase digests the cell walls of fungal pathogens. The bialaphos gene also was successfully incorporated into bentgrass plants, making them tolerant of the pesticide. Bialaphos has both herbicidal and fungicidal properties.

Genetic Basis of Biological Control in a Bacterium Antagonistic to Turfgrass Pathogens, Cornell University

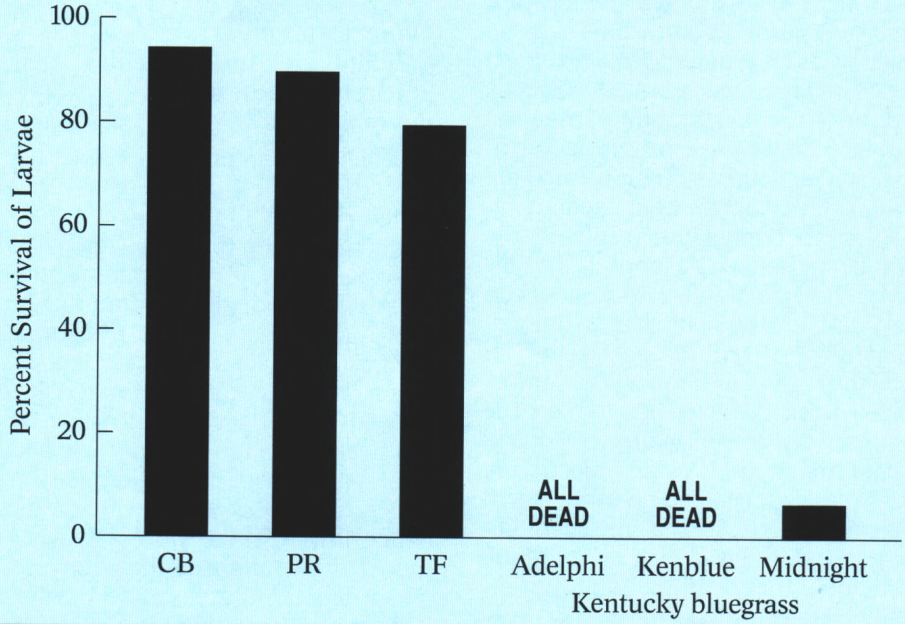
Using molecular biology, a bacterium strain was discovered that reduced the germination of soil-borne diseases, especially *Pythium*. Researchers established the relationship between seed or plant exudates and the germination of *Pythium*. This information can be valuable to plant breeders for incorporation into breeding programs (i.e., breed turfgrasses with low exudate levels). The study also provided convincing evidence for a biological control mechanism in which the bacterial agent interacts directly with the plant and only indirectly with the pathogen.

Cultural Control, Risk Assessment, and Environmentally Responsible Management of White Grubs and Cutworms in Turfgrass, University of Kentucky

This project has developed effective control strategies for cutworms and white grubs using cultural, environmental, and insect behavioral considerations that will reduce pesticide usage. The tremendous biodiversity of beneficial insects in golf course turfgrasses and the importance of certain predators in the reduction of pest populations were clearly demonstrated. Effective control strategies for cutworms, such as mowing putting greens early in the morning, not disposing of clippings near the putting green, or controlling insect populations in the surround areas, will reduce pesticide use on golf courses. Cutworms do not like Kentucky bluegrass as a food source when compared to bentgrass, ryegrass, and tall fescue (see Figure 2). Endophyte-infected cultivars did not provide significant resistance to cutworms. Two insecticides (Merit and Mach 2) were effective control measures and had low impact on beneficial and non-target arthropod species.

Figure 2

High survival of black cutworms reared on creeping bentgrass (CB), perennial ryegrass (PR), and tall fescue (TF), and lack of suitability of three diverse cultivars of Kentucky bluegrass



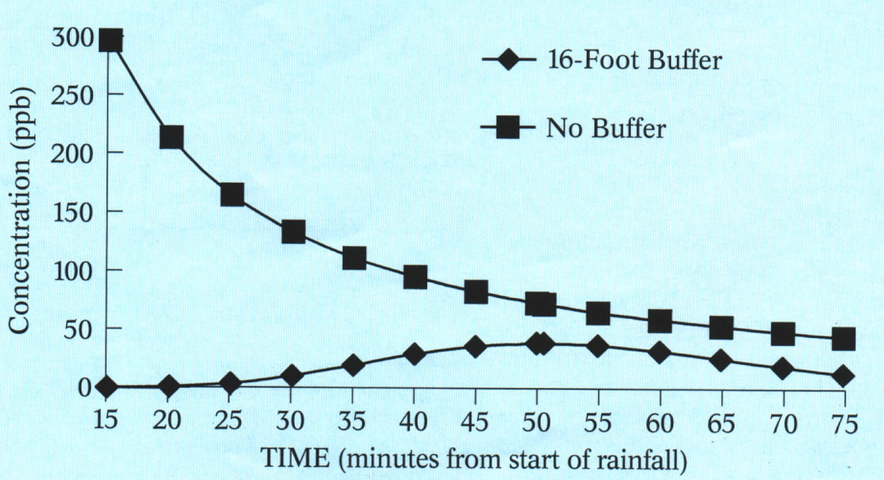
Behavioral Studies of the Southern and Tawny Mole Cricket, North Carolina State University

Behavioral, biological, and environmental factors that influence mole cricket activity on golf courses were identified. The tawny mole cricket has a unique Y-shaped tunneling behavior that allows for easy feeding, escape from predators, and selection of comfortable temperature and soil moisture conditions. The two species are aware of the presence of the other, but a pheromone is not involved in their ability to detect each other. Management factors (i.e., soil texture, moisture, temperature, pesticides, etc.) that influence mole cricket behavior were identified and should be considered together to achieve better insect control.

Figure 3

Plot of the predicted concentration of 2,4-D in surface runoff versus time in the 1996 buffer length experiment

***, ** Significant at alpha levels 0.05 and 0.01, respectively**



Pasteuria sp. for Biological Control of the Sting Nematode in Turfgrass, University of Florida

A new species (*Pasteuria*) of bacterium that parasitizes the sting nematode (*Belonolaimus longicaudatus*) was discovered. Results demonstrated that the sting nematode relationship with *Pasteuria* is density dependent. For example, as the number of nematodes increases, so does the number of *Pasteuria* bacteria. The study showed that a relatively small amount of *Pasteuria*-infested soil can be introduced into a USGA green with a high number of sting nematodes and bring about suppression within about 12 months.

Pesticide and Nutrient Fate

Understanding and quantifying the fate of applied turfgrass pesticides and fertilizers are required to understand the environmental impacts of golf courses. From 1991 through 1994, the USGA sponsored comprehensive research that examined the fate of pesticides and nutrients applied to golf course turfgrasses. Three key findings from this research were: 1) measured nitrogen and pesticide leaching generally is minimal when these materials are applied properly; 2) the turf-soil ecosystem enhances pesticide degradation; and 3) current agricultural models need calibration/validation in order to accurately predict the fate of pesticides and fertilizers applied to turfgrasses grown under golf course conditions.

As a continuation of a responsible and scientifically based investigation of the environmental impact of golf courses, the USGA sponsored additional research to understand the effects of turfgrass pest management and fertilization on water quality and the environment.

Evaluation of Best Management Practices to Protect Surface Water from Pesticides and Fertilizer Applied to Bermudagrass Fairways, Oklahoma State University

Chemical losses in surface runoff from turf can be reduced by maintaining non-treated buffers between surface water and areas treated with chemicals (see Figure 3). The effective buffer length is dependent upon site conditions (i.e., longer buffers, in excess of 16 feet, will perform better). A three-inch buffer mowing height was more effective than 0.5 or 1.5 inches. Chemical applications following heavy irrigation or rainfall events should be avoided. Finally, select pesticides and nutrients with low runoff potential (i.e., low solubility, high adsorption coefficient).

Evaluation of Management Factors Affecting Volatile and Dislodgeable Foliar Residues of Turfgrass Pesticides, University of Massachusetts

Of the 13 pesticides examined, 10 were deemed safe based on U.S. Environmental Protection Agency Hazard Quotients (HQ). Organophosphorous insecticides with high vapor pressures and inherent high toxicity (i.e., ethoprop, isazofos, and diazinon) were deemed not completely safe to humans under certain conditions. The critical vapor pressure below which no turfgrass pesticide will volatilize to the extent that it will result in an inhalation HQ greater than 1.0 was found to be between 3.3×10^{-6} and 5.6×10^{-6} mm Hg. Thatch management or the use of spreader/stickers will likely be ineffective in mitigating unwanted pesticide volatilization.

Mobility and Persistence of Turfgrass Pesticides in a USGA Green, University of Florida

The research project found that most pesticides are bound to the thatch. Clippings were not a major pathway for removal of pesticides from treated turfgrass areas. Even after several weeks of light, infrequent irrigation, heavy rain can still cause fenamiphos to leach. Fenamiphos was not a major concern from a volatility viewpoint. The amount of dislodgeable residues decreased rapidly after irrigation was applied. Finally, a synthetic coating applied to sand demonstrated the ability to increase pesticide retention in the rootzone.

Modeling Pesticide Transport in Turfgrass Thatch and Foliage, University of Maryland

The thatch produced by different grasses did not have the same ability to retain pesticides. Bentgrass thatch retained (or adsorbed) more pesticide than zoysiagrass thatch. The amount of highly soluble 2,4-D retention to thatch and soil was less than carbaryl retention. Desorption losses of both pesticides were greatest during the first leaching event after application and declined with subsequent events. There was a significant interaction between the solubility of the pesticide and the medium (soil or thatch type) to which it was applied.

Evaluation of the Potential Movement of Pesticides Following Application to Golf Courses, University of Georgia

If high-sand-content putting green rootzones are considered a worst-case scenario, pesticide transport in soil water was not a major problem when the pesticides were applied correctly and not irrigated heavily. Irrigation management is an essential factor in pesticide movement. High soil moisure content (at or above field capacity) at the time of application results in the greatest potential for runoff. In this study, the small buffer zone between the point of application and the exit point did not reduce the fraction of applied water-soluble pesticide transported from the site, but diluted the solution concentration due to reduced area of treatment. Pressure injection of pesticides reduced the quantity found in runoff. The research further documented that the water solubility of the pesticide influenced the amount of pesticide transported from the fairways. The more water-soluble pesticides were more easily transported from the treated fairway. The less water-soluble pesticides were resistant to transport in surface runoff.

Quantifying the Effect of Turf on Pesticide Fate, University of Illinois

This study compared bare soil with three levels of turf/thatch cover. Plots were vertically mowed so that 100, 66, and 33 percent of the turf/thatch remained. Pesticides were then applied and the results document that a healthy turf with thatch prevents most of the pesticide from moving into the soil. As the amount of turf and thatch decreased, the amount of pesticide reaching the soil increased. As would be expected, the bare soil plots had the greatest amount of pesticide found in the soil.

Degradation of Fungicides in Turfgrass Systems, Purdue University

Two-thirds of the applied fungicides remained bound to the leaf surface, unavailable for microbial degradation or loss into the environment. The amount of pesticide adsorbed to the leaf surface was dependent on the chemical characteristics of the applied material (i.e., adsorption coefficient, water solubility). Analysis of leaf fungicide residues indicated that the dissipation rates were similar, regardless of application frequency. The similarity of the fungicide dissipation curves suggests that there was no change in the loss mechanism and that enhanced microbial degradation was not present on the leaf surface.

Model Calibration and Validation for Turf Pesticides in Runoff and Leachate, Environmental and Turf Services

PRZM 2.0, a computer model used to estimate pesticide fate, overestimated runoff and was less effective in predicting runoff than GLEAMS. With adjustments to the runoff curve number and the pesticide degradation rate, the GLEAMS model was able to accurately predict pesticide runoff from a bermudagrass fairway. If a thatch layer is used in any prediction model, the physical characteristics must be accurately described. Modeling leaching data was more problematic than runoff data; however, the new PRZM 3.0 model shows more promise for accurate prediction of pesticide transport from turfgrass systems.

Conclusion

The USGA will continue to fund research in the foreseeable future. The goals remain: 1) reduce turfgrass water requirements, pesticide use, and maintenance costs; 2) protect the environment while providing good quality playing surfaces; and 3) encourage young scientists to become leaders in turfgrass research. Rather than focusing on variety or cultivar development, breeding efforts will focus on creating new and innovative germplasm for seed companies to use in their commercial breeding programs. Putting green rootzone and golf course construction projects are underway and will be emphasized in the future. Integrated turfgrass management (cultural practices) and environmental research projects also will be continued. If you would like more information about these or other projects, please see the USGA website (*http://www.usga.org*) or contact the USGA Green Section Research Office (405-743-3900 or *mkenna@usga.org*).

DR. MICHAEL P. KENNA *has been Research Director of the USGA Green Section since February 1990. His position was created out of a need to extend greater administrative support to the USGA's growing turfgrass and environmental research program, which distributes more than $1.5 million in grants annually.*

Let's Be Realistic!

The relationship between golfers' expectations and real world golf course management.

by BRIAN MALOY

THE FIRST ROUND of the U.S. Open is about to begin. In Hometown, USA, a group of golfers is crowded around the clubhouse television set in anticipation. As the camera pans slowly, giving the television audience a glimpse of the course, one golfer says to another, "Why doesn't our course look like that?" Sound familiar?

In the case of the U.S. Open played at Congressional Country Club in 1997, 50 employees and 70 volunteer golf course superintendents from the Mid-Atlantic area worked from sunup to sundown manicuring the course. This extraordinary labor force accomplished what no other had even thought of attempting — they used walk-behind putting green mowers to cut the fairways during the entire championship. While spectacular from an aesthetic viewpoint, this effort undeniably created unrealistic expectations in the minds of many golfers.

Duplicating course preparation feats seen on television has long been a sore topic of discussion between superintendents and golfers. Following major championships, such as the U.S. Open and the Masters, superintendents have to explain to golfers that the courses seen on television prepare months, if not years, in advance to host a four-day event for professional players. Furthermore, they have to explain that it is impossible to produce championship conditions on a daily basis because of environmental and budgetary restrictions.

Environmental quality has become a serious public concern and will likely be a major campaign issue during the next presidential election. The threat of global warming, the gradual disappearance of the South American rainforests, toxic waste disposal, and endangered species protection are all topics discussed at the dinner table. The public's interest in environmental issues and, specifically, pesticide usage, will affect

Televised coverage of extreme maintenance practices, such as the use of walk-behind mowers on the fairways at the 1997 U.S. Open, create unrealistic expectations for day-to-day course conditioning.

superintendents and their ability to produce perfect turf conditions.

Unless golf course superintendents adopt a proactive approach and voluntarily reduce the frequency and amount of both pesticide and fertilizer applications, new governmental regulations probably will force them to do so. In fact, a number of chemicals have already been banned for use on golf courses because of public concern. The most notable example is the insecticide Diazinon, which no longer can be applied to golf courses but is, ironically, still sold to homeowners for use on lawns and ornamental gardens. Mandatory restrictions may well affect the condition of golf courses by limiting the superintendent's ability to control certain weeds, insects, and disease pathogens.

The best way for superintendents to respond to growing environmental concerns is to develop and implement an Integrated Pest Management (IPM) program. The focus of an IPM program is to reduce pesticide and fertilizer usage by establishing maintenance practices that produce healthy turf, which is more resistant to weed, insect, and disease incidence.

Adopting certain IPM programs can conflict with golfers' expectations, as they may involve raising the cutting height on greens during the summer months and/or allowing the appearance of the course to wane slightly with minor weed and insect invasions and disease infections. To many golfers, slower greens and insignificant pest outbreaks are perceived as being unacceptable. Some even go so far as to believe that superintendents who do not make multiple pesticide and fertilizer applications are simply unwilling to do their job.

To protect the environment for all citizens, golfers need to learn and accept that some degree of weed, insect, and disease incidence is acceptable. They must realize that the playing condition of the course will vary from time to time based on the prevailing weather, and that championship conditions are temporary.

Matching golfers' expectations with the bottom line of the maintenance budget is another area where superintendents have difficulty communicating with golfers. Most expect their course to be in great condition but rarely understand how much must be spent to achieve such a goal. According to the accounting firm of Pannell, Kerr and Forster (PKF), many of America's most prestigious 18-hole courses spend more than $1 million annually on routine maintenance (Pannell, Kerr, Forster. 1997. *Clubs in Town & Country*). This is a staggering figure considering the Golf Course Superintendents Association of America (GCSAA) reports that the average annual maintenance budget, including payroll, is only $459,500 (GCSAA. 1998. *1998 Compensation and Benefits Report*). Being that the average budget is only half of what it actually takes to maintain a golf course in superior condition, it should come as no surprise that superintendents are often unfairly criticized for not keeping pace with golfers' expectations.

The largest expense in a golf course maintenance budget is payroll. Employee salaries normally account for one-half to two-thirds of a maintenance budget. A common trap set by golfers who scrutinize maintenance budgets is to compare their own course's expenses with the average payroll expense reported by the GCSAA. Average payroll figures are very misleading, however, since the length of the playing season and the hourly rate for employees varies considerably across the country.

In addition to the length of the playing season and hourly wages, labor costs also vary according to factors such as acreage, course design, staff efficiency, and equipment inventory. Acreage variations from one course to the next can be as much as double. On the flip side, courses with average total acreage can have exceptionally large greens, tees, and/or fairways that require larger staffs to maintain.

The architectural theme of a course is a factor in budget determination, as certain features, such as bunker design and layout, can add to the length of time it takes to complete routine maintenance tasks. For example, courses with more than 50 bunkers and/or with layouts stretched through a housing development take more man-hours to maintain than those with fewer bunkers laid out on a square plot of land. Not only does it take longer to get from one hole to the next, but there is simply more work that needs to be done.

The efficiency with which tasks are completed on a golf course is another factor that determines how much labor is required for proper maintenance. Staff efficiency is seldom discussed until it is necessary to justify additional employees to keep pace with golfers' expectations. Staff efficiency is most commonly affected by heavy play that forces employees to stand idle while golfers play through.

To improve staff efficiency, many courses choose to remain closed one day per week. This gives the staff a chance to complete important practices, such as applying topdressing and treating the turf with plant protectants, that cannot be completed ahead of early morning golfers. When possible, courses also start golfers off of one tee, as opposed to two, to give employees a chance to perform their morning duties without interruptions.

To provide the playing conditions expected by golfers, superintendents must have a complete equipment inventory. Moreover, the inventory must be in good mechanical condition and technologically up to date. As a point of reference, most maintenance facilities house more than $600,000 worth of equipment to properly care for the course. Assuming that the average life expectancy of each inventory item is 8.5 years, an annual replacement expense of more than $70,000 is required to keep the equipment in sound mechanical condition.

Many courses find it difficult to replace equipment based on life expectancy and, in fact, the GCSAA reports that the average annual amount spent on replacement equipment is only $50,000 for 18-hole facilities. Consequently, most golf courses are maintained with equipment that is mechanically unreliable or technologically obsolete. When the equipment inventory is not turned over based on life expectancy, meeting golfers' expectations becomes impossible.

In conclusion, superintendents are faced with bridging the gap between golfers' expectations and what can actually be accomplished given their particular circumstances. This task is made difficult by environmental pressures that demand good environmental stewardship and budgetary shortfalls that limit available manpower and equipment. On the other hand, if golfers just played golf on the weekends instead of sitting in front of the television set viewing immaculately groomed courses, everything would probably look a whole lot better.

BRIAN MALOY *has been an agronomist in the Green Section's Mid-Continent Region since 1996. He conducts Turf Advisory Service visits in Texas, Oklahoma, Louisiana, and New Mexico. His office is located in Carrollton, Texas.*

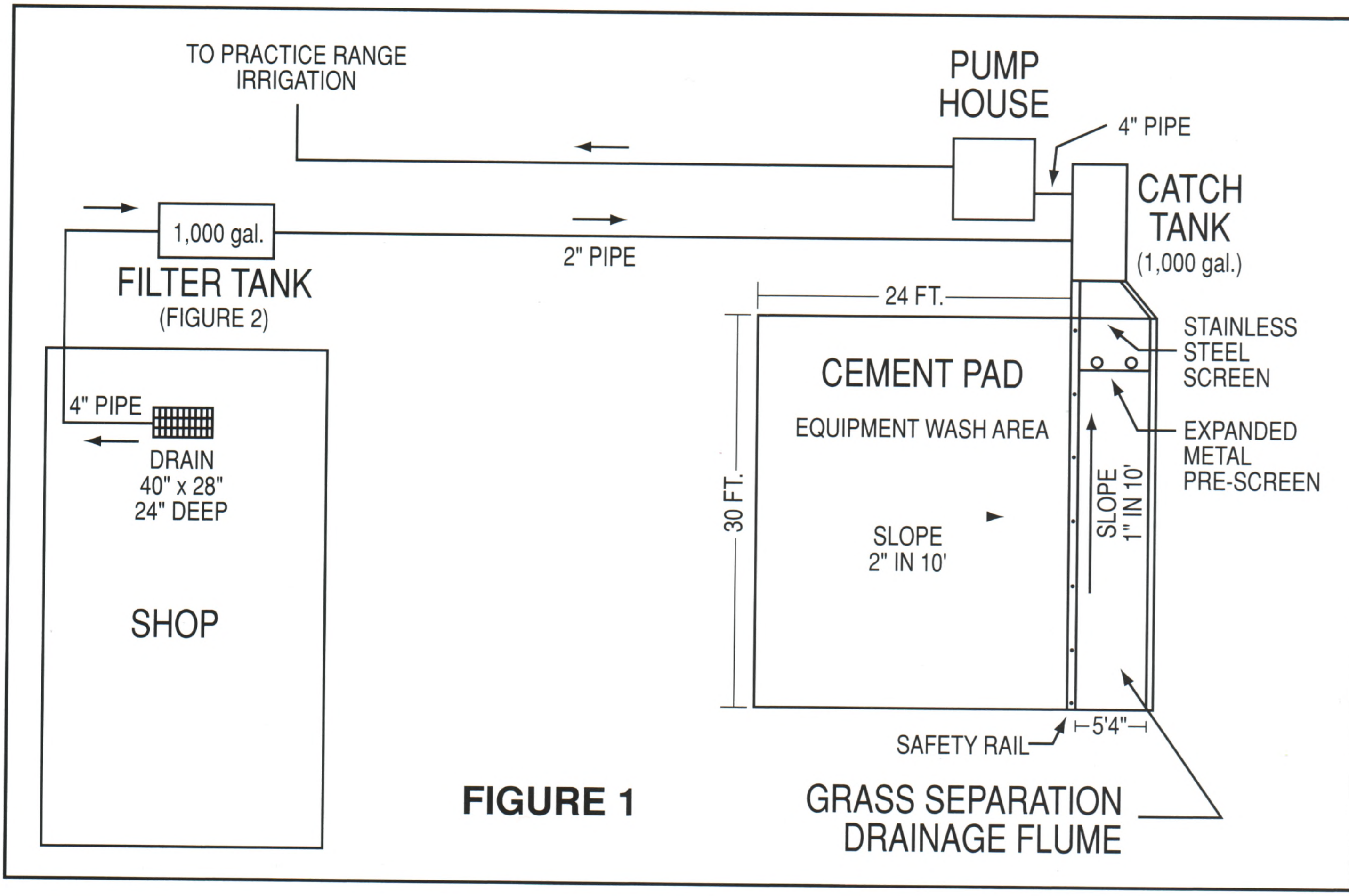


FIGURE 1

WASH AWAY YOUR CARES

A group solution to the dilemma with wash pads.

by BRAD G. KOCHER, CGCS

IN THE planning stages of our golf course maintenance facility for the Pinehurst #8 course, we determined that we needed a well-designed, functional wash area for our equipment. The wash area needed to achieve several objectives:

1. Screen out grass clippings.
2. Provide easy cleanup of grass clippings.
3. Prevent rinse water from traveling into any surface water.
4. Process shop rinse water.

Using a common-sense approach to meet these objectives, we designed a wash area and rinse system that retains all water on site and uses a series of

A unique wash area and rinse system was implemented at Pinehurst Course #8 to retain all water on-site. The system uses a series of natural filters to cleanse wash-down water before it is discharged onto the turfgrass.

natural filters to cleanse our wash-down water. The original concept involved the collective thinking of our golf course superintendent on #8, Jeff Hill, CGCS, our assistant director of golf and grounds, Bob Farren, CGCS, and our shop manager, Richard Yow.

As shown in Figure 1, we essentially have two systems that culminate in a standard below-ground septic tank. This water is then pumped onto an area generally acknowledged as the greatest filter on golf courses — turfgrass. Here, the plant utilizes the water, possible contaminants go through a natural microbial degradation process in the thatch, and nutrients are taken up by the turfgrass as food.

A concrete pad 24' × 30' in size was designed with a slope of approximately 2 percent, allowing all grass clippings to flow into a 5'4"-wide concrete channel. At the end of the channel or trough is a stainless steel screen of 18-gauge mesh with 40 percent opening.

The channel was designed to be wide enough to accommodate the bucket of our Bobcat loader in order to facilitate clipping removal. Typically, our clean-out occurs twice a week in the busier months of the year. The clippings are then stockpiled in a nearby area and later mixed with sand and topdressed onto turf, thereby returning nutrients to the turfgrass.

The water that passes through the screens is held in a 1,000-gallon below-ground tank. Adjacent to the tank is a pump, which is activated by a float. This water is then pumped onto our nearby practice range through two irrigation heads with nozzles that have 3/16" diameter orifices. The pump is activated daily during our busy washing times.

Following the success in dealing with equipment washing and clipping removal, we then dealt with the rinse water that comes off the shop floor. Since the potential for contaminants in this area was higher, we decided that a more sophisticated filter system would be necessary.

Again, we brainstormed that an adaptation of a below-ground septic tank would fulfill our needs. We created three separate layers of materials the rinse water would pass through before draining downhill (which was most convenient) to the septic tank that holds clipping rinse water. The three layers consisted of small gravel, sand, and granulated charcoal. As the rinse water flows into the tank, it passes through eight inches of charcoal (1/16" × 5/32" particle size). The water then passes through 20 inches of normal bunker sand and then 20 inches of 1/4" × 3/8" size gravel (see Figure 2).

Periodically, the charcoal and sand are replaced and the old material is topdressed onto turf areas. The charcoal material is replaced once a year.

The following is a list of materials used to fabricate this system and costs:

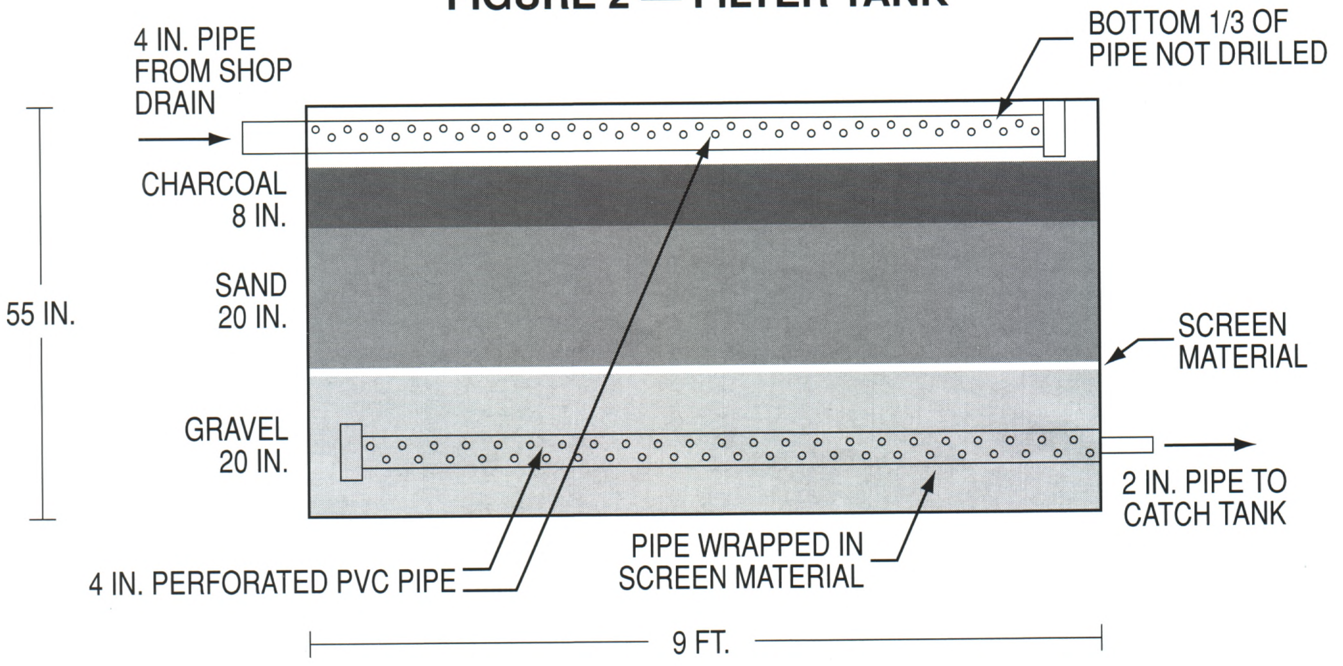
1,000-gallon septic tank (2)	$ 300
Charcoal — 100 lbs.	58
Sand and stone	30
Piping	125
Pump and controls	875
Pump house	800
Guard rail	200
Cement (pad and drainage flume)	5,000

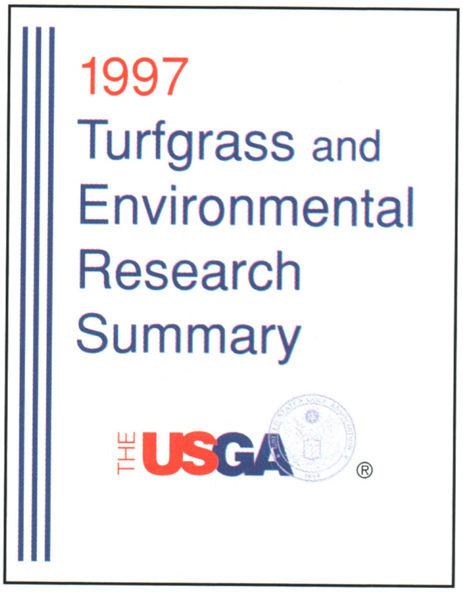
Would we do some things differently? Yes. We keep refining the system to make adjustments and improvements. We added a second screen, reduced the particle size of the charcoal in order to be able to topdress onto turf areas more efficiently, and plan to install a better filter on our pump intake.

By working together to come up with a common-sense approach to the challenge of designing an effective wash pad, we've devised a system that can be modified to improve effectiveness at a reasonable cost. We retain all water and rinse by-products on site and use nature's products as the ultimate recycler.

BRAD G. KOCHER *is a certified golf course superintendent and has been with Club Corporation International for the past 22 years. He served as golf course superintendent at Inverray Country Club in Ft. Lauderdale, Florida, and is currently director of golf course maintenance at Pinehurst Resort and Country Club in the Village of Pinehurst, North Carolina.*

FIGURE 2 — FILTER TANK





1997 Research Summary Available

The 1997 Turfgrass and Environmental Research Summary is now available from the USGA.

The Turfgrass and Environmental Research program has three broad, primary goals: reduce turfgrass water requirements, pesticide use, and maintenance costs; protect the environment while providing good quality playing surfaces; and encourage young scientists to become leaders in turfgrass research. Within each of these goals, the USGA sponsors research projects at land grant universities across the nation in turfgrass breeding, alternative pest management, best management practices, and pesticide and nutrient fate. The accomplishments of the 37 research projects currently funded through the Turfgrass and Environmental Research Program are summarized in the 1997 research summary.

In addition to the environmental research work, the document contains summaries of the ten projects funded in the area of construction and maintenance of greens.

The 113-page research summary is available free of charge by contacting Mary McConnell at the USGA Green Section at 908-234-2300, *mmcconnell-@usga.org,* or by writing to the USGA Green Section, P.O. Box 708, Far Hills, NJ 07931-0708. Please include your postal mailing address if sending an e-mail. In the near future, the entire 1997 Research Summary will be available on the USGA Internet site (http://www.usga.org).

Physical Soil Testing Laboratories*

The following laboratories are accredited by the American Association for Laboratory Accreditation (A2LA), having demonstrated ongoing competency in testing materials specified in the USGA's Recommendations for Putting Green Construction. The USGA recommends that only A2LA-accredited laboratories be used for testing and analyzing materials for building greens according to our guidelines.

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308 S. Main Street
New Knoxville, OH 45871
Attn: Mark Flock
(419) 753-2448
(419) 753-2949 FAX

EUROPEAN TURFGRASS LABORATORIES LIMITED
3 Cunningham Road
Springkerse Industrial East
Stirling FK7 7SL Scotland
Attn: John Souter
(44) 1786-449195
(44) 1786-449688 FAX

N. W. HUMMEL & CO.
35 King Street, P.O. Box 606
Trumansburg, NY 14886
Attn: Norm Hummel
(607) 387-5694
(607) 387-9499 FAX

THOMAS TURF SERVICES, INC.
1501 FM 2818, Suite 302
College Station, TX 77840-5247
Attn: Bob Yzaguirre / Jim Thomas
(409) 764-2050
(409) 764-2152 FAX

TIFTON PHYSICAL SOIL TESTING LABORATORY, INC.
1412 Murray Avenue
Tifton, GA 31794
Attn: Powell Gaines
(912) 382-7292
(912) 382-7992 FAX

TURF DIAGNOSTICS AND DESIGN, INC.
310-A North Winchester Street
Olathe, KS 66062
Attn: Chuck Dixon
(913) 780-6725
(913) 780-6759 FAX

*Revised January 1998. Please contact the USGA Green Section (908-234-2300) for an updated list of accredited laboratories.

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B. 1. Sales through dealers and carriers, street vendors, and counter sales (not mailed)	None	None
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I certify that the statements made by me above are correct and complete.

JAMES T. SNOW, Editor

ALL THINGS CONSIDERED

TOO MUCH CONSISTENCY?

Evaluating our turf conditioning priorities.

by JIM SKORULSKI

MORE AND MORE often we hear complaints about inconsistent playing conditions. Some comments may be valid, but more often than not the complaint is unjustified or unrealistic. What causes golfers to place more and more emphasis on consistency? Is it a general increase in expectations? Are priorities shifting as our turf conditioning programs improve? Perhaps it is a by-product of television or an arrogance created by large operating budgets that instill a confidence that anything can be controlled. There is probably no single answer. The bottom line seems to be that the game and golfers are evolving, and with the evolution come increasing demands that the golf course play consistently from hole to hole and day to day.

You may ask what is wrong with that goal. Nothing is wrong with the goal itself. However, the golfer, the turf manager, and even this agronomist must be reminded from time to time that we are working with a natural system that is and always will be dynamic. After all, that is what makes golf the game it is. It provides a test of our skill and our abilities to adjust to varying conditions in the field. The better golfer will be the player who has the skill level, can recognize the varying conditions, and can adjust to those conditions.

Our management capabilities have improved significantly and we can now better manage golf courses with sophisticated equipment, new technology, larger staffs, more effective and safer pesticides, and ready access to information. Yes, we can make the golf course play relatively consistently from hole to hole on a given day. But keeping the golf course in a consistent condition, season long, is another thing altogether. And then we have to ask ourselves, do we really want to make the golf course that consistent? After all, it's the variability that keeps golf, well, golf.

How much money are we willing to spend to obtain the consistency? Take, for example, green speed. It is important that the greens roll at relatively the same speed. The Stimpmeter is a helpful tool to determine and maintain that consistency. But can golfers actually perceive small differences in green speed? Do all greens have to be maintained in an artificially soft condition so as to accept shots even from poor players? Shouldn't a golfer have some responsibility to read the green, or through playing experience determine if a particular green may be slightly faster, slower, or harder than the other greens? Reading the green is as much a part of the game as making the stroke itself. Sure, we should develop our programs to make the greens as consistent as possible, but at the same time realize that the greens are going to vary depending on weather conditions, the time of the season, and the growing environment in which the green is located. Trying to eliminate these inconsistencies altogether is probably not possible and will add significant costs to our already high operating budgets.

Another often-heard complaint is that the sand in the bunkers is not consistent or that it is too hard or too soft. Excessively soft sand is not desirable, and steps should be taken to eliminate that condition. However, isn't it becoming a bit foolish when we have to irrigate the sand daily to maintain a certain level of firmness from bunker to bunker? I have little sympathy for golfers who whine about inconsistent playing conditions in a hazard. After all, it is a hazard and, more and more, that fact is being overlooked. A golfer should be able to identify the sand's playability by its feel and adjust the shot to those conditions. Yes, it is a good idea to make the sands favorable and consistent from bunker to bunker, but in the meantime learn to play the necessary shots, and focus attention on more important maintenance priorities.

The final example that is equally troubling is the demand to set the tee markers at or very near the permanent distance marker from which the course is rated. The idea is that the course should play consistently from the same yardage for handicap purposes. Demands such as this are disastrous for the turf and in time make for a pretty boring round of golf. There is no reason why the markers should not be moved widely over the teeing surface to distribute traffic and create some variety from day to day. Yardage lost on one hole can be made up on another. Spend more time concentrating on the shot and not your handicap.

The same complaints can be heard concerning consistent lies in the fairways and, yes, even roughs. Where does it end? Will it end? I certainly hope it does. It would be a shame if we removed the variability from the game. It would take away something that makes golf and the art of maintaining golf courses special and different from other games and professions. It would also make golf a lot less affordable. Fortunately, as long as golf is played on grass and in the outdoors, we will always have some variability to contend with. Let's begin to look at the variability not as a bad thing but as part of the game — local knowledge, if you will. It is the variability of the playing field that separates golf from other games.

A marvelous and true story printed in the May 1998 issue of *Greenkeeper International* sums it up nicely. Mr. Shaig Logan, a past Greenkeeper at Muirfield, was presented with a Stimpmeter prior to The Open being held at the course. "What's this for?" he asked. It's for measuring the speed of the greens, he was told. "Why would I want to do that?" So that you can make each green roll at the same speed. "Why would I want to do that?" So the 1st green would not be slower than the 9th, and the 10th would be equal to the 17th and 18th, not slower, not faster. "But laddie," he said, "that's why we have practice rounds."

JIM SKORULSKI *has been an agronomist in the USGA Green Section Northeast Region since 1989. In recent years, he has consistently concentrated his efforts on making Turf Advisory Visits in the New England states.*

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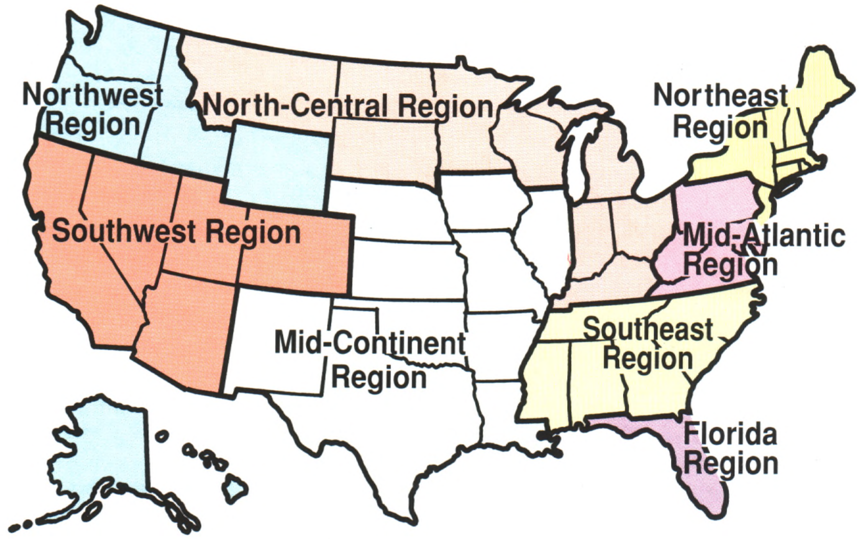

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TURF TWISTERS

REDUCE PRESSURES

Question: In our area, it never really gets cold enough in the winter for the bermudagrass on the fairways and roughs to go fully dormant and off color. Yet, each year we get a lot of complaints about very tight fairway lies and a loss of definition between the fairway and rough cuts during the primary play season. Also, at some other courses in the area, fairway winter overseeding is being practiced and there is increasing pressure for us to do the same. What are the pros and cons of this practice? (Florida)

Answer: For the vast majority of American golfers, the presence of a green turf cover has a big impact on their perception of quality. Winter overseeding of bermudagrass fairways ensures that the desired aesthetic character and improved overall course definition can be provided. Also, fluffier lies occur, which are preferred by average to high handicappers. These are the main benefits of winter overseeding.

As far as negatives, there are several. The main ones would be: additional disruptions and inconveniences during the fall establishment process and spring transition out of the overseeding cover, an impact on year-round health and quality of the base bermudagrass, and the cost. Along with the cost of the overseeding material, a mowing frequency of at least three days per week and preferably daily mowing needs to be practiced. This consumes a large number of manpower hours and exerts additional wear and tear on the equipment, which in turn shortens its life. Doubling the cost of the overseeding material is sometimes used as a means of estimating the total cost of this practice. With golfers being so color conscious, no doubt winter overseeding of bermudagrass fairways is here to stay. Yet from the agronomic standpoint, the compromises that must be made are difficult to justify in a lot of cases.

WHEN MIXING

Question: Why do the USGA's guidelines for green construction call for *off-site* mixing? Commercial blenders often mix on the golf course in a parking lot or open area.

Answer: The term *off-site mixing* is often confused. The USGA's guidelines call for the mixing of the rootzone materials (sand, organic material, etc.) **outside of the green cavity**. This is referred to as *off-site*. The most common example of off-site mixing is the use of a commercial blender located at the sand plant or somewhere on the golf course (often a parking lot). The rootzone material is blended and then hauled to the green site, where it is dumped into the cavity.

Although the practice is less common these days with the availability of commercial blenders, there continue to be instances where a rootzone is constructed by placing sand in the cavity, overlaying the sand with organic matter, and then rototilling the two together. This is referred to as *on-site mixing*. Since it is impossible to get a uniform blend of the materials throughout the entire depth of the root-zone with this method of mixing, the USGA discourages on-site mixing.

TREES AND TURF

Question: Many golfers become emotional with any mention of tree removal on our course. Other than the debris they leave after a wind storm, what are the major reasons why trees and turf do not mix well, and how do I get the golfers to understand? (Washington)

Answer: First, don't try to overcome the emotional response with any emotion of the opposite opinion. Failure is guaranteed! Trees and turf do not mix well due to the reduction of light (food) to the grass, competition from tree roots (water and fertilizer) with the grass, and the stress of traffic. Two methods have proven successful when dealing with this topic. Research from the 1930s visually shows the impact of trees on turf root growth — especially morning sunlight! Your local USGA Green Section office has copies of this research for use as a communication tool. For trees that are directly in the line of play, ask the question, "If the tree in question was not there, would you plant one in the same place?" The obvious answer will be no, because trees are not planted in the middle of fairways!