Air Force Center for Engineering & the Environment

Golf and the Environment: Guidelines for the 21st Century

The United States Air Force Golf course Environmental Management (GEM) Handbook

January 2008

This Handbook is a slightly revised version of the 2006 Comprehensive Golf course Environmental Management (GEM) Planning booklet written and copyrighted by William H. Bushman/Ecodesigns.

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Air Force Center for Engineering & the Environment

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Mamala Bay Golf Course, Hickam AFB, HI

The U.S. Air Force Golf course Environmental Management (GEM) Program

The comprehensive GEM planning process espoused by this study while fully embracing the ISO 14001 standard, will allow a golf course facility, municipal entity, or a multi-national golf course management company to establish an environmental policy, quantify overall environmental compatibility, identify potential environmental challenges, and establish appropriate management practices to ensure the long-term economic viability of the operation and their desire to satisfy customers, supervisors, regulators, and community.

Blue Course, Eisenhower Golf Club, U.S. Air Force Academy, CO

Foreword

Golf and the environment have been intimately linked since man first played early forms of the game over 500 years ago. Golf, unlike most other sports, does not involve a standard playing field or arena. Instead, golf utilizes the landscape and for that reason maintains an intimate relationship with the environment (Love, 1999). James T. Snow, National Director of the United States Golf Association (USGA) Green Section, said, "Perhaps no issue is more likely to have a significant impact on the game of golf in the 21st century than that of how golf courses and golf course maintenance affect the environment."

Bradley S. Klein, editor of *Golfweek's Superintendent News,* asks if we should "incorporate ecological considerations into the existing rating program, or develop a separate list entirely of the most environmentally sensible courses?" (Klein, November 1, 2002). Klein should know. He manages 200 golf course raters throughout the United States in compiling the annual "America's Best" list for his publication. Also, as a long-time supporter of *'the golf course superintendent as environmental steward concept'*, Klein feels that the golf industry needs to continue their efforts to forge a more environmentally compatible future. He answers his own question above by stating, "It's time to evaluate golf courses on their

environmental sensibility. If ecological sustainability and adherence to sound principles of nature were part of the criteria by which layouts were nationally ranked, architects, owners, superintendents and golfers would be more willing to embrace sound management practices. Everyone would benefit. The cost of maintenance would go down. Most importantly, courses would become even more ecologically friendly."

By the end of the 20th century, there were approximately "16,000 golf courses in the United States with the number of rounds played exceeding 540 million. The next decade will present a need for more golf facilities there are likely to be more than 30,000,000 golfers playing more than 650 million rounds annually" (Love, 1999). These golf courses provide the means for immeasurable enjoyment for millions of golfers. Golf course managers and superintendents have been challenged to satisfy the ever-increasing, ever-changing, and dizzying array of environmental rules and regulations while providing an economically viable, quality recreational experience for their customers - the increasingly passionate and demanding golfer.

This passion needs to be fully explored and embraced in order to understand the status that golf has reached in today's world society. According to Dr. James B. Beard, "golf has been described in many ways, but never better." than as follows by David R. Forgan.

> "GOLF-It is a science- the study of a lifetime, in which you may exhaust yourself but never your subject. It is a contest, a duel or a melee, calling for courage, skill, strategy and self-control. It is a test of temper, a trial of honor, a revealer of character. It affords a chance to play the man, and act the gentlemen. It means going into God's out-of-doors, getting close to nature, fresh air, exercise, a sweeping away of the mental cobwebs, genuine recreation of the tired tissues. It is a cure for care - an antidote to worry. It includes companionship with friends, social intercourse, opportunity for courtesy, kindliness and generosity to an opponent. It promotes not only physical health but moral force" (Beard, 2002).

To millions of people worldwide, golf is more than just a game. A brief examination of the history of the game and how it has grown to its present state may reveal some of the reasons behind this phenomenon.

Eagle Creek Golf Course, Dover AFB, DE

Introduction

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Manatee Cove Golf Course, Patrick AFB, FL

Man, Golf, and the Environment: A short history

One of golf's greatest attributes is its history – the game's origins, its players, and its courses. The following section describes the intimate relationship of golf and the environment and how this wedding of diverse, natural landscapes and arguably the greatest game ever invented has evolved over the years to what it is today.

Yesterday

"Golf differs from almost every other game in that every piece of land on which it is played has its own characteristics and scenery and flavour. It is no flat, bare expanse, but is made up of miniature hills and valleys, each with a personality of its own" (Darwin, 1946). The original landscapes where man began playing a game similar to modern day golf were the open, windswept, sand dune laden natural grasslands near the coasts of Scotland. These early golfers did little to impact the landscape as they struck at spherical stones with their shepherd's staff toward abandoned rabbit burrows whiling away time tending their sheep.

"Golf historians generally agree that the game originated in the British Isles hundreds of years ago. Records indicate that there was an actual golf course near St. Andrews, Scotland in the 1400s where the receding seas left sandy wastes with

ridges and furrows; the natural plateaus became greens and tees" (Jones and Rando, 1974). "Interwoven with the history and antiquity of St. Andrews are the history and antiquity of golf. We do know that golf is the national game of Scotland, and that the links of St. Andrews are and always have been one of its inspirations" (Macdonald, 1985). According to golf course architect Bill Love, "These early courses came about in linksland areas because the land was ideally suited to the game. Linksland is characterized by distinct features such as dunes or small hills and numerous hollows, covered with native grasses and few, if any, trees. Early courses simply evolved from the linksland and became known by the names of the towns nearby, such as Prestwick, Guillane [sic] and Leith" (Love, 1999). It appears that at this time of the game's history, its impacts to the natural environment were still minimal to nonexistent.

Golf began to gain popularity in England in the 1600s and was introduced into the New World in the late eighteenth century. According to Bernard Darwin, changes in the golf ball contributed greatly to eventual changes in the golf courses and the growth of the game (Darwin, 1946). "There were at least two dates for every earnest student to remember since each mark the beginning of a new epoch. They are 1848 and 1902. For untold years before 1848 the golf ball had been made of feathers tightly stuffed into a leather cover. In 1848 a new star arose to lighten the golfer's darkness, the star of gutta-percha. There was unquestionably a revolution but there was a still greater one in 1902, when the gutty was hurled from the throne it had held unchallenged for hard on fifty-four years by the rubber-cored Haskell from America. Beyond all doubt the Haskell made the game more enjoyable for the great mass of players" (Darwin, 1946).

The new ball was both more durable and easier to hit. Even the least talented players gained advantage with the Haskell ball. Unfortunately, the ball also went much farther than the old gutty and threatened to reduce the classic courses to mere drive and pitch status.

This is truly amazing considering that today's technological advances have added tremendous distances to nearly every golfer's game. History continues to repeat itself as many of the "old-timers" in the golf industry believe that the current trend in equipment once again threatens classic courses and the overall integrity of the game.

On the cusp of the twentieth century, development of the game was still rather unremarkable, as there were only sixty-one courses in Scotland and forty-six in England in 1888 (Darwin, 1946). "Golf courses constructed prior to this era were largely seaside, linksland courses. The unique qualities of this type of landscape dictated its desirability as well as its eventual short supply. If golf was to continue growing, the game and its golf courses would have to adapt to landforms other than seaside linksland. Golf would begin migrating inland" (Darwin, 1946).

"With this rise of inland golf there came an immense upward step in the art of designing courses. With the twentieth century the golf architect came into being. Sometimes he was a professional, more often an amateur golfer. In either case he was an artist. The new inland course sprang largely from one man's brain and became his monument" (Darwin, 1946). It was about this time that the game finally began to take root in the United States. One of the first designers to voyage across the ocean to America was Charles Blair MacDonald. According to golf course architect, Robert Trent Jones, "MacDonald was educated in St. Andrews, and he was obsessed with the idea of building a truly classical golf course in America that incorporated the best features of the most famous holes in England and Scotland" (Grimsley, 1966). In 1907, MacDonald realized his dream by building the National Golf Links on Long Island.

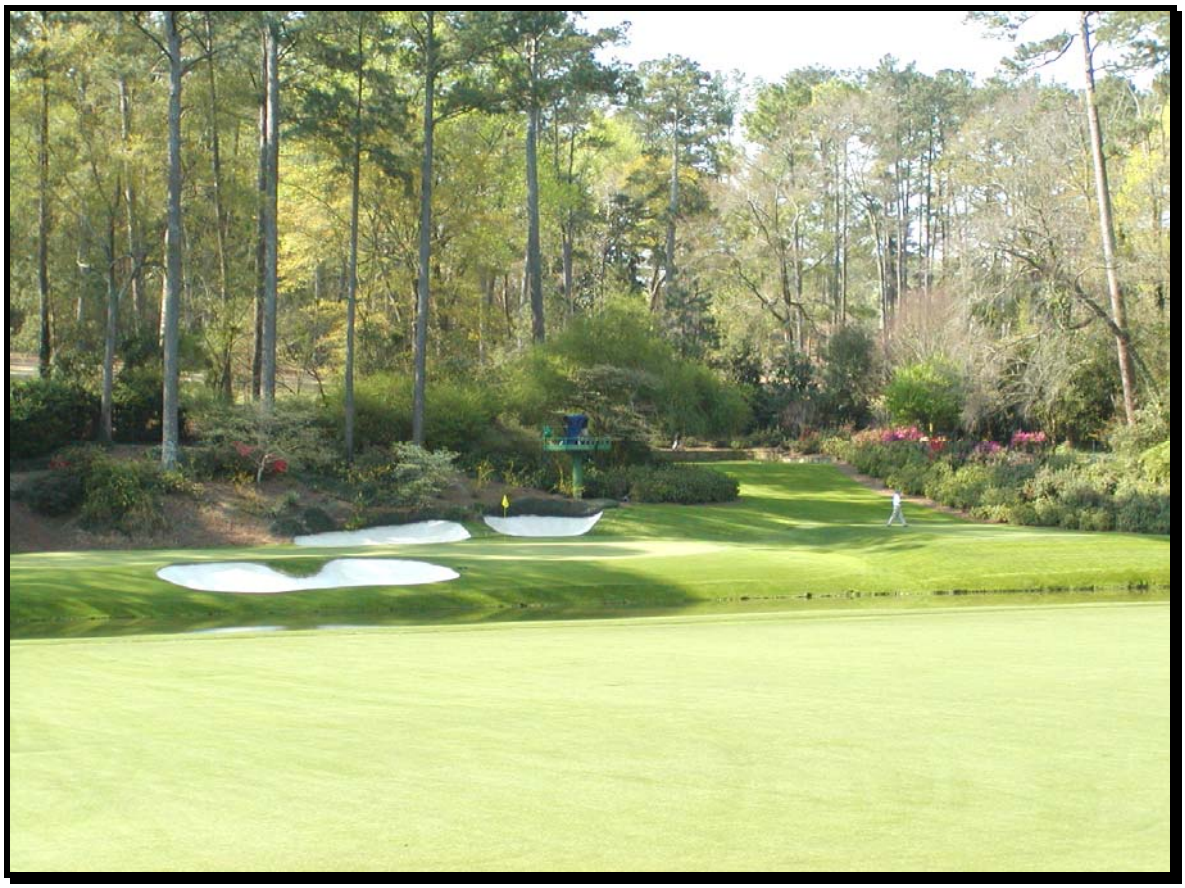
Five years later in Pine Valley, New Jersey, George Crump began what was to become a masterpiece in golf course design. Pine Valley "featured pine-tree-framed fairways that accentuated the island design of the holes and the ingenious contrast between the turf and the artistically patterned sand and sod" (Grimsley, 1966). Pine Valley continues as an example of the best in golf course design. Since golf publications began ranking golf courses based on their design, Pine Valley has been at or near the top. The latest iteration of "America's Best" courses in the United States places Pine Valley at the pinnacle of the "classical", or those constructed pre-1960 (Klein, 2003).
The next year produced one of the major catalysts for the growth of the game in America. "An unknown 21-year old, amateur American caddie by the name of Francis Ouimet beat the greatest golfers of the day-English professionals Harry Vardon and Ted Ray-in the 19th United States Open Championship at the The Country Club, in Brookline, Massachusetts" (Beard, 2002).

From the turn of the century to 1929, the number of courses in the United States jumped from less than a thousand to over 5,600 (Cornish and Whitten, 1981). The "Golden Age of Golf Course Design" started with great designers like Donald Ross, Alister MacKenzie, and A.W. Tillinghast building superb, world-class courses from coast to coast that included the likes of Cypress Point, Pinehurst #2, Riviera, Oakmont, and Pebble Beach. *Golfweek's Superintendent News* list of America's Best golf courses includes 57 courses from this era, by far more than any other decade. (Klein, 2003). These courses were largely developed using horses, mules, and hand labor. Accordingly, since courses of this time were usually integrated with their site and its landscape, relatively minimal soil movement and potentially negative impacts to the environment resulted from their development.

Largely driven by economics while lacking appropriate technologies, greenkeepers used native, relatively low maintenance turfgrasses and mowing equipment. It was also extremely rare for a course at this time to be irrigated with a permanently installed automatic underground system. In fact, the first underground irrigation system was installed at Dallas' Brooklawn Country Club in 1920 (Golfweek, 1996). Similarly, fertilizers were largely natural products made available from local farms

or ranches while most pesticides had not been formulated or in general use on golf courses.
"In 1930, amateur Robert Tyre Jones Jr. achieved an unmatched Grand Slam of golf by winning the United States Amateur and United States Open Championships plus the British Amateur and British Open Championships in the same year" (Beard, 2002). In a move that amazed the world of golf, Jones, when he was at the absolute pinnacle of the game, quit competitive golf. Later that year, New York investment banker, Clifford Roberts came to Jones in Atlanta to suggest that they join together in "organizing a club and building a golf course near Augusta" (Jones, 1960).

After visiting the Georgia property, Jones agreed and hired renowned Alister MacKenzie to help design his course. Together they routed a stunning layout through the grounds of the old Berckmans family arboretum (Cornish and Whitten, 1981). Jones and MacKenzie were of the opinion that the first purpose of any golf course should be to give pleasure, and that to the greatest possible number of players, without respect to their capabilities (Jones, 1960). Thus began one of the most influential creations in the world of golf. Bobby Jones and Clifford Roberts strove to create the epitome of golfing excellence (Sampson, 1998).



Augusta National's 13th may be the world's greatest par 5.

Accordingly, in nearly every April since 1934, the golf world has turned to Augusta National in northeast Georgia for the inspirational start to the golf season. Aromatic, free-blooming azaleas and dogwoods, seemingly weed-free turfgrasses and rolling, speedy, and perfectly smooth greens have raised the bar to nearly unattainable heights for almost every other golf course in the world. Good or bad, for the past forty years, Augusta National has truly been "the yardstick by which other courses are measured" (Bushman, 1983).

During the 1950s, Robert Trent Jones embarked on the most prolific golf course design career of all time. "Probably the most influential golf architect in history - in truth, the man who almost single-handedly made golf course design a well-respected and well-paid profession" (Finegan, 2003). Jones brought huge, undulating greens and landing strip-like teeing areas by utilizing man's technological advances such as earth moving machines and newly discovered turfgrass varieties as no one else had. Many of the over 400 courses touched by Jones' hand in the last half century are highly regarded. Jones' unique place in the history of American golf is revealed in *Golfweek's*

Superintendent News architect breakdown of America's Best courses. Jones is the only golf course architect listed that can claim a significant number of courses on both the classical and modern lists with seven each. Some of Jones' modern courses were built with state of the art machinery where huge quantities of soil were moved and recently developed turfgrass strains were planted. The beginning of potentially negative impacts of golf course management probably was a result.

Sharing the blame at this time were profit-driven developers as well as the golfers who increasingly longed for and eventually demanded more perfect conditions. One of the biggest culprits of this mindset was Augusta National, now home to one of the world's four major championships, The Masters.

Arnold Palmer is synonymous with golf in the United States.

The modern era of golf boomed with the Cold War, President Dwight D. Eisenhower, Arnold Palmer, television, and two car garages. Large numbers of courses were being built worldwide. "Elaborate water systems, new construction techniques and better machinery made them possible, just as these were instruments in the transformation of desert, mountain and marsh into land that was fit for golf. It has been possible to build a golf course almost anywhere given the two major requirements, money and technical knowledge. Swamps can be reclaimed, jungles cleared, deserts irrigated and mountains moved" (Hurzdan, 1996). The ability of man to impose courses nearly anywhere provided a vivid contrast with golf's early roots on the natural turf of the Scottish linksland.

Rachel Carson's 1962 classic, *Silent Spring,* exposed the nightmares of America's past chemical use and awakened the public to several environmental concerns. Four years later, the Masters golf tournament was televised for the first time and the world was treated to the emerald wonders of what chemicals and fertilizers combined with a nearly unlimited budget and a huge maintenance staff can produce. "A bitter debate raged on many fronts, and overwhelming public opinion forced the establishment of national environmental oversight" (Labance and Witteveen, 2002).

The National Environmental Policy Act (NEPA) was signed in late 1970 and laid the foundation for the beginnings of America's regulation-driven environmental movement. The Act created the United States Environmental Protection Agency (EPA) to protect America's environment. The Clean Water Act (CWA) was passed by Congress in 1972 and the use of DDT, invented in 1943 and one of the key culprits in Carson's book, was banned by the federal government (Golfweek, 1996).

As public environmental awareness continued to increase in the 1970s, the golf industry began to look at issues ranging from design and land use to course management (Klemme, 1995). Moreover, environmental research shifted from identification of pollution problems to development of solutions, using such techniques as best management practices (BMPs), which attempt to minimize the adverse environmental impacts of golf courses (Balough and Walker, 1992). "When the GCSAA [Golf Course Superintendent's Association of America] asked Ralph Nader to keynote the 43rd annual conference in Cincinnati in 1972, many of these issues were affecting not only golf courses, but also the general public. Nader left little room for debate. 'It is not a question of can we afford to clean up our pollution,' he noted, 'but if can we afford *not* to. If we would spend one dollar on pollution prevention now, it would save spending $100 for a cure later'" (Labance and Witteveen, 2002).

During this same period, wetland preservation became a national issue (Balough, et al, 1992). Also, some environmentalists began to equate all golf with overuse of chemicals and fertilizers, irreparably changing the landscape by clearing natural vegetation, and draining valuable wetlands. The environmental activists were just beginning to organize their efforts to curb the irresponsible development of golf courses here in the United States and the world. Palmer Maples, Jr., CSGS, then president of the GCSAA, summed up the situation in 1976. "Today regulations govern not only people and how they work, but machinery, chemicals, noise, pollution of air and water, and housekeeping of the maintenance area and building before we even get out to the turfgrass area itself" (Labance and Witteveen, 2002).

Accordingly, environmental organizations began to challenge golf course construction and management practices using the relatively recent regulations such as the NEPA and the CWA. Golf courses together with threatened or endangered wildlife habitat, ecosystem protection, water quality, erosion control, and misuse of pesticides continued to gain attention. Inquiries by citizens and well-funded environmental advocacy groups such as the Sierra Club, Friends of the Earth, and the Nature Conservancy into the management practices of golf course superintendents rapidly increased to a fever pitch. According to Klein (1996), "the general public was led to believe that golf courses spoil pristine wetlands, forests and meadows, and that golf leaves little more than a legacy of lethal chemicals, poisoned underground water supplies, and dead fish, birds, mammals, snakes and reptiles."

Unfortunately, some of these concerns were at least partially justifiable. The time had come for the game of golf to return to its historically-based, natural roots with practices that were compatible with the stewardship of the environment.

Today

The golf boom of the late 1980s and 1990s brought renewed attacks on golf on several fronts: water use, possible pollution by fertilizers and pesticides, and the loss of natural areas (Achenbach, 1996).

Sensing the growing threat, the golf course industry began an honest review of their maintenance practices. By utilizing an open-minded, candid assessment process, they discovered that there were in fact some issues worthy of concern. Smart and Peacock (2000) report that "among the potential detrimental effects golf courses may have to the environment include:

- Contamination of surface water with sediment and nutrients during construction
- Contamination of runoff water and groundwater with applied nutrients and pesticides
- Development of pest populations with increasing resistance to chemical control
- Negative impacts of chemical management on beneficial soil and non-target organisms
- Potentially toxic effects of applied chemicals to non-target plants and animals; excessive use of water resources during drought conditions and in semiarid and arid climates
- Loss or degradation of wetland resources during construction and maintenance"

A call to action

"Heightened public awareness of environmental impacts and demand for environmental quality has affected all of our communities and lives. Golf has been no exception. Like many of the other environmental debates taking place in the previous decade, questions regarding golf's impact on the environment were increasingly being asked by citizen and advocacy groups" (Center for Resource Management, 1996). "In 1991, the United States Golf Association (USGA) began providing funds to Audubon International, a non-profit organization as well as the on-going New York state chapter of the Audubon Society, to support the organization's cooperative sanctuary program for golf courses. The Audubon Cooperative Sanctuary Program (ACSP) offers a comprehensive approach to environmental planning and education for proposed developments, with a primary focus on sustainability. The organization has published several informative and helpful guides to assist golf courses, golf clubs, homeowners, businesses, and schools to enhance and protect wildlife and their habitats and conserve natural resources" (Audubon International, 2001). Audubon International (2001) further stated that "the ASCP for Golf Courses is designed to give golf course managers the information and guidance they need to implement stewardship projects and receive recognition for their efforts."

The USGA responded by initiating an investigation of the extent of pesticide and fertilizer pollution and their effects on water supplies. The goals set by this organization resulted in the 1992 publication *of Golf Course Management & Construction: Environmental Issues* edited by James C. Balough and William J. Walker. Several additional environmental management publications followed that greatly enhanced the amount of reference material available to golf course managers and their staffs.

In January 1995, the first major national meeting of key representatives of the golf industry and the environmental community took place at the Pebble Beach Resort on the Monterrey Peninsula of northern California. The meeting was organized and facilitated by the Salt Lake City non-profit firm, Center for Resource Management, in cooperation with Golf Digest Magazine, the National Wildlife Federation and the Pebble Beach Resort Company.

"The diverse group of 75 participants represented many of the country's most influential golf and environmental organizations together to address issues related to 'golf and the environment'" (Center for Resource Management, 1996). This group represented both sides of the issue and included Friends of the Earth, Environmental Protection Agency, Save the Bay, Golf Course Superintendents Association of America, United States Golf Association, and National Coalition Against the Misuse of Pesticides.

"The participants met to consider the issues at the heart of the questions, 'Is golf as environmentally safe and sensitive as it can be?' and 'How can we make it more so?' The conference opened a long-overdue dialogue between these two communities and resulted in a commitment to seek collaborative solutions to the challenges of the game of golf and the environment. Through a process described as 'highly collaborative and iterative' they eventually developed a set of principles that seek to produce environmental excellence in golf course planning and siting, design, construction, maintenance, and facility operations" (Center for Resource Management, 1996).

Minimizing impacts through quality design and management.

Environmental Principles for Golf Courses in the United States

"The resulting 'Environmental Principles for Golf Courses in the United States' were envisioned as a tool of universal value, for national use under a wide variety of circumstances. These principles were developed through a collaborative research and dialogue process, and represent a consensus of all endorsing organizations. They represent areas of agreement but do not resolve all environmental issues related to golf. The dialogue and process is ongoing, as is the implementation of these principles" (United States Golf Association, 1997).

"The principles, as originally introduced at the March 96 – Golf & the Environment Summit in Pinehurst, North Carolina:

- To enhance local communities ecologically and economically
- To develop environmentally responsible golf courses that are economically viable
- To offer and protect habitat for wildlife and plant species
- To recognize that every golf course must be developed and managed with consideration for the unique conditions of the ecosystem of which it is a part
- To provide important greenspace benefits
- To use natural resources efficiently
- To respect adjacent land use when planning, constructing, maintaining, or operating golf courses
- To create desirable playing conditions through practices that preserve environmental quality
- To support ongoing research to scientifically establish new and better ways to develop and manage golf courses in harmony with the environment
- To document outstanding development and management practices to promote more widespread implementation of environmentally sound golf
- To educate golfers, managers, and the local community about the principles of environmental responsibility and to promote the understanding that environmentally sound golf courses are quality golf courses" (Center for Resource Management, 1996).

According to the Center for Resource Management (1996), these principles "assume regulatory compliance and are designed to provide opportunities to go beyond that which is required by law." They provide a framework for environmental responsibility for existing golf courses and address environmental issues associated with new courses. However, these principles are only voluntary in nature, and do not bind the actions of course developers and managers. If local communities want to ensure that their golf courses are environmentally friendly, it is up to them to get involved in the regulatory process and to assess environmental compatibility within their community (Center for Resource Management, 1996).

Tomorrow

The application of the principles above can and should educate and inform golfers and relevant decision-makers and concerned community members about the golf industry's environmental responsibility and commitment to help set goals for environmental compliance. Compliance for golf course managers not only means adherence to national and state laws and regulations, but conformity with their own industry's prescribed environmental stewardship practices. Greg Norman, member and chairman of the Golf Course Superintendents Association of America's newly redirected philanthropic arm, The Environmental Institute for Golf, stated "There may be no issue more important to golf than its relationship to the environment. Research, education and technological advancements have resulted in positive results for golf's relationship with the environment, but we cannot rest on what has been accomplished" (Newsline, March 2003).

One of the ways to address these challenges is to completely alter the way we look at golf course superintendents and their responsibilities. Although some superintendents firmly believe that they have always been stewards of the environment, continued criticism of the golf industry may require a more dedicated and coordinated strategy to further ensure the future of the game as well as themselves.

Comprehensive GEM planning may be the vehicle as positive proof of their environmental stewardship to the community, their customers. By utilizing a proven, internationally recognized and accepted systematic approach that scientifically establishes policy, determines and documents all actions, implements daily in the field, strives for continual improvement, regularly revises, and begins again will the golf manager's actions be taken seriously. Bottom line, environmental stewardship is golf course management.

Wild turkeys can enjoy a day on the links, too.

The superintendent as environmental steward

For years superintendents managed their golf courses like farmers managed their crops. Do whatever it takes to produce the best possible yield. In years past this might have meant using whatever type and quantity of pesticides, herbicides, or fungicides to get the job done. Golf course superintendents and their management techniques must conduct their business very different at the golf course of tomorrow.

With the legal and economic challenges faced by the superintendent in the 21st century alone, it is no wonder that the wide majority of them possess a college degree.

Another example of the positive shift in the superintendent's field is Tim Hiers, CGCS, recipient of the Golf Course Superintendents Association of America's President's Award for Environmental Leadership in 1994 (Mattimore, 1996). Hiers' course at Collier's Reserve in Florida continues to elevate the industry standards in environmental stewardship. "What used to be called 'The maintenance barn' is now referred to as 'The Natural Resource Management Center'. 'It's not simply a politically correct name change,' says Hiers, 'We re-use water, re-cycle pesticides, have a separate fuel barn, make use of skylights to cut down on electric bills, and use a lot less fertilizer. This issue is important to us and our maintenance budget has actually gone down" (Mattimore, 1996). Hiers established several goals at the Old Collier Golf Club's Resource Management Center to include reducing air conditioning costs, lowering energy use, and minimizing the use of cleaning agents. Adds Hiers, "We don't do these things because they are politically correct - we do them because they make good business sense" (Blais, July 2002).
This informed, professional concern and oftentimes personal caring for the environment is embodied in many of the new golf course management approaches being employed across the world.

Several natural resource management-based methodologies have been proposed for adaptation to golf course maintenance operations. All have valuable applications to golf course management, but none have been designed to specifically address environmental issues faced by superintendents in the proper context of an economically viable product. They include "working theories like conservation biology, sustainable development, integrated environmental management, and ecosystem management" (Mackay, 2000).

The golf course as an ecosystem

Viewing a golf course as an ecosystem forces golf course managers to address each and every action they take in light of its potential adverse affect on other resources within or adjacent to the golf course property. An ecosystem consists of biologically diverse communities of plants and animals that are functionally integrated with their physical and chemical surroundings. Within the ecosystem, each component is an integral part of the whole, and is also affected by every other component (Smart and Peacock, 2000). An ecosystem management-based system "seeks to protect viable populations of native species…and allow human use to levels that do not result in long-term ecological degradation" (Mackay, 2000).

The golf course as an industrial process

Like any large land use imposed by man upon the natural landscape, golf courses and their maintenance can be analyzed as an industrial process. Although this may not be obvious to the casual observer, the golf course is an industrial process with inputs, products, by-products and, of course, residuals.

In their landmark text, *Industrial Ecology*, Graedel and Allenby (1995) introduce the "master equation" that assumes that every one of us here on earth creates environmental impacts and as our population grows, the impacts must get worse. They go on to point out that “human activities appear to be rapidly consuming the ability of the atmosphere to act as a sink for the by-products of our economic practices”.

Although there are potential adverse impacts associated with all phases of golf course development; construction, grow-in, maintenance, and long-term use, this thesis will focus only on the maintenance process. There is basically only one product sought by golf course superintendents - high quality turfgrass. With a few exceptions like caring for sand bunkers, cart paths, signs, and water features and natural areas, every aspect of a superintendent’s focus is on maintaining the turf to keep their customers happy. Ironically, the most labor-intensive practice in managing a high quality golf course facility is mowing the same turfgrass that almost all the other maintenance activities are focused on producing.

Inputs

Most likely, anyone who has seen a well-maintained golf course can testify to the innate beauty of the grounds. For many, the soft lines of the naturalistic landscape and the simplicity of the turf, sand, and water features are pleasing to both the eye and the mind as well as soothing to the soul.

Pond maintenance can sometimes require extreme measures.

Fertilizers are another major input to the golf course process. Although the turfgrass industry is constantly striving to develop new varieties with improved durability, drought tolerance, and lowered nutrient requirements, turf on a busy golf course is almost perpetually under debilitating stress. This stress, combined with the uninformed, yet passionate desire for the proverbial "verdant lushness" from the golfing customer, continues the potential overuse of manmade fertilizers.

Water used for turfgrass irrigation and maintaining water features is the most obvious input for maintaining a top-notch golf course. In arid climates like the lower Sonoran desert of Phoenix, Arizona, a total of up to 6 feet of water may be required annually to maintain vigorous, healthy turfgrass including naturally spotty and inconsistent rainfall. Highly stressed turf, such as greens and tees, may require even more supplemental irrigation during extreme drought conditions. Some may question if golf in a low rainfall/high evapotranspiration area is appropriate, much less environmentally compatible. The same argument could be applied to the development of the town or city itself. To say it simply, people, like golf courses, have adapted to almost every conceivable climatic challenge. And, wherever people establish themselves, the seeming eventuality of golf course development is not far behind. In cities like San Antonio, when regulator-imposed conservation practices and watering restrictions can keep the public from irrigating their lawns, golf course irrigation practices have become highly visible and socially and politically problematic. Other inputs include labor, petroleum products such as oil, fuels, hydraulic fluids, and the golfers themselves.

Products

The primary product of the golf course industrial process is turfgrass. Golf courses today can have several different types of turfgrass by design depending on the aesthetic and playability intents of the golf architect and the maintenance goals and objectives of the superintendent. "The average 18-hole golf course includes 120 to 200 acres; of which only three to six acres feature intensively managed greens and tees, and 25 to 50 acres are mowed fairways. Most of the remaining 92 to 144 acres constitutes out-of-play areas, comprised of rough, woods, and water" (GCSAA, 1999). The greens are the most important playing surface on the course. Most modern day courses have an average green size of around 5500 square feet. Including a large practice green or two, the total area of this highly maintained part of a golf course is over 100,000 square feet or 20+ acres. Golf greens are usually mowed daily to exacting heights of less than a quarter-inch making them highly susceptible to the most common and persistent golf course pests and diseases.

One of the ways golf course superintendents can reduce their inputs is to maintain less turfgrass. According to a 1999 North Carolina Turfgrass Survey, it costs an average of $2,600 per acre annually to maintain golf course turf. While it's safe to assume that a large percentage of that cost is dedicated to greens maintenance, opportunities for cost savings still abound. The Audubon International's recent "Managed Lands Survey of Golf Courses" reveals that superintendents have been able to increase the non-mown areas of courses by 22 acres per course without

sacrificing play while reducing mowing time, gas, and maintenance (Fletcher, November 2002).

Fairway and rough turfgrass varieties and their management requirements vary greatly from region to region. Many varieties are highly refined hybrids that can require special maintenance and care. Teeing areas are the most physically abused on the course. Properly designed, they are sufficiently sized to allow the superintendent adequate flexibility to daily move the markers that delineate the beginning of play for each hole. Unfortunately, many courses have teeing areas that do not have this flexibility, complicating their management by creating requirements for additional water and possibly pesticide and fertilizer applications to coax more rapid recovery of the turf.

By-products

Some of the most interesting ramifications of golf courses on the landscape are their indirect contributions to improving the surrounding environment especially when the courses are sited in or near an urban or suburban land use. Some of the by-products of golf courses include:

- "Additional community greenspace
- Additional and more diverse wildlife habitats
- Improved air quality
- Cleaner runoff with increased absorption and filtering of rain water
- Increased protection against potential erosion
- Restored damaged areas like landfills and quarries" (Balough and Walker, 1992).

Residuals

Potentially, the runoff of pesticides and fertilizers from applications to the golf course are the primary residuals of golf course management practices. Growing a high quality turfgrass product requires chemicals for damaging weed and insect control as well as supplemental nitrogen, phosphorous, and potassium and other necessary micronutrients. Petroleum products, chemicals, and fertilizers that may be washed from maintenance equipment are the others. Many of the residuals are rapidly disappearing from this process, as golf course superintendents become more aware. According to the Golf Course Superintendents Association of America (GCSAA, 1999) "Fertilizers and pesticides used on a golf course are similar to those used by the general public on home lawns and for recreational areas."

The strategic mandates of the GCSAA include a significant environmental focus. "Superintendents should be proud of their active role in the development of environmental stewardship programs. Aside from the commitment that superintendents have as individuals and as a profession to preserve and protect the environment, the increasing scrutiny from governmental regulatory agencies and from the general public regarding the environmental impact of golf courses often requires swift articulation of our positive community contributions" (GCSAA, 1999). Gary T. Grigg, CSGS, MG, past president of the GCSAA, takes this sentiment a little

further. “Professional golf course superintendents are true environmentalists. As caretakers of the land, we give top priority to selecting maintenance practices that are safe for the environment. Today’s golf course superintendents are aware of and care about the consequences of overuse of pesticides and fertilizers” (Klemme, 1995).

Combine the natural beauty of Kauai with Jack Nicklaus' design expertise and you get the awesome Kiele Course.

Environmental Compatibility Categories

Many diverse and complex aspects of golf course management have been revealed through the literature search conducted to compile this study. In order to simplify the process, these aspects have been summarized into eight main topics and incorporated into five distinct environmental compatibility categories.

- Planning & Compliance
- Operations & Maintenance
- Water Resource Management
- Conservation
- Pesticides & Pollution Prevention

The environmental compatibility quotient (ECQ) checklists have been compiled from several sources (Audubon International, 2000) (AFCEE, 2001) (Smart, et al, 1999). The ECQ checklists represent the best method currently available to determine the actual relative environmental compatibility of a golf course's management practices. The ECQ checklists can be completed through interviews with the golf manager and the golf course superintendent, a professional examination of the course's golf

course management process, and review of the available environmental or planning documents.

Planning & Compliance

In an interview, Jimmy Thomas, CGCS, environmental award-winning superintendent at Hyatt Hill Country Resort in San Antonio, Texas, stated, "Although daily maintenance practices are important, in regards to the potential for negative environmental impacts, the most significant overall issue is planning" (2003). Audubon International (Mackay, 2001) lists the following benefits of golf course environmental planning:

- "Coordinates environmental management activities
- Illustrates how conservation activities complement one another
- Paves the way for improved property management
- Facilitates communication about environmental stewardship
- Helps managers set goals and objectives
- Provides a means to evaluate progress"

Another reason superintendents should plan "is to balance the demands of golf with their responsibility to the natural environment. The resulting plan will help safeguard the quality of the environment and responsibly care for the water, land, and wildlife habitats upon which the course is sustained" (Mackay, 2002).

Successful, experienced superintendents are keenly aware of these issues and prepare required documents, reports, permits, and etc. well in advance of their submittal deadlines. Additionally, actions that may be inherently risky to the health and welfare of their customers and the environment should receive special attention from the superintendent. Water quality sampling reports, water use permits, storm water detention requirements, easements, spill plans, and pesticide use permits are just a few of the potential compliance issues facing today's golf course superintendent (Beard, 2002).

How can the superintendent possibly stay in compliance? A good question says Rory Cox, superintendent at Shaw Air Force Base's Carolina Lakes Golf Course in Sumter, South Carolina. "Not so long ago we had a lot of help from our engineering staff and few, if any, important issues other than keeping the grass green and regularly mowed. Now we worry about algal blooms killing fish in our lakes, Canada geese running into airplanes, chemical use reduction measures, and reporting requirements for everything from spray lubricant use to fuel spills. It really is a difficult job for us, since we have fewer people on staff now than ever. On top of that, it seems as if the rules are constantly being changed or reinterpreted" (Cox, 1999).

Planning & compliance action items

- Enhance ecological and economical health of the golf course property and the surrounding community
- Demonstrate that the golf course is managed with consideration for the unique conditions of the ecosystem of which it is a part
- Document management practices to promote a more environmentally-sound golf course
- Share information on the environmental challenges and the course's approach to the management of the entire golf facility with customers and the local community
- Educate all employees on the benefits of an environmentally compatible golf course management approach
- Regularly train employees on the potential health hazards associated with their duties
- Involve entire staff in ensuring a safe golfing opportunity for their customers
- Demonstrate to customers and employees the benefits of an environmentally-responsible golf course management approach and its contribution to protecting both the future of the environment and the game
- Keep abreast of changing regulatory or permitting requirements
- Maintain good records as accurate proof of past actions in case of litigation
- Be an expert on spill or health hazard notification requirements
- Always be ready to communicate with customers, owners, and the community

Operations & Maintenance

Today, operating and maintaining a golf course facility embraces several diverse aspects. Outside of the golf course turf and associated amenities such as water features, bunkers, and forests, there are parking lots, clubhouse, cart storage facility, maintenance complex, service and utility areas, and other landscaped areas that compliment all of the above both functionally and aesthetically.

"In 1754, the Society of St. Andrews Golfers sought special playing privileges, or starting times, at the Old Course. In exchange, they were to supply funds for maintenance of the course. This may be the first historical reference to the actual contemplation of golf course maintenance. The first published scientific papers related to turfgrass research were initiated in 1880 by the renowned botanist Professor William J. Beal of the Michigan Agricultural Experiment Station, East Lansing, Michigan" (Beard, 2002).

As discussed earlier, the primary product of golf course operations and maintenance is quality turfgrass. A large majority of the inputs of the operation are directly related to growing, mowing, and caring for turfgrass. Since most of a golf course's equipment uses petroleum-based products for fuel and lubrication, potential impacts related to these products are a daily reality. In addition, operating the equipment creates exhaust emissions. Storing and cleaning the course's equipment contributes other situations where the potential for adverse impacts arises.

"The use of integrated management of turfgrass would be very effective for reducing detrimental non-point source environmental and water quality impacts. These practices would coordinate all management factors required for long-term sustained productivity and quality of turfgrass, golf course profitability, and ecological soundness of selected management options. Critical components of integrated management systems include proper design and construction of golf courses; selection of appropriate turfgrass species and cultivars; soil practices; clipping and cultivation practices; nutrient management; irrigation and drainage management; chemical, biological, and cultural pest management; and soil, water, energy, and natural resource conservation during construction and maintenance of lawns and golf courses" (Balough and Walker, 1992).

Operations & maintenance action items

- Integrate environmental protection into all course management decisions and practices
- Employ the principles of integrated pest management
- Document all activities for future reference
- Further reduce solid waste streams from clubhouse operations
- Increase the use of slow release fertilizers
- Constantly examine management practices to look for improvements
- Insist on a well-trained staff
- Incorporate contour mowing procedures
- Educate employees and customers about the benefits of environmentally responsible golf course management and the future of the game and the environment
- Enlist customer support and assistance on caring for the course and its facilities as well as Golf course Environmental Management Plan goals
- Create a location to communicate environmental management goals
- Take proper actions after a chemical or fuel spill
- Implement recycling procedures throughout the golf course operation

Extraordinary efforts have been taken at Kiawah's Ocean Course to protect water quality and native plant and animal species.

Water resource Management

Water is the primary limiting resource for life and golf. No other issue is as significant or as prevalent as those concerning water resources and their management. "Protecting ground and surface water from chemical pollutants is a national initiative. The Environmental Protection Agency (EPA) estimates that 1.2 billion pounds of pesticides are sold annually in the United States. About 70 percent of the pesticides applied are used for agricultural production of food and fiber. Only a small fraction is used on golf courses. Yet, increased public concern about chemicals has drawn attention to golf because of the perception that the intense maintenance on golf courses creates the potential for environmental contamination" (Kenna, 2000).

According to Balough and Walker (1992), "Prevention of adverse environmental impacts, such as surface water and groundwater contamination, by implementation of rational water, nutrient, and pesticide practices is a cost-effective measure. Avoidance or protection of wetlands prior to construction and continued protection during turfgrass maintenance will eliminate the need for expensive wetland

mitigation or restoration. Avoiding protracted permit processes or litigation prevents losses of revenues and natural resources."
"Understanding on-site water resources, as well as local and regional influences affecting water quality, is the first step in developing a management plan that is right for your course" (Mackay, 2002). Several complex and diverse, yet intimately connected water resource issues command a dominant position on the list of environmental concerns for golf course managers to include water quality, watersheds, rivers and streams, lakes and ponds, wetlands, and recycled water.

Excessive nutrients from a sewage treatment plant just upstream of the golf course property enhance plant growth in this small stream.

Water quality

"Protection of both quantity and quality of drinking water supplies is a major environmental concern of the public, regulators, and ecosystem managers in the United States" (Balough and Walker, 1992). "Properly managed water resources provide good quality irrigation water, aesthetically pleasing ponds and streams, appropriate storm water treatment, and no offsite surface or groundwater pollution problems" (Mackay, 2002).

In the eyes of the public and some environmentalists, golf has long been associated with impacts to water quality. Since this is easily quantifiable through scientific experiment, many universities are actively testing and monitoring water quality near golf courses with interesting results. "Numerous studies and reviews have shown that fertilization of turfgrasses according to established practices presents negligible potential for nutrient movement into groundwater or surface water because the dense turf canopy, thatch and root system, when properly managed, are an effective filter" (Georgia Golf Course Superintendents Association, Georgia State Golf Association). "Sound management of water, nutrients, and pests involves practices designed to retain the applied chemicals onsite and within the soil root zone" (Balough and Walker, 1992). Ultimately, it is either the Clean Water Act or the Safe Drinking Water Act that dictate the water quality standards in the United States. Each of these laws are complicated and armed with potent fines for violators.

The Clean Water Act

The Clean Water Act stated objective is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. § 1251(a)). In the past, the Clean Water Act has focused on end-of-the-pipe point sources through the National Pollutant Discharge Elimination System (NPDES) permits. Recently, the U. S. EPA has promulgated Phase II NPDES regulations that are beginning to focus on non-point pollution sources. General construction permits are now needed for projects that disturb an acre or more. In addition, these projects will also require a Storm-water Pollution Prevention Plan (SWP3) as part of the permitting process. Add to this the much tougher regulations for regulated small municipalities, Phase I medium and large cities, and discharges to designated non-attaining streams.

The Safe Drinking Water Act

Enacted in 1974, the primary objective of the Safe Drinking Water Act (40 CFR § 141-149) is to protect the public from risks posed by drinking water contamination. Although it is mainly aimed at public water systems and their operators, it does have its application to golf course management. Issues such as sole source aquifer protection, a major consideration in San Antonio, Texas, underground injection control (septic systems), and wellhead protection. Once again, great care must be taken when these types of issues are part of the golf course or adjoining property.

Watersheds

Watershed science is a rapidly growing and relatively new field of study. "A watershed is the entire area of land that drains into a specific river or river system" (Mackay, 2002). Knowing where in a particular watershed their golf course property lies is an invaluable piece of information that most golf course superintendents usually do not have at their fingertips. "To protect natural resources within a watershed, a threefold approach should be taken as follows: 1) preventative measures; 2) control measures; and 3) detection. This proactive approach stresses protecting water quality through removal, filtration, detention or rerouting potential contaminants before they enter surface waters; and developing strategies for protection of environmentally sensitive areas and guidelines for detection through an

environmental monitoring program that provides feedback to the golf course superintendent as to conditions and movement of materials" (Peacock, et al, 1998).

Rivers and streams

Rivers and streams are intimately related to watersheds. These water features are the most dynamic and unpredictable on a golf course. "Because water is always moving, what happens in one area can impact water quality in other parts of the watershed. Golf courses must be mindful of five primary impacts to water quality as a result of their operations:

- Discharges of chemical pollutants via leaching, drift, or runoff from chemical applications and storage, equipment maintenance, grass clippings, and parking areas;
- Sedimentation due to eroding shorelines;
- Thermal pollution-water temperature increases due to lack of shade when tree cover is removed along stream margins;
- Impacts associated with excessive water withdrawals; and
- Oxygen depletion due to excessive growth of algae, often caused by nutrient loading from spring fertilizer applications" (Mackay, 2002).

String trimming right to the edge of water features may not always be desirable.

Lakes and ponds

Lakes and ponds are used on golf courses "to add to the beauty of the setting and to enhance the playing experience. They are a dramatic and integral part of the landscape that superintendents are charged to manage" (McNabb, 2001). Maintenance of water features is one of the few tasks that does not focus on or relate to the quality of the golf course's turfgrass. Accordingly, superintendents oftentimes do not have the expertise to adequately maintain these water features, potentially resulting in difficulties ranging from negative environmental impacts to customer or neighborhood complaints.

"Any evidence of unsightly aquatic plant growth can detract from that beauty, and this easily draws the attention of members or the playing public. Aquatic plant and algae growth can obscure balls that have been hit into the lake, adding to the stress of the players when they can't be found. Excessive aquatic plant growth can cause flow problems in the irrigation lakes because intakes can be plugged or holding capacity of the lake as a reservoir can be reduced by the volume of plant material. Poor water quality can increase the presence of insect vectors like mosquitoes and cause odor problems near the feature. As such, superintendents need to have a good understanding of the dynamics of these lake systems" (McNabb, 2001). Since every lake may require different management practices and the fact that they are a living, changing biological element that attract birds, animals, regulators, and environmentalists, the superintendent must be diligent, knowledgeable, and ready to take action when required. Although the design of a lake may be the most important issue for the ease of their long-term maintenance, superintendents need at least a basic understanding of lake chemistry and biology to ensure success. Fish kills, nitrification, foul odors, and potential pollution from inappropriate pesticide or fertilizer applications are among the most common incompatible results of poor water feature management on golf courses.

Wetlands

Wetlands cover about six percent of the earth's surface. In the lower 48 United States, wetlands cover about five percent. Unfortunately, "between 1930 and 1995 this country lost wetlands roughly equal to the size of the state of Oregon" (Sodikoff, 1996). "The current national trend regarding wetlands and land development is for no net loss of wetlands. Environmental legislation both at the state and federal level has been enacted to establish a comprehensive program to conserve and manage wetlands in the United States" (Balough and Walker, 1992). These "prime tracts of acreage may not be drained, filled or built upon because they gained legal protection in 1972 under the Clean Water Act" (Sodikoff, 1996). "The United States Environmental Protection Agency (EPA) and the United States Army Corps of Engineers (COE) produced a definition that has been incorporated into Section 404 of the 1979 Clean Water Act Amendments" (Balough and Walker, 1992). "The term 'wetlands' means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally included swamps, marshes, bogs and

similar areas" (33 CFR 323.2(c); 1984). "Section 404 of the Clean Water Act has become the federal government's primary tool for protecting wetlands" (Salvesen, 1990). It gave "the Corps authority to establish a permit system designed to regulate the dredging and filling of materials into water of the United States" (Balough and Walker, 1992).

Storm water may not always be manageable.

Stormwater management

"In some cases, any earth disturbance activity could trigger regulation under state erosion and sedimentation control requirements" (White, 2005). Under Section 402 of the Clean Water Act, is Phase II of the National Pollutant Discharge Elimination Stormwater Program (NPDES) requires a permit and a Stormwater Pollution Prevention Plan (SWPPP) for any project that disturbs one acre or more of soil. Not only can projects be delayed when these regulations are not satisfied in writing or in practice on the site, but fines can be imposed that can severely impact budgets. "Erosion is a real environmental problem, and those who make their living moving earth have a responsibility to understand the science behind that problem and take steps to control erosion. At http://cfpub.epa.gov/npdes/stormwater/cgpfaqs.cfm, the EPA provides an online FAQ [frequently asked questions] resource that provides precise answers to many specific questions construction contractors have relating to NPDES permits" (White, 2005).

Although dry as a bone most of the year, this wash is classified as a "water of the United States" and is subject to regulation by the USACE.

Floodplains

Another environmental challenge faced by golf courses worldwide is their susceptibility to flooding by being constructed in low-lying, otherwise difficult to develop properties. Usually, in order to develop within the delineated 100-year floodplain, a finding of no practicable alternative (FONPA) is required. This process can be lengthy and potentially contentious in the eyes of the community and regulators.

Coastal zone management

With the promulgation of the Coastal Zone Management Act of 1972, the federal government established a comprehensive policy to "preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations" (Public Law, 104-150). Additionally, the Act strives to "manage coastal development to improve, safeguard, and restore the quality of coastal waters, and to protect natural resources and existing uses of these waters" (Public Law, 104-150).

Seaside golf offers some of the greatest challenges – both to the player and the superintendent.

Recycled water

"Water use and reuse are the most significant issues faced by superintendents worldwide. There are several reasons to use effluent, recycled, reclaimed, or wastewater including opportunity, need, conservation, reliability of supply, economics, and pollution abatement" (Crook, 1994). "Beginning in the mid-sixties, the use of effluent [recycled] or wastewater on golf courses was thought to be the answer to many developers' dilemmas in states with restrictive water use laws such as Arizona and California" (Gill and Rainville, 1994). It may be that the use of recycled water for irrigating golf courses is the only way the game will eventually survive.

Many states have promulgated their own regulations for the use of recycled water for golf course irrigation purposes. In 1992, the EPA released *Guidelines for Water Reuse*. Some of the issues raised by the document include "limits for fecal coliform organisms, recommendations that wastewater receive secondary treatment, filtration, and disinfection, setback distances between wastewater irrigated areas and potable water sources, and maintenance of minimum chlorine residual" (Crook, 1994).

Recycled water is golf's future lifeblood regardless of the location.

Obviously, most of these requirements indicate there may be a potential to harm human health through the use of recycled water. Public safety and protection are the primary considerations, but native vegetation and wildlife must also be monitored to ensure no adverse affects. In addition, none of the recycled water should be allowed to runoff either the property or into non-recycled water bodies such as natural streams, lakes, or ponds.

Untold acre-feet of recycled water are not reused. In many communities like Tucson, Arizona, recycled water is nearly the only source available for golf course irrigation use. Unfortunately, in other communities the public perception of this valuable resource is not favorable. Education is paramount for golf to survive by utilizing recycled water at every opportunity worldwide.

Keeping expensive equipment clean is an important golf course water use.

Water use

"In order to ensure adequate water supplies not only for irrigation, but also for the healthy ecological functioning of water bodies, such as rivers, streams, wetlands, lakes, and ponds, golf courses must conserve the earth's most precious natural resource" (Mackay, 2002). Jim Snow, national director of the United States Golf Association's Green Section, revealed that "a series of widespread droughts during the late 1970s and early 1980s, highlighted by a severe drought in California and other Western states, resulted in extreme restrictions on the use of potable water by homeowners and businesses in hundreds of communities" (Achenbach, 1996). "No other golf course impact garners more attention from the general public than water use. When entire regions are limited by law on how much they are able to water their own property's lawns, golf course irrigation systems continue to pump large quantities of precious water on their turfgrass" (Mackay, 2002). Snow adds, "Golf courses were among the first and most severely restricted operations in many areas, due in part to their visibility in their communities and because they were considered nonessential users of water" (Achenbach, 1996).

"Though water use on golf courses varies widely depending on climate and other factors, an average golf course may use 10 to 30 million gallons of water per year. Several simple, yet inter-related practices can help a superintendent ensure that

their golf course uses only as much water as it needs. These practices include identifying potential water sources and equipment, operational, and behavioral changes such as optimizing efficiency and keeping records" (Mackay, 2002). For example, "A water conservation practice could be as simple as matching the irrigation rate with the course's soils infiltration rate to properly schedule irrigation cycles that minimize runoff" (Georgia Golf Course Superintendents Association). Choice of turfgrass varieties, mowing heights, sharpness of a mower's blades, soil compaction, quality of the irrigation system design and installation, and water quality all play significant roles in the conservation of water on golf courses.

Water resource management action items

- Improve water hazard care to eliminate unwanted vegetation while improving aesthetics and habitat
- Closely monitor and manage water use to prevent unnecessary depletion of available company or local water resources
- Maintain a vegetative buffer around all water features to filter or trap potential pollutants
- Reduce offsite transport of sediment, nutrients, and pesticides
- Compile and utilize a Drought Management Plan for the entire golf course facility
- Reduce total chemical loads by use of Integrated Pest Management, economic thresholds, alternate pest control options, and fertility testing
- Employ appropriate water feature management techniques possibly including biological and mechanical controls prior to using chemicals
- Ensure there is never a violation of Section 404 of the Clean Water Act by increased employee training and awareness
- Eliminate the potential for fish kills in golf course ponds or lakes through intelligent, science-based management
- Never allow water use permit violation by maintaining good records
- Be prepared to minimize water use on the golf course facility grounds in case of extended regional drought
- Insist on proper application of pesticides and fertilizers along water feature banks to eliminate potential for spills or drift
- Avoid a buildup of heavy metals like mercury and cadmium in soils due to using poor quality recycled irrigation waters
- Ensure that a Stormwater Pollution Prevention Plan is submitted for all construction disturbances over one acre

Excessive runoff from a housing area upstream is the culprit here.

Conservation

"By their very nature, golf courses provide significant open spaces and opportunities to provide needed wildlife habitat in increasingly urbanized communities across North America" (Mackay, 2002). Audubon International, quoting the United States Golf Association's Green Section, says "The average course covers 150 acres, yet just 30% is generally used for greens, tees, fairways, and buildings, leaving 70% as rough, woods, water, and other habitats. These non-play areas provide significant opportunities to enhance and protect wildlife and native habitats, provide corridors that link to other natural areas, filter pollutants, produce oxygen, and stabilize soils" (Mackay, 2002). Among the other natural resources that can be potentially impacted by golf course management operations are soils, air, water, and wildlife and their habitats.

Soils

"Properly maintained turfgrasses stabilize topsoil, reduce erosion, and improve and restore soil structure" (Beard and Green, 1994). Since most quality golf courses maintain turfgrass cover on nearly 100% of their grounds, soil impacts are usually not a major issue. It is when turfgrass quality lags and soil is bared to the effects of weather and artificial inputs such as fertilizers and pesticides do potentially adverse

impacts become possible. Soil testing is a common task for golf course superintendents as they strive to maintain the best possible conditions for turfgrass cultivation. Erosion control, compaction, and contamination are some of the potential impacts to golf course soils.

Air

Although it may seem an insignificant contributor to air emission problems, golf course tools and machinery, chemical use, and gas-powered golf carts are being scrutinized. Even though most courses cover no more than 150 acres, air emissions can be notable. Studies are on going to develop solar-powered golf carts. Cleaner, more efficient engines are more likely to be seen on fairway mowers. And, skirted pesticide sprayers inhibit volatilization and wind drift during applications. Recent modifications to The Clean Air Act that change how the United States Environmental Protection Agency (EPA) determines how dirty our air is may lead to changes at the course. In cities where the region's air quality is already poor, golf course equipment will likely be subject to annual emission testing.

The state of California is currently examining the emissions of nearly every turf industry-related tool from string trimmers to small tractors. It is just a matter of time before new rules are enacted requiring emissions controls and regular testing. If the past holds true, the U. S. EPA will in all likelihood adopt these rules and aggressively enforce them in at least the non-attainment, or bad air quality, areas of the United States.

Wildlife and their habitats

"It is critical to be aware of potential golf course lands which are biologically productive areas rich in wildlife and unique vegetation. Urban areas continue to expand as natural wildlife habitat dwindles in the United States. Wildlife is given the ever-burgeoning problem of finding natural areas in which to survive. Golf courses can provide a critical natural habitat. Enjoying the game of golf and preserving our wildlife heritage are mutually compatible goals" (Balough & Walker, 1992).

According to Audubon International (Mackay, 2002), "Golf courses have tremendous opportunities to provide valuable open space for people and wildlife and become part of local green spaces within their communities." Ironically, this can become an additional complication for some golf course managers when the golf course attracts waterfowl and other birds that can foul turfgrass and water bodies with their actions.

Turkeys and other desirable species are abundant on many courses.

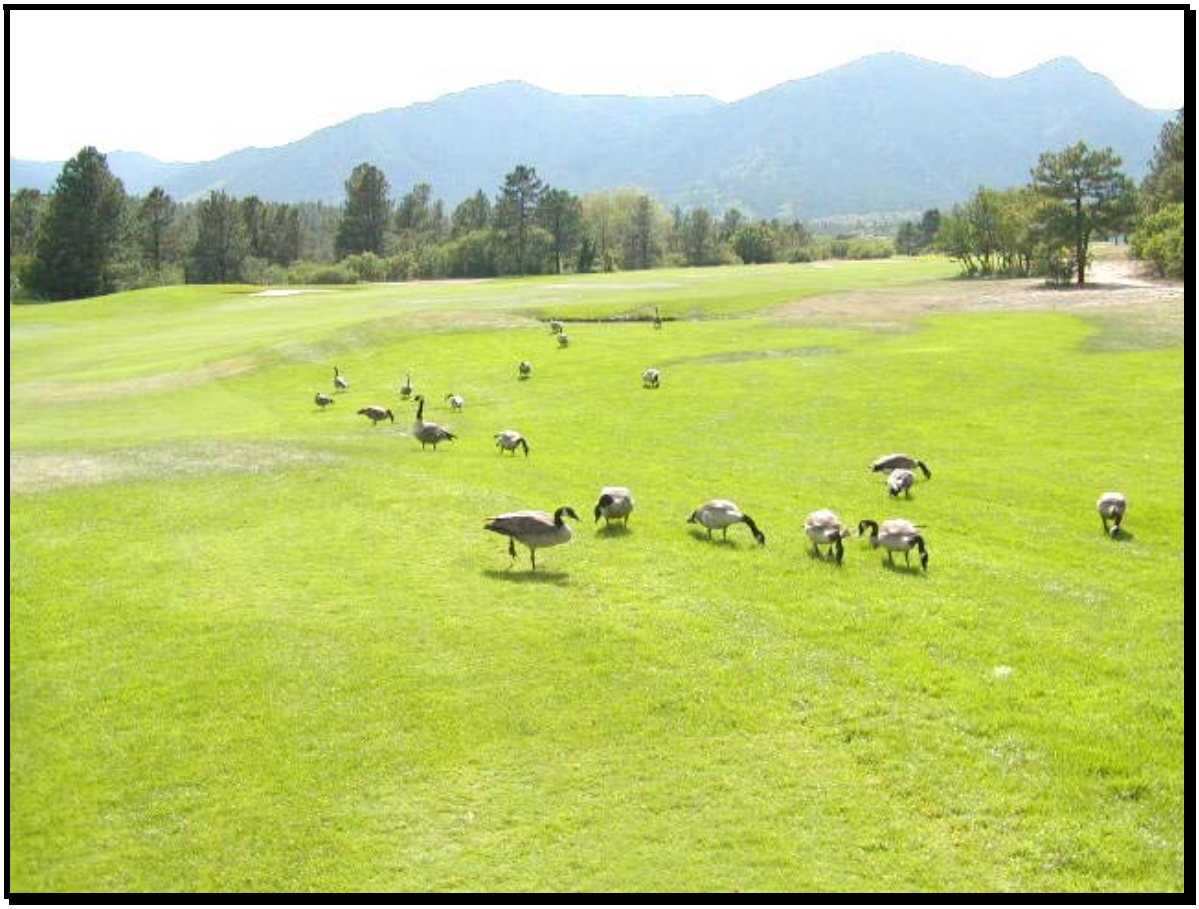
The Endangered Species Act of 1973 (7 U.S.C. § 136 & 16 U.S.C. § 460) adds impetus and motivation, as it is one of the most pervasive and liability driven laws of the age. It is imperative that golf course managers understand what wildlife occurs on their courses and what they can do to improve the populations of the desirable species. Wildlife has specific needs that include space, food, water, and cover that, taken together, define the habitat. Naturally occurring, diverse landscapes obviously satisfy more species' needs and are more valuable as habitat resources on the course grounds and contiguous properties. Audubon International (Mackay, 2002) identifies these as core habitats and suggests that "they should be protected from disturbance by players and employees."

"As urban areas continue to expand into places once used as wildlife habitats, golf courses are becoming increasingly critical to the preservation of natural habitats in urban and suburban environments. There are a surprising number of wildlife species that inhabit golf courses. Not only do golf courses provide a habitat for wildlife reproduction, they serve as critical overwintering areas for migratory and nonmigratory species" (Balough and Walker, 1992).

The Migratory Bird Treaty Act of 1918 provides an additional environmental challenge to golf course managers. Basically it prohibits, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill,

possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, or any part, nest, or egg of any such bird" (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755 as amended).

To say the least, the interpretation and enforcement of this particular law is still quite murky. Fines for violations can be up to $100,000 for individuals and $200,000 for organizations. It is probably a good idea to consult with local natural resources manager, United States Department of Agriculture representative, or your friendly Fish & Wildlife Service agent if there are any situations where migratory birds could possibly be harmed by golf course management activities.



Superintendents need to be aware of laws that protect geese and other migratory species that may call their course "home" for a few days or weeks during the year.

Superintendents may need special assistance if cultural resources are discovered or are known to exist on their golf course property.

Cultural resources

Archaeological remains or Native American cultural items are just a few of the environmental challenges under the heading of cultural resources. Golf course managers must ensure that they comply with the National Historic Preservation Act (36 CFR § 800), the Native American Graves Protection and Repatriation Act (43 CFR §10), and the Archaeological Resources Protection Act (32 CFR § 229). Legal complications arise when cultural resources are discovered and not handled per these complicated laws. In case of encountering historical resources, one should immediately cease construction activities in the vicinity of the discovery, immediately notify the nearest National Park Service cultural resources manager, do not further disturb or remove any cultural or natural items or remains from buried contexts, and protect those items or remains exposed or brought up. There are additional requirements that also must be satisfied prior to resuming the construction activity.

Conservation action items

- Use natural resources efficiently while respecting their long-term value to the local community
- Continue building relationships with community regulators, educators, and natural resource consultants and other environmental professionals
- Utilize native or indigenous plant materials whenever possible
- Consider every aspect of the golf course facility as a positive contributor to the overall satisfaction of the customer
- Enlist local consultants to determine how the golf course staff can assist in the removal of invasive exotics that may occur
- Increase number and variety of native plant materials
- Eliminate damage or disturbance of threatened or endangered species and their habitats in accordance with the Endangered Species Act
- Minimize excess air emissions from maintenance equipment in a non-attainment or poor air quality region

This pesticide mixing area is regularly inundated by rainfall.

Pesticides & Pollution Prevention

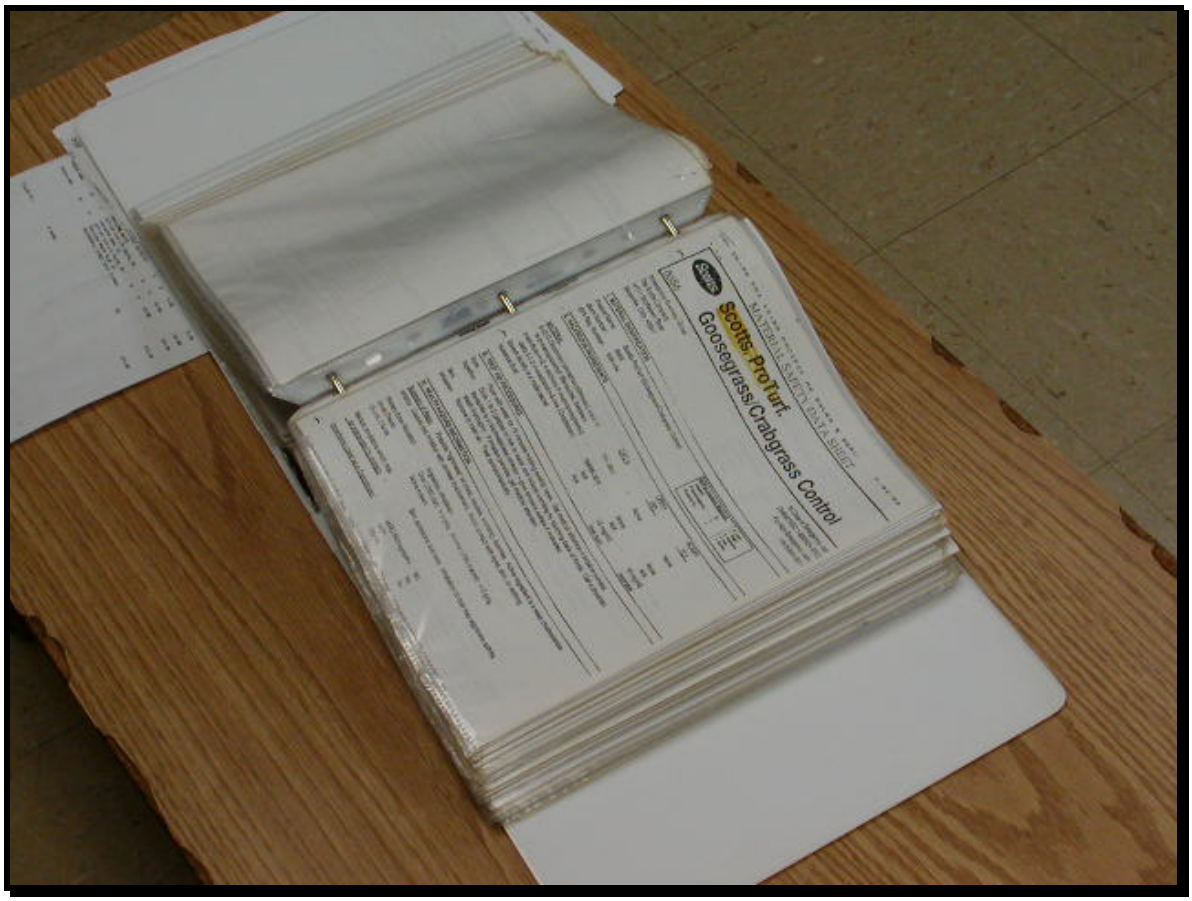
"The golf industry has come a long way since the heavy chemical application era of the 1950s and '60s. Most of the standard procedures of those days have been abandoned, in part through government regulation, in part because more efficient (and less toxic) chemicals have been developed. There's something of a back-to-nature movement afoot among superintendents. The result is healthier turfgrass, greater diversity of plant material, increase biodiversity on the course, and less-poisonous runoff into the surrounding environment" (Klein, 1996).

The Federal Insecticide, Fungicide, and Rodenticide Act of 1947, or FIFRA, 1970, amended 1988, is the primary regulator for pesticide use on golf courses in the United States. "This act seeks to protect humans and the environment by providing for the controlled use of pesticides" (Kammel, et al, undated). Pesticides are defined as any substance intended for "preventing, destroying, repelling or mitigating any pest," and substances intended for "use as a plant regulator, defoliant, or desiccant" (FIFRA § 2 (u), 7 U.S.C. § 136(u), 1997). "A pesticide may only be used as specified by the pesticide label and application of a pesticide other than as directed by the label is a FIFRA violation" (White, 2005). In addition, "All pesticides must be registered by the U.S. Environmental Protection Agency before they are allowed on the open market. However, registration does not ensure that

pesticide formulations have been tested adequately for health and environmental effects" (TNRCC, 1999).

Once they have been applied to turf, "pesticides are subject to many forces operating within the natural environment. Some are caused naturally like wind-induced drift, runoff, volatilization, and absorption" (Turgeon, 1980), whereas others "are a result of maintenance practices like mixing and handling and accumulation in clippings" (Schumann, et al, 1998).

"Other problems associated with pesticide use include direct contamination of storm drains with pesticide runoff, drift from lawn applications, unknown effects when chemicals combine (synergist effects), possible resistance to the chemicals by pests, and the killing of beneficial non-target species, including the pest's natural predators. Pesticides can directly enter the groundwater system through spills around a poorly cased well, back-siphonage into domestic wells during spray tank/container filling, or improper disposal of pesticide containers" (TNRCC, 1999).



A Material Safety Data Sheet, or an MSDS, must be readily available for all potentially harmful products anywhere on the golf course property.

In maintaining golf courses for today's golfers, "pesticides and fertilizers are used only on certain portions of the golf course. The rest of the property often consists of natural areas not maintained with turf care products. These areas can provide a home for wildlife, and include a diverse variety of native plants and trees" (GCSAA, 1999). "Ecologically sensible use of biocides in golf course management should emphasize localized application of highly specialized toxins that act quickly, effectively, and which are then naturally and quickly degraded" (Smart and Peacock, 2000).

According to Hurzdan (1996), "Despite exhaustive research that has clearly established that properly selected and applied golf course fertilizers will not contaminate groundwater. Nearly the first reason given in opposition to a golf course project is that applied fertilizer will pollute the groundwater-or runoff of chemicals will kill fish in nearby water bodies, or massive bird kills occur as a result of golf course pesticides". Hurzdan (1996) continues "This is hogwash -pure urban legend - with no routine basis in fact, as isolated and unusual as lightning strikes, but at every environmental hearing these accusations are made."

"Next to having satisfied golf customers, complying with today's regulatory requirements has become the most important element for the golf course manager. Nearly every aspect of the business of growing high quality turf has come under the scrutiny of the regulator. Several articles in the turfgrass trade literature suggest that chemical management of turfgrass will not be a source of surface water or groundwater contamination if appropriate management practices are followed" (Balough and Walker, 1992).

Future complications

No action since the elimination of diazinon use on golf courses has had the potential to affect the use of pesticides by golf course managers more than the Food Quality Protection Act of 1996. Under the Act, which addresses safety based on residue levels on food, the U. S. EPA must reassess all existing pesticide tolerances (more than 9,700) within the next ten years. The primary concern for superintendents is how the act determines risk and a hint that the Act will try to eliminate all of the organophosphates. Rather than quantifying risk one chemical at a time, the act will group related chemicals together and calculates their risk as a "family". For example, organophosphates such as popular Malathion, chlorpyrifos, and Orthene will be counted together. The same for carbamates and B1/B2 carcinogens that include most of the fungicides used on golf courses. Recently, Dursban, the trade name for chlorpyrifos, a long-time multi-purpose pesticide, was removed from the shelves for most users. Also on tap for the future, are lower application rates, lower frequencies of treatment, and longer time periods between applications (U.S. EPA, 2000).

The key result will be how the U. S. EPA will interpret those risks and apply them to golf course products. Eventually labeled use of some of these important pesticides on golf courses will be removed from many of the higher risk chemicals

effectively limiting golf course managers' choices. Repercussions and impacts of the act are still being quantified and are expected to be significant. About the only way superintendents can cope with these sweeping changes is to utilize natural pest control mechanisms whenever possible. "Healthy turfgrass is a powerful ally against infestations and integrated pest management programs are essential to the environmentally sound operation of the modern golf course" (Hock and Thomas, 1999).

Integrated Pest Management (IPM)

Integrated pest management involves using a variety of management measures to keep turfgrass pest populations below levels that are economically and aesthetically damaging, without creating a hazard to people and the environment (Mackay, 2002). In August 1996, Congress declared that federal agencies "shall use IPM techniques in carrying out pest management activities and shall promote IPM through procurement and regulatory policies and other activities" (7 U.S.C. § 136r-l, August 3, 1996). One of the primary goals of IPM is to minimize pesticide use and dependency on chemicals, thereby lessening their impact on the plant ecosystem and the environment (Chaltas, 1987). One of the ironic realities of the golf course management business has always been that the good superintendents always employed IPM, but rarely, if ever, used the name or documented their regular, intuitive thought processes or pest management planning on paper. According to Audubon International (Mackay, 2002), the "basic components of Integrated Pest Management include:

- Employing sound cultural practices to promote plant health
- Scouting and monitoring potential pest populations and their environment
- Selecting thresholds for acceptable and unacceptable levels of pest injury
- Accurately identifying the problem and choosing the best management strategies
- Educating personnel about various management strategies
- Proper timing and spot treatment for cultural, biological, or chemical methods
- Evaluating the results and keeping records"

Pesticides & pollution prevention action items

- Integrate management practices with appropriate regulatory requirements and procedures
- Create and maintain an attractive golf course facility that requires minimal outside chemical or fertilizer inputs
- Reduce total chemical loads by use of Integrated Pest Management, economic thresholds, alternate pest control options, and fertility testing
- Guarantee safe, healthy, and enjoyable experience for golfers while ensuring long-term success
- Properly store and handle all potentially harmful products to minimize employee exposure

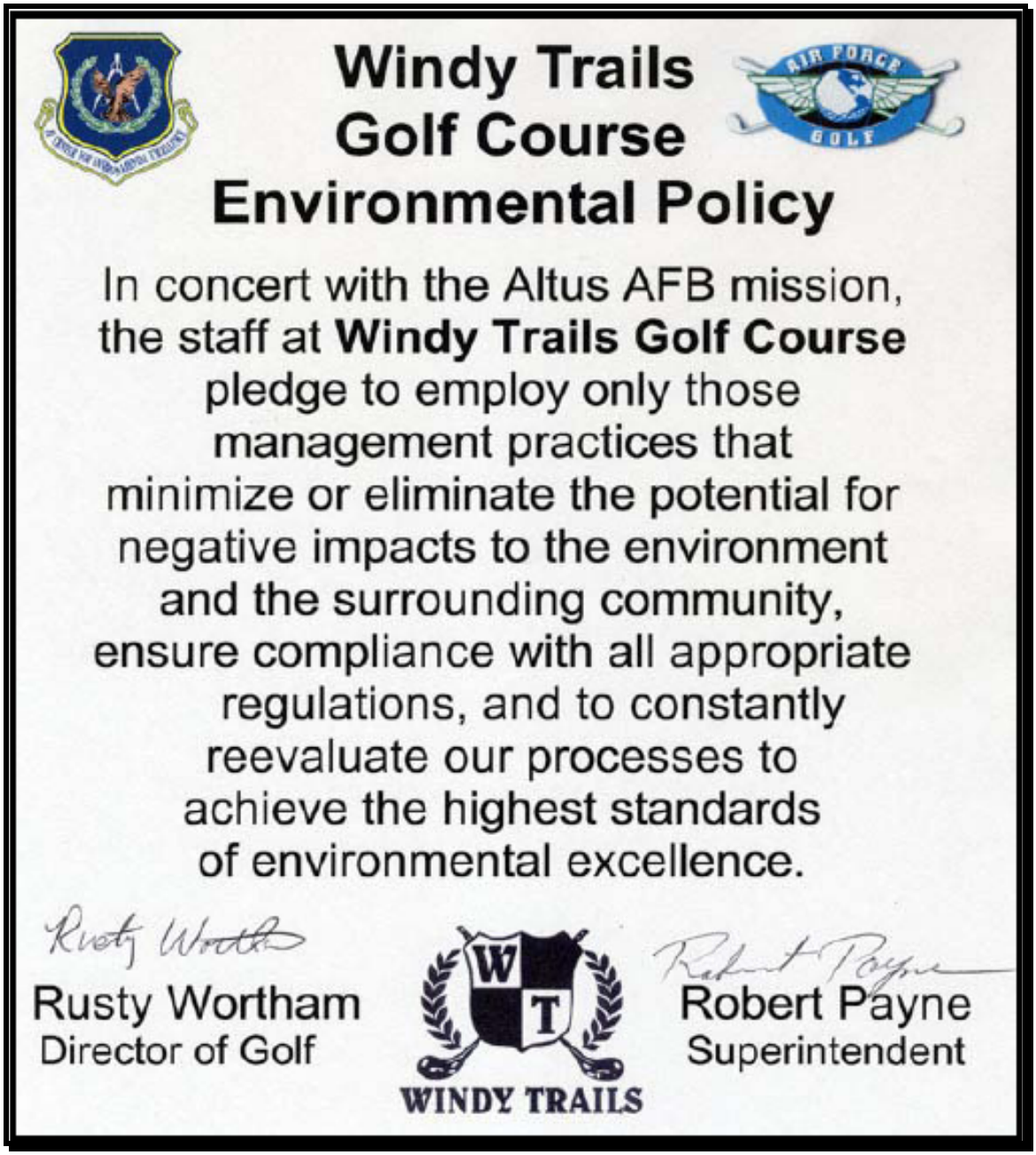
- Increase training and involvement of staff on integrated pest management procedures
- Compile written pest profiles of common pest species
- Employ practices that eliminate or avoid the potential for polluting the environment and harming employees, customers, or the community
- Guarantee that the golf course facility will not allow chemicals, fertilizers, detergents, or petroleum products they use to migrate outside their property boundaries
- Increase number of trained scouts on staff
- Create and utilize a comprehensive pollution prevention plan for all aspects of the golf course and its facilities
- Regularly provide training for all employees on the specifics of pollution prevention and how they can help
- Completely cover equipment refueling area
- Insist on a pesticide facility that is at least safe and functional, if not state of the art
- Ensure compliance with appropriate pesticide regulatory requirements and procedures
- Minimize pesticide damage to non-target or desirable species

A buffer is used on the out-of-play side of the water feature.

The Environmental Policy

ISO 14001 requires an environmental policy. This step should be established early in the GEM Planning process described below. "Top management shall define the organization's environmental policy and ensure that it:

- is appropriate to the nature, scale and environmental impacts of its activities, products or services;
- includes a commitment to continual improvement and prevention of pollution;
- includes a commitment to comply with relevant environmental legislation and regulations, and with other requirements to which the organization subscribes;
- provides the framework for setting and reviewing environmental targets and objectives;
- is documented, implemented and maintained and communicated to all employees;
- is available to the public" (International Organization of Standardization, 1996).



Windy Trails Golf Course Environmental Policy

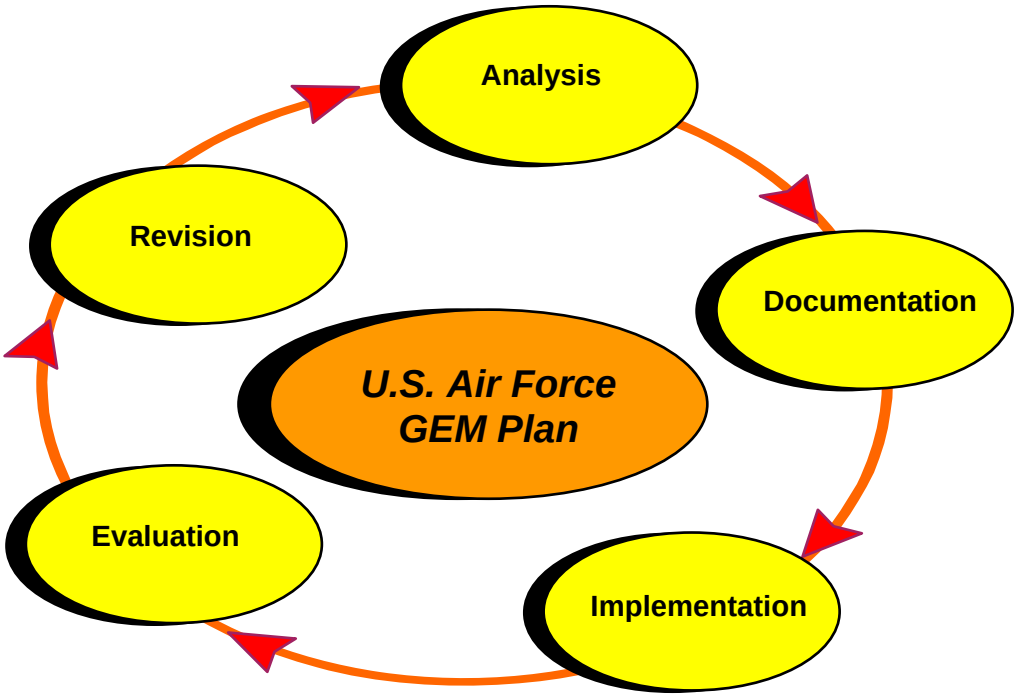
In concert with the Altus AFB mission, the staff at **Windy Trails Golf Course** pledge to employ only those management practices that minimize or eliminate the potential for negative impacts to the environment and the surrounding community, ensure compliance with all appropriate regulations, and to constantly reevaluate our processes to achieve the highest standards of environmental excellence.

Rusty Wortham
Director of Golf

WINDY TRAILS

Robert Payne
Superintendent

A sample environmental policy is provided for use that satisfies these considerations. Statements such as minimizing the potential for negative impacts, always staying in compliance, and a commitment to regularly reevaluating your actions takes care of most of the requirements. Since all employees must be aware of the policy, a simple mention in the newcomer's brief or a three minute discussion during weekly staff meetings or as an additional item during required safety briefings are some of the ways to get the word out to employees. As far as the requirement for public availability, the golf course manager or superintendent can easily create a professional-looking document to be posted in highly visible locations throughout the facility.



The GEM Planning Process

The primary reason to compile a Golf course Environmental Management (GEM) Plan is to comply with the established environmental policy as defined and adopted by golf course management (Bushman, 2003). The GEM Planning process guides the comprehensive management of all aspects of the golf course facility while establishing a baseline for current methods and identifying potential environmental challenges. Additionally, a GEM Plan will assist in attaining and maintaining daily compliance with all appropriate rules and regulations and constantly examining employed processes of all aspects of golf course management to achieve the highest standards of environmental excellence. There are five steps in the GEM planning process:

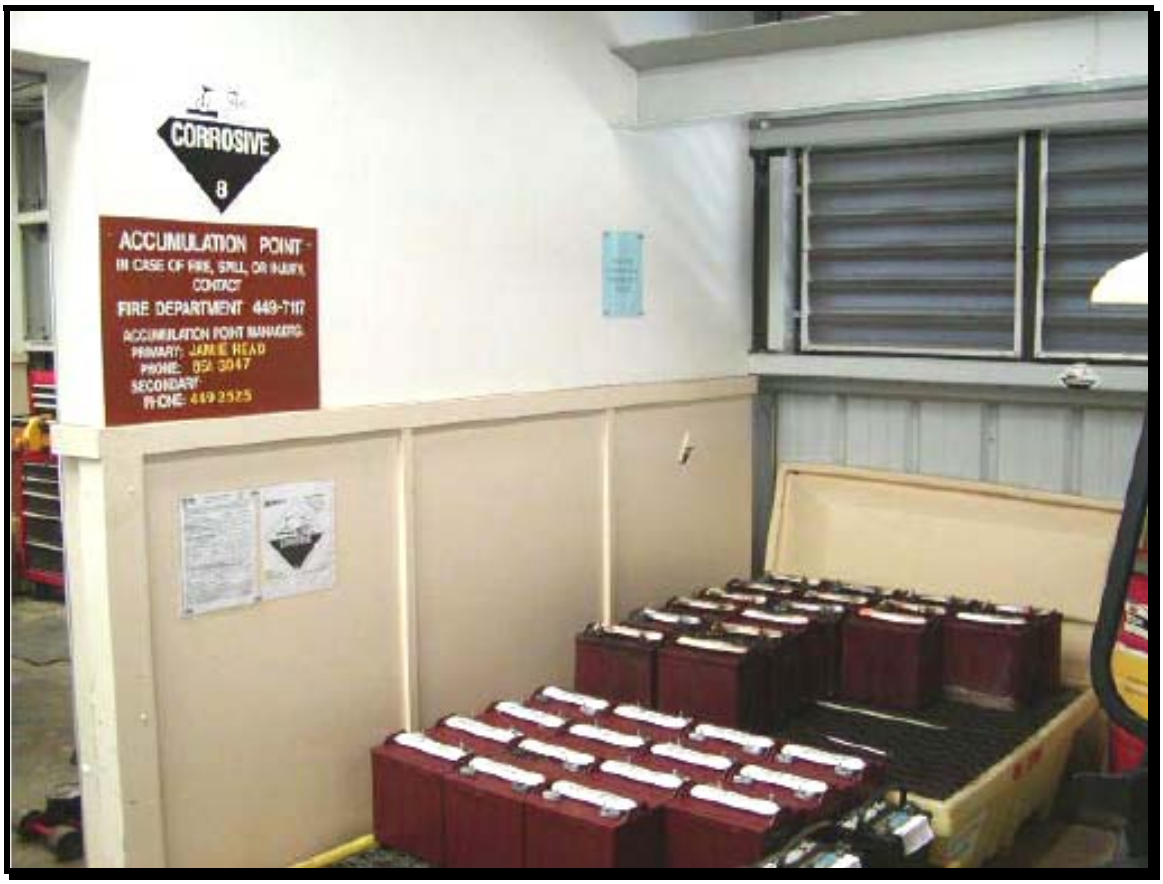
- Analysis
- Documentation
- Implementation
- Evaluation
- Revision (AFCEE, 2001)

The ultimate intent of the Golf course Environmental Management (GEM) Plan is to provide a logical management tool that will free up course managers and superintendents to devote more of their efforts to caring for their customers and the course. Properly designed and implemented, the GEM Plan will keep the golf course in compliance with the ever-changing environmental rules and regulations

while providing an economically viable recreational opportunity for their members or the community (AFCEE, 2001).

Analysis

Experienced professionals realize the importance of assembling all of the data relevant to a problem prior to determining its best possible solution. The analysis phase of the GEM Plan is comprised of the compilation of the golf course environmental baseline assessment (GCEBA). Completing the GCEBA (Draft GEM Plan) is vital to creating a GEM Plan that comprehensively addresses all of the environmental compatibility issues of the golf course's management practices (AFCEE, 2001).



Old vehicle battery storage areas can be a regulatory nightmare if not handled properly by the manager or superintendent.

Golf course environmental baseline assessment (Draft GEM Plan)

The golf course environmental baseline assessment (GCEBA) provides the initial input into the formulation of a golf course environmental management plan (Bushman, 2003). The baseline is an actual numerical score of the relative environmental compatibility of a specific course's management practices as recorded in the 100 question environmental compatibility quotient checklists. The assessment portion of the GCEBA is the identification and prioritization of

environmental challenges and the resulting management practice or procedure utilized by the superintendent or manager in their daily care of the entire golf course facility.

GCEBA process

The GCEBA (Draft GEM Plan) process is similar to any investigational study. Collecting pertinent data, determining inherent opportunities and constraints of the land, its setting, its environmental challenges, and its management, as well as playing and examining the course itself firsthand are all key tasks to be performed. The following is an example of the sequence of tasks used by an environmental professional or the superintendent to accomplish a golf course environmental baseline assessment:

- Receive assessment request
- Schedule course visit
- Conduct primary interviews with golf manager, superintendent, certified pesticide applicators, greens committee, golf professional, and players (random survey)
- Records search/data collection including: environmental studies, aerial photos, geographic information system (GIS), facility as-builts, wetlands delineations, maps, utility drawings, future plans, and state/local regulations and requirements to determine the potential environmental challenges, if any
- Physical site inventory and analysis of facilities including maintenance complex, cart storage facility, pesticide mixing and storage facilities, fuel storage and delivery area, clubhouse, pro shop, restaurant, and snack bar
- Physical site inventory and analysis of golf course include: tour and photograph each hole and assess aesthetics, natural characteristics, grading and drainage, turf quality, trees, existing/potential wildlife habitat, unique landforms, hazards, and maintenance practices (AFCEE, 2001)

GCEBA components

The Golf Course Environmental Baseline Assessment (GCEBA) is a summary report comprised of the course specific analysis, miscellaneous facility review, compilation of the environmental compatibility quotient checklists, and the identification and description of any potential environmental challenges (AFCEE, 2001).

Course specific analysis

One of the most pragmatic and enjoyable tasks in the GCEBA process is the course specific analysis. From a general overall description of the course to the details of the course's history and makeup to the various observations on the way the course plays, looks, and is managed, the course specific analysis sets the stage for the rest of the GCEBA report.

Managing golf courses today requires more than just knowledge of turfgrasses and equipment.

Although not always required of a quality GCEBA, this portion of the analysis allows observations on course playability, aesthetics, and directly observable environmental management issues to be compiled. Direct observation of the course can act as a reference point for recommendations for improvement as well as positive reinforcement on worthy characteristics or practices. Overall trends can be identified by comprehensively examining the various observations noted for each hole.

The hole-by-hole analysis section provides a convenient vehicle to enable visitors, owners, prospective golfers, or interested community members to more readily visualize the course. Most importantly, the course specific analysis helps to insure that the all-important customer point of view is always part of the process. A phenomenal environmental management program may be noteworthy, but if there are no golfers the effort becomes futile and misguided.

Coconut palms are a welcome addition to tropical golf courses. Unfortunately, the safety hazard posed by falling coconuts creates an expensive, recurring maintenance requirement.

Miscellaneous facility review

Although the course is primary to the enjoyment and eventual return of most of a course's customers, the support facilities play a huge role in the overall success of the operation. This section of the GCEBA will examine the following facilities for their aesthetic, functional, and environmental values:

- Clubhouse/pro shop/snack bar/restaurant
- Cart storage facility
- Practice areas
- Maintenance complex
- Fuel delivery and storage
- Equipment wash rack
- Pesticide mixing and storage
- Infrastructure to include irrigation, pump houses, cart paths, landscape development, and site amenities such as benches, signs, ball washers, & drinking fountains or coolers

Clubhouses can also be sources of potential environmental challenges.

Environmental compatibility quotient checklists

Another attribute of the Golf course Environmental Management (GEM) planning process is that it can quantify the environmental compatibility of a particular golf course's management practices. Anyone with a golf and environmental background can successfully complete the process by completing the environmental compatibility quotient (ECQ) checklists through interviews, inquiries, and observation. The ECQ checklists are a convenient method of assessing the overall performance, implementation, and completeness of a course's GEM Plan.

Appendix 1 - Environmental Compatibility Index Checklists.

PLANNING & COMPLIANCE				
#	Environmental Compatibility Indicator	Yes	Partial	No
1	Has management demonstrated that caring for the environment is an important part of their responsibilities by initiating the Comprehensive Golf course Environmental Management (GEM) Planning process?			
2	Has the golf course adopted and posted an environmental policy?			
3	Is the GEM Plan complete, updated regularly, and readily available to employees and customers?			
4	Is a map of the property highlighting environmental challenges posted for employees and customers?			
5	Are environmental challenges and their management practices evaluated at least annually and are they regularly communicated to employees, customers, management, and the local community?			
6	Are there signs appropriately located to warn golfers of hazards of drinking reclaimed or otherwise non-potable water?			
7	Are there interpretive signs posted to highlight key habitats or have appropriate areas been designated "Environmentally Sensitive Zones" per USGA rules?			
8	Is there a general understanding by the clubhouse, pro shop managers of how their management practices may potentially adversely impact the environment?			
9	Are the environmental impacts of pest control measures considered as part of the Comprehensive GEM Planning process?			
10	Are projects planned and funded for the next year that would increase the compatibility of the course's management program with Comprehensive GEM Planning goals and objectives?			

The ECQ checklists begin the process of quantifying the overall compatibility of a golf course's management practices.

The checklists can be used in many ways including:

- As a tool to establish a current snapshot or baseline of a golf course's relative environmental compatibility
- As a tool to identify areas for improvement or to demonstrate current successes
- As a self-assessment tool for the golf course manager and superintendent
- As documentation for an environmental award nomination
- As documentation for regulatory requirements or inquiries from customers, the media, or the general public (AFCEE, 2001)
- As part of a more comprehensive assessment of a course's management practices to use for establishing an international standard for environmental compatibility

Most importantly, the ECQ checklists will, for the first time, allow comparisons between golf courses of similar types all over the United States and eventually the world to determine the best environmental management programs and the reasons why.

Determining the Environmental Compatibility Quotient (ECQ)

The Environmental Compatibility Quotient (ECQ) for a specific golf course is a snapshot of the overall performance and compatibility with the tenets identified by the environmental and golf industries that are documented in this study. The ECQ checklists can be used to determine the actual as well as the potential environmental compatibility quotients. The actual ECQ is the total number of "Yes" responses for all five ECQ checklists and represents the current level of a course's environmental compatibility. The potential ECQ is the total number of "Yes" responses plus the total number of "Partial" responses for all five ECQ checklists and represents a course's level of environmental compatibility if a little more effort was employed to complete changes or to finalize projects or studies. The ECQ scoring scale gives the golf course superintendent a relative status of their management practices' environmental compatibility.

Environmental challenges

Having established the baseline, the next step is to complete the assessment by identifying the course's environmental challenges. Environmental challenges can be defined as concerns or issues of local, state, regional, or national significance that may be impacted by the golf course management practices. Another definition for an environmental challenge is simply any environmental issue that is bigger than the golf course.

Ideally, the golf course superintendent will address each challenge to determine the most environmentally compatible method that satisfies the goals and objectives of the golf facility to create an acceptable quality of course playability and customer satisfaction (AFCEE, 2001).

Fuel tanks should be double-walled and protected from accidental damage.

Environmental challenge significance test

One of the important results of the GCEBA process is the identification of the potentially significant environmental challenges that should receive high priority treatment each and every day by the superintendent as well as be prominently addressed in the Golf course Environmental Management (GEM) Plan. This is accomplished by examining all of the course's management practices that could possibly negatively impact an identified environmental challenge. By identifying those practices that can have a profound or significant effect on management's perceived ability to be stewards of the environment, more emphasis can be placed on employees to take special care during these tasks. Of course, this simple significance test does not relieve the wary manager from constant vigilance on the entire operation. It does, however, ensure that everyone is aware that there are some important tasks that must be performed in an extra-careful manner.

Potential environmental challenges

There are specific potential environmental challenges for each of the environmental compatibility categories discussed earlier in this study. Each golf course facility must be thoroughly analyzed to ensure that all potential environmental challenges and their management approach are included in the final

Golf course Environmental Management (GEM) Plan. Some examples of environmental challenges include but are not limited to the following:

- Wetlands
- Floodplains
- Federal or state listed threatened or endangered species
- Landfills
- Water conservation
- Water quality management
- Sensitive or special wildlife habitats
- Groundwater, wellhead, and/or injection well protection
- Chemical or pesticide restrictions
- Poor past environmental management practices
- Cultural/historical/archaeological resources
- Regional non-attainment status
- Permit violations
- Restoration or environmental cleanup site
- Migratory or raptor bird specie residents or visitors
- Coastal zone management requirements

Documentation

It is not enough just to know how to create a successful golf course environmental management program. There has to be a written record of existing site data, maintenance practices, pesticide applications, and other historical golf course activities. By documenting what we know, we will be able to determine how to make better decisions in the future. "It is fine to tell people that you do a significant amount for the environment while caring for the golf course, but the statement is much more powerful when it is documented in a written format" (Erusha, et al, 2005).

The completed GEM Plan is a comprehensive tool that should assist in the daily management of the course while providing a convenient vehicle to communicate the golf course's specific environmental challenges and the superintendent's plans to manage them to the course's customers (AFCEE, 2001). "Establishing a record regarding prevention of adverse environmental impacts and chemical losses not only reduces operational costs, but minimizes exposure to loss of revenues from litigation and unfavorable publicity" (Balough and Walker, 1992).

Golf course Environmental Management (GEM) Plan

A living document, the GEM Plan strives to simplify the maze of environmental issues and concerns for the golf course manager while satisfying the concerns of the community and management. In addition, the GEM Plan will attempt to keep the focus on the ultimate customer, the golfers. The bottom line goal of this document is to provide a systematic approach that will ease the environmental requirements for the golf course operators while protecting, preserving, and furthering the great game of golf (AFCEE, 2001).

GEM Plan components

At a minimum, a comprehensive Golf course Environmental Management (GEM) Plan should be comprised of the following components:

- Environmental policy
- Golf Course Environmental Baseline Assessment summary report
- Map of the golf course property depicting the golf course facilities and its environmental challenges
- Booklet to accompany map that describes the environmental challenges and the specific practices employed by the golf course staff to manage them as well as a list of the best management practices employed on the property
- Management approach, target, and objective for each of the environmental challenges (AFCEE, 2001)
- Complete examination of all course management activities resulting in a list of those activities that could potentially negatively impact one of the identified environmental challenges to include all aspects determined to potentially impact these challenges

Implementation

Positive, decisive action is the only true measure of a GEM Plan's success. By implementing new practices, whether to knowingly improve the course's environmental compatibility or to just try new ideas to determine their value, superintendents and golfers should both benefit. The golf course superintendent should post for customers and employees alike a map of the property depicting its particular environmental challenges and immediately begin finding ways to minimize or eliminate any and all potentially negative environmental impacts (AFCEE, 2001).

ISO 14001 requires that "management provide the resources essential to the implementation and control of the environmental management system" (ISO, 1996). This is especially important as it pertains to awareness, education, and training. In addition, based on the aspects identified during the analysis process that could possibly negatively impact one of the environmental challenges should be monitored to ensure compliance with the established environmental policy. Measuring performance and documenting all actions taken, especially those based on valuable lessons learned in the field, is paramount to properly implementing the comprehensive GEM Plan.

Mamala Bay Golf Course has several holes that are located right on the coast adding complex issues to the superintendent's responsibilities.

Evaluation

In order to ensure the highest quality of customer service and environmental stewardship, there must be continual self-evaluation and improvement. There also should be consistent, on-going measurement of the reduction or elimination of environmental impacts the newly implemented practices have on the course. For example, documenting the reduced use of inputs such as fertilizers, pesticides, and irrigation can be used to demonstrate the increased environmental stewardship of the golf course management practices as well as the overall value of the GEM Plan. It is important that all golf courses show improvement in their environmental compatibility over time. One way this can easily be accomplished is to regularly evaluate golf course management practices and changing, refining, or adjusting them where appropriate (AFCEE, 2001).

Not surprisingly, the ISO 14001 environmental management system requires the establishment of documented objectives and targets. An objective is defined as an "overall environmental goal, arising from the environmental policy" (ISO 14001). An example of an environmental objective may be to "minimize or eliminate all potential negative impacts". A target is a "detailed performance requirement,

quantified where practicable…that arises from the environmental objectives" (ISO 14001).

Revision

The very nature of a superior Golf course Environmental Management (GEM) Plan implies that all documents are regularly maintained to represent the most current conditions. Golf course managers and superintendents should be constantly looking for ways to improve their environmental compatibility. Acting on lessons learned is right behind initial implementation as the most important aspect of a successful golf course operation. Accordingly, the GEM Plan should be kept as current as possible at all times with major revisions regularly scheduled at appropriate intervals (AFCEE, 2001). "If your actions will not stand up to scrutiny, then it will reflect poorly on the industry as a whole" (Erusha, et al, 2005). Regularly reviewing the operation, its methods, and procedures will go a long way toward satisfying this important step in the GEM planning process.

Renovation of existing courses is one of the strongest growth areas for the course design and construction industry.

The great Arnold Palmer and former U. S. EPA director, Christie Todd Whitman, enjoy each other's company.

Conclusion

Golf has been played over naturally turfed landscapes since the early 1400s. Man's desire to pursue this difficult and confounding, yet innately rewarding game has continued to grow since its birth in the linksland of Scotland and eventual spread to America in the late 19th century. Today over 75 million men, women, and children of all nationalities play the game of golf each year. The ever-increasing demand has created at least a perceived shortfall of golf courses fueling almost unprecedented construction activities in America and in many other countries around the globe.

Golf courses today are pristine playing fields populated with genetically-altered turfgrasses that were crafted by powerful construction equipment and maintained with highly specialized machinery and state of the art, space age chemicals to create ideal playing conditions to draw in droves of golfers of all ages and abilities. Many of the general public (both golfing and non-golfing) and, somewhat surprisingly, members of the scientific and environmental industries, believe that pesticides and other artificial inputs are often abused to achieve the desired results. The facts do not always seem to support this belief.

Christine Todd Whitman, speaking as the director of the Environmental Protection Agency in an address at the fourth national golf and the environment summit meeting held at the Arbor Day Farms in June 2002, reiterates this concept. "The greatest environmental challenges are educating the public to the benefits of environmental golf courses and how they can apply them at home by increasing wildlife habitats, using less water, fertilizer and pesticides, and educating young golfers on environmental issues" (Hurzdan, 2002). Golf course architect Tom Doak (1992) in a quote from his book, *Anatomy of a Golf Course*, said, "As long as potentially lethal chemicals are used on golf courses, no amount of research will eliminate the potential risk to the satisfaction of the non-golfer. The burden of proof will remain on the golf community if pesticides are to be re-approved for use and permits for building new golf courses are to be obtained." Additionally, "voluntary adoption of sound turfgrass management practices is a superior alternative to regulatory mandates" (Balough and Walker, 1992). Continually satisfying the vagaries of these regulatory mandates and their potentially inconsistent interpretation may be one of the most difficult tasks facing golf course superintendents.

The golf course environmental management process outlined above can be used to quantify the environmental compatibility of golf course management practices. The process is rooted in the historical context of the game of golf and its intimate relationship with the environment. Accordingly, the game's impacts on the natural ecosystems in which they are created must be minimized for it to thrive. Utilizing this process to quantify the environmental compatibility of the management of golf courses will allow one to:

- Determine what measures can minimize or eliminate potential negative environmental impacts
- Allow comparisons to be made between courses' management practices
- Identify potentially poorly managed courses or aspects of a particular management approach requiring improvement

According to the editors at Golfweek (1996), "Golf has come nearly full circle in its relationship with the environment. The game began as an ecologically benign pursuit. In the second half of this century, golf ran roughshod over the landscape. Lately a more balanced and subtle approach has emerged with a new generation of course designers: moving less earth, preserving wetlands and shifting from the obsession of lush lawns."

"With the many societal responsibilities prominent in today's world, we cannot avoid the fact that we must respond to them. Conservation of water, energy, and maintenance man-hours have taken on as much importance as playability and aesthetics" (Bushman, 1983).

Compared to even a decade ago, today's superintendents use less water, fertilizer, pesticides, and fossil fuel than their predecessors, but without a reduction in turf quality (Hurzdan, 1996). Good environmental management and design is the

result of a multitude of factors including a thorough understanding of how these factors interrelate on a specific site in a specific locale.

The innate beauty of a golf course shines as one of the game's greatest attributes for players and superintendents alike.

Hurzdan (1996) goes on to say, "In general, golf can become part of any environment and materially affect it, and if proper planning, construction, and maintenance are done it can enhance the site." "The golf industry conveys a more cooperative sensibility towards environmentalism than it did a decade or two ago" (Klein, 1996). By utilizing these relatively new environmental management concepts, the golf course industry will be able to more efficiently realize compliance with the many environmental requirements and regulations thrust upon it by numerous governmental entities. The overall goal should be to achieve the highest level of environmental awareness by demonstrating a genuine concern for the health of the golfer, employee, and the course that will create an "environmentally-friendly" and legally compliant golf course management approach.

The practices espoused by this study can guide appropriate and legally sound environmental decision-making relative to the management and operation of a golf course and its associated facilities. They are voluntary and should be interpreted as representing a holistic philosophy of good environmental design and

management rather than specific dictates, each of which must be met in all cases. It is hoped that these practices will be widely adopted and used to improve the level of environmental awareness, practice, dialogue, and quality achieved within the great game of golf.

Nature and golf come together in a special way along Ireland's southwestern coast courtesy of Greg Norman design.

Benefits of comprehensive golf course environmental management planning

Planning in the context of golf course management simply means preparing for tomorrow's challenges today. A good superintendent must first satisfy his customers. Many complex tasks have to be performed each week in order for this to occur. When complicated with budgeting, labor force hiring and training, equipment maintenance and purchasing, trade sales, customer complaints, and environmental compliance, most superintendents struggle to stay above the fray and maintain their employment status. Accordingly, one of the last things on the superintendent's long list of things to do is to write down all they know and do at the course and assemble it into a comprehensive Golf course Environmental Management (GEM) plan. This, however, is paramount to the eventual success of a golf course and its management approach.

Environmental compliance simply means preparing for tomorrow's emergency today. To satisfy environmental compliance requirements, superintendents must be completely informed on the actual requirements of local, state, and federal regulations. More importantly, they need to know in advance of taking actions that could get them in trouble. "The industry needs to follow and understand local environmental policy" (Erusha, et al, 2005). This is one of the key components of the National Environmental Policy Act where federal proponents are required to assess the impacts of their actions prior to deciding to take action. In the case of golf course management impacts, the key to compliance is knowing in advance what a law, ordinance, permit, or regulation requires and satisfying those requirements in a timely manner. In addition, changes to these requirements regularly occur creating more headaches and concern. Unfortunately, this is usually not an enjoyable process and the reality is that compliance requires significant time and effort. All too frequently, superintendents do not take enough time or expend adequate effort.

Benefits of environmental compatibility

Property surrounding golf courses often has a higher appraised value than other areas. Turfgrass creates an 'oasis-like' effect in urban areas, providing living greenery and aesthetic value to communities and residences. Turfgrass provides an excellent aesthetic alternative to blacktop (asphalt), concrete, and other artificial surfaces (Balough and Walker, 1992) typical to most American neighborhoods of the 21st century. Ultimately, a golf course environmental management philosophy based on the principal goal of minimizing or eliminating potential negative impacts can provide golf courses the following benefits:

- Protect the golf course owner's legal interests by minimizing risks and liability
- Ensure continuous compliance with rules and regulations
- Maintain managers currency on latest information, policies, and practices
- Demonstrate environmental stewardship and concern for the community
- Reduce operation costs
- Increase overall enjoyment and participation by the customer

Discolored storm water can lead to rapid inquiries easily answered by knowledgeable course managers who are ready for situations like this.

"Research has also proven that golf courses:

- Help reduce loss of topsoil from erosion
- Absorb and filter rain and runoff water, recharge ground and surface water
- Capture and clean runoff water
- Improve the soil and restore damaged areas
- Improve air quality and moderate temperature
- Reduce noise, glare and visual pollution
- Create and enhance wildlife habitats
- Contribute to the community's economy" (GCSAA, 1999).

Good golf course management is environmental stewardship.

"Although research studies demonstrate that proper turfgrass management does not threaten environmental quality, as an industry we cannot afford to claim victory too early. Without due diligence when making day-to-day management decisions and continually communicating the responsible efforts taken to care for the environment, the golf industry is only one misapplication away from receiving a black eye and finding itself scrambling to improve its environmental image yet again" (Erusha, et al, 2005).

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Appendix 1 - Environmental Compatibility Quotient Checklists.

Planning & Compliance				
#	**Environmental Compatibility Indicator**	**Yes**	**Partial**	**No**
1	Has management demonstrated that environmental stewardship is an important part of their responsibilities by initiating the Comprehensive Golf course Environmental Management (GEM) Planning process?			
2	Is the GEM Plan complete, updated regularly, and readily available to employees and customers?			
3	Has the golf course adopted and posted an environmental policy?			
4	Is a map of the property highlighting environmental challenges posted for employees and customers?			
5	Are environmental challenges and their approved and implemented management practices, objectives, and targets evaluated at least annually and are they regularly communicated to employees, customers, management, and the local community?			
6	Are there signs appropriately located to warn golfers of hazards of drinking reclaimed or otherwise non-potable water?			
7	Are there signs posted to highlight key habitats or have appropriate areas been designated "Environmentally Sensitive Zones" per The Rules of Golf?			
8	Is there a general understanding by the entire course management staff of how their practices may potentially adversely impact the environment?			
9	Are the environmental impacts of pest control measures considered as part of the comprehensive GEM planning process?			
10	Are projects planned and funded for the next year that would increase the compatibility of the course's management program with comprehensive GEM planning goals and objectives?			

Planning & Compliance Checklist (continued).

#	Environmental Compatibility Indicator	Yes	Partial	No
11	Have all employees been familiarized with the GEM Plan and are they trained regularly on the importance of environmental performance and compliance with its goals and objectives?			
12	Are environmental management issues regularly discussed during staff meetings?			
13	Does the superintendent document the actual amount of each pesticide or fertilizer annually used on each major golf course feature (greens, tees, fairways, roughs, water features, and natural areas)?			
14	Has the course attained full certification in the Audubon Cooperative Sanctuary Program or similar industry-recognized environmental management program?			
15	Are employees trained in their native language on the benefits of minimizing potential negative impacts?			
16	Are comprehensive written records maintained to measure and document the environmental compatibility of the entire facility's management practices?			
17	Are there documented functional and aesthetic thresholds integrated into pest control decisions?			
18	Is there a written and regularly updated Integrated Pest Management Plan for the entire golf course property?			
19	Are employees trained on what to do in case of a spill and have spill containment kits been provided at all appropriate locations?			
20	Has course management comprehensively examined the course to determine the activities that have a potential to negatively impact an identified environmental challenge?			
	Totals			

Operations & Maintenance				
#	Environmental Compatibility Indicator	Yes	Partial	No
1	Is contour mowing used to conserve fuel and/or to increase playability and aesthetics?			
2	Are there designated non-maintained or minimally-maintained buffers around core wildlife habitats?			
3	Are green, tee, and fairway mowing heights maintained at levels that do not excessively stress important playing surfaces?			
4	Are aeration, topdressing, and drainage improvements regularly implemented to improve soil health and minimize or eliminate use of pesticides or fertilizers?			
5	Have all playing surfaces been inventoried and mapped for soil types including soil structure, nutrient levels, organic content, compaction, and water infiltration?			
6	Are soil tests or plant tissue analysis used to determine turfgrass nutritional requirements?			
7	Are there projects planned and funded for the next year that would increase the compatibility of the course's management methods with protection of the environment?			
8	Are all appropriate employees trained to be familiar with (national, federal, state, and OSHA) regulations that apply to storage and handling of potentially hazardous materials used on the property?			
9	Has there been a complete examination of all aspects of the operation other than the golf course (snack bar/restaurant, clubhouse, pro shop, pesticide mixing and storage facilities, fuel storage and delivery areas, and maintenance complex) for potential negative environmental impacts?			
10	Are all employees encouraged to apply for education and training opportunities that may increase their awareness of the GEM Plan goals?			

Operations & Maintenance Checklist (continued).

#	Environmental Compatibility Indicator	Yes	Partial	No
11	Are containers used to store used oil for equipment maintenance in good condition, not leaking, and clearly labeled?			
12	Are oil/water separators and/or golf course wash racks operating properly and correctly maintained?			
13	Are all golf course vehicles and equipment maintained and cleaned in a manner that eliminates the potential for spreading of contamination?			
14	Are recycling containers located throughout the facility for use by customers and employees?			
15	Are grass clippings left in place (other than greens) collected, composted, and/or recycled?			
16	Are products that minimize unnecessary packaging purchased for use throughout the facility?			
17	Are energy efficiency ratings factored into equipment purchases for use throughout the facility?			
18	Has the entire facility been studied to quantify solid waste streams to identify functions that produce the greatest quantities?			
19	Does the restaurant/snack bar facility utilize at least 90% plates, cups, and utensils that are reusable rather than disposable?			
20	Is the food storage and prep area regularly cleaned to reduce the likelihood of pest infestations and required pesticide applications?			
	Totals			

Water Resource Management				
#	Environmental Compatibility Indicator	Yes	Partial	No
1	Are written records of water quality monitoring activities, results, and pollution control measures readily available?			
2	Where appropriate, are slow-release fertilizers and/or spoon-feeding techniques used to reduce the potential for runoff impacts and nutrient loading to water quality?			
3	Has the irrigation system been completely checked for proper water distribution in all irrigated areas and are water leaks fixed in a timely manner?			
4	Are outdoor irrigation of non-golf course areas and indoor plumbing regularly monitored and maintained for leaks?			
5	Have low-flow water saving devices been installed wherever possible?			
6	Are recycled or other non-potable water supplies being used to irrigate at least 65% of the golf course property?			
7	Are there projects planned that should eliminate or minimize a potential water quality or erosion problem?			
8	Are water features regularly monitored for algae, erosion, excessive aquatic plant growth, eutrophication, and sedimentation?			
9	Is runoff from parking lots cleansed by control measures such as vegetative or drainage filters prior to leaving the golf course property?			
10	Are there procedures for reporting water quality problems to supervisors (as required) for appropriate action?			

Water Resource Management Checklist (continued).

#	Environmental Compatibility Indicator	Yes	Partial	No
11	Is the irrigation pumping station and associated equipment regularly checked for proper operation and leaks?			
12	Has the irrigation system or its components recently been upgraded to reduce inefficiency, malfunction, and overall water use and are flow meters used to monitor water use and detect potential waste?			
13	Is there a map of the watershed in which the golf course property resides and location(s) of floodplains and stormwater drainage that exist on the property?			
14	Is the quality of the water entering and leaving the property tested regularly for contaminants, pH, dissolved oxygen, and nutrients?			
15	Is water quality data collected to establish baseline conditions for all water features on the property?			
16	Are settling ponds and/or detention ponds used to effectively remove sediments and pollutants from water features?			
17	Are biological processes such as the addition of grass carp or white amur used to control unwanted aquatic vegetation in water features?			
18	Is there a written Water Resources Management Plan that delineates the care of the course's water features?			
19	Has the property been examined for potentially significant wetlands or associated sensitive water-based habitats?			
20	Has the property's water features been studied to determine the aquatic and amphibious species population?			
	Totals			

Conservation				
#	Environmental Compatibility Indicator	Yes	Partial	No
1	Is all motorized golf course equipment checked regularly for excessive air polluting emissions?			
2	Has the entire golf course property been examined for critical habitats, state species of concern, and threatened or endangered species?			
3	Have all potentially significant wildlife habitats and their maintenance practices been coordinated with local natural resource manager, the Fish & Wildlife Service, or other appropriate local or regional regulatory agency?			
4	Are employees encouraged to minimize their trips around the course to conserve on the use of fossil fuels?			
5	Have efforts been made to connect natural areas to facilitate wildlife movement through the course property?			
6	If applicable, have all necessary permits been updated and their requirements satisfied in a timely manner?			
7	Are recycling containers conveniently provided for customer and employee use throughout the golf course facility?			
8	Has there been a study to determine the presence of invasive exotic species on or near the course?			
9	Is there a readily available Drought Management Plan for the entire golf course facility?			
10	Are there projects planned and funded that may minimize or eliminate the course's potential negative environmental impacts?			

Conservation Checklist (continued).

#	Environmental Compatibility Indicator	Yes	Partial	No
11	Is stormwater collected for supplementing irrigation water supplies for use on the course or golf course facility grounds?			
12	Are at least 85% of plants used in landscaped areas drought-tolerant native trees, shrubs, groundcovers, or their cultivars?			
13	Have local wildlife species and their habitats been documented and mapped?			
14	Does the course have a Tree Management Plan complete with planting plan and maintenance schedule?			
15	Are all employees trained to understand that poor management practices may adversely impact worker and environmental health and welfare?			
16	Is there an inventory of bird and mammal species documented, maintained, and readily available?			
17	Are food, shelter, and nesting attributes of plant species for landscape development considered during the design/selection process?			
18	Have all degraded habitats due to construction or maintenance of the course been fully restored or improved?			
19	Has the entire property been examined for archaeological, cultural, or historical resources?			
20	Are customers and employees regularly informed/trained on the golf course's conservation practices?			
	Totals			

Pesticides & Pollution Prevention				
#	Environmental Compatibility Indicator	Yes	Partial	No
1	Are there minimally maintained, natural areas, no spray zones, and buffer areas around water features or sensitive landscapes and have they been communicated to equipment operators and pesticide applicators?			
2	A spill containment kit is readily available and spill containment procedures are in place?			
3	Does the chemical storage area have a sealed metal or concrete floor and are all pesticides handled over an impermeable surface?			
4	Does the chemical storage area have a lip along the edges to contain spills?			
5	Are liquid products stored below dry products and are dry materials stored on pallets or shelves to keep them off the floor?			
6	Are equipment or vehicle wash and wastewater kept from making direct contact with surface water?			
7	Is equipment cleaned with compressed air on part of the course instead of or prior to washing at a designated wash rack where pollution prevention measures are employed?			
8	Are gasoline, motor oil, brake and transmission fluid, solvents, and other chemicals used to operate or maintain equipment and vehicles prevented from directly or indirectly entering water bodies?			
9	Does the fuel storage/delivery area comply with local, state, federal, or other applicable regulations?			
10	Are written records maintained of all applications of pesticides to include: - the pest and treatment type (preventative/curative); - the location (specific playing area) of each pesticide used; - the area (SF/SM) and quantity of each pesticide used; - the chemical or common name of the active ingredient(s); - the date, location, or purpose of the application?			

Pesticides & Pollution Prevention Checklist (continued).

#	Environmental Compatibility Indicator	Yes	Partial	No
11	Is there a map of the course's "hot spots" that may require regular or special care or attention?			
12	Are there trained scouts on staff other than the superintendent to monitor turf and plant health and pest problems?			
13	Are there scouting forms utilized and are they collected and organized into a report or guide for use in future pest control decisions?			
14	Is there an established aesthetic or functional threshold for insects, fungal diseases, and weeds for all managed areas that may possibly reduce pesticide and fertilizer inputs?			
15	Are current copies of all Material Safety Data Sheets (MSDS) for all chemicals used anywhere on the golf course property maintained and readily available?			
16	Are chemical applicator(s) encouraged to apply for regular training to maintain currency?			
17	Is the chemical storage structure/area locked, well-ventilated, fire resistant and is access limited to appropriate personnel?			
18	Are records of pest treatments and their effectiveness maintained and used to guide future pest control decisions?			
19	Are golfers adequately notified in the pro shop and on the first and tenth tees about the day's planned or recently completed spraying of any chemical or fertilizer?			
20	Are there written pest profiles for common regional pests along with alternative potential control measures readily available?			
	Totals			

Appendix 2 - Environmental Compatibility Quotient Summary & Scoring Scale

ENVIRONMENTAL COMPATIBILITY QUOTIENT SUMMARY			
Environmental Compatibility Category	**Yes**	**Partial**	**No**
Planning & Compliance			
Operations & Maintenance			
Water Resource Management			
Conservation			
Pesticides & Pollution Prevention			
Totals			

- Key to checklist responses
  - **Yes** = Practice is complete or ongoing and can be verified
  - **Partial** = Practice has been initiated but needs improvement or completion
  - **No** = Practice is not in place

ENVIRONMENTAL COMPATIBILITY QUOTIENT SCORING SCALE	
Total Yes or Partial Responses	**Environmental Compatibility Level**
86-100%	**Advanced (Green)**
70-85%	**Showing progress (Yellow)**
69% or less	**Just started (Red)**

Appendix 3 - Environmental Challenge Worksheet Sample & Blank

Curiously Excellent Golf Course, Environmental Challenges

Superduper, FL - Mar 05

Challenge #1 of 5, **Water Quality Management** *The county's Integrated Natural Resources Management Plan (INRMP) recommends that course management establish spraying and fertilization buffers along each of the golf course's many water features. This will increase overall environmental stewardship of the course through improving water quality and thereby increasing wildlife habitat and save desperately shrinking funds*.	 *A diverse, natural wildlife population thrives in Superduper, Florida.*
Objective: *Minimize or eliminate the potential for pesticide or fertilization applications to easily leach into course's water features.*	**Management Approach:** Approved Apr 05 *After thorough analysis of all water features, specific buffer distances will be established and communicated to all pesticide and fertilizer applicators.*
Driver/requirement: *Coastal zone management, sensitive species habitat, and migratory water fowl species using the course for food, shelter, or nesting.*	**Target:** *Within 45 days of approval of management approach, we will conduct training, and visit each water feature with applicators to confirm buffer locations.*

_____ *Golf Course, Environmental Challenges*

***Course name*_____, *City*_____ *State*_____**

Challenge #__ of _____, _____	*Photo/Drawing/Map*
Objective:	**Management Approach:**
Driver/requirement:	**Target:**

Air Force Center for Engineering & the Environment
Technical Directorate
Natural Infrastructure Division

For additional assistance or more information, please contact:

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Please visit our Golf course Environmental Management (GEM) Program website:
http://www.afcee.brooks.af.mil/ec/golf/.