Appendix C

Golf Course Best Management Practices

DRAFT

BEST MANAGEMENT PRACTICES FOR THE HONUA'ULA GOLF COURSE

Prepared By:

Kenneth Ingram, M.S., CGCS
Turf Agronomist

N. LaJan Barnes, M.S., P.G.
Hydrogeologist

Stuart Z. Cohen, Ph.D., CGWP
Study Director

Reuben Baris
Environmental Scientist

Qingli Ma, Ph.D.
Environmental Hydrologist

Environmental & Turf Services, Inc.
Wheaton, MD

Prepared for:

Honua'ula Partners, LLC

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EXECUTIVE SUMMARY

Honua'ula Partners, LLC is proposing to develop an 18-hole golf course in the Kihei-Makena region of south Maui. It would be located in the Wailea area, associated with 1150 homes and related amenities. The original project was approved for two golf courses by the Maui County Council in 1993 and the State Land Use Commission (SLUC) in 1994. The current project design is for an 18-hole homeowner's golf course and related facilities including a driving range and clubhouse.

The overall goal of this document is to reduce the turf chemical and water inputs required to manage the 18-hole golf course, and to minimize waste generation. This document exceeds the minimal requirement of SLUC approval condition #5 (Docket No. A93-689). This condition required compliance with the Hawaii Department of Health's (DOH) guidelines for new golf course development. The DOH published a much more comprehensive guidance document for new golf courses in November 2005, "Golf Course Best Management Practices." As of July, 2009, this is the first document developed to comply with the new draft guidelines. In addition, this document complies with a portion or all of condition numbers 12, 14, and 18, and it describes compliance with condition 20, pursuant to the County of Maui Ordinance No. 3554, 2008.

Design and Operations

The most important Best Management Practice (BMP) in this plan is the use of seashore paspalum throughout the golf course. Traditionally, Hawaii golf courses have used Bermudagrass, which presents an excellent playing surface under typical Hawaii conditions. However, the new varieties of seashore paspalum have the potential to reduce nitrogen requirements by two-thirds and reduce the needs for herbicides and fungicides.

Construction BMPs are recommended in nine subtopic areas, including site layout and erosion control. Guidelines are provided for irrigation operations and irrigation system design. Green waste (plant material) will be managed with a general goal toward sustainable development and operations. This document identifies 11 insects, 42 weeds, and 12 diseases that are potential pests; however, only seven of these are considered 'key' (i.e., they are likely to occur at infestation rates sufficiently high to require some combination of mechanical, chemical, and biological controls). The recommended pesticides were risk assessed in this document, which updates an assessment approved by the DOH in 1993. Six of the recommended pesticides are classified as "Reduced Risk" and/or 'natural'/'organic'/'biorational'. Detailed pest infestation

thresholds are also provided (i.e., pest infestation densities that should be met or exceeded before pesticides are applied).

A facility operations manual is included as an appendix that should be consulted during the design and construction phases. It satisfies several of the State and County approval conditions as stated above and throughout this document.

Waste management and emergency response procedures are provided. Some general guidance for education and outreach are also provided.

Water Quality Monitoring

Ground Water. Tentatively, two monitoring wells are proposed for installation onsite. An existing irrigation well will also be sampled. Baseline sampling and semi-annual operational phase sampling will be done. Analytes will include pesticides and any relevant key metabolites, standard field parameters, nitrate, and inorganic substances relevant to the ongoing nearshore monitoring program described immediately below. The ground water monitoring program, as designed in the ground water monitoring protocol, satisfies conditions 18 'a' and 'b' of the Unilateral Agreement and Declaration for Conditional Zoning (Zoning Condition), and conditions 1-3 of the DOH's '12 Conditions' Applicable to all New Golf Course Development (1992, version 4; since amended with a condensed list of 10 guidelines/conditions; this project also complies with the newer version).

Nearshore Coastal Water. Six rounds (2005, 2006, 2008, and 2009) of baseline monitoring of nearshore coastal water and associated well water that specifically considers this project began in 2005. This was done in the context of related and indirectly related monitoring that was done in the same area in 1990 and from August 1995 to February 2003 for the Wailea Resort. Samples are collected from seven stations along each of five transects perpendicular to the shoreline (35 sampling locations). Analytes include nutrients and standard marine chemistry parameters. [This complies in part with Zoning Condition 20 and SLUC Condition 13.]

This BMP should be considered a 'living' document. Therefore it should be reviewed and revised - - if needed - - soon after the golf course is built, and every year or two thereafter.

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INTRODUCTION & PURPOSE

Honua'ula Partners, LLC requested the preparation of this Best Management Practices (BMP) document adhering to the Hawaii Department of Health's "Golf Course Best Management Practices" guidelines (BMPs; DOH, 2005. See Appendix A.1.) to ensure this project is developed in an environmentally responsible manner. This document also satisfies the recommendations in "Guidelines Applicable to Golf Courses in Hawaii" (Version 6; DOH, 2002. See Appendix A.2.), and "Twelve (12) Conditions Applicable to all New Golf Course Development" ('12 DOH conditions;' Version 4; DOH, 1992. See Appendix A.3.). Compliance with the latter document is a State Land Use Commission (SLUC) approval condition (#5; Docket No. A93-689) as well as a County of Maui approval condition (#18[a-c], 2008). This document also specifically satisfies the County of Maui Ordinance No. 3554, 2008 conditions ("Conditions of Zoning"): 18 'a', 'b', 'e', 'f', 'h'; and, in part, it satisfies conditions 18 'd', 'g', and 'i' (Exhibit 2); and it describes compliance with condition 20. Parts of this document are also relevant to County conditions 12(b) and 14. These conditions are noted throughout the document and/or in the facility operations manual (Appendix B).

Thorough environmental considerations and scrutiny of developmental standards must be met so that the Honua'ula golf course is constructed with minimal impacts on the surrounding environment (terrestrial, ground water, and marine systems). An Environmental Impact Statement was completed by PBR Hawaii (EIS, 1988) in 1988 for the original project, which was proposed to contain two golf courses and approximately 2000 residential units. Pre-development aspects of this site have not changed significantly since 1988 (e.g., geology, hydrology, climate, flora and fauna, existing conditions, etc.). As part of the approval process for the previous, more intensive proposal, Environmental & Turf Services also developed and submitted the following: a water quality risk assessment, an Integrated Golf Course Management Plan© (IGCMP), and a ground water monitoring protocol. The first two products were submitted in one document in 1992 (Durborow et al.), and reviewed and approved by the DOH in 1994 (Appendix C). This current document comprehensively updates the 1992 submission, as well as the 1992 ground water monitoring protocol.

This BMP document has been written for the 2010 Project District Phase II permit submission, long before the first tee shot is hit. In order for this plan to be effective, we recommend that it be considered as a 'living' document. Accordingly, this should be revised during or shortly after (within six months) of the grow-in, and it should be revised again after two years of operation. This would enable site-specific conditions and activities to improve the relevance and feasibility of the BMP, which should aid in compliance and the attainment of the ultimate goal - - environmental protection.

PART 1: SITE SELECTION, DESIGN, AND CONSTRUCTION

The organization of this document follows the arrangement of the DOH BMP guidelines (2005) noted in the introduction above (Appendix A.1).

A. Site Selection

Honua'ula Partners, LLC proposes to develop a recreational golf community in the Kihei-Wailea-Makena region of the leeward side of south Maui. It would consist of one 18-hole golf course, 1150 residential units, and related facilities. The 670 acre project site is located on the lower slopes of Haleakala, immediately south of Maui Meadows, mauka of the Wailea Resort (Figure 1).

The soils on the site are primarily stony to extremely stony aggregated clays over fragmental aa lava. The site overlies a freshwater aquifer system most of which is below the Underground Injection Control (UIC) no-pass line. The ground water likely discharges to the ocean, and may flow within the zone of influence of at least five Wailea Resort irrigation wells. Also, runoff from peak storm events may hypothetically flow to the ocean, but this infrequent runoff will be mitigated by detention basins. Homes and other community buildings are proposed in locations that could be downwind of areas where pesticides may be sprayed (approximately 100-150 foot setbacks; Part 4: section E.3); however, the distances are relatively large, and proper development of pesticide application timing and scheduling will be completed to minimize risk of human exposure (Part 3: sections D & F; Part 4: sections D & E).

Honua'ula Partners, LLC will employ a qualified golf course superintendent with the capability to implement the best management practices (BMPs) described herein, and demonstrate sensitivity as it relates to environmental issues. This will include consistent compliance with federal, State, and County environmental regulations, on-site water quality monitoring of ground water resources, the protection of wildlife and environmentally sensitive areas, and continued leadership in addressing environmental concerns as it relates to public safety and overall environmental stewardship. In addition, nearshore marine environment monitoring is being done.

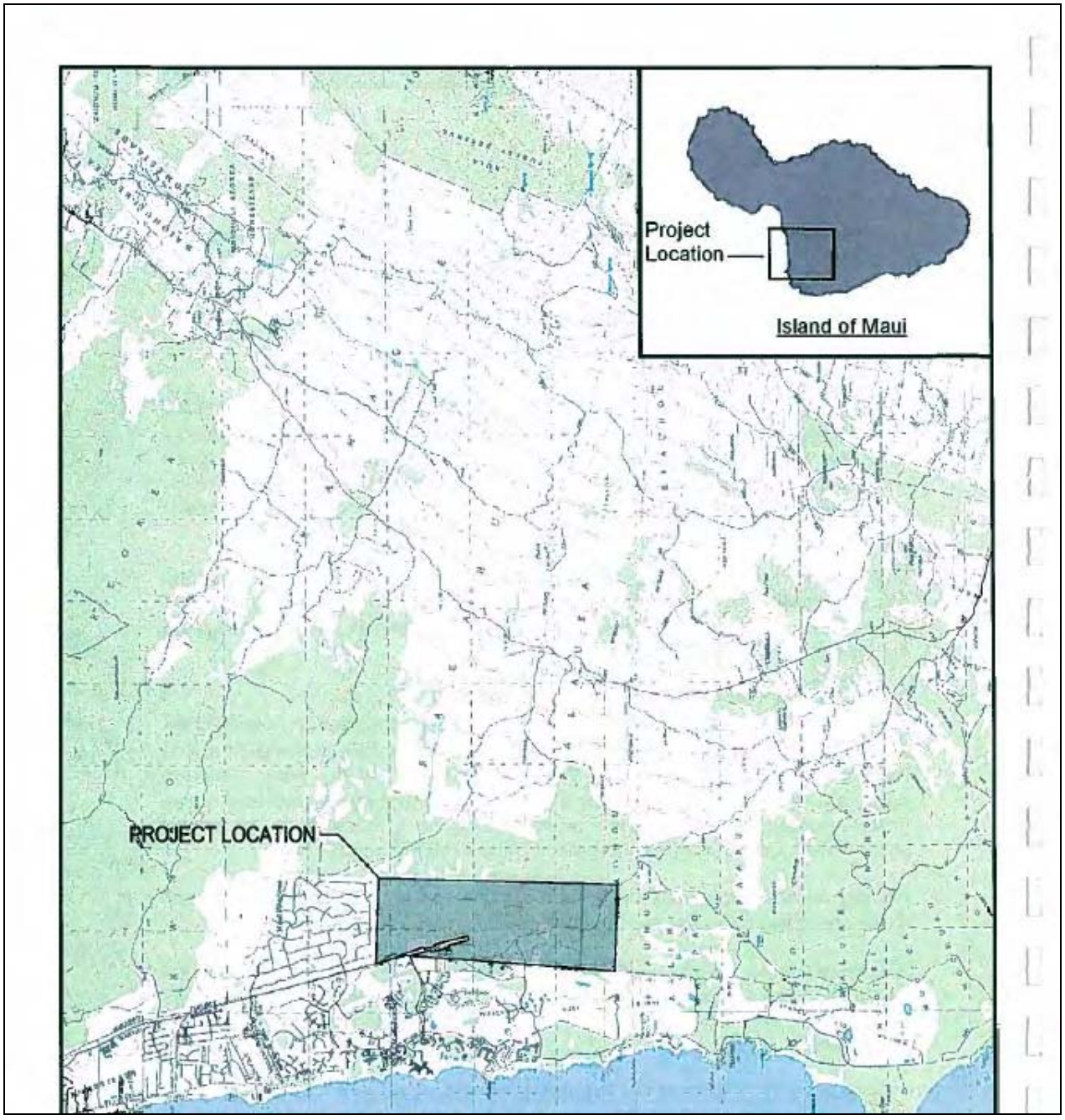

FIGURE 1. Project Site Location

B. Site Design and Management Goals

The goals of the design and management of the Honua'ula Golf Course are as follows:

1) Be leaders in environmental management and environmental monitoring.
2) Be protective of the physical and environmental resources of the site.
3) Develop pest management strategies with an emphasis on reducing the use of pesticides.
4) Provide water conservation materials and methods to maximize usage of water efficiently.
5) Hire and maintain qualified personnel sensitive to the environmental issues of the site.
6) Establish earthen berms and vegetative swales functioning as buffers to prevent surface discharge off the site.
7) Minimize the amount of waste products generated on-site as well as the exporting of materials off-site.

It is important, when possible, to maintain natural vegetation and wildlife habitat while incorporating the site design goals. The golf course will be designed to minimize impact on the surrounding environment and provide enhancement of ecological functions (i.e., buffer zones/strips, water features, natural topography, wildlife habitat). The site is currently characterized by a light to moderately dense growth of Kiawe trees and, to a lesser extent, Wiliwili trees. There are also meadow-type grasses and low shrubs. The makai side of the property is approximately one mile from the ocean.

The design and construction of the golf course will allow for structural elimination of many potential environmental problems. For example, there are no perennial streams on the project site, although there is evidence of soil erosion from rainwater runoff. The installation of turfgrass as a soil stabilizer and the shaping of land features to match intermittent gulches will assist in retaining soils, preventing movement off-site, and slow the movement of surface runoff. The transformation of the kiawe/buffelgrass pastureland into nodes of noninvasive turfgrass will result in better use of the existing land and provide a more diverse set of living spaces for plant and animal life. The incorporation of these environmentally conscious techniques into the design will maximize the overall environmental quality, playability, and aesthetics of the course.

Water use is an important consideration in the design of a golf course. Irrigation, drainage, and retention systems will be designed to provide efficient water usage while protecting water quality. Stormflow retention systems and water collection and reuse strategies will be incorporated into the overall management plan of the Honua'ula golf course in order to

provide for both short and long term irrigation needs while protecting the natural resources of Maui County (see also Part 2: Water Use, and Part 5: Surface and Ground Water Protection below).

C. Construction

This section specifically addresses the control of soil runoff during construction, which satisfies Zoning Condition 18 'i' in part (also condition 12 of the DOH's '12 Conditions' is satisfied below. See Appendix A.3.).

The primary concern throughout the construction process will be preserving existing natural resources, establishing healthy turfgrass as quickly as possible, and using construction methods (e.g., following USGA specifications and recommendations) that ensure environmentally sound management in the future (e.g., erosion controls, soil preservation, reducing compaction from machinery, etc.).

1. Surveying and Layout of Work

The project engineer or surveyor will be responsible for the initial location of boundaries, benchmarks, and control points with special concern given to delineating environmentally sensitive areas.

2. Sediment and Erosion Control

A National Pollution Discharge Elimination System (NPDES) permit will be obtained before construction of the golf course begins. Erosion control drawings and specifications will be provided by the contracted engineer as required by the County of Maui. Federal, State, and Maui County regulations and guidelines will be observed at all times.

The contractor will be responsible for the maintenance of all erosion control features (e.g., silt fencing, sediment ponds, etc.) during construction and for the removal of all such materials upon project completion. Dust control measures will also be used to prevent the migration of fugitive dust particles. Those measures include, but are not limited to, sprinkling water, provide barriers, and mulch where appropriate as to not interfere with turfgrass establishment (IDEQ, 2005).

3. Clearing, Grubbing, and Tree Protection

This work includes the satisfactory removal and disposal of grass, roots, rocks, unsalvageable trees and plants, brush, and stumps in areas designated for disturbance. Equipment will be limited to designated work areas, easements, and haul roads. Disposal of all debris will be done in accordance with all State and county regulations. Recycling, where feasible, for all these materials will be incorporated into the final design specifications.

All preserved plant material will be protected from injury to roots and tops by bright colored (e.g., orange) construction fencing placed 10 ft outside the dripline. No grading, trenching, or storage of machinery and materials will be permitted in these areas. Transplanting preserved plant material will be done by qualified nurserymen and/or arborists.

4. Topsoil Preservation and/or Selection

Topsoil is limited on the Honua'ula property. Good topsoil is critically important to grow and maintain healthy turfgrass. Every possible measure will be taken to preserve soils on this site and amend poor soils through fertilization, addition of organic matter and compost, and adjusting soil pH.

5. Earthwork and Rough Grading

All cuts and fills shall closely follow the designer's contour plans. Fill material shall be relatively clean of debris, suitable for grading, and compacted to ASTM D-1557 90% modified proctor (http://www.astm.org/Standards/D1557.htm) so that no future settling or sloughing occurs. All grading will be done in a manner such that no water-holding pockets are produced. Fairway and rough slopes should be no greater than 3:1, and green, tee, and bunker slopes should be no greater than 5:1 unless specified by the designer. Sufficient subsurface drainage should be installed if surface drainage is not possible. This will be completed under the direction of the contracted engineer(s).

6. Irrigation

Irrigation installation can begin once golf course features are rough graded. A functional irrigation system is essential to quickly establish healthy turfgrass. Poor irrigation during grow-in can eventually lead to the increased use of pesticides and fertilizers. All trenches must be

sufficiently compacted to prevent future settling and sprinkler heads can be installed above grade until final grades are established allowing irrigation installation to closely follow rough grading. The irrigation system will be designed, or at the very least, reviewed, by a qualified golf course irrigation consultant. Detailed irrigation specifications will be provided under a separate cover.

7. Fine Grading and Topsoil Cleaning

After topsoil is re-spread, all stones, roots, and debris greater than 3/4" in diameter will be removed by stone pickers, rakes, or other devices that do not disturb grade or create water-holding pockets.

The project will be coordinated so that finish work begins in the corners of the property, never allowing construction traffic to cross over fine graded 'finished' work.

8. Tees

Tees will be built to the designer's plans and specifications. Tee surfaces should be flat. This construction method requires internal drainage with the sub-grade pitched a minimum of 1% toward the drainlines. All tees will be built with the same rootzone mix used in greens to a depth of six inches.

9. Greens

The designer's instructions regarding greens specifications will be closely followed according to field drawings. The method of construction will conform to current United States Golf Association's (USGA) "Specifications for a Method of Putting Green Construction." Slope on the pinnable areas of the green shall not exceed 1.5%.

The USGA method of putting green construction is the standard of the industry. The method includes a very specific mixture of sand and organic matter with an underlying drainage system of gravel and drainpipe. The sand rootzone resists compaction, drains readily, and provides the ideal medium for healthy turfgrass if specifications are followed closely. Details of the construction methods are provided as Appendix D.

D. Physical Barriers

A complete archaeological reconnaissance survey has been completed on the Honua'ula project site. Honua'ula Partners, LLC has agreed that if subsurface remains such as artifacts, burials, or deposits of charcoal or shells are found during construction activities, that work will stop in the immediate vicinity or the find and the find will be protected from further damage. The State Historic Preservation Division will be contacted to assess the significance of the find and recommend appropriate mitigation measures, if necessary (EISPN, 2009).

PART 2: WATER USE

This section addresses Zoning Conditions 14 and 18 ‘d’ (noted as condition 5 of the ‘12 DOH conditions’). It is important that the superintendent consider the results of the soil analyses (Appendix E) when planning the irrigation strategy.

A. Water and Ecological Conservation

Water conservation is central to the economic viability of the golf course. Water resources are important means by which a golf course maintains all essential functions. Therefore careful examination and monitoring of water usage must be appropriately maintained to reduce the impact on the surrounding environment. Turf selection, efficiently planned irrigation, water retention systems, and reuse plans are important design criteria considered while planning sustainable water use. These factors contribute to the overall consumption and discharge of water from the golf course, as well as the surrounding lands comprised within the Honua’ula property. All uses of water (including landscape features, indoor activities, chemical wash areas, maintenance areas, etc.) must be considered and properly managed to appropriately treat and divert runoff to detention basins or ponds whenever possible. Nonpotable water will be used, which satisfies Zoning Condition 14 (Exhibit 2)and condition 5 of the DOH ‘12 Conditions’.

B. Irrigation Plan

The design and implementation of a detailed irrigation plan satisfies Zoning Condition 18 ‘d’ (noted as condition 5 ‘a’ of the DOH ‘12 Conditions’).

Modern irrigation systems are extremely complex and very efficient. They are closely related to communication systems and share much of the same technology, including wireless technology. Total automation is quite possible, where a weather station calculates evapotranspiration (ET) losses and a central computer calculates how much water is needed to replace that loss as well as how long each sprinkler will run.

The key component is the central computer. Information is stored for every sprinkler on the property including the type of sprinkler, nozzle sizes, location, soil type, slope, infiltration, exposure, etc., so that the exact amount of water needed is applied (not just, e.g., 10 minutes per

sprinkler every night). Cycle/Soak features prevent runoff when heavy irrigation is needed. Flow management features ensure optimum pressure and amount to every sprinkler. Computer control saves electricity and extends the life of pumps and equipment, often irrigating the course in half the time required by the older, electromechanical, timer-based systems. This reduced run time or watering 'window' can easily be accomplished at night when winds are low, temperatures are cooler, and humidity is higher. These systems also print out detailed records of daily water consumption and operation.

Manufacturers have developed wireless radio and palm pilot devices that can be used to activate individual sprinklers or start entire programs within seconds when water stress is detected. In the event of computer failure, field or 'satellite' controllers have similar stored data and programs and can operate sprinklers in their respective zone.

The major irrigation system manufacturers are Toro and Rainbird. Toro Site Pro, Rainbird Nimbus, and Rainbird Cirrus systems have all the features listed above and more. The field is quite specialized, and while the manufacturers offer design services, it is fairly common to employ a certified irrigation designer, as well as an irrigation contractor. Because irrigation installation follows so closely behind earthmoving and shaping, many golf course builders employ their own irrigation installation crews. The irrigation system is a significant investment, usually between one and two million dollars. Like all underground utilities, the trenching and installation is laborious and slow. Historically, there is a 50/50 differential between the costs of equipment (pipe, fittings, wire, sprinklers, and controls) and the cost of installation. Field change orders are inevitable and the installer must provide an accurate, as-built drawing of the final irrigation system.

Water quality is an extremely important issue for the project. Initial test results are extremely favorable for the wells. We anticipate that ground water quality at this location, following development, will be consistent with these concentrations. Irrigation for the golf course will include two on-site and two off-site brackish water wells mixed with recycled wastewater (R-1) and the concentrate from the RO treatment of the potable water supply system. Water from the wells and/or the reclaimed wastewater system will be pumped into a holding pond. The parameters listed below are ideal for irrigation water. However, the selection of seashore paspalum turfgrass for the golf course means that the quality of irrigation water is less critical. (Turfgrass selection is discussed in Part 3(B) below.)

- pH (5.5 - 8.0)
- Conductivity (ECw) $\leq$ 0.75 dS/m

- TDS (total dissolved salts) $\leq$ 500 ppm
- SARw (sodium absorption ratio) $\leq$ 10 meq/L
- RSC (residual sodium carbonate) $\leq$ 1.0
- Dissolved Nutrients: Na $\leq$ 138 ppm, Ca $\geq$ 20 ppm, chlorides $\leq$ 335 ppm, Mg $\geq$10 ppm, bicarbonates $\leq$ 122 ppm, carbonates $\leq$ 15 ppm

Records of irrigation procedures must be maintained for each management zone and kept with other detailed management records in the maintenance facility. Each management zone is treated independently; the highest priority zones (greens, tees, fairways) will receive the highest amounts of water, while lower priority zones (secondary roughs, natural areas) will receive less water. These priority designations help to efficiently manage the overall water use on the golf course, providing the highest level of playability and aesthetics while incorporating environmentally sustainable management practices.

C. System Layout and Leak Detection

Irrigation designers calculate the hydraulic information needed to size pipelines and route them in appropriate directions. Proper selection reduces the friction losses associated with moving water and ensures adequate volume and pressure at the sprinkler head. Individual head control with valve-in-head sprinklers is desired for maximum efficiency. In general, smaller sprinklers, placed closer together at a lower operating pressure, are more efficient than larger, high pressure sprinklers at a greater spacing. A wide range of adjustable arc and radius sprinklers are available and are particularly useful on small tees which are easy to 'overshoot' with conventional sprinklers.

Gasketed PVC piping with ductile iron fittings in sizes greater than 2" produce the best results with fewer leaks. Solvent-welded or 'glued' joints should be restricted to smaller pipes. Isolation valves should be located so that no more than one green, tee, or fairway should be turned off at any given time for repair. Snap valves, for easy hand watering, should be installed at every green, tee, and several on each fairway.

Pump stations are also highly efficient. Variable frequency motors are preferred because they run at a speed comparable to the output needed, consuming much less electricity. Low pressure discharge features are able to detect major leaks and blowouts, automatically shutting down the system. Digital flowmeters will be used to track water usage. Prefabricated, steel floor pump stations are the norm, such as those manufactured by Flowtronics/PSI.

Maintenance is minimal but still required. Most golf clubs employ a competent irrigation technician to perform these duties. Periodic inspection with the manufacturer's authorized personnel is desirable.

PART 3: OPERATIONS, MAINTENANCE - MANAGEMENT PLAN

An Integrated Golf Course Management Plan® (IGCMP) and Risk Assessment was developed by Environmental & Turf Services, Inc. in 1992 for the originally proposed Wailea 670 project consisting of two 18-hole golf courses (Durborow et al., 1992). As part of the approval process for the original Wailea project, Environmental & Turf Services developed and submitted a water quality risk assessment, an Integrated Golf Course Management Plan© (IGCMP), and a ground water monitoring protocol. The first two products were submitted in one document in 1992 (Durborow et al.), which DOH reviewed and approved (Appendix C) in 1994. This current document comprehensively updates the 1992 submission, as well as the 1992 ground water monitoring protocol.

The most important BMP in this plan is the choice of turfgrass varieties (seashore paspalum specified in section A(2) below). Seashore paspalum turfgrass varieties will enable the golf course to use significantly less fertilizer and pesticides than bermudagrass at this location. These turfgrass varieties were not available to Hawaii golf courses in 1992.

This part of the BMP document satisfies condition 11 of the '12 DOH conditions' (as amended by DOH), which is part of Zoning Condition 18 'f'. Specifically, sections F & G below satisfy condition 11 with respect to handling and application of chemicals according to label requirements. Also, methods that reduce off-site drift during chemical applications are addressed in Part 4(E)(3) below.

A. Site Description and Site Evaluation

The project is on the lower slopes of the Haleakala volcano near Makena in south Maui. Elevations range from approximately 320 ft to 710 ft. There is an approximate 250-300 ft elevation change from the makai property boundary (western) to the mauka property boundary (eastern) and little elevation change from the northern property boundary to the southern boundary.

The property contains of four soil classifications: Kaewakapu stony silty clay loam; Makena loam; Oanapuka stony silt loam; and very stony land. The Keawakapu soil type comprises the majority of the property (approximately 56%) with slopes of 3-25% (USDA/NRCS, 2006). "Very stony land (rVS)" comprises the next largest percentage at approximately 32% of the entire property located in the southern portions of the parcel. Makena

loam comprises 12% of the property mainly in the northwestern portions, with slopes of 3-15% (USDA/NRCS, 2006).

There are no existing surface water features. The golf course will include several ponds and drainage ditches serving multiple functions, from stormwater retention and hydrologic regulation to aesthetics and wildlife habitat.

The project site climate tends to be semi-arid with mild temperatures throughout the year (with limited seasonal variability), moderate humidity, and an average annual rainfall of 12-15 inches (EIS, 1988). The limited seasonal variability and a low amount of rainfall affect the choices and recommendations of turfgrass types for the golf course.

A hole-by-hole description of the golf course, complete with aerial photos, will be produced after build-out of the golf course. These photos and description will highlight the site drainage patterns and indicate which environmentally sensitive areas, if any, must be protected during routine maintenance operations. This will help the management team pinpoint potential concerns so that management strategies can be appropriately updated.

B. Turfgrass Selection

The most desirable turfgrass for this project, in an environmental context, is seashore paspalum. The selection of this plant implements guidance in the DOH's BMP document to "Use turf grasses that are best adapted to local conditions..." (Part 1), and "Select appropriate turfgrasses..." (Part 2). Bermudagrass has been the turf of choice for years in Hawaii, but seashore paspalum is slowly replacing bermudagrass. Newer varieties of seashore paspalum rival hybrid bermudagrass in turf quality and have many additional environmental attributes including the tolerance of:

- Alternative water sources including, effluent, gray water, brackish, and even ocean water for short periods.
- High salt and sodium levels.
- Low light intensity (shade).
- Waterlogged and poorly drained soils.
- High and low pH soils.

Other desirable features of seashore paspalum are:

- Lower fertilizer requirements, approximately 1/3 the nitrogen required for bermudagrass.
- Minimal pesticide requirements, especially herbicides. Weeds cannot compete well in the thick turf produced with seashore paspallum. Fungicide use requirement is lower, there is no battle with the 'bermuda decline' disease complex when using poor quality water, and there are fewer insect pests.
- Withstands prolonged droughts better than bermuda.
- Darker green color than bermuda.
- Stripes like cool season grasses when mowed.
- Allows the same turfgrass to be used on greens, tees, and fairways.
- Waxy leaf surfaces repel dew and enhance playability and mowing quality in the early morning.
- Can be used throughout all playing surfaces of the golf course.

Seashore paspalum is now widely used where irrigation water is less than desirable (e.g., salt affected soils). Improved varieties of seashore paspalum are fine textured and superior to hybrid bermudagrass. Seashore paspalum can be used throughout all playing surfaces of the golf course (greens, tees, fairways, and roughs) showing the versatility of this specific turfgrass. ***The variety SeaIsle 1 Supreme™ is a good choice at this time.*** The golf course designer will have considerable input into the specific variety selected for the course.

C. Turf Management and Cultivation Practices

Selecting the right turfgrass is nullified if it is not properly maintained. The complexities of management strategies for a golf course are far greater than for many other areas of agriculture or forestry. This is due to the intensity of the intended use and the need for the turfgrass to resist and recover from damage incurred during normal daily play and maintenance. These management strategies (e.g., mowing, fertilizing, irrigation, etc.) are referred to in this report as cultivation practices.

The following cultivation practices and golf course management techniques should be used as a guideline. These are recommendations for the use of effective and low impact methods and materials, as well as current industry standards used to successfully build and operate a golf course in an environmentally responsible way. These practices involve cultivation, mechanical, and biological methods which modify the environment so that it is less suitable for pests (Durborow et al., 1992).

The positive results of cultivation practices and biological controls may not be readily apparent. Both are much more effective over the long-term. However, the goal of cultivation management is to maintain healthy turf that keeps the incidence of weeds, insects, nematodes and disease at a minimum without the use of chemical treatments. New technology is continually on the rise, enhancing cultivation techniques and providing a superintendent with more efficient strategies for managing turf on the golf course. As this newer technology becomes available, and these methods recommend safe and efficient materials, the plan will adjust and expand to incorporate the newest and best technology advancements.

Below is an outline of the cultivation practices expected for use on the Honua'ula golf course.

- Proper pH and electrolytic balance of soils and irrigation water will be established, monitored, and maintained to provide optimum growing conditions.
- Adequate air circulation, thatch control, and exposure to sunlight will be analyzed and improved in areas under stress, if necessary.
- Advanced soil aerification techniques to maintain healthy root zones with less than desirable irrigation water, including shallow and deep tine machinery with adjustable spacing, patterns, depth, and tine sizes.
- Adequate tee and green size will be provided to accommodate traffic, wear, and compaction.
- Misting by means of the irrigation system will be used to provide effective control on the rate of evapotranspiration and heat stress.
- Selection and planting of the appropriate turfgrass for the climatic zone is important in helping with the natural resistance of certain species to pest infestations.
- Daily inspection by the golf course management team helps identify potential pest problems as early as possible.
- Action threshold levels will be established to limit the unnecessary use of pesticides.
- Careful attention paid to mowing operations. Mowing is the single most important daily operation on golf courses. This involves careful selection of equipment, intense maintenance to maintain razor sharp edges and height of cut, not removing more than 1/3 of the leaf blade in any single mowing, avoiding mowing in wet conditions when soil compaction is possible, and changing the direction of cut daily to avoid grain and wear patterns.

D. Safety Details and Worker Protection

1. Pesticide Storage

Pesticide storage will be in a pre-fabricated (pre-fab) pesticide storage building specifically designed to be ventilated, fire resistant, vapor explosion resistant, vandalism protected, spill self-containment, and climate controlled. The pre-fab building like those produced by US Hazmat Storage Inc. or Hazvault Inc. can be customized for any hazmat storage need. Often these buildings exceed code requirements for safe storage of hazardous materials. Storage should be limited to a minimal amount of materials needed for one application. Typically a 400 sq ft building is sufficient for an 18-hole golf course. Further storage procedures and recommended facilities are included in the Facility Operations Manual and Emergency Procedures (Appendix B). Also included in the operations manual is a facility checklist for the pesticide storage buildings.

2. Disposal and Record Keeping

The disposal of pesticides, pesticide containers, and residual wash waste will be managed and treated in accordance with label instructions. There will be an up-to-date record of all pesticides used on the golf course, as well as MSDSs (Material Safety Data Sheets) for all chemicals on site. The MSDSs will be stored in a separate building, preferably the superintendent's office.

3. Worker Protection

The golf course superintendent should implement a worker-training program in which workers are trained in safety procedures for operating equipment and handling fertilizers and pesticides. Other areas of training include spill response, first aid, blood borne pathogens, proper golf course etiquette, maintenance techniques, employee benefits, turf management, fire safety procedures, and use of safety devices. Training should take place when workers begin employment and continue on a regular basis.

First aid kits, safety stations, wash stations, personal protective equipment (when appropriate) should be readily available in designated areas so employees can effectively protect themselves against hazardous situations and efficiently perform their duties.

E. Operation Procedures and Emergency Response

The Facility Operations Manual and Emergency Response (Appendix B) provides details for routine and non-routine maintenance of the golf course and the facilities on the property, including emergency response procedures and contingency plans.

F. Chemical Management

Pesticides can safely be used on the golf course, minimizing potential dangers to humans and the environment. However, care and attention must be paid toward the proper application of chemical controls to prevent contamination of drinking, ground and surface waters, as well as to limit impacts on of wildlife and aquatic populations.

The strategy for minimizing pesticide use at Honua'ula will include but not be limited to the following.

1) Plant turf species adaptable to climatic conditions found on the leeward coast of eastern Maui.
2) Use sound cultivation management practices and irrigation management to minimize pesticide use (section C above).
3) Use best management practices and sound environmental technology for inclusion in the baseline data of pest management practices.
4) Use spot treatments to provide early, effective control of problems before damage thresholds are reached.
5) Minimize transport to surrounding environments (e.g., do not apply during periods of heavy rainfall, high winds, or periods when there is high potential for chemicals to be quickly transported away from the designated areas).
6) The golf course superintendent will employ the necessary assistance, support, and technology that will be needed to provide the very best in turf management.

Licensed applicator(s) and their registered employees will be the only individuals applying pest control products to ensure that appropriate application and safety measures are performed. Suitable personal protective equipment (PPE) will be worn whenever chemicals are used.

Additional pesticide application recommendations can be found in Part 4 of this report.

G. Waste Management and Waste Reduction

This section satisfies Zoning Condition 18 'h', which is also condition 10 of the DOH's '12 conditions.' These conditions relate to the County of Maui's Department of Environmental Management's concerns and recommendations relating to solid waste disposal, and solid waste management. This section describes methods that Honua'ula will use to reduce the amount of solid waste produced and strategies to reuse waste products.

There are several strategies that managers can implement to minimize waste and maximize recycling. The neighboring Grand Wailea Resort prides itself on being 'green.' This means they reduce waste, recycle waste products when possible, and conserve natural resources when possible. The Wailea Resort also incorporates their landscape waste (grass clippings, mulch, trees, etc.) into a composting program. For example, EKO (located in Puunene, Maui) manufactures and sells compost. The Wailea Resort collects all greens waste (e.g., grass clippings, landscape waste, etc.) and incorporates them into EKO's manufacturing process, which the Wailea Resort eventually buys back as high quality fertilizer. The golf facility at Honua'ula will strive toward a program similar to The Wailea Resort for managing green waste. Maui Recycling Group, Inc., Pukalani, Maui, is a firm that can be contracted to design and implement a facility-wide reduction and recycling program. This will provide the Honua'ula facility with an effective resource conservation program.

Strategies that the facility can apply to reduce the amount of products that eventually accumulate in discarded trash include reducing the use of paper products, and converting to computerized tracking and send/receive electronic communications. Other strategies that reduce waste exportation include the use of refillable containers that can be recycled after use, drinking fountains that need no cups, investing in more durable equipment or products, and bulk purchases of fertilizer and amendments to reduce the number of bags and packages.

1. Green Waste

The use of organic waste material generated on-site is a central part of an environmentally sound waste management and waste reduction strategy. Consistent with reducing the amount of waste generated, every attempt should be made to export as little as possible. A company such as Maui Recycling Group, Inc., Pukalani, Maui, can design and incorporate a green waste, composting, and recycling program for Honua'ula.

Grass clippings will not be removed in fairways, roughs and other turf areas. Clippings will be removed from greens and tees. They will be incorporated into the final compost pile (location TBD) or placed in a bulk spreader and spread in rough areas every couple of days. The final composted product can be applied as topdressing and has been proven to reduce the dependency on chemical treatments. For example, Mike Burgett, Landscape Director at Wailea Resort, has cut his insecticide treatments by 80%, after using EKO compost (Burgett, 2006), most likely because the improved health and vigor of plants increase their tolerance to insect pests.

2. Chemical Waste

Applicators use specific techniques to minimize the amount of chemical waste and/or overuse of chemicals. Pesticides are very expensive; therefore efficient managers tend to mix and load only what is needed. Often the excess solution is sprayed on roughs or used in the next spray tank. Small quantities of remaining spray solution and wash-down water from the wash area should be drained into a closed loop retention sump and treated for future use. Examples of effective wash-down water treatments are carbon filters and Waste2Water™ ozone treatment systems. The list below includes recommended techniques that will minimize the amount of chemical misapplications and reduce the amount of waste produced.

- Select spraying equipment that is appropriate and versatile (i.e., to prevent the over spraying and waste of chemical material).
- Use computerized control systems to achieve the exact gallons applied and ground speed of spraying equipment such as the Toro ProController™.
- Ensure that all spraying equipment is properly calibrated and checked at least once a year by a licensed pesticide applicator or a representative from the manufacturer of the equipment.
- Use spray-dye indicators and/or foam makers to avoid overlaps and misses during applications.
- Select the appropriate size of spray nozzles to cover intended acreage with the appropriate number of spray tanks (i.e., select nozzles which maximize efficiency).

Chemical waste that is generated will be disposed in accordance with the label directions, e.g., triple rinsing, recycling, or returning to the manufacturer. Rinse-water must be disposed in such a way as to avoid point and non-point source pollution, through recycling or spraying out diluted compounds in previously untreated areas. Used motor oil, electric batteries, or unused solvents are examples of other waste products that will be recycled or disposed according to State of Hawaii law and community disposal techniques (§342H, HRS) (DOH, 2006).

H. Botanical and Wildlife Resources Management

Honua'ula will not impact any Federal or State of Hawaii listed rare, threatened, or endangered plant species, as none were identified on the property. One plant species, the native *ʻāwikiwiki* (*Canavalia pubescens*), is listed by the United States Fish and Wildlife Service (USFWS) as a candidate endangered species.

Honua'ula is not expected to significantly impact any endangered animal species. Evidence of the endangered Blackburn's sphinx moth (*Manduca blackburni*) was found within the Honua'ula property and a single endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) was sighted flying seaward over the property. No other Federal or State of Hawaii listed rare, threatened, or endangered animal species were identified on the property.

A Habitat Conservation Plan (HCP) will be prepared under Section 10(a)(1)(B) of the Endangered Species Act and in collaboration with the State of Hawaii Department of Land and Natural Resources and the USFWS. The HCP will provide for a partnership between Honuaʻula, the State, and the Federal government to conserve the ecosystem upon which listed species depend, and will ultimately contribute to their recovery.

Honua'ula Partners LLC will comply with the County of Maui Ordinance No. 3554 regarding conditions 7, 8, and 9 (see EISPN, 2009 for details).

I. Education and Outreach for Regular Golfers & Maui Junior Golf

It is important to incorporate the daily golfer into the management plan; golfers must recognize that golf courses are managed land areas that complement the natural environment. Golf courses are much more than the stereotypical green grass, blue water, and white sand that most people envision. The superintendent and maintenance staff should produce literature to inform daily patrons and/or annual members about the specifics of the golf course management techniques. Golfers must be encouraged to respect environmentally sensitive areas within the course, and accept the natural limitations and variations of turfgrass plants growing under conditions that protect environmental resources (e.g., brown patches, thinning, loss of color, etc.). Environmental conservation plans -- consistent with the golf course's overall goal of existing as part of the surrounding environment -- must extend beyond the immediate maintenance and management staff to the golfers who use the services of the golf course. It is the responsibility of the superintendent and his or her maintenance team to inform golfers about

environmentally friendly maintenance practices such as reduced pesticide use, reduced fertilization, limited play on sensitive turf areas, and reduced watering. This can be achieved through educational notes associated with the scorecards and poster signs. Additionally, golfers should educate other golfers and the general public about the benefits of environmentally responsible golf course management that they learn from the Honua'ula golf course.

Another opportunity for environmental education and outreach is through programs with the Maui Junior Golf Association. County approval conditions 12(a) and (b) require access to the golf course by junior golfers. (The specific details can be found in the two subsections/paragraphs.) This will be an excellent opportunity to educate the youngsters about the following measures implemented at the golf course: energy conservation, water conservation, habitat restoration, and habitat protection. We recommend that this be done via short, informal discussions, perhaps twice per year, led by the golf course superintendent and, perhaps, a biological consultant.

Finally, the golf course could prepare an 'environmental scorecard' to give to the junior golfers. This will be a list of wildlife that might be observed on the course during play. Such sightings should be recorded in association with the golf holes where they are observed. This will be an educational experience for the junior golfers, and it will help the golf course track the effectiveness of its habitat restoration and protection measures.

PART 4: INTEGRATED PEST MANAGEMENT (IPM)

This section satisfies, in part, condition 18 'f' of the Zoning Conditions with respect to chemical applications performed in accordance with label instructions. Further, incorporating modern Integrated Pest Management (IPM) strategies will optimize success of the employed pest control methods. (These methods satisfy condition 11 of the '12 DOH conditions.')

Please note that this Part is complemented by the text in Parts 1-3 above. This Part is not independent of the others.

A. Overview of IPM Strategies

Managing turfgrass in an economical and ecological manner requires the implementation of sound pest management strategies that use reasonable approaches to turfgrass quality and provide acceptable safeguards for human health and the environment. Integrated Pest Management (IPM) is an interdisciplinary program that manages pest control tactics in a single system to prevent unacceptable levels of pest damage. IPM uses the least toxic control approach to address pest problems, only using chemical controls when other strategies are not effective. ***Appropriate control methods are generally not designed to eradicate pest populations but to manage turfgrass in the most economical way with the least effect possible on people, property, and the environment.***

The successful use of IPM avoids the conventional spray approach to pest management and is likely to reduce pesticide usage by 30% or greater. This approach will ultimately develop hardier turfgrasses and increase the population of beneficial organisms and natural enemies to pests. Control tactics are implemented based on pest populations and not by spray intervals and calendar dates.

There is no single pest control method available that provides complete control of turfgrass pathogens (pathogens cause disease), but the multifaceted IPM approach provides the best and most economical control of pests. Golf courses, like other agricultural commodities, are susceptible to occasional attacks from a rather complex list of pests (see Appendix F). These pests and causal agents may be observed during various climatic conditions and life cycles. They may be controlled by a variety of turfgrass methods.

With the IPM system, pest populations are monitored such that an appropriate treatment is implemented when pest pressure exceeds the action tolerance level of damage to turf. A threshold is a level of damage or potential damage such as the number of insects or weeds per square foot of turf. Thresholds for pest infestations and turfgrass diseases are provided in Tables 2-5 of Appendix F (Pest Infestation Tables and Threshold Guidelines). The treatment may be one of a variety of pest control measures (e.g., mechanical removal, biorational products, chemical treatments, etc.). The IPM system will work on every defined management area but must be tailored for each tee, green, fairway, and rough.

B. Objectives of IPM

The following are inter-related guidelines that will help the golf course superintendent to achieve the goals of IPM, thereby enabling a strategy of pest control rather than pest eradication.

- Develop healthy turf and ornamentals that can withstand pest pressure.
- Keep damaging insects, weeds, and diseases at or below acceptable threshold levels.
- Use natural control methods (biological, cultivation, mechanical, and physical) that will maximize beneficial organisms rather than destroying them.
- Use chemicals more wisely, less often and/or in lower quantities.
- Develop a strategic approach for the continued presence of harmful species that will remain as host for aerobic fungi, bacteria, parasites, and predators.
- Time chemical treatments more precisely at vulnerable pest stages and thereby more effectively and economically control pests.
- Accept a certain level of loss or damage to the turf areas (develop a threshold of response).

C. Developing an IPM Incorporated into the Business Plan

The golf course superintendent must develop a time plan with a step-by-step approach that identifies the type of resources that will need to be available. The plan should include a statement and purpose on the level of maintenance that must be provided. There should be a sufficient level of technically trained staff available to carry out the plan.

The plan should include the following resources:

1) Knowledgeable staff trained to implement an effective Integrated Pest Management Program.

2) Sufficient staff time to consistently monitor each management unit (tee, green, fairway and rough).
3) Proper equipment for ease of transportation and identification.
4) Availability of a diagnostic laboratory or the assistance of an advisory firm responsive to proper pest identification and control.

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A calendar that includes a list of all tournament play and normal play functions will assist in the proper timing of cultivation practices. This allows for control methods to be planned in advance providing the highest level of playability without hindering the control strategies in place. The calendar also should include a schedule for pest monitoring and provide documentation that a site-specific analysis has occurred.

The golf course superintendent should delegate a proper chain of command and appoint key personnel who will be trained as part of a monitoring team. It is best for at least three people to be designated as 'scouts' to avoid confusion and misdiagnosis of turf pathogens. These staff will report directly to the golf course superintendent and will be responsible for daily monitoring of each playing unit within the golf course system.

D. Monitoring Control Systems

Monitoring control systems will provide the basis for developing economic thresholds and determining any actions necessary for control. It is anticipated that a maximum of two hours per day will be needed in order to implement and effective monitoring control program. The system should be simple, accurate, and part of the daily regimen for turfgrass management. A thorough understanding of potential pest species will be required of each member of the monitoring team. An assessment of the role that beneficial organisms provide will be performed before any organism is identified as a pest. A secondary pathogen may be a pest under certain conditions but may also provide a balanced beneficial role in similar turfgrass situations. The observation team should note any visual reduction in turfgrass quality and accurately secure the proper information regarding the phenology (or life cycle) of the pest.

Pests may be defined as bacteria, plant pathogenic fungi, insects, nematodes, rodents, viruses, weeds etc. The information obtained through monitoring will provide site specific educational knowledge and limit the levels of predictable loss to turfgrass.

The golf course superintendent must require documentation of the location and the environmental condition of the causative agent affecting the plant species. The importance of the pest should be noted on a scouting form, which also should include the biological,

environmental, and physical factors affecting the presence of the species. For example, an excellent time to observe mycelium is prior to removing the dew from the playing surfaces. The visible detection of sclerotia will provide a good indication of the potential for movement of the pathogen on the host biotic tissue. In the early stages of development, active disease is easier to identify, when dew is present on the turfgrass. This can be performed prior to mowing without interrupting the players.

The level at which the pest population or its damage endangers crop quality is often called the economic threshold (Bohomont, 1990). Detailed point sampling (i.e., number of insects), should measure the density of the pest population relative to their damage on the area of turfgrass. This information will be used to determine site-specific threshold levels for the golf facility at Honua'ula. Actual field observations can be used to fine tune the limits of the pre-determined threshold action levels.

Pest occupancy is very weather-dependent; therefore it is necessary to observe pest populations for several years to have a good idea about the range of pest problems. It will likely require at least three years for development of a comprehensive database to establish site-specific baseline pest occupancies.

Additional samples should be taken to determine the level of infestation (high and low). Random sampling will provide additional documentation on the potential impact to the entire acreage. Accurate field data will allow the golf course superintendent to make reasonable and timely decisions about when to apply the appropriate method for control. The monitoring process will gain confidence and experience in all levels of the management personnel.

The experience using IPM will produce effective control and tolerance of pest population outbreaks. It will be through this knowledge that the golf course superintendent will be able to realize the fallacy of relying solely on chemicals for control.

The golf course superintendent will develop a tracking procedure to evaluate and predict when conditions exist that would encourage damaging pest populations. The skills obtained will allow the superintendent to be a leader in pest management control. This will also generate information on the success of the applied control measures against the pest(s).

An example of a monitoring and scouting summary report is provided as Appendix G. This can be used to determine the appropriate treatment based on specific areas.

E. Control Measures

Pest infestation tables and guidelines for managing these infestations (thresholds) are described in Appendix F. The different types of actions (cultivation, biological, and chemical controls) which are used to efficiently manage pest infestation are described in the following sections.

1. Turf Cultivation and Nutrient Management

An overview of cultivation techniques was provided in Part 3(C) above.

It is often assumed that the main reason that a golf course needs to be fertilized is to make it look green. The color of the grass is important, but it is only secondary to the many other important functions in the plant. A fertilizer/nutrient management plan provides a superintendent with the site-specific guidelines and plant requirements to maintain healthy turfgrass, avoiding the over-application of nutrients resulting in transportation of dissolved nutrients offsite. The goals of a fertilizer/nutrient management program are to:

- Be environmentally responsible.
- Produce a healthy stand of turf that can recuperate from damage caused by diseases, insects, as well as traffic from golfers and maintenance equipment.
- Produce a healthy, visually attractive playing surface, but not at the expense of the root system.
- Make the golf course competitive against the invasion of weeds.
- Provide the necessary amount of nutrients, being careful not to over-fertilize. Excess nitrogen can increase the need for irrigation and increase the potential for leaching. A fertilizer deficit can reduce the competitiveness of the turfgrass and lead to the invasion of weeds, insects, disease, and heavy traffic).
- Apply organic fertilizers (e.g., compost) that feed the soil stimulating naturally occurring microorganisms, and provide plants (turfgrass) with food and natural protection from harmful pests and diseases.

Approximately half of the nitrogen fertilizer applied to turfgrass is incorporated into the plant; the other half can be found stored in the soil and lost to the atmosphere. Thus there is limited fertilizer nitrogen remaining that can leach into ground water or be transported as runoff into surface water (e.g., Petrovic, 1990; Cohen et.al., 1999). Golf courses can be managed so nitrogen from fertilizers does not contaminate ground water supplies (Petrovic, 1990; Cohen et.al 1999).

Table 1 below provides the nutrient requirements for seashore paspalum. ***Seashore paspalum requires significantly less nutrients than bermudagrass turf.*** These nutrient requirements can be reduced with proper water management and traffic control.

Table 1. Seashore Paspalum Nutrient Requirements (Greens, Tees, Fairways, and Roughs)

Nutrient	Application rate
Nitrogen (N)	0.2 - 0.6 lbs per month*
Phosphorous (P)	0.1 - 0.3 lbs per month*
Potassium (K)	0.2-0.6 lbs per month*

* slightly higher applications for greens and tees because of clipping removal.

These nutrients can be obtained in a variety of organic and inorganic sources, and nitrogen is available in quick and slow releasing forms. Applications will be properly timed by the golf course superintendent and carefully applied for maximum benefit. A nutrient management plan will be developed by the golf course superintendent. To develop this plan, the superintendent should consider the soil analytical results in Appendix E, and the nutrient discussion in the original management plan (Durborow et al., 1992, section VI(F)).

2. Biological Controls

'Biorational'/'organic' products (fungi, bacteria, viruses, nematodes, and non-target insects) should be used whenever it is feasible, and there is a scientific basis to support their use (i.e., cost effective, efficient, amount of pest pressure, etc.). Biorational products can provide an effective and efficient method of eradicating disease and other pest pressures. Additional methods, such as applying composts containing microorganisms as top dressing and the use of compost teas may also suppress diseases before they harm turfed areas. EKO Compost manufactures and sells compost and compost-based mixtures. One of their branch locations is located in Puunene, HI on the Island of Maui. EKO compost, when applied as top dressing, has been shown to improve yellowing areas on tees and fairways (Burgett, 2006; EKO, 2006).

3. Chemical Controls

Chemical treatments should only be used when a pest is present at significant levels to cause damage and should only be applied when the pest is most vulnerable to the pesticide (i.e., in juvenile stages of development) and when the environment is best suited to manage the

application (e.g., do not apply pesticides when soil is saturated, or during windy or rainy weather, decreasing the amount of potential drift and surface water runoff). If the pest infestation is limited in scope, the superintendent is encouraged to use spot treatments when possible. It is also important when applying chemical controls that equipment is properly calibrated and adequately maintained. Table 2 below lists the pesticides that will likely be used on the golf course during the first five years of operation; however, they will not be used at the same time, but only as needed. (Appendix H contains information on the mobility, persistence, and toxicity of these pesticides.) This relatively small list includes three products that many call 'organic' or 'natural.' The recommended pesticides have undergone a water quality risk assessment (Appendix H).

Pesticide use should be rotated (use alternative chemicals, or alternative pest control methods and cultivation controls) to reduce the possibility of pests becoming resistant to the applied chemicals, and also to reduce the frequency of chemical applications.

Below are the policy recommendations that will be used when applying pesticides for the Honua'ula golf course.

- The pest will be properly identified. The use of disease, insect, and weed identification guides will be used. Diagnostic aid kits/methods will be used on pathogens.
- Extension service, commercial, and/or university laboratory assistance will be used to identify any unknown pathogen activity.
- The golf course superintendent will identify and document when the threshold of pest activity has been exceeded.
- Pesticide applications will be used only when there is no alternative measure for control.
- The actual application of a pesticide will be made under the direction of a certified, licensed applicator.
- The golf course superintendent will be a licensed applicator in the following categories: aquatic weeds, turf, and ornamentals.
- All pesticide applications will be made in accordance with label specifications.
- Minimizing drift from the target areas will require applications not be made in winds in excess of 15 knots. Winds in the vicinity of 5-15 knots are acceptable using a windfoil (shrouded) spray system.
- All protective clothing as specified by the label will be worn by the applicator (see Part 3(A)(4) above).
- Liquid application of a pesticide will be made using a low pressure boom-type sprayer with nozzles sized to produce fine to medium droplets resistant to drift. Boom height should be no higher than 18 inches above the turf.

Table 2. Preliminary Pesticide List for Use on the Honua'ula Golf Course*

Common Name	Trade Name	Recommended App. Rate lb/a.i./Ac	Projected No. of App./Yr (Max.)	Projected Maximum Annual Total a.i./Yr.	Max. Acres Treated	Areas Treated
HERBICIDES						
Glyphosate	Roundup	2.0	2	4	5.0	R
Foramsulfuron	Revolver	0.026	1	0.026	30	G T F
Quinclorac	Drive	0.75	2	1.5	60	T F R
2-4-D	Trimec	1.23	2	2.46	60	T F R
Dicamba	Trimec	0.65	2	1.3	60	T F R
MCPP	Trimec	0.12	2	0.24	60	T F R
Halosulfuron	Sedgehammer	0.062	2	0.124	50	F R
Oxadiazon	Ronstar G	4.0	2	8.0	60	T F R
Potassium Salts of Fatty Acids±	M-Ped	1.35	3	4.05	30	R
INSECTICIDES						
Bacillus thuringiensis±	Bio-bit	0.25	3	0.75	3	G
Spinosad±	Conserve	0.42	2	0.84	36	G T F
Fipronil±	ChipcoChoice	0.025	2	0.05	50	F R
Indoxacarb±	Provaunt	0.075	2	0.15	6	T G
Bifenthrin	Talstar	0.05	2	0.1	36	T G F
Imidacloprid	Merit	0.40	1	0.4	50	F R
FUNGICIDES						
Chlorothalonil	Daconil	4.1	4	16.4	6	T G
Propiconazole	Banner	0.44	2	0.88	36	T G F
Boscalid±	Emerald	0.35	1	0.35	36	T G F
GROWTH REGULATOR						
Flurprimidol	Cutless	0.25	4	1	33	F T

*Appendix H contains information on the mobility, persistence, and toxicity of these pesticides. This pesticide list should be appropriate for the first five years of golf course operations. It is likely that only a small subset of these will be needed during the first two years of operation. The application rates listed below are recommended; however, some products were risk assessed using a higher rate. Thus the potential risk to the environment would be lower (see Appendix H).

± These pesticides are commonly called 'natural' or 'organic' products and/or they have been registered by the US EPA under the Reduced Risk program.

- No pesticides will be applied within fifty feet (50') of any sensitive area.
- Notification of pesticide applications will be made to alert the facility staff and golfers.
- All pesticide applications will be posted prior to the application and will remain posted for a minimum of 24 hours.

The golf course superintendent will be responsible for the administration of the above policies.

a. Summary of Risk Assessment to Ground Water and Surface Water

The DOH reviewed and gave final approval of the original risk assessment and management plan in 1993 (Appendix C, finding #67). (The SLUC finding that this project was not expected to significantly impact the environment was based, in part, on that DOH-approval document.) However, this project has evolved, and it has been necessary to amend the pesticide list for two reasons: the pesticides registered for use in Hawaii and nationally have changed since 1992, and the turfgrass planned for this golf course has changed from bermudagrass to seashore paspalum (Part 3.B). Therefore the pesticide requirements are expected to be different, which affects the list of recommended pesticides. Thus, we reevaluated the pesticides that will likely be used on the golf course.

Our 1992 report (Durborow et al., 1992) thoroughly evaluated potential ground water and surface water contamination risks of 16 pesticides and metabolites using hundreds of site-specific and chemical-specific input parameters. The complex USDA model SWRRBWQ (subsequently renamed SWAT) was used for the stormwater runoff evaluation, and the US EPA's linked PRZM-VADOFT model was used to estimate potential ground water contamination impacts. This work required hundreds of person-hours of work. Therefore instead of using the more labor-intensive models, we decided to use two of EPA's tier I conservative screening level models to evaluate the newly proposed pesticides (Table 2): GENEEC (surface water) and SCI-GROW (ground water).

The details and results using the more conservative screening level models for the current pesticides proposed for use are presented in Appendix H. The new risk assessment results show that the pesticide proposed for use as presented in Table 2 pose no higher risk than the DOH-accepted results.

b. Aerosol Drift Control

There are windy conditions on Maui throughout the year. Particularly in the afternoons the wind tends to increase and shift directions. The potential for pesticide drift to adjacent properties and sensitive areas can be minimized by applying on days when wind is minimal and applying at the times of day (early morning, late evening) when winds are naturally diminished. The spray equipment should have lights suitable for use in low light conditions. Nozzle selection can also aid in drift reduction. Nozzles with larger droplet sizes such as Turf-Jet® nozzles reduce drift. Nozzles must be operated within an acceptable pressure range as well to avoid drift.

The use of drift control devices, such as the 'windfoil' shrouded sprayer made by the Rogers Sprayers Inc., gives the applicator more control and essentially eliminates the potential for drift of sprayed pesticides to non-target areas. Verification of wind and environmental conditions will be recorded by the environmental Pestcaster™ or from the irrigation system weather station. The Pestcaster™ will provide the superintendent with accurate weather information for proper timing of any application.

The use of an on-site weather station will be used to measure wind speed and direction. Boom sprayers (unshrouded) will not be used if winds exceed 8 mph. The use of a windfoil style sprayer will be allowed for pesticide applications during wind speeds ranging from 8-20 mph. No pesticides or irrigation will be applied if winds exceed 20 mph.

Pesticides are not likely to drift to homes and resort dwellings off-site (typically 100 ft to 150 ft away from managed turf areas). Approximately 65-70 ft of drift may be expected when crosswinds are 15 mph. All pesticide applications should be prohibited when wind speeds exceed 20 mph.

F. Evaluation of IPM

Periodic evaluation of the IPM strategies will be completed to determine the effectiveness of the plan. Evaluation will analyze treatment results, review pest records and record keeping, audit monitoring techniques, compare pre- and post-IPM implementation and treatment successes, as well as make any adjustments to the IPM plan as necessary. It is especially important to re-evaluate the pesticide list in Table 2 to determine whether it needs to be

supplemented and/or whether new products have entered the market that are low in risk and are cost-effective.

PART 5: SURFACE AND GROUND WATER PROTECTION

Surface and ground water protection is a priority for the Honua'ula golf course, and these considerations will be taken into account during the design phase to ensure the protection of the Island of Maui's surface and ground water resources. Previous Parts of this document (1, 2, and 3) included BMPs to protect water resources through the collection of runoff and reuse/recycling of the wastewater. Additionally, natural areas (described in Part 3(A)) will serve multiple functions including the protection of surface and ground water resources. These natural areas, requiring little maintenance, provide natural hydrologic regulation to prevent stormwater runoff from contacting waste and raw material storage areas. Waters discharging off the property will be appropriately managed to not impact the surrounding water resources of Maui. See Parts 1, 2, and 3 for specific design characteristics such as vegetative swales, recycled material, stormwater management, and construction (see Part 1(C)).

A. Erosion and Sediment Control

Erosion and sediment loading is a significant concern when developing and constructing a golf course. See Part 1: Site Selection, Design, and Construction, under the Structural Control Program.

Minimizing the amount of exposed soils at any one time will help to reduce the amount of erosion during construction. Semi-annual inspection of stormwater drainage pathways will be conducted to determine the location and extent of any erosion to further reduce soil erosion. In some cases, geomorphic modification of drainage ditches may be required to prevent future erosion problems. Preserving as much existing vegetation as possible can help to secure erosion prone areas.

B. Turf Management

See Parts 3 and 4 for appropriate management and control strategies for turfgrass areas, as well as pesticide applications for managing turfgrass infestations (see also Appendix F for pest infestation and threshold tables).

C. Equipment Maintenance, Chemical Storage and Mixing Areas

It is recommended that Honua'ula use a state-of-the-art boom sprayer (manufactured by the Toro Corporation or similar manufacturer) for pesticide applications. Computerized flow meters, independent boom separation, ground tracking speed, calibration for precise liquid applications, windfoil boom protection, and a sonar boom leveler will be provided on this vehicle. The sprayer will be maintained to the highest standards and will immediately cease operation if any failure is noted by the golf course superintendent or operator. This vehicle will be totally self-contained and will only be used to apply pesticides to the designated target areas.

For further details about the maintenance facility, equipment maintenance, chemical storage, etc. refer to Appendix B Facility Operations Manual and Emergency Procedures.

D. Spill Response

The Facility Operations Manual and Emergency Procedures (Appendix B) and the IGCMP (Durborow et al. 1992) contain emergency procedures and a spill response plan for the golf course.

E. Waste Management Plan

See Part 3(G) above: Operations, Maintenance - Management Plan; Waste Management and Waste Reduction.

PART 6: MONITORING PROGRAM

A ground water quality monitoring protocol was developed to satisfy the 2002 DOH Guidelines Applicable to Golf Courses in Hawaii (DOH, 2002; see Appendix A.2). The Protocol (Appendix I) satisfies Zoning Conditions 18 'a' and 'b' of Exhibit 2. Appendix I also satisfies conditions 1-3 of the DOH's '12 Conditions' (Appendix A.3) relating to water quality monitoring.

Nearshore water quality and ground water quality will be monitored until such time as the DOH certifies that no further monitoring is needed.

A. Ground Water

"Hawai'i State Department of Health Guidelines Applicable to Golf Courses in Hawai'i", July 2002, was used to develop the water quality monitoring protocol at the Honua'ula golf course. The protocol was prepared in accordance with the 2002 DOH guidance (Appendix A.2). The objective of the protocol is to present and implement a ground water monitoring study design that can produce reliable quality data.

The portion of the basal aquifer under the site appears to have a thin lens of fresh water. This conclusion is based, in part, on chloride concentrations measured in two of the irrigation wells. However, most of the site is below the Underground Injection Control (UIC) 'no-pass line', and chloride concentrations are likely to increase once the wells begin pumping heavily for irrigation.

Ground water discharges to the ocean and may flow within the influence of five irrigation wells of the Wailea resort complex, which is makai of the site. Therefore the purpose of this two-part study is to determine the extent to which turf chemicals may migrate from the Honua'ula golf course to ground water and to the coastline.

Tentatively, two monitor wells are proposed for installation onsite. In addition, an existing irrigation well will also be used for monitoring ground water quality. The irrigation well will be used as a background well and the remaining two wells will monitor ground water downgradient of managed turf.

Four rounds of samples will be collected from the selected monitoring wells and prior to construction to obtain baseline water quality data. One round will include a comprehensive pesticide list, inorganics, and field parameters. The remaining three rounds will include inorganic and field parameters only. Wells will be sampled semi-annually during the routine monitoring phase during golf course operation. The first routine monitoring samples will be collected six months after golf course operations begin.

The pesticide and nutrient analytes specified in Appendix I are based on the turf management program and the ongoing marine monitoring program (Appendix J). Standard field parameters such as pH, temperature, etc. will be included.

A contingency plan is proposed that would trigger pesticide use restrictions or bans if pesticides are detected at predetermined concentrations.

B. Nearshore Coastal Monitoring

The nearshore coastal monitoring described in this section and Appendix J satisfies Zoning Condition 20 and SLUC Condition 13. Hawaii DOH, which is the agency responsible for the TMDL program described in Zoning Condition 20, has not developed the TMDL program for any marine areas off of Maui.

Baseline monitoring of nearshore coastal water that specifically considers this project began in 2005 (Marine Research Consultants, 2005). This was done in the context of related and indirectly related monitoring that was done in the same area in 1990 and from August, 1995 to February 2003. The latter monitoring was done for the Wailea Resort, and future monitoring will be done specifically for Honua'ula.

Annual samples are collected from seven stations along each of five transects perpendicular to the shoreline (35 sampling locations). Well water is also sampled. Analytes include nutrients and standard marine chemistry parameters. Appendix J contains the most recent nearshore coastal monitoring that was completed in September 2009 (Marine Research Consultants, 2010).

There have now been six rounds of nearshore coastal and associated well monitoring done for the Honua'ula project, as of September 2009 (Marine Research Consultants, 2010) and will continue on an annual basis.

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APPENDIX A. Hawaii DOH Documents

A.1. DOH Golf Course BMPs (2005)
A.2. DOH "10 Conditions" (2002)
A.3. DOH "12 Conditions" (1992)

A.1. DOH Golf Course BMPs (2005)

GOLF COURSE
BEST MANAGEMENT PRACTICES

Introduction

Golf courses impact the environment in which they are built and operated. During golf course construction, site clearance often disturbs the site and removes trees, shrubs and other vegetation. Site grading may cause loss of topsoil and erosion. Golf course management requires fertilizers, pesticides, herbicides and massive amounts of water applied to turf. Some potential risks from these activities include human exposure to chemicals, groundwater contamination, disturbance of ecosystems, and harm to plants and animals.

Golf courses should develop and implement a comprehensive environmental management plan to conserve water, protect surface and groundwater quality, minimize erosion, and preserve and protect native plant and wildlife habitats. The management plan should address water pollution prevention and abatement, Integrated Pest Management, nutrient management, irrigation, water quality monitoring, and wellhead and source water protection.

Best management practices (BMPs) can help prevent and alleviate some of the negative environmental impacts of golf courses. BMPs are effective and practical strategies to prevent pollution and reduce the amount of pollution generated by specific and non-specific sources. BMPs are based on science, holistic in approach, incorporate all possible strategies to address an issue and consider economic and environmental implications.

The Hawai`i State Department of Health has prepared guidelines for all golf courses to promote, protect and enhance environmental quality and public health. Please refer to the Department of Health's Guidelines Applicable to Golf Courses in Hawai`i, July 2002. If a golf course uses recycled water (treated wastewater), please refer to the Department of Health's Guidelines for the Treatment and Use of Recycled Water, May 15, 2002.

The following BMPs were developed for golf courses and are categorized into six parts: 1) Site Selection, Design and Construction, 2) Water Usage, 3) Operations and Maintenance, 4) Integrated Pest Management (IPM), 5) Surface and Groundwater Protection, and 6) Monitoring Program. Please refer to the specific sections for detailed BMPs.

Part 1: Site Selection, Design and Construction

Every golf course site will have environmental issues and conditions that need to be addressed. The site selection, design and construction of golf courses should use natural resources efficiently, enhance the community economically and ecologically, provide important green space benefits, respect adjacent land uses and create desirable playing conditions through practices that preserve environmental quality.

Part 2: Water Usage

Water source(s), water conservation, water usage, and water quality are important and critical components of golf course management. Effective golf course water management is essential given a limited supply of water, increasing water use demands and water restrictions during drought conditions. Golf courses should develop an Irrigation Plan that identifies management zones and irrigation requirements for each management zone. Precise and efficient irrigation will conserve water and result in healthy and stress tolerant turf.

Part 3: Operations and Maintenance

A comprehensive environmental management plan will provide a scientific, rational and responsible way to make decisions. Some operating and maintenance aspects of an management plan include: turf management, chemical management, water usage, facility operations, waste management, and wildlife management.

Part 4: Integrated Pest Management (IPM)

Most turf grasses are susceptible to a variety of pests including weeds, diseases, insects as well as rodents, birds and pets. Establishing a pest management program requires planning, knowledge of turf grass culture, an understanding of pests and the damages they cause, pest life cycle, pest cultural conditions, and methods of control. Integrated Pest Management (IPM) is a pest management system that incorporates all suitable control techniques to keep pest damage below an established threshold level. Various pest control options include biological, genetic, and chemical controls.

Part 5: Surface and Groundwater Protection

A number of design and management practices can help protect surface and groundwater. Buffer zones, stormwater management, erosion and sediment control, turf management, waste management practices can help protect surface and groundwater sources. In addition, the proper handling, storage and disposal of equipment and materials and timely response to spills and accidents can have significant impacts in protecting water quality.

Part 6: Monitoring Program

Monitoring programs help to demonstrate that environmental impacts are negligible, or that environmental impacts must be mitigated. Operational and environmental monitoring programs should be included as BMPs for golf courses. A water quality monitoring plan will help prevent and minimize surface and groundwater contamination by monitoring (1) runoff and leachate within the golf course, (2) the impacts of the golf course on adjacent water bodies, and (3) the impact or potential impact of the golf course on the underlying groundwater aquifer. The minimum parameters for groundwater monitoring are outlined in the State of Hawai`i' Guidelines Applicable to Golf Courses in Hawai`i, July 2002.

GOLF COURSE
BEST MANAGEMENT PRACTICES

Part 1: Site Selection, Design and Construction

Every golf course site will have environmental conditions that need to be addressed. Golf course site selection, design and construction should use natural resources efficiently, enhance the community, provide green space, respect adjacent land uses and create desirable playing conditions that preserve environmental quality.

Site Selection

- Hire and work with a golf course manager/superintendent early on in the site selection, design and construction process to develop sustainable maintenance practices.

- Work closely with local community and environmental groups, and regulatory/ permitting bodies during the planning, site selection, design and development phases to address local environmental issues and regulatory requirements that need to be met.

- Involve a team of qualified golf and environmental professionals to thoroughly analyze the positive and negative attributes of each site being considered and to determine the environmental, financial and management impacts of the site selection.

- Use extra precaution for certain types of sensitive environments such as wetlands, threatened or endangered plant or animal species, aquatic habitats and water bodies.

- Conduct a site analysis and site feasibility study to identify environmentally sensitive areas and other natural resources and incorporate them into the design to maximize environmental quality, playability and aesthetics.

Site Design

- Identify existing ecosystems; enhance and protect environmental resources that will allow efficient maintenance of the course and will likely reduce permitting and site development costs.

- Use experienced professionals to conduct a site analysis and feasibility study to identify environmentally sensitive areas and other natural resources so that the design can carefully balance environmental factors, playability and aesthetics.

- Minimize site disturbance where possible to maintain consistency with the topography and golf course design objectives.
- Site fairways to minimize cuts and fills, and avoid wetland crossings.

- Preserve existing vegetation such as forested or grassland areas as much as possible. Seek opportunities to create and/or preserve habitat areas that enhance local ecosystems.

- Use buffer zones to protect environmentally sensitive areas and to maintain high quality surface water. Consult with local regulatory agencies and environmental groups for advice on the design and placement of such zones.

- Use native or naturalized vegetation for areas that will not be in play. Use turf grasses that are best adapted to local conditions for areas that are in play. Both will maximize the efficiency of environmentally sustainable maintenance techniques.

- Design irrigation, drainage and retention systems to create efficient water usage and to protect water quality. Incorporate storm water retention and water reuse strategies to provide for short and long term irrigation needs to save resources.

- Design the course with sustainable maintenance in mind and incorporate integrated plant management and resource conservation strategies that are environmentally responsible, efficient, and cost effective. Integrated plant management should include integrated pest management and emphasize plant nutrition and overall plant health.

Construction

- Use qualified contractors who are knowledgeable and experienced in the special requirements of golf course construction.

- Develop and implement a construction sequence plan. Schedule construction to maximize efficient turf establishment, environmental conservation and resource management.

- Develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species and designated environmental resource areas.

- Minimize soil erosion by limiting the amount of exposed soil at any one time, using silt fences and mulching of exposed areas.

- Conserve topsoil during site grading and removal of existing vegetation. Use appropriate equipment such as excavators to remove stumps.

- Avoid soil compaction and keep rubber tire machinery except for landscape tractors to haul roads where possible. Use harrows, rotary tillers and or chisel plows to alleviate soil compaction.

- Amend soils low in organic matter with organic material to promote soil aggregation and increase water available to plants.

GOLF COURSE
BEST MANAGEMENT PRACTICES

Part 2: Water Usage

Water Conservation

Water conservation on golf courses is essential to its economic viability and should be addressed on a long term, sustainable basis. The following water conservation strategies provide numerous possibilities.

- ✓ Design golf course and landscape for water conservation
- ✓ Select appropriate turfgrasses and landscape plants
- ✓ Develop water conservation strategies for indoors and landscaped areas other than the golf course
- ✓ Use non-potable water sources for irrigation
- ✓ Design efficient irrigation system and use monitoring devices
- ✓ Schedule and operate irrigation system efficiently
- ✓ Provide continuing education for management, staff, golfers and general public
- ✓ Develop written conservation and contingency plans
- ✓ Monitor the effectiveness of conservation strategies and BMPs

Irrigation Plan

- Develop an Irrigation Plan that identifies management zones for greens, tees, fairways, roughs and landscape/natural areas, and irrigation requirements for each management zone.

- Identify BMPs for irrigation operations within each management zone.

- Specify irrigation patterns within each management zone.

- Utilize computerized irrigation management system with flow management to control and manage the timing, rate and frequency of irrigation to control runoff and leaching of water, to meet the needs of the plant materials, and to avoid over watering.

- Include soil-based irrigation scheduling that utilizes soil-based moisture sensors, including tensiometers, soil moisture blocks, soil moisture probes and other soil moisture sensing devices to time irrigation to replace available soil moisture.

- Establish an overall water conservation strategy that prioritizes turfgrass areas the require irrigation. Greens and tees should have the highest priority followed by fairways, roughs, ornamental plantings, and natural areas.

- Maintain accurate information on each management zone in the event that water restrictions occur.

System Layout and Leak Detection

- Design the irrigation system to allow individual sprinkler zones to operate independently

- Perform leak detection on a regular basis several times a year.

- Install water meters in critical locations throughout the irrigation system.

- Use isolation valves before all main lines and major laterals to be able to quickly shut off leaking areas before turf is damaged and water is lost.

- Make irrigation system design changes as needed to eliminate water going off target and excessive water application. Consider converting to valve-in-head (VIH) sprinkler control to reduce water use.

- Use irrigation consultants and Global Positioning System (GPS) software to conduct an irrigation system audit. Strive for 80 percent distribution uniformity (DU) to insure precise water application for optimal water conservation and turf health. A 10 percent DU improvement corresponds to 2½ percent to 5 percent water savings.

Irrigation Heads and Sprinklers

- Install low volume irrigation heads in new irrigation systems and in existing courses where feasible. Low volume sprinklers can reduce water loss due to evaporation, wind drift, leaching and runoff from sloping surfaces.

- Use low or adjustable trajectory nozzles to allow the irrigation manager the ability reduce the effects of wind evaporation during irrigation and to compensate for sloping areas.

- Choose sprinkler heads that do not exceed the lowest infiltration rate of the specific soil.

- Replace full-circle sprinklers with part-circle sprinklers to reduce water being applied to out-of-play areas.

- Use automatic controllers or portable hand-held devices, where feasible, to apply water more efficiently.

- Annually inspect and replace nozzles that are worn, partially clogged, or do not rotate freely.

- Use/replace correctly-sized nozzles in accordance with the position along the system, pressure head distributions and water requirements for the specific turfgrass and landscape position.

- Evaluate design criteria such as nozzle size, rotation speed, spacing, scheduling, and pressure selection to improve irrigation uniformity.

Irrigation Practices

- Apply enough water to turfgrass and plants to moisten as much of the root zone as possible without loss to drainage or runoff. Use a soil probe to determine the average rooting depth in a turf area.

- Recognize that all turf irrigation is not created equal. More water may be needed at the edge of a turf area to achieve equivalent turf quality compared to turf in the middle.

- Water at appropriate times to minimize evaporation and reduce potential for diseases. The most efficient time is late evening throughout early morning between 10 p.m. and 8 a.m. Night time is generally less windy, cooler and more humid, resulting in less evaporation and a more efficient water application. Irrigating at night does not stimulate disease development, contrary to popular belief.

- Use manual spot metering for high-priority management zone irrigation to conserve water.

- Keep accurate water use records along with weather data, such as high and low temperatures and wind speed. Accurate records enable fine tuning of irrigation operation for good stewardship of water resources.

GOLF COURSE
BEST MANAGEMENT PRACTICES

Part 3: Operations & Maintenance

Management Plan

A comprehensive management plan should be well documented and structured to provide a scientific, rational and responsible way to make decisions and should include the following:

Site description and site evaluation

- ✓ physical setting (preferably hole-by-hole, with the surrounding environment, drawings, and/or aerial photos to delineate where concerns must be focused)
- ✓ topography (how it intersects with natural areas and affects management practices)
- ✓ soils mapping (soil classification, fertility, percolation rates, depth to bedrock and/or groundwater)
- ✓ surface water features
- ✓ climate conditions (temperature, rainfall, potential evapo-transpiration that affect the growth of turfgrass and impact pest management strategies)

Golf course cultural practices

- ✓ mowing factors (species, cultivars and golfers' expectations)
- ✓ irrigation factors (slope, type of grass, cutting height/frequency, rooting depth, weather factors, soil types, irrigation system performance, inspection and maintenance)
- ✓ chemical factors (fertilizers, pesticides, application rates and procedures, monitoring, spills and accidents)
- ✓ supplemental practices (aerification, top dressing, vertical mowing)

Safety details (storage, handling, disposal, record keeping of pesticides, worker protection, employee-right-to-know, and OSHA)

The management plan should include a operating manual as part of the BMPs for a golf course that:

- ✓ documents operating procedures for routine and non-routine maintenance (i.e. turfgrass, pesticide and fertilizer management)
- ✓ identifies a management and reporting structure
- ✓ documents emergency response procedures
- ✓ describes the details of the monitoring program
- ✓ describes triggers for management action
- ✓ describes contingencies to deal with unexpected environmental and management conditions

Turf Management*

- Choose grasses that are suited to the local climate and growing conditions, preferably native species.

- Choose grasses that are drought and disease resistant with minimal loss of nitrogen through volatilization, leaching and surface runoff.

- Set mowers to remove no more that 1/3 of the grass height to improve infiltration and soil moisture retention, reduce surface runoff, and encourage deeper root systems.

- Use sharp mower blades to maintain healthy turf.

- Retain grass clipping on the course to encourage better thatch and moisture retention.

Chemical Management*

Golf courses use a variety of chemicals (fertilizers and pesticides) on the turf. The most commonly used pesticides on golf courses are fungicides, herbicides and insecticides. With careful application, pesticides can be safely used on golf courses, and potential dangers to humans and the environment and be minimized or eliminated. The improper use of pesticides and fertilizers may result in human health problems, contamination of drinking, ground and surface waters, and reduction of wildlife and aquatic populations

- Always read and follow label instructions when using any chemical and nutrient products.

- Treat problems at the proper time and under the proper conditions to maximize effectiveness with minimal environmental impact.

- Use spot treatments to provide early, effective control of problems before damage thresholds are reached.

- Store and handle chemicals and nutrients in a manner that minimizes worker exposure and the potential for point and non-point source pollution.

- Store chemicals properly and use suitable personal protective equipment and handling techniques.

* See also Part 5: Surface and Groundwater Protection for additional BMPs.

- Use nutrient products and practices that reduce the potential for surface and groundwater contamination. Strategies include using slow-release fertilizers, selected organic products and/or fertigation, the application of nutrients through irrigation systems.

- Use trained, licensed applicators to apply all plant and pest-control products or to supervise personnel.

- Encourage continuing education for applicators including state licensing, professional association training and IPM certification.

- Monitor the soil regularly to ensure that turfgrass needs are being met and not exceeded.

- Inform golfers and guests about golf course chemical applications.

Water Usage

- See Part 2: Water Usage.

Facility Operations*

- Conduct an environmental assessment to develop and implement an overall environmental policy and/or long-range plan.

- Maintain ongoing records to measure and document progress toward environmental improvement.

- Adopt and implement environmentally-responsible practices for all areas of the facility and grounds. Adopt practices and technologies that conserve natural resources, including water and energy.

- Develop and initiate comprehensive programs for recycling, reuse and waste reduction.

- Store and dispose of solvents, cleaning materials, paints, and other potentially hazardous substances properly.

- Take active steps to educate golfers, neighbors and the general public about the golf course's environmental policies and practices.

* See also Part 5: Surface and Groundwater Protection: Equipment Maintenance, Chemical Storage and Mixing Areas for additional BMPs.

Waste Management*

- Leave grass clippings and other organic materials in place wherever possible. If clippings are removed, compost and recycle them if possible.

- Dispose of chemical rinse-water to avoid point and non-point source pollution by recycling rinse-water, or spraying out diluted compound(s) in previously untreated areas.

- Dispose of chemical packaging according to label directions, e.g. triple rinsing, recycling, or returning to manufacturer.

- Recycle or dispose of waste products such as used motor oil, electric batteries and unused solvents according to the law and available community disposal techniques.

- Purchase products that minimize unnecessary packaging to reduce waste.

Wildlife Management

- Provide buffer strips along watercourses to create habitats for wildlife species whenever feasible and environmentally desirable.

- Manage habitats to maintain healthy populations of wildlife and aquatic species.

- Adopt a policy of no application of pesticide or fertilizer in naturalized wildlife habitat areas.

- Replant any eroded areas with native plant species.

- Remove any direct discharge of stormwater to surface waters or wetlands in favor of discharge to vegetated filter strips or swales.

What Golfers Can Do

- Recognize that golf courses are managed land areas that should complement the natural environment.

- Respect designated environmentally sensitive areas within the course.

- Accept the natural limitations and variations of turfgrass plants growing under conditions that protect environmental resources e.g. brown patches, thinning, loss of color.

* See also Part 5: Surface and Groundwater Protection for additional BMPs.

- Support golf course management decisions that protect or enhance the environment and protect wildlife and natural habitat. Encourage development of environmental conservation plans.

- Encourage and support environmentally friendly maintenance practices such as aerification, reduced fertilization, limited play on sensitive turf areas, reduced watering, etc.

- Commit to long-range conservation efforts, e.g. efficient water use, integrated plant and pest management, etc. on the golf course and at home.

- Educate others about the benefits of environmentally responsible golf course management.

GOLF COURSE
BEST MANAGEMENT PRACTICES

Part 4: Integrated Pest Management (IPM)

An Integrated Pest Management (IPM) system prevents and controls pests (e.g. (weeds, insects and diseases) by monitoring pests, identifying action thresholds, evaluating options, and implementing the most environmentally-beneficial control. IPM uses the least toxic control approach to address pest problems, and only uses chemical control when other strategies are not effective.

The fundamentals of an IPM plan include:

- ✓ Planning and managing turf
- ✓ Identifying potential turf pests
- ✓ Monitoring pest populations
- ✓ Establishing an action threshold
- ✓ Applying appropriate control measures
- ✓ Evaluating the effectiveness of pest control measures used

Planning and Managing Turf

- Ensure root zone mixture and subsurface drainage are properly constructed and properly drained to help minimize turf problems.

- Select appropriate turf species and cultivars for resistance to drought, insects and diseases.

- Irrigate at the appropriate time with the correct amount of water.

- Use soil testing to develop an effective fertilizer program and tissue testing to evaluate fertilizer requirements.

- Maintain the proper mowing height and remove no more than one-third of the leaf blade in a single mowing to help maintain a vigorous turf.

- Control thatch regularly by verticutting (de-thatching), topdressing and aeration (core cultivation) to alleviate compaction and improve water infiltration.

  Thatch is a tight, brown, organic layer of living and dead grass crowns, roots and stems that accumulate above the soil surface. Excessive thatch can lead to drought stress and susceptibility to insect and disease damage.

Pest Identification

- Routinely monitor for pests and correctly identify the damage and the pest.

- Determine which stage the pest is in and which stage is the most susceptible to pesticide treatment.

Monitoring

- Inspect the turf for pests regularly and systematically to determine the presence and activity of a pest before turf loss occurs.

- Keep track of weather conditions and know what conditions encourage disease and insect development.

- Monitor treatment to determine success in reducing pest population.

- Recognize that a relationship exists between temperature and insect development. The speed of insect development depends on the amount of heat accumulated above a certain base temperature.

- Establish a monitoring schedule and define monitoring units by subdividing a golf hole into green, tee and fairway. Determine how each area will be monitored.

Thresholds

- Use thresholds to determine the number of pests that turf can tolerate without causing unacceptable damage. Thresholds have been established for many common turf insect pests.

- Consider the overall health and vigor of turf when deciding if a treatment should be made.

- Maintain accurate record keeping and record all pesticide treatments made, application dates, active ingredients and treatment outcomes.

Control Measures

Cultural Control

- Select the best adapted, disease-resistant turf species for the intended use.

- Develop a nutrient management plan to address the timing and placement of fertilizers based on seasonal demand and usage of specific turf species, landscape position and weather.

- Take special care in the timing and placement of nutrients in areas of seasonally high water tables.

- Provide adequate and timely irrigation. See BMPs on Water Usage.

- Use appropriate cultivation techniques to alleviate compaction, manage thatch and maintain proper turf height.

Biological Control

- Consider using biological controls such as fungi, bacteria, viruses, nematodes and insects to inhibit turf pests.

- Apply composts that contain micro-organisms which may suppress diseases as a top dressing.

Chemical Control

- Use pesticide treatment when a pest is present in sufficient levels to cause turf damage and when the pest is most susceptible to the pesticide. Pesticides include fungicides, insecticides, nematicides, herbicides and any other chemical used to control pests.

- Use spot treatments when a pest problem is restricted to an isolated area.

- Apply pesticides with a properly maintained and calibrated equipment to insure the appropriate amount of pesticide is applied to the turf.

- Avoid spraying pesticides when the soil is saturated, or when heavy rains are imminent, or under any other conditions where surface runoff may result.

- Establish pesticide-free zones around water bodies and near drinking water wells.

- Spray pesticides when the wind is calm. Avoid drifting of pesticides towards sensitive water areas.

- Select the least toxic alternative with the least possibility of leaching and least persistence in the environment.

- Alternate pesticides with different modes of action to minimize the possibility of pests resistance to the pesticide.
- Combine cultural and mechanical practices with chemical control to reduce the frequency of chemical applications.

Evaluation

- Evaluate the Integrated Pest Management strategies periodically to determine if the plan is successful.

- Analyze treatment results, fine-tune monitoring techniques, and compare the number of treatments before and after IPM implementation.

GOLF COURSE
BEST MANAGEMENT PRACTICES

Part 5: Surface and Groundwater Protection

Design and management practices can help protect surface and groundwater and include buffer zones, stormwater management, erosion and sediment control, turf management and waste management practices. In addition, the proper handling, storage and disposal of equipment and materials and timely response to spills and accidents can have significant impacts in protecting water quality.

Buffer Zones

- Use existing woody vegetation to provide natural buffers. Protect and maintain existing woody vegetation during golf course construction and maintenance activities.

- Plant grasses and other herbaceous and woody vegetation in buffer strips where vegetation is lacking.

- Mow grass buffers infrequently, e.g. 1 or 2 times per year, to preserve the buffer and control vegetation. Remove clippings after mowing to help reduce the cycling of nutrients back into the buffer.

- Do not dispose of grass clippings or prunings in the buffer areas.

Stormwater Management

- Prevent stormwater contact with all waste and raw material storage areas.

- Discharge or divert surface runoff onto wide, flat, vegetated areas to promote infiltration and groundwater recharge. Use structural measures such as infiltration trenches, detention basins, filter beds or soaking pits. These may require site-specific, engineered design.

- Control surface runoff with appropriate filtration practices such as grassy swales, filter strips and constructed wetlands. Avoid runoff from parking lots, service areas, buildings and drives into wetlands.

- Minimize impervious surfaces by using pervious pavers for walkways, paths and parking lots. Incorporate landscaped areas in large parking lots to help maintain natural recharge.

- Use detention techniques such as wet ponds and detention basins to moderate surface runoff and store peak flows.

- Minimize the flow of runoff into natural waterways to reduce the possibility of nutrient and pesticide movement into those areas.

- Use a combination of vegetative swales, detention ponds and buffers to treat runoff from intensively managed areas like tees and greens.

Erosion and Sediment Control

- Inspect stormwater drainage pathways to determine the location and extent of any erosion.

- Use channel linings, increased channel cross-section and increased length of channel path to repair and prevent the erosion problems from recurring.

- Preserve as much existing vegetation as possible in erosion prone areas.

- Minimize the amount of exposed soil at any one time.

- Control cart traffic in highly erodible areas.

- Stabilize and maintain stream banks and ditches to limit erosion.

- Maintain roughs at 2" to 3" mowing heights to act as additional buffers.

Turf Management*

- Do not apply fertilize to soggy areas until the water table is lowered enough for the turf to be able to absorb the nutrients.

- Avoid spraying pesticides when the soil is saturated, or when heavy rains are imminent, or under any other conditions where surface runoff may result.

- Establish pesticide-free zones around water bodies and near drinking water wells.

- Spray pesticides when the wind is calm. Avoid drifting of pesticides towards sensitive areas or water.

- Locate compost piles away from surface waters, wetlands and floodplains and avoid steep slopes and areas with high water tables to reduce nutrient loads to waterways.

* See also Part 3: Operations and Maintenance for additional BMPs.

Equipment Maintenance, Chemical Storage and Mixing Areas*

- Store and maintain vehicles and equipment on covered, sealed, impervious areas.
- Locate fueling facilities on concrete paved areas and in paved, roofed areas equipped with spill containment and recovery facilities.
- Eliminate floor drains unless they drain to storage tanks.
- Keep containment booms and absorbent materials on hand for the remediation of spills.
- Provide secondary containment for all hazardous materials including liquid fertilizer storage areas.
- Store all hazardous materials in sealed, locked areas or buildings. Identify locations for these materials on the site plan. Register all materials with the fire marshal.
- Locate pesticide, fertilizer and hazardous material storage, mixing and loading areas in separate areas to avoid confusion with one another.
- Provide impervious surfaces in mixing areas.
- Dispose of hazardous materials according to the label and regulations.
- Buy fertilizer and pesticides in limited quantities and do not store large volumes of chemicals on site.
- Minimize the use of underground fuel storage tanks and eliminate chemical storage tanks in drinking water and groundwater supply areas.

Spill Response

- Develop plans to be followed in case chemicals are spilled. Identify all potential hazards; develop safe handling procedures; and incorporate appropriate spill response procedures into this plan.
- Clearly identify the appropriate responding authorities. Maintain a list of people to be notified in the event of a spill.

* See also Part 3: Operations and Maintenance for additional BMPs.

Waste Management Plan*

- Dispose of all non-hazardous wastes and litter in trash cans, dumpsters, or other appropriate receptacles.

- Properly store, recycle or dispose of waste products such as used motor oil, electric batteries, and unused solvents according to the law and available community disposal techniques.

- Use septic systems for domestic sewage waste only. Do not dispose of process waste water, hazardous waste, or raw chemicals down the drain because they can pass untreated to ground water.

* See also Part 3: Operations and Maintenance for additional BMPs.

GOLF COURSE
BEST MANAGEMENT PRACTICES

Part 6: Monitoring Program

Monitoring programs should be an integral component of golf courses to demonstrate that the environmental impacts are negligible or non-existent, and/or that environmental impacts must be mitigated. Operational and environmental monitoring programs are two types of monitoring programs that should be included as BMPs for golf courses.

An operational monitoring program tracks water usage, fertilizer application, turf management (seeding and cutting), and other routine management actions to improve golf course management. An effective operational monitoring program:

- ✓ identifies specific management requirements (watering rates, pesticide and fertilizer application triggers and rates) for each area of the golf course (tees, roughs, wetlands, buffers, fairways, etc.),
- ✓ includes emergency contingency plans and triggers for implementation, and
- ✓ identifies responsible employees and government agencies so that environmental problems can be dealt with quickly.

An environmental monitoring program tracks sensitive resources at risk, where mitigation may be required, or where public concern warrants it. This monitoring program will ensure that environmental safeguards are effective and identify unforeseen impacts.

Hawai`i Water Quality Monitoring Program

The Hawai`i State Department of Health has prepared groundwater monitoring guidelines for golf courses. Please refer to the Department of Health's Guidelines Applicable to Golf Courses in Hawai`i, July 2002, for more information. If a golf course uses recycled water (treated wastewater), please refer to the Department of Health's Guidelines for the Treatment and Use of Recycled Water, May 15, 2002.

In addition, the following water quality monitoring BMPs are recommended.

- Develop a water quality monitoring program that is scientifically based, include action thresholds, provide corrective action(s), specify sampling schedules and reflect the hydrologic conditions and management practices for the golf course.

- Use lysimeter sampling to monitor surface runoff and leachate in surface water, irrigation lakes, catch basins and other on site locations and to determine water quality within the golf course.

- Monitor adjacent surface water bodies to identify water quality impacts on a watershed basis.
- Monitor groundwater to determine the impact, or potential impact on the underlying aquifer.
- Have sampling locations and sampling parameters reviewed and approved by the Hawai`i State Department of Health, Safe Drinking Water Branch.
- Collect sufficient water quality monitoring data to identify and establish background levels and provide specific "trigger levels" for corrective action after background levels have been established.
- Undertake corrective action if sampling data is above approved background levels.
- Maintain all sampling locations and equipment in proper condition at all times.
- Perform all water quality sampling, documentation, handling and analysis in accordance with standard scientific methods recognized by the U.S. Environmental Protection Agency and approved by the Hawai`i State Department of Health.
- Use independent licensed laboratories to analyze all water quality samples. All laboratories should utilize detection limits that are lower than initial "trigger level," and background concentrations after they have been determined for any analyte.
- Submit quality assurance/quality control samples to the laboratory with each sample.
- Provide a copy of the analytical reports and testing laboratory's quality assurance/quality control data to the Hawai`i State Department of Health, Safe Drinking Water Branch.

2. DOH "10 Conditions" (2002)

STATE OF HAWAI'I
DEPARTMENT OF HEALTH
July 2002 (Version 6)

GUIDELINES APPLICABLE TO GOLF COURSES IN HAWAI'I

The State Department of Health recommends the following guidelines for all golf courses in Hawai`i to promote, protect, and enhance environmental quality and public health. These recommendations cover measures that could prevent groundwater and surface water pollution, soil contamination, chemical spills, noise and solid waste nuisances, and unsafe exposure to applied chemicals. Under certain situations, a state or county regulation may be necessarily applicable to a given activity, and such a regulation would require mandatory compliance. However, the intent of these guidelines is to voluntarily foster environmental protection and safety. Thank you for supporting these guidelines and caring about Hawai`i.

1. A groundwater or soil water monitoring plan for the purpose of preventing or minimizing groundwater contamination should be established with the following components:

    a. Baseline groundwater quality;

    b. Monitoring locations consisting of monitoring wells or lysimeters, or combination of both;

    c. Routine groundwater and/or soil water monitoring at frequencies such as quarterly, semiannually, or annually depending on the use of chemicals and the detection of contaminants;

    d. A list of chemicals and fertilizers that will be or have been used that may affect soil or groundwater adversely, and the analyses for such contaminants;

    e. Recordkeeping of monitoring results and a system of tracking trends in order to prevent, minimize, or mitigate occurrences of contamination;

    f. A procedure to notify all affected parties and the Department of Health of occurrences of contamination that pose, or may pose, a threat to public health or the environment.

    g. Availability of monitoring data to any interested person.

2. A surface water monitoring plan, if applicable, for the purpose of preventing or minimizing surface water contamination should be established using the principles of item No. 1.

3. If the golf course uses recycled water (treated wastewater) for irrigation, please refer to the Department of Health's Guidelines for the Treatment and Use of Recycled Water, May 15, 2002, for recycled water requirements. Information about this subject may be obtained from the Department's Wastewater Branch at 586-4294 (Honolulu).

4. The use of an above-ground storage tank with applicable safety considerations for petroleum products, used for fueling golf carts, maintenance vehicles, or emergency generators, should be preferred over an underground storage tank in order to easily detect leaks and minimize the risk of soil and groundwater contamination resulting from a leaking storage tank. Information about underground storage tanks may be obtained from the Department's Solid and Hazardous Waste Branch at 586-4226 (Honolulu).

5. Buildings used to store fertilizers, pesticides, algicides, fungicides, herbicides, and other chemicals especially in liquid form should be designed purposely for the containment and recovery of a catastrophic spill or leak of contents. An early warning system for spill or leak detection is advantageous.

6. Noise and dust from maintenance or construction activities should not disturb neighbors. Maintenance or construction activities should be scheduled and conducted accordingly.

7. Solid wastes should be managed without creating a nuisance. Furthermore, all green waste generated by the golf course should be reused on-site. Shredding and composting are activities that precede the reuse of green waste as a soil conditioner or a ground cover for weed control. Space and equipment should be provided to accomplish these activities. Additionally, where practicable, locally produced compost and soil amendments should be used whenever available.

8. Chemicals should be handled and applied according to instructions, and offsite drift during application should not occur. Methods of application and weather conditions should be chosen to optimize success.

9. A Best Management Practices (BMP) plan should be made for the golf course. The BMP plan functions as a hands-on environmental and worker safety maintenance manual that describes in plain English the elements and procedures for irrigation, chemical use, processing and reuse of green wastes, minimizing or preventing runoff, soil erosion and nuisance conditions, and sustaining worker safety. Use of the BMP should prevent the occurrence or recurrence of environmental or safety problems. The BMP should be available to any interested person.

10. Agencies or organizations such as the State Department of Agriculture, the Federal National Resource Conservation Service, and the Golf Course Superintendents Association of America may provide ideas or practices that would help to achieve the intent of these guidelines. Inquiries to these sources of information are advantageous.

The Department of Health appreciates your cooperation to preserve and protect environmental quality in Hawai`i. Questions about these guidelines may be directed to the Groundwater Pollution Control Section of the Safe Drinking Water Branch at 586-4258 (Honolulu). Direct toll free calls can be made from Kaua`i: 274-3141, ext. 64258; Maui: 984-2400, ext. 64258; Big Island: 974-4000, ext. 64258; Molokai and Lana`i: 1-800-468-4644, ext. 64258.

3. DOH "12 Conditions" (1992)

STATE OF HAWAII
DEPARTMENT OF HEALTH

January, 1992 (Version 4)

TWELVE (12) CONDITIONS APPLICABLE TO ALL NEW GOLF COURSE DEVELOPMENT

The following conditions are recommended for all new golf course development in Hawaii to assure that environmental quality is preserved and enhanced as it relates to human health and the protection of sensitive ecosystems. Additional conditions may be imposed based on site-specific considerations.

1. Baseline groundwater/vadose zone and/or, if appropriate, coastal water quality shall be established. Once the sampling plan has been determined and approved by the State Department of Health, the owner/developer shall establish the baseline groundwater/vadose zone water quality, and, if appropriate, nearshore water quality, and report the findings to the State Department of Health. Analyses shall be done by a laboratory approved by the Department of Health.

2. The owner/developer and all subsequent owners shall establish a groundwater monitoring plan and system which shall be presented to the State Department of Health for its approval. The groundwater monitoring plan and system shall minimally describe the following components:

   a. A monitoring system tailored to fit site conditions and circumstances. The system shall include, and not be limited to, the use of monitoring wells, lysimeters, and vadose zone monitoring technologies. If monitoring wells are used, the monitoring wells shall generally extend 10 to 15 feet below the water table.

   b. A routine groundwater monitoring schedule of at least once every six (6) months, or more frequently, if required by the State Department of Health in the event that the monitoring data indicates a need for more frequent monitoring.

   c. A list of compounds which shall be tested for as agreed to by the State Department of Health. This list shall include, but not be limited to the following: total dissolved solids; chlorides; PH; nitrogen; phosphorus; and other compounds associated with fertilizers, biocides, or effluent irrigation.

3. If the data from the monitoring system indicate increased levels of a contaminate that poses, or may pose, a threat to public health and the environment, the State Department of Health shall require the owner to take immediate action to stop the source of contamination. Subsequently, the owner shall mitigate any adverse effects caused by the contamination.

4. Owner/developer shall provide sewage disposal for the clubhouse and other facilities by connecting to the public sewer system or by means of a treatment individual wastewater system approved by the Department of Health in conformance with Administrative Rules, Title 11, Chapter 62, Wastewater Treatment Systems. The use of wastewater for irrigation will be generally encouraged, with appropriate controls (see Condition 5).

5. If a wastewater treatment works with effluent reuse becomes the choice of wastewater disposal, then the owner/developer, and all subsequent owners, shall develop and adhere to a Wastewater Reuse Plan which shall incorporate the provisions of the Department of Health's Guidelines for the Use of Reclaimed Water which includes:

   a. An Irrigation Plan encompassing buffer distances, pipe and appurtenance placement, and labeling.

   b. An Engineering Report encompassing treatment options and treatment levels.

   c. Hydro-geologic and hydrologic surveys to determine application rates, sizing and storage needs.

   d. A monitoring plan.

   e. A management plan.

   f. Public and employee education plans.

6. Underground storage tanks (USTs) used to store petroleum products for fueling golf carts, maintenance vehicles, and emergency power generators that pose potential risk to groundwater shall be discouraged. Use of electric golf carts and above-ground storage tanks for emergency power generators shall be encouraged.

   Should the owner/developer/operator plan to install USTs that contain petroleum or other regulated substances, the owner/developer/operator must comply with the federal UST technical and financial responsibility requirements setforth in Title 40 of the Code of Federal Regulations Part 280. These federal rules require, among other things, owners and operators of USTs to meet specific requirements in release detection and response, and subsequent corrective action. Also, the owner/developer/operator must comply with all State UST rules and regulations pursuant to the Hawaii Revised Statutes, Chapter 342-L, Underground Storage Tanks.

7. Buildings designed to house the fertilizer and biocides shall be bermed to a height sufficient to contain a catastrophic leak of all fluid containers. It is also recommended that the floor of this room be made waterproof so that all leaks can be contained within the structure for cleanup.

8. A golf course maintenance plan and program will be established based on "Best Management Practices (BMP)" in regards to utilization of fertilizers and biocides as well as the irrigation schedule. BMP's will be reviewed by the State Department of Health prior to implementation.

9. Every effort shall be made to minimize the amount of noise from golf course maintenance activities. Essential maintenance activities (e.g., mowing of greens and fairways) shall be conducted at times that do not disturb nearby residents.

10. Solid waste shall be managed in a manner that does not create a nuisance. Whenever possible, composting of green wastes for subsequent use as a soil conditioner or mulching material is encouraged. The composting and reuse should be confined to the golf course property to eliminate the necessity for offsite transport of the raw or processed material. In addition, during construction, the developer should utilize locally-produced compost and soil amendments whenever available.

11. Fugitive dust shall be controlled during construction in accordance with Hawaii Administrative Rules, Title 11, Chapter 60, Air Pollution Control. Pesticides and other agricultural chemicals should be applied in a manner that precludes the offsite drift of spray material. The State Department of Agriculture should be consulted in this regard.

12. To avoid soil runoff during construction, the developer should consult with the U.S. Department of Agriculture, Soil Conservation Service to assure that best management practices are utilized. If the total project area is five (5) acres or more and the development activities include clearing, grading, and excavation, a National Pollutant Discharge Elimination System (NPDES) stormwater permit application shall be submitted to the Department of Health in accordance with the Federal Clean Water Act requirements.

If there are any questions regarding the twelve (12) conditions mentioned here, please contact the Environmental Planning Office at 586-4337. We appreciate your cooperation in preserving and protecting environmental quality in Hawaii.

APPENDIX B. Facility Operations Manual and Emergency Procedures

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Facility Operations Manual and Emergency Procedures

This appendix satisfies multiple sections of the Maui County Zoning Condition 18; specifically, conditions 18 'e', 'f' (in part), 'g' (in part), and 'i' in part (also satisfies conditions 6, 7, 8, 11, and 12 of the DOH's '12 conditions'). The sections that are identified to be satisfied 'in part' are also partially satisfied in other sections of this document (e.g., 'f' is also satisfied [in part] in Part 3 of the main document and section F of this appendix). Condition 18 'g' will be satisfied by other documentation for the project (i.e., layout, master plan, or other submissions by Honula'ula Partners, LLC) to complete the Phase II development application process. Condition 9 of the DOH's '12 conditions' (relating to addressing noise from maintenance facilities through design and layout) will be satisfied as the project moves forward.

A. Overview

The maintenance facility will be located on approximately 1.1 acres. It will be a modern, carefully designed, fenced and secured, state-of-the-art complex containing offices, maintenance shop, employee lunch and locker room, equipment and material storage. It has been designed with the following goals in mind: operational efficiency (i.e., provide the equipment and layout required for the superintendent to do his or her job efficiently); worker health and safety protection; environmental protection (i.e., containment and management of possible spills so that the surrounding environment would not be impacted); and compliance with relevant federal, state, and local regulations.

B. Traffic Flow and Worker Access

Main access to the facility will be planned from the major entrance to the golf course complex. A secondary road will provide a direct route from the maintenance facility for maintenance vehicles (pickup trucks, golf carts, and tractors) to the golf course.

Adequate space will be designed in order to provide for a semi tractor-trailer to circle around the maintenance facility. The maintenance facility will be accessible from all sides. This will allow for emergency vehicle access as well as easy worker access. Adequate space will also be planned in front of the chemical storage buildings (TBD in site design) for emergency vehicles. Delivery of chemical products, equipment and equipment products, fuel, and bulk materials are not seen to be a problem.

C. Conceptual Stormwater Management

More detail will be provided, specifically including the actual drainage contours of the site, when the engineering report is completed by Wilson Okamoto Corporation, which will be included in the draft EIS (EISPN, 2009). This also satisfies Zoning Condition 18 'i' in part (condition 12 of the DOH's '12 conditions') relating to drainage.

The site will be graded, and curbs will be erected, so that parking lot drainage cannot flow directly into drainage features, but rather into a BMP such as a detention pond. There will

be catch basins on the east and west sides (one each) of the fuel island to capture contaminated stormwater runoff and significant spills. Minor spills will be contained within the scores (shallow grooves) around the fuel island. The two catch basins at the fuel island will contain petroleum absorbent 'pillows' (Passive Skimmers with Smart Sponges®, or equivalent) and Snout® vertical traps, or an equivalent. The latter will catch surface-floating contaminants and trash.

There will be catch basins throughout the complex, as indicated in the proposed maintenance facility site plan. One, immediately west and downslope of the storage bins, will include a special retention system to trap sand, soil, and mulch. All catch basins will be tied into a drainage system that terminates in a Vortechnics® treatment system (or equivalent) to remove sediments, floating debris, and petroleum contaminants.

The covered mixing/loading pad will have its own drainage control system. The drainage and contouring of the site will be designed by Wilson Okamoto Corporation. The stormwater management plan will be designed with consideration of the fact that runoff from the maintenance facility complex may include soil, sand, grass clippings, petroleum products (small amounts of oil and gasoline), fertilizers, and other typical hard surface runoff substances. There should be minimal to no presence of pesticides in runoff water due to the use of closed-loop recirculating systems and special containment pads (see sections D and G below).

D. Equipment Washbay

The golf course will install a recycling wash water system for the turfgrass equipment wash pad area. The recycling wash water system will be capable of capturing grass clippings, oil and grease, and trace organics. The system installed will be a closed-loop wash/recycle wash-down water system independent of the storm water drainage system. A back-up overflow system is normally installed to collect potential spills and divert the wash-down water onto the wash pad apron and/or collection system.

The wash bay will be designed so that equipment can be driven in one entrance and out the opposite entrance. The area will be approximately 500 sq ft. This system recycles the exterior equipment wash-down water for reuse as wash water. (Turf chemical spray solutions are addressed in section G below.)

Several companies provide closed-loop systems specifically designed for golf course use: RGF Inc., Chappell Supply, and Golf Structure Alternatives are examples. A list of suppliers is provided below. Filtration and treatment methods range from strictly physical (filters, separators and activated carbon) to those that incorporate environmentally friendly bacteria. All of these systems are designed for recycled wash water to eliminate the release of hydrocarbons and solid waste (grass clippings).

Closed Loop Wash System Suppliers

Carbtrol Inc. - carbtrol.com/advanced_washwater_recycle_system.html
Dultmeier - dultmeier.com
Hydroengineering Inc. - hydroblaster.com
RGF Inc. - rgf.com

Chappell Supply & Equipment - chappellsupply.com/bioandgolftreatment.htm (biological)
EPSI (Grass Grabber) - epsiusa.com/golfpage.htm
Pac Environmental GC Systems - pac-env.com/golfcoursesystems.htm
Cyclonator - megator.com/cyclonator.htm
Safety Storage Inc. - safetystorage.com
Golf Structure Alternatives - golfstructures.com

E. Fuel Storage, Pump/Fill Area, and Golf Carts

The maintenance compound will contain a fuel island of approximately 450 sq ft with a split, above-ground fuel tank. One tank will be used for gasoline, and one for diesel. Each tank should have the capacity to hold approximately 250 to 500 gallons of fuel. Both tanks will have double walls with vehicle barriers for accident prevention, and they will be covered with carport-type roofs.

The sump and concrete pad will be designed with a carport roof to protect the tanks from rainfall and evaporation. The tanks shall consist of a UL listed primary tank, a high-density polyethylene secondary compartment, and a six-inch reinforced concrete encasement. The concrete vault that provides thermal and corrosion protection can be poured on location or shipped precast. The tanks installed will conform to the Uniform Fire Code and NFPA.30 regulations for above-ground tanks. The tanks will be designed to meet the above-ground regulatory storage requirements in the State of Hawaii, and the State Fire Council (e.g., 6,000 gallons per tank up to 18,000 gallons per facility at private fleet fueling facilities, meeting the standards of UL 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids, or Southwest Research Institute 93-01).

The appropriate signs indicating 'No Smoking' and 'Fuel Safety Warnings,' in addition to, an emergency cutoff switch will be installed in the fueling areas. A waste oil and solvent storage tank will be installed at the fuel storage area. Secondary containment will be able to handle twice the waste oil storage capacity. Non-hazardous waste, such as used oil which is comprised of crankcase oil, transmission fluid, gear oil, hydraulic fluid, and power steering fluid can be placed in a codified waste disposal system.

Golf carts used by golfers and other customer service vehicles (beverage carts, etc.) will be battery-powered electric vehicles requiring no fuel storage tanks. Emergency generators or any other internal combustion engine powered equipment on the property will use above ground storage tanks.

F. Pesticide and Fertilizer Storage

Pesticide storage will be in a pre-fabricated pesticide storage building specifically designed to be ventilated, fire resistant, vapor explosion resistant, vandalism protected, spill self-contained, and climate controlled. The pre-fab buildings like the ones produced by US Hazmat Storage Inc., or Hazvault Inc., can be customized for any hazardous material storage need. Often these buildings exceed code requirements for safe storage of hazardous materials. Building size

can be custom-made, and storage should be limited to a minimal amount of materials needed for one application. Typically a 400 sq ft building is sufficient for an 18-hole golf course. Several pre-fab chemical storage building vendors are listed below.

Pro-Tec Chemical Storage Buildings (cores.com/core_building.htm)
Affordable Pesticide Storage Inc.(pesticidebuildings.com)
Turfloc Inc. (chemicalbuildings.com)
US Hazmat Storage Inc. (ushazmatstorage.com)
Hazvault Inc. (hazvault.com
Safety Storage Inc. (safetystorage.com)
Golf Structure Alternatives (golfstructures.com)

The facility will be designated and posted as a pesticide storage area (as required by law), with a list of all chemicals contained in storage on file in the superintendent's office. One copy of this list will be provided to the local fire marshal. Additional copies will be located in the maintenance facility and/or clubhouse or in an appropriate file located away from the pesticide storage structure.

Pesticide Storage Facility Check List

The following operating procedures are proposed for the pesticide storage facility:

- The building will be secured and locked at all times.
- An additional key will be placed in the administrative office and in the office of the golf course superintendent in case of emergency; an equitable option is to provide a lock box at the entry to the building.
- Materials will be stored on shelves located high enough to permit cleaning of the floor. No material should be stored above 6 ft from the ground.
- All materials will have legible labels attached. Materials whose packaging has been damaged must be in containers clearly marked and labeled.
- Plastic secondary containers are used to store liquids shipped in quantities of 1 (one) gallon or more for protection against spillage.
- A fire extinguisher will be available.
- A plastic trash barrel with lid will be located inside the storage facility for cleanup.
- All golf course maintenance personnel will be trained in the operating procedures regarding this building.
- Appropriate protective clothing and equipment will be provided for use by those who handle pesticides.
- Absorbent materials designed to contain accidental spills will be available within the pesticide storage facility. An eyewash station will be available near the building.
- Disposal of pesticide containers shall comply with the instructions on the labeling and other state and federal regulations. Empty containers will not be allowed to accumulate or be stored within this building.
- The building will be inspected at least monthly by the golf course superintendent, and a record of each inspection recorded in the records for pesticide use.

Fertilizer and other dry bulk material typically contained in bag form should be stored in a separate, larger building. Size should be large enough to allow loaders or forklifts to handle materials on pallets, and be able to stack them up to three pallets high for maximum storage. This usually means a building with a large garage type overhead door with at least a 12' ceiling. Typically 800 sq ft of floor space is sufficient. A minimum amount of product should be stored in this building (i.e., enough for the next application and a little extra for spot applications). A ceiling fan that provides ventilation, with a switch by the door, should be sufficient ventilation in this building. Masonry construction for the walls of this building will prevent corrosion caused by fertilizer salts. Climate control for bulk materials is not necessary, as freezing is not a concern. When a spill occurs here, a broom and empty trash container are sufficient for clean up of dry materials. The appropriate fire extinguishers for the housed material should be placed by the entrance(s). A hazardous material placard marked for oxidizers should be displayed.

G. Mixing/Loading Area

A self-contained mixing/loading pad (concrete), that is enclosed on three sides and sloped to contain twice the capacity of the largest sprayer to be used, is recommended. The size is approximately 240 sq ft. On the low side of the pad a shallow sump hole will allow recovery (using a small electric pump) of product back to the sprayer. The purpose of this pad is to safely contain any spill, or emergency release of materials in the sprayer. In the event of a problem with a filled sprayer, the operator can release the material, repair the problem and recover the material to be sprayed.

Typically the largest sprayer used on the golf course for fairways and roughs is 300 gallons in capacity. This would require the mixing/loading pad to contain 600 gallons as a precaution. The height of the sidewalls can be calculated appropriately. This pad should also be covered to prevent rainwater filling the pad, and require pumping out after rain events. However, the main purpose is to prevent release of any chemicals or spray mix other than proper application to the turf.

H. Storage Bins

Four semi-enclosed bulk storage bins will be provided in the design. Two of them will be covered. The bins will hold various materials like topdressing sand, bunker sand, topsoil, or organic materials. The storage bins should be large enough to allow a dump truck direct access. The proposed bins will each be 16' x 16' or approximately 1024 sq ft. Proper storage of these materials maintains the integrity of the products. Sides and rear walls will be tall enough to contain the bulk materials and to prevent contamination with adjacent bins. Walls four to six feet high are adequate for this purpose.

Storage bins should have concrete floors for easy material loading. Walls will be composed of concrete block, formed concrete, or pressure-treated lumber.

I. Vehicle Maintenance and Storage

Golf course maintenance equipment and vehicles used onsite will be stored in a 5,000 ti 8,000 sq ft paved area of the maintenance facility. Drive-through overhead garage doors facilitate easy access in and out of the shop. Equipment used on a daily basis (mowers, utility vehicles) can be pulled in one side and be ready for exit the following day through the opposite doors. Equipment not used on a regular basis can be parked along the sides and accessed as needed (e.g., aerators, spreaders, topdressers).

The floor of the equipment storage area will be hard surfaced, allowing easy clean-up of oil leaks, spills, or other fluids that might come from the equipment. Proper absorbent materials should be easily accessed throughout the storage area for quick clean up of spills. No fluids should be allowed to escape this area. Floor drains are not allowed in this facility.

A modern equipment maintenance shop of approximately 3000 sq ft will be designed with considerable input from the mechanic. An equipment lift should be centrally located in the shop with adequate work benches lining the walls. Shop equipment such as air compressors, gas and arc welders, bench grinders, drill presses, and tire changers should be included in appropriate locations. A separate, well ventilated room should be constructed to house mower grinding and sharpening equipment. The entire shop area should be well ventilated, including exhaust fans to prevent the buildup of fuel vapors or exhaust fumes. Overhead exhaust hoses allow work to be done on running equipment, venting exhaust to the outside. Proper fire extinguishers will be placed by all doors and exits.

J. Worker Training, Personal Protection, and Eyewash Stations

It is important for the golf course superintendent to implement a worker-training program. Workers should be trained in safety procedures for operating equipment, handling fertilizers, fungicides, herbicides, and insecticides. Training should be done upon employee hiring and continued on a regular basis. Other areas of training include spill response, first aid, blood borne pathogens, proper golf course etiquette, maintenance techniques, employee benefits, turf management, fire safety procedures, and use of safety devices.

First aid kits and eye wash stations should be placed at various locations throughout the maintenance facility. Typically these items are placed near areas where accidents could occur. Examples are: mechanic's work space; reel or blade grinding area; pesticide or fertilizer storage areas; employee area (lunch room); and fuel station. All employees need to be trained in the location and use of first aid kits and eye wash stations.

Personal protective equipment (PPE) will be supplied to all appropriate employees (e.g., superintendent, applicators, etc.). PPE includes, but is not limited to, hard hats, eye protection, dust masks, proper gloves (e.g., chemical resistant) as needed, chaps, and ear protection. Some other specialty items may be required for individuals using specialized equipment or products (e.g., welder's face mask and fitted respirators for pesticide applicators).

The above mentioned safety and worker protection precautions are included but not limited to the HIOSH (Hawaii Occupational Safety and Health) regulations for Hawaii. OSHA (Occupational Safety and Health Administration) and HIOSH organizations' regulatory information and worker safety programs are to be maintained by the golf course's management team in place for the workers' protection and safety.

K. Emergency Management Plan

Two types of emergency spill plans could theoretically be required under EPA's 40 CFR Part 112 regulations, but the more comprehensive Spill Prevention Control and Countermeasure Plan is not required due to the facts that: the golf course will not be storing 1320 or more gallons of petroleum products above ground; no single fuel tank will have a capacity of 660 gallons or more; and there will be no underground storage tanks for fuel.

An emergency management plan will be written after the maintenance facility is built that will contain the following information.

ACCIDENTAL SPILL RESPONSE PROCEDURE

The following information and materials must be in place and an inventory of these items posted in the chemical storage area:

- Telephone numbers for emergency assistance, including Maui County law enforcement and fire departments;
- Sturdy gloves, footwear, and aprons that are chemical-resistant to most pesticides (e.g., foil-laminate gear), and protective eye wear;
- An appropriate respirator for any materials where one is required during handling activities or for spill cleanup (reference Material Safety Data Sheets on file for each product used);
- Containment 'snakes' or booms to confine the leak or spill to a small area;
- Absorbent materials, such as spill pillows, absorbent clay, dry peat moss or sawdust to soak up liquid spills;
- A water spray mist bottle to keep dry spills from becoming respirable dust during cleanup;
- A shovel, broom, and dustpan made from non-sparking and non-reactive materials;
- Heavy duty liquid detergent;
- A fire extinguisher rated for all types of fires;
- Any other spill clean-up items specified on the labels of any products used; and
- A sturdy plastic container with tightly closing lid that will hold the volume of material from the largest pesticide container being handled.

Reporting the Spill. The golf course superintendent or his/her assistant will be notified as soon as possible following a spill and have the responsibility of reporting all chemical spills to all responsible parties.

The following should be included when reporting a chemical spill:

1. Name and phone number of reporting party;
2. Time and location of spill;
3. Identity and quantity of material released; and
4. Status of containment and clean-up.

Controlling the Spill. Onsite responders should (a) protect themselves with appropriate protective clothing and eye-wear, (b) stop the source of the spill, (c) protect others by warning them of the spill, and (d) stay at the site until the spill is cleaned up.

Containing the Spill. Onsite responders should (a) confine the spill as quickly as possible, (b) protect water sources and water resources, (c) use absorbent material for liquid spills, and (d) cover dry materials to prevent them from becoming airborne or solubilized.

L. Personnel Areas

The typical golf course maintenance facility requires approximately1500 to 2500 sq. ft. that is dedicated to offices, restrooms, and an employee lunch and break room. This area needs to have separate ventilation and plumbing from pesticide and fertilizer storage areas. Offices are usually part of the main maintenance building. Office and staff areas should be equipped with appropriate climate control units, plumbing, telephone, and communications. Multiple phone lines for the superintendent, assistant superintendent, and mechanics will be needed. Additionally, fax machines, office computers, and a dedicated irrigation computer (discussed in Part 2: section B) and a weather station will be needed. All office equipment and individual phone needs will be considered in the design of this area. This area is where the superintendent, assistant, mechanics, and staff give and get their daily assignments, take breaks, and eat lunch. Therefore it should be an environment where all employees feel comfortable.

Generally, the superintendent and assistants have separate offices totaling 300 to 500 sq ft. These offices house the irrigation computer, office computers, fax, and other office machinery. The superintendent will conduct meetings with vendors, members, and staff here. Privacy and a professional appearance should be considered.

The mechanic should have dedicated office space that can also double as a parts storage area. Approximately 300 to 500 sq ft should be planned to this, either as part of the 1500-2000 sq ft offices/lunchroom space or the 1500-3000 sq ft repair shop space. Shelving and desk space will provide the mechanic with sufficient space to maintain records and provide storage for routine items such as filters, hoses, bedknives, and other parts used on a regular basis. A dedicated telephone line will provide the mechanic with the ability to contact his vendors, while keeping dirt and grease out of other office areas.

The remaining space (1000 sq ft or more) can be dedicated for employee-shared space. Restrooms should meet all current code requirements. Shower facilities and locker space can be located in the restroom area. Male and female accommodations should be separate and equal,

and ADA accessible. The lunch area should be large enough to hold the entire staff for lunch/breaks, meetings, training, and other group activities. Typically a refrigerator/freezer, sink, and microwave oven are provided in the lunch area.

The maintenance facility is a direct reflection of the golf course. A neat, well-organized, clean work space in the shop usually translates to the same in the field. All of the top golf courses have excellent maintenance facilities. Table B-1 provides a summary of dimensions for the proposed maintenance facility.

Table B-1. Summary of Proposed Dimensions for the Maintenance Facility

	Square Feet	Comments
1. Main Structure		
Offices/Lunchroom	1500-2000	
Repair Shop	1500-3000	Includes part storage
Subtotal	***3000-5000***	
2. Storage Areas		
Equipment Parking	5000-8000	Large, small equipment
Fertilizer & Seed Storage	800	
Pesticide Storage	400	Self contained structure
Subtotal	***6200-9200***	
3. Exterior Areas		
Storage Bins	1024 total	4 bins
Equipment Washing	500	
Chemical Mixing/Loading	240	
Fuel Island	450	
Subtotal	***2214***	
TOTALS	**11,414-16,414**	

APPENDIX C. Relevant SLUC Findings of Fact (1994)

BEFORE THE LAND USE COMMISSION

STATE OF HAWAII

In the Matter of the Petition of PALAUEA BAY PARTNERS To Amend the Agricultural Land Use District Boundary into the Urban Land Use District for approximately 669.387 acres at Paeahu, Palauea and Keauhou, Makawao District, Maui, Hawaii, TMK Nos.: 2-1-08: 43, 56 (por.), 71	DOCKET NO. A93-689 FINDINGS OF FACT, CONCLUSIONS OF LAW, AND DECISION AND ORDER

This is to certify that this is a true and correct copy of the Decision and Order on file in the office of the State Land Use Commission, Honolulu Hawaii.

SEP 20 1994 by _____
Date Executive Officer

LAND USE COMMISSION
STATE OF HAWAII
SEP 20 7 47 AM '94

FINDINGS OF FACT,

CONCLUSIONS OF LAW, AND DECISION AND ORDER

EXHIBIT "A"

BEFORE THE LAND USE COMMISSION

STATE OF HAWAII

In the Matter of the Petition of PALAUEA BAY PARTNERS To Amend the Agricultural Land Use District Boundary into the Urban Land Use District for approximately 669.387 acres at Paeahu, Palauea and Keauhou, Makawao District, Maui, Hawaii, TMK Nos.: 2-1-08: 43, 56 (por.), 71	DOCKET NO. A93-689 FINDINGS OF FACT, CONCLUSIONS OF LAW, AND DECISION AND ORDER

FINDINGS OF FACT,

CONCLUSIONS OF LAW, AND DECISION AND ORDER

PALAUEA BAY PARTNERS, a Hawaii limited partnership, ("Petitioner"), filed a Petition for District Boundary Amendment on August 6, 1993, and a First Amendment to the Petition on June 29, 1994, (cumulatively "Petition"), pursuant to chapter 205, Hawaii Revised Statutes, ("HRS"), and chapter 15-15 Hawaii Administrative Rules ("HAR"), to amend the Land Use District Boundary to reclassify approximately 669.387 acres of land at Paeahu, Palauea and Keauhou, Makawao District, Island and County of Maui, State of Hawaii, specifically identified as Tax Map Key Nos. 2-1-08: parcels 43, portion of 56 and parcel 71, ("Property" or "Petition Area") from the Agricultural District to the Urban District, to develop a planned residential community, commercial area, two (2) golf courses, parks, open space, roadways and an electrical substation ("Project"). The Land Use Commission ("Commission") having examined the testimony and evidence

FERTILIZER AND PESTICIDE USE

66. Through compliance with the approved Integrated Golf Course Management Plan ("IGCMP") and the practice of responsible turf management, the Project is not expected to have any significant adverse impact on the basal aquifer, nearshore organisms or residents.

67. In July 1993, the Department of Health gave final approval to the IGCMP for the Project, which specifically addresses how golf courses should be developed and managed in a manner to minimize any potential impacts related to fertilizers or pesticides.

Done at Honolulu, Hawaii, this 20th day of September 1994, per motion on September 8, 1994.

LAND USE COMMISSION
STATE OF HAWAII

By _____
JOANN N. MATTSON
Chairperson and Commissioner

By _____
TRUDY K. SENDA
Vice Chairperson and Commissioner

By _____
ALLEN K. HOE
Commissioner

By (abstain)
M. CASEY JARMAN
Commissioner

By (abstain)
ALLEN Y. KAJIOKA
Commissioner

By _____
LLOYD F. KAWAKAMI
Commissioner

By _____
EUSEBIO LAPENIA, JR.
Commissioner

By _____
RENTON L. K. NIP
Commissioner

By _____
ELTON WADA
Commissioner

Filed and effective on
September 20, 1994

Certified by:

_____
Executive Officer

APPENDIX D. USGA Greens Construction Methods

USGA Greens Construction Methods

A. Shaping Procedures

The putting surface should be graded with the green cavity excavated to a depth of 18" (12 inches if top soil is to be added later); such grade to be approved by the designer. Once such approval is made, the Contractor is then responsible for installing the putting surface according to the specifications. The finished grade will identically replace the originally approved sub-grade.

B. Sub-Grade and Compaction

The contours of the sub-grade should conform to the proposed finish grade with a tolerance of plus or minus one inch. The sub-grade should be compacted to approximately a 90% ASTM modified proctor, as specified, to prevent future settling that might create water-holding depressions in the sub-grade surface and corresponding depressions in the putting surface. It will be noted that layers of materials above the sub-grade consist of 4" of gravel, 2" of coarse sand, and 12" of topsoil mixture. Thus, the total depth will be eighteen inches.

It is important to note that the collar of the green is included in these specifications with the only difference being an eventual higher height of cut.

C. Drainage

Drainage is the most important feature of greens built to USGA specifications. All materials must be tested and approved by a USGA recommended laboratory. Clean workmanship and adherence to the designer's methods and specifications is essential to building the highest quality putting greens.

A pattern of the drainlines will be laid out on the sub-grade with marking paint by the designer or the designer's designee. Drainlines will be installed no more than twenty feet apart, in a typical herringbone pattern, in straight lines with 45 degree fittings. Whenever possible, the mainline drain on each green shall run along the line of maximum fall. A semicircular 'smile' drain should be installed at the lowest point of the green cavity at the mainline exit point. The location of suitable outfalls and sumps will be designated by the designer. Frequently, green drains are directed to larger storm water drains around the green or approach area. The outfall or end of the drainline must be protected from crushing and screened from burrowing animals.

Trenches eight inches in diameter and twelve inches deep should be excavated along the lines in the sub-grade by trenchers or mini-excavators. All soil excavated from the trenches will be removed from the green cavity. All drainlines will have a minimum of 0.5 % slope. Trenches should then be lined with washed pea gravel of 1/4 to 3/8 inch diameter (as approved by a USGA recommended laboratory). All pipe shall be four inches in diameter corrugated plastic ADS N-12 with smooth interior walls. Only those fittings and connectors recommended by the pipe manufacturer will be used. At the upper end (or highest point) of each green, the mainline shall exit the green cavity 2 to 3 feet and directed to the surface with a 90 degree elbow and capped at grade with a 4-inch grate. This allows air to enter the system, improving drainage and providing a 'clean out' for flushing drainlines in the future. A 14-gauge insulated copper wire (sprinkler system wire) should be installed alongside the mainline drainpipe from the clean-out grate to the outfall so the pipe can be located with tracking devices. With the pipe in place, the trenches should be filled with gravel with care taken to keep the pipe in the middle of the trench. When the drainlines are covered, a grid of 36-inch survey stakes should laid out and clearly marked at 4 inches for the gravel layer

and at 16 inches for the rootzone mix (an additional 2 inches is needed if a choker layer is required) with the top of the stakes spray painted with a bright color for visibility.

D. Plastic Interface

To prevent capillary water movement between the greensmix and surrounding site soils, a plastic interface shall be installed to ring the putting green and collar. The plastic will be one millimeter in thickness and two feet in width. The plastic will be placed vertically around the cored sub-grade so that the top coincides with the height of the finished grade. The sheet shall be staked at five foot intervals to ensure that it remains in a vertical position. A 14-gauge tracer wire should be installed alongside the plastic to allow future tracking and location of original edges.

E. Gravel Base

The entire sub-grade should be covered with a layer of clean, washed pea-gravel or crushed stone to a uniform thickness of four inches. The preferred material for this purpose is washed pea gravel (with less than 3% combined silt and clay) of 1/4" to 3/8" diameter (as approved by a USGA recommended testing lab). Particles of any other size will be screened out. This is important to the proper functioning of the perched water table (see sub-section f below).

F. Intermediate Sand Layer

Creation of a perched water table is essential in USGA putting green construction. It is imperative to work closely with a USGA-approved soil testing laboratory in the selection of all materials. Depending on the particle sizes of gravel and rootzone mix, an intermediate sand layer may be required. If the gravel is relatively large in particle size and the rootzone mix is relatively small in particle size, an intermediate sand layer is required to prevent the migration of rootzone particles into the gravel layer and also to create the perched water table effect. However, engineering principles can be used in material selection to create bridging between the smallest 15% of the gravel particles and the largest 15% of the rootzone particles thereby eliminating the need for the intermediate sand layer. Eliminating the intermediate sand or choker layer is desirable - - not only in the cost of the material but in the hand labor required to spread a thin 2-4” layer of sand. This has been an over-abused and confusing part of the USGA specifications for years.

G. Rootzone Mixture

Selection of the rootzone mix is one of the most important decisions made during construction. Sand is the primary component of rootzone mixes, but sands vary widely in physical characteristics and are frequently blended with organic matter to increase moisture and nutrient retention. Thorough testing by a USGA recommended laboratory is required, and a quality control program during construction is strongly recommended. It is entirely possible for a sand to meet USGA specifications without organic amendments. However, these straight sand greens frequently have poor nutrient and moisture retention and will require more fertilizer and irrigation. While there are many straight sand greens on Maui, a small fraction of organic matter, even 10% will reduce the need for fertilizer and irrigation. Peat moss is normally used for this organic fraction. However, due to the lush environment of Maui, there are many high quality composts available that may be a possible substitute. Laboratory testing will determine the suitability of compost for rootzone mix. Inorganic soil amendments such as Zeolite™ and porous ceramic products such as Profile™ should be avoided. These products are designed to hold moisture without increasing the soil’s cation exchange capacity. Problems arise if water quality deteriorates. These water holding amendments will then be retaining water with contaminants and make the greens difficult to

flush. Suitable sands are somewhat limited on Maui and may need to be imported. There are sand and peat suppliers on Maui capable of supplying putting green rootzone mixes however. This convenience satisfies the very important requirement of off-site mixing. Under no circumstances should any amendment be mixed on-site by tilling, etc. The use of local materials is highly desirable as freight costs frequently surpass the cost of the materials themselves.

The final rootzone mixture will be decided by laboratory analysis. The basis of that decision is determined primarily by particle size and distribution as summarized in Table 1 below.

Table 1. Particle Size Distribution of USGA Rootzone Mix

Particle Type	Particle Diameter	Recommendation (by weight)
Fine Gravel	0 - 3.4 mm	Not more than 10% of the total particles in this range, maximum of 3% fine gravel
Very Coarse Sand	1.0 – 2.0 mm	Minimum of 60% of the particles must fall in this range
Coarse Sand	0.5 – 1.0 mm	
Medium Sand	0.25- 0.50mm	Not more than 20% of the particles may fall in this range
Fine Sand	0.15-0.25mm	
Very Fine Sand	0.05-0.15mm	Not more than 5 % total particles
Silt	0.002-0.05mm	Not more than 5% in this range not to exceed 10%
Clay	Less than 0.002	Not more than 5%

Other considerations in sand selection are particle shape and chemical properties. Particle shape has some influence on the physical properties of the rootzone mix. Sand particles that are too round in shape may cause a lack of surface stability resulting in scalping and wheel tracking problems during grow-in. Sands that are too angular may cause root shearing. These are usually short term problems. Once turf is established, particle size has little bearing on performance, but it is important to avoid extremes in particle shape. However, particle shape is extremely important in bunker sand selection. The mineral content of sand affects it's chemical properties. Quartz sands are preferred because they are chemically inert and resistant to future weathering. Calcareous and feldspar sands will weather faster than quartz but it is thought this process will take decades.

H. Organic Matter

If organic matter is included in the rootzone mix the amount is generally 10-20% by volume or 2-4% by weight. Laboratory analysis will determine the exact amount and type of organic matter to be used. As with sands, there are wide variations in peat materials and it is quite possible that composts, sawdust, rice hulls, and other organic materials can be used. Factors considered in organic matter selection are: source, pH, ash content, degree of decomposition, moisture, and fiber size and content.

Special precautions should be used with the organic matter during the mixing process. It is important not to overshred the peat which can happen to very dry material, literally turning into dust and

not mixing properly. Conversely, these organic materials frequently appear clumpy and proper screening is needed so balls of material do not appear in the mix.

Table 2 below provides the recommended range for the rootzone mix after the addition of organic matter.

Table 2. Physical Properties of the Rootzone Mix

Physical Property	Recommended Range
Total Porosity	35%-55%
Air Filled Porosity (at 40 cm tension)	15%-30%
Capillary Porosity (at 40 cm tension)	15%-25%
Saturated Hydraulic Conductivity: Normal Range: Accelerated Range:	 6-12 inches/hr 12-24 inches/hr
Organic Matter Content (by weight)	1%-5% (ideally 2%-4%)

The final rootzone mix for this project should have a saturated hydraulic conductivity in the accelerated range of 12-24 inches/hr. While water quality does not appear to be an issue now, well water tends to increase in salinity with time and it will be necessary to periodically flush the greens to remove salts.

Sand is generally low in fertility. Thus it is desirable to blend fertilizer and/or lime into the rootzone mix whenever possible to accelerate the establishment of turf. This can reduce the number of fertilizer applications needed in the first few weeks after planting when traffic on the surface is detrimental to young plants. Blending also mixes nutrients uniformly throughout the profile. Soil testing will identify any nutrient deficiencies. Generally, one pound of starter fertilizer per cubic yard of mix is sufficient. A rapid grow-in will reduce weed pressure and reduce herbicide treatments.

I. Delivery, Soil Covering, Placement, Smoothing, Firming and Sterilization

Advanced planning is needed between the contractor and the supplier of the rootzone mix to schedule delivery. Most suppliers will have minimum order requirements for custom mixes, and storage of the material can pose problems for both parties. It is generally desirable to mix large quantities of material with fewer production runs, and samples should be taken of each load for quality control reasons.

A suitable storage area near the access road should be developed to stockpile material as it is delivered. Large over the road trucks generally are not able to traverse golf course construction sites. Material should be dumped and stored on a hard surface or synthetic liner to reduce contamination. Care should be taken when loading and transporting any rootzone mix to avoid contamination, and when possible, equipment should be dedicated solely for that purpose.

The rootzone should be transported to the green site with small, maneuverable tip carts, dump trailers, or small trucks, and dumped directly into the cavity around the perimeter. Small crawler type loaders should be used to spread the mix, keeping their weight on previously spread material, never on the

gravel base. The material should be compacted and watered if extremely dry. Repeated raking and firming is needed until uniform firmness is obtained.

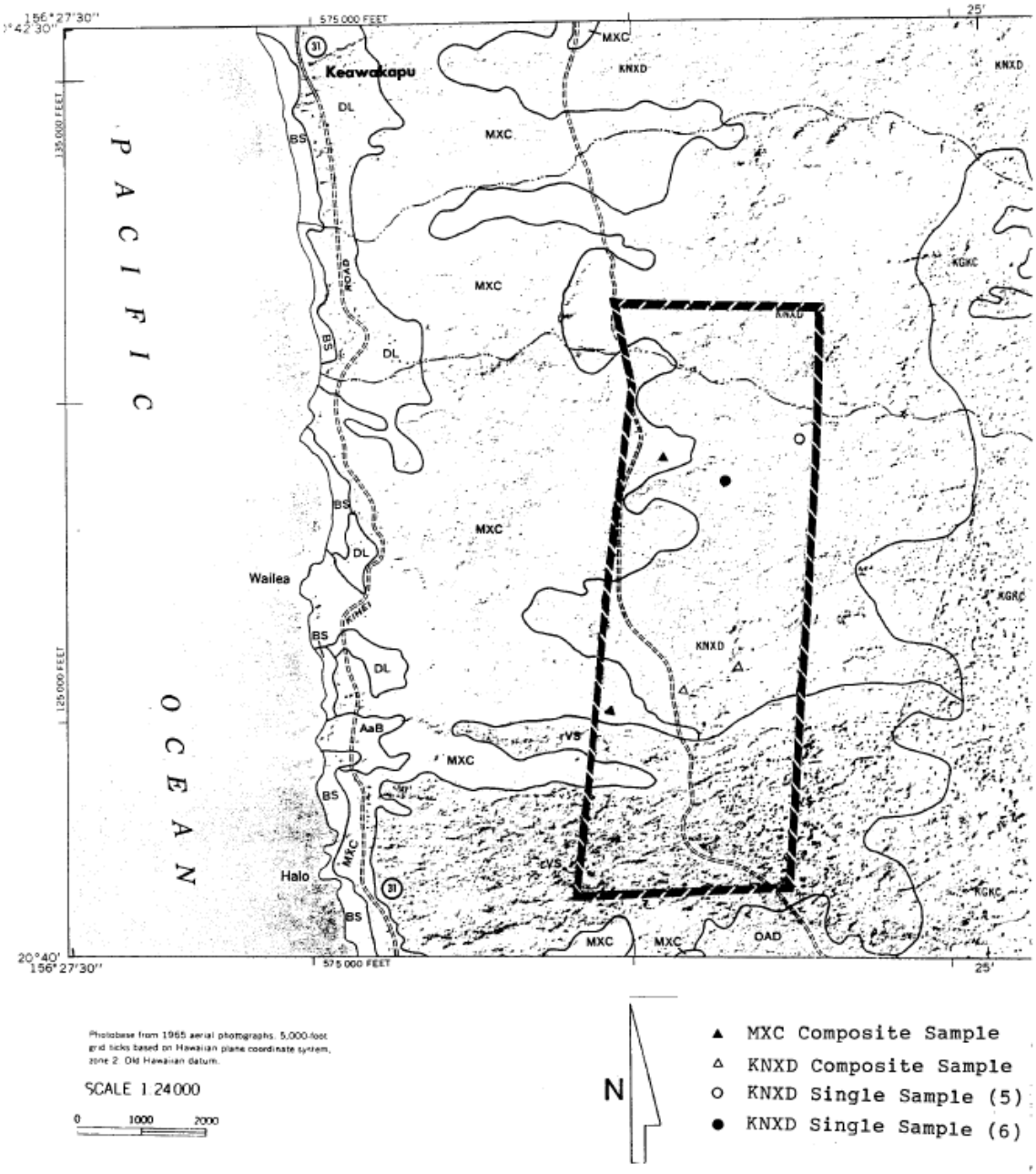
Once the rootzone mix is in place, fumigation can be considered if there is a concern for weed or nematode contamination. At this writing the use of methyl bromide is still allowed but rumored to soon be suspended and golf course superintendents on Maui report that it is already unavailable in Hawaii. There are few substitutes. Basamid, a granular product, could possibly be used as a substitute. Some soil blenders have the ability to sterilize soils with heat treatments. It is a complex problem. The seashore paspalum turf that will be used has a high level of tolerance to weeds and nematodes if fumigation proves to be impossible.

J. Fine Grading

The entire green area shall be fine graded and floated so all contours blend into fairways, bunkers, and mounds as shown on the greens plans or as directed by the designer. No water-holding pockets shall remain and slopes should not exceed the designer’s specifications.

[Note: If the designer's final specifications for construction differ from the text above, the designer's specifications must be considered as alternatives from those provided.]

APPENDIX E. Soil Sampling Results


156°27'30"
20°42'30"
575 000 FEET
25'
135 000 FEET
125 000 FEET
20°40'
156°27'30"
575 000 FEET
25'
PACIFIC
OCEAN
Keawakapu
Wailea
Halo
MXC
KNXD
KGKC
KGRC
OAD
DL
BS
AaB
CVS
31
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 2. Old Hawaiian datum.
SCALE 1:24000
0
1000
2000
N
▲ MXC Composite Sample
△ KNXD Composite Sample
○ KNXD Single Sample (5)
● KNXD Single Sample (6)

TURF DIAGNOSTICS & DESIGN

"Managing the Elements Through Science"

Environmental & Turf Services
Tom Durborow
11141 Georgia Ave., Suite 208
Wheaton, MD 20902
PHONE:301-933-4700
FAX:301-933-4701

Account No. 79130100
Date 2/29/92
Facility Wailea 670

		Textural Analysis					Chemical Evaluation		
	USDA (mm)	Sand .05 to 2.00	Silt .002 to .05	Clay <.002	USDA Textural Class	Mean Diameter (mm)	pH	Organic Matter %	Electrical Conductivity umhos/cm
	U.S. Sieve (mesh)	270 to 18							
LAB ID NO.	SAMPLE NAME								
-1	0-6" MXC Composite	17.8	27.2	54.6	Clay		6.8	3.3	
-2	6-12" MXC Composite	16.9	24.1	58.9	Clay		6.8	1.8	
-3	0-6" KNXD Composite	21.9	27.2	50.9	Clay		7.1	3.3	
-4	6-12" KNXD Composite	18.4	22.2	59.4	Clay		6.9	2.7	
-5	0-6" KNXD One Location	23.7	27.5	47.8	Clay		7.0	3.6	
-6	0-6" KNXD One Location	22.0	24.3	52.1	Clay		7.2	4.2	

		Gravel Content			Sand Distribution				
		Gravel > 4.0mm	Gravel	Total Gravel	Very Coarse	Coarse	Medium	Fine	Very Fine
	USDA (mm)	> 4.0	2.0	> 2.0	1.0	0.5	0.25	0.10	0.05
	U.S. Sieve (mesh)	> 5	10	> 10	18	35	60	140	270
LAB ID NO.	SAMPLE NAME	% Material Retained on Sieve							
-1	0-6" MXC Composite	0.0	0.3	0.3	0.9	1.3	2.1	6.0	8.0
-2	6-12" MXC Composite	0.0	0.1	0.1	0.5	1.0	1.6	5.9	8.5
-3	0-6" KNXD Composite	0.0	0.0	0.0	0.4	1.5	3.3	7.2	9.5
-4	6-12" KNXD Composite	0.0	0.0	0.0	0.9	1.8	2.9	5.9	7.1
-5	0-6" KNXD One Location	0.0	1.0	1.0	2.9	5.1	5.8	5.4	4.6
-6	0-6" KNXD One Location	0.0	1.6	1.6	1.5	2.9	5.0	6.3	6.4

Reviewed by: _____
VP Technical Operations

TURF DIAGNOSTICS & DESIGN

"Managing the Elements Through Science"

Environmental & Turf Services
Tom Durborow
11141 Georgia Ave., Suite 208
Wheaton, MD 20902
PHONE:301-933-4700
FAX:301-933-4701

Account No. 79130100
Date 3/13/92
Facility Wailea 670

		Textural Analysis					Chemical Evaluation		
		Sand	Silt	Clay	USDA	Mean	pH	Organic	Electrical
	USDA (mm)	.05 to 2.00	.002 to .05	<.002	Textural	Diameter		Matter	Conductivity
	U.S. Sieve (mesh)	270 to 18			Class	(mm)		%	umhos/cm
LAB ID NO.	SAMPLE NAME								
92010018-7	6-12" KNXD One location	18.3	17.1	64.5			7.2	2.5	
	Duplicates								
92010018-3D	0-6" KNXD Composite								
92010018-7D	6-12" KNXD One location							2.5	
92010018-2D	6-12" MXC Composite						6.8		

		Gravel Content			Sand Distribution				
		Gravel > 4.0mm	Gravel	Total Gravel	Very Coarse	Coarse	Medium	Fine	Very Fine
	USDA (mm)	> 4.0	2.0	> 2.0	1.0	0.5	0.25	0.10	0.05
	U.S. Sieve (mesh)	> 5	10	> 10	18	35	60	140	270
LAB ID NO.	SAMPLE NAME	% Material Retained on Sieve							
92010018-7	6-12" KNXD One location	0.0	0.1	0.1	0.6	1.9	2.7	5.3	7.9
92010018-3	Duplicate								

Reviewed by: _____
VP Technical Operations

A Kansas Corporation

310-A North Winchester • Olathe, Kansas 66062 • (913) 780-6725 • Fax: (913) 780-6759

TURF
DIAGNOSTICS
& DESIGN

"Managing the Elements Through Science"

Samples Submitted By

Environmental & Turf Services
Tom Durborow
11141 Georgia Ave., Suite 208
Wheaton, MD 20902
PHONE:301-933-4700
FAX:301-933-4701

Account No. 79130100
Date 2-Mar-92
Facility Wailea 670

LAB ID NO.	SAMPLE NAME	Infiltration Rate in/hr	-1/3 Bar Water Holding % Moisture	Bulk Density g/cc	Porosity Total %	Porosity Capillary %	Porosity Non Capillary %
92010018-1	0-6" MXC Composite	0.2	26.5	1.2	53.6		
92010018-2	6-12" MXC Composite	0.9	27.0	1.1	58.8		
92010018-3	0-6" KNXD Composite	0.4	29.6	1.1	57.0		
92010018-4	6-12" KNXD Composite	0.8	27.8	1.1	57.0		
92010018-5	6-12" KNXD Composite	0.9	25.5	1.0	60.7		
92010018-6	0-6" KNXD One Location	0.8	25.7	1.1	56.8		
92010018-7	6-12" KNXD One Location	1.5	23.7	1.2	54.7		

Reviewed by: _____
Title: Vice President Technical Operations

A Kansas Corporation
310-A North Winchester • Olathe, Kansas 66062 • (913) 780-6725 • Fax: (913) 780-6759

ENVIRONMENTAL & TURF SERVICES, INC.

11141 Georgia Ave. Suite 208
Wheaton, MD 20902
(301) 933-4700

Sample Chain of Custody Record

Project: WAILEA 67C Site:
Client: ENVIRONMENTAL + TURF SERVICES, INC
Address: 11141 GEORGIA AVE, STE 208 WHEATON, MD 20902
Phone: (301) 933-4700
Sampler's Name/Firm: T. DURRELL / L. BARNES
Phone: same Sampler's Signature: L. Jon Barnes

Preservative Used

Analyses Required: PH; CHLORIDE, NITRATE; TEXTURE; USGA PHYSICAL

Sample Number	Date	Time	Matrix	No. of Containers	Remarks or Sample Location
SS#1/0-6"	1-13-92		SOIL	1	MIX COMPOSITE
SS#1/6-12"	1-13-92		SOIL	1	MIX COMPOSITE
SS#2/0-6"	1-14-92		SOIL	1	MIXED COMPOSITE
SS#2/6-12	1-14-92		SOIL	1	MIXED COMPOSITE
SS#3/0-6	1-14-92		SOIL	1	MIXED ON LOCATION
SS#3/6-12	1-14-92		SOIL	1	MIXED ON LOCATION
SS#4/0-6	1-14-92		SOIL	1	MIXED ON LOCATION
SS#4/6-12	1-14-92		SOIL	1	MIXED ON LOCATION

will call for testing
1/21/92 to [illegible]

samples in 2 containers shipped together

Relinquished by: (Signature) [1]	Date/Time	Received by: (Signature)	Relinquished by: (Signature) [4]	Date/Time	Shipping Carrier:
[signature]	1/[illegible]				
Relinquished by: (Signature) [2]	Date/Time	Received by: (Signature)	Received for **Laboratory** by: (Signature)	Date/Time	Shipping Ticket Number: Fed-X
			[signature]	1/24/92 1500	3055101464
Relinquished by: (Signature) [3]	Date/Time	Received by: (Signature)	Sampler Remarks	Lab Remarks	
[signature]	1/24/92 17:10	[signature]		9123T0D56650	

White-Return to Client Yellow-Retain by Lab (Project File) Pink-Retain by Lab (Client Services) Gold-Retain by Sampler

APPENDIX F. Pest Infestation Tables and Threshold Guidelines

Pest Problems Associated With Turf at Honua'ula

Table 1 represents the pest problems that might be encountered at Honua'ula. They are listed in the order of insects, weeds, and disease. Each of the pests listed in 6 have been given a Pest Index code that determines the probability of impact. A corresponding Frequency Index to determine the degree of likelihood that this pest should be monitored is also provided. The location of probable impact is also provided.

Preliminary Threshold Guidelines

Lists of Preliminary Threshold Guidelines have been established for each of the anticipated pests and are presented on the following pages in Tables 2-5. These thresholds set a period of time for the golf course superintendent to analyze turf pest occupancy and establish baseline density for implementing cultivation and mechanical control methods. They also have been established for the golf course superintendent to determine when a potential pesticide may be needed for control.

Development of economic thresholds in field crops attempts to relate pest populations with the amount of damage caused. This relationship can then be used to decide if the cost of applying a control will actually result in more money being made from the crop. Obviously, turfgrass is mainly used for its ornamental value and is not harvested like a field crop. This ornamental value varies according the turf use and in some cases can not even be determined. Therefore, the traditional use of 'economic' threshold should probably be changed to aesthetic threshold. Again, this is a value judgement because each person would value turf in a different way. Some people would not mind a few dandelions or brown spots in their lawn while others demand flawless turf.

Turf specialists have attempted to study the relationship of turf insects to damage observed and, unfortunately, don't seem to be able to come to any set rules. In the past, controls were recommended for annual grubs when populations reached 6-10 per square foot. We now know that skunks or raccoons may consider this number good enough reason to rip up the turf. On the other hand, with good irrigation and fertilizer over 20 grubs per square foot may not be noticeable.

TABLE 1. Location and Extent of Pest Infestation

Pest Infestation Index			
INSECTS			
Insect	**Pest Index**	**Location**	**Frequency Index**
Bagworm	P	F	1
Bermudagrass mite	P	T F	3
Bermudagrass scale	P	T F G	3
Black cutworm	O	T G	3
Fiery Skipper	P	F	1
Frit Fly	O	F R	2
Grass webworm	**K**	T F G R	4
Hunting billbug	O	F R	2
Lawn armyworm	O	T G	2
Rhodesgrass mealybug	O	T F	2
Southern chinch bug	O	T F R	2
WEEDS (Monocotyledons)			
Weed - Monocotyledon	**Pest Index**	**Location**	**Frequency Index**
Annual bluegrass	O	T G	3
Bahiagrass	O	T F R	2
Cyperus sedge	P	T F R	3
Dallisgrass	O	F R	3
Goosegrass	***K***	***T F G R***	***5***
Green kyllinga	P	T F R	3
Henry's crabgrass	P	T F G R	4
Hilograss	O	T F R	3
Kikuyugrass	O	T F R	3
Lovegrass	O	T F R	2
Molasses grass	O	F R	2
Purple Nutsedge	**K**	**T F R**	**3**
Sandbur	P	F R	1
Smutgrass	O	T F R	4
Stargrass	O	T F R	2
Swollen finger grass	O	T F R	2
Vaseygrass	O	T F R	2
Wainaku grass	P	T F G R	3
White kyllinga	O	T F R	1
Yellow Nutsedge	O	T F R	3

Frequency of Severe Outbreaks: 1-Low.....5-High
Location Index: T=Tees F=Fairways G=Greens R=Roughs
Pest Index: **K**=Key Pest P=Potential Pest O=Occasional Pest

TABLE 1. (cont'd)

Pest Infestation Index			
WEEDS (Dicotyledons)			
Weeds - Dicotyledons	**Pest Index**	**Location**	**Frequency Index**
Ageratum	**K**	T F R	4
Alternanthra	O	F R	2
Asiatic pennywort	P	T F R	4
Broad-leaved plantain	O	F R	2
Buttonweed	O	F R	2
Creeping indigo	O	F R	2
Dandelion	P	T F R	3
Drymaria	O	F R	2
Garden spurge	O	F R	2
Kaimi clover	O	T F R	3
Marsh pennywort	O	T F R	2
Milkwort	O	F R	2
Pigweed prostrate	O	T F R	3
Pigweed spiny	O	T F R	3
Pink wood sorrel	P	R	1
Prostrate spurge	O	F R	4
Purslane	O	F R	2
Sensitive plant	P	F R	3
Sow thistle	O	F R	2
Spurge spotted	O	T F R	2
Synedrella	O	F R	2
Yellow wood sorrel	O	F R	2
DISEASE			
Disease	**Pest Index**	**Location**	**Frequency Index**
Algae	**K**	T F G	4
Anthracnose	O	T G	3
Brown patch	**K**	T F G	4
Dollar spot	O	T G	2
Dreschlera leaf spot	P	T F	2
Fairy ring	O	T F G R	2
Fusarium blight	O	T G	2
Pythium blight	**O**	T G	4
Leaf rust	O	F	3
Melting out	**K**	T F	4
Nematodes	0	T F G R	1
Take all patch	P	T G	1

Frequency of Severe Outbreaks: 1-Low.....5-High
Location Index: T=Tees F=Fairways G=Greens R=Roughs
Pest Index: **K**=Key Pest P=Potential Pest O=Occasional Pest

TABLE 2. Preliminary Threshold Guidelines - Turfgrass Insects

INSECT DENSITY			
Area	**Pest**	**Cultivation Controls**	**Curative Controls**
Greens/Tees	Baqworm	3-5/sq ft	6/sq ft
Fairways		5-8/sq ft	8/sq ft
Roughs		5-8/sq ft	8/sq ft
Greens/Tees	Bermudagrass mite	1-2/sq ft	4/sq ft
Fairways		3-4/sq ft	6/sq ft
Roughs		4-8/sq ft	10/sq ft
Greens/Tees	Bermudagrass scale	1-2/sq ft	4/sq ft
Fairways		3-4/sq ft	6/sq ft
Roughs		4-8/sq ft	10/sq ft
Greens/Tees	Black Cutworm	1-2/sq ft	3/sq ft
Fairways		2-3/sq ft	4/sq ft
Roughs		3-4/sq ft	5/sq ft
Greens/Tees	Fiery Skipper	1-2/sq ft	3/sq ft
Fairways		2-3/sq ft	4/sq ft
Roughs		3-4/sq ft	7/sq ft
Greens/Tees	Grass webworm	1-3/sq ft	4/sq ft
Fairways		3-5/sq ft	6/sq ft
Roughs		5-8/sq ft	8/sq ft
Greens/Tees	Hunting billbug	3-4/sq ft	4/sq ft
Fairways		4-5/sq ft	6/sq ft
Roughs		5-8/sq ft	8/sq ft
Greens/Tees	Lawn armyworm	1-3/sq ft	4/sq ft
Fairways		3-5/sq ft	6/sq ft
Roughs		6-8/sq ft	8/sq ft
Greens/Tees	Rhodesgrass	3-5/sq ft	4/sq ft
Fairways	mealybug	5-8/sq ft	6/sq ft
Roughs		6-8/sq ft	8/sq ft
Greens/Tees	Southern chinch bug	10-15/sq ft	12-16/sq ft
Fairways		16-25/sq ft	25-30/sq ft
Roughs		26-30/sq ft	30-35/sq ft

*Currently there are no established industry standards for pest threshold guidelines. The following thresholds for insects, weeds and disease are established as a preliminary guide to assist the golf course superintendent in deciding when to choose the appropriate form of control. We fully expect that local experience will result in the refinement of these threshold guidelines.

TABLE 3. Preliminary Threshold Guidelines - Turfgrass Weeds

TURFGRASS WEEDS (Monocotyledons)			
Pest Control	**Area**	**Cultivation Management**	**Curative Management**
Purple Nutsedge	Tees/Greens	spot treat	post emergence
	Fairways	spot treat	post emergence
	Roughs	spot treat	post emergence
Sandbur	Tees/Greens	mechanical removal	spot treat
	Fairways	spot treat	post emergence
	Roughs	spot treat	post emergence
Smutgrass	Tees/Greens	preventative	spot treat
	Fairways	preventative	spot treat
	Roughs	preventative	spot treat
Stargrass	Tees/Greens	mechanical removal	spot treat
	Fairways	spot treat	spot treat
	Roughs	spot treat	spot treat
Swollen finger grass	Tees/Greens	preventative	spot treat
	Fairways	preventative	spot treat
	Roughs	preventative	spot treat
Vaseygrass	Tees/Greens	mechanical removal	spot treat post emergence
	Fairways	spot treat	post emergence
	Roughs	spot treat	
Wainaku grass	Tees/Greens	spot treat	post emergence
	Fairways	spot treat	post emergence
	Roughs	spot treat	post emergence
Yellow nutsedge	Tees/Greens	spot treat	post emergence
	Fairways	spot treat	post emergence
	Roughs	spot treat	post emergence

* Control of annual turfgrass weeds on Bermudagrass greens and tees are best obtained with the use of a pre-emergent herbicide. The use of spot treatment will serve as a guide to those compounds modeled for use under the maximum number of acres treated per year.

TABLE 4. Preliminary Threshold Guidelines - Turfgrass Weeds

Turfgrass Weeds – Dicotyledons			
Pest	**Area**	**Cultivational Management**	**Chemical Control**
Ageratum	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Alternanthra	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Asiatic pennywort	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Broad-leaved plantain	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Buttonweed	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Creeping indigo	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Dandelion	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Drymaria	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Garden spurge	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Kaimi clover	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Marsh pennywort	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Milkwort	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Pigweed prostrate	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence

Turfgrass Weeds – Dicotyledons			
Pest	**Area**	**Cultivational Management**	**Chemical Control**
Pigweed spiny	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Pink wood sorrel	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat spot treat spot treat
Prostrate spurge	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Purslane	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Sensitive plant	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Sow thistle	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Spurge spotted	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Synedrella	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence
Yellow wood sorrel	Tees/Greens Fairways Roughs	mechanical removal spot treat spot treat	spot treat post emergence post emergence

* Dicot weeds may be controlled with consistent cutting heights on Greens and Tees. The use of clean treated topsoil or topsoil blended with cinder, organic matter, and ash should result in lower counts of weed infestation. Consistent monitoring and proper timing of spot treatment will result in less need for post emergent applications.

TABLE 5. Preliminary Threshold Guidelines - Turfgrass Disease

Turfgrass Disease			
Pest	**Area**	**Cultivation Management Threshold**	**Chemical Control Guidelines**
Algae	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 120 hours
Anthracnose	Tees/Greens Fairways Roughs	upon detection 48-72 hours 48-72 hours	spot treat 96 hours 96 hours
Bacterial stripe	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	72 hours 96 hours 120 hours
Brown Patch	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 96 hours
Dollar spot	Tees/Greens Fairways Roughs	upon detection 24-48 hours 48-72 hours	spot treat 72 hours 96 hours
Dreschlera leaf spot	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Fading out	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Fairy ring	Tees/Greens Fairways Roughs	24-48 hours 48-72 hours 96 hours	72 hours 96 hours 120 hours
Fusarium blight	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Grease spot	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 24-48 hours	48 hours 48 hours 48 hours
Leaf rust	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat 96 hours
Melting out	Tees/Greens Fairways Roughs	24-48 hours 24-48 hours 48-72 hours	spot treat spot treat spot treat
Moss	Tees/Greens Fairways Roughs	upon detection 96 hours 120 hours	spot treat spot treat spot treat
Nematodes	Tees/Greens Fairways Roughs	sample counts sample counts sample counts	spot treat spot treat spot treat
Take all patch	Tees/Greens Fairways Roughs	upon detection upon detection upon detection	spot treat spot treat spot treat

*Currently there are no established industry standards for pest threshold guidelines. The following thresholds for insects, weeds and disease are established as a preliminary guide to assist the golf course superintendent in deciding when to choose the appropriate form of control. We fully expect that local experience will result in the refinement of these threshold guidelines.

APPENDIX G. Monitoring and Scouting Summary Report Example

Monitoring and Scouting Summary Report

NAME OF SCOUT OR IPM SPECIALIST_____
DATE_____ TIME IN_____ TIME OUT_____
Disease_____ Weed_____ Insect_____ Other_____

Host Site: Tee____ Fairway____ Green____ Rough____ Ornamental____ Other_____
Hole Number:_____

Observations (Comments):

_____
_____
_____

IDENTIFY AND CATEGORIZE PEST POPULATION

MACRO ENVIRONMENT	MICRO ENVIRONMENT
Key Pests	Potential Pests
Occasional Pests	Non Pests
Migrant Pests	

DRAW MAP

Qualitative Assessment
Low ___ Medium ___ High ___ Pest/_____Sq. Yd.
Ranking-1(low)-5(high) _____ Action Limit/_____Sq. Yd.
Turfgrass Quality _____
Color _____
Quantity _____
Presence or Absence of Beneficial Organisms YES NO

Weather Information
_____
_____
_____
Computer Weather Station Information Attached YES_____ NO_____
Disease Immunoassay Kit Used_____ Positive Identification: YES_____ NO_____
Mechanical Damage Observed or Noted (EXPLAIN CAUSE)
Form of Control Method Used
Biological
Cultivation
Follow Up:
Mechanical
Chemical
None

Signature of Golf Superintendent: _____

APPENDIX H. Updated Pesticide Risk Evaluation

UPDATED PESTICIDE RISK EVALUATION FOR THE HONUA'ULA GOLF COURSE

I. Context, Purpose, and Approach

The project previously planned for this site was called Maui Wailea 670. An EIS was prepared for the overall project ca. 1989. In March, 1992 a comprehensive package that included our golf course risk assessment, water quality monitoring program, and management plan (Durborow et al., 1992) was submitted, "Application Submittal for Change in Zoning and Project District Development Approval Phase I Kihei-Makena Community Plan Project District 9." (Our report was Exhibit F in Volume II of that submittal.) The DOH reviewed and gave final approved of that original risk assessment and management plan in 1993 (see Appendix C) and stated that "…the Project is not expected to have any significant adverse impact on the basal aquifer, nearshore organisms or residents."

Our 1992 report thoroughly evaluated potential ground water and surface water contamination risks of 16 pesticides/metabolites using hundreds of site-specific and chemical-specific input parameters. The complex USDA model SWRRBWQ (subsequently renamed SWAT) was used for the stormwater runoff evaluation, and the US EPA's linked PRZM-VADOFT model was used to estimate potential ground water contamination impacts. This work required hundreds of person-hours of work.

This project has evolved, and it has been necessary to amend the pesticide list for two reasons: the pesticides registered for use nationally and in Hawaii have changed since 1992, and the turfgrass planned for this golf course has changed. Previously, the widely used turf species bermudagrass was planned for this golf course. Since that time, a more environmentally desirable species has become available in Hawaii: seashore paspalum (Part 3(B) of this BMP plan discusses this issue in more detail.) Insect, weed, and disease pest pressures can be different for seashore paspalum compared with bermudagrass. Therefore the pesticide requirements are expected to be different, which affects the list of proposed pesticides.

Accordingly, this BMP plan lists 16 conventional pesticide active ingredients proposed for this golf course, plus other products that are 'organic'/'biorational' and/or "Reduced Risk" (EPA). Our 1992 report recommended 14 conventional pesticides. The two lists are combined in Table H-1. The proposed pesticide active ingredients listed in **bold** and in ***bold and italics*** are our 2009 recommendations, the remaining pesticides were recommended in 1992 and are not recommended now. These currently recommended pesticides (in **bold** and in ***bold and italics***) might be needed at some point during the first five years of course operation.

As noted above, the original water quality risk assessment process was site-specific, highly detailed, and resource intensive. Although it is necessary to conduct a risk evaluation of the newly proposed pesticides, it is preferable not to repeat the intensive evaluation conducted 1991-1992. Therefore the following approach was been taken.

1. Maximum pesticide application rates are provided for all pesticides: original (1992) and new (2009).
2. Environmental fate data - - pesticide mobility and persistence - - have been obtained for all pesticides and updated for the original pesticides.
3. Human and aquatic toxicity data have been obtained and used to determine the toxicity reference points.
4. The US EPA's highly conservative GENEEC pond model for surface water (http://www.epa.gov/oppefed1/models/water/geneec2_description.htm) was applied to all pesticides to estimate their environmental concentrations. The GENEEC-predicted concentrations are irrelevant to nearshore coastal waters (these predicted concentrations are much higher, more conservative), but these predicted concentrations provide a common reference point for internal comparisons.
5. Similarly, the US EPA's conservative, Tier I SCI-GROW model for ground water (http://www.epa.gov/oppefed1/models/water/#scigrow) was also applied to the updated pesticide list. These results provide an extreme upper limit on potential pesticide concentrations in Maui ground water.
6. Pesticide concentrations predicted using GENEEC and SCI-GROW were divided by the MACs (maximum allowable concentrations for aquatic organisms) and HALs (lifetime drinking water Health Advisory Levels), respectively, to produce risk ratios. Concentrations predicted by GENEEC were further diluted by onsite and upstream site runoff to refine the surface water risk ratios.
7. The risk ratios for the original and the revised pesticide lists were compared to each other in order to qualitatively evaluate their potential environmental risks.

Sections II-IV below summarizes this process and provides the results.

II. Environmental Fate, Human Health Criteria, and Aquatic Criteria

Table H-1 provides a list of all pesticides, with the currently recommended pesticides being in bold and bold italic fonts. This table also includes pesticides that were recommended in our 1992 risk assessment and golf course management plan (Durborow et al., 1992) for comparison. Expected application rates, key environmental fate parameters, aquatic maximum allowable concentrations (MACs), and lifetime drinking water Health Advisory Levels (HALs) are presented.

A. Pesticide Chemistry and Environmental Fate Properties

A risk assessment is a process that either measures or estimates the probability of harm. This is done by quantifying both exposure to particular substances and their toxicity to humans and/or other organisms. (When using EPA-based standards, a risk assessment is actually an evaluation of the probability of exceeding an action level, defined as a level just below the concentration that may cause

harm, allowing for uncertainty.) Thus it can be said that the dose makes the poison, i.e., neither toxicity alone nor exposure alone determines whether a pesticide would cause harm to humans or the environment. Rather, the two must be combined.

The technical terms listed and defined below are used frequently in the risk assessment using EPA tier-I models (GENEEC and SCIGROW):

Half-life (t½) - The time required for half (50%) of the original pesticide to transform to chemicals that are nontoxic or have significantly lower toxicity. For example, the herbicide 2,4-D is degraded rapidly, with a 6-day half life in soils, depending on the climate. Modeling requires the use of rate constants, k, which are related to other terms as follows for first-order decay:

$k = 0.693/t_{½}$,

k = decay rate/[P],

where [P] = concentration of the parent pesticide.

K_d - soil/water distribution coefficient. The higher the K_d, the more tightly bound the chemical is to the soil. This varies for each pesticide from soil to soil. Pesticides with K_d values less than 1 are very mobile in soils and can leach to ground water if they are persistent. K_d or Koc (see below) is needed for running GENEEC and SCIGROW models.

K_{oc} - the K_d divided by the organic carbon fraction of the soil. This is supposed to be constant among different soils for each pesticide that is neutral. The K_{oc} can be calculated from the water solubility if experimental data are not available.

ADI - Acceptable Daily Intake for humans in milligrams/kilogram body weight/day. Usually referred to as the reference dose (RfD) when it represents an EPA-wide consensus. This term is generally not used by the EPA anymore, but it is used by the World Health Organization.

cPAD - Chronic Population Adjusted Dose. See section B below.

RfD - See ADI.

HAL - the Health Advisory Level is an acceptable concentration level in drinking water based on the RfD. An HAL is the maximum concentration of a substance that can be consumed for a lifetime from drinking water without causing ill effects. The HALs were obtained directly from EPA when available. Otherwise, they were calculated based on cPAD, as described in section B below.

B. Human Health Risk Assessment for Drinking Water Impacts

Tier I ground water modeling results were compared with chronic (lifetime) drinking water standards or guidelines. EPA's legally enforceable Maximum Contaminant Levels (MCLs) were only available for two of the pesticides, and EPA's non-enforceable lifetime drinking water HALs were available for an additional three pesticides (www.epa.gov/waterscience/health). The remainder of the lifetime HALs was calculated as follows, generally following the approach used by the EPA's Office of Ground Water and Drinking Water. Chronic reference doses (cRfDs) adjusted with the Food Quality Protection Act (FQPA) uncertainty factors (the maximum unit dose in mg chemical/kg body weight/day calculated that one could consume without suffering any adverse effects) were generally obtained from the EPA's Office of Pesticide Programs Registration Eligibility Decision documents (www.epa.gov/oppsrrd1/reregistration/status.htm) or food tolerance notices published in the Federal Register. A secondary source was the EPA's Integrated Risk Information System (IRIS). (The first two sources are preferred because IRIS information can be less up-to-date.) The lifetime HAL was calculated using this formula for non-neurotoxic endpoints:

(1) lifetime HAL = cPAD X 70 kg body wt/2 L/day X food factor

where cPAD = cRfD divided by the FQPA uncertainty factor (usually 1, 3, or 10), and the food factor = 0.2 if there are tolerances registered for the subject pesticide on any foods other than a limited number of minor crops. Eqn. 1 is modified for neurotoxic agents by substituting 10 kg body wt/1 L/day as the consumption rate multiplier appropriate for toddlers.

Most pesticides are not considered probable or possible human carcinogens by the US EPA. (None are considered to be human carcinogens.) Theoretically, the cancer slope factor, in units of $(mg/kg/day)^{-1}$, should be used to provide an estimate of a pesticide concentration that generates a $1x10^{-6}$ (one chance in a million) risk at the upper 90% confidence level. However, this is rarely done because EPA scientists usually recommend that the RfD or cPAD (see above) be used due to the relative lack of carcinogenic potency and/or the weak confidence that the pesticide is likely to be carcinogenic in humans.

C. Risk Criteria for Fish and Aquatic Invertebrates

In general, any water quality risk assessment for a site next to a key surface water resource must consider potential impacts on aquatic vertebrates (fish) and invertebrates. Hawaii ambient fresh water quality standards were only available for one of the 31 pesticides (including 3 metabolites): chlorpyrifos. Likewise, there was only one saltwater criterion available: chlorpyrifos. The following procedure was used for the other pesticides.

The USEPA, Office of Pesticide Programs, Environmental Fate and Effect Division established a database called the Aquatic Life Benchmarks for use in ecological risk assessments. The aquatic life benchmarks are based on toxicity information presented in the data that support the registration of the

selected pesticides. These benchmarks are estimates of concentrations below which the pesticide(s) are "not expected to have adverse effects" (USEPA, 2007). We obtained the lowest acute LC_{50} concentrations for the most sensitive fish species and invertebrates from the EPA's ECOTOX database (http://cfpub.epa.gov/ecotox) and calculated the MAC for those pesticides lacking federal criteria. This was done by dividing the lowest LC_{50} for the chemical by 10; i.e., multiplied the low LC_{50} values by 0.1 to obtain an estimate of the No Observable Effect Level (NOEL). This may be a conservative estimate of the exposure to fish species. In some cases, the algae EC_{50} values were lower than the 0.1 x LC_{50} values for fish and insects. When this occurred, the plant EC_{50} was used as the MAC.

D. Availability and Significance of Aquatic Toxicity Data

The US EPA and other government agencies have reported extensive databases on acute and chronic toxicity of chemicals to aquatic organisms. As extensive as these databases are, many organisms and chemicals have not been evaluated. It would be an enormous and very expensive task to evaluate each chemical for each organism. The available data are generally provided for certain indicator species, as recommended by the EPA Office of Pesticide Programs guidance document, "Hazard Evaluation Division Standard Evaluation Procedure, Ecological Risk Assessment." These indicator species are selected based on criteria such as demonstrated sensitivities to toxic chemicals and ecological significance in widespread habitats (EPA-OPP/HED, 1986). These data allow for assumptions and extrapolations to be made in assessing the risk of chemicals to other organisms (Mayer et al., 1987).

Mayer and Ellersieck (1986) and Mayer et al. (1987) conducted statistical analyses of acute toxicity data and found that correlations for toxicity exist among aquatic organisms. These correlations are best within the same families of fishes and are generally better between fish than between fish and invertebrates. Correlations are also good among invertebrates of the same families (Mayer et al., 1987). While good correlations do not imply that each species will be equally sensitive to a particular chemical, sensitivity ranges can be predicted for species with little or no data using known sensitivity data of other species. The estimated environmental concentrations (EEC) can then be compared with the low end of the sensitivities for species more taxonomically distant from the test species and compared more closely to the test values for species within the same family.

At least some aquatic toxicity data were available for all pesticides

III. Screening-Level Tier I Modeling

A. GENEEC model

The environmental fate and human and aquatic toxicity for the proposed pesticides, including three toxic degradates, described in Table H-1 were evaluated using EPA's GENEEC model (http://www.epa.gov/oppefed1/models/water/geneec2_description.htm), as noted above. The principles

for evaluation of environmental fate have been described in part by Cohen et al. (1984). The principles for human and aquatic toxicity evaluations were described in sections II(B) and (C) above.

The GENeric Estimated Environmental Concentration (GENEEC) model is a surface water screening level tier I model that was designed to mimic the results of a tier II model (i.e., PRZM-EXAMS). The model conservatively assumes a pesticide is applied to a 10-hectare field and runs off into a 1-hectare pond with no renewable source of water.

Key chemical properties (K_{oc}, soil aerobic metabolic half life, water solubility, and others) are used to evaluate the chemicals in the model. It would be impractical to cite in the table all the references that were used. However, whenever available, the US EPA and the USDA recommendations for environmental fate parameters were used. The model is also able to account for multiple applications, if applicable, and pond degradation (if aerobic aquatic metabolic half-life, hydrolysis, and/or photolysis are available). It should also be noted that GENEEC was created for agricultural scenarios, not for turfgrass scenarios, and therefore results for this risk screening assessment are overly conservative (i.e., it produces higher concentrations than expected). Further, it does not allow for the significant dilution that occurs at the shoreline. The model output consists of peak, 4-day, 21-day, and 56-day estimated environmental concentrations (EECs).

A risk ratio was computed to evaluate the potential risk of a pesticide to aquatic life. The risk ratio for each chemical was calculated by dividing the 4-day EEC from GENEEC model by its MAC. Values greater than or equal to 1 indicate a highly conservative presumption of risk with the use of the pesticide. A value less than 1 suggests that the use of the pesticide would not present a risk to aquatic life.

B. SCIGROW model

The tier I SCIGROW (Screening Concentration In Ground Water) model (v. 2.3.0.0; EPA, 2005) is a screening level model that the EPA Office of Pesticide Programs uses to calculate pesticide concentrations in vulnerable ground water. These concentrations are approximately the upper 99^{th} percentile of actual monitoring results. The model provides an exposure value that is used to determine the potential risk to the environment and to human health from drinking water contaminated with the pesticide(s) modeled. The SCIGROW estimate is based on environmental fate properties of the pesticide(s) (aerobic soil degradation half-life and linear sorption coefficient normalized for soil organic carbon content), the maximum application rate, and existing data from small-scale prospective ground water monitoring studies at sites with sandy soils and shallow ground water. Pesticide concentrations estimated by SCIGROW represent conservative or high-end exposure values.

The SCIGROW results were used conservatively to determine a presumption of risk for humans using the HALs based on the assumptions of the assessment. This was done by computing the risk ratios (i.e., the ratio of the SCIGROW estimated concentration to the level of concern). This is used for ground

water risk assessment. Values greater than or equal to 1 indicate a conservative presumption of risk with the use of the pesticide as defined in the calculations. A value less than 1 suggests that the use of the pesticide would not present a risk to human health.

C. Tier I Modeling Results

Table H-2 provides the results for the GENEEC and SCIGROW models (both model output files are available upon request) and pesticide risk ratios. Risk ratios greater than or equal to 1 (bold) indicate a presumption of risk. Two sets of risk ratios were calculated (Table H-2) for surface water based on the GENEEC results. One set was based on the GENEEC 4-day EECs in the pond; and the other set was refined and based on the same EECs; but, after additional dilution. The additional dilution accounts for surface water runoff from onsite and upstream of the site. Runoff volumes for 1-year return storm event from both onsite (8.9E7 L) and upstream of the site (2.07E8 L) were generated by the SWRRWQ model (Durborow et al., 1992). Risk ratios from the refined calculations are still conservative since there will be additional dilution and filtration before the onsite runoff reaches the ocean.

There are two new proposed pesticides (bifenthrin and chlorothalonil) with risk ratios greater than 1. The risk ratio for bifenthrin is 3.3 and that for chlorothalonil is 2.4. Both risk ratios were less than 5. We think the potential risks imposed by both pesticides will be insignificant given further dilution and filtration after initial dilution in the ocean. [Chlorpyrifos and trichlorfon risk ratios were greater than 1; however, neither of these products are proposed for use on the golf course (see discussion below).]

All risk ratios calculated from SCIGROW results for ground water are below 1, indicating the use of the pesticides would not present a risk to human health.

IV. Discussion

There are 16 pesticides that were proposed in our 1992 report (Durborow et al., 1992). Seashore paspalum will replace the previous turfgrass selection. Therefore, the new pesticide list was updated accordingly. The pesticides currently proposed include eight herbicides, three fungicides (including one reduced-risk fungicide), six insecticides (including two organic insecticides and one reduced-risk insecticide), and one plant growth regulator (see Table 2, Part 4(E) in the main body of this BMP report).

Surface water and ground water risk assessments were conducted for all pesticides using tier I screening model, GENEEC and SCIGROW, respectively. Both models are very conservative. Thus, the risk ratios calculated based on these model results tend to significantly overestimate pesticide risk potential.

Only bifenthrin and chlorothalonil show potential risks to aquatic lives of the 19 new pesticides proposed for the golf course,. However, considering the extremely conservative nature of GENEEC model

and further dilution before they reach the ocean, the chances of these two pesticides to impact water quality and aquatic lives are minimal. The risk ratios calculated from the SCIGROW results for ground water are all below 1, indicating that the use of the pesticides would not present a risk to human health.

We also calculated the risk ratios for pesticides evaluated in 1992 (Durborow et al., 1992) for risk comparison purpose and include them in Tables H-1 and H-2. The risk ratios from the SCIGROW results for ground water are all below 1. Two of the original pesticides, chlorpyrifos and trichlorfon have risk ratios greater than 1 based on the conservative GENEEC surface water assessment. The risk ratios for chlorpyrifos are approximately 10 and 92 for freshwater and saltwater, respectively (Table H-2). The risk ratio for trichlorfon is 1.5 (Table H-2). It appears that the currently proposed pesticides pose no higher risks than those proposed in 1992.

Table H-1. Pesticide Chemistry and Toxicity for the Honua'ula Golf Course: 2009 and 1992 Products

Active Ingredient*	Max. lbs a.i./yr	H_2O solubility (ppm)	Koc‡	Half life (days)		Health Advisory Levels (HALs) or MCL (ppb)	Aquatic Toxicity**
				Aerobic soil[1]	Turf field[2]		MAC (ppb)
Herbicides							
Glyphosate - new	4	12,000	2,100	2		700	21,500
Glyphosate	0.62	12,000	2,100	2		700	21,500
Foramsulfuron	0.026	3,290	89	40		>10,000‡‡	9,360
Imazaquin	1.02	60	460	60		8,750	10
Metribuzin	1.5	1,200	95	24		70	2,100
MSMA	6	57,000	300,000	90		700	234
2,4-D	2.46	900	20	5	16.2	70	12,500
MCPP-new	0.24	620	130	12	3	35	9,200
MCPP	1.3	620	130	12	3	35	9,200
Dicamba-new	1.3	4,500	8	9	8.7	4,000	14,000
Dicamba	0.24	4,500	8	9	8.7	4,000	14,000
Halosulfuron	0.124	1,650	100	18		700	2,100
Quinclorac	1.5	64	36	280		2,800	316
Oxadiazon	8	0.7	3,345	180		40	53
Potassium salts of fatty acids[3] (RR)	4.05	NA	NA	NA		NA	NA
Insecticides							
Bacillus thuringiensis[3](RR)	0.75	NA	NA	NA		NA	NA
Spinosad (RR)	0.84	NA	NA	NA		NA	NA
Trichlorfon	16	15,400	45	5	3.1	20	18
Dichlorvos[4]	8	10,000	150	7		1	55
Chlorpyrifos	2	2	9,000	36	19.3	2	0.05, 0.011[5]
Fipronil	0.05	3.78	427	225		1.4	19
Indoxacarb (RR)	0.15	0.2	5,200	23.6		40	60
Bifenthrin	0.1	0.1	237,000	26		105	0.00225
Imidacloprid	0.54	510	530	306		399	35
Fungicides							
Fenarimol	5.44	14	716	357		42	90
Iprodione	5.44	13	500	26		280	120
Mancozeb	52.2	7.2	1,000	28		21	230
ETU[4]	14.1	2,000	3.7	2.1		0.2	134,500
Metalaxyl	2.72	7,100	35	32		420	6,250
Thiophanate methyl	5.44	3.5	1,000	1		560	167.5
MBC[4]	2.72	8	1,390	35 (est.)		90 (est)	123 (est)
Chlorothalonil	16.4	0.8	2,680	13	4.2	2	1.8
Propiconazole	0.88	100	682	60	13.5	9.2	425
Boscalid (RR)	0.47	6	1,622	337		153	82
Growth Regulator							
Flurprimidol	1	130	300	364		700	118

*Pesticides in bold are currently recommended for use on the golf course. Pesticides in bold and italics are currently recommended and were also recommended in our original report (Durborow et al., 1992) for use on the golf course. The remaining pesticides were recommended in our original report (Durborow et al., 1992) but are no longer recommended. RR = pesticides that are natural products and/or are classified by the US EPA as reduced risk pesticides.

‡ organic carbon absorption coefficient
[1] These soil metabolism half lives are derived from lab experiments in dark chambers at constant temperature. Actual field dissipation half lives will tend to be much shorter for turf in general, as shown in the table; e.g., 19 day field half life for turf vs. 36 day aerobic soil metabolism half life for chlorpyrifos, respectively. See footnote 2.
[2] Turf field dissipation half life (Magri and Haith, 2009).
**These MAC values are for freshwater, except for chlorpyrifos, for which the water quality standard for saltwater is available from the Hawaii Administrative Rules, Title 11, § 11-5-4, Department of health, September 22, 2004.
‡‡ The foramsulfuron HAL is an estimate due to its extremely low toxicity. No toxic effects were noted in the six chronic and delayed toxic studies at the highest doses tested, 500 – 1,115 mg/kg/day (US EPA Pesticide Fact Sheet [for foramsulfuron], 3/27/02).
New = new application rates are recommended.
[3]Environmental fate and toxicity parameters for these "biorational" pesticides are not listed here due to their inherent safety.
NA = not applicable
[4] ETU, MBC and dichlorvos, are metabolites of mancozeb, thiophanate methyl and trichlorfon, respectively. For modeling purposes, 27% of mancozeb was applied as ETU, 50% of thiophanate methyl was applied as MBC, and 50% of trichlorfon was applied as dichlorvos.
[5]Hawaii water quality standard for saltwater.

Table H-2. Tier I Modeling Results and Risk Ratios*

Active Ingredient‡	GENEEC Result§ (ppb)	GENEEC Risk Ratio**	Refined GENEEC Risk Ratio***	SCI-GROW Results (ppb)	SCI-GROW Risk Ratio
Herbicides					
Glyphosate - new	10.23	4.8E-5	3.2E-5	2.48E-3	3.5E-6
Glyphosate	1.59	7.4E-5	5.0E-6	3.84E-4	5.5E-7
Foramsulfuron	1.20	1.3E-4	8.7E-6	1.21E-2	<1E-6
Imazaquin	28.87	**2.9**	0.2	1.52E-1	9.1E-6
Metribuzin	47.67	2.3E-2	1.5E-3	3.13E-1	4.5E-3
MSMA	7.73	3.3E-2	2.2E-3	3.6E-2	5.1E-5
2,4-D	48.47	3.9E-3	2.6E-4	1.21E-2	1.7E-4
MCPP - new	5.6	6.1E-4	4.1E-5	1.27E-2	3.6E-4
MCPP	30.35	3.3E-3	2.2E-4	6.87E-2	1.9E-3
Dicamba - new	32.81	2.3E-3	1.6E-4	8.57E-2	2.1E-5
Dicamba	6.06	4.3E-4	2.9E-5	1.58E-2	3.9E-6
Halosulfuron	3.54	1.7E-3	1.1E-4	1.57E-2	2.2E-5
Quinclorac	75.58	0.2	1.6E-2	3.07E+1	1.1E-2
Oxadiazon	55.91	**1.1**	7.1E-2	2.05E-1	5.1E-3
Potassium salts of fatty acids‡‡ (RR)	NA	NA	NA	NA	NA
Insecticides					
Bacillus thuringiensis‡‡ (RR)	NA	NA	NA	NA	NA
Spinosad‡‡ (RR)	NA	NA	NA	NA	NA
Chlorpyrifos	7.44	**149(fw), 676 (sw)[1]**	**10.1 (fw), 91.9 (sw)[1]**	1.96E-2	9.8E-3
Trichlorfon	410.34	**22.8**	**1.5**	1.47	7.4E-2
Dichlorvos[2]	209.53	**3.8**	0.3	9.87E-2	9.87E-2
Fipronil	1.55	8.2E-2	5.5E-3	2.56E-2	1.8E-2
Indoxacarb (RR)	0.68	1.1E-2	7.7E-4	1.43E-3	3.6E-5
Bifenthrin	0.11	**49.3**	**3.3**	6E-4	5.7E-8
Imidacloprid	11.85	0.3	2.3E-2	1.92E-1	4.8E-4
Fungicides					
Fenarimol	136.76	**1.5**	0.1	5.48E-1	1.3E-3
Iprodione	78.66	0.7	4.4E-2	3.16E-1	1.1E-3
Mancozeb	589.14	**2.6**	0.2	5.27E-1	2.5E-2
ETU[2]	118.74	8.8E-5	5.9E-5	6.77E-2	0.3
Metalaxyl	122.75	1.9E-2	1.3E-3	1.21	2.9E-3
Thiophanate methyl	11.18	6.7E-2	4.5E-3	8.82E-2	1.6E-4
MBC[2]	32.06	0.3	1.8E-2	9.21E-2	1.0E-3
Chlorothalonil	64.91	**36.1**	**2.4**	1.94E-1	9.7E-2
Propiconazole	19.42	4.6E-2	3.1E-3	8.67E-2	9.4E-3
Boscalid (RR)	4.89	5.9E-2	4.0E-3	3.28E-2	2.1E-5
Growth Regulators					
Flurprimidol	31.11	0.3	1.8E-2	1.32	1.9E-3

* Key input parameters are provided in Table H-1. All surface water risk ratios were calculated based on freshwater MACs except for chlorpyrifos for which both freshwater and saltwater risk ratios were calculated.

‡ Pesticides in bold are currently recommended for use on the golf course. Pesticides in bold and italics are currently recommended and were also recommended in our original report (Durborow et al., 1992) for use on the golf course. The remaining pesticides were recommended in our original report (Durborow et al., 1992) but are no longer recommended. RR = pesticides that are natural products and/or are classified by the US EPA as reduced risk pesticides.

[§]GENEEC maximum 4-day average concentrations
**It appears that there is no consistent trend in aquatic toxicities between freshwater and saltwater. Thus, the risk ratios are mainly used for internal comparison.
***The refined risk ratios were calculated by accounting for further dilution from onsite and upstream site runoff. See section C above for details.
New = new application rates are recommended.
[‡‡] Environmental risk analyses were not done for these "biorational" pesticides due to their inherent safety.
[1]The freshwater (fw) risk ratio was calculated based on freshwater MAC and the saltwater (sw) risk ratio was calculated based on saltwater MAC.
NA = not applicable
[2] ETU, MBC, and dichlorvos are metabolites of mancozeb, thiophanate methyl and trichlorfon, respectively.

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APPENDIX I. Proposed Honua'ula Ground Water Quality Monitoring Protocol

PROPOSED GROUND WATER MONITORING PROTOCOL FOR THE HONUA'ULA GOLF COURSE

For:

Honua'ula Partners, LLC

By:

N. LaJan Barnes, M.S., P.G.
Senior Hydrogeologist
Field Study Director

Stuart Z. Cohen, Ph.D., CGWP
Study Director

Environmental Scientist
Environmental & Turf Services, Inc.
Maryland

Originial
August 21, 1992

Revised
December 1, 1992
October 2, 2006
March 30, 2007
October 9, 2009
January 19, 2010

PROPOSED GROUND WATER MONITORING PROTOCOL
FOR THE HONUA'ULA GOLF COURSE

SPONSOR:	Honua'ula Partners, LLC 381 Hukulii Place, Suite 202 Kihei, Maui, Hawaii 96753
TEST SUBSTANCES:	Pesticides, fertilizers and related substances as noted herein
STUDY SPONSOR:	Charlie Jencks Honua'ula Partners, LLC s
STUDY DIRECTOR:	Dr. Stuart Z. Cohen, President Environmental & Turf Services, Inc. Wheaton, Maryland
FIELD STUDY DIRECTOR:	N. LaJan Barnes, M.S., P.G. Environmental & Turf Services, Inc. Wheaton, Maryland
ETS JOB NUMBER	6-138-G
FIELD COOPERATOR:	To be determined
PROPOSED START DATES:	2010 - well installation 2010 - baseline sampling Routine semiannual (following golf course completion)
PROPOSED TERMINATION DATE:	Sunset determined by Hawaii Department of Health
TEST LOCATION:	Wailea, Maui, Hawaii
ANALYTICAL TESTING FACILITY:	Underwriters Laboratory (pesticides) or Hawai'i certified lab, and State of Hawaii Certified Lab (nutrients)

PROTOCOL APPROVAL
SIGNATURE PAGE

Charlie Jencks Honua'ula Partners, LLC Kihei, Hawaii	Date
Stuart Z. Cohen, Ph.D. Study Director Environmental & Turf Services, Inc. Wheaton, Maryland	Date
N. LaJan Barnes, M.S., P.G. Field Study Director Environmental & Turf Services, Inc. Wheaton, Maryland	Date
To Be Determined Field Cooperator Honolulu, Hawaii	Date
Chauncey Hew Geologist Hawaii Department of Health Honolulu, Hawaii	Date

EXECUTIVE SUMMARY

Honua'ula Partners, LLC is proposing to develop an 18-hole golf course and related facilities in the Kihei-Wailea-Makena region of the leeward side of eastern Maui. The 670 acre project site is located on the lower slopes of Haleakala. The 18-hole golf course would parallel the coastline within the project site boundaries. The site is approximately one mile east (mauka) of the Wailea community and the southern portion of the proposed golf course is immediately adjacent to Wailea's Gold golf course. Site elevations range from approximately 320 to 710 ft.

The project site overlies a brackish aquifer system, most of which is below the Underground Injection Control (UIC) no-pass line. Ground water discharges to the ocean at the coast, and may flow within the influence of five irrigation wells of the Wailea resort complex. Therefore the purpose of this study is to determine the extent to which turf chemicals may migrate from the Honua'ula golf course to ground water and to the coastline. Baseline monitoring of ground water discharge in the ocean began in 2005.

The objective of this protocol is to present and implement a ground water monitoring study design that can produce reliable, quality data.

Two monitor wells are proposed for installation on site. In addition, an existing irrigation well will also be used for monitoring ground water quality. The irrigation well will be used as a background well and the remaining two wells will monitor ground water downgradient of managed turf.

Two to four rounds of samples will be collected after well installation and prior to construction to obtain baseline water quality data. One round will include a comprehensive pesticide list, inorganics, and field parameters. The remaining two to three rounds will include inorganic and field parameters only. Wells would be sampled semi-annually during the routine monitoring phase during golf course operation. The first routine monitoring samples will be collected six months after golf course operation begins and continue until such time that the Hawaii Department of Health certifies that no further monitoring is necessary.

The pesticide and nutrient analytes specified are based on the turf management program and the on-going marine monitoring program. Standard field parameters such as pH, temperature, etc. will be included.

A contingency plan is proposed that would trigger pesticide use restrictions or bans if pesticides are detected at predetermined concentrations.

Monitoring will stop when the Hawaii Department of Health certifies that no further monitoring is required based on a review of the monitoring data following no less than five years of routine monitoring.

Amendment(s) to this protocol will be written and submitted following acceptance of this protocol if it has been determined that additional provisions have not provided in this basic protocol. In addition, an amendment will be written for any major changes to the monitoring procedures following approval of this basic protocol.

TABLE OF CONTENTS

TABLES AND FIGURES

I. INTRODUCTION, PURPOSE AND OBJECTIVE

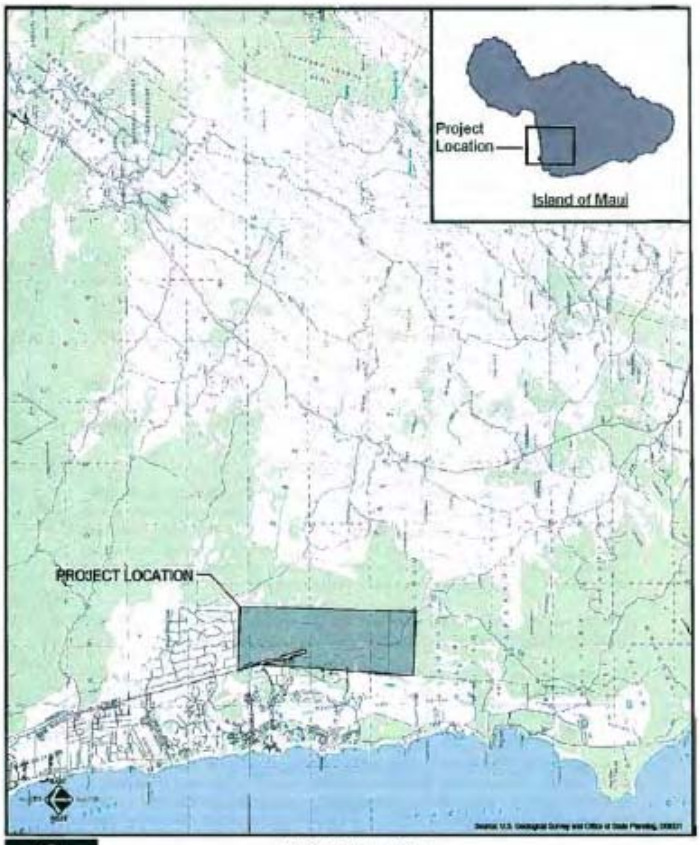
Honua'ula Partners, LLC is proposing to develop an 18-hole golf course and associated facilities in the Kihei-Wailea-Makena region of the leeward side of south eastern Maui. The 670 acre project site is located on the lower slopes of Haleakala, immediately south of the Maui Meadows community. The location of the site is shown on Figure 1.

The site overlies a brackish aquifer system, most of which is below the Underground Injection Control (UIC) no-pass line. Ground water discharges to the ocean, and may flow within the influence of five irrigation supply wells of the Wailea resort complex. Therefore the purpose of this study is to determine the extent to which turf chemicals may migrate from the Honua'ula golf course to ground water and to the coastline. The objective of this protocol is to present and implement a ground water monitoring study design that can produce reliable, quality data.

Specifically, the protocol will establish the following:

- a characterization of the Honua'ula project site including soils, climate, and the hydrologic and hydrogeologic setting;
- a monitoring study design, including detailed descriptions of monitor well installation, placement, turf chemical applications, sample collection, scheduling and analyses;
- a quality control program that addresses recordkeeping, sample custody, and quality assurance procedures; and
- a plan that defines response strategies if contaminants are detected above response triggers.

Figure 1. Site Location Map



HONUA ULA

Location Map

FIGURE 1

II. SITE LOCATION AND CHARACTERIZATION

A. Site Location

The Honua'ula project site comprises approximately 670 acres of gentle to steeply sloping terrain on the lower, leeward slopes of Haleakala near Wailea on east Maui. The project site is east (mauka) of the existing Wailea resort area and directly adjacent to Wailea's Gold golf course on the southern boundary. In addition, the Ulupalakua ranch is mauka of the property and the Maui Meadows community is to the north. Elevations range from about 320 ft to 710 ft. The west (makai) boundary of the property is about 1 mile from the coastline.

B. Site Characterization

1. Soils

There are four soil types that comprise the project area. These are indicated on the figure in Appendix A. The dominant soil types are the Keawakapu extremely stony silty clay loam (KNXD), the Makena loam, stony complex (MXC), and very stony land (rVS). A small portion of the site in the southeast corner includes the Oanapuka very stony silt loam (OAD). These soils are described in some detail in Okamoto (2009) and USDA, SCS, (1972). The most significant characteristic of these soils is that they have severe limitations with regard to cultivation and are generally unsuited for agricultural purposes. The SCS has assigned a capability classification range of VIs to VIIs for these soils. These limitations are related to extreme stoniness, and unfavorable texture.

Four soil samples were collected in January, 1992 from the project site by Environmental & Turf Services (ETS) and analyzed for physical characteristics. The sampling locations are indicated on the figure in Appendix A. Two samples from two different locations for each of the two major soil types (Keawakapu and Makena) were collected and composited into one sample to represent each of those two soil types. In addition, two individual samples were taken from two locations in the northeast portion of the site comprising the Keawakapu soil type. These samples were not composited, because the samples were noticeably different. Based on the consistency of the results, the difference in those two samples was most likely due to the variability in the stoniness.

The results of the soil analyses are presented in Appendix A. Additional soil samples in 2006 were not collected because the soil is not expected to be different from 1992.

The southern quarter of the property is comprised of very stony land (rVS). Due to the nature of the rVS, it could not be sampled. 'A'a lava covers most of the rVS surface and there was not enough soil to collect samples for the physical characteristics analysis. There is a potential that the 'a'a lava surface that comprises a significant portion of the southern part of the site may be worked into a "cinder soil" by mechanical means to provide a growing medium for turf in these areas.

2. Climate

The climate at the project site is semi-arid and receives an average rainfall of about 12 inches/year (EIS, 1988). The majority of the rainfall occurs during the months of November to March. Temperatures fluctuate very little throughout the year.

Morrow (1988) analyzed wind conditions for a location near the project site in the Air Quality Impact Report of the Maui Wailea 670 EIS (PBR Hawaii, 1988). The report indicated that northwesterly winds with a strong westerly component are dominant. Afternoon winds on the average tend to be less than 17 knots (~15 mph) about 75% of the time and less than 11 knots (~10 mph) about 50% of the time. We do not expect that this would have changed significantly.

3. Surface Hydrology

The site is characterized by a moderate to dense cover of Kiawe trees, and, to a lesser extent, Wiliwili trees. The land surface is densely covered with pastureland grass and low shrubs. The project site exhibits relatively simple hydrology. No perennial streams exist on the site, because there is neither adequate rainfall nor shallow depth to ground water to support a continuous base flow. Surface runoff does occur at times of heavy rainfall on-site or mauka on the slopes of Haleakala. There are many channels and gulleys that route surface runoff across the site. There are no plans to significantly alter the drainage characteristics of the site. The major channels will be left in their natural condition or improved to facilitate off-site drainage and erosion control.

The drainage report (Okamoto, 2009) describes the drainage patterns at the site. The study reported that 12 distinct drainage areas exit (comprising about 4,687 acres) that contribute to runoff that may course the site. Only five of these drainage areas constitute major drainage basins and the study goes only as far as the Piilani Highway. The project site occupies a small percent (~ 14%) of the total acreage of these contributory drainage areas extending from western (maiki) property boundary to the upper slopes of Haleakala.

ETS staff witnessed a 1.75 inch storm event during the January, 1992 soil sampling site visit. No runoff was observed leaving the project site; however, flow was observed in the large channels coursing the Wailea resort area into the ocean. Very little surface runoff was observed on the Wailea golf course areas. Runoff from within the Wailea resort apparently occurred primarily from the impervious areas such as roads, buildings, and parking areas.

4. Regional and Site Specific Geology

The proposed project is located on the west side of Haleakala Volcano, which forms east Maui. The proposed site parallels the coastline approximately 1.8 miles and is mauka of the Wailea community less than one mile within the Makawao District.

Approximately three fourths of the northern portion of the project site is overlain with Keawakapu and Makena soils (discussed above) while the remaining area is covered with very stony land of the Kaula and Hana volcanic series. Underlying the soils in the northern portion of the site is mostly the Kula volcanic series composed of andesitic `aa lava flows, which contain many interstratified, thin ash-soil layers (Stearns, 1966). The interstratified ash-soil layers described by Stearns seems to be supported by one of the two borings which is described as soft cinder. Those borings are located at approximately the 520 ft elevation on the northern end of the site drilling to depths of 550 ft and 559 ft.

5. Site Hydrogeology

The site has elevations that range from approximately 320 ft on the makai side to

approximately 710 ft on the mauka side. The basal ground water lens is approximately 3 to 4 ft above sea level under the site and has a chloride content which has a range of 500 to 1000 mg/L (Mink, 1986). A chloride content of this nature is considered brackish (one criteria for potable water is a chloride content of less than 250 mg/L). Water quality results from the two wells located on the northern end of the site show chloride concentrations that range from 140 mg/L (2001) to 211 mg/L (2006).

There are five wells located downgradient of the project site that are used to irrigate the Wailea golf course. These wells are part of an ongoing water quality monitoring program. The aquifer system under the site is the Kamaole [60304], within the Central Aquifer Sector. The Kamaole Aquifer system extends from Kihei to south of Makena and up to the center of Haleakala where most of the recharge takes place. The Kula volcanics is the dominant rock with the Hana series covering the southern portion of the system (Yuen, 1990).

Ground water under the site flows toward and discharges into the ocean and it is not considered a drinking water source; but should be protected.

III. STUDY DESIGN

A. Monitor Well Locations

Two monitoring wells will be constructed on the project site. There are two exiting wells located on the northern end of the property designated as irrigation wells. At least one of these wells will be included in the water quality monitoring program and serve as the background well since ground water at that location will not be impacted by golf course management.

Two downgradient wells are proposed to be installed. These wells will be dedicated for water quality monitoring and will be located downgradient of managed turf. The exact location of these two wells will be determined in the field; but, will be dependent on rig accessibility. Figure 2 (at the end of this section) shows example locations where downgradient monitoring wells could be in stalled. Both wells will be located in out of golf course play areas.

B. Well Construction Procedures

Constructing the wells in a pattern to determine ground water flow will not be necessary, since the general direction of flow is not a question. The total depth of the wells will be determined by depth to ground water, but could be as deep as 400 ft depending on the exact location. All wells will be surveyed at ground surface and the top of casing. The top of the casing will be marked by a notch at the time of the survey so that water level measurements can be measured in the same place at each sampling event.

The drilling technique used will be the technique that is the most appropriate considering the lava rock at the site. Generally, the diameter of the boreholes for monitoring wells is 8-10"; however, considering the potential depth (~400 ft) of the downgradient wells, the diameter will be dependent on the collection system selected for obtaining ground water samples. Standard installation procedures for Hawaii geology will be used to construct the downgradient wells so that ground water samples can be retrieved and used for water quality monitoring. Details of the final installation procedures will be provided in the well completion report following installation.

The monitoring wells will be protected by at least three 4 to 6 ft tall, heavy duty steel posts forming a triangle installed around the well stick-up to protect the well(s) from heavy

equipment movement during golf course construction. The steel posts will be seated in cement at least 2 ft below the surface and extend at least 4 ft above ground surface.

Standard well development will be conducted long enough to remove silt and fines from the well bore by pumping and/or surging. The wells will be allowed to stabilize for approximately one week after development so that accurate water level measurements can be taken and to allow stabilization of the ground water. All boreholes will be logged by a geologist/hydrogeologist. Photographs of well installation and completion activities will be taken using a digital camera. The diagram will contain the following information:

- Date/time of construction
- Well location
- Borehole diameter
- Well depth
- Depths and description of lithologies encountered
- Casing material/diameter
- Screen material
- Screen slot size/length
- Sand pack (depths from ___ to___)
- Bentonite seal (depths from ___ to___)
- Cement/grout (depths from ___ to___)
- Ground surface elevation
- Elevation at top of casing
- Depth to static water

C. Sampling Procedures

All activities and measurements will be recorded in water-resistant ink in a bound log book with water resistant pages. Ground water sampling will not be collected during heavy rains to prevent cross contamination. At no time should roller ball-type pens be used in the field log book. A pump dedicated for this project will be used to purge and sample the wells. The pump will be of such capacity that it will lift ground water from at least 400 ft depths.

The following sampling procedures are general guidelines use to collect ground water samples; however, some of these procedures may be adjusted for the sampling technique implemented at this site.

- The wells will be uncapped and allowed to stabilize to ambient air pressure prior to taking water level measurements.

- Weather conditions and the time that the well cap is removed will be noted in the log book(s).

- Measurements from the top of the casing to static water level will be measured from the same point (i.e., notched casing) and recorded prior to each sampling event. Depth of ground water will be recorded to the nearest 0.01 ft. The volume of water in each well will be calculated using the appropriate equation for the well diameter (e.g., for a 4" well -- length of water column (ft) * 0.653 gal/ft of water = total volume of water in well (gal)).

- The top of the casing will be marked by a notch at the time of the survey so that water level measurement can be measured in the same place for each sampling event. Ground water level measurements will be taken from the top of the well casing at the notch, not the protective steel well casing.

- The field parameters will be taken and recorded after each well volume is purged. The purged water and the sampled water shall be analyzed in the field for the following three field parameters: pH, temperature (°C), and specific conductance (µS/cm). All field parameters units will be recorded.

- If submersible pumps are used in the wells to purge and sample the ground water the pump must be decontaminated between each well. Standard decontamination procedures recommended by the pump manufacturer should be followed.

- Disposable latex-type protective gloves will be worn on both hands and changed at each well during sampling and decontamination procedures (and as necessary) to prevent cross contamination during sampling events.

- Low-flow dedicated pumps may be used in two downgradient wells in which case removal of 3-8 well volumes prior to sampling will not apply. However, the stabilization of field parameters will be used to collect representative ground water samples. The wells will be purged until two of the following three parameters stabilize: pH, temperature and specific conductance (typically 3 to 8 well volumes). This procedure ensures that the ground water sample is representative of the aquifer. Purging will be performed by the dedicated pump and tubing from ground water to the surface. The wells will be pumped at a rate that will be within the specifications of the pump selected. A portion of the pumped water will be collected into a glass cylinder each time a well volume has been evacuated; then the temperature, pH, and specific conductance will be measured and recorded. Evacuation will continue until two of the three parameters have stabilized for three consecutive well volumes or until 8 well volumes have been purged, whichever comes first. Stability in this context is defined as temperature readings differing by no more than 0.3°C, pH varying no more than 0.1 pH unit, and specific conductance varying by no more than 3 umhos/cm, in three successive well volumes.

- Appropriate aliquots of ground water will be placed into properly labeled sample containers as provided by the approved laboratory immediately after stabilization of the previously described parameters. The time of collection, sample ID, and

description of water will be recorded in the log book(s) and samples will be placed in a cooler to maintain a temperature of approximately 0-4 °C.

D. Sampling Schedule and Chemical Analysis

This section discusses the number and timing of sample collection during the baseline and operational phases of monitoring, and the chemical analyses for each phase (Table 1).

1. Baseline Sampling

Water samples will be collected from the designated monitoring wells before construction begins to establish baseline conditions. Attempts will be made to collect two to four rounds of samples to be analyzed for inorganics. One of the rounds will include samples that will be analyzed for pesticides and/or metabolites.

Ground water monitoring will begin no less than one week after the wells have been installed and developed, to allow the aquifer around the well bore to stabilize. Pesticides and inorganics will be sampled according to the schedule below.

The baseline analysis is based on product use within the same watershed and upgradient of the site, pesticides proposed for use on the golf course, the Hawaii Department of Health (HDOH) requirements, and previous monitoring by Steve Dollar (2009). All pesticides proposed for use on the golf course will be included in baseline monitoring if a method exists (Table 2 at the end of this section). Baseline monitoring will also include inorganics (i.e., nutrients, anions, cations as appropriate).

2. Routine Sampling

Samples will be collected semi-annually at designated monitoring wells during the operational phase of the Honua'ula golf course. The first routine monitoring samples will be collected six months after golf course operation begins and continue until such time that the HDOH certifies that no further monitoring is necessary. Monitoring for all inorganic parameters is required during each sampling event. Pesticides selected for ground water monitoring will be based on those chemicals that are more likely to leach and have been applied to the golf course.

Table 1. Monitoring Matrix

Stations	Baseline Monitoring			Biannual Routine Monitoring		
	Pesticides	Inorganics	Field Parameters	Pesticides	Inorganics	Field Parameters
Wells	1	2-4	2-4	2[†]	2	2

[†] selected pesticides only

E. Quality Control Samples

1. Field QA/QC

Field quality control samples are analyzed to check contamination and to detect any systematic or random error from the time of sampling to the time of analysis. Three types of field QA/QC samples may be used to assess field quality control: field duplicates, field blanks, and decontamination samples. Quality control samples will be analyzed for any and all relevant parameters required by this protocol.

a. Field Duplicates

One set of duplicate samples will be collected during each sampling event. The location of the duplicate sample will be chosen randomly, and will be rotated between the downgradient wells from one event to the next. This set of samples will be "blind" coded, i.e., the station identification and time of collection will not be written on the sample containers nor the chain-of-custody (COC). Instead, only "field duplicate" or "GW DUP" will be written on the COC. However, it is imperative that a note be made in the field notebook as to the location of the field duplicate (e.g., field duplicate taken from well MW-1). The laboratory will provide an extra set of bottles for the collection of the duplicate sample. The purpose of the field duplicate is to look for sampling contamination during the time of sampling, and to verify the accuracy of the laboratory analysis.

b. Decontamination Samples

The purpose of the decon rinsate sample is to look for sources of contamination associated with decontamination of equipment washing

procedures. Proper decontamination between stations reduce the likelihood of cross-contamination. If dedicated sampling equipment is used (e.g., low-flow dedicated micro-purge pumps in each well), this sample is not required. This sample is also not required for the pH meter nor the container used for measuring field parameters.

If a well does not contain a dedicated pump, then a decontamination sample ("decon rinsate") will be collected. The decon sample will be collected from the final rinsate water (i.e., the water that passes through the pump) using standard decontamination procedures recommended by the pump manufacturer. This sample should be collected between sampling of the two downgradient monitoring wells. The sampler will obtain distilled water for decontaminating field equipment. This sample will be poured in lab-supplied bottles. The bottle will be labeled "decon rinsate," and will be shipped and analyzed with all the other samples. If detergent is used for the decon procedures, it should be phosphate free.

2. Laboratory QA/QC

A laboratory that is certified for drinking water and/or wastewater analyses in Hawaii or that participates in a reciprocating program will be contracted to conduct the analyses for this monitoring program. It is possible that two labs will be contracted for this monitoring program - a local lab for inorganics and microbiologicals and an out-of-state lab for pesticides. The laboratory will follow related standard procedures where standard methods are not available for a constituent of interest. In addition, the laboratory will demonstrate accuracy and precision of the adopted methods with at least five-point standard curve, sample spikes, and duplicate analyses.

The results from each sampling event will also include the following laboratory quality control results: trip blanks, matrix spikes (MS), MS duplicates (MSD), method blanks, quality control samples, and surrogate recoveries where appropriate. The laboratory will note any analytical QC problems.

a. Trip Blanks

The trip blank (TB) sample is designed to assess any potential source of contamination associated with the lab, e.g., bottle washing or lab contamination. A complete set of sample containers for all water quality parameters required for the sampling event will be filled with inorganic-free reagent/distilled water in the laboratory, preserved in the same fashion as other field samples, and labeled as the "trip blank." This sample set will be included with the bottle shipment sent from the lab to the field sampling cooperator and taken into the field during a sampling event. The TB bottles are not to be opened by the field personnel at any time. When the sampling event is completed, the TB samples shall be processed as any other sample, listed on the COC, and shipped back to the laboratory for analyses. One set of TB samples/day of sampling will be submitted during each sampling event.

b. Matrix Spike/Matrix Spike Duplicates

The purpose of the MS/MSD samples are to test laboratory equipment accuracy. One set of MS and MSD samples will be collected during every event. The lab will provide appropriately labeled bottles for these samples. Field personnel will collect water samples from a randomly selected station. This sample will be collected from the well other than where the duplicate samples are collected. The location of the MS/MSD sample will rotate from one event to the next. The MS and MSD samples will be designated as such on the COC and processed accordingly. In addition, the location of collection will be recorded in the field notebook.

F. Sample Recording

A unique identification number will be assigned to each sample. Ground water samples will be labeled with an ID that is a function of the well number and collection date (e.g., MW-2-013107 = monitor well #2, January 31, 2007). The duplicate sample identification will be labeled "GW DUP" or given a bogus well number not associated with any of the monitoring wells. The MS/MSD samples will be identified on the COC with the appropriate well (e.g.,

MW-2 013107 (MS). All labels and COCs will be written using waterproof ink or ball point pen ink. Roller-ball or jel-type pens are not allowed to be used on any monitoring documents for this project to prevent smudging.

G. Monitoring Sunset Provision

Monitoring will stop when the HDOH certifies that no further monitoring is required based on a review of the monitoring data following no less than five years of routine monitoring.

H. Protocol Amendments

Amendment(s) to this protocol will be written and submitted following acceptance of this protocol if it has been determined that additional provisions have not provided in this basic protocol. In addition, an amendment will be written for any major changes to the monitoring procedures following approval of this basic protocol.

Figure 2. Proposed Monitoring Well Locations
(Map taken from 092409 Concept Plan)


Legend
Proposed monitoring wells and irrigation wells
Figure 2
Project District Phase 2
Master Plan
HONUA'ULA
WAILEA, MAUI

Table 2. Baseline Monitoring List and Possible Methods

Parameters	Analytical Method	Container Volume	Preservative	T (°C)	Holding Time
INORGANICS					
TKN	351.4	500 mL	H_2SO_4	1-4	28 d
Nitrate-Nitrogen	353.2	120 ml	None	1-4	48 h
Nitrite-Nitrogen	353.2	120 ml	None	1-4	48 h
Ammonia-Nitrogen	350.3	250 ml	H_2SO_4	1-4	28 d
Total Phosphorus	4500-PE	120 ml	HCl	1-4	28 d
Ortho-Phosphorus	4500-PE	120 ml	None	1-4	48 h
Chlorophyll a					
Silica	200.7	500 ml	HNO_3	ambient	6 mos
Turbidity	180.1	120 ml	None	1-4	48 hr
ORGANICS (PESTICIDES)					
Bifenthrin	S150	1 L	Trizma mixture	1-4	14 d
Chlorothalonil					
Fipronil					
Flurprimidol					
Indoxacarb					
Propiconazole (a&b)					
Imidacloprid	L300	1 L	Trizma mixture	1-4	14 d
Oxadiazon					
Boscalid	L302	1 L	HCl	1-4	14 d
Halosulfuron					
Quinclorac					
Foramsulfuron					
2,4-D	515.3	1 L	$Na_2S_2O_3$ + H_2SO_4	1-4	14 d
MCPP					
Dicamba					
Glyphosate	547	2 x 44.7 ml	$Na_2S_2O_3$	1-4	14 d

TBD = to be determined

Table 2. (cont'd)

Field Parameters	Analytical Method	Units	Hold Time
pH	EPA 150.1	standard buffer index	at time of sampling
Temperature	SM 2550B	°C	at time of sampling
Dissolved Oxygen	ASTM D 5543-94	% saturation (or O2 ppm)	at time of sampling
Salinity		ppt	at time of sampling

IV. QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Establishing a sound quality assurance/quality control (QA/QC) program is an essential part to any water quality monitoring study. QA/QC programs help ensure the quality of the data collected by setting in place a series of quality control "checks" that help identify sources of sample contamination, human error, and lab equipment inaccuracies, and it establishes a chain of custody so that the locations of the water samples are known at all times. The QA/QC program established for this monitoring study is in the spirit of EPA's Good Laboratory Practice Standards (GLPs) (40 CFR Part 160). GLPs were developed to create uniformity from study to study to help ensure the quality of data collected. Listed below are the most important parts of the QA/QC program that field and lab personnel must follow.

A. Sample Preservation and Shipment

Possible sample volumes and preservatives are listed in Table 2. However these may change as dictated by the analyzing lab. Prior to each sampling event, all bottles for analytical purposes will be sent directly from the lab to the field personnel. The field personnel should be careful not to overfill the bottles provided by the lab during sample collection. This is because some of the bottles contain preservatives to prevent the chemicals from spilling out during collection.

Coolers will be packed with sufficient frozen blue packs and supplemented with bagged ice to insure that the samples remain cool as possible during sample collection and shipment to the lab (4° C is sufficiently low to eliminate degradation of sample). If packages are lost or delayed by the shipping carrier such that the samples exceed analytical holding time(s) or are received at the lab at greater than ambient temperatures as collected at the time of sampling, the Study Director will determine if samples are to be recollected (at the expense of the golf course). If a distant lab is used, samples will be shipped via overnight carrier, not by the U.S. Postal Service, to that lab.

NOTE: If samples are received at the lab significantly above ambient temperatures as measured at sample collection, they will be recollected at the expense of the field personnel, if it is found that insufficient ice and/or cold packs were used in the shipping containers.

B. Field Safety

Field personnel should always remember basic field safety while collecting samples. Dress attire should be appropriate for weather conditions on the day of sampling and/or inspection of equipment. Field personnel should drink plenty of fluids (e.g., water) frequently throughout the day.

It is recommended that all field personnel be certified by the American Red Cross, or other organization, in basic first aid and adult CPR. In addition, field personnel should have a basic first aid kit that is easily accessible during sample collection. In addition, field personnel will contact the Study Director prior to collecting samples.

C. Field Quality Control

All collection of water quality samples will be conducted by qualified personnel trained in water collection and familiar with the QA/QC program established herein. Field personnel should never hesitate to contact ETS in the event of any questions.

1. Field Personnel General Procedures

A field logbook (see below) will be maintained exclusively for this water quality monitoring program. In addition, a copy of this protocol will be prepared on water-resistant paper and given to the field contractor. This water-resistant copy will be kept with the field logbook and will be taken to the field for all sampling events should sampling procedure questions arise. If there are any questions regarding sampling procedures, this protocol should be consulted first and then, if necessary, the current Study or Field Director (301-933-4700, eastern time zone) shall be consulted. It is especially important for the field cooperator to contact ETS prior to any sampling event at this project, due to the 6 hour time difference so that an alternative telephone number can be provided for after hours contact. The following procedures should be followed at all times.

- Standardized and approved methodologies are to be used by the field personnel.
- Records should be kept and maintained for calibration of all field instruments.

- Records should be kept of all irregular incidents or experiences that may affect the measurement taken.
- All field equipment and instruments should be kept clean and in good working condition.
- Records should be kept of all repairs to the field instruments and apparatuses.
- Each chain-of-custody sheet shall be signed and dated by at least the lead member of the sampling team.
- Samples should be iced immediately after collection. Adequate methods shall be used to ensure sample temperatures are maintained at 0-4°C. Where applicable, samples received at the lab significantly above ambient temperatures, as measured at the time of sample collection, will be considered for recollection as described above in section A.

2. Prevention of Sample Contamination

The quality of data generated in the laboratory depends on the integrity of samples received by the laboratory. The field personnel should take appropriate measures to protect samples from cross-contamination and deterioration.

- The sample collector should keep his/her hands clean and avoid smoking and eating while working with water samples.
- Sample containers (bottles) must be kept in a clean environment, away from dirt and dust. Vehicle cleanliness is important for transporting sampling equipment.
- All metal objects should be kept out of contact with acids and water samples.
- Petroleum products and exhaust fumes should be kept away from samples.
- Only the lab-approved or provided sample container for each water quality sample submitted for analysis shall be used.
- If the field measurement equipment (e.g., pH, temp., etc.) does not provide a sample holding device to record the data, the field measurement sample shall be taken in a glass or plastic container (provided by the field personnel). All sample holding devices used for field measurement collection shall be decontaminated by the field personnel between sampling sites using standard decontamination procedures.
- All field measurements will be taken from separate sub-samples and should never be taken from the water sample that is collected in the

sample bottle(s) for analysis. Once the field measurements have been taken and recorded, the sample shall be discarded.

- Measurements for specific conductance should never be made in the sample water that was used for a pH measurement. Potassium chloride diffusing from the pH probe may affect the conductivity of the sample.
- All field parameters measurements should be taken immediately after the water sample is retrieved from the well.
- All field personnel involved in handling the water samples will wear disposable latex-type gloves to prevent direct contamination of the sample and to protect the sampler. Gloves shall be changed at each new location or as needed.
- The inner portions of sample containers and container caps should never be touched with bare hands, gloves, or placed on the ground.
- Once collected, the sample shall be stored in the lab provided container/ice chest. Samples must be kept at 0-4 °C using bagged ice and frozen blue packs and packed to eliminate bottle breakage.
- Samples must be shipped overnight or hand delivered to the laboratory the same day of collection via UPS, FedEx, or other over-night carrier. **Two-day or U.S. Postal Service delivery to the lab is unacceptable**. Friday shipment may be possible, but acceptance by the lab must be verified in advance.

3. Field Log Forms/Book

A field sampling log/notebook containing water resistant pages will be maintained. Only water-resistant ink pens will be used to make notations. Roller ball pens, erasures, and scratch-outs are not allowed. If mistakes are made in recording, corrections will be made using a one line strike-through, initialed, dated, and rewritten. The field log will include site conditions, observations, weather conditions (e.g., temperature, precipitation, etc.), time of sample collection, field measurements (e.g., pH, water temperature, and specific conductance), sample location, and sample station condition (e.g., brush overgrowth, DTW, and total depth of well). Specific observations such as discoloration of the water, presence of sediment, or any other unusual circumstances will also be noted. Any deviations from this protocol must be approved by the Study Director and/or Field Director at the time of or immediately following the deviation(s). The deviation must follow generally accepted sampling practices and must be noted in the field notebook.

Copies of original field notes, completed chain of custodies (COCs), and airbill tracking numbers (e.g., FedEx, UPS) will be faxed to the Study Director within 24 hrs of each sampling event. In addition, hard copies of the field notes and COCs will be sent to the Field Director within one week of each sampling event. Alternatively, pdf files can be made of field notes, COCs, and shipping labels and emailed to the current Study Director at ETS@ETS-MD.COM.

D. Chain-of-Custody and Shipment

A chain-of-custody (COC) program will be followed to ensure that proper transportation and storage practices are documented. Information that will be included on the COC form are: project identification (e.g., Honua'ula golf course); date; time; sample identification (except asd noted above in section III(F); preservatives, if any; requested lab analysis; overnight courier and package tracking number; special instructions for the lab, if any; names and signatures of field personnel; and time of sample relinquishment to the overnight courier. ETS or the analyzing lab will provide blank or pre-printed COC forms. Should there be any questions regarding how to properly fill out the COC form, field personnel should call ETS for clarification.

The COC will be a triplicate (i.e., carbonless pages) form used to record and document sample shipment to the lab. Each sample box sent to the lab will contain the completed original (1st page) and the 2nd page of the triplicate COC form and will be placed in a plastic, airtight bag (e.g., baggie) and placed inside the shipping container. The bottom copy (3rd page) will be torn off and retained by field personnel for record keeping and making copies to send and to fax to ETS.

The field personnel shall fax a copy of the COC along with the field notes to ETS as soon as possible (preferably the same day or day following sampling).

At no time should samples collected for analyses be sent to the lab via the U.S. Postal Service or without a completed COC form.

E. Protocol Deviations

All protocol deviations will be documented in the log books/forms; ETS must be notified of all protocol deviations. Whenever possible, approval for protocol deviations will be requested

in advance from the Study Director and/or Field Director. The annual report (see "Reporting" below) containing the analytical results for the monitoring event should include a summary of the deviation(s) and the significance of the deviation(s) on the reliability of the results. Finally, the lab will be notified only if the deviation(s) may impact analytical analysis (e.g., a preservative was lost in a bottle due to overfilling the bottle).

F. Field Audit

The Study Director, or his designee, will conduct an audit of field collection techniques during one monitoring event no less than bi-annually. All aspects of sample collection will be observed including, but not limited to: bottle preparation, water collection and transfer into bottles with preservatives, collection of field data (pH, specific conductivity, and temperature), preparation of chain-of-custody sheets, and equipment decontamination. The field personnel will be informed of any QA/QC violations and recommendations will be given to reduce the likelihood of future violations. Results will be included in the annual report in which the audit took place.

G. Reporting

1. Baseline Report

A comprehensive report will be issued after all baseline sampling results have been analyzed. It will include the following topics: background, sampling stations, well construction/logs, field results, lab results, conclusions, and protocol amendments, if any.

Data obtained during the baseline monitoring will be analyzed using appropriate statistical procedures and will be presented in graphical form to study water quality trends. Descriptive statistics such as mean and standard deviation, and statistical procedures such as t-tests and regression analysis will be used to interpret the data as necessary. Multiline charts, bar charts, pie charts, and scatter plots are examples of graphical presentations that may be useful to help visualize the trends of the water quality variables at the site. The statistical analyses will be used to revise the final protocol for the operational phase monitoring. In addition, historical monitoring data will be incorporated where applicable.

2. Annual Report

The Study Director will submit comprehensive, interpretive, annual reports to the HDOH within two to three months after receipt of the lab results from the last sampling event of the monitoring year. The annual report will include a review of all pertinent golf course management data and water quality results. Significant water quality trends between sampling events and from year to year will also be discussed in the annual report. Comparison of the results of the Wailea resort wells and the ocean sample results will be included in as much as the data are available to ETS.

Data obtained during field sampling and laboratory results will be analyzed using appropriate statistical procedures and will be presented in graphical form to study spatial and temporal trends of water quality parameters. Descriptive statistics such as mean and standard deviation, and statistical procedures such as t-tests and regression analysis will be used to interpret the data as necessary. Multiline charts, bar charts, pie charts, and scatter plots are examples of graphical presentations that may be useful to help visualize the spatial and temporal trends of the water quality variables at the site. Recommendations regarding changing management practices, and using alternative pesticides and fertilizers may also be made based on the monitoring results.

After five years of operational phase monitoring has been completed, the Study Director will review monitoring results to determine the need for additional monitoring. Any recommendations to the monitoring program will be included in the annual reports.

V. CRITERIA FOR MANAGEMENT RESPONSE

This section will be revised after all baseline data have been evaluated.

The following chapter describes the methodology used for establishing the response thresholds (RTs), at the Honua'ula golf course and the required management response to a parameter that exceeds its RT. Briefly, the RTs for inorganic parameters are based on baseline monitoring data. Details follow.

Repeated exceedances of pesticide and/or nutrient limits will, at a minimum, trigger a review of the particular BMPs designed to prevent such exceedances.

A. Inorganic Parameters

Baseline concentrations of nitrate-nitrogen (N) and total phosphorus (TP) will be established prior to construction following a review of all baseline data. Operational phase RTs will be the upper 95% confidence limits (CL) of each of the baseline phase for N and TP. Natural fluctuations as observed during baseline monitoring in the hydrologic system will be considered when establishing these triggers.

Exceedances of the thresholds will trigger a proportionate reduction in N or TP use for the affected subbasin until the residues stabilize. For example, a 20% exceedance of the N threshold will trigger a 20% decrease in N use in the affected subbasin.

The references points contained in Table 3 will also be considered.

To be determined after all baseline samples have been collected, analyzed, and reviewed.

1. Actions for Inorganic RT Exceedances

The following action will be required if nutrient (nitrogen and phosphorus) concentrations are detected above a station's respective RT (as defined by baseline results) not including the background station:

- The offending station(s), plus the background, will be resampled within two weeks following the receipt of results.
- A review of chemical application records, site conditions, and weather records will be conducted to identify possible causes for the increased nutrient concentration(s).
- Fertilizer applications will be reduced proportionately to the percentage of excess that the nitrogen or phosphorus concentrations exceed the RT (e.g., If a concentration of 3 mg/L represents a level of 50% above a 2 mg/L RT, a 50% reduction in fertilizer application to the turf upgradient of the offending ground water station will be required).
- An evaluation will be conducted of the extent to which the superintendent is complying with the soil and plant tissue testing program outlined in the BMP.
- Additional use of slow-release fertilizers and alternative fertilizer sources will be considered, as will more 'spoon feeding' (frequent applications of small amounts).

Fertilizer restrictions will be limited to the subbasin(s) contributing to the offending ground water station(s). Restrictions will remain in place until the review of management practices, weather, and site conditions is conducted, and nutrient concentrations at the offending station(s) return to concentrations below the respective RT, or the Study Director determines the elevated concentrations are not the result of golf course management practices. If a significant increasing trend as determined from statistical analyses is detected at any monitoring station, fertilizer application rates and/or types will be adjusted accordingly.

B. Pesticides

Any pesticide detections above the minimum reporting limit (MRL) will trigger a response. Detections exceeding 20% of the reference concentrations – the lower of the Health Advisory Levels (HALs) or Maximum Concentration Levels (MCLs), and/or the HDOH water quality standards as appropriate – will trigger a restriction of use for the particular pesticide in the affected subbasin (Table 3). These 20% values will be called response thresholds (RTs).

Two levels of management response have been established to respond to pesticide detections in ground water: alert level and response level.

1. Alert Level

The alert level is triggered when a pesticide or pesticide metabolite concentration is detected above the MRL (i.e., method reporting limit) but below the RT. The following management responses will be triggered if a pesticide used on the golf course is detected at a concentration corresponding to the alert level.

- A review of management practices, weather, and site conditions will be conducted to identify possible reasons for detections.
- Alternative pest control measures will be considered and a recommendation regarding the continued use of the problem pesticide will be made.

2. Response Level

If a pesticide or pesticide metabolite used on the golf course is detected at or above the RT (Table 3), the following management responses will be triggered. These actions assume detections resulted from normal pesticide use. In the event contamination resulted from a point source activity, e.g., a spill or well breach, the Study Director may recommend alternative responses.

- The use of the pesticide will be immediately stopped and routine monitoring for the pesticide will continue until it is not detected in the on-site down gradient wells.
- A review of management practices, weather, and site conditions will be conducted to identify possible reasons for the detection.
- Alternative pesticides for replacement of the problem pesticide(s) will be evaluated.

The evaluation should discuss circumstances which led to the elevated detection of the pesticide, reasons why the superintendent needs the specific pesticide compared with alternatives, and a presentation of management practices that will be implemented to prevent further detections of the offending pesticide. The chemical will continue to be monitored as long as it is used on the golf course. If the chemical continues to be detected above its RT for two consecutive rounds, the pesticide will be permanently removed from the management program.

Table 3. Preliminary Pesticide List and Water Quality Standards

Parameters	HAL/MCL (ppb)	Response Thresholds[†]
Bifenthrin	105	
Boscalid	153	
Chlorothalonil	2	
Dicamba	200	
Fipronil	1.4	
Flurprimidol	700	
Foramsulfuron		
Glyphosate	700	
Halosulfuron	700	
Imidacloprid	399	
Indoxacarb	40	
MCPP	35	
Quinclorac	2,800	
Oxadiazon	40	
Propiconazole (isomer a&b)	9.2	
2,4-D	70	
Nitrate-Nitrogen	10 ppm	
Nitrite-Nitrogen	2 ppm	

[1] TBD = to be determined after baseline data has been collected and evaluated

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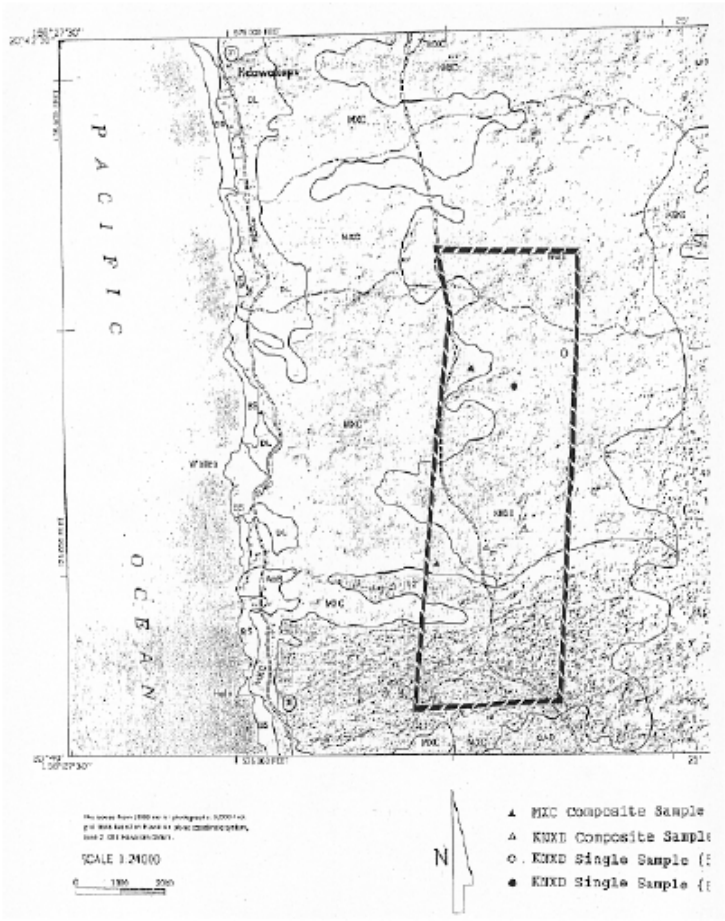
APPENDIX A. Soil Sampling Results (1992)


PACIFIC OCEAN
Keauwaikapu
SCALE 1:24000
N
▲ MXC Composite Sample
△ KMXD Composite Sample
○ KMXD Single Sample
● KMXD Single Sample

APPENDIX J. Nearshore Monitoring (2010)

Marine Research Consultants, Inc. (Steve Dollar)

(Please refer to Appendix D of this EIS for the full report.)