Integrated Golf Course Management Process

The Villages at Hokukano

prepared for

1250 Oceanside Partners
74-5620A Palani Road, Suite 200
Kailua-Kona, Hawaii U.S.A. 96740

By

William Berndt Associates
William L. Berndt, Ph.D., President

January, 1993

Revised December 30, 1998

EXECUTIVE SUMMARY

This document provides a description of the *Integrated Golf Course Management Process (IGCMP)* that is to be employed at The Villages at Hokukano. In this process an array of modern golf course management strategies are deployed within the confines of a course that has been constructed to mitigate environmental impacts. Employing an IGCMP provides the best chance at culturing top quality turfgrasses and ornamental plants which are essential to the subsistence of a golf course while at the same time preventing the deterioration of water quality or other adjacent environmental resources.

The body of this document provides details on the major elements of this modern management process, including details on specific *Best Management Practices (BMPs)* to be used in managing and constructing the golf course. In addition, the document provides readers with a section on *Integrated Pest Management (IPM)*, which includes:

- a list of pests of turf and ornamentals
- action thresholds for selected pests
- a list of pesticides available for use
- select environmental data for the pesticides

Other sections of the document address issues relating to:

- course maintenance facilities
- environmental monitoring
- irrigation and water use

It should be emphasized that people are an important environmental determinant within the IGCMP frameworks. For this reason the successful IGCMP requires the development of an extensive management knowledge base coupled with continuing education and the accrual of vital management experiences. Utilizing education, experience, and common sense is paramount to the success of the IGCMP. It should also be emphasized that the IGCMP approach to golf course management is *dynamic* in nature. This means that as new elements of environmentally responsible management are developed and proven reliable they will be incorporated into the management regime.

The dynamic IGCMP approach to golf course management is not foolproof, but it is the most modern, most complete attempt at managing golf courses while at the same time mitigating any environmental impacts that can be associated with management practices.

TABLE OF CONTENTS

THE VILLAGES AT HOKUKANO: AN OVERVIEW

The "Villages at Hokukano" is a proposed low density residential golf community being developed by 1250 Oceanside Partners. It has been designed within the boundaries of a 1,540 acre parcel located on the border of the North and South Kona districts on the Big Island of Hawaii. The parcel is approximately ten miles south of Kailua-Kona.

The master plan features single-family residential neighborhoods comprised of 1 acre and larger lots. In addition, the plans include establishing a historic park, a significant conservation district, a series of coastal trails, and a 50-unit members lodge. One special project amenity will be a championship golf course designed by Jack Nicklaus. The golf course will serve as a marketing tool for the real estate, attracting property buyers from all regions of the world. It will also provide a visually pleasing open space element for the entire project.

The presence of the golf course will provide several benefits to the surrounding communities including short term and long term employment. It will provide 30-35 full time jobs, not including the professional staff or other service oriented personnel. It will bolster the local housing market and construction industry, provide for additional tax-based revenues, generate limited tourism, and stimulate the local economy with reference to sales and services. In short, development of the golf course should translate into a positive economic impact for the area.

In addition to the economic benefits, the presence of the golf course should have a positive impact on the local environment. Well maintained turfgrass within an appropriate golf course design can absorb pollutants, fix carbon dioxide, generate oxygen, provide a cooling effect, trap dust, dampen noise, and stabilize soil. The physical design of the course will help to retain run-off and associated sediment originating at higher elevations. This in turn will help to preserve the pristine character of the ocean. The transition zones from open space to native vegetation will also serve as habitat and sanctuary for many species.

PURPOSE OF THE DOCUMENT

Even though the golf course can and will offer many benefits, its development and management can be perceived as being detrimental to Hawaii's fragile environment, especially with reference to water quality. To help mitigate environmental concerns Hokukano intends to develop and manage the golf course within the context of an Integrated Golf Course

Management Process (IGCMP). This document describes the features and benefits of the intended IGCMP.

Integrated Golf Course Management Process (IGCMP)

In the IGCMP at Hokukano qualified, experienced, well-educated people will deploy an array of modern development and management strategies within the confines of a golf course that will mitigate environmental impacts to the extent possible. The fully developed IGCMP is intended to coordinate modern *Best Management Practices (BMPs)* related to all major aspects of golf course development and operation, including construction practices and turf management. Employing an IGCMP style provides turf managers with the best chance at culturing top quality turfgrasses and ornamental plants while at the same time avoiding any deterioration of Island water quality or the deterioration of other environmental resources.

Best Management Practices (BMPs)

Implementing and coordinating modern Best Management Practices (BMPs) is central to the IGCMP. BMPs can herein be defined as a modern direction or focus of construction and management employed to mitigate environmental deterioration. As management strategies BMPs are an important element in protecting against potential threats to water quality. At the same time, BMPs are intended to produce high quality turfgrass, which is essential to the subsistence of a premium golf course.

The Villages at Hokukano will develop and follow a BMP protocol that is consistent with defined BMP goals. The basic goals of BMPs are to:

- minimize the offsite transport of nutrients, sediments, and pesticides
- control the rate, type, and method of chemical applied
- minimize chemical loading by using an integrated pest management concept and by utilizing fertility testing schemes
- implement surfacewater and groundwater conservation practices
- educate turf professionals and the public on the relationship of environmental issues and systems management

To help meet these goals and to minimize risk to the environment Hokukano's BMP strategies will generally consist of:

- employing an environmentally conscious, well educated, responsible construction and management staff

- implementing a course design that is conducive to environmental responsibility
- practicing environmentally sound construction methods
- establishing then maintaining a healthy, vigorous, high quality turf that is inherently resistant to imposed stresses such as pests, drought, and practical use
- practicing an integrated problem solving approach in management
- performing cultural practices in an environmentally responsible manner
- utilizing state-of-the-art management tools
- creating a system of checks designed to continuously evaluate the efficacy of the BMPs
- contributing to the BMP knowledge base through research and experience

The BMP protocol will be continuously updated as the BMP knowledge base is expanded. Central to expanding the BMP knowledge base will be continuing education involving technical research aimed at better understanding interactions between construction practices, maintenance practices, and the environment.

Key Management Personnel

One of the most important considerations with respect to implementing a successful IGCMP is that people are an important environmental determinant. The attitudes and experiences of golf course employees determine whether or not the objectives of the IGCMP are met. They also determine whether or not the environment is compromised as a result of management processes. For these reasons, The Villages at Hokukano will strive to employ key people who:

- have an environmentally sensitive, responsible attitude
- are knowledgeable, experienced, and well educated in the area of golf course operations & turfgrass management, with special reference to managing both pests and people
- are committed to performing their functions in a manner that is consistent with the described IGCMP approach

An intensive and highly specific interview process will be conducted to initially help select proper agents and employees. Continuous training and education will be implemented to ensure that the proper focus remains intact. Such training will consist of attending classes and seminars, attending conferences, reading, and networking with other IGCMP practitioners. Employing people with the above traits, especially with reference to the golf course superintendent, is a most important BMP that will help The Villages at Hokukano to realize the objectives of the IGCMP process.

Golf Course Superintendent

The golf course superintendent may likely to be the single most important environmental influence on the golf course on a day to day basis. Because of this, the superintendent employed by The Villages at Hokukano will possess the traits as outlined in the above section. In addition, he or she will also be able to effectively communicate with all other course employees, as well as with upper level management and club members or patrons. The ability to effectively communicate with people, coupled with an extensive knowledge base, would be paramount to performing the daily duties that are necessary to realizing the IGCMP objectives.

Support Staff

The golf course superintendent will be supported in his/her daily endeavors by the actions of several key staff members including:

- assistant superintendent: responsible for the care of the turfgrasses
- mechanic: responsible for equipment/tool maintenance
- spray technician: responsible for mixing, loading, and applying pesticides on the golf course
- irrigation technician: responsible for distributing water to the golf course and the upkeep of the irrigation system
- horticulturist: responsible for care and maintenance of the ornamental plants
- consultants: responsible for questioning every aspect of the IGCMP process

The Villages at Hokukano will be committed to filling these support positions with highly qualified, experienced people.

ELEMENTS OF GOLF COURSE INFRASTRUCTURE

The infrastructure of the golf course, with respect to the IGCMP process, is comprised of the following general elements:

- the golf course proper (i.e., greens, tees, fairways, and rough)
- the maintenance facilities (i.e., pesticide storage building, pesticide loading/mixing pad, etc.)
- the irrigation systems (i.e., for both the golf course and for ornamental plants)

How each of these elements is configured or designed plays a crucial role in achieving the IGCMP objectives. For that matter, the presence or absence of certain elements can be central to the success of the IGCMP process. As an example, utilizing a modern, self-contained storage

building for housing pesticides greatly reduces the chance of stored pesticides from escaping into the environment. Maintaining a *low volume* pesticide inventory within the self-contained storage structure further increases the margin of safety.

Because the infrastructure of the course is vitally important to realizing the IGCMP objectives, The Villages at Hokukano will be committed to developing it in a manner that is environmentally responsible. Modern design concepts and appliances that are conducive to protecting environmental resources will be employed to the extent practical. Once established, the existing infrastructure will also have the inherent flexibility to incorporate new appliances and concepts as they evolve. Building environmentally compatible elements of infrastructure into the golf course is a most important *BMP* for successfully realizing the IGCMP objectives.

GOLF COURSE DESIGN APPROACH

The design intent at The Villages at Hokukano will be to develop a golf course in harmony with the site, rather than to impose a design upon it. Golf course design will stress the *avoidance* of sensitive environmental areas. The approach used by the designers will be to locate the golf course within the confines of the proposed site so as to minimize impact to the natural lay of the land. Special land forms or other nuances will be used to develop a suitable theme for the course, and well identified parameters of work will give a clear definition in formulating the most appropriate routing plan. Factors considered thus far in the routing have included:

- natural drainage characteristics & slopes
- indigenous vegetation
- archaeological areas & special land forms
- environmentally sensitive areas & buffers
- costs of construction
- erosion and sedimentation control

Putting Greens

The putting greens at The Villages at Hokukano will be constructed according to United States Golf Association specifications and methods, as outlined by the U.S.G.A.. Utilization of the U.S.G.A. style greens helps to encourage both water retention and drainage, thereby conserving water and enhancing the quality of the turfgrasses.

Turfgrass Selections

The *Champion* variety of hybrid bermudagrass will be used for creating the turfgrass surface on greens, and Tifway 419 hybrid bermudagrass will be utilized for creating turf on the remainder of the course, including tees, approaches, fairways, and roughs. Once turfgrasses are planted it should be considered critical to the success of the IGCMP process that the grow-in phase of turf establishment, and subsequent agronomic cultural practices, be properly conducted to ensure that a healthy, vigorous turf is established in a timely fashion.

Specific Environmental Design Features

Several specific features to be implemented within or near the golf course (as deemed appropriate) consist of:

- vegetative buffers: non-maintained or minimally maintained areas located between highly maintained sections of the course and sensitive environmental areas; prevents the encroachment of pesticides into sensitive by acting as a physical barrier
- diversion berms: subtle physical undulations within the course that direct surface drainage waters to specific collection sites or points; prevents drainage runoff (that may contain contaminants) from entering sensitive areas
- retention/detention basins: concave catchment areas that collect surface drainage waters and permit the water to percolate into and through soil of a suitable depth; prevents drainage runoff (that may contain contaminants) from entering sensitive areas; also helps to clean drainage waters by stripping it of contaminants
- sub-surface drainage system: underground drainage collection system that permits rapid removal of sub-surface drainage waters; keeps soil aerobic, which is fundamental to plant health and vigor
- littoral shelves: shallow areas of water features that permit growth of desirable vegetation and wildlife species; such areas typically enhance actions of vegetative buffers
- multi-celled water feature system: deep potions separated by shallow areas or wetlands; permits conservation of water quality;
- reduction of turfed areas: a reduced turf concept can result in a diminished need for pesticides, fertilizers, and water resources; reduces need for pesticide & fertilizer inputs

- non-maintenance areas: areas of the course that are untreated; waste bunkers a examples of non-maintenance or minimal-maintenance areas; reduces need for pesticide & fertilizer inputs

Avoiding sensitive areas, employing proper kinds of turfgrasses, and employing mitigative design concepts like buffers, retention basins, and multi-celled water features are innovative BMPs that can and will help The Villages at Hokukano to successfully realize the IGCMP objectives.

Site Clearing and Grading

In order to implement the design, a certain amount of vegetation clearing and terrain grading will take place. The intent of the designers and developers is to minimize the necessity of clearing healthy specimen trees by incorporating them into the design strategy when practical. The designers and developers also intend that grading of terrain be a blending and sculpting of land rather than a general movement of massive amounts of earth.

Because the design strategy involves concave, collecting shapes grading work will enhance drainage control for the property. Thus, directing and controlling surface drainage will be made easier, and run-off can be intentionally diverted to established retention basins. This design concept will help to control sediments, nutrients, and pesticides carried with run-off thereby avoiding the potential for off-site impacts.

Construction Time Frame

The construction period without weather interference should be approximately twelve months. Soil conditions and contractor size and competence will be two other factors to consider. An additional three to eight months may be needed after completion of construction for grassing and grow-in.

Erosion and Sedimentation Control

The involuntary movement of soil during the construction period can be an environmental concern. Soil can be transported through the actions of water or wind, and is especially vulnerable to facilitated transport when in an open, disturbed condition. In keeping with the BMP's philosophy, and the Twelve Conditions Applicable to Golf Course Development set forth by the Department of Health, Hokukano will establish and follow an erosion control plan during construction. The plan will be implemented in conjunction with county and state guidelines and regulations, and in consultation with the Department of Agriculture and the Soil Conservation

Service. The goal of the plan will be to minimize the inadvertent movement and/or loss of soil and thereby prevent any associated degradation of environmental quality, especially with reference to water quality. Strategies to be implemented to meet this goal will include:

- using design and construction methods which minimize the need for disturbance of soils including staged construction if relevant and practical
- utilizing erosion control methods implementing siltation devices or soil stabilizing devices during the construction phase
- using accepted dust control practices during earthwork
- preventing the extended exposure of open earth as much as is practical during construction
- utilizing temporary vegetation to mitigate extended exposure of open earth if necessary
- establishing permanent vegetation on open earth as soon as possible
- maintaining a perspective conducive to conserving soil and preventing erosion related problems

To ensure that soil resources are conserved after the construction phase Hokukano will employ strategies such as:

- designing the development with regard to diverting or re-directing surface drainage which flows onto or across the golf course to settling basins via grassy swales and berms, and drain inlets
- frequently maintaining the settling basins and retention areas
- managing soil to help maintain structure and prevent consolidation or compaction
- maintaining a healthy, dense stand of turfgrass and other permanent vegetation
- precisely controlling irrigation events
- constantly monitoring the site for erosion related problems and mitigating any problems as soon as possible

Strategies such as the ones listed will help to prevent degradation of water quality because interactive erosion variables that may lead to the movement or loss of soil will be controlled to the extent practical. However, the developers will ensure that the strategies have been effective and that the goals of the erosion control plan have been met by:

- collecting baseline water quality information prior to the construction phase
- implementing a routine water quality monitoring plan during the construction phase and after construction

- checking the site frequently for erosion related problems
- mitigating any problems detected by the monitoring or observance using acceptable procedures

There are many different methods used to help prevent erosion. One will involve minimizing the total area to be disturbed by implementing a strategic design in balance with the lay of the land. Another will be to prevent the untimely disturbance of soil by implementing staged construction when practical. Staged construction involves disturbing limited portions of the site at select times and stabilizing these sites prior to additional disturbance. Using such methods the exposure of disturbed soil is minimized and there is a lesser chance of erosion taking place.

To minimize erosion on disturbed areas the contractors will utilize erosion control, soil stabilization, and dust control methods where appropriate. Such methods include silt fencing and sediment catchments to trap sediment, check dams or terraces to slow the velocity of run-off, erosion matting or mulching and temporary vegetation to stabilize soils, and the frequent moistening of disturbed sites to prevent formation of dust. Long term stabilization structures for highly erodible areas could include rip-rap, bulkheads, and the planting of trees with stabilizing root systems. The appropriate method to be used will be dependent on the specific site and the specific needs for that site. It will be very important for the contractors to maintain the erosion control arrangements so that they function properly. It will also be important to maintain vegetation on steeper slopes, which may be prone to erosion. As construction wanes, it will be important to establish a permanent vegetation cover as quickly as practical. Establishing turfgrass and other vegetation is a BMP for erosion control.

Once construction ceases the design of the golf course will in itself promote conservation of soil for much of the entire property. The course will act as a buffer separating up-slope development from the coastline. Surface drainage onto and across the course will be internalized to control run-off to the ocean. Capturing of drainage water will be encouraged at strategically located settling basins. Any sediment moving with surface water will be trapped at these locations. This will also help to prevent nutrient or pesticide losses related to surface drainage. In addition, the maintenance of a vigorous, dense turf coupled with soil management practices designed to prevent compaction and consolidation will help to reduce surface water movement. It will do so by slowing the velocity of sheet flow helping to make it conducive to absorption into the turfgrass rootzone. A sub-surface drainage system will be instituted to help facilitate

water movement from infiltration basins to collection points, then subsequently back to water reservoirs. In this way drainage water can be recycled and re-used for irrigation.

Construction Noise

During the construction phase it is desirable to avoid excessive noise. Thus, the contractors will be obliged to follow all local regulations pertaining to noise abatement including adhering to construction time schemes and utilizing noise abatement devices where required.

GOLF COURSE MAINTENANCE FACILITY

The golf course maintenance facility should be considered the headquarters for implementing and maintaining the IGCMP process. For that reason, a modern facility equipped with features conducive to *containing* potential contaminants (i.e., petrochemicals, fertilizers, etc.) will be constructed at The Villages at Hokukano. The maintenance area will also employ the concept of *limited access*. The construction and utilization of a modern maintenance facility that emphasizes containment and limited access is an important BMP for successfully realizing the IGCMP objectives.

Equipment Storage Area and the Mechanics Shop

The areas used to store and maintain golf course equipment will be configured to *contain* the inadvertent release of oil, grease, hydraulic fluid, gasoline, coolant, or other hazardous fluids associated with equipment storage and upkeep. This is typically done by:

- constructing the floors so that they can contain spilled fluids (i.e., prevent fluids from escaping to the outside)
- using commercially available containment flooring devices (for the storage of bulk oils, coolants, and other materials like waste products)
- using self-contained hazardous material bins and cabinets (for storing flammable substances like gasoline and hazardous materials like coolants)

These shop areas will feature limited access, and the recycling of shop materials will be employed to the extent that is reasonable.

Equipment Wash Bay

The equipment wash rack will be designed to prevent environmental contaminants such as oil and grease from being released into the environment during the equipment washing operation. The wash bay is typically configured as a pitched cement pad with a recovery sump. Drainage

water from the washing operation is collected in the sump and then filtered prior to either terminal discharge or storage for re-use. By collecting and filtering wash waters, any oils or other non-soluble hydrocarbon type contaminants can be prevented from being discharged to the environment. Recycling of wash waters (i.e., filtration and storage for re-use) promotes conservation of water resources.

Storage and Dispensing of Fuels

Codes for the development of fuel storage and dispensing facilities will be strictly followed. Above ground storage with secondary containment facilities for all fuels will be emphasized. The use of underground storage tanks will be discouraged. The fuel depot will be located away from general work areas, and will also feature limited access.

Storage of Pesticides and Fertilizers

The portion(s) of the maintenance area used for storing pesticides and fertilizers will be configured to follow existing state or federal regulations. The pesticide storage area (in general) will:

- be located away from water sources and away from general work areas
- emphasize limited access as well as complete containment of pesticides and fertilizers
- be properly ventilated and posted as required by law
- be equipped with proper shelving and lighting, and locking doors or gates
- feature ready access to spill response kits, fire extinguishers, and first aid kits or other emergency supplies, including the course's Hazard Communication Program
- be equipped with an eye wash station and an emergency shower

The most modern trend for storing pesticides and other hazardous substances is to use pre-manufactured buildings or suitable containment structures designed specifically for housing these hazardous materials. An accurate inventory of all pesticides stored in the facility will be kept. Pesticide labels and MSDS sheets will compliment the inventory records. A most important BMP in reference to pesticide storage is maintaining a *low-volume* inventory. Allowing pesticide distributors to store pesticides until their use is warranted is an innovative BMP for reducing environmental exposure of pesticides.

Pesticide Loading and Mixing Area

An area of the maintenance facility will also be devoted exclusively for the loading and mixing of pesticides. The Chemical Mixing Facility (CMF) area will emphasize limited access

and complete pesticide containment. In most instances the loading/mixing area is configured as an impervious concrete pad with a 1-2% pitch to a center recovery sump. The sump is generally designed to hold 110% of the volume of the largest pesticide application device used at the site. Pesticides inadvertently spilled within the confines of the pad during the mixing/loading operation can be rinsed to the sump. Collected pesticide rinseate can then be pumped from the sump into an application device for application to the intended target. Pesticide application devices can also be rinsed free from pesticide residues on this pad, and again, the rinseate can be collected and applied to an intended target.

The water source used for filling pesticide application devices on the mixing pad area is to be fitted with anti-back siphon devices to protect it from contamination. This area is to be completely separate from the general equipment wash pad area. It will also have close proximity to the area used for pesticide storage.

GOLF COURSE IRRIGATION SYSTEM

Distributing the irrigation water to the course at The Villages at Hokukano in an efficient fashion will be critical to conserving water. Precisely applying irrigation water is also a BMP that can help to:

- prevent the leaching or run-off of sediments, nutrients or pesticides
- culture healthy, vigorous turfgrasses and ornamental plants that resist stresses and pest pressures

For these reasons, The Villages at Hokukano will be committed to implementing state of the art irrigation system(s) to distribute water to the golf courses as a part of the IGCMP process.

To distribute water in the most efficient, precise fashion, the system at The Villages at Hokukano will be of the valve-in-head type. Each head will have the capability of operating on its own, as needed. The actions of the entire system will be governed by a scheduling computer. The computer can help to adjust the system to provide only the amount of irrigation that is necessary for any given area. Data bases compiled with input from on-site, electronic weather stations linked directly to the computer can help to provide accurate, reliable computer scheduling information. With such a system the turfgrass manager will have the utmost in irrigation system flexibility and control. In turn, the wasting of water can be prevented, as can over application of irrigation water. Thus, the inadvertent movement of sediments, nutrients, and

pesticides can be prevented, and a healthy, vigorous turf can be cultured in keeping with the IGCMP approach.

Another major benefit provided by coupling a computer to the irrigation system is termed flow management. Flow management allows the various portions of the irrigation system to operate simultaneously, or as needed, thus maintaining an optimum system flow rate. Flow management helps to conserve water, time, and electricity. It also helps to promote a healthy, vigorous turf by maintaining an adequate flow of irrigation water to areas which require it.

The system itself will be designed by a professional irrigation system designer with inputs from water service contractors and professional agronomists. It's design should facilitate delivery of irrigation water within a prescribed time window. It's design will also be commensurate with site soil types, and be constructed according to established design criteria.

The need to irrigate will be determined in part by using indices of soil moisture. Several indices include open evaporation pans, soil tensiometers, and computer generated predictive equations. Comparing actual evaporation from the open pan to soil moisture content and calculated Et rates generated by the weather station computer should give an accurate indication of the need for moisture replacement. The use of electronic soil moisture sensors has not yet been sufficiently developed for practical use on golf courses.

Irrigation Water Source

Many developments utilize wastewater effluent for irrigation purposes. The use of this water source for irrigation is often coupled with a need for disposal. Effluent water can be an excellent source for irrigation provided that the level of sanitary treatment is sufficient, the nutrient load is acceptable, there are no residual industrial contaminants, and sufficient water is available. If wastewater is considered to be utilized for irrigation purposes, Hokukano will develop and adhere to a wastewater re-use plan which shall incorporate the Department of Health's Guidelines for the Use of Water Reclamation, and the Twelve Conditions Applicable to All New Golf Course Developments.

Brackish groundwater may be the most feasible source to develop initially, as long as quality in terms of salinity and sodium is not limiting for turfgrass growth. Data generated from a test well on site indicates there is a sufficient source of brackish water available.

The selected irrigation source must have sufficient capacity to sustain the peak irrigation demands through the lifetime of the course. Thus, the sustainable yield of the source based on

perceived use rates will be calculated and documented. Generally, all warm season grasses require a minimum replacement of 60-70% of measured Et to avoid quality declines. Towards that end it will be important to firmly establish Et rates specific to the site. This will be done by implementing weather monitoring stations and open evaporation pans on site prior to the establishment of turf. Once Et is firmly established soil conditions in terms of physical characteristics will be considered so that a reliable index documenting the need for water use can be implemented specifically for the site.

Water use minimization features to be implemented at Hokukano will include designing the golf course to have less area that requires intensive irrigation. Management will also emphasize maintaining an appropriate turfgrass using appropriate cultural practices with special emphasis on proper mowing height, proper mowing frequency, fertility levels, soil manipulation practices, the use of wetting agents, and possibly the selective use of plant growth regulators.

ELEMENTS OF TURFGRASS MANAGEMENT

INTEGRATED PEST MANAGEMENT

The style of pest management to be practiced at The Villages at Hokukano is termed *Integrated Pest Management* (IPM). Integrated pest management is a blending of modern pest control processes and strategies that emphasizes the avoidance of environmental pollution. It is a decision making process for determining which pest control measures are most appropriate for a given pest on a given site at a given time (see Table 1 & Figure 1).

The IPM philosophy does not advocate eradication of pest populations. Rather, IPM favors suppression of pests to the level that resulting damage is acceptable in terms of economics, aesthetics, and function. With reference to golf courses, IPM is the latest and most complete attempt at managing pest populations while at the same time mitigating environmental impacts that can be associated with pest management tactics. It is also a primary method for sustaining premium quality turfgrasses and ornamental plants, which are essential to the existence of a golf course.

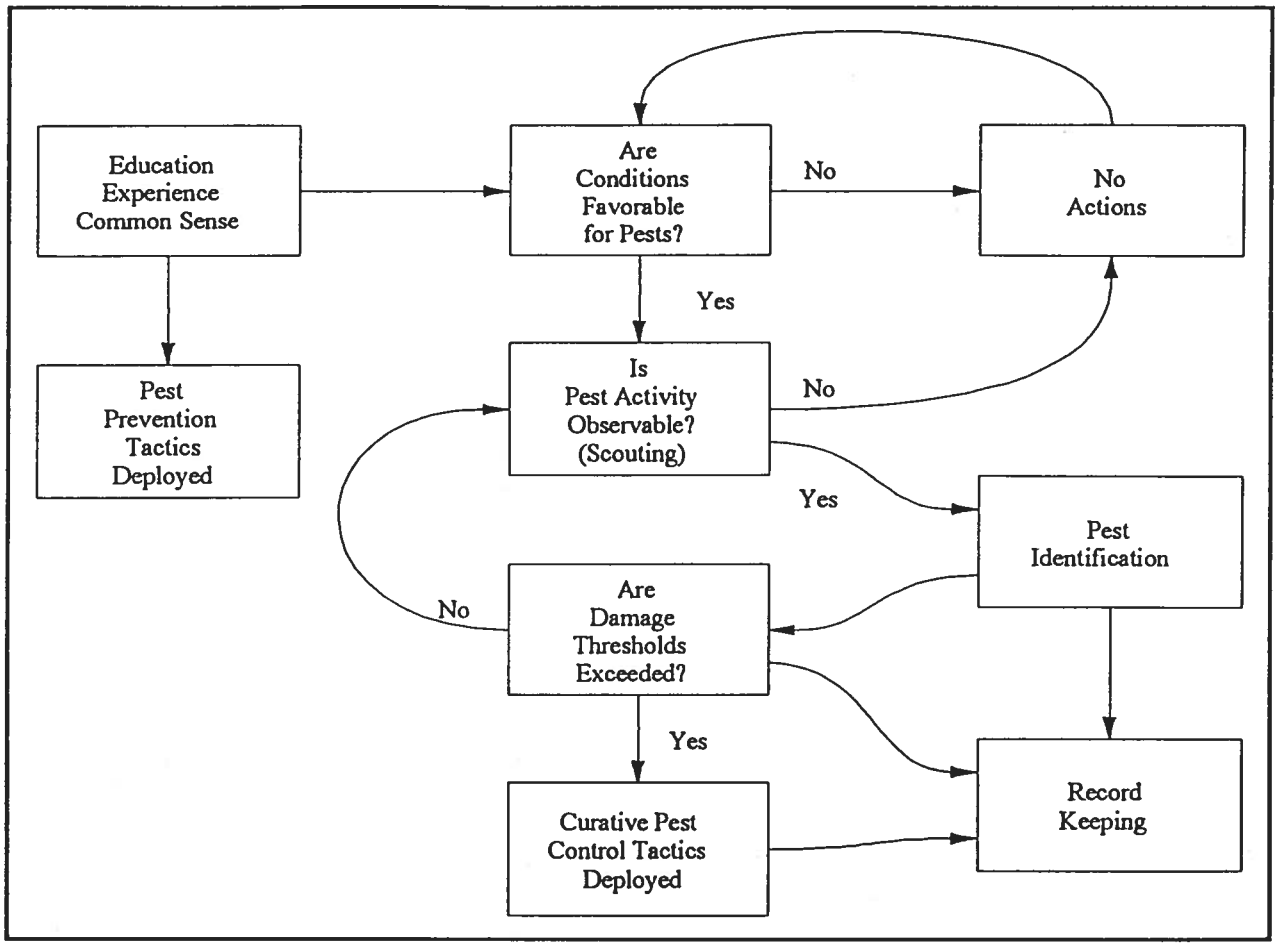

Figure 1. Simplified flow chart type diagram of the IPM process.

Table 1. The basic elements of the IPM process at The Villages at Hokukano.

- Defining the management areas: Defining individual management areas to which an IPM process will be applied. Each specific area of the golf course at The Villages at Hokukano (i.e., greens, water features, ornamental plantings) will require a unique IPM process, according to intensity of management and expectations of quality.
- Initial information gathering: Compiling background information on potential pests and non-target entities. Such information would include identifying species, documenting life cycles, finding appropriate cultural and biological controls, finding applicable chemical controls, documenting prior pest pressure histories, documenting prior records of successful and unsuccessful pest control, and obtaining any other applicable information which contributes to the knowledge base.
- Monitoring pests and non-target entities: Making observations in order to determine which pests are present, to what extent they are present, where they are, and how active they are in that area. Monitoring pests is made easier with the use of diagnostic kits and computerized pest prediction models.
- Establishing economic damage thresholds: Establishing the degree of pest injury, which becomes unacceptable. Differing management areas will tolerate differing levels of pest damage, depending on quality expectations.
- Establishing action levels: Correlating the pest population level, along with other variables such as weather or cultural practices, with the degree of injury deemed unacceptable from that pest. This procedure often takes a long time with constant work.
- Establishing effective treatments: Development of biological, cultural, genetic, or chemical treatment regimes and strategies. The ideal direction behind implementing effective treatment strategies involves mixing pest control methods, which are most effective against the target, least disruptive to non-targets, and produce minimal impacts to the environment.
- Making a decision: The aforementioned components, when coupled with practical experience, should facilitate an informed decision making process.
- Evaluating treatment assessment: A follow-up to the treatment phase, and could be considered highly integrated with the monitoring phase. In essence, it will be an evaluation of how effective the treatments were in impacting the target, and in bypassing the non-target or minimizing environmental impacts.
- Record keeping: This is one of the most important phases to deal with in IPM. The Villages at Hokukano will keep highly accurate, very detailed records on all aspects of it's pest control program.

The specific objectives of employing the IPM process are to:

- culture the best quality turfgrasses and ornamental plants possible
- reduce the overall use of pesticides
- increase pesticide effectiveness on target organisms
- prevent the encroachment of pesticides or other contaminants into the non-target environment
- reduce pesticidal effects on non-target organisms
- conserve money and other essential resources

In order to realize these objectives it will be necessary to take advantage of:

- genetics (i.e., pest resistant plant materials)
- structural controls (i.e., modern design concepts and appliances)
- biological controls (i.e., use of predators and parasites of pest populations)
- conventional pesticides (i.e., herbicides, insecticides, and fungicides)

It will also be necessary to ensure that proper agronomic practices are employed at appropriate times. For the best chance at success, the IPM process will need to be supported by:

- a broad base of pest management knowledge and experience
- a broad base of turfgrass/ornamental plant management experience
- experience in communicating with and managing people
- effective, long term planning
- an environmentally sensitive attitude & teamwork

Combining a sound decision making process and sensitive attitude with a comprehensive knowledge/management base is the true foundation for encouraging the IPM process into becoming a workable, responsible pest management plan.

In addition to employing environmentally sensitive, knowledgeable people and utilizing an appropriate system of infrastructure components and devices, the IPM process at The Villages at Hokukano will also emphasize the implementation of:

- appropriate fertilizer practices
- conservative irrigation practices
- judicious use of pesticides and other pest management tools
- initiation of appropriate cultural practices for each management area

The timely consideration of these elements, plus an intimate knowledge of potential on-site pests, will be a cornerstone to culturing healthy, vigorous plants which resist the activities of pests.

Turfgrass Fertilizers

The periodic application of fertilizer nutrients, such as nitrogen, potassium, and phosphorus, is necessary to culture healthy, dense, stress resistant turf and ornamentals. Fertilizer also enhances recovery from pest related damage. Fertilization should be considered an intricate element of a successful IPM process. For these reasons, The Villages at Hokukano will be committed to establishing and implementing an environmentally safe fertilizer use plan. The main goals of the fertilizer use plan will be to:

- prevent the contamination of ground waters and surface waters, or other non-target sites, by preventing the inadvertent loss of fertilizer nutrients
- culture healthy, pest resistant turfgrasses and ornamentals

These objectives will be realized by:

- utilizing slow-release nitrogen carriers when appropriate
- using a light, frequent approach to applying nitrogen
- basing the need for fertilizer nutrients other than nitrogen on the results of soil testing and plant tissue testing
- precisely controlling the timing and duration of irrigation events after fertilizer application
- precisely calibrating fertilizer application devices, and using computer driven delivery devices to the extent possible
- controlling drainage run-off via course design (i.e., utilizing vegetated buffers, grassy swales, berms, and/or drainage inlets)
- maintaining a perspective conducive to preventing the loss of nutrients including proper handling, storage, and loading
- implementing new fertilizer technologies as they develop and become accepted

Turfgrass Irrigation

The judicious distribution of irrigation water is another essential cultural practice necessary for establishing and sustaining healthy, vigorous turf. Because periodic irrigation will be necessary at The Villages at Hokukano an irrigation water use plan will be developed. The goals of the plan will be to:

- conserve irrigation resources
- conserve electricity
- prevent water related movement of sediments, nutrients, and pesticides
- culture healthy, pest resistant turfgrasses and ornamentals

These objectives will be realized by:

- utilizing a state-of-the-art irrigation system coupled to a computer generated scheduling system and electronic weather station
- designing the irrigation system to be compatible with on-site soils
- utilizing soil moisture indices such as open evaporation pans to help determine true irrigation needs (in addition to the weather system)
- encouraging use of non-potable water such as waste water effluent for irrigation (if possible)
- implementing water minimization features where possible, such as the reduced turf concept, use of plant growth regulators (Primo), and xeric style landscaping
- employing proper surface drainage and sub-surface drainage concepts
- maintaining an attitude and perspective conducive to conserving water
- implementing new irrigation technologies as they develop and become accepted

Turfgrass and Ornamental Plant Pesticides

The judicious use of pesticides helps to culture high quality turfgrasses and ornamentals that resist imposed pest-related stresses. Thus, the occasional use of pesticides as part of the IPM process will be necessary at The Villages at Hokukano. For this reason, a pesticide use plan will be developed. The goals of the plan will be to:

- prevent the release of pesticides into the non-target environment
- ensure pesticide effectiveness against target species
- reduce pesticidal effects on non-target species
- preserve human health and the health of other non-targets
- reduce the need for pesticide use
- culture a healthy turf in keeping with the IPM approach

These specific objectives will be realized by:

- employing modern storage facilities and handling practices (as outlined)
- utilizing an impervious loading/mixing pad (as outlined)

Table 2. General elements of safe pesticide use at Hokukano.

- Store pesticides in the original container. Follow all storage requirements as prescribed by the label and OSHA or EPA regulations.
- Read the entire information label before handling or using a pesticide. Using a pesticide in contradiction to the label or in a manner inconsistent with label directions is a violation of law.
- Handle pesticides in compliance with local, state, and federal regulations, including OSHA and EPA regulations.
- Never smoke, eat, or drink while handling or applying pesticides.
- Use personal protective equipment as recommended by the label when working with pesticides. Avoid direct contact with pesticides. Bathe and change into clean clothing after application.
- Calibrate application equipment precisely. Use closed systems for loading and mixing pesticides when appropriate.
- Avoid spills. If spills occur take immediate action to contain the spill. Make proper notification, if necessary.
- Dispose of all used containers according to label directions.
- Treat all agricultural chemicals with caution.

Note: Modern pesticides are developed and tested under strict protocols designed to provide maximum safety to users. However, care and common sense should prevail during their handling and use.

Table 3. Management guidelines for using turfgrass pesticides at Hokukano.

- All pesticide applicators will be properly trained in the use and application of pesticides. Only pesticides specifically labeled for use on turfgrass in Hawaii will be considered for application. All local, state, and federal regulations pertaining to pesticide use, storage, handling, and disposal will be strictly followed.
- Application equipment will be precisely calibrated and maintained to ensure precise distribution at the intended rate. Pesticide use rate will be determined by label instructions. Application equipment will possess flow regulation devices (when available) to ensure accurate delivery.
- Pesticide application will be accurately timed relative to climactic conditions to help prevent leaching, run-off or drift. Pesticide application will be restricted prior to anticipated storm events, or during high winds.
- An established buffer zone between water bodies or non-target zones and application zones will be maintained to increase the transport distance of pesticides and to prevent contamination via pesticide movement.
- Selection of pesticides will be based on education and experience using a risk analysis concept. Additionally, the user will consider efficacy of treatment and the criteria that reduce off-site movement and potential adverse impacts.

Table 4. Partial listing of pesticides available for use at Hokukano. Select environmental data are also included.

	Common Brand Names	Coefficient of Adsorption (K_{oc})	Solubility in Water (mg L^{-1})	Half Life in Soil (days)	SCS Runoff Rating		SCS Leaching Rating	GUS Ranking	Persistence Ranking	Toxicity LD50-Rat Oral
					Sediment	Soluble				mg/kg
INSECTICIDES										
acephate	Orthene TT&O		650,000							1030-1447
bendiocarb	Turcam	570	40	3-21	small	large	small	nonleacher	3-5	141-250
bifenthrin	Talstar T&O									> 5000
carbaryl	Sevin 80WSP	79-570	32-40	6-110	small	medium	small	nonleacher	4	281
chloropyrifos	Dursban Turf	6,070-14,800	1.1-4.8	6-139	medium	small	small	nonleacher	2-4	530-940
cyfluthrin	Tempo 2									647-695
ethoprop	Mocap 10G	26-120	700-750	14-63	small	medium	large	intermediate	2-4	160-425
fenamiphos	Nemacur 10G	26-249	400-700	3-30	medium	large	large	leacher	3-5	10-14
fonofos	Crusade 5G									205-465
imidcloprid	Merit 75 WSP									1858-2591
isofenphos	Oftanol 5G	17-536	20-24	30-365	medium	large	medium	intermediate	1-3	565-821
lindane	Gamma Mean	1,300		266						
trichlorfon	Dylox 80	2-45	15,400 to 154,000	3-27	small	medium	large	leacher	3-5	395-933
FUNGICIDES										
chlorothalonil	Daconil 2787	500-14,000	0.6-1.2	5-90-1.3	medium	medium	small	nonleacher	2-4	4200
ehtazole	Koban 1.3	1,000-4,400	50-200	20	medium	medium	small	nonleacher	3	1077
fenarimol	Rubigan	600-1,030	14	360	medium	large	large	intermediate	1	
fosetyl Al	Alliette T&O	20	120,000	1	small	medium	small	nonleacher	5	2860
iprodione	Chipco 26019	500-1,300	13-14	7-50	small	large	small	nonleacher	3-4	> 5000
mancozeb	Fore	1,000-2,000	0.5	28-139	large	large	small	nonleacher	1-2	> 5000
maneb	Maneb-4	2,000	0.5	12-56	large	large	small	nonleacher	2-4	
metalaxyl	Subdue 2E	29-287	7,100-8,400	7-160	medium	large	large	leacher	1-4	1290-3000
propamocarb	Banol	1,000,000	700,000 to 1,000,000	30	medium	small	small	nonleacher	3	2000-8550
propiconazole	Banner	387-1,147	100-110	109-123	large	large	medium	intermediate	1	1310
thiophanate methyl	Fungo 50	1,000-1,830	3.5	<10	medium	medium	small	nonleacher	4	6640
triademefon	Bayleton 25	73-517	70-260	6-28	small	large	medium	intermediate	3-4	2828-3668
HERBICIDES										
2,4-D	Weedone	0.1-6,900	0.2-3,000,000	2-30	small	medium	medium	intermediate	3-5	
benefin	Balan 2.5	781-15,500	<1	2-130						> 5000
bensulide	Betasan	740-10,000	5.6-25	30-180						
bentazon	Basagran T&O									2063
dicamba	Banvel	0.4-470	4,500-850,000	3-315						
dithiopyr	Dimension		138							3600
glyphosate	Round-Up	2,000-24,000	12,000-900,000	30-50	large	large	small	nonleacher	2-4	> 5000
imazaquin	Image	460	60	60						> 5000
isoxaben	Gallery 75									> 5000
mecoprop	Lescoplex	3-130	620-790,000	12-21	small	medium	large	leacher	3	
metribuzin	Sencor	41-95	1,200-1,220	24-30						2379-2794
MSMA	Daconate 6	2,000-300,000	57,000-1,400,000	1,000	large	small	small	nonleacher	1	1820
oxidiazon	Ronstar 50	3,241-5,300	0.7	30-180	large	medium	small	nonleacher		> 5000
pendimethalin	Pre-M 3.3	5,000	0.275-0.5	8-480						3956
pronamide	Kerb				medium	large	large	leacher		> 16000
simazine	Princep	135-890	3.5-5	32-75	medium	large	large	leacher	2-4	

- using pesticides strictly according to label directions
- using only pesticides registered for use in Hawaii (as the law permits)
- applying pesticides on an as needed basis, utilizing a risk avoidance concept and the concept of damage thresholds
- properly calibrating pesticide application devices
- avoiding pesticide application to non-target areas
- precisely controlling the timing and duration of irrigation events after pesticide application
- paying strict attention to the weather in terms of rainfall and wind
- controlling drainage run-off by implementing vegetated buffers, swales, berms, and drainage inlets
- maintaining a perspective conducive to preventing the loss of pesticides
- implementing new pesticide related technologies as they develop and become accepted
- placing only qualified, responsible people in charge of pesticide related work

A partial listing of commercially available pesticides for use on turfgrasses and ornamental plants in Hawaii is presented as Table 4. This listing also includes selected environmental data for each of the pesticides, including:

- the coefficient of adsorption
- solubility in water
- soil half life
- the results of running the SCS Runoff model
- the results of both the SCS Leaching Rating and the GUS Ranking
- a persistence ranking
- a listing of oral LD50 (toxicity)

The decision to use pesticides, and the selection of specific pesticides for use, will be based in part on:

- how toxic the material is (i.e., listing of LD50 values as presented)
- the material's potential for escaping into the environment
- the damage threshold concept
- education, experience, and common sense

Table 5. Turfgrass pest tolerance matrix. This array describes the projected acceptable levels of pest activity in specific areas. The acceptable level of pest activity in any given management area is dependent upon quality expectations. High quality areas such as greens can not tolerate pest activity. Lower quality areas such as roughs can tolerate a greater degree of pest activity.

Management Area	Weed Pests	Insect Pests	Diseases
Green Surface	NT	NT	NT
Collar	NT	NT	NT
Green Surround	NT	Low	NT
Approach	NT	Low	Low
Tee Surface	NT	NT	NT
Tee Surround	Low	Low	Low
Fairway	Low	Low	Low
Rough	Medium	High	Medium
Amenity Turf	Medium	High	High
Ornamental Lawn	NT	NT	NT

- For weeds: NT indicates no tolerance for weeds; Low indicates that up to 3 weeds per 1,000 s.f. is acceptable; medium indicates that up to 6 weeds per 1,000 s.f. is acceptable; high indicates that up to 12 weeds per 1,000 s.f. is acceptable.
- For insects and diseases: NT indicates there is no tolerance for pest activity; Low indicates a low level of tolerance for pest activity; Medium indicates successively higher tolerance; High indicates a high level of tolerance for pests. In general, pest population numbers are not considered for insects and diseases because treatment action levels have not been sufficiently developed.

Table 6. Partial listing of weeds of turfgrass. Weeds are comprised of three basic types: grassy weeds, sedges, and broadleaf weeds. Not all weeds will be present at any given time.

	COMMON NAME	SCIENTIFIC NAME
GRASSY WEEDS	Annual Bluegrass	*Poa annua*
	Bahiagrass	*Paspalum notatum*
	Bullgrass	*Paspalum setaceum*
	Crabgrass	*Digitaria spp.*
	Dallisgrass	*Paspalum dilitatum*
	Dove Weed	*Murdannia nudiflora*
	Goosegrass	*Elusine indica*
	Lovegrass	*Eragrostis pilosa*
	Rattailgrass	*Sporobolus africanus*
	Smallflowered Alexandergrass	*Brachiaria subquadripara*
	Smutgrass	*Sporobolus poiretti*
	Spreading Dayflower	*Commelina diffusa*
	Stargrass	*Chloris divaricata*
	Globe Sedge	*Cyperus globulosus*
SEDGES	Green Kyllinga	*Kyllinga monocephala*
	Purple Nutsedge	*Cyperus rotundus*
	White Kyllinga	*Cyperus brevifolus*
	Yellow Nutsedge	*Cyperus esculentes*
BROADLEAF WEEDS	Brazil Pusley	*Richardia brasiliensis*
	Chamber Bitter	*Phyllanthus urinaria*
	Common Beggar-tick	*Bidens alba*
	Florida Betony	*Stachys floridana*
	Florida Pusley	*Richardia scabra*
	Match-Head	*Phyla nodiflora*
	Pennywort	*Hydrocoytle spp.*
	Rust Weed	*Polypremum procumbens*
	Sagotia Beggarweed	*Desmodium triflorum*
	Spurge	*Chamaesyce spp.*

Table 7. Partial listing of insect pests of turfgrass. Broad groups consist of caterpillars and worms, beetles, mites, and scale type insects.

Armyworm	*Spodoptera spp.*
Bagworm	*Brarachycyttarus spp.*
Bermudagrass Mite	*Eriophyes cynodoniensis*
Bermudagrass Scale	*Odonapsis ruthae*
Black Ateanius	*Ataenius spp.*
Black Cutworm	*Agrotis ipsilon*
Southern Chinch Bug	*Blissus insularis*
Fiery Skipper	*Hylephila phyleus*
Fire Ants	various species
Grass Loopers	*Mocus spp.*
Ground Pearls	*Margarodes spp.*
Hunting Billbug	*Sphenophorus venatus*
Rhodesgrass Mealybug	*Antonina gramini*
Short Winged Mole Cricket	*Scapteriscus abbreviatus*
Sod Webworm	*Herpetogramma phaeopteralis*
Southern Masked Chafer	*Cyclocephala lurida*
Stunt Mite	*Aceria neocynodonis*
Tawny Mole Crickets	*Scapteriscus vicinus*
Tropical Webworm	*Herpetogramma phaeopteralis*
Twolined Spittlebug	*Prosapia bicincta*
White Grubs	various species

Table 8. Partial listing of diseases of turfgrass. Turfgrass diseases can be caused by fungi, bacteria, and other micro-organisms.

FUNGI	Anthracnose	Colletrichum graminicola
	Bermudagrass Decline	Gaeumanomyces graminis
	Brown Patch	Rhizoctonia spp.
	Dollar Spot	Lanzia spp.
	Localized Dry Spot	various fungi
	Fairy Ring	Basidiomycetes spp.
	Gray Leaf Spot	Bipolaris spp. & Dreschslera spp.
	Pythium	Pythium spp.
	Spring Dead Spot	Leptosphaeria korrea
	Rust	Puccinia spp.
	Cerospora Leaf Spot	Cerospora spp.
	Southern Blight	Sclerotium rolfsii
	Yellow Tuft	Sclerophthora macrospora
BACTERIA	Bacterial Wilt	Xanthamonas spp.
	Bacterial Stripe	Xanthamonas spp.
	Slime molds	Mucilago spp.
VIRUSES	St. Augustine Decline	Panicum Mosaic Virus
NEMATODES		many species
MISCELLANEOUS	Algae	many species
	Black Layer	Sulfate-reducing Bacteria
	White Leaf	Mycoplasma

Table 9. Summary of Control/Management Options and General Information for Selected Pests.

INSECTS:

Bermudagrass Mites:

- control may be warranted when 4-8 witchesbroomed tufts occur per square foot of turf
- predaceous mites (i.e., *Neocunoxoides andrei* and *Stenotarsonemus spirifex*) have been used as biocontrol agents with limited success
- traditional pesticides such as fluvalinate (Mavrik®) or dicofol (Kelthane®) are needed for control

Tropical Webworm:

- BT type microbial toxins (i.e., B.t. var. *spodoptera*--Javelin® or Steward®) are used for control
- insect parasitic nematodes (i.e., *Steinernema* spp) are also effective contorl agents when applied at 10^9 juveniles per acre
- contact insecticides (i.e., acephate-Orthene®; chloropyrifos-Dursban®) give good control when applied onto turf during early evening

Armyworms:

- BT type microbial toxins give some control
- poison baits also give limited control
- contact/stomach poisons (i.e., acephate-Orthene®; chloropyrifos-Dursban®) control actively feeding larvae
- apply pesticides in late evening and do not irrigate after application
- liquid pesticide more effective than granular types

Bermudagrass Scale:

- water and fertilize turf and apply conventional insecticides such as Dursban®
- irrigate pesticide into thatch immediately after application

Mole Crickets:

- insect parasitic nematodes (i.e., *Steinernema* spp) give some limited control
- baits/attractants also give control of young nymphs
- apply baits when soil is moist but not when turf is wet
- avoid watering for several days after applying baits
- conventional pesticides are needed (i.e., ethoprop-Mocap®)
- use lemon scented detergent with pesticide as an irritant
- apply pesticides in evening
- Chipco Choice® reported to effect excellent, season long control
- scouting and mapping strategies are necessary for adequate control

DISEASES:

Bermudagrass Decline:

- preventative measures are necessary (i.e., preventative application of a DMI type fungicide)
- raise mowing height during stress periods
- enhance drainage
- do not raise pH

Table 9 Diseases...continued

Brown Patch:
- avoid excessive use of quick release N
- use contact fungicides (i.e., chlorothalonil-Daconil 2787®) at regular intervals

Pythium:
- improve drainage
- reduce level of irrigation
- use contact fungicides labeled for Pythium (i.e., ethazole-Koban®)
- reduce nematode pest populations

Spring Dead Spot:
- avoid low mowing heights
- avoid excessive summertime fertilization
- DMI type fungicides necessary for control

Nematodes:
- must sample for accurate population estimates
- irrigate to promote healthy root system
- avoid stresses to the turf
- apply adequate potassium
- fenamiphos (i.e., Nemacur®) is registered for control

WEEDS:

Crabgrass:
- apply pre-emergent herbicide
- avoid verticutting turf or core-cultivation during time of crabgrass germination
- reduce N applications when crabgrass is most competitive
- hand pick to extent possible

Goosegrass:
- apply pre-emergent herbicide
- post-emergent herbicides effective when applied prior to tillering (i.e., diclofop methyl-Illoxan®)
- releive soil compaction
- hand pick to extent possible

Dallisgrass:
- Post-emergent control in bermudagrass via MSMA (i.e., monosodium methanearsonate) + Lexan® (metribuzin)

Nutsedge:
- improve drainage
- lower height of cut and increase mowing frequency
- use post-emergent herbicides (i.e., imazaquin-Image®)

Spurge:
- relieve compaction
- use post-emergent herbicide containing 2,4-D + dicamba

- weather conditions
- the specific pest at hand

By implementing this kind of strategy "pesticides of concern" can be avoided in the management program to the extent practical. Highly toxic, restricted use pesticides will be avoided to the extent possible at The Villages at Hokukano.

The turf manager at The Villages at Hokukano will use pesticides only when deemed necessary, and will base the selection of pesticides on efficacy towards the pest as well as criteria that mitigate environmental impacts. Precise records indicating how much of which material was applied on specific dates will be kept. It should be stressed that applications of pesticides will be made by persons possessing a pesticide applicators license and who are knowledgeable in the use of pesticides and are familiar with the IPM approach.

ENVIRONMENTAL MONITORING

Environmental monitoring should be thought of as a tertiary control or final check for maintaining environmental quality. Proper planning, maintaining an environmentally conscious perspective, designing an environmentally compatible course, and utilizing proper management tools are considered primary controls. Specific strategies outlined for dealing with issues such as erosion control, nutrients, pesticides, and other materials are the secondary controls.

Water Quality Monitoring

In order to assure that groundwater or surfacewater quality is being maintained with reference to erosion, pesticides and nutrients, or other potential contaminants, Hokukano will establish a comprehensive water quality monitoring and mitigation plan. In this plan coastal waters and groundwater as underlying aquifers and drainage water will be sampled on a prescribed basis for potential contaminants. The goal of the plan will be to ensure that primary and secondary lines of control have been successful in protecting water quality. A secondary goal will be mitigate any problems the monitoring has detected. Monitoring should be considered a major check system. The success of monitoring will depend in part on:

- establishing a water sampling plan according to the requirements of the Department of Health and established protocol

- implementing a routine sampling plan designed specifically for the site using modern, accepted technologies including wells, lysimeters, and other appropriate devices
- utilizing appropriate analytical techniques with established protocol by qualified laboratory personnel
- establishing a reliable, valid background index of water quality including the documentation of concentrations of dissolved solids, chlorides, nitrate, phosphorus, and other compounds as mandated by the Department of Health
- accurately comparing background indices with collected data in a timely fashion
- reporting valid results and conclusions or recommendations in an expedient manner

The analysis conducted in this manner will help to preserve water quality by:

- alerting the developers to indications of changes in water quality relative to background indices
- providing initiative for investigating the potential cause of changes and addressing specific issues which can mitigate the problem if necessary
- allowing for the mitigation procedure to be instituted in a timely manner
- documenting that the mitigation procedure has been effective.

In following the monitoring plan, drainage water samples will be analyzed for contaminants according to established protocol. Sampling sites will be located strategically in association with fairways and greens at the upper and lower elevations of the golf course. Analysis of this water will give the first indication of quality change because contaminants should be most concentrated in drainage water. The next analysis marker would be water from the aquifer, while the final marker would be coastal water.

In order to be successful, a most important aspect of monitoring will be to establish a valid, reliable background index of water quality for all water sources. That index is what all subsequent analyses will be compared to. It will be equally important to obtain representative samples and conduct analysis according to an established, reliable protocol. Hokukano will prepare and adhere to a water quality monitoring and mitigation plan delineating the procedures for monitoring, reporting, and implementation of appropriate mitigation measures should significant changes to baseline conditions be detected.

By using monitoring in this fashion, a change in water quality attributable to management activities can be mitigated. The primary purpose of mitigation would be to prevent the sustained contamination of aquifers or coastal water by changing management practices.

SUMMARY AND CONCLUSIONS

In summary, the IGCMP process at The Villages at Hokukano will require that experienced, qualified people deploy modern, reliable best management practices within the confines of an environmentally sensitive golf course infrastructure. Such an approach to golf course management is not foolproof, but is the most modern, most complete attempt at managing golf courses while at the same time mitigating environmental impacts that can be associated with management practices. It is also the primary method for sustaining premium quality turfgrasses and ornamental plants, which are essential to the existence of an up-scale golf course.

SELECTED REFERENCES

1) Anonymous. 1990. Crop Protection Chemicals Reference. John Wiley and Sons, New York, NY.

2) Anonymous. 1991. Turf and Ornamentals Chemicals Reference. John Wiley and Sons, New York, NY.

3) Balogh, J.C., et al. 1992. Background and overview of environmental issues. in J.C. Balogh and W.J. Walker (eds.) Golf Course Management and Construction: Environmental Issues. Lewis Publishers, Boca Raton, FL.

4) Balogh, J.C., et al. 1992. Development of integrated management systems for turfgrass. in J.C. Balogh and W.J. Walker (eds.) Golf Course Management and Construction: Environmental Issues. Lewis Publishers, Boca Raton, FL.

5) Balogh, J.C., and J.L. Anderson. 1992. Environmental Impacts of turfgrass pesticides. in J.C. Balogh and W.J. Walker (eds.) Golf Course Management and Construction: Environmental Issues. Lewis Publishers, Boca Raton, FL.

6) Balogh, J.C., and J.R. Watson, Jr. 1992. Role and conservation of water resources. in J.C. Balogh and W.J. Walker (eds.) Golf Course Management and Construction: Environmental Issues. Lewis Publishers, Boca Raton, FL.

7) Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall Publishers, Englewood Cliffs, NJ.

8) Beard, J.B. 1982. Turf Management for Golf Courses. Burgess Publishers, Minneapolis, MN.

9) Leslie, A.R. 1989. Development of an IPM program for turfgrass. in A.R. Leslie and R.L. Metcalf (eds.) Integrated Pest Management for Turfgrass and Ornamentals. U.S.E.P.A. Press, Washington DC.

10) Walker, W.J., and B.B. Branham. 1992. Environmental impacts of turfgrass fertilization. in J.C. Balogh and W.J. Walker (eds.) Golf Course Management and Construction: Environmental Issues. Lewis Publishers, Boca Raton, FL.

11) Weber, J.B., and C.T. Miller. 1989. Organic chemical movement over and through soil. in B.L. Sawhnet and K. Brown (eds.) Reactions and Movement of Organic Chemicals in Soils. SSSA Special Publication #2. SSSA/ASA Publications, Madison, WI.