Hawai'i Golf Course Maintenance
BEST MANAGEMENT PRACTICES

Hawaii Chapter GCSAA
Golf Course Superintendents Association of America

GCSAA
Golf Course Superintendents Association of America


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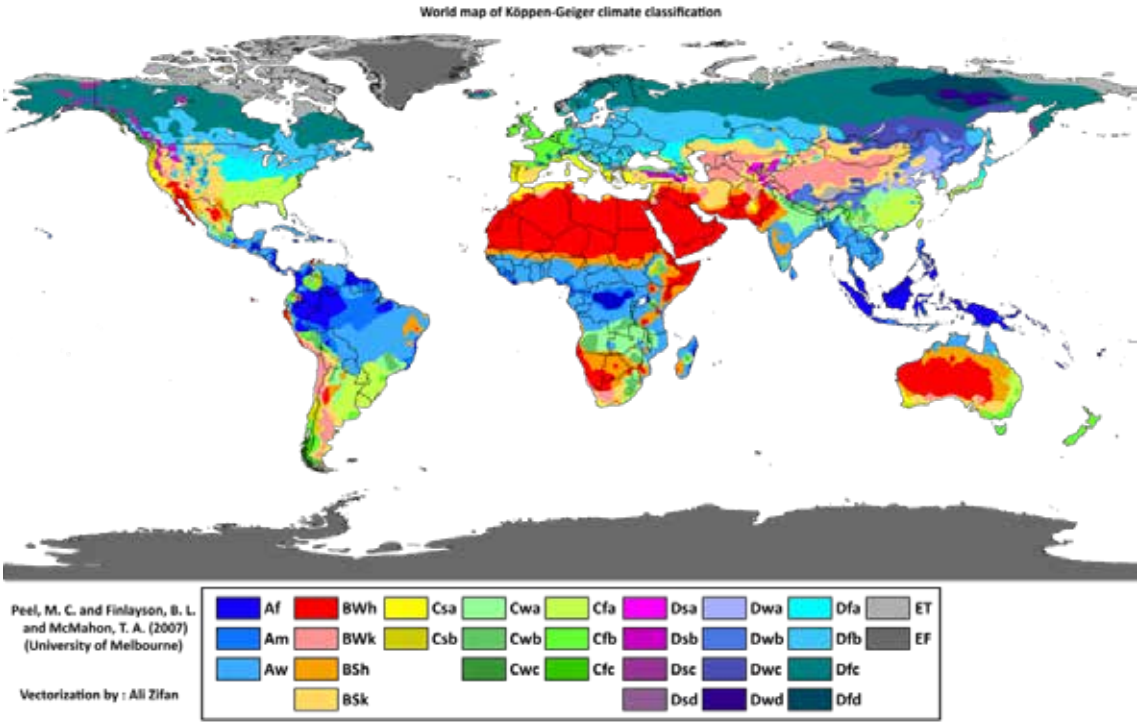
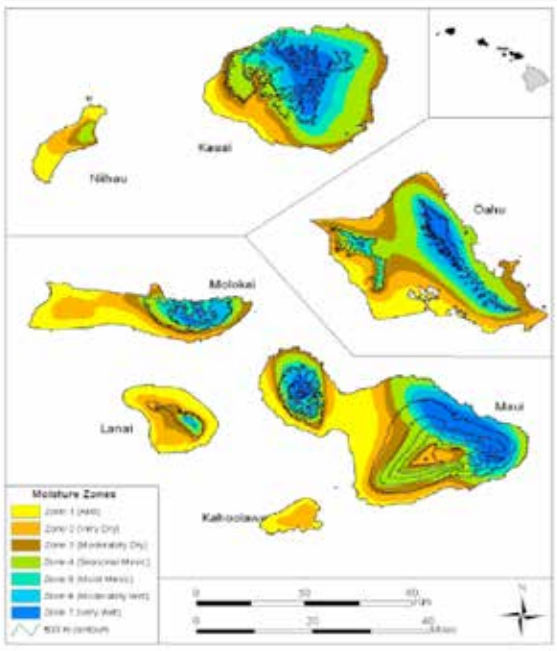
Introduction

The State of Hawai'i is a desirable destination and host to visitors, residents, new developments, and golf courses. Vast coastal areas, available water sources, and diverse native flora and fauna have made golf in Hawai'i one of the most enjoyable experiences in the world. The Hawaiian Island chain possesses 10 zones of the Köppen Climate Classification System, the most widely used system adopted by climatologists for identifying and defining worldwide climate zones. It is essential for sustainable conservation management to have an understanding and knowledge of the microclimates and meteorological conditions. The fragile ecosystems in the State of Hawai'i need guidelines and protection to preserve this sensitive environment beyond the Environmental Protection Agency (EPA), Federal, and State regulatory agencies. All members engaged in the Hawai'i golf industry or new developments need to be responsible stewards and abide by best management practices (BMPs) when creating, managing, and maintaining a golf course synergistically with surrounding communities and ecosystems.

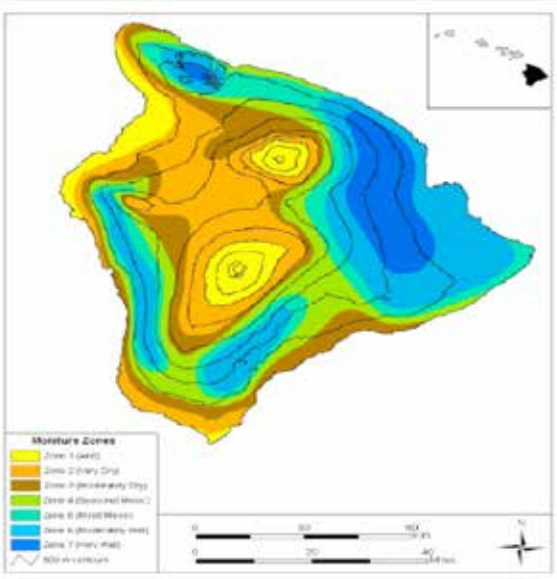
The Hawai'i Golf Course Superintendents Association (HGCSA) Hawai'i Handbook of Golf Course Maintenance Best Management Practices provides a concise overview of 12 BMPs in golf course maintenance to support environmental stewardship and optimal course conditions in the state of Hawai'i. Our goal is to create and maintain courses that are ecologically functional and healthy green spaces, honoring the land, tradition, and people of Hawai'i, while contributing to the local economy.



World Map of Koppen-Geiger Climate Classification



Moisture Zones
Niihau, Kauai, Oahu, Molokai,
Lanai, Maui, & Kahoolawa



Moisture Zones
Hawai'i (The Big Island)

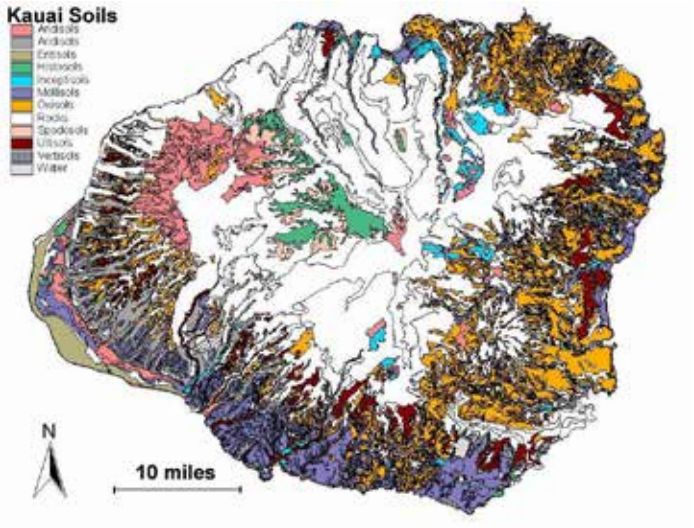


Figure 1

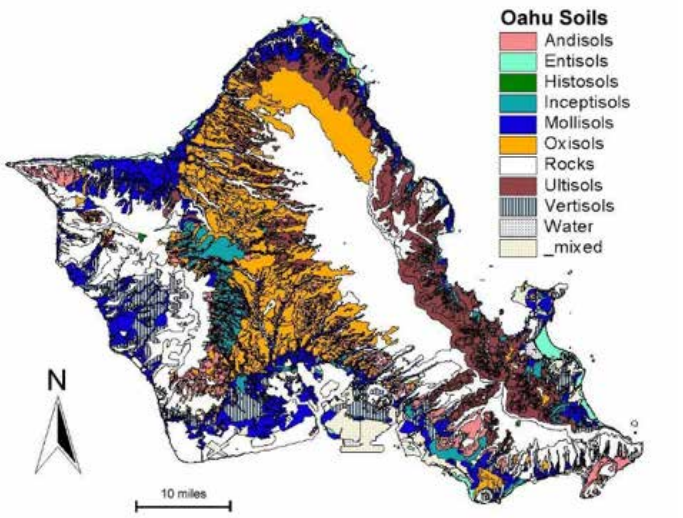


Figure 2

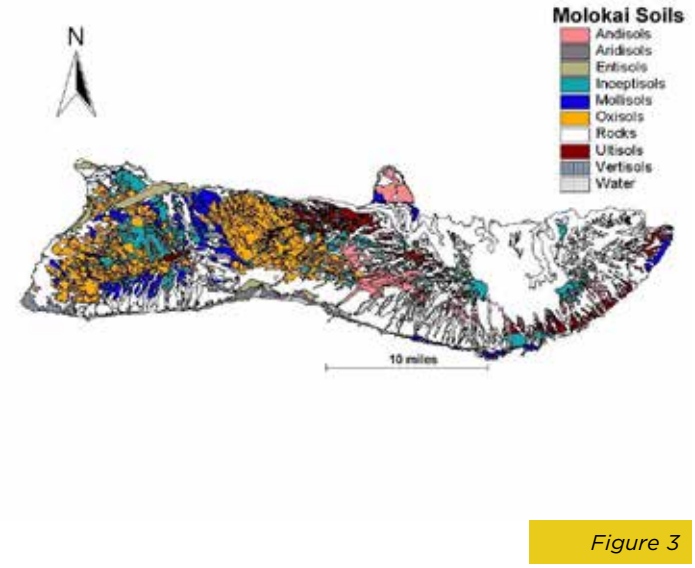


Figure 3

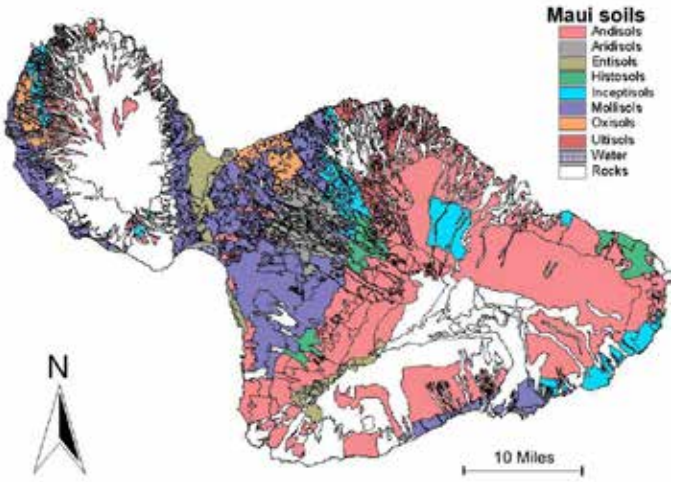


Figure 4

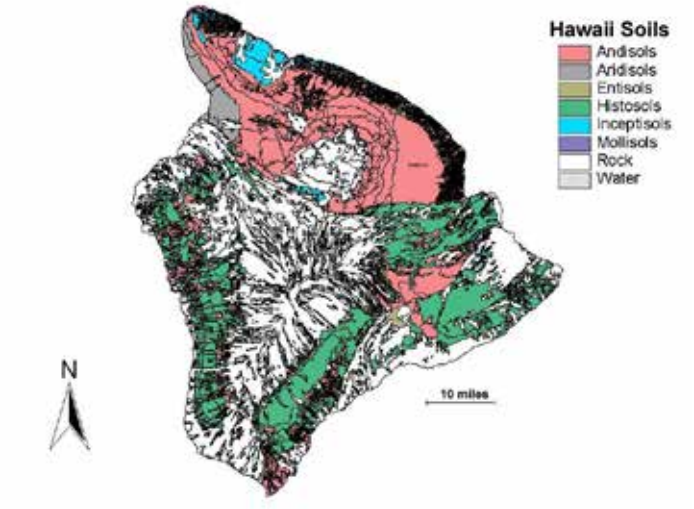
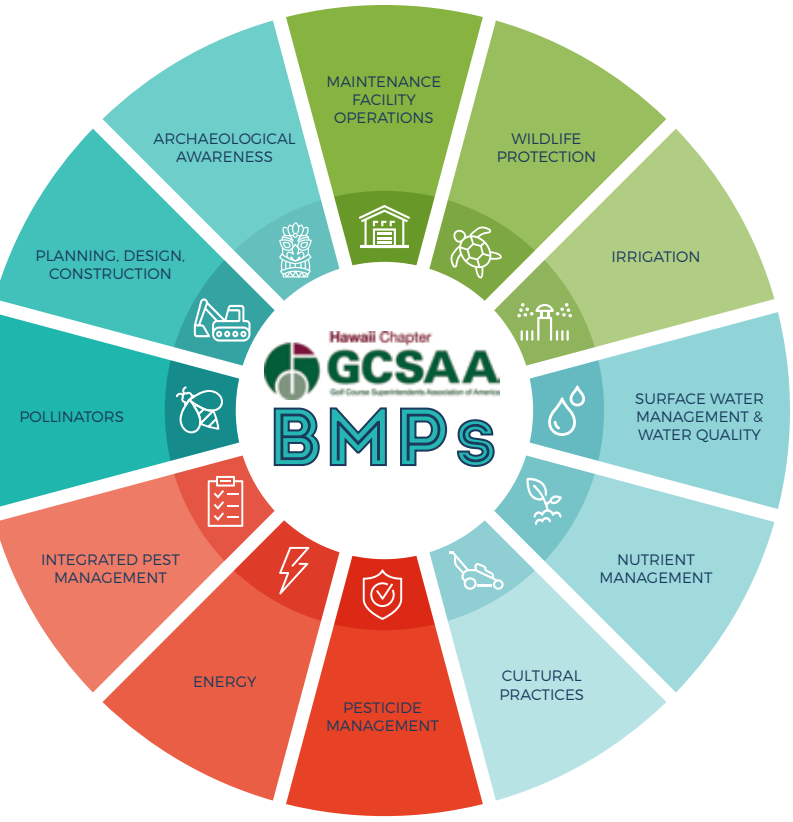


Figure 5

Fig, 1 *Distribution of soil orders on Kauai.*
Fig. 2 *Distribution of soil orders on Oahu.*
Fig. 3 *Distribution of soil orders on Molokai.*
Fig. 4 *Distribution of soil orders on Maui.*
Fig. 5 *Distribution of soil orders on Hawai'i (the Big Island)*

Background

The HGCSA represents 125 members within the state. Our ‘ohana includes superintendents, agronomists, assistant superintendents, mechanics, greenskeepers, and industry suppliers. We believe it is our *kuleana* (responsibility) to our land and communities to operate using sustainable methods of natural resource management. This handbook provides guidance for all areas of golf maintenance for golf courses of all sizes, with BMPs specific to our state. Our goal is to promote environmental stewardship, community engagement, and the overall health of the Hawai’i golf and tourism industries.



BMP guidelines for nutrient, energy, biodiversity, and water management are important for all golf courses in Hawai’i – they provide a roadmap for superintendents and a resource for additional stakeholders including golf professionals, general managers, owners, regulators, lawmakers, our communities, guests, members, and resorts. Examples of items which affect BMPs that are unique to Hawai’i include climate, geography, salinity levels, native plant and wildlife, and turf grass species - all impact water and nutrient management, cultural practices, energy, and pest management.

The Golf Course Superintendents Association of America (GCSAA), supported by the United States Golf Association (USGA) and PGA TOUR, initiated a nationwide initiative by providing state associations with a general BMP handbook and resources to develop and adopt guidelines specific to each state. Our handbook customizes content to address local sustainability needs, aligning with the state’s *Sustainable Hawai’i Initiative*, and regulatory areas of importance.

The HGCSA BMP Steering Committee, comprised of six superintendents representing different counties, plus three experts from the Hawai’i regulatory community, University of Hawai’i, and sustainability field, authored each of the twelve sections. The committee worked with Radius Sports Group, a sustainability consulting firm, to develop the handbook. The handbook was reviewed by leaders in the golf maintenance, architectural, construction, regulatory, academic, and sustainability fields.

Sustainable Hawai'i Initiative

The Sustainable Hawai'i Initiative incorporates ambitious goals to promote environmental, social, and economic sustainability for our state. The goals, identified under the Aloha+ Challenge, outline objectives to achieve greater local food production, biosecurity (reducing invasive species), water quality, biodiversity and watershed protection, and renewable energy. HGCSA is committed to these goals which are integrated within our handbook and golf course operations.

For additional information, visit: https://governor.Hawai'i.gov/wp-content/uploads/2017/01/Sustainable-Hawai27i-Initiative-Brochure.pdf

100% increase in local agricultural production by 2020

strong invasive species policy, infrastructure and capacity by 2027

30% of priority watersheds protected by 2030

30% of nearshore narine areas effectively managed by 2030

Complete transfer to clean, renewable energy by 2045

SDG Integration

The Sustainable Development Goals (SDGs) or Global Goals are a universal call to action to end poverty, protect the planet, and promote peace and prosperity. Global goals have been integrated within states, cities, and leading organizations worldwide and have been integrated within Hawai'i legislation. The goals are highlighted by section throughout our handbook to show how proper use of BMPs can drive local and global impacts.

For additional information, visit: https://www.un.org/sustainabledevelopment/

Mahalo

The HGCSA would like to extend our gratitude to everyone who contributed time, expertise, and resources to develop and publish the HGCSA *Hawai'i Handbook of Golf Course Maintenance Best Management Practices*. Thank you to superintendents across the state who provided photo contributions.

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Golf Course Superintendents Association of America (GCSAA)
Since 1926, GCSAA has been the top professional association for the men and women who manage golf courses in the United States and worldwide. Based in Lawrence, Kansas, the association provides education, information, and representation to more than 17,000 members in more than 72 countries. GCSAA's mission is to serve its members, advance their profession, and enhance the enjoyment, growth, and vitality of the game of golf.

United States Golf Association (USGA)
The USGA provides governance for the game of golf, conducts the U.S. Open, U.S. Women's Open and U.S. Senior Open, as well as 10 national amateur championships, two state team championships and international matches, and celebrates the history of the game of golf. The USGA establishes equipment standards, administers the Rules of Golf and Rules of Amateur Status, maintains the USGA Handicap System and Course Rating System, and is a foremost authority on research, development, and support of sustainable golf course management practices.

Environmental Institute for Golf (EIFG)
The EIFG fosters sustainability by providing funding for research grants, education programs, scholarships, and awareness of golf's environmental efforts. Founded in 1955 as the GCSAA Scholarship & Research Fund for the Golf Course Superintendents Association of America, the EIFG serves as the association's philanthropic organization. The EIFG relies on support from many individuals and organizations to fund programs advancing stewardship on golf courses in the areas of research, scholarships, education, and advocacy. The results from these activities position golf courses as properly managed landscapes that contribute to the greater good of communities, benefit the game, and positively impact the environment for years to come.

The GCSAA and EIFG wish to thank the **University of Florida**, Institute of Food and Agricultural Sciences, faculty, Dr. J. Bryan Unruh, Dr. Travis Shaddox, Dr. Jason Kruse, and Mr. Don Rainey, who worked on the core BMP initiative, providing knowledge and expertise; the **USGA** for their grant to help fund this important project; the **volunteers who served on the initial task group**; and the **Florida Department of Environmental Protection** for permission to copy its publication, "Best Management Practices for the Enhancement of Environmental Quality on Florida Golf Courses" for use as a core template.

Champion Partners

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Big Island Mechanical & Construction

Planning, Design, and Construction

1

Building a new golf course or renovating an existing golf course requires careful consideration and understanding during planning, design, and construction. Designers can draw inspiration and develop a balanced, functional design through extensive evaluation. Evaluation includes onsite and neighboring ecological features, water resources, habitat documentation, topography analysis, physical settings, historic and cultural use of the land through involvement of lineal descendants, and a variety of other constraints and attributes.

Considerate use of BMPs during planning, design, and construction should result in an environmentally sustainable golf course that operates efficiently and has minimal effect on the environment. There are differences between every golf course location and project, resulting in considerable variance in the design process and vision. The native volcanic substrate can differ drastically from island to island. The approach outlined in this handbook is general and may not be applicable to all situations. However, this approach provides a framework for sound decision-making throughout each project phase.

Planning, Design, and Construction

Best Management Practices

- Comply with Federal and Hawai'i State laws and regulations
- Assemble qualified team of internal and external stakeholders
- Establish objectives and conduct a feasibility study
- Incorporate an understanding of topography, access to water, energy, labor, and material sources into plan
- Identify rare, protected, endangered, threatened plant/animal species; plan, design, construct to preserve
- Preserve existing archeological finds and historic sites on property
- Retain qualified Director of Agronomy, golf course superintendent, and project manager at beginning of design and construction process to integrate sustainable maintenance practices
- Design to minimize the need to alter or remove existing native landscapes
- Plant only certified turfgrass and select a species that meets needs of stakeholders and the site
- Design to maximize play and minimize negative environmental impact
- Retain as much natural vegetation as possible
- Use only qualified contractors who are experienced in the special requirements of golf course construction
- Complete construction with care to minimize environmental impact and financial ramifications
- Archaeological awareness of the site and surrounding area should be a priority
- Minimize environmental risk during grow-in and establish Special Management Areas where needed
- Ensure proper steps are taken and state requirements are followed for erosion and sediment control
- Preserve and maintain adjacent wetlands, ensure proper permitting is obtained
- Incorporate proper drainage for containment of runoff, adequate buffer zones, and filtration techniques
- Incorporate a storm water "treatment train" approach; a storm water pollution prevention plan (SWPPP) may be required for construction activities
- Design irrigation systems to minimize water use, drift or overspray
- Design and construct maintenance facilities to provide optimal ventilation, containment of site runoff, pesticide mixing area containment, energy efficiency, and proper storage of pesticides, fertilizers, equipment, oils, solvents, and fuel
- Understand, and when practicable, pursue certifications and recognized frameworks to support environmentally-focused programs, community, health and wellness
- Promote a healthy habitat for plant and wildlife

Planning

Proper planning is essential from an environmental, economic, and social perspective. Good planning provides opportunities to maximize and integrate environmentally favorable characteristics into the property. It also minimizes expenses resulting from unforeseen construction requirements. Planning that integrates archaeological, cultural, and historical sensitivities is equally important in Hawai'i and essential for community relations. Careful planning requires the involvement of a qualified team of internal and external stakeholders.

Determine the objectives for construction prior to getting started. Objectives should be well-defined, measurable, and time-bound. Complete a feasibility study to identify needs, resources, obstacles, strengths and weaknesses of potential site(s), possible environmental and cultural impacts, potential opposition to development, timeframes, cost estimates, and expected return on investment. Consider whether needs are feasible given existing resources. Select an appropriate site that can achieve the needs of stakeholders and ideally exhibits features that contribute to a "Wow Factor".

Access to Resources

Incorporate an understanding of topography and access to water, energy, labor, and material sources into the plan. In Hawai'i these components are particularly important given challenges associated with limited access and resources. For example, materials that need to be transported from the mainland or internationally could impact completion time, logistics, and costs. Labor could be limited based on existing construction projects on-island and/or time of year; this can impact costs and completion time. Also, understand state, county, and city regulatory requirements and/or restrictions in regards to construction, labor, and logistics.

Getting to Know Golf: Greens, Bunkers, Tees & More!

- Tees or tee boxes are the starting point on each hole of a golf course.
- Fairways are where the grass is cut short, spanning between the tees and the putting greens (hole).
- Rough is the term used for the tallest grass on the golf course, located outside the fairways.
- Greens are located at the culmination of a golf hole, the area where the flag and hole are positioned.
- A bunker is a depression near the fairway or the green, usually filled with sand

Planning, Design, & Construction: Internal and External Stakeholders

- Golf course architect
- Golf course superintendents
- Civil engineer
- Agronomist
- Irrigation designer & engineer
- Landscape architect
- Clubhouse architect
- Ecologist
- Entomologist
- Geologist
- Soil scientist
- Environmental engineer
- Archaeologist
- Land planner
- Golf course builder
- Energy analyst
- Cultural advisory team
- Resource management team
- Consultants
- Public relations professional
- Legal team

Sensitivity to Plant and Animal Species

Golf courses provide vast areas of green space. In counties like Oahu or Maui with significant urban development, native areas have been eliminated to make way for increased infrastructure. Impermeable surfaces including concrete, asphalt, and office buildings often dominate urban areas. Golf courses provide acres of green space helping to reduce the urban heat island effect, providing surface water filtration, and supporting habitat for wildlife and ecosystem function. In places like the Big Island, where significant lava rock areas exist, there is limited green space. Courses have designed ways to build on crushed lava rock, making the area home to plants and wildlife. Maintaining habitats on golf courses improves biodiversity for our islands.

Part of the planning phase includes identification of rare, protected, endangered, or threatened plant or animal species on the site, including species the state deems "of special concern". Determine whether any species are endemic. Examples include the *Maiapilo (Capparis sandwichiana)* and the Hawaiian Coastal Bee *(Hylaeus anthracinus)*. Reference the US Fish and Wildlife Service to identify species federally protected under the Endangered Species Act and develop a long-term protection plan that preserves, promotes, or expands critical habitat.

Remove nuisance and exotic/invasive plants that have been identified as pests and replace with native species adapted to the site, based on site needs and preference. Maintain clearance between the ground and lowest portion of a fence or wall to allow wildlife to pass, except in areas where feral animals need

to be excluded. Retain dead tree snags for nesting and feeding sites, provided they pose no danger to people or property.

Assess and identify wildlife habitat requirements (food, water, cover, space). Implement operations and areas that preserve wildlife habitat and migration corridors. Design and locate cart paths to minimize environmental impacts. Design unavoidable crossings to accommodate wildlife movement.

Construct and place birdhouses, bat houses, nesting sites, and beehives in out-of-play areas. Plant butterfly gardens around the clubhouse and out-of-play areas. Retain riparian buffers along waterways to protect water quality and provide food, nesting sites, and cover for wildlife. Minimize stream or river crossings to protect water quality and preserve stream banks.

Reference Appendix A Table 1A and 1B for Endangered Plant and Animal Species in Hawai'i.

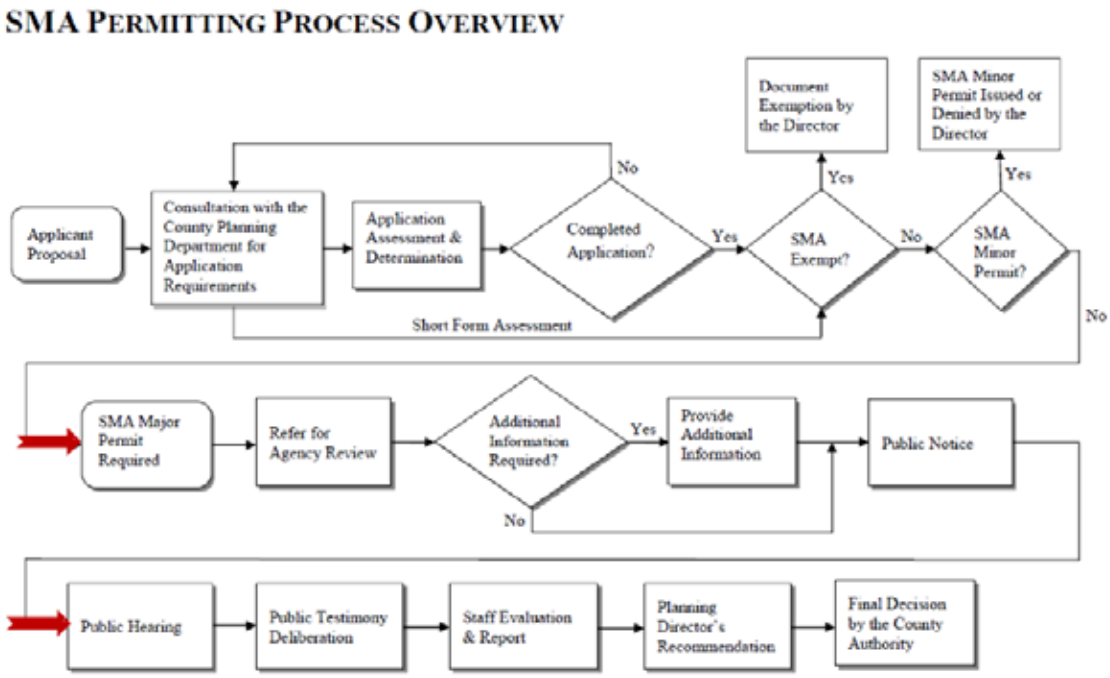
Reference Pollinator Protection and Wildlife sections for additional BMPs.

Regulatory Considerations

Research and understand local and state regulations which may be in place at the site. Early engagement between developers, designers, local community groups, and permitting agencies is essential to designing and constructing a golf facility that minimizes environmental impact and meets the approval process.

The construction phase poses the greatest risk of ecosystem alteration. With proper planning and design, golf facilities can be constructed and maintained with minimal impact to existing wildlife and their habitat. A Special Management Area (SMA) permit is essential for any shoreline-intended development and construction. This permit must be obtained and is available through the Coastal Zone Management Department Program by Hawai'i State Office of Planning. A civil fine of up to $100,000 (or $10,000 per day) could be enforced for violations.

Reference for more information: http://files.Hawai'i.gov/dbedt/op/czm/program/sma/SMA-Permit-Short.pdf



Source: *Special Management Area (SMA) Permit System Project - Final Assessment Report*, 2005

Design

Proper design will meet the needs of stakeholders, protect the location's environmental resources, and be economically sustainable. Retain a qualified Director of Agronomy, golf course superintendent, and project manager at the beginning of the design and construction process to integrate sustainable maintenance practices in the development, maintenance, and operation of the course. Design to minimize the need to alter or remove existing native landscapes. Routing should identify areas that provide opportunities for restoration and retain as much natural vegetation as possible. Where appropriate, consider enhancing existing vegetation through supplemental planting of native vegetation/materials adjacent to long fairways, out-of-play areas, and along water sources supporting fish and other water-dependent species. Nuisance, invasive, and exotic plants should be removed and replaced with native species that are adapted to the site.

Determining Factors in Selecting Best Turfgrass Species

- Climate
- Water usage
- Water quality
- Adaptation
- Drought tolerance
- Salinity tolerance
- Pest & disease susceptibility
- Fertility requirements
- Color
- Shade tolerance
- Seed head production
- Cost to plant (seed vs. sprigs) & patented rights
- Cost to maintain

Available & Proven Varieties of Golf Course Turf in the State of Hawai'i

Bermudagrass Cultivars
- Tifway419
- TifEagle
- Tif dwarf
- Miniverde
- Champion
- TifGrand (New)
- Princess 77 – seed available
- Celebration
- Common – seed available

Seashore paspalum
- Platinum TE
- Sea Dwarf
- Sea Isle Supreme
- Sea Isle 2000
- Salam
- SeaStar
- Sea Spray – seed available
- Pure Dynasty – seed available (New)

Zoysia
- Zeon (New)
- Geo Zoyia
- Emerald
- Empire (New)
- El toro
- Zenith – seed available

Selecting Turfgrass

Select a turf species/variety that meets the needs of stakeholders while adhering to the principle of "right plant, right place." Create turfgrass research plots and/or a research green to test for the desired species and cultivars for density, color, and tolerances. In regards to selecting one species and cultivar versus multiple, consider whether the maintenance team will be able to keep the greens pure and uncontaminated long-term. One species is usually a cost-effective selection. The approach surrounds, tees, fairway, and rough height-of-cut are usually determining factors. Blends, or multiple species, are not commonly practiced, except at higher elevation golf courses (e.g., Makalei Hawai'i Island). Multiple species and cultivars can be a nuisance long-term and contaminate planted areas. Plant only certified turfgrass and check for the most updated restrictions of turfgrass propagation and cultivation.

Aesthetic Turf

Turfgrass may be used for purely aesthetic reasons to provide a pleasing view around clubhouses, entries, and other areas. However, remember that turfgrasses provide minimum wildlife benefits and require considerable maintenance inputs. Use turf as a landscape element where needed, designing for ease of maintenance and keep in mind that building shade and tree canopy can negatively impact health and function of turf.

Landscape & Garden Areas

Landscape (non-play) areas are an essential part of the overall course design, providing enhanced course aesthetics, wildlife habitat, external sound/noise abatement, and natural cooling. An environmental landscape design approach addresses environmentally safe and energy-saving practices; and is economically important. The fundamental principle for the environmentally-sound management of landscapes is RIGHT PLANT, RIGHT PLACE.

Choose the most stress tolerant species or cultivar for your area. Know the ultimate sizes and growth rate of trees, shrubs, and ground covers. This reduces the need for pruning and debris removal, and lowers maintenance costs. Non-play areas require a mix of sun and shade, optimal soil conditions, and adequate canopy air movement to sustain growth and function. Use "xeriscape" landscaping and native drought tolerant plants where feasible around buildings, parking areas, or other appropriate places. In most instances, established, drought-

tolerant landscape plants have a root system substantial enough to keep them alive with little or no supplemental irrigation. Consider the use of water-holding polymers, water-sorbing polymers, or water storing crystals as means of water retention and reducing water loss to evaporation. Use mulches in shrubs and flower beds to reduce water evaporation losses. The use of rocks, sand, gravel, volcanic cinder or lava, and decorative pebbles have functional aesthetic purpose and conserve water.

Vendors & Licensed Turf Farms

- Simplot (Kailua Kona, HI; Kapolei, HI; Kahului, HI)
- Nutrien Ag Solutions (Hilo, HI; Kahului, HI, Kunia, HI, Lihue, HI)
- Ali'i Turf (Wahiawa, HI)
- Hawaiian Turfgrass (Mililani, HI)
- Southern Turf Hawai'i (Kailua Kona, HI; Mililani, HI)
- Turf Hawai'i (Kailua Kona, HI)
- Seed Ranch (International)
- PhillipJennings Turf Farms, LLC (International)
- Stover Seed Company (International)
- Pencross (International)
- Atlas Turf (International)

Lab Resources for Soil Testing

- Ana-Lync
- Wallace Labs
- Turf & Soil Diagnostics Services
- Brookside Laboratories, Inc.
- Hummel & Co Inc.
- Soil Horizons
- UH Manoa Department of Agriculture
- Environmental Assessment

Greens

When designing greens, select a location with adequate sunlight to meet plant-specific needs and sufficient drainage. Work with the architect to determine total greens size. The average total greens area in Hawai'i is approximately four acres. The greens size is determined by gauging the appropriate number of hole locations. Greens should be large enough to accommodate traffic and play, while remaining sustainable using existing resources.

Select an appropriate root-zone material as designated by the USGA. Sand blended with peat moss should be sent to a soil testing facility for analysis. Sand base and future topdressing sand should be from the same sand source. Determine whether to incorporate a greens sand liner and install tracer wire to maintain greens shapes long-term. Install yardage reference points for consistency when selecting hole locations.

Greens should be irrigated separately from surrounding turf. Consider designing greens to receive water from a potable water source separate from the main water source if water quality is poor.

Bunker Liner Products

- Better Billy Bunker
- Capillary Concrete
- Sand trapper
- Polylast
- Flexxcape
- Zline
- Sand Guard by Porus Pave, Inc
- Klingstone

Bunkers

For bunker design, understand the planned number of bunkers as it relates to resources available for daily maintenance. Bunker reduction and added native areas can save both resources and water. Additional design factors include determining bunker entry and exit points, wear patterns, and creating adequate space for ingress/egress points on greens, tees, fairways, and bunkers. Also decide what type of drainage the bunkers will contain.

Bunker construction includes preparation, creating slopes and shapes, deciding whether to use sod or sprigs or a combination, and calculating the cost to maintain the bunkers. It's also important to consider what long-term maintenance will be required. Lastly, identify how to prevent against soil, rocks, or sediment from getting into the bunkers.

When it comes to bunker sand, select the proper color, size, and shape to meet your needs. Availability and sand analysis are keys for determining the ideal penetrometer rating and drainage characteristics.

Tees & Approaches

Tees and approaches are commonly constructed with cinder soil or are sand-capped. Minimizing the size of Tee Complexes can reduce maintenance costs. Understanding the long term objective of play levels can assist in determining the projected space requirements - too small for heavy play levels or too big for low play levels may have significant long term financial and resource impacts. Be sure to determine the size for each and what type of mower will be maintaining these areas.

Fairways

Landing areas should be considered when working with the architect to determine the size of each fairway. In Hawai'i, total fairway areas have been trending larger t han rough areas.

Rough

Work with the architect to define play and non-play maintenance boundaries. Consider adding more sprinklers on the perimeter edge to combat potential wind and help conserve water.

Construction

Construction should be completed with care to minimize environmental impact and financial ramifications. Permitting must be complete and abided by, especially in Special Management Areas. Use only qualified contractors who are experienced in the special requirements of golf course construction.

Guide contractors to ensure optimal safety and environmental preservation; conduct a pre-construction conference with relevant stakeholders. Maintain a construction progress report and communicate the report to the proper permitting agencies.

Schedule construction to maximize turfgrass establishment and site drainage, environmental conservation, and resource management. Build temporary construction compounds in a way that minimizes environmental impacts. Use environmentally sound construction techniques and soil stabilization techniques to minimize erosion and maximize sediment containment.

Establishment of ground water testing protocols as well as coastal water sites before, during, and after construction will assist in assuring any potential impacts to the environment are actively observed and managed. Testing sites on properties where elevations vary should include testing sites above and throughout the gradient of the property to ensure impacts outside and on the site can be mitigated and properly recorded. Testing protocols should be determined in advance, including testing intervals for each site based on sensitivities toward surrounding features, ground water flows, proximity to drinking wells, coastal impacts, and other related factors.

Grow-In

Turfgrass establishment is an important and unique phase in turfgrass growth. It can require greater quantities of water and nutrients than established turfgrasses, care should be taken to minimize environmental risk. Special Management Areas may require a different approach and should be calculated.

A "Grow-in" Fertility Program is usually recommended by the agronomist or superintendent and should create calculated rates of pre-plant and establishment nutrient guidelines. Soil test reports of the topsoil or sand base should identify amendments and nutrient requirements for pre-planting. The normal establishment period can range from three to six months and nutrient input can accelerate or create potential pollutants if a BMP is not followed. In parts of the state where soils used for turf establishment consist of extremely porous materials such as sand or crushed lava, extreme care should be used to avoid the use of too much water that can move applied nutrients out of the grow-in zone and into waterways, coastal areas, and down gradient areas.

During the establishment period, mow as soon as the sod has knitted-down, when sprigs have rooted at the second to third internode, and seedlings have reached a height of one-third greater than intended height-of-cut. Most agronomists or superintendents will create a timeline when areas are planted to give consistent time for establishment.

Heights of cut will also be determined by the establishment period timeline as turf becomes established, and will be managed depending on area. Light verticutting and topdressing will improve playing surface and assist when reducing height-of-cut in each turf area. Reducing the height-of-cut often reduces weed establishment. Improper herbicide application timing can slow down turf establishment; consider spot application versus wide-spread applications.

Grow-In Key Factors

- Prepare area properly and clear of pests (weeds, pathogens, etc.)
- Erosion and sediment control devices must be in place and properly maintained
- Sprigs should be "knifed-in" and rolled to hasten root establishment
- Utilize hydro mulching and/or topdressing with compost on bunkers, slopes, special management areas
- Top-dress sod to fill gaps between sod pieces, hastening establishment and providing a smoother surface
- Use appropriate seeding methods for course conditions
- If using sod, delay nutrient applications until sod has sufficiently rooted

Erosion and Sediment Control

Soil carried by wind and water erosion may transport contaminants with it. Contaminants can dislodge, especially on entering water bodies, where they can cause pollution. Erosion and sediment control are critical components of construction and grow-in. Develop a working knowledge of erosion and sediment control management, work with the contractor to ensure proper steps are taken and state requirements are being followed in regards to types of structures, materials, and design features.

Develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species, and designed environmental resource areas. Hydro-seeding, hydro-mulching, and sodding offer soil stabilization and assist in water retention and erosion control.

Reference for more information:http://health.Hawai'i.gov/cwb/clean-water-branch-home-page/standard-npdes-permit-conditions/

Reference Surface Water Management and Water Quality Protection Section for additional BMPs.w

Wetlands

Most states consider wetlands "waters of the state," a designation that carries significant legal ramifications. Permitting requirements for wetlands can have multiple overlapping jurisdictions of federal, state, and local agencies. At the federal level, the U.S. Army Corps of Engineers (USACOE), EPA, U.S. Fish and Wildlife Service (FWS), National Oceanic and Atmospheric Administration (NOAA), and maritime agencies may be involved. State agencies that may be involved in wetlands include the Hawai'i Department of Land and Natural Resources (DLNR) and the Department of Health (DOH).

Wetlands act as filters for pollutant removal and as nurseries for many species of birds, insects, fish, and other aquatic organisms. The biological activity of plants, fish, animals, insects, and especially bacteria and fungi in a healthy, diverse wetland is the recycling facility of our ecosystem. When incorporated into the golf course design, wetlands should be maintained as preserves and separated from managed turf areas with native vegetation or structural buffers. Constructed or disturbed wetlands may require a permit to be an integral part of the storm water management system. Ensure proper permitting has been obtained, properly delineate, and establish buffer zones and erosion control before working in, and around, wetlands.

Reference Surface Water Management and Water Quality Protection section for additional BMPs.

Drainage

Adequate drainage is necessary for growing healthy grass. Damaged, improperly installed, or poorly maintained drainage systems will result in inferior performance that negatively impacts play and increases risks to water quality. A comprehensive drainage plan addresses containment of runoff, adequate buffer zones, and filtration techniques in the design and construction process to achieve acceptable water quality.

Subsoil preparation, gravel placement, slopes, and backfilling are important in constructing drainage systems. Internal golf course drains should not drain directly into an open water body, but should discharge through pretreatment zones and/or vegetative buffers to help remove nutrients and sediments. Proper drainage and storm water management devices, such as vegetative buffers or swales should be deployed. The drainage system should be routinely inspected and maintained to ensure proper function.

Reference Surface Water Management and Water Quality Protection section for additional BMPs.

Surface Water: Storm Water, Ponds, Lakes, Coastal Waters

Controlling storm water on a golf course prevents flooding of facilities and play areas, plus controls amount and rate of water leaving the course. Storm water control also involves storing irrigation water, controlling erosion and sediment, enhancing wildlife habitat, and addressing aesthetic and playability concerns.

Storm water on a course may not originate from the course, but from adjoining lands, including residential or commercial developments. An environmental benefit that golf courses provide includes filtering storm water naturally to remove waterborne pollutants through planned "treatment trains" (i.e., vegetated swales, depressed landscape islands, and constructed wetlands). DOH's Clean Water Branch can be of assistance with understanding State rules and regulations.

Reference Surface Water Management and Water Quality Protection section for additional BMPs.

Maintenance Facilities

Maintenance facility design and construction should promote positive environmental impact, health, and wellness. Ensure proper placement of the pesticide mixing and storage facility, equipment wash pad, and fuel center to minimize potential for contamination of soil and water resources. Locate operations away from groundwater wells and areas where runoff may carry spilled pesticides into surface waterbodies. Do not build new facilities on potentially contaminated sites. An open building must have a roof with a substantial overhang (minimum 30˚ from vertical, 45˚ recommended) on all sides. Other considerations include ensuring optimal ventilation, lighting, space, logistics, and energy efficiencies.

Design and build pesticide storage structures to keep pesticides secure and isolated in a roofed concrete or metal structure with a lockable door. Construct floors of seamless metal or concrete sealed with a chemical-resistant paint.

Ensure that flow from floor drains does not discharge directly to the ground and that drains are not connected to the sanitary sewer line or septic system, they should drain to a contained sump. Equip the floor with a continuous curb to retain spilled materials. Provide storage for personal protective equipment (PPE) where it is easily accessible in the event of an emergency, but do not store PPE in the pesticide storage area.

Additional Maintenance Facility Construction Considerations:

- Provide adequate space and shelving to segregate herbicides, insecticides, and fungicides
- Use shelving made of plastic or reinforced metal; keep metal shelving painted; do not use unsealed wood
- Provide appropriate exhaust ventilation and an emergency wash area
- When constructing a concrete mixing and loading pad, concrete should have a water-to-cement ratio no higher than 0.45:1 by weight
- Sumps should be small and easily accessible for cleaning
- Always store nitrogen-based fertilizers separately from solvents, fuels, and pesticides, since many fertilizers are oxidants and can accelerate a fire
- Ideally, fertilizer should be stored in a concrete building with a metal or other type of flame-resistant roof
- Store fertilizers in an area that is protected from rainfall
- Storage of dry bulk materials on concrete/asphalt pad may be acceptable if protected from water flowing across the pad
- Each piece of equipment should have an assigned parking area
- Spill and decontamination kits are required for any golf course with a nursery (that grows own grasses); some pesticides are required to be secured by a lock and key; be sure to read all labels
- Dry pesticides are to be stored above wet/liquid pesticides

Reference Pesticide Management, Maintenance Facility Operations, and Energy sections for additional BMPs.

External Certification Programs & Standards

Environmental management programs, health and wellness platforms, and environmentally-friendly building design can help courses protect the environment and promote community relations. These programs can help enhance the natural areas and wildlife habitats that golf courses provide and improve efficiencies. Obtaining certifications and adhering to standards can enhance community, member/guest, employee, and civic relations.

Certifications and internationally-recognized frameworks that golf courses and clubs can pursue range from environmentally-focused programs to certifications related to health and wellness. The State of Hawai'i has integrated the United Nations Sustainable Development Goals within its legislation. Aligning initiatives and operations with these goals helps create local and global impacts, and supports priorities of the State. Establish a communications plan to educate members/guests and the community of alignment with these standards or certifications.

Reference GCSAA Environmental Institute of Golf for more information: www.eifg.org

External Certifications and Frameworks

- Audubon International Cooperative Sanctuary, Signature, and Sustainable Communities Program ***audubonintenational.org***
- US Green Building Council Leadership in Energy and Environmental Design (LEED) ***usgbc.org/leed***
- Global Reporting Initiative GRI Standards ***globalreporting.org/standards***
- Blue Zones Project ***Hawai'i.bluezonesproject.com***
- B Corp Certification ***bcorporation.net/certification***
- Sustainable Development Goals ***sustainabledevelopment.un.org/sdgs***

Archaeological Awareness

2

Good stewardship includes respecting the traditions, history, and culture of Hawai'i. This impacts community, employee, and business relations. Historical knowledge can also contribute to the culture of the golf course, its name, or marketing strategy. A cultural advisory team is recommended, often comprised of Lineal Descendants, Kahu (Hawaiian Priest), a stakeholder representative, and an archaeologist. This team can help determine how to preserve existing archeological finds and historic sites. They can also determine optimal ways to incorporate unique features throughout the property which will highlight its cultural significance. Additional resources may be found at www.haunandassociates.com.

Once a site is selected, determine which stakeholders are best to create the name or identity of the golf course. Consider location and/or *ahupua'a*. Identify what surrounding biological or historical factors can be used in creating the identity.

Obtain information through conducting or preparing Archeological Assessments, Burial Treatment Plans, Site Preservation Plans, Archaeological Inventory Surveys, Cultural Impact Assessments, and gathering historical research. Archaeological awareness should be a priority of owners and stakeholders of the golf course and/or development.

During pre-construction and construction, a qualified archaeologist licensed in the State of Hawai'i is necessary to provide an Archaeological Inventory Survey report prepared in connection with Chapter 6E projects. It is expected to include (§13-275-3 and §13-284-3):

- Identification and documentation of all historic properties within a project area
- Evaluation of significance (eligibility for listing in the HRHP) for each historic property
- Determination of the project's effect on each historic property
- Proposed mitigation commitments to minimize the effect of the project on significant historic properties

Archaeological, Cultural, and Historic Sites

Best Management Practices

- Assemble qualified team of internal/ external stakeholders
- Conduct archeological assessments
- Prepare burial treatment plans
- Create site preservation plans
- Conduct archaeological inventory surveys
- Conduct cultural impact assessments
- Gather historical research
- Abide by Hawaii DLNR, Historic Preservation Division, HRS Chapter 6E-42, when applicable, including Archaeological Inventory Survey (§13-275-3 & §13-284-3)

Archaeological Awareness

Under Hawai'i State law, the Hawai'i Department of Land and Natural Resources, Historic Preservation Division HRS Chapter 6E-42 applies to any project that requires a permit, license, subdivision, land use change or other entitlement from the state or any county.

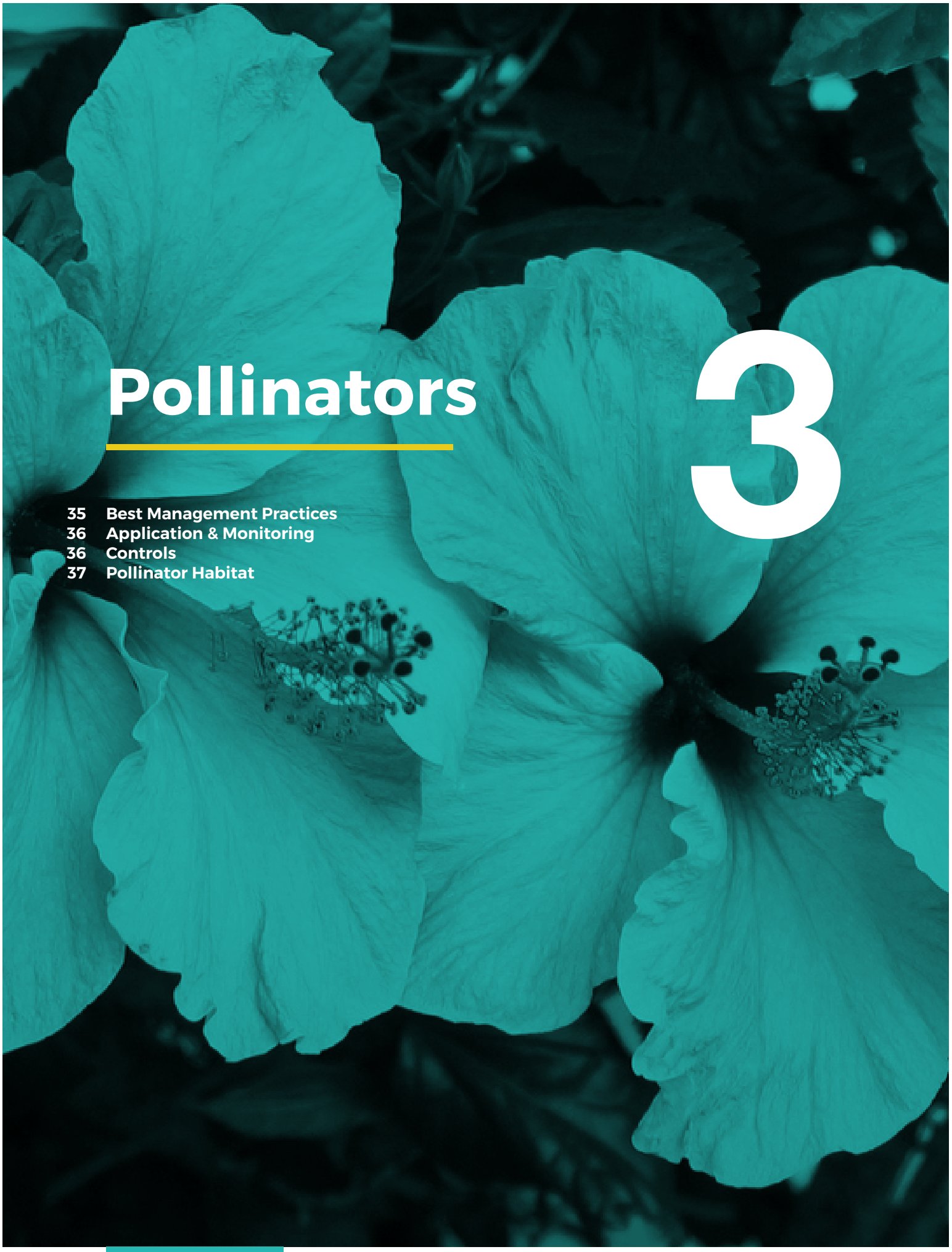
Examples of permits that require an archaeological survey:

1. State-issued permits and entitlements such as:
   - Conservation district use permits (CDUP) to allow for any activity within a state-designated conservation district; much of this district is private land and the owner needs approval from the Office of Conservation and Coastal Lands (OCCL), a division of DLNR
   - Permits to install water wells and pumps on private land, issued by the Commission on Water Resource Management (CWRM), a division of DLNR;
   - Revocable leases of state land to private entities for purposes of long term agricultural, commercial or residential use or access, issued by DLNR Land Division or the state Department of Agriculture
   - Rights of entry to access state land for short term activities
   - Requests for changes in state land use/zoning to allow for non-conforming activities, issued by the state Land Use Commission (LUC)
   - Projects subject to Chapter 343, which defines when an environmental assessment (EA) or environmental impact statement (EIS) is required for a project

2. County planning department permits and entitlements such as:
   - Special use permits (SUP, SPP) to conduct activities not specifically allowed within a zoning district; i.e., bed and breakfast operations, stores, commercial garages in agricultural or residential zoned areas
   - Special management area (SMA) assessments, minor or major permits to conduct activities within the special management/ shoreline area designated by each county; includes vegetation management, any type of construction, certain types of improvements, and any land modification
   - Applications or requests to change zoning (CIZ) in order to allow for such entitlements as smaller lot size, higher residential density, or other land uses that are not allowed in current zoning rules
   - Subdivision (SUB) of large land tracts into any number of smaller parcels, or consolidation of land parcels with re-subdivision into differently configured parcels

3. County department of public works permits for land alteration and construction:
   - Grubbing permits for mechanical removal of vegetation
   - Grading permits for cutting, filling and other land modification, in connection with construction activities
   - Stockpiling permits to allow for the deposition of soil removed from a different location; can be permanent
   - Building or demolition permits, both of which usually involve land alteration

Historic Ahu at Kohanaiki Golf Hole #12 Kailua-Kona, HI



Pollinators

3

Healthy pollinator populations are critical to our wellbeing. Macadamia nuts, avocados, guava, and coffee are examples of crops that rely on honeybees and native bees for pollination. Honeybees have faced an increasing level of threats nationwide. Deadly parasites, habitat destruction, invasive alien species and lethal chemical pesticides are identified threats to pollinators which support agriculture in Hawai'i. Seven species of Hawaiian yellow-faced bee, decimated by invasive species and habitat loss, are now federally protected. The yellow-faced bees are the only bees native to the Hawaiian Islands. They are a keystone species in the islands' ecosystems, as many of Hawai'i's native plant species are not well adapted to pollination by non-native pollinators.

With so much focus on honeybees, it can be easy to overlook other pollinators. Midges, for example, are important in pollinating Theobroma cacao, the tree that gives us chocolate. Flies, beetles, and butterflies also play an important role in pollination, and endemic moths, birds, and bees that co-evolved with Hawai'i's native plants are of critical importance.

Pollinators

Best Management Practices

- Utilize Integrated Pest Management (IPM) practices and always follow insecticide label precautions
- Inspect area for harmful and beneficial insect populations
- Choose insecticides with low impact on pollinators
- Apply only when indicated threshold of damage is reached
- Avoid applying pesticides during bloom season
- Monitor wind and active pollinator periods; utilize targeted applicators to prevent drift
- Consider alternatives to insecticides
- Plant ornamentals that encourage pollinator habitat
- Consider placement of beehives or herb gardens in native areas

Professionals who apply pesticides must diligently follow label precautions when using insecticides including irrigating, mowing weeds before applications, and choosing the proper insecticide class and formulation. Proper insecticide stewardship can control pests, reduce harm to beneficial insects, and ensure that insecticide tools remain viable for use in turf. By diversifying golf courses and other turf areas, we take a proactive role in protecting pollinators by providing food plants and habitat, while educating the public about the importance of these insects to our environment.

Application & Monitoring

Insecticides have been a focal point for concerns regarding pollinator decline. It is important to implement IPM practices and avoid applying certain chemical formulations. In particular, the neonicotinoid class (including imidacloprid). Insecticides can have lethal or sub-lethal effects on pollinators, underscoring the need to always follow label precautions, including instructions for irrigating products to increase below ground efficacy and removal of residues from foraging zones of pollinating insects. Pollinator-protection language is a requirement found on pesticide labels. Follow label information concerning application when plants may be in bloom; avoiding application during bloom season. Stay on target by using coarse-droplet nozzles and monitor wind to reduce drift. Before applying a pesticide, scout the area for both harmful and beneficial insect populations; do not apply pesticides when pollinators are active. Apply pesticides only when the indicated threshold of damage has been reached. If possible, mow flowering plants (weeds) before insecticide application and if flowering weeds are prevalent, control them before applying insecticides.

Controls

Use of insecticides that have a lower impact on pollinators is a best practice and use of the latest spray technologies, such as drift-reduction nozzles will assist to prevent off-site (target) translocation of pesticides. Avoid applications during unusually low temperatures or when dew is forecasted. Finally, try to use granular formulations of pesticides that are known to be less hazardous to bees and consider lures, baits, pheromones, or beneficial insects as alternatives to insecticides for pest management.

Reference Integrated Pest Management section for additional BMPs.

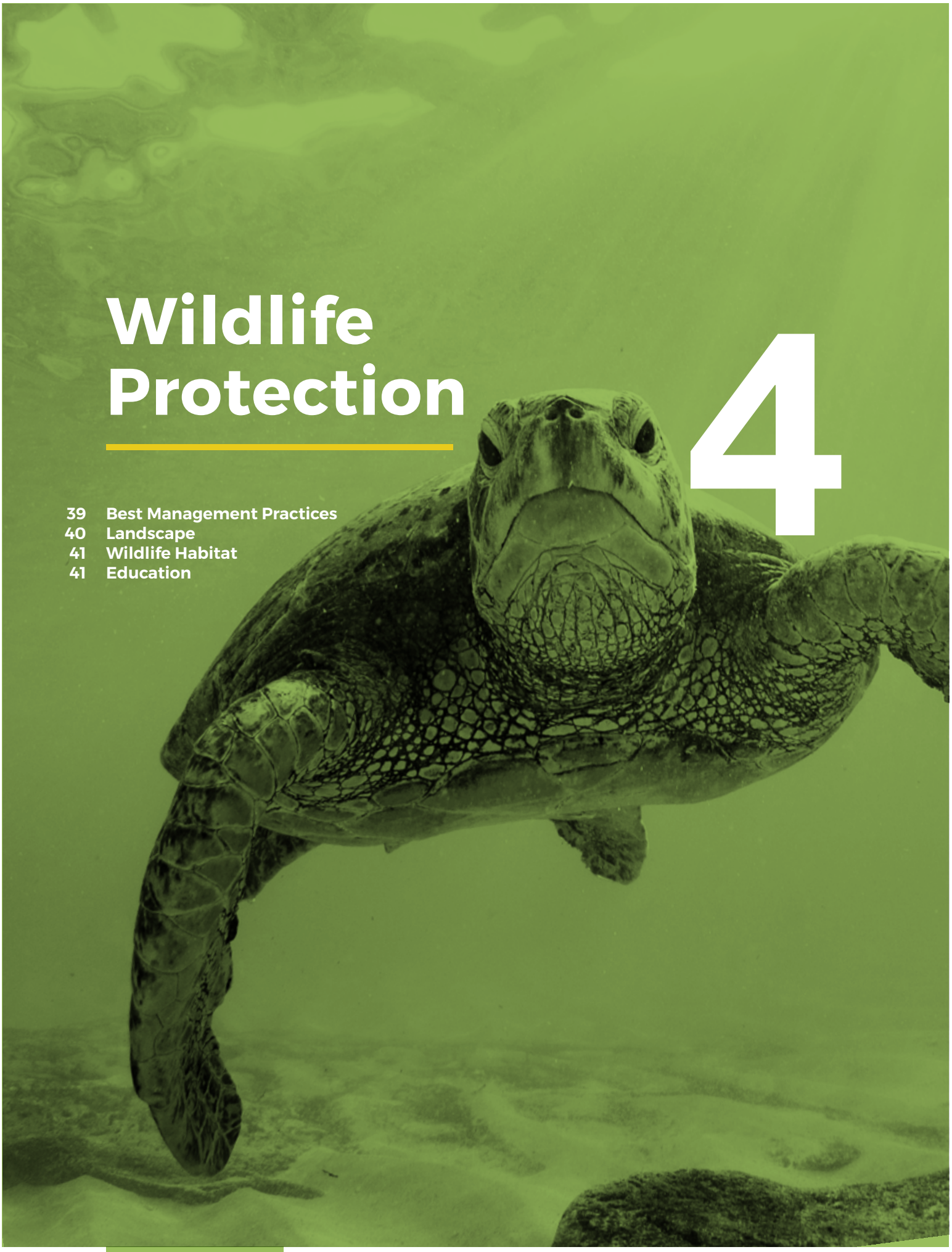
Pollinator Habitat

Identify plant varieties that encourage pollinator populations. This includes color, shape, odor, and native species. Aesthetic gardens, window boxes and container gardens, should contain a variety of plants of different heights that provide attractive color and nectar for bees and butterflies.

Resources for plant varieties that attract pollinators specific to Hawai'i include The Pollinator Partnership and North American Pollinator Protection Campaign Hawai'i Islands Regional Guide, or your local Natural Resources Conservation Service (NRCS). The North American Pollinator Protection Campaign (NAPPC) compiled guidelines, Pollinator Friendly Practices (PFP), to be used by organizations in support of land management practices in schools, private industry, public spaces, agriculture, forests, and homes.

Wildlife Protection

4



According to the Audubon Society, Hawai'i is home to a critically endangered community of native bird species found nowhere else on earth. Its flora and fauna face conservation challenges magnified by the fragility of the islands' unique ecosystems, evolved in isolation over millions of years. Habitat destruction and introduced animal species and disease have greatly impacted many native birds over the past few centuries. More than half of Hawai'i's endemic bird species have become extinct, while the majority of those remaining are listed under the U.S. Endangered Species Act. Many native bird species now find refuge only in high-elevation forests. Golf courses often provide critical habitats for these avian species.

Wildlife Protection

Best Management Practices

- Develop relations with your local fish and wildlife service
- Understand whether your property is an existing or potential habitat to endangered species
- Develop a management plan and objectives
- Retain existing vegetation when possible and plant native vegetation
- Use "xeriscape" landscaping and native drought tolerant plants where feasible
- Educate staff, members/guests, and community

Landscape

The ideal plant from an environmental stand point is the one nature and evolution placed there. It has adapted specifically to the soil, microclimate, rainfall and light patterns, insects and other pests, and endemic nutrient levels over thousands of years. As humans, we often have a need to change the natural landscape for living, working, and recreation. When we do so, our challenge is to use the most suitable plant materials for the new conditions that meet our design needs. The goal of BMPs is to maintain as close to a natural ecosystem as practical, while meeting the needs of the course.

Research

One of the first steps in golf course landscape planning is to assess the site's general environment and ecology. Map any environmentally sensitive areas such as sink holes, lava tubes, wetlands, anchialine ponds, or flood zone areas, and identify federal and state endangered or threatened species. It is important to preserve natural surroundings and wildlife habitats.

Contact the local fish and wildlife service or the Hawai'i Audubon Society to determine if your property is home to, or provides potential habitat for, endangered species. Develop a written management plan to protect and manage core (and supporting) wetland habitats in order to maximize productivity and survival of endangered waterbirds. Understand factors limiting Hawaiian waterbird population numbers, refine recovery objectives, and improve management techniques. Consider implementing a predator trapping program in conjunction with the local Humane Society and contact the Department of Health's Vector Control to remove mongoose and feral animals that endanger protected species.

Hawai'i has fifty-one rare plant species, eleven rare animal species, and six federally endangered waterbird species that use, or are dependent upon, wetlands. These six species are endemic, found only in Hawai'i, and golf courses often provide critical habitats for these avian species:

1. Hawaiian coot; 'alae ke'oke'o
2. Hawaiian moorhen; 'alae 'ula
3. Hawaiian Stilt; āe'o
4. Hawaiian duck; koloa maoli
5. Hawaiian goose; nēnē
6. Laysan duck

Wildlife Habitat

Protecting wildlife habitat on golf courses is especially important in urban environments where highly fragmented forested areas often provide the best, and sometimes the only, habitat for many wildlife species. Landscape, design, and upkeep are critical components for protecting and encouraging habitat.

Forested buffers along golf course streams and wetland areas can provide sanctuaries for birds and other wildlife, while protecting water quality. When riparian buffers connect isolated blocks of habitat, they also serve as important travel corridors for species that may not cross large open areas.

Natural vegetation should be retained and enhanced through supplemental planting of native trees, shrubs, and grasses in non-play areas. Avoid exotic species, particularly invasive plants, or plants that are not well adapted to the local environment. The primary wildlife will probably be small mammals and birds. Natural cover around a course also serves as a buffer to reduce urban traffic noise and visual distractions, and filters pesticides and nutrients from runoff entering streams or ponds.

Well-designed forested buffers should contain a mixture of fast and slow growing native trees, shrubs, and grasses to provide a diverse habitat. By leaving dead trees and supporting "no-mow" and native grass areas, the amount of labor and resources needed to maintain a course are reduced. These practices also:

- Provide ability to trap and remove upland sources of sediment, nutrients, and chemicals
- Protect fish and wildlife by supplying food, cover, and shade
- Maintain a healthy riparian ecosystem
- Remove or restrict feral ungulates that reduce native plant vitality and variability

Education

Train your crew on identifying endangered species and educate members and guests through newsletters, meetings, and signage. Section off habitat areas so that nesting birds are left undisturbed. Plan and implement a public awareness program to increase landowner and land manager knowledge of waterbird needs and public support for waterbird recovery.

Reference Planning, Design, and Construction and Irrigation sections for additional BMPs.

Hawai'i Native Plants

- Noni
- Maiapilo
- Pa'uohi'iaka
- Pohuehue
- 'Ilima
- 'Ihi
- Milo
- Naio
- A'kuli'kuli
- A'e A'e
- Naupaka kahakai
- Ohelu kai
- Makaloa
- Mau'u 'aki 'aki
- 'Uki
- 'Uhaloa
- Pili
- 'Aaki'aki
- Kipukai
- Hina Hina

Irrigation

5

Irrigation for golf course maintenance is an important part of the golf course operation. A system is needed when rainfall is not enough to sustain healthy playable turf, especially during dry periods. It's crucial to maintain irrigation practices that support conservation and operating standards.

Before an owner or company begins construction, a water source must be obtained. In the event a new well is to be constructed, owners will need a well driller with a Hawai'i C-57 license. All work requiring the installation of pumps and pumping equipment will require either a well drillers with a Hawai'i C-57, pump installers with a license C-57a license (pumps installation contractor), or a general contractor with an A (general engineering) license. Guidelines and requirements for well construction, pump installation and well abandonment is can be found in the Hawai'i Well Construction and Pump Installation Standards (February 2004).

The Department of Land and Natural Resources, Commission on Water Resource Management (CWRM) will work with the contractor on required permits. CWRM regulates all ground water and surface water use. All appropriate Permits for well construction, pump installation and well abandonment need to be submitted to CWRM for approval (HAR 13-168-12). In event that the Well is located within a Water Management Area, a Water Use Permit will also need to be obtained, only wells for domestic consumption are exempted from this requirement. If there is an existing well, these contractors are licensed (as indicated above) to investigate and facilitate maintenance.

Once permitting is achieved and the well is installed, it is the owner's responsibility to understand what will need to be reported to the state or county. A Monthly Ground Water Use Report, which includes Quantity Pumped, Salinity (Chloride and/or Conductivity) with temperature, and Water Level, is required (HAR 13-168-7) to be submitted to CWRM. All guidelines from the state water commission must be followed.

Irrigation

Best Management Practices

- Comply with all Federal and Hawai'i State laws and regulations
- Identify optimal water source for accessibility, sustainability, water quality, and turf selection
- Consult with an irrigation designer to evaluate site and water availability
- Pump station should consist of Variable Frequency Drive (VFD) motors, pressure sensors (both high and low), water meters, and leak detection
- Consider Gravity Feed to reduce energy consumption and costs
- Utilize a Central Computer to allow for time adjustments, use weather stations for a baseline, and control costs by using efficiency to run the shortest water cycle with best pressure and distribution
- Use the weather station to calculate ET and determine amount of water that needs to be returned to the soil
- Conserve water using tools like soil moisture meters, infrared pictures to detect hot spots quicker, hoses, and live feeds of the system via a computer or smart phone
- Consider reduction of manicured turf and conversion to native areas to help reduce water consumption
- Separate the landscape into separate program for clubhouse and common areas
- Monitor soil moisture, set an acceptable threshold, and when below threshold, hand water the specific site
- Use mulches in shrubs and flower beds to reduce water evaporation losses
- Use drip irrigation in landscape areas to supply water only to plants that need it
- Use recycled water when and wherever possible
- Perform daily, weekly, quarterly, and annual inspections of the irrigation system
- Choose correct type of irrigation for area requiring water; ranging from full or part circle sprinkler heads to rotor or pop up to drip irrigation
- Place meters at wells and pump stations; monitor daily

Water Sources

Many sources of water can be used for irrigation. Water sources should be investigated on supply and quality for selected turf. Sources include potable water, well water, reclaimed water, desalinized water, and blends of multiple sources.

- Potable water: Water suitable for drinking. Used where no other alternatives for securing water are possible. Often the most expensive water source. Sustains many Hawai'i turf selections for golf courses.
- Well water: Underground water held in the soil and in pervious rocks. Used from an aquifer of water floating on saltier water. Requires a motor, pump, and state permits. Quality can range from fresh, brackish to salt water. Analyzing for Chloride or measuring the conductivity can determine the quality. Depending on salinity, this water could influence turf selection.
- Surface water: Water from streams, ditches or diversions. Requires a state permit from CWRM.
- Reclaimed water: Water processed from converting wastewater to a form reused for other purposes such as irrigation. It is common in Hawai'i to use water from large treatment plants. A contract is negotiated with the Water Company. Special attention should be noted on cost, amount, timing, and length of contract before renewal. Quality can range from good to bad. Testing is needed to analyze quality. Depending on salinity, this water could influence turf selection.
- Desalinization: A process of removing salt and other minerals from ocean water to make it suitable for agricultural use or human consumption. Most common methods use reverse osmosis and force water through membranes that collect salt and other molecules from passing. Correct disposal of the brine generated in the process is necessary. Generally a more costly alternative.

Equipment & Controls

Irrigation Design

An irrigation designer and water quality specialist should be hired to evaluate the site, water quality mitigation requirements, and water availability. An owner should make the designer aware of details such as plant materials, soils, elevation, expectations, and budget. Based on pre-planning meetings the designer will be able to produce drawings for the pump station, hydraulics, configure pipe sizing, and decide sprinkler locations. The water quality specialist will assist in determining any required source balancing delivery system (blending needed to allow for a waters acceptability), material requirements (types of metals best suited for components used in the delivery system), flushing requirements, as well as future complications that could arise from water quality issues.

Pump Station

The pump station needs to be sized correctly to deliver the most efficient use of water and electricity. The pump station should consist of Variable Frequency Drive (VFD) motors, pressure sensors (both high and low), water meters, and leak detection.

- VFD motors: Regulate water pressure and deliver pump control based on pressure. Help reduce energy costs by alternating pump starts and running at lower RPMs based on flow and pressure needed for the system.
- Pressure Sensors: Provide adjustable sensor pressure to maintain optimal system pressure with current flow; can set high pressure and low pressure levels for automatic shutdown.
- Water Meters: Current flow monitored by control unit to optimize energy consumption.
- Leak Detection: A combination of pressure and water output that can activate shutdown for low pressure.

Kohanaiki Pump Station

Gravity Feed

Some courses use gravity to supply pressure to the irrigation system. This type of system uses Pressure Reducing Valves (PRV) to regulate pressure as it travels downhill. This design has the reservoir placed at a higher elevation than the highest point of area needing water. The system uses less energy to run, as electrical motors are not needed to supply pressure. There is maintenance required with quarterly upkeep to the PRVs, but compared to energy costs, it is much less.

Central Computer

The central computer is the brain of irrigation. By creating programs and schedules, superintendents are able to optimize water management and maximize course playability. Managers can allow for time adjustments, use weather stations for a baseline, and help control costs by using efficiency to run the shortest water cycle with the best pressure and distribution.

Programs are areas within the central computer that let you define areas on the golf course. It is common for courses to have 12 to 40 programs. For example, a course may have a program called “greens”, another called “tees”, and another designated as “fairways”. These programs can allow superintendents to irrigate designated areas for a defined period of time. Within each program there are individual heads connected to its program, or area. Each of these heads can be adjusted based on the environment around it. So a sprinkler could water 50 percent, 80 percent, 100 percent, 120 percent, 130 percent, etc. The higher the percentage, the more water delivered. Schedules are days in which each program will water. A course manager may use soil moisture readings or visual inspection to decide what programs will run on a scheduled day.

Many managers use the weather station to calculate ET to determine amount of water that needs to be returned to the soil. Below is a basic explanation of converting ET to a run time based on nozzle size of the sprinkler.

Weather stations are also part of the central computer system. A weather station can record environmental variables across the course. The station is able to record sun intensity, temperature, humidity, wind, and rain. It uses data collected to produce a daily reading called evapotranspiration (ET). ET is the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by the transpiration of plant cells.

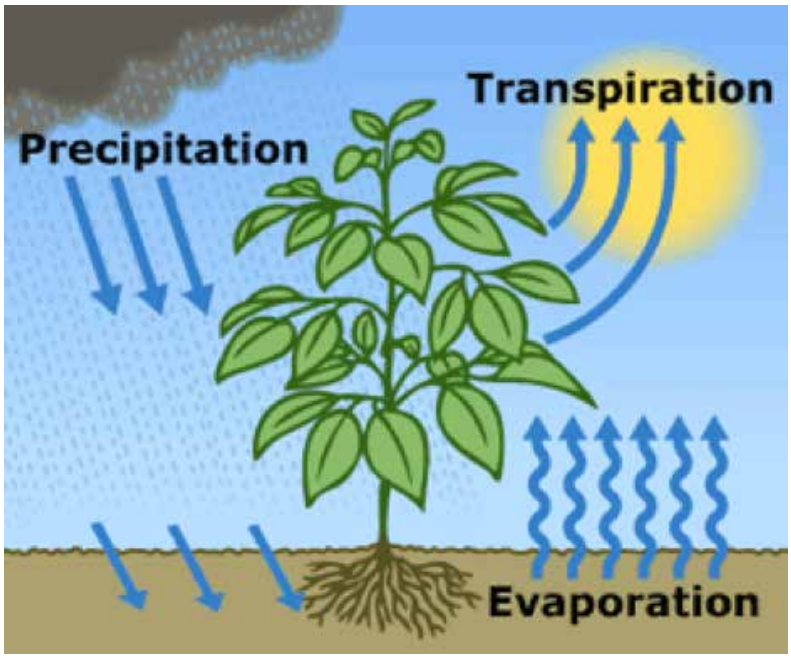


Photo credit: water.usgs.gov

Nozzle gallons per minute (GPM)	Actual run time based on ET .21
.01" GPM	21 minutes
.025" GPM	8.5 minutes
.03" GPM	7 minutes

Weather Station

Irrigation Head with Brown Nozzle

Glenn Perez of Nanea Golf Club hand watering collars on #1 green

Water Management

Having a superior designed system has allowed superintendents to control water not only by area, but down to specific sprinkler heads on the course. Managers are using other tools and technology as well to conserve water. Tools include the weather station to monitor ET, soil moisture meters, infrared pictures to detect hot spots quicker, hoses, and live feeds of the system via a computer or smart phone.

Reduction of manicured turf can help cut down water consumption. Maintained areas that are out of play can be converted to a native species that requires only local rainfall to survive.

Another area to gain water conservation is by separating the landscape into a separate program. Clubhouse and common areas, with correct species selection, can require one to two cycles of irrigation per week compared to four or five cycles for turf. You can also use drip irrigation in landscape areas to supply water only to the plants that need it. Utilize reclaimed water when possible. Separate irrigation zones within landscapes, combine plants with similar water requirements (verses watering to the highest water requiring species in a planting) to minimize water usage and pruning requirements.

Sensors that are placed in the soil, or portable sensors operated by hand, can be used to monitor soil moisture. Through record-keeping and visually inspecting, a manager can make a water decision based on percentage of moisture in the soil. Each course will need to set an acceptable threshold. Once the threshold falls below the acceptable level, then the area can be watered by hand or with the overhead sprinkler.

Digital reading of volumetric water content percentage and average moisture of green

Maintenance

Irrigation systems require maintenance to continuously run efficiently. Preventive maintenance can be handled by the course or by outside companies. Managers and irrigation technicians perform daily inspections of the irrigation system in the field. These include visual inspections for leaks in pipes or heads, stuck-on heads, monitoring actual flow to projected flow, meter readings, and computer logs. More detailed inspections of the system are done with less frequency, but are just as important.

Weekly inspections are more detailed. These include inspecting individual clocks, running the system and watching sprinklers, cleaning filters at the pump station to remove debris, checking rotation of heads, and adjustments. This can be done while watering-in products or by checking areas that are too wet or too dry.

Quarterly inspections may or may not be done internally. Testing consists of reading electrical current drawn by pumps, voltage at breakers, recording run time hours, inspecting motors, cleaning PRV, and cleaning of the clay valve. This inspection should be recorded and kept onsite to help avoid significant maintenance issues.

Every manager should check all sprinklers on the course annually. Each sprinkler should be thoroughly inspected and worn parts need to be replaced. Nozzle wear may not be visible to the eye, however can impact distribution of water, operating pressure, water consumption, and rotation. Each head should be recorded so the irrigation central computer can match the field audit. A visual inspection of the reservoir should be included.

Irrigation System Inspection Checklist

Daily

Visual field inspections for:

- _ Leaks (in pipes or heads)
- _ Stuck-on heads
- _ Flow (actual vs. projected)
- _ Meter readings
- _ Computer logs
- _ Rapid pressure loss at pump stations cycling motors
- _ Visually inspect resevoir

Weekly

- _ Inspect individual clocks
- _ Run the system & watch sprinklers
- _ Cleaning filters at the pump station to remove debris
- _ Check rotation of heads
- _ Make needed adjustments
- _ Inspect for proper pressures at sprinklers (visual and measured)

Quarterly

- _ Read electrical current drawn by pumps
- _ Check voltage at breakers
- _ Record run time hours
- _ Inspect motors
- _ Inspect PRV
- _ Pressure adjustments to each zone or sprinkler

Annually

- _ Inspect all sprinklers on the course
- _ Replace worn parts
- _ Record each head
- _ Visually inspect reservoir
- _ Sprinkler nozzle replacement program by zone or area

Types of Irrigation

Delivery of water to the turf can be achieved in numerous ways. Irrigations systems can consist of different types of sprinklers to conserve water and provide even distribution. Irrigation heads on golf courses can be full circle or part circle and deliver large amounts of water to areas such as greens, tees, fairways, and roughs. These sprinklers can have coverages of 20 to 80 feet and are operated one to two at a time from a central controller. In scenarios where areas aren't as big in size, a smaller rotor or pop up head can be used to conserve water, distributing only to the turf needing irrigation. These heads can cover 5 to 20 feet and are operated in a series of heads off of one valve.

In other circumstances, drip irrigation may be needed. This is a tube laid in the ground or above ground that delivers small amounts of water to plant material. It is most notably used in landscaping. Quick couplers should be throughout the golf course and used when small areas need additional water. Typically, it is a one to three quarters of an inch connection to which a hose can be hooked up and small areas can be hand watered.

Metering

It is important for a golf course to understand the amount of water it is consuming. Meters should be placed at wells and pump stations, and monitored. A designated person should be in charge of taking daily readings. Using a central computer can also be helpful in comparing the projected flow to the actual output of the pump station. It is an easy way to see if the programming in the computer is correctly calibrated with proper nozzles, head types,
and valving.

Pressure Regulating Valves

On properties with significant elevation variability it may be necessary to install various pressure regulating valves to control or maintain pressures throughout the system. These critical devices should be actively managed with weekly observations, quarterly inspections, and annual cleaning/rebuilding. Maintaining proper pressures reduces system fatigue, breakage, pressure losses, and water hammer.

Surface Water Management & Water Quality

6

In Hawai'i, programs designed to protect surface water quality are administered by the Hawai'i Department of Health. The USDA Forest Service National BMP Program for water, which was developed to improve management of water quality consistently with the Federal Clean Water Act (CWA) and State water quality programs, also serves a great resource, in general. BMPs are specific practices used to reduce or control impacts to water bodies from nonpoint sources of pollution, most commonly by reducing the loading of pollutants from sources into storm water and waterways. Golf courses provide acres of green space helping to reduce the urban heat island effect, providing surface water filtration, and supporting habitat for wildlife and ecosystem function. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate pollutants to receiving waters.

Ahupua`a

**"Ahupua`a"** is the Hawaiian word that comes closest to meaning watershed. Ahupua`a principles that may be transferred to watershed planning and management include access to a complete resource base, reverence for water, respect for all living things, coordination and cooperation, intergenerational learning, `ohana among people, and the connection between people and the land.

Surface Water Management & Water Quality

Best Management Practices

- Identify and explore your watershed
- Follow Federal and Hawai'i State laws and regulations
- Evaluate golf course impact and take steps to reduce pollution
- Develop a Storm Water Pollution Prevention Plan
- Establish source control practices
- Establish a storm water capture train
- Establish erosion and sedimentation control practices
- Maintain storm water treatment train
- Implement the Hawai'i Coastal Nonpoint Pollution Control Program management measure for golf courses
- Develop a water quality monitoring plan to monitor surface water, groundwater, and pond sediments
- Sample water quality four to six times per year including field and lab analyses
- Inspect vegetation condition, color and clarity of surface waters, water quality of ponds, streams, and anchialine pools twice annually, in spring and autumn
- Inspect vegetated buffers strips for presence of debris, integrity of vegetative cover, existence of channels or other indicators of concentrated storm water flow
- Incorporate adequate buffer strips, including native species, along streambanks
- Maintain buffers regularly and repair observed damage immediately
- Establish wetlands where water enters lakes to slow water flow and trap sediments
- Establish an Aquatic Plant Management Strategy
- Encourage clumps of native emergent vegetation at shoreline; use ecosystem, watershed, cost-benefit perspectives to determine long-term management strategies
- Educate construction staff, golf course maintenance crews, and members/guests, including preventative communications and procedures to promote water quality

Identification

It is important to identify and explore your watershed. You can find your watershed by zip code at http//cfpub.epa.gov/surf/locate/index.cfm. Another easily accessible reference can be through using Google Earth's digital aerial satellite view. Identify the nearest major river to your location. If a stream or creek is not present, consult a map for the names of local streams and look downslope where water from your land drains. A good clue may be the nearest bridge.

Trace your local stream to its closest outlet point and then follow it to its final destination - the major river or other water body into which it drains. Evaluate your impact and take steps to reduce pollution. What you do can affect water quality both on and off-site.

Once the watershed is identified, check the HDOH to see if there is a watershed plan for it: https://eha-cloud.doh.Hawai'i.gov/cwb/#!/watershed-based-plan/list. Watershed plans may include golf course management recommendations. If a golf course is located in a watershed with a watershed plan, it may be eligible to receive federal funding (through the CWA) to implement BMPs to protect water quality.

Regulations

Understand federal, state, and local regulations regarding water quality and management. Hawai'i regulations include:

- Water Quality Standards (Hawai'i Administrative Rules Title 11, Chapter 54)
- Water Pollution Control (Hawai'i Administrative Rules Title 11, Chapter 55)
- Total Maximum Daily Loads (Clean Water Act Section 303(d))
- Statewide Storm Water Principles (SSWMP) www.stormwaterHawai'i.com
- Clean Water Act Sections 404 and 401
- Water Resource and Protection Plan (WRPP) - while not a regulation, the Hawai'i Water Plan is the master water plan for the state and consists of the WRPP, the Water Quality Plan, and other state and county water plans. It is required by the State Water Code (Hawai'i Revised Statutes §174C)

As you plan effective water management strategies, answer the following questions:

- ✓ How does water naturally enter your property: rain, wetland, springs?
- ✓ What is the lowest point or points where water settles?
- ✓ Where does water leave the property, and where does it go?
- ✓ Could it pick up any contaminants because of your land use practices?
- ✓ Does water quality improve, decline or stay the same as it moves over your property?

Planning & Management

Erosion Control During Construction

Erosion and sediment control (E&SC) is a term used in the construction industry, related to storm water runoff at a project's site. The website www.stormwaterHawai'i.com breaks down the term to demonstrate how erosion control measures prevent wind and water soil erosion at a construction site, while sediment controls are designed to capture eroded soil within a site.

Develop a Storm Water Pollution Prevention Plan (SWPPP)

A SWPPP is required by the construction general permit and helps prevent storm water pollution. State requirements for SWPPPs can be found in Hawai'i Administrative Rules §11-55, Appendix C. The SWPPP is more than a sediment and erosion control plan; it describes all construction site operator activities to prevent storm water contamination, control sedimentation, and comply with requirements of the Clean Water Act.

Developing your Storm Water Pollution Prevention Plan

Begin by asking yourself the following questions:

Who? Construction site operators (generally the person who has operational control over construction plans and/or the person who has day-to-day supervision and control of activities occurring at the construction site)

Where? Construction sites required to comply with storm water discharge requirements

What? A guide to help you prevent storm water contamination, control sedimentation, comply with regulations

Why? Storm water runoff from construction sites can cause significant harm to rivers, lakes, and coastal waters

Establish Source Control Practices

Source control practices should prevent pollution by limiting or reducing potential pollutants at their source, which involve keeping a clean, orderly construction site. These practices involve day-to-day operation of the site and are usually controlled by the contractor. This should include establishing water quality buffers and special management zones. Water quality buffers consist of drain lines and special management zones include a series of vegetative filtration buffers such as a 25 foot turf swale, followed by a 25 foot native area, and finally a sheet flow to an undisturbed forest area. Special management zones are more clearly defined in the next section as a "Storm Water Treatment Train", in which water is conveyed from one treatment to another by conveyances that themselves contribute to the treatment.

Not all storm water on a golf course originates there; some may be from adjoining lands, including residential or commercial developments. The golf course serves as an important community resource for filtration. Storm water control involves more than preventing flooding of facilities and play areas, including:

- Controlling amount and rate of water leaving the course
- Storing irrigation water
- Controlling erosion and sediment
- Enhancing wildlife habitat
- Removing waterborne pollutants
- Addressing aesthetic and playability concerns

Establish a Storm Water Capture Train

A storm water "treatment train" approach conveys water from one treatment to another, filtering or treating water at each stage. It incorporates at least two processes to maximize control of pollutants from runoff. A successful treatment train will help eliminate or minimize as much directly connected impervious area (DCIA) as possible. A common treatment train includes turf swales on side slopes designed to filter and slow down the movement of storm water, the second car in the train includes a swale or main channel that directs storm water to the final car in the train, often a constructed wetland. Vegetated swales slow and infiltrate water and trap pollutants in the soil, where they can be destroyed naturally by soil organisms.

Depressed landscape islands in parking lots can catch, filter, and infiltrate water, instead of letting it run off. When hard rains occur, an elevated storm water drain inlet allows the island to hold the treatment volume and settle out sediments, while allowing the overflow to drain away.

Additional measures include maximizing use of pervious pavements, such as brick or concrete pavers, separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots. Also, disconnect runoff from gutters and roof drains from impervious areas, so that water flows onto permeable areas, allowing it to infiltrate near the point of generation.

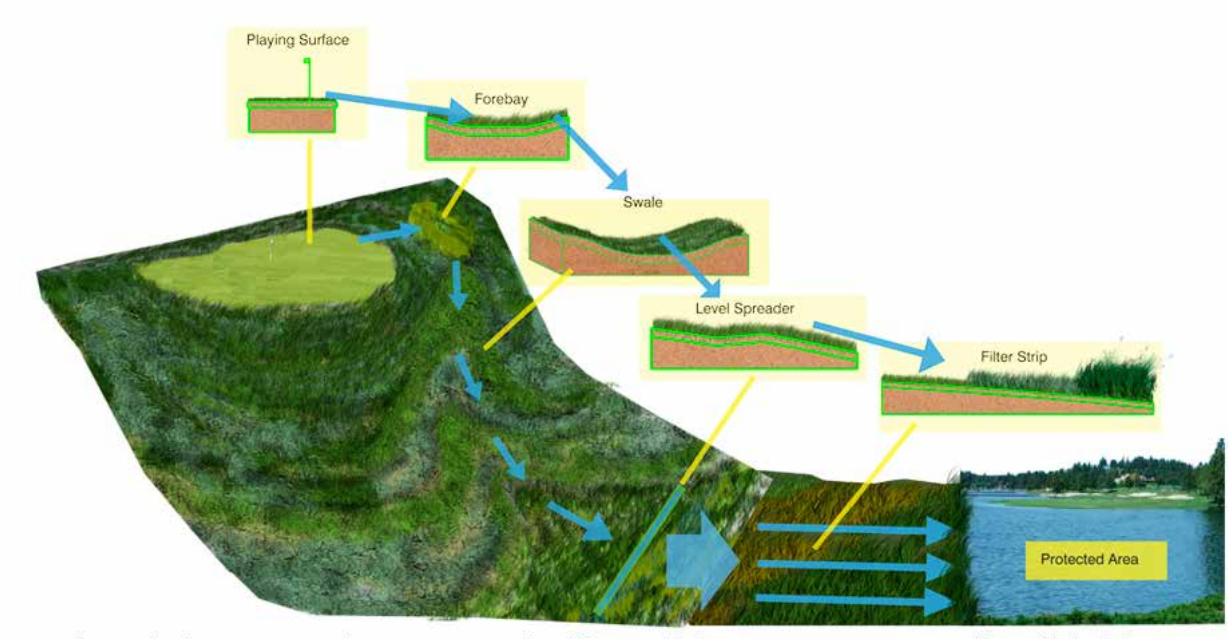
Example: Steps for Maintainin A Storm Water Treatment Train

Step 1: Establish Special Management Zones defined as areas that have distinct management practices that coincide with their position in the watershed, and are based on the analysis of resources and habitat protection requirements.

Step 2: Use a Natural Systems Engineering Approach to storm water management that maximizes the use of natural systems to treat water. Vegetative swales, storm water ponds, marshes and wetlands can serve as habitat for many creatures, including wetland birds and other waterfowl.

Step 3: Maximize Use of Pervious Pavements such as brick or concrete pavers separated by sand and planted with grass. Special high-permeability concrete is available for cart paths or parking lots.

Step 4: Establish Best Management Practice "Trains" for maximum environmental protection. The most effective way to protect surface water and groundwater is by using a comprehensive systems approach that includes integration of preventative practices and structural controls. Preventative measures include nonstructural practices that minimize or prevent the generation of runoff and contamination of runoff by pollutants; for example, using organic fertilizers. Structural controls are capital improvements designed to remove, filter, detain, or reroute potential contaminants carried in surface water.



A comprehensive systems approach uses a treatment train and the natural drainage systems to protect water quality at a high priority area.

Establish Erosion & Sedimentation Control Practices

Erosion prevention practices may include ground covers such as vegetation, riprap, mulch, and blankets that absorb the energy of a rain drop's impact and reduce erosion. Also included are BMPs such as swales and ditches that divert water around a site to prevent contact.

Sedimentation control should include installation of erosion control barriers between planned turfed areas and streams or ponds. Barriers may include silt fencing and sedimentation ponds. Locations should be determined and shown in the erosion control plan. These erosion control measures should remain in place until turf matures.

Hawai'i Coastal Nonpoint Pollution Control Program (CNPCP)

The program goal is to reduce polluted runoff to coastal waters. This helps promote stewardship of the marine ecosystem. The program establishes management measures to control runoff from five main sources, including urban areas. The management measure for golf courses in urban areas includes:

1. Develop and implement grading and site preparation plans to:
   - Design and install a combination of management and physical practices to settle solids and associated pollutants in runoff from heavy rains and/or from wind;
   - Prevent erosion and retain sediment, to the extent practicable, onsite during and after construction;
   - Protect areas that provide important water quality benefits and/or are environmentally-sensitive ecosystems;
   - Avoid construction, to the extent practicable, in areas that are susceptible to erosion and sediment loss;
   - Protect the natural integrity of waterbodies and natural drainage systems by establishing streamside buffers; and
   - Follow, to the extent practicable, the amended U.S. Golfing Association (USGA) guidelines for the construction of greens.

2. Develop nutrient management guidelines appropriate to Hawai'i for qualified superintendents to implement so that nutrients are applied at rates necessary to establish and maintain vegetation without causing leaching into ground and surface waters.

3. Develop and implement an integrated pest management plan. Follow EPA guidelines for the proper storage and disposal of pesticides.

4. Develop and implement irrigation management practices to match the water needs of the turf.

These management measure recommendations are discussed in relevant sections in this handbook. More information about the Hawai'i CNPCP and the golf course management measure can be found at http://planning.Hawai'i.gov/czm/initiatives/coastal-nonpoint-pollution-control-program/

Water Quality Monitoring & Testing

A water quality monitoring program must include monitoring surface water, groundwater, and pond sediments. It should be implemented in three phases: background, construction, and long-term management. A complete water analysis is recommended on all waterbodies onsite to establish a baseline and identify any issues. Sampling should occur four to six times per year - at a minimum, twice during dry periods and twice during wet periods.

Surface water sampling may include irrigation lake, pond, wetlands, or anchialine pools within golf course boundaries. Groundwater samples should include sites located near the ingress and egress ends of the golf course, in addition to wells for golf courses near the coast. Obtaining water samples from the same location is important to establish a baseline and so comparisons can be made. Sample locations should be identified on maps, and photographed so they are easily located during subsequent sampling. The objective is to maintain required water quality standards.

- Field analyses should include pH, water temperature, specific conductance, and dissolved oxygen
- Laboratory analyses should include chlorophyll a, total nitrogen, nitrate-nitrite nitrogen, ammonia-nitrogen, total phosphorus, orthophosphate, silica, total dissolved solids, and turbidity
- Pesticide analyses should identify if there is a presence of pesticides from past land use

All ponds, streams, wetlands, and anchialine pools should be inspected twice annually, once in the spring and once in autumn. Inspections should focus on examining vegetation, color and clarity of surface waters, and water quality. In conjunction with inspections, vegetated buffer strips should be inspected for debris, integrity of vegetative cover, and existence of channels or other indicators of concentrated storm water flow.

Contact your local regulator for additional advisement.

Protecting Environmentally Sensitive Areas

Riparian buffers and wetlands can provide long-term pollutant removal capabilities without the comparatively high costs associated with constructing and maintaining structural controls. Preservation of these areas is important to protect the water quality of streams, wetlands, lakes, anchialine pools, coastal zones, and reservoirs. Land acquisition programs help preserve critical areas for maintaining surface water quality.

Adequate buffer strips along streambanks provide protection for stream ecosystems, help stabilize the stream, and can prevent erosion. Buffer strips can also protect near-stream vegetation that minimizes the release of sediment into stream channels. Levels of suspended solids have been shown to increase at a slower rate in stream channel sections with well-developed riparian vegetation.

Buffers around the shore of a waterbody, or other sensitive area, filter and purify runoff as it passes across the buffer. Plant buffers with native species can provide a triple play of water quality benefits, pleasing aesthetics, and habitat/food sources for wildlife. It is important to continue plantings into the water to provide emergent vegetation for aquatic life, even if the pond is not used for storm water treatment. Maintain vegetative conditions and practices established during construction, these include:

- Herbaceous composition of buffer filter strips (buffers with native species provide a triple play of water quality benefits)
- Mow herbaceous cover of buffer filter strips twice per year
- Remove cut material by hand

Remove damage to existing topography and ground cover conditions, including siltation, erosion, and compaction or trampling by golfers. Accumulated silts should be removed, eroded channels filled, and compacted areas should be raked. All repairs should be conducted using hand tools only, unless a mechanical tool "arm" can reach into the wetland to perform a task. Damaged groundcover vegetation should be restored by seeding or planting, depending on the vegetation damaged. Channels which form within the filter strips should be filled and immediately reseeded. Grading may be necessary to prevent reformation of the channel and to restore sheet flows. Trash, golf balls, and other debris should be removed from buffers.

Stages of Surface Water Planning & Management

Correct Siting & Design of Green

Correct Construction

Appropriate Turfgrass Selection

Management Zones
No Spray Zones, Limited Spray Zones

Preventative BMP's
IPM, tissue testing, pesticide selection, irrigation management, slow release fertilizers

Land Use Control BMP's
infiltrators, water quality basins

Vegetative Land Use Control BMP's
vegetative filter strips, natural areas, grassed swales

Environmental Monitoring

Hawaii's Wetlands: Mauka to Makai

What is a Wetland?

Wetlands are lands periodically covered or saturated by fresh or salt water and characterized by:

Hydrology (water): from precipitation, surface flow or shallow groundwater.

Soils: poorly drained and saturated or covered with water for at least two weeks a year.

Vegetation (plants): adapted to grow, reproduce, and persist in water or saturated soils.


Āe a, C. Tucker

Wetlands can be seasonal or permanent, and are found in landscapes such as depressions, coastal shorelines, fringes along running or standing water, and Hawaii's cloud forests. Wetlands are home to almost one third of threatened and endangered species in the U.S.

In the Hawaiian language, ***wai*** means water. Many places in Hawai'i are named for wetlands and the extraordinary species that live there: Waikiki, Wai'alae, Waikoloa, Waiāhole, Waipi'o and countless more.

Hawaii's Wetlands

Natural wetlands* most common in Hawai'i:

Riverine wetlands are surface water systems found along the edge of rivers or streams. These areas are critical to the endemic koloa maoli.


Montane bog, Hakalau Forest NWR, K. Uyehara

Palustrine wetlands, such a marshes and bogs, are found in depressions where rain or groundwater collects. Hawaii's rare montane bogs take millions of years to form.

Estuarine wetlands, such as swamps and mudflats, occur on coasts where streams empty into the ocean. These tidally influenced brackish (mixed fresh & salt water) areas provide habitat for fish, shellfish and waterbirds.

Marine wetlands, such as intertidal shorelines, seagrass beds, or tidepools, are saltwater systems, and provide habitat for many species harvested by humans for food.

Other Aquatic Habitats in Hawai'i


Anchialine pool, M. Ramsey

Anchialine pools are land-locked systems in porous lava or limestone on coastal shorelines. These brackish pools are connected underground to both fresh and salt water, and are home to native shrimp like ʻōpae ʻula.

Aquaculture Habitats are wet areas created or modified for growing food, including wet taro (kalo) grown in a lo'i (paddy) and fish ponds. These areas are used by native species, but usually lack the biodiversity and habitat functions found in natural wetlands.

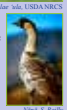

Taro (kalo), C. Tucker

Native Wetland Species

Hawai'i has fifty one rare plant species, eleven rare animal species, and six federally endangered waterbird species that use, or are dependant upon wetlands. These six species are endemic, found only in Hawai'i:

Hawaiian coot; ʻalae keʻokeʻo
Hawaiian moorhen; ʻalae ʻula
Hawaiian Stilt; āeʻo
Hawaiian duck; koloa maoli
Hawaiian goose; nēnē
Laysan duck


ʻAlae ʻula, USDA NRCS


Nēnē, S. Reilly

Fossil records show that at least 13 species of endemic Hawaiian waterfowl used wetlands. Of these, only three remain: the ducks and goose listed above. Other wetland species include ʻauku'u (the black-crowned night heron), and kōlea (the Pacific golden-plover).

Seeds of wetland sedges, grasses and rushes are a main food source for many wetland birds. Makaloa, an indigenous sedge, grows in coastal wetlands and was used to make the fine woven mats used by the ali'i, Hawaiian royalty.

Native shrimp like ʻōpae ʻula feed on wetland algae. ʻO'opu ʻakupa, an endemic fish, is found in lowland streams and estuaries on all of the main Hawaiian Islands. Over 30 species of dragonfly (pinao) and damselfly (pinao ʻula) are endemic to Hawai'i, and most depend on wetlands.


ʻOʻopu nākoli, G. Smith, USFWS

Why Protect Wetlands?

Flood Protection. Wetlands can store excess water during heavy rainfall, reducing flood impacts to roads, parking lots and homes.


Koloa maoli, © J. Denny

Water Quality & Sediment Filtration. Wetlands can store, filter, and absorb excess nutrients, sediments, and pollutants. This reduces the pollution that ends up in streams and marine reef areas.

Surface and Groundwater Supply. Wetlands absorb and release water; they capture excess during heavy rains and slowly release it during droughts. This helps recharge groundwater aquifers.

Biodiversity. Wetlands are transition zones between upland and deep water habitats where biological communities blend and have increased diversity.

Wildlife Habitat. About 60 species of migratory waterbirds and shore birds travel thousands of miles over the Pacific Ocean to winter in Hawai'i. Many native Hawaiian plant and animal species have evolved to live in Hawaii's unique wetlands.

Recreation and Aesthetics. Wetlands are scenic landscapes that hold cultural and historical significance. Recreational opportunities include photography, bird watching, walking trails, nature study and fishing.


Pinao, C. Tucker

Threats to Wetlands

Invasive Species Challenges:

Non-native predators. Feral cats, mongooses, rodents, and other predators eat ground-nesting birds and chicks. Cane toads and bullfrogs eat fish eggs, native insects and young waterbirds.

Non-native plants out-compete native plants, quickly taking over wetland areas, reducing plant diversity and ecological function.

Non-native fish eat native damselflies and wetland vegetation, reducing food availability for waterbirds.

Hybridization. The endangered koloa maoli is at risk of extinction due to cross-breeding with feral mallards.

Human Induced Challenges:

Pollution. Non-point source pollution from septic wastewater, agricultural runoff, and contaminated stormwater can overwhelm the filtering capacity of wetlands, impacting downstream coastal waters.

Climate Change. Rising temperatures lead to rising sea levels and impacts to coastal wetlands. Changes in local precipitation and temperatures will impact montane bogs and ephemeral (seasonal) wetlands.

Development. Many wetlands in Hawai'i have been drained or filled for agriculture production, resort development and community expansion.

Wetlands in Hawaii

1. Montane bog **2.** Aquacultural **3.** Riverine **4.** Estuarine **5.** Palustrine Marsh **6.** Anchialine pool **7.** Marine

You Can Help Wetlands!

Some wetlands are open to the public, but some require permission or permits.

- **Learn about wetlands.** Visit the websites below.
- **Volunteer.** Pick up trash and remove invasive plants.
- **Prevent pollution.** Avoid using fertilizer and pesticides on lawns and gardens. These chemicals wash into downstream ecosystems.
- **Don't release exotics.** Call 808-643-PEST or the Humane Society to find out where to take your unwanted pets.
- **Care for wetlands on your property.** If you own a wetland, get technical assistance for restoration and management.
- **Prevent bird predation.** Keep cats indoors and dogs away from wetlands and endangered bird species.
- **Keep feral mallards out of Hawaii's wetlands.** If you own a mallard, keep it penned or clipped.
- **Remember: Wild birds need wild food.** Do not feed human food to wild birds.
- **Be a wetland advocate.** Contact your government representative and ask them to support wetland programs.


Koloa maoli, B. Zaun, USFWS

The Ahupua'a or Watershed Drainage

Traditionally, ahupua'a was a subdivision of the moku (island) that went from mountaintop to sea following the banks of streams, much like a watershed. Ahupua'a encompass the land, water, and elements in the sky and also integrate cultural, human, and spirit resources. All types of wetlands in Hawai'i can be found within the ahupua'a: bogs in the upper reaches of the mountains, marshes in lowlands, and anchialine pools near the sea.

Wetland Classification:** The Cowardin Classification System is a descriptive method developed by the US Fish & Wildlife Service that defines wetlands according to their landscape position and water source. Within broad classes are wetlands known by common names: marsh, bog, mudflat, and swamp. Visit: **www.npwrc.usgs.gov/resource/wetlands/classwet.

Wetlands on the Web:

www.hiwetlands.com
www.wetland.org
www.pcjv.org
www.nrcs.gov
www.hear.org
www.fws.gov/wetlands
www.malamahawaii.org
www.hawaii.gov/dlnr/dofaw
www.hamakuamarsh.com
www.kawainuimarsh.com
www.projectwet.org
websoilsurvey.nrcs.usda.gov

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Wetland illustrations by Naomi Swenson.

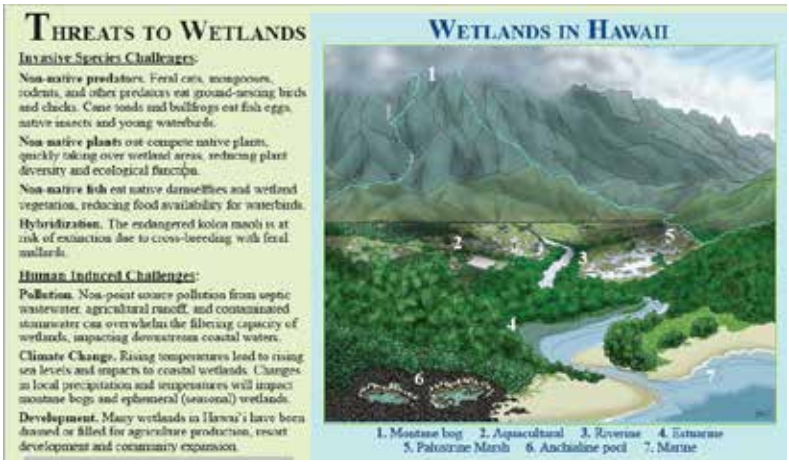
Produced by State of Hawai'i Department of Land and Natural Resources Division of Forestry and Wildlife.
Funded by Pacific Coast Joint Venture 2009.

Wetland Protection

In general, wetlands in Hawai'i vary substantially from wetland environments found in the continental United States. The islands' small size, relatively steep topography, and unique soils and microclimates engender different types and distributional patterns of wetlands than those on the mainland. For example, Hawai'i tends to have fewer lakes, reservoirs, deep ponds, and other large-scale lacustrine systems typically associated with areas of flat topography. Hawai'i also has 148 anchialine pond sites located in coastal areas. Today, Hawai'i's wetlands comprise approximately 110,800 acres.

Several considerations should be observed when establishing or maintaining wetlands:

- Wetlands should be established where water enters lakes to slow flow and trap sediments
- Appropriate resources should be applied to maintain silt fencing
- Employ BMPs on projects upstream to prevent erosion and sedimentation; natural waters should not be considered treatment systems and must be protected (natural waters do not include treatment wetlands)
- Establish low – to – no maintenance level within a 75-foot buffer along non-tidal and tidal wetlands
- Establish and maintain 100-foot riparian buffer around wetlands, springs, spring runs



References for further information:

Protection of wetlands: http://water.epa.gov/polwaste/nps/wetmeasures/upload/2005_08_19_NPS_wetmeasures_ch4. pdf

Restoration of wetlands: http://water.epa.gov/polwaste/nps/wetmeasures/upload/2005_08_19_NPS_wetmeasures_ch5. pdf

Vegetated treatment systems: http://water.epa.gov/polwaste/nps/wetmeasures/upload/2005_08_19_NPS_wetmeasures_ch6.pdf

Definition of Wetlands in Hawai'i

Although wetlands are not explicitly included in Hawai'i's definition of state waters, the Hawai'i Administrative Rules specifically state that "basic" water quality standards apply to wetlands. The rules also outline general numeric and narrative water quality criteria and include criteria specific to "elevated wetlands," "inland waters," "marine waters," "marine bottom types," and "recreational areas." Anti-degradation policies and use designations are also described. Reference more information on state water quality standards adopted in 2014 at:

http://health.Hawai'i.gov/cwb/files/2013/04/Clean_Water_Branch_HAR_11-54_20141115.pdf

Designing an Aquatic Plant Management Strategy

According to the Aquatic Ecosystem Restoration Foundation, the extensive damage caused to many aquatic ecosystems by invasive and nuisance aquatic plant species in the United States has been well documented...managers can employ a variety of practices to assist in restoring these aquatic ecosystems to health, including biological, mechanical, cultural, and chemical methods. These methods have been extensively researched over the last several decades and results have shown the benefits of combining more than one technique. Collecting and reviewing these practices for a specific site is one of the first steps in formulating an integrated control strategy.

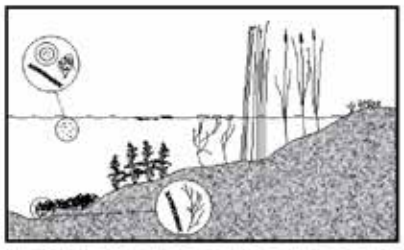


Figure 1. Main groups of aquatic plants found in both still and moving waters: (a) emergent plants (b) floating leaved plants (c) submersed plants (d) filamentous algae (e) microscopic algae. (Adapted from Seagrave 1988).

Properly designed ponds with a narrow fringe of vegetation along the edge are more resistant to problems than those with highly maintained turf. In ponds with littoral plantings, problem plants should be selectively controlled without damaging littoral shelves. It's frequent practice to remove filamentous algae by hand and/or frequently apply algaecide to small areas of algae (spot treatment). Superintendents should encourage clumps of native emergent vegetation at the shoreline, plus use ecosystem, watershed, and cost-benefit perspectives to determine long-term management strategies. Practice and develop an ongoing system of integrated control methods that include mechanical, cultural, biological, and chemical BMPs as needed.

Regularly assess results of invasive weed control programs (including quantitative documentation of results from control strategies) and re-evaluate management options as part of a professional plant management strategy.

Education

Education should be conducted on multiple levels, including communications and procedures for construction staff, golf course maintenance crews, and members/guests. Develop an education program for construction staff to create a common vision around the SWPPP. Include signage and communications for members and guests to identify and provide education regarding environmentally sensitive areas. Educate managers and the public about the importance of protecting water resources from invasive weeds to maintain healthy water quality and fish and wildlife habitat. Education promotes proper operating procedures, heightened awareness, and environmental stewardship.

Education and notification of players and guests of environmentally sensitive areas is an important part of the overall management strategy for surface waters. Appropriate signs identify areas that are ecologically sensitive.

Nutrient Management

7

Hawai'i environmental conditions vary greatly including differences between soils, topography, rainfall, and temperature. These differences require a nutrient management plan that allows turfgrass managers to address unique needs.

Proper nutrient management plays a key role in the reduction of environmental risk and improvement of golf course economic sustainability. Among other benefits, applied nutrients allow turfgrass to recover from damage and player wear. Nutrients also increase turf resistance to stresses such as drought, disease, and insects. The goal is to apply the minimum necessary to achieve an acceptable playing surface, if not applied properly, nutrients may move beyond turfgrass via leaching or runoff. It is crucial to have an understanding of application rates and timing for effective use of applied nutrients at minimum environmental risk.

References for additional information:

"Selected Fertilizers Used in Turfgrass Fertilization" at http://ufdc.ufl.edu/IR00003123/00001

Nutrient Management

Best Management Practices

- Comply with all Federal and Hawai'i State laws and regulations
- Conduct a site analysis & establish a written nutrient management plan
- Conduct a water analysis annually
- Undergo soil tests, understand pH levels, conduct plant tissue sampling
- Understand the components of fertilizers, labels, and functions of each element
- Calibrate application equipment according to manufacturer's recommendations
- Choose the appropriate spreader for a given fertilizer material
- Use caution when loading, applying, & storing nutrients
- Apply nutrients when turfgrass is actively growing
- Apply slow release N fertilizers at appropriate time of year (from fall into winter in Hawai'i) to maximize product release characteristics
- Follow N application rate recommendations from University of Hawai'i, College of Tropical Agriculture and Human Resources (CTAHR)
- Adhere to proper fertilizer storage, loading, and clean-up procedures

Site Analysis

A nutrient management plan should be established in written format and shared with all parties associated with management of the site. The site can be divided by soil types if there are great fluctuations in nutrient content and/or soil pH. Sites can also be divided into playing surfaces and non-turf landscaped areas, and, by water sources if it varies in quality within the site. Research your soil types, water sources, and drainage plans to aid in selecting the right products. Some products leach quickly through certain soils and if water is high in sodium or bicarbonates it affects the plant's ability to assimilate nutrients.

Three types of professional analysis provide a foundation for the nutrient management plan, soil, water, and plant tissue sampling. Proper soil sampling, laboratory analysis, interpretation of results, and professional recommendations, can show what nutrient base is present and what is available. Take ten to 15 random soil samples from each site. Each sample should be from the same depth. Soil analysis combined with proper plant tissue sampling can provide the best picture of what is missing and what needs to be done to remediate the soil. Soil testing may be conducted by your local extension agent with your University or Community College.

For plant tissue sampling, two to four tests per year is common on greens and one to two tests per year on tees and fairways. The largest input to turfgrass is often water applied through irrigation. Impacts of water quality can have significant impacts on soil nutrients, soil structure, and nutrient availability. Water tests, along with soil sampling, will provide the greatest level of understanding to the proper ratios of applied nutrients required. Keep accurate records to show impact from your nutrient management plan. Managing a spreadsheet of sampling over time greatly assists in understanding overall long term impact on soil and plant health.

Fertilizers Used in Golf Course Management

Understanding components of fertilizers, the label, and function of each element within the plant are essential to an efficient nutrient management program. Depending on the species, plants need approximately 16 elements, divided into two categories: macronutrients and micronutrients. Macronutrients carbon, hydrogen, and oxygen are derived from carbon dioxide and water. Macronutrients are further subdivided into primary (nitrogen, phosphorous, potassium) and secondary nutrients (calcium, magnesium, sulfur).

Table 1. The essential turfgrass nutrients.

Nutrient	Symbol	Available form(s)*	Sufficiency range**
Macronutrients			
Carbon	C	CO_2	~44%
Hydrogen	H	H_2O	~6%
Oxygen	O	O_2, H_2O	~44%
Nitrogen	N	**NO_3^-**, NH_4^+	2.75-4.2%
Phosphorus	P	**$H_2PO_4^-$**, HPO_4^{2-}	0.3-0.55%
Potassium	K	K^+	1.0-2.5%
Calcium	Ca	Ca^{2+}	0.5-1.25%
Magnesium	Mg	Mg^{2+}	0.2-0.6%
Sulfur	S	SO_4^{2-}	0.2-0.45%
Micronutrients			
Iron	Fe	**Fe^{2+}**, Fe^{3+}	30-100 ppm
Manganese	Mn	Mn^{2+}	20-150 ppm
Zinc	Zn	Zn^{2+}, $ZnOH^+$	20-55 ppm
Boron	B	$B(OH)_3$	10-60 ppm
Copper	Cu	Cu^+, **Cu^{2+}**	5-20 ppm
Molybdenum	Mo	MoO_4 +	0.15-0.5 ppm
Chlorine	Cl	Cl^-	not known

*Bold type indicates the form more commonly available to turfgrasses.

**Sufficiency ranges are expressed as percentages or parts per million (ppm) on a dry weight basis. Values were obtained from publications by J. B. Jones, "Turf Analysis," *Golf Course Management*, 48, no. 1 (1980): 29-32; H. Marschner, *Mineral Nutrition of Higher Plants* (New York: Academic Press,1995); and E. Epstein, *Mineral Nutrition of Plants: Principles and Perspectives* (New York: John Wiley, 1972). In some cases, ranges are based on general observations and not necessarily applicable to all turfgrasses or every growing condition or management situation.

Macronutrients

A fertilizer bag typically displays three numbers equating to the percent by weight of (N) nitrogen, (P) phosphorous, and (K) potassium guaranteed to be in the fertilizer. A complete fertilizer contains N, P2O5, and K2O. N, P, and K are required in the greatest quantities by turfgrass. Nitrogen is required in the greatest quantity after carbon, hydrogen, and oxygen.

Role of Nitrogen (N)

Nitrogen plays key roles in plant functions including an essential component of amino acids, proteins, and nucleic acids. Understanding the below processes can increase ability to make sound management decisions.

Nitrogen Processes

Mineralization	microbial-mediated conversion of organic N into plant available NH4 (ammonia)
Nutrification	microbial-mediated conversion of NH4 to NO3 (nitrate)
Denitrification	microbial-mediated conversion of NO3 to N gas; this primarily occurs in low oxygen (anaerobic) environments and is enhanced by high soil pH
Volatization	conversion of NH4 to NH3 gas
Leaching	the downward movement of an element below the root zone
Runoff	lateral movement of an element beyond the intended turgrass location

Each N source is unique and should be managed accordingly. Applying a polymer-coated urea in the same manner you would apply a sulfur-coated urea greatly reduces the value of the polymer coated urea. Similarly, applying two pounds of N from ammonia sulphate may cause burning, while applying two pounds of N from certain polymer-coated ureas may not provide the desired turfgrass response. Rate, release curve, application date, location, turfgrass species, and seasonality should be included in the nutrient application decision.

Know & Understand Nitrogen Sources

- Soluble Nitrogen Sources: Urea (46-0-0), Ammonium nitrate (34-0-0), Ammonium sulfate (21-0-0), Diammonuim phosphate (18-46-0), Monoammonium phosphate (11-52-0), Calcium nitrate (15.5-0-0), Potassium nitrate (13-0-44)
- Slow Release Nitrogen Sources: An N- containing fertilizer where the release of N into the soil is delayed either by requiring microbial degradation of the N source, by coating the N substrate which delays the dissolution of N, or by reducing water solubility of the N source. These include Sulfur-coated urea, Polymer/resin-coated, Isobutylene diurea, Urea-formaldehyde, Urea-formaldehyde reaction products, Natural organic
- Urease inhibitors: Reduce the activity of the urease enzyme resulting in a reduction of volatilization and increase in plant available N
- Nitrification inhibitors: Reduce the activity of nitrosomonas bacteria which are responsible for the conversion of NH4 to NO2. This reduced activity results in reduction of N lost via denitrification and an increase in plant available N

Role of Phosphorous (P)

Phosphorous is essential for plant growth and is involved in the transfer of energy within the plant. It is often the limiting factor in many natural systems. It can be abundant in some soils and is a major contributor to eutrophication of water bodies. It should never be added to turf without a specific reason. Soil and tissue testing will be the best tools to arrive at sufficient application rates. P deficiency symptoms include slow growth and weak stunted plants. P tends to bind to soil creating less potential for leaching versus N.

P fertilizer sources:

- Diammonium phosphate
- Concentrated super phosphate
- Monoammonium phosphate
- Natural organics

Role of Potassium (K)

Potassium is an essential element directly involved in maintaining the water status of the plant, turgor pressure of cells, and opening and closing of the stomata. Potassium needs to be maintained at sufficient levels because of its major "health" influence strengthening the turf plant against the stresses of cold, heat, drought, disease, and traffic wear. Potassium is very mobile in the plant, and very soluble and mobile throughout the soil profile. Saline soils and brackish water will create difficulties with plant uptake of K. Deficiency symptoms include interveinal yellowing of older leaves, plus rolling and burning of the leaf tip.

K fertilizer sources:

- Potassium sulfate
- Potassium chloride
- Potassium nitrate

Secondary macronutrients are essential to plant function and are required in lesser amounts than N, P, and K, but more than micronutrients. These include calcium (Ca), magnesium (Mg), and sulfur (S). These elements can be vital when low quality water is applied as a water source.

Role of Secondary Macronutrients (Ca, Mg, S)

Calcium (Ca)	Primary component of cell walls and structure. Found in gypsum, limestone, and calcium chloride.
Magnesium (Mg)	Central ion in the chlorophyll molecule and chlorophyll synthesis. Found in S-Po-Mg, doloitic limestone, and magnesium sulfate.
Sulfur (S)	Metabolized into amino acid, cysteine, used in various proteins and enzymes. Found in ammonium sulfate, elemental sulfur, gypsum, potassium sulfate.

Micronutrients

Micronutrients are as essential for proper turfgrass health as macronutrients, but in very small quantities compared to macronutrients. Micronutrients include (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), and chlorine (Cl).

Role of Micronutrients

Iron (Fe)	Part of the catalytic enzymes and required for chlorophyll synthesis. It affects photosynthesis, N fixation, respiration. Contributes to normal, rich green color of turf.
Manganese (Mn)	Involved in photosynthesis. Required as a co-factor for ~35 enzymes. Lignin biosynthesis depends on Mn.
Boron (B)	Used in photosynthesis, important for protein synthesis, necessary for growth. Found in the cell wall, supports integrity of the wall.
Copper (Cu)	The Cu-protein plastocyanin is involved in photosynthesis. Copper is a co-factor for a variety of oxidative enzymes.
Zinc (Zn)	Structural component of enzymes. Required for protein synthesis. Affects growth and carbohydrate metabolism
Molybdenum (Mo)	Primarily related to nitrogen metabolism. Affects structural and catalytical functions of enzymes.
Chlorine (Cl)	Required for the oxygen-evolving reactions of photosynthesis. Appears to be required for cell division in both leaves and shoots.

Soil pH

Identifying pH levels may be the most important soil test result for turfgrass managers. In most cases, a pH of 6.3 is ideal because it provides the greatest probability of micronutrient availability. Soil pH adjustments may occur slowly and are temporary.

To increase soil pH, apply a liming material (calcium carbonate, calcium oxide, dolomitic limestone) that contains Ca and neutralize acidity. To lower soil pH, products containing elemental sulfur (calcium sulfate, magnesium sulfate, potassium sulfate) should be applied. It is critical to understand your soil's nutrient balance before making applications. Applications should be tailored to correct imbalances. In some cases, utilizing injection pumps into irrigation water to address pH can be beneficial.

Application & Management

Callibration & Equipments

The only way to accurately know how much fertilizer is being applied is to calibrate application equipment. Calibration reduces environmental risk and improves cost savings. Calibration should be done in accordance with manufacturer's recommendations or when wear or damage is suspected. Sprayer and metering pumps on liquid systems need to be calibrated regularly.

Choose the appropriate spreader for a given fertilizer material. Not all fertilizers can be spread with every spreader. Spreader types include walk-behind rotary, drop spreader, bulk rotary or vicon, and spray. For example, granular fertilizer is usually applied with a rotary spreader. When applying it near waterways, cart paths, or other non-target areas, always use a deflector shield to prevent inappropriate fertilizer distribution. An example of the wrong spreader choice includes applying sulfur-coated urea through a drop spreader, this could damage its coating and lead to an application of soluble urea.

Foliar feeding and liquid fertilization (fertigation) involve the use of a soluble nutrient. Fewer total pounds are applied at any one time, nutrients are used more rapidly, and deficiencies are corrected in less time. Frequent "spoon feeding" is most effective for avoiding accidental fertilizer losses to the environment while also reducing the potential for spikes or low growth rates that impact play, turf recovery, clipping yield, weed establishment, disease outbreaks, and aesthetics.

Storage & Transport

Proper fertilizer storage, loading, and clean-up are important to reduce environmental risk. Load fertilizer into application equipment away from wells or surface water bodies. If a hard surface pad is not available, a tarp can be spread to collect spillage. Clean up spilled material immediately and apply as fertilizer. If fertilizer is deposited on cart paths, parking lots or other impervious surfaces, sweep the material onto the turf to be properly absorbed.

Area & Timing

The reduced height-of-cut and excessive traffic damage on putting greens results in an increased need for growth leading to an increase in nutrition. Tees and landing areas often have higher fertility requirements than fairways and roughs because they suffer constant divot damage. Fairways and roughs often require less nutrient inputs because of increased height-of-cut, less damage, and clipping return.

Exercise caution when applying nutrient applications during turfgrass establishment as these applications are particularly susceptible to loss via leaching and runoff. Utilize appropriate rates and products to minimize N loss without reducing turfgrass establishment. Consult your local land grant university for efficient N:K in your location.

Avoid applying fertilizer to soils that are at, or near, field capacity or following rain events that leave soils wet. Do not apply fertilizer when the National Weather Service has issued a flood, tropical storm, or hurricane warning, or if heavy rains are likely.

Landscape & Garden Areas

Adding proper soil amendments in garden areas can improve the soil's physical and chemical properties, increase water holding capacity, and reduce leaching of fertilizers. The use of organic mulches in gardens and aesthetic areas increases moisture-holding capacity of plantings and prevents weed growth when applied in sufficient depth. Organic amendments are decomposed by soil microorganisms and add to soil tilth.

Cultural Practices

8

Cultural turf management practices can vary from one property to the next. Factors such as turf variety, budget, and course expectations have an impact on what practices best meet a facility's needs. Examples of cultural practices that are frequent and have minimal impact on playing surface include mowing, grooming, and rolling. Other practices such as aerification, spiking, and deep verticutting are used to promote healthy turf, but create a temporary disturbance to the playing surface.

Areas that receive a high level of foot traffic, such as a putting green, deteriorate over time due to soil compaction, thatch accumulation, and day-to-day stress. These soil issues are usually found in the top three inches of the soil profile. Cultural practices can have a significant impact on health, playability, and efficiencies of the course. In this section we talk about different cultural practices and the importance behind them.

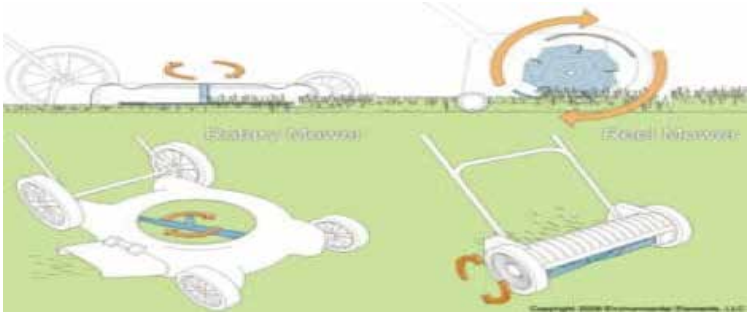
Cultural Practices

Best Management Practices

- Utilize appropriate mower and height of cut for playing surface, grass, and location
- Maintain a schedule for rotating mowing direction to keep grass growing in an upright growth habit
- Dispose of clippings properly, including composting or distributing in natural areas to decompose naturally
- Maintain and clean equipment regularly, adhering to manufacturers recommendations
- Aerification, vertical mowing, spiking, and topdressing are essential to ensure extended life of the course
- Consider rolling greens to improve ball roll without lowering the height of cut
- Conduct a shade audit to identify problem areas, tree locations, species, health, life expectancy, safety concerns, value, and maintenance requirements
- Tree trimmings which are removed should be disposed of properly; disposal can include composting, spreading chipped trimmings over native areas, or repurposing

Mowing

Mowing is the most fundamental practice on a golf course to create a desirable playing surface. It has advanced over the years to become a science in achieving lower heights and better cut quality. With a quality cut, you improve the health of the plant by cutting the leaf blade, instead of pinching or tearing the blade. This improves look and playability of the turf dramatically. Mowing practices can affect turf density, texture, color, root development, and wear tolerance. The greater frequency of a surface being mowed increases turf density, but at the same time can decrease root and rhizome growth, due to stress from the mower removing lead tissue.



Types of Mowers

There are two types of cutting units used for mowing turf: reel mowers and rotary mowers. A reel mower is a cylinder with eight to 16 blades evenly spaced and a sharp stationary bedknife mounted under the reel. As this cylinder spins, the grass is cut like a pair of scissors between the blade and bedknife. If the mower is adjusted properly it will provide the highest cut quality and lowest mowing heights available. Reel mowers require less power allowing for fuel savings or battery-operated options. There are a few disadvantages to a reel mower such as height-of-cut options, plus the amount of maintenance and skill it takes to adjust properly.

Rotary mowers have blades that mount horizontally to a vertical shaft and spin at high speeds. The impact from the sharp blade contacting turf cuts the leaf blade. So rather than a scissor cut, you get a knife cut. This works well for grass being maintained at higher heights as long as the blade is sharp. The rotary mower also has as few disadvantages such as inability to mow below one inch and danger associated with the swinging blade.w

Height of Cut

Golf courses have multiple playing surfaces that require varying frequency and height-of-cut. For example, most courses will use a rotary mower set anywhere from one to two inches for height-of-cut on roughs. On average, rough will be mowed once or twice per week. This varies based on time of year and how fast grass is growing. In winter, temperatures are cooler, and days are shorter - as a result, there is less opportunity for the plant to photosynthesize, so the plant does not grow as fast. During summer months, temperatures are higher, and days are longer. The opportunity for the plant to photosynthesize makes for rapid growth and additional mowing. If turf is not mowed frequently enough, you will scalp. As a guideline, mow often enough to ensure no more than one-third of the top growth is removed at any one time.

To mow the remaining golf course requires reel mowers. Areas such as the tee, fairway, and approaches are maintained around 0.5 inch or less. Due to the height of cut and importance of playability, it is not uncommon for these areas to be mowed two or three times per week. Like the rough, time of year and growing conditions can vary this practice.

The most important aspect of a golf course is the greens. Greens have the highest priority and receive the most maintenance. Golf course greens are always mowed with a reel mower that needs to be frequently adjusted and sharpened. Mowing heights are much lower and require daily attention. Most courses will mow daily or substitute with a roller on occasion. To have a quality playing surface, the cut quality, frequency, and mowing height have huge impacts. Average mowing heights for greens range from .07 to .125 inch.

	Greens Regular Maintenance	Greens Tournament Play	Collars and Approaches	Tees	Fairways	Roughs
Bermudagrass Range	0.110"–0.250"	0.090"–0.125"	0.375"–0.500"	0.250"–0.500"	0.375"–0.600"	0.750"–2.000"
Seashore paspalum	0.110"–0.125"	0.090"–0.125"	0.375"–0.500"	.375"–.500"	.375"–.500"	1.00"–1.500"

* Golf course mowing heights vary within these ranges and may temporarily vary outside these ranges due to numerous factors, including weather, budget, season, tournaments, member expectations, and a variety of other agronomic considerations such as the turf growth rate, cultivar being grown, soil type, age of turf, shading, pest outbreaks, rooting depth, thatch management, grow in, and overseeding.

Recommended Golf Course Mowing Heights, by Area; Unruh, Cisar, and Miller, 1999.

Mowing Directions

Varying mowing directions is very important to keep grass growing in an upright growth habit and provide a smooth playing surface. By rotating directions, grass is prevented from lying over and growing in the direction it is being mowed. Lateral growth habit creates what is called “grain” which creates inconsistent ball roll speed and can influence the ball to roll in the direction the grass is growing - the mower will eventually create a very poor cut and accumulation of thatch will create marcelling. Marcelling is a wavy or washboard look that occurs over time and creates unfavorable playing conditions. Another issue that can arise is “rutting” from tires going over the same spot repeatedly, creating wear and soil compaction. This is why most courses will have a chart showing the daily mowing direction. For example, based on the position of a clock, Monday might be 12 to 6, Tuesday 3 to 9, Wednesday 8 to 2 and Thursday 10 to 4. Rotation ensures grass is consistently mowed in a different direction and helps operators see the lines to provide the ability to create a checkerboard pattern. Mowers with a roller will lie the grass over the direction of mowing. This creates a striping effect from light to dark. The light-colored pass is the direction moving forward and the dark pass is the opposite.

Grass Clippings

With all of this mowing, what happens to the clippings? With frequent mowing most courses will not pick up clippings in large areas, such as the rough and fairways. If there is a lot of debris behind the mower, blowers will disperse clippings and provide a clean playing area. This reduces costs and improves waste management because clippings contain nutrients that grass can use, and it can cut the amount of fertilizer needed. Areas where clippings are removed include places where balls roll, such as the greens, tees, and approaches.

Removed clippings should be disposed of properly. Courses can compost clippings or distribute them in native areas to decompose naturally.

Equipment Care

Equipment in Hawai'i does not last as long as most places. Courses are open year-round so machine operating hours add up quickly. The tropical climate also takes a toll on equipment with sun and salt air breaking it down over time. This is why equipment care and operating leases are incrementally important in Hawai'i. Storing equipment under cover helps extend life, in addition to proper preventative maintenance based on manufacturer's recommendations. Washing and waxing equipment after every use helps prolong appearance and life of the machines. To achieve the mowing heights desired and get the cut quality expected, it takes trained personnel to sharpen and maintain equipment.

Turfgrass Cultivation Practices

In order to maintain a healthy playing surface, cultural turf maintenance practices are implemented. These practices provide an opportunity for both turf and soil to recover from daily play. During the year, soil conditions can become very compact from cart and foot traffic, creating unfavorable growing conditions. Another common issue over time is the accumulation of thatch that builds from years of organic matter. Thatch is found under green vegetation and above the soil which is made up of dead and living shoots, stems, and roots. The goal is to have a healthier plant by providing relief to the soil compaction, reduce thatch, and improve water and air exchange. Some of these practices result in disturbance of the playing surface and can require weeks to fully recover. Equipment has advanced through the years, providing ways to manage these issues, while minimizing impact to playing conditions. Practices such aerification, vertical mowing, spiking, and topdressing are essential to ensure extended life of the golf course.

Aerification

Core Aerification is a common practice done on any surface where soil compaction is an issue. Soil compaction normally occurs in the top 3 inches of a profile and can create an unfavorable environment for plant roots to grow. Because of the lack of oxygen getting to the plant roots, it is a struggle to carry out respiration, which is necessary for the plant to convert stored food to energy and vital for survival.

Specialized machines called aerifiers have the ability to pull multiple soil cores from the turf surface in a timely manner. This practice provides the ability to physically remove unwanted organic matter from the upper portion of the root zone. Aerifiers provide important health benefits:

- Reduce compaction and removal of thatch
- Provide oxygen to the roots
- Allow water infiltration
- Reduce dry spots
- Minimize water runoff

This process normally occurs two to three times per year on heavy traffic areas such as greens, tees, fairways and approaches.

The size of the tine can vary in diameter and length. Common sizes are 0.25 to 0.75 inch inside diameter at a depth of three to four inches, with two to 2.5 inch spacing. You will remove more thatch with a large tine, at closer spacing, however recovery time will increase. Due to surface disruption, recovery time, and cost, it is not uncommon for courses to push for less frequent or smaller-tine core aerations. Over time this can have long-term negative effects costing more in the long run. Ideally try to impact 15 to 20 percent of the green surface every year with core aerification to promote a well maintained green in Hawai'i.

Technology and equipment aerification advancements have improved, offering new options to meet varying needs. Deep tine aerification with a solid tine is becoming very popular. It provides the ability to reach a depth of 10 inches or greater with a tine's diameter from .125 to 1 inch. The spacing and angle in which the tine enters and exits the holes can be adjusted. These options do not remove any material and are quick to recover, while still providing positive health benefits. Determining what type, size, and depth of aerification can vary by property depending on what option will best solve the existing problem.

Vertical Mowing

Vertical mowing has increased in popularity amongst warm season turf varieties. A vertical mower is a series of knives that vertically mount on a horizontal shaft and spin at a high rate. The blades are made to slice though turf while pulling out thatch and debris. Depth can be adjusted to tickle or rip as much as necessary. As soon as thatch levels reach 0.25 to 0.5-inch depth, initiate a vertical mowing program. Verticutting is incorporated into almost every cultural program in Hawai'i because of the aggressive nature of Bermuda and Paspalum having a lateral growth habit. On putting surfaces this lateral growth is called "the grain of the green". To minimize grain on the putting surface, knives are adjusted to a depth that just nicks the surface of the green. This light, frequent verticutting will have minimal impact on play and help minimize the grain. Deep verticutting on a putting green surface may be performed, however because of the potential damage that can occur and extensive recovery time, managers should use extreme caution and test the practice before implementing. Shallow verticutting on greens may be implemented one to two times per month. New ultradwarf varieties may require even more frequent vertical mowing to prevent excessive thatch build up. To meet this demand, interchangeable vertical mower units are available for triplex greens mowers. This allows for quick and precise verticutting of the green surface while collecting debris in the basket at the same time. The blades are spaced 0.25 to 0.5 inches apart. Verticutting directions should be rotated similar to daily mowing.

Figure A

Grooming and brushing are options to provide light grooming to the putting surface. Miniature vertical mowers are attached in front of the reel cutting unit and grooming can be done in conjunction with daily mowing. This helps improve playing surface by standing up leaf blades before the reel cuts it. It is another way to help reduce surface grain.

On areas such as rough, fairways, and tees verticutting can be conducted at deeper depths for thatch removal to help provide a smooth, firm playing surface. Figure A demonstrates what can happen over time if turf is mowed in the same direction and thatch is not managed.

Adjust the depth so blades can reach the bottom of the thatch layer and extend into the soil below the thatch. This aggressive depth can stimulate new growth by cutting through stolons and rhizomes while removing unwanted thatch. When going this deep, set blade spacing one to two inches apart to maximize thatch removal and minimize damage. Reference Figures B and C When verticutting in multiple directions, use perpendicular angles to lessen the occurrence of damage from too aggressive removal.

Figure B

Figure C

Topdress

Topdressing is an important cultural practice to make the putting surface meet player expectations. Adding a thin layer of sand to the turf surface, followed by dragging or brushing, provides multiple benefits to the putting surface. There is a common misconception by players that topdressed greens disrupt play, however without it, the quality of the putting green would diminish over time.

Topdress programs are unique and need to work for what you are trying to achieve. On putting greens, it is common for courses to apply light, frequent applications of topdressing sand to help smooth out the playing surface and aid the breakdown of thatch. This process can be done one to two times per month. A light sand topdressing program establishes smooth playing surfaces, controls thatch and grain, and promotes recovery from injury.

After cultural practices, such as core aerifing and verticutting, follow up with a topdress application. Sand is used to fill, smooth, and speed recovery of turf. The amount of sand can vary depending on capacity of the turf canopy to absorb material without burying the plant. Rates vary from 0.125 to .25 inch (two to four cubic yards of soil per 5,000 square feet) or until surface is smooth and level after dragged in. Filling holes after core aerfication might require a couple applications to ensure holes are filled to the top without smothering the turf.

Make sure the sand particle matches the greens profile in shape and size when purchasing. If the sand is a finer material it can create layering and have a negative impact on water infiltration. This is known as perched water table and can be very difficult to get rid of. Surprisingly, sand is very expensive in Hawai'i because it is imported. The majority of the silica sand used in Hawai'i is from Asia.

What's the difference between Hawaiian sands and Vietnam?

Hawaiian sands are classified as Calcium Carbonates or Calcareous sand. This means they are derived from the coral reef over several hundreds of years. In comparison, silica sand is formed during volcanic action such as explosive eruptions with extremely high pressure. Minerals in the area of the volcanic explosive action are fused together creating silica, quartzite, granite and other feldspar materials.

Rolling

Rolling greens has increased in popularity over the past few years. Daily rolling of a putting green can increase putting speeds by roughly 10 percent allowing for improved ball roll, without lowering the height-of-cut. Any time height-of-cut is raised, turf is healthier. Rolling also helps improve smoothness of the ball roll by pushing down imperfections. Research has proven that more rolling contributes to less weeds and occurrence of dollar spot, a common disease.

There are two types of rollers being used today: stand-alone rollers and triplex rollers replace the reels with roller units. Stand-alone units come in different weights and sizes. When operating, the driver faces perpendicular to the direction they move. In

Figure D you can see a heavy roller compared to a light roller in Figure E. These rollers require a cart or large utility vehicle to pull from location to location.

If you use a heavy roller you could risk issues such as soil compaction thus affecting air and water movement through the profile. For this reason, light weight rollers are recommended. It is not wise to roll with a heavy roller after a heavy night of irrigation. To further prevent compaction, extra aerification may be required to relieve any soil issues. If done properly, rolling has numerous benefits and can help create that extra speed often desired.

Figure D

Figure E

Shade and Tree Management

One of the most important factors for turf to survive is sunlight. Full sun provides increased photosynthesis and improves air circulation. This aids in evaporation of moisture, decreasing the susceptibility of pest and disease potential. Factors such as trees can substantially reduce air circulation and sunlight to surrounding turf. This often creates shaded areas, stagnant air, and leaf blades that stay wet for an extended period of time. As temperatures increase throughout the day, shady areas become warmer and more humid, compared to open areas. This results in weaker turf that is thin and more prone to pest and diseases. To minimize issues, observe the sun pattern and see what trees are blocking light from reaching desired areas throughout the year. Selectively remove branches to open up air and light; if the problem is severe, it may be necessary to remove select trees.

Conduct a shade audit annually to identify problem areas. Identify each tree location, species, health, life expectancy, safety concerns, value, and maintenance requirements. If removing or pruning trees is not an option, there are still a few things which can be done:

- Increase mowing height by at least 30 percent to provide more surface area to capture light and improve benefits for roots
- Reduce fertilizer applications to avoid depleting the carbohydrate source for the plant
- Monitor irrigation and prevent the shaded area from getting too wet
- Prevent traffic from going into shaded areas through using signage or rope and stakes
- Add fans set with timers to dry the area and provide fresh air movement across surface

These measures can help minimize damage and provide a weak plant the best opportunity to survive.

In the event trimmings are removed, they should be disposed of properly. Disposal can include composting green waste, spreading chipped trimmings over native areas, or cutting wood that falls into logs to provide to employees, local woodshops, or chefs for carving, barbecue smoking, or grilling.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Wiedenmann

Integrated Pest Management

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The basis of an environmentally sound pest control program is a process called Integrated Pest Management (IPM). IPM aims to reduce conventional pesticide use, when feasible, by using a combination of tactics to control pests, including cultural, biological, genetic, and chemical controls. Objectives include reducing pest management expenses, conserving energy, and reducing the risk of pesticide exposure to people, animals, and the environment.

Pest management on golf courses requires significant time, labor, and financial resources. Golf course superintendents must understand what IPM is and how to implement it for each pest group, including arthropods, nematodes, diseases, and weeds. Superintendents must be well-versed in pest identification, lifecycles and/or conditions that favor pests, and all possible methods of pest control.

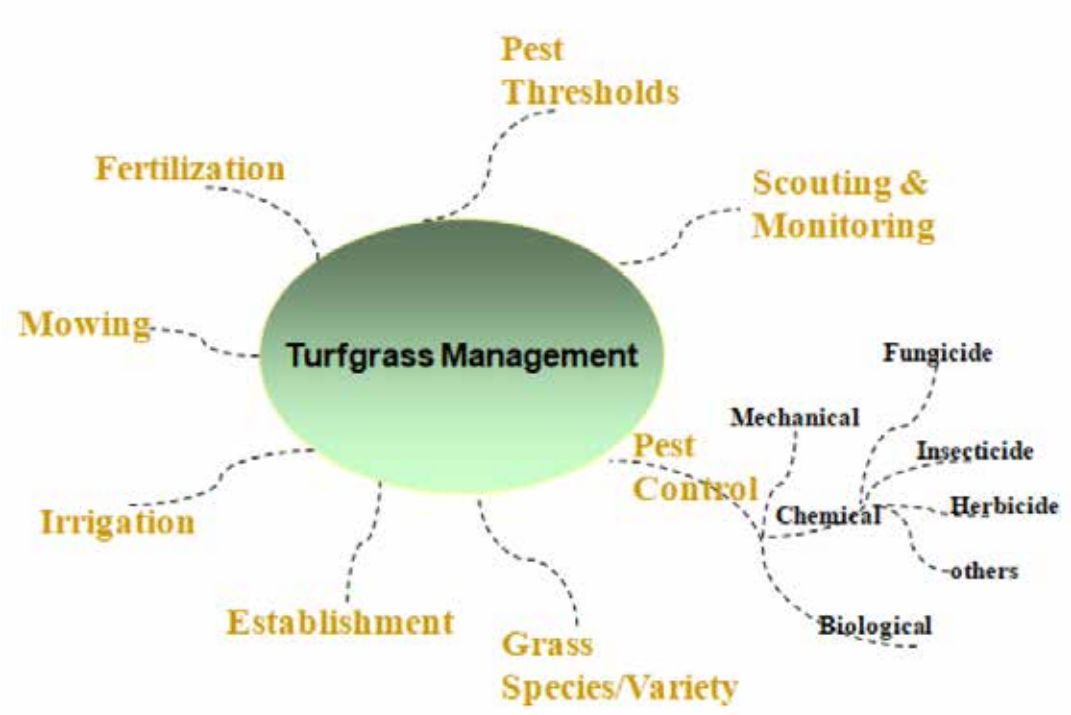
Integrated Pest Management

Best Management Practices

- Always adhere to local, state, and federal regulations for pesticide application, RUP, and biological controls
- Proper records of all pesticide applications should be kept according to local, state, or federal requirements
- Identify key pests on key plants
- Determine pest's lifecycle, know which life stage to target (e.g., for an insect, whether an egg, larva/nymph, pupa, or adult)
- Decide which pest management practice (mechanical, chemical, biological) is appropriate and carry out corrective actions. Direct control where the pest lives or feeds
- Establish a written IPM plan. Monitor, observe, and document turf conditions regularly (daily, weekly, or monthly, depending on the pest), scouting which pests are present, how damaging they are, determining pest thresholds, and necessary control strategies
- Use proper cultural, mechanical, or physical methods to prevent problems from occurring (e.g., prepare site, choose correct turfgrass for Hawai'i, select resistant cultivars), reduce pest habitat, (e.g., practice good sanitation, pruning and dethatching) turf stress, and weed encroachment; or promote biological control
- Consider use of biological controls that support natural predators and beneficial organisms to reduce pests
- Chemical pesticide applications should be carefully chosen for effective and site-specific pest control; use properly timed preventive chemical applications only when professional judgment indicates they are likely to control the target pest effectively, with minimal environmental and economic impact; If possible, rotate chemicals and modes of action if chemical controls are used to reduce resistance in pests; always follow label instructions
- Train employees on proper pest identification, pesticide selection, and application techniques; entomologists and other specialists are available from HDOA and other extension agencies for assistance with pest identification
- Determine whether corrective actions reduced or prevented pest populations; were economical and minimized risks; record and use information when making similar decisions in the future

IPM Plan & Monitoring

IPM on golf courses focuses on identifying pests, choosing pest-resistant varieties of grasses and other plants, enhancing habitat for natural pest predators, scouting to determine pest populations and acceptable thresholds, and applying biological and other potentially less toxic alternatives whenever possible. Chemical controls should have minimal effect on beneficial organisms and the environment; controls should also minimize development of pesticide resistance. A diagram summarizing key components of a typical turf IPM program is provided below (Cheng, 2013).



Written Plan

IPM includes biological controls, mechanical or cultural methods, chemical controls, pest monitoring, and other applicable practices. A written IPM plan should be established to provide guidance and align crew members. A pest-control strategy should only be used when the pest is causing, or is expected to cause, more damage than what can be reasonably and economically tolerated. A control strategy should reduce pest numbers to an acceptable level, while minimizing harm to non-targeted organisms and the environment. Pesticide selection should be based on effectiveness, potential toxicity to non-target species, cost, and site characteristics, as well as solubility and persistence.

Pest Thresholds & Scouting

IPM is generally more challenging on golf courses than in an agricultural setting where economic thresholds for key pests have been determined and pest levels exceeding the site's thresholds warrant treatment. The golf industry is sensitive to aesthetic damage, and golfers can be intolerant of anything that could affect the appearance of turfgrass or ornamental plants. Educating golfers and maintenance personnel can raise tolerance of minor aesthetic damage without compromising plant health, play, and aesthetics. Available pest thresholds can help guide application decisions and associated education, while minimizing economic and environmental costs.

Include "scouting" locations and steps for all areas of the course in the IPM written plan. Scout to identify populations, pest damage, determine acceptable thresholds, and what control strategies are necessary. Scouting methods include visual inspection, soil sampling, soap flushes, and insect trapping. Record scouting results to develop historical information, document patterns of pest activity, and note successes and failures. Use this information when making similar future decisions.

Monitoring

Monitor, observe, and document the presence and development of pests regularly (daily, weekly, or monthly, depending on the pests); note conditions that are conducive for outbreaks throughout the year. Note time of day, month, year, weather, and flowering stages of nearby plants. Map pest outbreak locations (including number of insects per unit area, disease patch size, and percent of area affected) to identify patterns and susceptible areas for future applications. Document with photos when possible. Problem areas might include the edges of fairways, shady sites, or poorly drained areas.

Personnel should be trained to determine the pest's lifecycle and know which life stage to target. For example, for an insect pest - identify whether it is an egg, larva/nymph, pupa, or adult. Train personnel to document, identify, and record key pest activities on key plants. Signs of the pest may include mushrooms, animal damage, insect frass, or webbing. Symptoms of the pest may include chlorosis, dieback, growth reduction, defoliation, mounds, or tunnels. Staff should identify which corrective actions reduced or prevented pest populations and they should be trained to understand what actions are most economical, while minimizing risks.

Pest Groups

Insects

In the presence of a susceptible host and a conducive environment, certain insects can disrupt play by damaging and destroying turf, or by being a nuisance to golfers. Correctly identify the responsible insect pest(s). This often involves sending samples to diagnostic clinics. Entomologists and other specialists are available from HDOA and other extension agencies for assistance with pest identification. Turfgrass managers have multiple tactics and tools that can be used to control turf insect pests, including cultural and chemical practices.

Ensure proper cultural practices to reduce turfgrass stress are used. Healthy, well-managed turfgrass is more likely to resist insect problems and has better recuperative potential than stressed, unhealthy turf. Cultural factors that influence stress include organic layer management, fertility programs, water management, and mowing height selection. Correct any conditions that produce stressful environments for turf. (e.g., improve airflow and drainage, reduce or eliminate shade, etc.)

Insecticide use may be integrated into an overall management strategy for a golf course. The appropriate (most effective) preventive insecticide can be applied to susceptible turfgrasses when unacceptable levels of insect damages are likely to occur. Certain well-studied biological control agents (i.e., entomopathogenic nematodes, fungi, and bacteria) can be used against certain turf insect pests, but application in Hawai'i is limited compared to the mainland.

Record and map insect outbreaks. Identify trends to help guide future treatments and focus on changing conditions within susceptible areas to reduce insect outbreaks.Sprayer and metering pumps on liquid systems need to be calibrated regularly.

Pesky Pests!

Since the discovery of Wasmannia auropunctata on the Big Island in 1999, the Hawai'i Department of Agriculture has enacted quarantine regulations to prevent the shipment of potted plants infested with little fire ant from the Big Island to other islands. Additionally, the Hawai'i Ant Lab (HAL) was established to address invasive ant species in Hawai'i including little fire ants (LFA). Besides a painful sting, welts, and infestation, fire ants promote plant pests such as aphids, white flies, and scale insects, which secrete plant sap that the ants eat.

Harmful turfgrass insect pests also include "lawn caterpillars" such as the grass webworm and lawn armyworm, plus mites, in addition to mole crickets and billbugs that live in the soil.

More information: https://www.ctahr.Hawai'i.edu/uhmg/easthi/little-fire-ant.asp

For a list of Hawai'i invasive species, visit: http://dlnr.Hawai'i.gov/hisc/info/invasive-species-profiles/.

Common Turfgrass Diseases in Hawai'i

- Dollar spot, *Sclerotinia homoeocarpa*
- Brown patch, *Rhizoctonia solani*
- Pythium blight, *Pythium aphanidermatum*
- Fusarium patch, *Microdochium nivale*
- Mini Ring, *Waitea circinata* var. *zeae/ Rhizoctonia zeae*
- Bermudgrass decline, *Gaeumannomyces graminis*

Diseases

In the presence of a susceptible host and conducive environment, plant pathogens can disrupt play by damaging and destroying turf. Correctly identify the disease pathogen; this often involves sending samples to diagnostic clinics. Fungicide use should be integrated into an overall management strategy for a golf course. The appropriate (most effective) preventive fungicide can be applied to susceptible turfgrasses when unacceptable levels of disease are likely to occur.

No measure can completely eliminate the threat of turfgrass disease on a golf course. However, managers have multiple tactics and tools that can reduce the likelihood of disease. Cultural factors include organic layer management, fertility programs, water management, and mowing height selection. Correct the conditions that produce stressful turf environments (e.g., improve airflow and drainage, and reduce or eliminate shade). Healthy, well-managed turfgrass is less likely to develop disease given its better recuperative potential.

Preventively apply appropriate fungicides where diseases are likely to occur and when conditions favor disease outbreaks. Record and map disease outbreaks. Identify trends to guide future treatments and alter conditions in susceptible areas to reduce disease outbreaks.

For lab diagnostic services in Hawai'i, contact the University of Hawai'i Agricultural Diagnostic Service Center: https://www.ctahr.Hawai'i.edu/site/ADSC.aspx

Weeds

People, animals, birds, wind, and water can distribute seeds which reproduce into weeds. Weeds also reproduce from root pieces and special vegetative reproductive organs such as tubers, corms, rhizomes, stolons, or bulbs. They compete with desired plants for space, water, light, and nutrients. They are hosts for pests such as plant pathogens, nematodes, and insects. Certain weeds also cause allergic reactions in humans.

Weed management is an integrated process where good cultural practices are used to encourage desirable turfgrass ground cover, and herbicides are intelligently selected and judiciously applied. A successful weed management program consists of:

- Preventing weeds from being introduced into an area
- Selecting appropriate turf species or cultivars adapted to prevalent environmental conditions to reduce weed encroachment that may lead to bare soils
- Using proper turfgrass management and cultural practices to promote vigorous, competitive turf
- Properly identifying weeds
- Properly selecting and using appropriate herbicide, if necessary

Adopt or maintain cultural practices that protect turfgrass from environmental stresses such as shade, drought, and extreme temperatures in order to prevent weed encroachment. Proper turf management practices include correct and appropriate use of fertilizers and chemicals, proper mowing height and frequency, proper soil aeration, and regulated traffic to reduce physical damage and compaction. Avoid scalping; it reduces turf density, increasing weed establishment. Use weed-free materials for topdressing. Proper fertilization helps resist diseases, weeds, and insects; it is essential for turfgrasses to sustain desirable color, growth density, and vigor.

Record and map weed infestations to help identify site specific issues for preventative actions. Address damage from turfgrass pests such as diseases, insects, nematodes, and animals to prevent density/canopy loss to broadleaf weeds.

Nematodes

Plant-parasitic nematodes adversely affect turfgrass health. These microscopic roundworms (unsegmented), usually between 0.0156 and 0.125 inch (0.25 and 3 mm) in length, are difficult to control. Nematodes debilitate the root system of susceptible turfgrasses. The roots under nematode attack may be very short, with few, if any, root hairs, or appear dark and rotten.

Plant-parasitic nematodes cause turf to be less efficient at water and nutrient uptake from the soil and make it much more susceptible to environmental stresses. Weakened turf favors pest infestation and especially troublesome weeds that necessitate herbicide applications. Turfgrasses begin showing signs of nematode injury as they experience stresses, including drought, high temperatures, low temperatures, and wear. Over time, turf in affected areas thins out or may die. Recommended practices when nematode activity is suspected:

- Assay the soil and turfgrass roots to determine extent of the problem
- Only apply nematicide on golf course turf based on assay results
- Divert traffic from areas stressed by insects, nematodes, diseases, or weeds
- Increase mowing height to reduce plant stress associated with nematodes (in addition to root-feeding insects, disease outbreaks, or peak weed-seed germination)
- Reduce or eliminate other biotic/abiotic stresses

Control Methods

Turfgrass Selection & Maintenance

Selecting pest-resistant cultivars or plant species can potentially lead to reduced pesticide usage. A species grown outside of its zone of adaptation is typically more prone to pest problems. Species and cultivars should be managed under conditions similar to the intended use. (e.g., not exceeding mowing height limitations that a grass was bred or selected for.)

Avoid use of turfgrass in heavily shaded areas and select shade-adapted grasses for areas receiving partial sun or shade. Reduce traffic in shaded areas to protect turfgrasses and trees from injury and soil compaction, if practical. Minimize moisture stress and leaf wetness. Reduce pest and disease pressures by correcting dead spots and air-circulation issues by pruning understory and adjusting irrigation scheduling. Mechanical control methods such as vacuuming, hand pulling weeds, and extracting pests work best when populations are low.

Educate builders, developers, golf course and landscape architects, sod producers, golfers and others on which plants are best suited to your area within Hawai'i. Turfgrasses must be scientifically selected for the eco-region of the golf course, resulting in minimized irrigation requirements, fertilization needs, and pesticide use.

Reference Planning, Design, and Construction section for common Hawai'i turfgrasses.

Biological Controls

The biological component of IPM involves the release and/or conservation of biological control agents, such as predators, parasites, and pathogens. Hawai'i regulations do not allow the importation of beneficial insects due to quarantine restrictions, so they must be sourced, collected, transported, and released by a local beneficial insects expert. Entomologists at the University of Hawai'i can provide informational resources.

Areas on the golf course can be modified to better support natural predators and beneficial organisms. This natural control can have immediate and long-term impacts including reduced pesticide use, improved native plant growth, lower energy use, water and cost reductions.

When feasible, avoid applying pesticides to roughs, driving ranges, or other low-use areas to provide a refuge for beneficial organisms. Targeted areas for biological controls should attract natural predators and protect them from pesticide applications. Plant insectary plants that provide pollen or nectar sources. Regularly monitor to spot outbreaks and transfer beneficial insects into the area needed.

Beneficial Insects in Hawai'i

- Ladybugs and lacewing larvae for controlling aphids and a variety of other insects
- Praying mantises for controlling many insects
- Predatory mites for controlling pest mites, thrips, and many others
- Ground beetles feed primarily on caterpillars that attack trees and shrubs

Conventional Pesticides

IPM involves prevention and suppression to reduce pest numbers or damage to an acceptable level. A pest-control strategy using pesticides should be used only when the pest is causing, or is expected to cause, more damage than what can be reasonably and economically tolerated. If possible, rotate chemicals and modes of action if chemical controls are used to reduce resistance in pests.

Pesticides are designed to control or alter behavior of pests. Pesticides should be evaluated on effectiveness against the pest, mode of action, life stage of the pest, personnel hazards, non-target effects, potential off-site movement, and cost. A control strategy should reduce pest numbers to an acceptable level, while minimizing harm to non-targeted organisms.

Always follow label instructions; state and federal pesticide laws require it. These directions have been developed after extensive research and field studies on the chemistry, biological effects, and environmental fate of the pesticide.

Train employees on proper pest identification and pesticide selection techniques. Choose the product most appropriate for the pest and mix only the quantity of pesticide needed in order to avoid disposal problems, protect non-target organisms, and

reduce costs. Spot-treat pests whenever appropriate. Rotate pesticide modes-of-action to reduce likelihood of resistance.

Note environmental hazards and groundwater advisories included on labels. Follow guidelines provided by the Fungicide Resistance Action Committee, Herbicide Resistance Action Committee, and Insecticide Resistance Action Committee. The Hawai'i Department of Agriculture (HDOA) Pesticides Branch Education Section may be contacted for more information about IPM or other pesticide concerns.

IPM Record Keeping

IPM principles include proper record-keeping of pest control activity to establish proof of use, application of protocols, and refer to past infestations in order to select best future course of action.

Record-Keeping

Record pesticide applications, along with results of scouting, to develop historical information, document patterns of pest activity, and note successes and failures. Record-keeping is required to comply with the federal Superfund Amendments and Reauthorization Act (SARA, Title III). Certain pesticides are also classified as RUP, record-keeping requirements apply per Hawai'i legislation.

Pesticide Application Record	Details
Date and time of application	
Name of applicator	
Person directing or authorizing application	
Weather conditions at time of application	
Target pest(s)	
Pesticide used (trade name, active ingredient, amount of formulation, amount of water)	
Adjuvant/surfactant and amount applied, if used	
Area treated (acres or square feet) and location	
Total amount of pesticide used	
Application equipment	
Additional remarks (e.g., severity of infestation or life stage of pest)	
Follow-up to check effectiveness of application	

Restriced Use Pesticides Recordkeeping is required via Act 45; forms are available at https://hdoa.Hawai'i.gov/pi/main/act45/.

Pesticide Management

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Pesticide use should be part of an overall pest management strategy that includes biological controls, cultural methods, pest monitoring, and other applicable practices, referred altogether as Integrated Pest Management (IPM). When a pesticide application is deemed necessary, its selection should be based on effectiveness, toxicity to non-target species, cost, site characteristics, and its solubility and persistence in the environment. Pesticides contain active ingredients (the component that targets the pest) and inert ingredients such as solvents, surfactants, and carriers. Both active and inert ingredients may be controlled or regulated by federal, state, and local laws because of environmental and health concerns.

Pesticide Regulations

- The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) is a federal law that authorizes the United States Environmental Protection Agency (EPA) to make and enforce pesticide rules for the entire U.S.
- The Hawai'i Pesticides Law is a State law that authorizes the HDOA to make and enforce pesticide rules for Hawai'i. Rules associated with pesticide use are 4-66.

Pesticide Management

Best Management Practices

- Comply with all Federal and Hawai'i State laws and regulations
- Select the least toxic pesticide with the lowest exposure potential
- Know the emergency response procedure in case excessive exposure occurs
- Follow all directions on pesticide's labeling
- Properly calibrate application equipment
- Always utilize Personal Protective Equipment (PPE) when required by the label
- Facilities for storing and handling must be properly sited, designed, constructed, and operated
- Ensure the site you're using the pesticide on is on the label
- A designated area should be used to mix, load, and clean the sprayers with accessible quality water
- Use caution when mixing, know what you are spraying, understand what chemicals can be mixed together
- Develop emergency response plan including procedures to control, contain, collect, store spilled materials
- Create and maintain a record for two years for each application (in Hawai'i) of a restricted use pesticide
- Properly rinse all used pesticide containers to dispose of as nonhazardous solid waste

Application

Responsibilities of Pesticide Owners, Users, or Handlers

Upon taking possession of a pesticide, the owner, user, or handler takes on two basic responsibilities. One responsibility is to comply with the Hawai'i Pesticides Law and the pesticide rules set by the HDOA. The second responsibility is to follow directions on the pesticide's labeling.

Sprayer Calibration

Properly calibrated application equipment is paramount to mitigating environmental and human health concerns. Personally ensure your spray technician is experienced, licensed, and properly trained. Minimize off-target movement by using properly configured application equipment. It's good practice to calibrate all application equipment at the beginning of each season (at a minimum) or after equipment modifications. Equipment should be checked daily when in use. Calibration of walk-behind applicators should be conducted for each person making the application to take into consideration their walking speed, etc. Always use recommended spray volumes for the targeted pest to maximize efficacy.

Common turf application equipment found in Hawai'i are low pressure boom sprayers, backpack or hand can, hand gun, and spreaders.

Equipment	Dry or Liquid	Use	Comments
Low Pressure Boom Sprayer	L	Large areas, Golf courses	Can cover large areas in short time
Backpack/Hand Can	L	Spot Treatment	Durable, portable, easy to use. Difficult to keep the pressure up. Difficult to control uniform application
Hand Gun	L	Small lawns and larger turf areas	Covers large area quickly. Very little maintenance needed.
Spreaders	D	Lawns and turf area	Can cover larger area more quickly with rotary than drop spreader.

Source: Integrated Pest Management for Turf and Ornamentals, Edited by Anne R. Leslie

Restricted Use Pesticides

A RUP is a pesticide that requires regulatory controls in addition to rules for controlling misuse of pesticides. The additional controls ensure only people with special knowledge, skills, equipment, and supplies are allowed to buy, use, or supervise use of RUPs. Pesticide regulators set up a system for controlling pesticide distributors who want to distribute RUPs and pesticide users who want to buy, use, or supervise the use of RUPs. Without this additional system of controls, pesticide regulators would not allow distribution or use of such pesticides.

Reference for additional information, licensing, registration, and certification: https://hdoa.Hawai'i.gov/pi/pest/

Personal Protective Equipment (PPE) & Human Health Risk

Pesticides belong to numerous chemical classes that vary greatly in toxicity. The human health risk associated with pesticide use is related to pesticide toxicity and level of exposure. The risk of a highly toxic pesticide may be very low if the exposure is sufficiently small. Employees will need to wash clothes that may have pesticide residues on them; washing requires the use of hot water with clothes that are suspected to have pesticide residues. Run another empty load once the clothes are washed.

PPE is used for protection against chemicals contacting the person loading, mixing, and spraying the chemical. It is important to read the label thoroughly and use the minimum required PPE listed on the label, users may always choose to use more PPE than required on the label.

Pesticide Management: Safety First with Personal Protective Equipment

Gloves
Always wear unlined, elbow-length chemical-resistant gloves when handling pesticides. The elbow-length protects wrists and prevents pesticides from running down sleeves into the gloves.

Apron
Wear a chemical-resistant apron when repairing or cleaning spray equipment and when mixing or loading. This is a good practice for all pesticides and is essential for pesticides of category I and II toxicity. Aprons offer excellent protection against spills and splashes of liquid formulations, they are also useful when handling dry formulations such as wettable powders. Aprons can be easily worn over other protective clothing and are comfortable enough for use in warm climates. Choose an apron that extends from the neck to at least the knees. Some aprons have attached sleeves. Nitrile, butyl, and neoprene offer the best protection. PVC and natural rubber are also available.

Boots
Wear unlined chemical-resistant boots which cover the ankles when handling or applying moderately or highly toxic pesticides. Purchase boots with thick soles. Nitrile and butyl boots appear to give the best protection. If chemical-resistant boots are too hot to wear, try wearing chemical-resistant overboots with washable shoes (such as canvas sneakers or layered socks.) Put your pant legs outside the boots, otherwise the pesticide can drain into the boot

Goggles or Face Shield
Wear shielded safety glasses; a full-face respirator; snug-fitting, non-fogging goggles; or a full-face shield whenever the chemical could possibly contact the eyes. Safety glasses with brow and side shields are acceptable for low exposure situations. Safety glasses without brow or side shields do not meet minimum requirements for eye protection under PPE rules. Always wear goggles or full-face respirator when pouring or mixing concentrates or working in a highly toxic spray or dust. In high exposure situations when both face and eye protection are needed, a face shield can be worn over goggles. Clean them after each use. Be careful of the headband; it is often made of a material which readily absorbs and holds chemicals. Have several spares and change them often or use a chemical-resistant strap. If possible, wear the strap under the head covering.

Body Covering
Regular work attire of long pants and a long-sleeved shirt, shoes, and socks are acceptable for slightly toxic (category III- Caution) and relatively non-toxic (category IV - Caution) pesticides. Many applicators prefer work uniforms and cotton coveralls that fit the regular-work-attire description and provide equal protection. Applicators should reserve one set of clothing for pesticide use only. Launder and store separately from all other clothing.

To apply moderately toxic (category II - Warning) or highly toxic (category I - Danger or Danger-Poison) chemicals, wear a clean, dry protective suit that covers the entire body from wrists to ankles. The sleeves must be long enough to wear over gloves. Openings, such as pockets, should be kept to a minimum. Protective suits are one- or two-piece garments, such as coveralls, and should be worn over regular work clothes and underwear. Protective suits may be disposable or reusable and are available in woven, nonwoven, coated, and laminated fabrics. The degree of protection increases as one moves from woven to nonwoven and from coated and laminated fabrics. Read manufacturer's label for specific information related to care and intended use. Good quality construction, proper fit, and careful maintenance or disposal are important.

Environmental Fate & Transport

Storage and handling of pesticides in their concentrated form poses the highest potential risk to ground or surface waters. It is essential that facilities for storing and handling these products be properly sited, designed, constructed, and operated.

Careful thought should be put into selecting pesticides that have a low runoff and leaching potential. Before applying a pesticide, evaluate the impact of site-specific characteristics (e.g., proximity to surface water, water table, and well-heads; soil type; prevailing wind, etc.) and pesticide-specific characteristics (i.e., half-lives and partition coefficients). Always consider selecting pesticides with reduced impact on pollinators and when applied according to the label, have no known effect on endangered species on the property.

Pesticide Transportation, Storage, and Handling

Environmental characteristics of a pesticide can be determined by the environmental hazards statement found on pesticide product labels. The environmental hazards statement (referred to as "Environmental Hazards" on the label and found under the general heading "Precautionary Statements") provides precautionary language advising the user of potential hazards to the environment from use of the product. The environmental hazards generally fall into three categories: (1) general environmental hazards, (2) non-target toxicity, and (3) endangered species protection.

Store, mix, and load pesticides away from sites that directly link to surface water or groundwater. Locate pesticide storage facilities from other types of structures to allow fire department access. Pesticides should be stored in a lockable concrete or metal building. Storage facility floors should be impervious and sealed with a chemical resistant paint. The floors should have a continuous sill to retain spilled materials and no drains, although a sump may be included, sloped ramps should be provided at the entrance to allow the use of wheeled handcarts for moving material in and out of the storage area safely.

Shelving should be made of sturdy plastic or reinforced metal (metal shelving should be kept painted to avoid corrosion). Wood shelving should never be used, because it may absorb spilled pesticides. Do not store pesticides near burning materials or hot work (welding, grinding), or in shop areas. Automatic exhaust fans and an emergency wash area should be provided. Explosion-proof lighting may be required. Light and fan switches should be located outside the building, so that both can be turned on before staff enter the building and turned off after they leave the building. Avoid temperature extremes inside the pesticide storage facility.

PPE should be easily accessible and stored immediately outside the pesticide storage area. Do not transport pesticides in the passenger section of a vehicle and never leave pesticides unattended during transport. Place a spill containment kit in the storage area, in the mix/load area, and on the spray rig.

Mixing

Use caution when mixing concentrated chemical and handling around the mix load area and wear the correct PPE. Mixing is an important part of proper spraying application. It is important to know what you are spraying and what chemicals can be mixed together. If you are uncertain, a jar test should be done to make sure the chemicals are compatible. A jar test is a simple method of using small samples of the mixture and mixing in a small jar. This will allow you to observe the reaction and make sure a complete mixture can be achieved. Some chemicals when mixed together could form a thick solution making it hard to spray and clean the tank. The specific mixing and sequence of mixing instructions on the label should

be followed. No chemicals should be mixed without proper supervision. Management should always be involved in the selection and initial stages of mixing to avoid accidents. The most common accidents occur by staff misunderstanding the rates, distractions, and mixing of the wrong materials. Practice WALES mixing; Wettable powder/flowables, agitate, liquid flowables, emulsifiable concentrates, surfactants last.

It is generally common to fill the tank half full of water and pour in the chemicals while the pump is running. Continue to fill the tank with water until reaching the desired amount needed to make the application.

Mix and Wash Station

A designated area with accessible quality water should be used to mix, load, and clean sprayers. Locate it closer to the chemical storage building to reduce chance of spills from transport. Mix load pads have become an important part of the maintenance facility to keep ground water safe from spills.

Mix load areas can be made of materials such as concrete, durable synthetics, or aluminum. Many companies offer off the truck containment for mix load pads and can be set up easily. The pad should be large enough to contain any spilled solution. Part of the area should contain a sump or pump to remove spills from the containment. Ideally, cover the pad to keep rain water from accumulating in the holding bay.

PPE such as eye wash stations, wash shower, and other safety equipment should be stored close to the mix pad area and available if needed.
Rinse used containers during the mixing and loading process and add rinsate water to the finished spray mix.

Pesticide Container Disposal

Rinse empty pesticide containers immediately in order to remove the most residue. Rinsate must be used for the pesticides intended use or managed as hazardous waste. Rinse emptied pesticide containers by either triple rinsing or pressure rinsing. Empty pesticide containers are classified as hazardous wastes if not properly rinsed, and as a result would be subject to regulations governing hazardous waste. Federal law (FIFRA) requires pesticide applicators to rinse all empty pesticide containers before taking other container disposal steps. Under the federal Resource Conservation and Recovery Act, or RCRA, a pesticide container is not empty until it has been properly rinsed. The improper disposal of a hazardous waste can result in fines and/or criminal penalties. Pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste. Puncture or crush empty and rinsed pesticide containers and dispose of according to the label. It is against the law to use empty pesticide containers for another function. Empty containers must be rendered unusable and discarded.

Emergency Preparedness & Spill Response

Accidents happen. Advance preparation on what to do when an accident occurs is essential to mitigate human health effects and environmental impact. Any material that collects on the pad must be applied as a pesticide according to the label or disposed of as a (potentially hazardous) waste according to state laws and regulations. Clean up spills immediately.

Develop a golf course facility emergency response plan which includes procedures to control, contain, collect, and store spilled materials. Prominently post "Important Telephone Numbers" including CHEMTREC, for emergency information on hazards or actions to take in the event of a spill. Ensure an adequately sized spill containment kit is readily available. Designate a spokesperson who will speak on behalf of the facility should an emergency occur and it's good practice to host a tour for local emergency response teams (for example, fire fighters, etc.) to show them the facilities and discuss the emergency response plan.

Pesticide Record Keeping

Restricted Use Pesticides

Two kinds of restricted use pesticides are sold in Hawai'i. Federal restricted use pesticides have labels that bear a restricted use pesticide statement in a box near the top of the label's front panel. (See example below.) State restricted use pesticides do not have such labels, but dealers who stock these pesticides can identify them.

Typical box on front panel of a label of a federal restricted use pesticide:

RESTRICTED USE PESTICIDE

Due to Xxx Yyy Zzz Hazard

FOR RETAIL SALE TO AND USE ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION AND ONLY FOR THOSE USES COVERED BY THE CERTIFIED APPLICATOR'S CERTIFICATION

Names of restricted use pesticide products may be found online through the Hawai'i Department of Agriculture: http://hdoa.Hawai'i.gov/pi/pest/.

Hawai'i-certified applicators are responsible for creating and keeping a record for each application (in Hawai'i) of a RUP they have purchased or otherwise acquired. Always review required information to record, per Hawai'i regulation, and maintain records for two years at the principal place of business. Use records to monitor pest control efforts and plan future management decisions, use electronic or hard-copy forms and software tools to properly track pesticide inventory and use, develop and implement a pesticide drift management plan, and keep a backup set of records in a safe, separate storage area.

Hawai'i State Regulations for Pesticide Use

The State of Hawai'i (Department of Agriculture, Department of Health, Department of Transportation, etc.) has regulations covering practically anyone who manufactures, formulates, markets, and uses pesticides. Act 45, passed by the 2018 Hawai'i legislature, requires all Certified Applicators of Restricted Use Pesticides (RUP) to submit a report to the HDOA of the RUP applied by Jan 30 of each year. Records that are required to be reported to HDOA include: Name/entity, applicator number, reporting year, permit number (if applicable), product name, EPA registration number, active ingredient(s) and percent, total used, area treated, date applied, and tax map key.

Act 45 also requires that all uses of chlorpyrifos and products which contain chlorpyrifos require a permit issued by the Hawai'i Department of Agriculture Pesticides Branch. All uses and sale of chlorpyrifos in Hawai'i will be banned and permitting of its use will cease as of 2023. Any chlorpyrifos permits that extend past December 31, 2022 will be terminated as of January 1, 2023. Reference additional information and access to the P-45 Registration Form at:

http://hdoa.Hawai'i.gov/pi/main/act45/
http://hdoa.Hawai'i.gov/pi/main/p-45-instructions/
http://hdoa.Hawai'i.gov/pi/pest/pesticides-rules-and-laws/

Reference Integrated Pest Management section for additional information.

Maintenance Facility Operations

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The golf course maintenance facility (GCMF) is one of the most important components of any golf course maintenance operation. It is not only the working heart of the property, but also the place for employee training, equipment maintenance, and storage of chemicals, fertilizers, fuel, and many other maintenance items. The facility should be designed by an experienced designer and qualified golf course superintendent. It would be beneficial to visit other state-of-the-art facilities to gather ideas for design efficiency.

Each of the areas highlighted in this section is aimed at reducing environmental liability and exposure. Depending upon your geographic location and local regulations, you can design your own GCMF. These guidelines are based on an average 18-hole golf course maintenance operation. Photos selected to demonstrate focus areas have been selected from existing certified Signature facilities.

Maintenance Facility Operations
Best Management Practices

- The facility should be designed by an experienced designer and qualified golf course superintendent; superintendent should collaborate with a qualified local building architect
- Address latest environmental regulations; incorporate energy, waste, water efficiencies (e.g., energy controls, recycling, composting, etc.)
- Design by Zonal Concept for efficiencies
- Ensure adequate space is provided for equipment and storage areas
- Designate wash down area with proper drainage for equipment; with recycled water
- Address all regulatory requirements (OSHA, fire department, Hawai'i Department of Health) for storage, handling, and waste disposal
- Maintain proper storage and washing of pesticide equipment in IPM Control Center
- Maintain set of Material Safety Data; sheets should be kept in IPM Control Center and main building area
- Store PPE where it is easily accessible; not in pesticide storage area
- Prevent moisture from accumulating in fertilizer and sand storage areas
- Employee lunch room/ break area should promote a relaxed atmosphere, and serve as an adequate professional training center
- Maintain clean, safe work environment with clearly designated storage areas, signage, labeling, instructions

Location

Location can contribute to decreasing fuel consumption, maintenance crew travel time, and excessive equipment wear. Ideally the complex should be located as close as possible to the first and tenth tees; it is even more productive if it can be near the center of the golf course. Designate the GCMF site as early as possible in overall site development of the property and retain a minimum of 1.5 acres of usable land. The GCMF could require more space depending on number of holes or total maintained turf acres. Different parameters need to be considered relative to a golf course with home sites versus no home sites, public or private, heavy play or light play, etc.

Design by Zonal Concept

Because resources and capital funds are precious, every square inch of the GCMF must have a specific function, be efficient in relationship to all other zones, and achieve the goal for which it was designed. Consider the following zones:

- equipment maintenance area - equipment manager's office and parts storage
- equipment storage
- equipment wash down
- fuel island
- tool storage - shovels, rakes, wheel barrel, etc.
- IPM Control Center - pesticide storage, mix & load, rinseate recycling building
- fertilizer storage
- soil storage
- nursery green
- composting area
- soils laboratory - can serve as a resource library and storage for videos and supplies
- master irrigation control room
- irrigation parts storage
- closet storage space (mops, brooms, vacuum, cleaning supplies for use in GCMF)
- golf course supplies storage (non-maintenance - ropes, flag poles, cups, signs, etc.)
- employee lunch room - also serves as a training/meeting center
- employee restrooms
- employee locker room and showers
- uniform storage area
- office support staff area and files space
- assistant golf course superintendent's office
- golf course superintendent's office
- employee and guest parking
- waste disposal

Golf Course Maintenance Facility Design

A well-designed and constructed facility will provide many excellent benefits, including:

- Efficient storage and traffic flow of equipment and personnel
- Reduced time to manipulate equipment coming into and out of buildings
- Reduced damage and repair costs to equipment
- Maximum preventative maintenance on equipment
- Maximum cleanliness with minimal labor to sustain it
- Reduced electric bills and water bills
- Peak effectiveness with employee morale and safety
- Positive atmosphere for safety and operational training
- Reduced worker compensation claims (planning and construction with worker safety in mind)
- Potential reduction in insurance premiums (due to reduced environmental liability)
- Opportunity to attract and/or retain top quality employees, including management
- 5 to 15 percent increased efficiency of operation on the golf course

Equipment Maintenance - Mechanics Workshop and Office Area

This area should be segregated from general employee activity areas and equipment storage. An experienced golf course equipment mechanic, along with the golf course superintendent, should be involved in designing this zone. Equipment is repaired and serviced in this area so adequate space for oil changes, reel grinding, and other service related jobs must be allocated. An assortment of lifts (portable, flush floor mounted and beam supported) can be distributed in the appropriate areas of this zone to facilitate moving all types of equipment and reduce the risk of back injury.

An overhead lube center (grease/oil dispensers supported by compressed air and connected to bulk drums) is convenient, uses overhead rather than floor space, and stores large drums out of the general view and work area. Shop necessities such as empty gas cans, towels and miscellaneous supplies, other than equipment parts, can be stored in cabinets distributed throughout the shop area for convenience. Ensure all combustible products and materials are stored properly in fire resistant cabinets.

Large work benches with underneath storage provide for work space at waist level (as opposed to working from the floor) and can decrease risk of back fatigue and injury. An adjoining air conditioned office with adequate parts storage bins, desk, computer, files and phone. Consider including a shatter-proof window facing the shop area to allow the mechanic a full view of the shop from the office. A sink and blower type hand dryer needs to be available in the shop.

Equipment Maintenance & Storage Area

Equipment used to apply pesticides and fertilizers should be stored in areas protected from rainfall. Rain can wash pesticide and fertilizer residues from the exterior of the equipment, and these residues can contaminate soil or water. Pesticide application equipment can be stored in the chemical mixing center, but fertilizer application equipment should be stored separately. Blow or wash loose debris off the equipment to prevent dirt from getting on the CMC pad, where it could become contaminated with pesticides.

Other equipment should be stored in a clean, safe and protected area when not in use. Every piece of equipment should have a designated spot, delineated by yellow or white lines, with its name or number and should be parked in the same spot every day. This allows for immediate identification of equipment if it develops a leak (oil, hydraulics, etc.) and increases accountability for maintaining premium operating condition. Use solvent-recycling machines or water-based cleaning machines to cut down on the use of flammable and/or toxic solvents. Use a service to remove old solvents and dispose of them properly.

A complete list of equipment needed to properly maintain the golf course must be developed. The exact size of all the equipment is important to appropriate the right amount of space needed.

The design should allow for all equipment to be driven in and out of the storage area without having to move other equipment. A superintendent who is experienced in the daily golf course maintenance program will be able to help design a floor plan for equipment storage to minimize unnecessary "shuffling."

Several overhead doors on both sides of the equipment storage area allow for a smooth transition of equipment entering and leaving the building and provide good air flow. Overhead fans in the equipment storage zone facilitate air flow and help reduce hidden moisture on equipment.

Waste oil should be collected from the equipment and stored in a container which is set on containment. If stored outside, there should be a roof over the container and a valve in the bottom of the containment to release rain water.

Since this is not generally a work space, it is also an excellent zone for the shop compressor, eliminating the loud running sound in a personnel work area. The compressor should be located away from walls adjacent to an inside wall where sound could penetrate and be disruptive.

Equipment Wash Down Area

Depending on current regulations, and size of operation, a combined fuel island and equipment wash-down area may be most productive and cost effective. Do not wash equipment unnecessarily. Clean equipment over an impervious area, and keep it swept clean. Brush or blow equipment with compressed air before, or instead of, washing. Use spring shutoff nozzles.

For a separate wash-down area, the following considerations should be taken into account:

- Water used to clean equipment should be potable water (as opposed to brackish or other)
  - Water used to wash equipment should be recycled and contaminating materials such as grease, oil, and gasoline need to be filtered from recycled water.
  - Closed loop water recycling systems with a proven track record should be utilized.
- Pesticide equipment should not be washed off in this area; it should be washed at the IPM Control Center.
  - A roof should cover the wash-down area to keep rain off the pad and prevent excessive water from going into the recycling storage tanks; the roof also serves as a sun shade for the crew during cleanup to reduce sun exposure.
  - Pad should be elevated to direct rain water away from the wash-down area.
  - Roof should be high enough to allow golf course equipment or fuel trucks proper clearance, yet low enough to meet aesthetic requirements (visibility to homeowners, etc.).
  - Several air hoses attached to posts prior to the wash-down pad can be used to remove excessive grass residue from equipment prior to moving onto the wash-down pad. This reduces grass clippings/debris entering the water recycling system.
  - Pad should have triple screen baskets, weighing less than 40 pounds each, to prevent excess grass clippings and debris from entering the recycling system.
  - Hoses with attachable spray bottles of liquid wax at the wash-down pad can be utilized so valuable equipment can receive a brief application of liquid wax (put with water) after each use.
  - Concrete in the pad should be impermeable to prevent leaching of contaminates.
  - Install lightning protection for worker and equipment protection.
  - Do not use brackish water (which could be detrimental to equipment).

Fuel Island

This zone should be located at least 80 feet from the main building and preferably combined, or working in conjunction with, the wash-down pad. Cover the fuel island to minimize sunlight on equipment, as well as degradation of hoses and fuel tank filters; also to minimize increased evaporation of fuel and provide protection for employees. Critical items for the safe and efficient operation of the fuel island zone are:

- Install adequate lighting around and beneath the roof to allow for operation during periods of darkness or inadequate light.
    - Install lightning protection on the fuel island roof.
    - Unless otherwise required by law, all fuel storage and carrying mechanisms should be above ground devices.
    - Fuel should be stored in above ground, double vaulted tanks from a reputable manufacturer (such as Convault)
- The fuel island pad should be concrete and recessed from normal ground level to allow for containment in the event of a fuel spill; the recession should be deep enough to contain a few hundred gallons of spillage but not so severe that it presents difficulty for equipment entering and leaving the fuel island.
- Being able to load fuel from both sides of the storage tanks cuts down time that employees spend waiting to fuel up.
- Prior to construction, Fire Marshall and other appropriate authorities should review specifications.
- Bollards should be placed near the tank and at other areas that could be hit and damaged by mowers or other equipment.
- Storage of fuel onsite during construction should follow guidelines for protection of water bodies, ground water, HIOSH, OSHA, and the local fire department.
- Tanks should be placed within containment and loading zone should be contained as well.
- Fuel management systems provide additional safeties, accountability and theft controls.

Fuel Storage and Loading During Construction

Fuel brought onto a dirt site in a stand-alone tank should be set in containment. This can be as simple as digging a shallow hole the size of the tank and covered the hole with a tarp or bladder. The tank would be placed on this tarp.

IPM Control Center

This is an important zone where pesticides will be stored, mixed, and recycled. The following features are critical to an efficient and environmentally sound IPM Control Center:

- Control center should be at least 200 feet from the main body of NRMC, if possible; one end of NRMC houses the fuel island and the opposite houses control center
- Control center should be at least 100 - 200 feet from a body of water or well
- A complete alarm system, with battery back-up, for burglary or fire
- Locks and bolts used at control center should be of highest quality materials
- Materials used inside the control center are comprised of high quality durable plastic, aluminum, or concrete to avoid absorption of chemical residues or vapors
- Install explosion proof fan and explosion proof lighting
- Ventilation design must be an integral part
- Locate all pesticides stored on non-absorbent shelving at least 6" off floor
- Segregate pesticides by liquid, powder, or granular class
- Store powders and granules above liquids
- Shelving must be sturdy and secured to avoid sagging and falling
- Slope floor toward center of the room with a recessed sump located at its center
- Construct floors of seamless metal or concrete sealed with chemical resistant paint
- Locate light/fan switch outside door of CC to turn on before anyone enters and turn off after exiting
- Install stainless steel sink with potable water, spigot, and hand blower (not paper towels) with drainage funneled back into the sump
- Attach mixing table to the sink at a slightly higher elevation to allow overspill to be washed into the sink
- Locate portable eye wash bottle over the sink; immediately outside, an eye wash/shower station supplied by potable water should be installed
- Locate a refill hose above the sump to allow proper and timely filling of spray tanks with water
- Only qualified personnel should be allowed access to the control center
- Beneficial to install a hot water heater in the control center to aid in the dissolving of water soluble products
- No wood should be used within the pesticide control center
- The sprayer should be stored within the pesticide control center
- Maintain a set of SDS; sheets should be kept in this location and main building area
- Store PPE where easily accessible; not in pesticide storage area, as it may be inaccessible in an emergency

Fertilizer Storage Zone

This zone could share the same building as the IPM Control Center but needs to be segregated by a solid concrete wall and a solid metal door (preferably rust-proofed).

If the building housing the fertilizer is metal, then steps should be taken to protect the metal building from degradation by fertilizer (such as adding painted plywood around the walls).

The building should be big enough to allow a small forklift to deliver fertilizer by pallet. If not, a pallet jack could be used to place the fertilizer in the room. Spreaders could be hung on the wall and the use of a dehumidifier would be beneficial in protecting the fertilizer from water absorption.

Soil Storage Zone

This area could be immediately adjacent to the fertilizer storage zone and should have a roof, although it need not be any higher than 12 feet. It does not need to be tall enough for a 22-ton dump truck to deposit sand, top dressing, or rock. More efficient use of the space is achieved by depositing the material immediately outside the storage bins and then pushing the material into the bin with a front-end loader.

It is important to keep this area covered to prevent rain from dampening the material and wind from dispersing weed seeds into the top dressing. The block walls segregating sand, top dressing, and rock should be filled solid with concrete. If possible, the opening should face away from prevailing rains or a durable drop cloth should be used to cover the opening. Ceiling fans could be installed overhead to help reduce moisture retention in the top dressing or sand.

Nursery Green

This area is developed to have a ready supply of the exact grass cultivar maintained on the actual greens playing surface. It can be used for the repair of damaged areas on greens surfaces. An average 18-hole course could utilize from 3,000 to 6,000 square feet for the nursery green.

The nursery receives the same cultural treatments as the course greens and should be located in close proximity to the GCMF. It can be used for training new greens mowers, cup cutters, and for testing new cultural products. It is also used as a valuable teaching tool for practice putting by the maintenance staff to demonstrate how a quality green and its cut interact; and demonstrate the importance of a properly installed cup on the putting surface.

Irrigation Control Room

The computer for the golf course irrigation system and storage shelves or cabinets is housed here with a lockable door.

Staff & Visitor Areas

Employee Lunch Room and Training Area

There should be administrative and managerial offices, in addition to an employee lunch room and break area. The break area should promote a relaxed atmosphere and serve as an adequate and professional training center (video training and technical seminars). The size of the crew and the number of holes in the golf operation will determine the appropriate size of the lunch room. Important items to include:

- Adequate tables/chairs for dining and training
- One or two microwave ovens (prevents long waits to heat up meals)
- One adequate sized (energy saver) refrigerator
- Drinking water with dispenser, coffee-maker, cold drink vending machine
- Kitchen area with sink, water, sufficient cabinet area
- Erasable communication board
- Air conditioned and insulated, with overhead fans for air flow
- Light attractive colors in semi-gloss for easy cleaning and to enhance the atmosphere make the room appear more spacious

Employee Restroom/Locker Room/Shower

Design restrooms to promote superior personal hygiene, ensuring they are easy to clean with adequate space/amenities to service several employees simultaneously. The locker room should be immediately adjacent to the restrooms and incorporate full-length lockers with at least one shower. A semi-gloss, high quality paint should be used for ease of cleaning.

A dry deck type material can be used on portions of the floor to prevent slippage and spread of bacteria. Both of these rooms should be insulated and air conditioned. Hand blowers should be used instead of paper towels.

Numerous considerations can contribute to water, energy, and cost reductions:

- Restrict water flow to the maximum necessary for adequate use
- Use automatic shut-offs on faucets
- Install 1.5 gallon tanks on toilets
- Use motion detectors to turn on lights when staff is present

Waste Disposal Area

This area should be located away from normal employee activity, but close enough to be reasonably functional. Proper access for waste pick-up vehicles should be incorporated in the design and location of this zone.

Prior to design or renovation of the GCMF the following specialists should be consulted to maximize desired benefits in energy, water, and waste management:

- Recycling expert
- Energy efficiency expert
- Water conservation expert
- Composting or waste management expert

Paper, Plastic, Glass, And Aluminum Recycling

Office paper, recyclable plastics, glass, and aluminum should be recycled. Place containers for recycling aluminum cans and glass or plastic soft drink bottles at convenient locations on the golf course.

Composting

Setting aside an area for compost can reduce the amount of grass clippings and debris, such as leaves or routine, healthy landscape trimmings that would normally go to a landfill. With the right expertise, compost can be used effectively to improve the soil for top dressing, non-putting surface areas, donated or sold to offsite vendors. Do not compost diseased material, as this may spread disease. Extensive research should be done before addressing this beneficial process.

Hazardous Materials Disposal

Ensure all containers are sealed, secured, and properly labeled. Use only FDEP-approved, licensed contractors for disposal.

Pesticide Containers

Empty pesticide containers are classified as hazardous wastes if not properly rinsed, and as a result would be subject to regulations governing hazardous waste. Federal law (FIFRA) requires pesticide applicators to rinse all empty pesticide containers before taking other container disposal steps. Under the federal Resource Conservation and Recovery Act, or RCRA, a pesticide container is not empty until it has been properly rinsed. The improper disposal of a hazardous waste can result in fines and/or criminal penalties. Pesticide containers that have been properly rinsed can be handled and disposed of as nonhazardous solid waste.

Used Oil, Antifreeze, and Lead-Acid Batteries

Collect used oil, oil filters, and antifreeze in separate marked containers and recycle them. Oil filters should be drained (puncturing and crushing helps) and taken to a place that recycles used oil, or to a hazardous waste collection site. Gas stations or auto lube shops may accept small amounts (including filters). Antifreeze must be recycled or disposed of as a hazardous waste. Commercial services are available to collect this material. Lead-acid storage batteries are classified as hazardous wastes unless they are recycled. Used acid from these batteries contains high levels of lead and must be disposed of as hazardous waste, unless the acid is contained within a battery being recycled. Make sure all caps are in place to contain the acid. Store batteries on an impervious surface and preferably under cover. Spent lead-acid batteries must be recycled if they are to be exempt from strict hazardous waste regulations. Do not mix used oil with used antifreeze or sludge from used solvents.

Solvents and Degreasers

One of the key principles of pollution prevention is to reduce unnecessary use of potential pollutants. Over time, the routine discharge of even small amounts of solvents can result in environmental and liability consequences, due to accumulation of contaminants in soil or ground water. As little as 25 gallons per month of used solvents to be disposed of can qualify as a “small quantity generator” of hazardous waste, triggering EPA and FDEP reporting requirements. Whenever practical, replace solvent baths with recirculating aqueous washing units (which resemble heavy-duty dishwashers). Soap and water or other aqueous cleaners are often as effective as solvent-based ones.

Blowing off equipment with compressed air instead of washing with water is often easier on hydraulic seals and can lead to fewer oil leaks. Store solvents and degreasers in lockable metal cabinets in an area away from ignition sources (i.e., welding areas or grinders), and provide adequate ventilation. They are generally toxic and highly flammable. Never store them with pesticides or fertilizers, or in areas where smoking is allowed. Keep basins or cans of solvent covered to reduce emissions of volatile organic compounds (VOCs) and fire hazards. Keep an inventory of solvents

stored and the MSDS's for these materials on premise, but not in the solvent storage area. Keep emergency response equipment recommended by the manufacturer of the solvent in a place that is easily accessible and near the storage area, but not inside the area itself.

Follow OSHA signage requirements. Always wear appropriate PPE, especially eye protection, when working with solvents. Never allow solvents to drain onto pavement or soil, or discharge into waterbodies, wetlands, storm drains, sewers, or septic systems, even in small amounts. Solvents and degreasers should be used over a collection basin or pad that collects all used material. Most solvents can be filtered and reused many times.

Store collected material in marked containers until it can be recycled or legally disposed of. Solvent disposal private firms provide solvent washbasins that drain into recovery drums and pickup service to recycle or properly dispose of drum contents. Collect used solvents and degreasers, place them into containers marked with contents and date, and then have them picked up by a service that properly recycles or disposes of them. Never mix used oil or other liquid material with used solvents. Use only FDEP-approved, licensed contractors.

Energy

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Energy is a critical focus within the State of Hawai'i. Under the Sustainable Hawai'i Initiative and the State's Aloha+ Challenge, the Hawai'i state goal is to reduce energy consumption and achieve 100 percent renewable energy use by 2045. Energy conservation efforts at golf facilities throughout Hawai'i support the state's initiatives and the United Nations' Sustainable Development Goals (SDGs), which are integrated within Hawai'i's legislation. Resorts and golf clubs serve Hawai'i residents and a global visitor industry - as stewards of the environment and community, it is important to reduce energy use and shift to renewables when practicable.

The GCSAA Golf Course Environmental Profile, Phase II, Vol. V (GCSAA 2017), estimates that turf maintenance accounts for 47 percent of energy use at a golf facility, with total facility uses encompassing clubhouses, swimming pools, tennis courts, and various other operations. The study identifies six major energy sources for golf course use: electricity, gasoline, diesel, natural gas, propane, and heating oil. Propane and heating oil use are not prevalent in Hawai'i.

Hawai'i superintendents can work toward achieving energy reductions within these six areas (where applicable) through implementing BMPs which drive behaviors and processes, improve product efficiencies, encourage optimal design, support innovative solutions, and promote education. Lower energy consumption can generate efficiencies and cost savings up to 25 percent. Reductions in energy use and facility costs support stewardship and sustainable development within our Hawai'i golf and visitor industries.

Energy

Best Management Practices

- Measure annual energy use for electricity, natural gas, gasoline, and diesel; propane, and heating oil (if applicable); input data from monthly utility statements
- Set baseline year to track improvements and future reductions; determine carbon footprint when practicable
- Analyze data to identify efficiencies, prioritize reduction targets and set goals; monitor metrics regularly
- Share data with golf maintenance crew and management; integrate daily checklists and monthly reporting into meetings, use visual management signage
- Prioritize opportunities and establish steps to implement initiatives, identify resources, projected energy and cost savings; incorporate champions, stakeholders, and task owners, include timeframe
- Establish and communicate position statement and energy policy; relate to guests, members, community
- Audit lighting and irrigation use to identify efficiency opportunities
- Establish energy consumption behavioral and product checklists, conduct supplier meetings to identify efficiencies; source locally, if practicable
- Establish Supplier Code of Conduct and Environmental Purchasing Plan
- Identify opportunities for product rebates and incentives with Hawaiian Electric
- Ensure efficient operation and maintenance of pump station, irrigation pumps, controls, components
- Incorporate energy efficiency and conservation measures into location, design, construction; collaborate with stakeholders to prioritize energy conservation; orient buildings to maximize solar gains
- Communicate with utility provider, insurance company, regulatory officials
- Incorporate onsite solar and electric vehicle charging stations when practicable; stay up-to-date with Hawai'i legislation on renewables and carbon offsets
- Adhere to State regulations, use guidelines from U.S. Green Building Council (LEED certification program)
- Educate, train, motivate employees on energy efficiency practices

Data Analysis

The first step in managing energy at a golf course is understanding consumption. This is gauged by conducting an energy audit through a third party or inputting data from monthly utility bills, receipts, and statements into a spreadsheet. Once annual data is entered, it should be designated as the baseline year to measure against in subsequent years. When practicable, conduct a carbon footprint analysis using total energy consumption to determine emissions, consult an expert if needed.

Make sure an adequate number of meters and gauges are installed and operating properly. If feasible, track energy used by the pump station separately; it accounts for the most significant energy use on the course. When practicable, segregate data on meters by area including maintenance buildings, clubhouse, tennis facilities, pools, or additional amenities for optimal monitoring and control.

Energy Use Conversion Factor: To understand aggregate energy used on a golf course for electricity, natural gas, gasoline, diesel, propane, and heating oil, a conversion factor to BTU for each energy input may be used. (reference chart footnote 12 GCSAA 2017* US Department of Energy)

Analyzing Data & Setting Energy Reduction Goals

Look at consumption metrics by month, area, day of week, and time of day. Factors to consider during analysis year-over-year, by month, or quarterly include:

- Electricity utilization during peak hours 7 a.m. to 9 p.m.
- Unusually high temperatures creating increased HVAC usage - Hawai'i's summer season between May and October
- Periods of drought causing increased irrigation - Hawai'i's heaviest rains usually come from winter storms between October and April
- Events and seasonality (by island) resulting in increased energy consumption
- Alterations to landscape or building renovations
- Faulty or damaged equipment

Energy Use Intensity

Energy use intensity, or EUI, expresses a building's energy use as a function of its size or other characteristics. It's calculated by dividing the total energy consumed by the building in one year (measured in kBtu or GJ) by the total gross floor area of the building. A low EUI signifies good energy performance. EUI helps to benchmark and gauge the effect of renovations and expansion within clubhouses or other built environments. Example benchmarks and conversion data may be found at www.energystar.gov.

Look for trends, spikes, or potential issues which could be caused by faulty equipment, leaks, or peak utilization.

Equipment maintenance can impact energy use and is important to consider when analyzing data. Keep proper equipment maintenance, maintain service logs, and consider whether you've acquired newer, more efficient equipment or shifted to an alternate approach (e.g., switching to hybrid diesel-electric fairway mowers vs. hydraulic diesel motors may change energy use composition). Take an equipment inventory on a regular basis - logging date of operation, energy used, patterns, issues, and operational hours. This shows changes in energy use and supports capital expenditures.

Once energy efficiency and reduction opportunities have been identified, prioritize opportunities within the context of the overall business and regulatory requirements. The broader business strategy may factor in guest/member experience and satisfaction, employee satisfaction, renovations, or area/departmental priorities; each property is unique. Regulations may require minimum efficiency standards for products and Hawai'i energy code compliance requirements for buildings, such as HB103 and HR203.

Reference Hawai'i State Legislature at www.capitol.Hawai'i.gov or through the US Department of Energy at www.energycodes.gov/adoption/states/Hawai'i for current legislation and codes.

After establishing priorities, determine annual goals for energy use versus prior year. Goals for energy conservation could encompass initiatives related to infrastructure, equipment, behavior, processes, and agronomic practices. Aim for SMART goals which are Specific, Measurable, Attainable, Relevant, and Timely. Share goals with employees at monthly meetings and post them in a clearly visible area

Monitoring, Tracking, and Communication

Establish a tracking mechanism to monitor energy use regularly. At a minimum, create a spreadsheet detailing units of measurement, energy used by day, month, meter or department, rates, weather, and energy conversion factors. There are tools and software services available for tracking, such as Energy Star. If feasible, particularly at resort facilities, consider energy management software which can provide robust data and controls, incorporating intelligent building automation systems and monitoring. Calculate savings achieved through energy reductions to track progress and support energy efficient capital investments.

Analyze data weekly or monthly to confirm progress toward goal attainment and note inefficiencies, spikes, or issues. Establish performance parameters to optimize irrigation pumps. Communicate results with employees on a weekly basis and post signage showing monthly progress to goal attainment to encourage teamwork and innovation, address opportunity areas, and reward successes. Consider scorecards and/or benchmarking performance between departments, or against similar-sized facilities.

Behavior

An energy management plan (EMP) moves priorities forward by aligning stakeholders around common goals. It creates structure, accountability, and a timeline. It is a continuous improvement process centered around the concept of "Plan-Do-Check-Act" which incorporates a roadmap, implementation, monitoring, and adjustments. The goals of an EMP often intersect with other BMPs, increasing impact across areas. For example, an effective preventive maintenance program can improve equipment efficiency and reliability. Irrigation efficiencies, leak detection, and monitoring can improve energy performance. Conversely, energy management practices can help lower maintenance, increase equipment life, and lower emissions.

Recommendations for energy efficiency opportunities come from a variety of sources, including reference materials, industry success stories, staff, consultants, or energy providers. Include relevant stakeholders and key management 'champions' as part of the energy management team. This includes employees responsible for a specific job or task, managers, and departments influential in decision-making or processes. Example departments include engineering, finance, IT, food and beverage, events/catering, stewarding, and guest/member services; key partners and contractors should also be considered. Effective engagement of stakeholders and champions will drive efficiencies, reduce bottlenecks, and positively impact departments.

What to Include in EMP: Prioritizing, Determining Steps, Assigning Tasks

Focus efforts by choosing the top three to five energy conservation opportunities based on your analysis or energy audit. Based on course size, Hawaiian Electric Industries (parent company of county utilities) can help assess and evaluate existing programs. An account manager can perform analyses and advise of opportunities for reductions.

Priority initiatives could include infrastructure updates, onsite renewable energy production, equipment upgrades or maintenance, behavioral/process changes, or agronomic practices. Designate priority initiatives by energy source (electricity, fuel, etc.). Consider benefits and investments, including upfront and long-term costs.

Establish steps to implement by identifying:

- Resources needed (capital expenses, acquiring/updating products/systems, communications, etc.)
- Departments involved
- Projected energy reductions
- Estimated cost savings
- Timeframe

Align priorities and steps with task owners to maximize teamwork and accountability.

Implementation

Tie EMP progress to overall energy reduction goals. Communication and engagement should happen on several levels.

- Engage energy management team weekly and/or monthly to review progress
- Engage leadership team regularly to provide updates to support investment decisions and show progress
- Communicate with all staff regularly, including updates to employees within stakeholders' departments
- Share EMP conservation highlights and achievements with members and guests

Policy and Performance Guidelines

Energy conservation requires behavioral changes. A commitment or position statement toward energy conservation, policies, and planning should be established at the facility or resort level. This shows employees, guests, and members that energy conservation is a priority.

Recommended (or required) performance guidelines should be distributed according to building or operational area such as the clubhouse, swimming pool, food and beverage, parking lot, offices, maintenance building, tennis courts, etc. Stakeholders from each area should be engaged in monitoring and adhering to conservation commitments.

Golf maintenance should establish its own position statement under the broader framework to include surrounding landscapes, the pump station, irrigation system, and related agronomic operations including turfgrass maintenance.

Behavioral Practices: Lighting, HVAC, Irrigation/Water, and Equipment

Heating, ventilating, air conditioning (HVAC) may account for 40 to 50 percent of total electricity usage for a building (e.g., clubhouse). Energy conservation measures for HVAC can have a significant impact on electric bills. Lighting may account for more than 20 percent of total electricity used in a building. Hot water within facilities is used for showers, hand-washing, and restaurant operations. Miscellaneous equipment, such as office equipment, can represent more than 20 percent of electricity used in a building.

Turning off devices and administering a regular maintenance program will help lower electricity expenses. Keeping mechanical systems clean improves HVAC efficiency by 10 to 20 percent.

For golf course maintenance, the irrigation pump is the largest user of energy. A well-engineered pump station, proper maintenance, and monitoring are critical to reducing energy (and water) consumption. Ensure efficient operation and maintenance of the pump station, irrigation pumps, controls, and components. Pumps in Hawai'i generally last five to seven years with proper maintenance. Common issues include power surges from the utility company which can damage the transformer and motor. Pump stations and well pumps with variable frequency drives (VFD) help minimize energy consumption and equipment damage based on reduced water surge. Audit the irrigation system to assess efficiency and determine needs for upgrades, alternative equipment, or components.

Schedule irrigation during off-peak demand hours in the evening or early morning. If feasible, consider a prescriptive irrigation system with remote mobile control capabilities to help manage usage and detect leaks in order to reduce energy consumption.

Hawaiian Electric Fast Demand Response Program

Commercial customers who qualify can lower energy use and electric bills. Hawaiian Electric Industries places automatic or semi-automatic controllers on non-essential equipment to lower use and support grid stability in exchange for financial incentives. For details visit: https://www.Hawaiianelectric.com/save-energy-and-money/demand-response/fast-demand-response

Wastewater Treatment

Hawaiian Electric estimates that 20 percent or more energy savings can be gained from energy efficiency measures in water and wastewater sectors. Onsite wastewater treatment is unique for a club in Hawai'i, however worth noting that opportunities for energy efficiency in water and wastewater systems can be found in electric motors, the use of controls to optimize operations, optimization of pump and well operations, and reduction of volume being treated and distributed; in addition to solids handling processes and disinfection systems (UV systems). There is potential for onsite electrical and thermal energy generation using anaerobic digester gas, a byproduct of the anaerobic sludge digestion process, as a renewable energy resource.

Energy Management Tip!

Create a checklist of energy reduction behavioral best management practices for your clubhouse, golf maintenance facility, and other buildings on property. This can be used as a self-audit and guide toward continuous improvement.

See next page for an example checklist >>

Energy Reduction Best Management Practices Checklist

Lighting	Y/N	HVAC	Y/N	Irrigation/Water	Y/N	Equipment	Y/N
Conduct a lighting audit		Clean & change air filters regularly		Maintain plumbing fixtures/piping to avoid losses		Check electricity meters at least once per month	
Arrange interior space to optimize natural light & comfort zones		Utilize ceiling fans		Run irrigation early in the morning or late at night		Operate machines according to manufacturers' recommendations for energy efficiency	
Initiate 'lights off' employee awareness campaign		Ensure HVAC units have proper ventilation		Repair leaks		Avoid automatically turning on kitchen equipment when arriving in morning	
Display reminders & visual management signage		Turn off air/set heating at minimum in unoccupied rooms		Check insulation on hot water pipes to reduce heat losses		Consider temperature of kitchen rooms when installing or relocating refrigerators/freezers	
Code light switches (labels or color) to switch on only those needed		Close exterior doors when not in use		Check laundry room equipment regularly for leaks		Turn off food & beverage equipment when not in use	
Reduce general lighting during daytime				Water less area, apply hand watering		Do not exceed oven preheating times	
Turn exterior lighting on only at night; utilize timekeepers				Evaluate cleaning practices (dry vs. wet washing)		Open refrigerators & freezers only when necessary	
Train staff & invite guests/members to get involved						Defrost refrigerators & clean door seals monthly	
Maintain routine preventive maintenance on lighting equipment						Fill dishwashers & washing machines to maximum capacity	
Turn off lights in unoccupied rooms						Use low temperature wash cycles & avoid overloading dryers	
Limit pool lighting that is not required for safety						Conduct regular PM on equipment, vehicles	
						Run washer/dryer during off peak hours	
						Do not leave televisions on standby	
						Switch off equipment (copiers, computers, printers, coffee) when not in use	
						Charge golf carts & equipment during off-peak hours (evening/ early a.m.)	
						Encourage car sharing; designate EV parking & charging stations	
						Source products locally to reduce logistics/transportation fuel consumption	
						Log equipment use including hours operated, length of use, patterns to determine efficiencies (e.g., shift to off-peak hours, minimize use per week, etc.)	

Energy Management Tip!

Create a checklist of energy reduction product selection best management practices for your clubhouse, golf maintenance facility, and other buildings on property. This can be used as a self-audit and guide toward continuous improvement.

Reference Hawaiian Electric General Best Practices in Appendix B.

See next page for an sample checklist >>

Equipment Efficiencies

Establish a Supplier Code of Conduct (SCOC) and Environmental Purchasing Plan (EPP) that aligns with your position statement. The SCOC should incorporate adherence to Hawai'i state laws and regulations as they pertain to environmental legislation, including energy codes and green building design. The EPP builds upon your energy policies, outlining product/service selection priorities for energy efficiencies, reductions, innovation, and environmental responsibility. Prioritize energy consumption as part of purchase decision-making for HVAC, food service, laundry, swimming pools, etc. This helps align suppliers with your energy conservation goals and objectives.

Conduct quarterly supplier meetings to identify new technologies, products, or upgrades that improve efficiencies. Examine fuel types, level of energy required, and use of alternative energy or fuels. Shifting to hybrid mowers and electric golf carts helps reduce fuel consumption and lowers greenhouse gas emissions, more closely aligning with the Hawai'i 2045 renewable energy and carbon neutrality goals.

Your carbon footprint extends beyond the course. Purchase goods locally on island or within the state, when practicable. Purchases which require transport from the mainland or internationally increase greenhouse gas emissions, in addition to time, potential damage, and shipping costs. Work with the Hawai'i GCSA, Chamber of Commerce, your finance manager, or existing suppliers to find local solutions.

For new equipment purchases throughout the club, consider programs like Energy Star or the EPA's WaterSense program for product labeling to identify products with high energy efficiency. The State of Hawai'i and Hawaiian Electric Industries offer rebates and incentives which may apply to an equipment purchase.

To learn more visit https://Hawai'ienergy.com/for-businesses/incentives or the Database of State Incentives for Renewables & Efficiency at http://www.dsireusa.org/.

Energy Reduction Best Management Practices Checklist

Lighting	Y/N	HVAC	Y/N	Irrigation/Water	Y/N	Equipment	Y/N
Install LED lighting and/ or retrofit devices		Install energy-efficient air conditioning/chiller equipment		Install shower flow restriction devices to reduce water usage		Choose programmable thermostats	
Replace less efficient T12s with low-wattage T8 & T5 lamps with electronic ballasts		Install HVAC fans & pumps with variable frequency drives (VFDs) that control pump speeds		Install insulation on water heater tanks and pipe		Install onsite photovoltaic solar panels for onsite electricty generation	
Replace incandescent bulbs with CFLs which use less energy & last longer		Install window film to reduce air/heat loss		Install energy efficient water-heating equipment		Install National Electrical Manufacturers Association's (NEMA) premium efficiency-rated pump motors	
Replace fluorescent light exit signs with LEDs		Maximize envelope efficiency; choose high performance insulation systems		Install aerators to reduce demand for hot water		Install solar/geothermal pumps for pools	
Install induction lighting in hard-to-reach places & public facilities		Add insulation for windows & doors, such as weather stripping & thresholds		Install water-saving devices (flow regulators, water flow sensors, self-closing taps, low-flush toilets)		Select a well-engineered pump station with variable frequency drives (VFDs) to minimize water & energy use	
Install pulse-start metal halide & high-pressure sodium lamps in spaces with prolonged use & high ceilings		Utilize energy management systems		Install prescriptive irrigation systems to manage use & detect leaks		Select hybrid equipment including fairway mowers	
Add occupancy sensors or programmable timers		Decrease daytime thermostat setting		Audit irrigation system		Choose electric or battery-powered golf carts	
Install light tubes & natural light maximizers		Install a night setback system to lower room temperature at night		Install localized devices (micro- sprinklers, drip irrigation) for plants & ornamentals		Choose Energy Star rated equipment for clubhouse operations	
		Install an economizer to use outdoor air for cooling		Incorporate native plants to reduce water & energy use			
		Install a timer on supply air fans		Install rooftop solar thermal panels for water heating			
		Install double-glazed windows		Incorporate drought resistant, salt tolerant turf (e.g., paspalum) to lower irrigation needs			
		Shade windows from sun to limit HVAC needs (awnings, automatic louvres, curtains, blinds, screens, heat reflecting sheets, trees)					
		Incorporate a green roof with vegetation or cool roof (white or cool colored)					

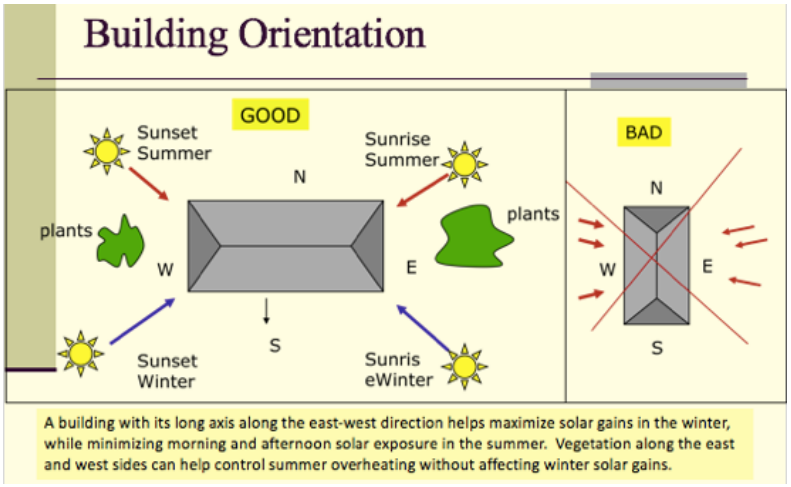
Stay Up to Date

Stay up-to-date on Hawai'i legislation to incorporate energy reduction measures and regulations. For example, HB2274 could expand the Hawai'i's electric vehicle charging requirements to include public parking lots based on a ratio calculating the total necessary electric vehicle parking stalls a facility with more than 100 stalls must have after 7/1/2021. (if facility was built after 2016) https://www.capitol.Hawai'i.gov/

Design

New construction and renovation offers an opportunity to integrate energy efficiencies into the built environment and golf course design. Engage partners including the building and golf course architects, builders, contractors, engineers, etc. to prioritize energy reductions and efficiencies as part of project requirements. Educate stakeholders on your club's energy conservation position statement. Work with Hawai'i regulators and Hawaiian Electric Industries to optimize programs and meet standards.

Assess initial investments and long-term gains, maintaining a focus on integrating energy conservation measures. Consider building location, orientation, course slope, native vegetation, landscape placement, drought resistant turf such as paspalum, and materials used (e.g., thermal conductivities, best materials for cooling, etc.) Conduct a lifecycle assessment on materials used to understand environmental impact. Utilize energy efficient lighting. Evaluate smart building automation systems, monitoring systems, programmable scheduling and controls, etc. and incorporate innovative technology.



A building with its long axis along the east-west direction helps maximize solar gains in the winter, while minimizing morning and afternoon solar exposure in the summer. Vegetation along the east and west sides can help control summer overheating without affecting winter solar gains.

For construction it is particularly important to source locally where practicable, especially heavy or bulky materials. This reduces embodied energy (energy used in the extraction, production, transportation and construction of a building material) to lower your carbon footprint. Energy conservation measures and suppliers may be found through the US Green Building Council, including details on the LEED framework and certification for highly energy efficient, green buildings; also the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, or ASHRAE for energy efficiency standards and guidelines.

Onsite Solar Electricity Generation

The state of Hawai'i has a goal of 100 percent renewable energy use and carbon neutrality by 2045. An increasing number of Hawai'i golf clubs and resorts are installing solar to provide onsite electricity. When evaluating benefits and costs, look at the long-term effect and payback period, in addition to employee and community well-being.

Hawaiian Electric Industries provides comprehensive resources and tools for evaluating onsite solar generation and alternative transportation options. Solar factors to consider include location, building design, distribution availability, required steps, timeframe, and financing. Hawaiian Electric provides a database of pre-approved EVO certified contractors to assist with the process for faster, easier installations.

State rebates and incentives are available for solar generation and electric vehicles, visit the Database of State Incentives for Renewables & Efficiency http://www.dsireusa.org/ or Hawaiian Electric https://www.Hawaiianelectric.com/clean-energy-Hawai'i/electric-vehicles.

Carbon Offset Program

Hawai'i does not formally offer a carbon offset program, 2018 legislation was passed to implement one effective January 28, 2045. HB1986 establishes a carbon offset program under the Department of Business, Economic Development, and Tourism, in partnership with the Department of Land and Natural Resources. Proceeds and revenue generated will be deposited into: forest stewardship fund; projects enhancing water infrastructure; or mitigating threats to water sustainability due to climate change.

Hawaiian Electric Solar Site Considerations: location (roof or ground mounted), area, orientation and tilt, and shading.

Hawai'i-specific guidelines to determine if your roof or site is a good fit for PV:

- The location is free of shading between 9 a.m. and 3 p.m.
- Preferred orientation allows for south facing
- Tilt (pitch of the roof) is close to 20 degrees, for Hawai'i
- No roof repairs are needed in the near term
- Roof structural members are sound
- Roof warranty will not be voided if penetrations are made
- The available roof area is sufficient for the size of system to be installed

Education

It is important to educate and engage employees. Incorporate energy conservation training that creates a connection between better quality of life, cleaner air, and preservation of natural resources. Provide tips and quizzes to make it fun and memorable. Educate through email, signage on bulletin boards, and handouts. Engage peer influencers to demonstrate importance.

Communicate progress toward departmental and organizational goals for energy reductions. Improve transparency by reporting facility usage and developing a departmental scorecard. Dynamic ideas come from employees engaged in daily operations. Shorten feedback delays by discussing energy as a weekly topic or in daily staff meetings. Restructure information flow by encouraging idea-sharing or providing a suggestion box. Incorporate incentives for ideas and achieving results.

Celebrate energy conservation successes and provide recognition on bulletins, in meetings, and newsletters. Award certificates of accomplishment for individual and team contributions. Rewarding successes and recognizing efforts helps institutionalize energy conservation.

Appendix A

Table 1A - Plant Species Listed as Endangered

Scientific Name	Common Name	Hawaiian Island
Asplenium diellaciniatum	No common name (NCN)	Kauai
Calamagrostis expansa	Maui reedgrass	Hawai'i, Maui
Cyanea kauaulaensis	NCN	Maui
Cyclosorus boydiae	kupukupu makalii	Hawai'i (H), Maui, Oahu
Cyperus neokunthianus	NCN	Maui (H)
Cyrtandra hematos	haiwale	Molokai
Deparia kaalaana	NCN	Hawai'i (H), Maui, Kauai (H)
Dryopteris glabra var. pusilla	hohiu	Kauai
Exocarpos menziesii	heau	Hawai'i, Lanai (H)
Festuca Hawai'iensis	NCN	Hawai'i, Maui (H)
Gardenia remyi	nanu	Hawai'i, Maui, Molokai, Kauai
Huperzia stemmermanniae	NCN	Hawai'i, Maui (H)
Hypolepis Hawai'iensisvar. mauiensis	olua	Maui
Joinvillea ascendensssp. ascendens	ohe	Hawai'i, Maui, Molokai, Oahu, Kauai
Kadua fluviatilis	kamapuaa	Oahu, Kauai
Kadua haupuensis	NCN	Kauai (H)
Labordia lorenciana	NCN	Kauai
Lepidium orbiculare	anaunau	Kauai
Microlepia strigosavar. mauiensis	NCN	Hawai'i, Maui, Oahu
Myrsine fosbergii	kolea	Oahu, Kauai
Nothocestrum latifolium	aiea	Maui, Lanai (H), Molokai, Oahu, Kauai (H)
Ochrosia haleakalae	holei	Hawai'i, Maui
Phyllostegia brevidens	NCN	Hawai'i, Maui
Phyllostegia helleri	NCN	Kauai

Scientific Name	Common Name	Hawaiian Island
Phyllostegia stachyoides	NCN	Hawai'i (H), Maui, Molokai
Portulaca villosa	ihi	Hawai'i, Maui, Kahoolawe, Lanai (H), Molokai, Oahu (H), Kaula (H), Lehua (H), Nihoa (H)
Pritchardia bakeri	Baker's loulu	Oahu
Pseudognaphalium sandwicensium var.molokaiense	enaena	Maui, Lanai (H), Molokai, Oahu (H)
Ranunculus hawaiensis	makou	Hawai'i, Maui (H)
Ranunculus mauiensis	makou	Hawai'i (H), Maui, Molokai (H), Oahu (H), Kauai
Sanicula sandwicensis	NCN	Hawai'i, Maui
Santalum involutum	iliahi	Kauai
Schiedea diffusa ssp.diffusa	NCN	Maui, Molokai (H)
Schiedea pubescens	maolioli	Maui, Lanai (H), Molokai
Sicyos lanceoloideus	anunu	Oahu, Kauai
Sicyos macrophyllus	anunu	Hawai'i, Maui (H)
Solanum nelsonii	popolo	Hawai'i, Maui (H), Molokai, Niihau (H), Pearl & Hermes, Kure, Midway, Laysan, Nihoa
Stenogyne kaalae ssp.sherffii	NCN	Oahu (H)
Wikstroemia skottsbergiana	Akia	Kauai

(H)=historically known from island, but not observed in the past 20 years.

Table 1B - Animal Species Listed as Endangered

Common Name	Scientific Name	Hawaiian Island
Band-rumped storm-petrel	*Oceanodroma castro*	Hawai'i, Maui, Kahoolawe, Lanai, Molokai (H), Oahu (H), Kauai, Lehua
Yellow-faced bee	*Hylaeus anthracinus*	Hawai'i, Maui, Kahoolawe, Lanai (H), Molokai, Oahu
Yellow-faced bee	*Hylaeus assimulans*	Maui, Kahoolawe, Lanai, Oahu (H)
Yellow-faced bee	*Hylaeus facilis*	Maui (H), Lanai (H), Molokai, Oahu
Yellow-faced bee	*Hylaeus hilaris*	Maui (H), Lanai (H), Molokai
Yellow-faced bee	*Hylaeus kuakea*	Oahu
Yellow-faced bee	*Hylaeus longiceps*	Maui, Lanai, Molokai, Oahu
Yellow-faced bee	*Hylaeus mana*	Oahu
Orangeblack Hawaiian damselfly	*Megalagrion xanthomelas*	Hawai'i, Maui, Lanai, Molokai, Oahu, Kauai (H)
Anchialine pool shrimp	*Procaris hawaiana*	Hawai'i, Maui

(H)=historically known from island, but not observed in the past 20 years.

Appendix B

Checklist for General Best Practices

Best Practice Analyzed? (Date)	Further Review Needed? (Yes/No)	Best Practice Possible? (Yes/No)	#	Best Practice	Typical Energy Savings of Unit Process (%)	Typical Payback (years)
			1	Facility Energy Assessments	10 – 50	Variable
			2	Real-Time Energy Monitoring	5 – 20	Variable
			3	Energy Education for Facility Personnel	Variable	Variable
			4	Comprehensive Planning Before Design	Variable	0.5 - 5
			5	Design Flexibility for Today and Tomorrow	Variable	1 - 5
			6	Electric Peak Reduction	Variable	< 1
			7	Manage Electric Rate Structure	Variable	Variable
			8	Idle or Turn Off Equipment	Variable	< 1
			9	Electric Motors: Install High Efficiency Motors	5 – 10	< 2
			10	Electric Motors: Automate to Monitor and Control	Variable	Variable
			11	Supervisory Control and Data Acquisition (SCADA)	Variable	Variable
			12	Electric Motors: Variable Frequency Drive Applications	10 – 40	0.5 - 5
			13	Electric Motors: Correctly Size Motors	Variable	Variable
			14	Electric Motors: Properly Maintain Motors	Variable	Variable
			15	Electric Motors: Improve Power Factor	Variable	Variable
			16	Pumps: Optimize Pump System Efficiency	15 – 30	0.25 - 3
			17	Pumps: Reduce Pumping Flow	Variable	Variable
			18	Pumps: Reduce Pumping Head	Variable	Variable
			19	Pumps: Avoid Pump Discharge Throttling	10 – 50	Variable
			20	Filtration: Sequence Backwash Cycles	Variable	Variable
			21	Ultraviolet (UV) Disinfection Options	10 – 50	Variable
			22	Energy Manager	Variable	Variable
			23	Utilize and Manage Monitored and Recorded Data	10 – 20	Variable
			24	Ensure Plant Personnel Receive, Review and Understand Monthly Energy Bills	Variable	Variable
			25	Utilize Life-Cycle Cost Analysis for Purchase Selection	Variable	Variable
			26	Energy Efficiency Projects Can Pay for Themselves	Variable	Variable
			27	How Do I Implement Energy Efficiency and/or Renewable Energy Projects	Variable	Variable
			28	Pump Station Assessment	20 – 50	Variable

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