CHAPTER 6

Source Water Protection

In this Chapter

Key Points

- Lana`i is unusually dependent upon its mauka watershed, because Lana‘i is dependent upon fog drip. Over 65% of the recharge in the primary high level aquifer for Lana‘i is believed to be attributable to fog drip. Loss of fog drip from Lana‘i Hale would lead to the loss of over 50% of the water levels in the Central aquifer, essentially the only viable water source for the island. Estimates from studies elsewhere indicate that fog drip interception by mountain forests increase precipitation by as much as 30%, and recharge by 10-15%.

- The watershed on Lana‘i is a low elevation cloud forest, with a strong mix of mesic species. Maintaining native cover becomes especially important in light of its role in the water budget for Lana‘i and the rising inversion layer. Yet less than 30% of the native cover in the cloud forest remains.
- Threats to the watershed include: habitat alteration by feral animals, human activity and invasive species; continuing intrusion of exotic plant and animal species which can trample, prey on or out-compete native species; loss of critical populations; loss of native pollinators and other keystone species; introduced pathogens and insects; erosion; drought, and; high vulnerability to fire due to mesic conditions combined with the spread of fire inducing weeds.
- Key management measures include: fencing the most valuable watershed; eliminating feral animal ingress to fenced areas; removal of non-desirable weed and animal species; planting of desirable native species; erosion and fire prevention measures; and limiting human activities in key areas. More specifics are provided.
- Where drinking water is concerned, prevention of pollution is less expensive and more efficient than cleaning it up. One of the first tasks in any effective prevention program is to identify and inventory wells to be protected, areas that feed them and activities or sources of pollutants that pose a potential risk or could degrade water quality.
- Drinking water wells on Lana‘i were mapped, and a computer model was used to evaluate the area surrounding each well which could contribute to its water withdrawals within a 2, 5, 10, 15, 20 and 25 year time periods.
- Water that can reach a well within two years can contribute bacteria and viruses to the drinking water in that well. Although chemical contaminants may be persistent well beyond 10 years, this is the time frame broadly used in wellhead protection programs, as it is assumed that within that time frame protective measures may be taken in the event of a spill.
- Among the potential contaminant sources identified were the following: Wells 1, 9 and 7 are located in or near former pineapple fields. Well 9 is also near some former underground storage, and Well 7 near some old above ground storage. Traces of atrazine have been found in Well 1 in the past. Well 8 is within 1,000 feet of the Koele golf course. A list of contaminants that may be generated by the types of activities found is provided.
- Potential management strategies and measures are described. These include regulatory measures such as overlay zones and prohibitions, non-regulatory measures such as purchase of easements or incentivization of best management practices, guidelines, education and others.
- The recommended wellhead protection strategy involves an overlay zoning ordinance which either prohibits or prescribes best management practices for various uses at different times of travel. Also included in the strategy are non-regulatory measures, such as guidelines for mixed use developments, protective land agreements, incentives and education for best management practices or protective measures, and measures to improve well siting. Implementation of this ordinance would require coordination between the DWS and other agencies, particularly the Planning Department.
- If water levels in pumping wells reach half their initial head level, this is now grounds for designation proceedings, based on a January 31,1990 decision by the CWRM. CCR has also offered voluntary guidelines which set action levels at about 2/3 of initial head. These are delineated in

the well operating guidelines section. Upon reaching a designation trigger or lowest allowable level, pumpage in a well is expected to stop. Upon reaching an action level, a well is to receive scientific review and investigation, as well as some public scrutiny.

- Action levels and lowest allowable levels from CCR's voluntary well operating and management guidelines, as well as designation triggers, are provided on page 6-121.

Watershed Protection

The Role of the Forest in Water Production

The Hawai'ian Islands are unique in their geology, their geographic isolation, their species endemism and their beauty. Rising 16,000' from the ocean floor at sea level, the tallest island rises nearly another 14,000' more, while the smallest barely tops the surface.

The Hawai'ian archipelago is a 1,500 mile chain of volcanic islands and atolls, created over more than 20 million years. The oldest islands are Kure atoll and Midway at the northwest extent of the archipelago. Rock formations on Kaua'i have been dated between 5 and 6 million years old, while the islands of Hawai'i and Lo'ihi are still growing.

Formed by volcanic eruption, shaped and molded by winds, wave action, erosion, rain and even ice (Mauna Kea sported an ice cap during the Pleistocene era), Hawai'i is also unique in its hydrologic qualities. Volcanic basalts include some of the most permeable formations on earth. Given the steep, mountainous terrain of much of the islands, highly permeable rocks and soils are an especial boon to water recharge in some areas. In other areas, denser lava flows, ponded lava, deposits of alluvium or volcanic ash, and rifts and dikes help to contain water, even creating warm, high elevation brackish water pockets in some places.

Surrounded by water and blessed with some of the wettest places on Earth, Hawai'i nevertheless is located in a fairly arid area, with rainfall in the open ocean surrounding the islands averaging only 25" to 30" per year. Yet Mount Wai'ale'ale on Kaua'i receives over 400" of rain per year.

The secret to Hawai'i's natural abundance of water lies in a convergence of winds upon its richly forested mountains. Northeasterly trade winds gain moisture and warmth as they flow for thousands of miles over the tropical Pacific. As these winds reach the islands they are deflected upslope, cooling as they rise and causing moisture to condense. From equatorial regions to the south, air heats and rises, flowing toward the poles. Meanwhile high, cold air from polar regions sinks and flows toward the equator. High elevation cool winds traveling from the northeast subside toward the ocean surface. This subsiding air forms a layer that blocks the rise of the trades up the mountains. The result is a subsidence inversion known as the trade inversion. The trade inversion causes a layer of warmer air to form between 4,800' and 7,000'. When the warm, moisture laden trades rise up the mountains, the rising air is held down by this inversion layer. This convergence of moisture laden air leads to the condensation and release of moisture in Hawai'i's cloud forests.

If not for Hawai'i's mountain forests, most of this moisture would simply run off immediately to the sea. Instead, as this moisture condenses, it adheres to thousands of stems, leaves, twigs, lichens and other surfaces in the watershed.

FIGURE 6-1 Cloud Forest

The multi-leveled, thickly vegetated nature of Hawai‘ian cloud forests provide abundant surface area to help capture and collect large amounts of water. The mosses, lichens, ferns, leaf litter and soils of the forest floor also help to increase the collection and storage value of the forest. The mist laden air surrounding the forest, and the abundant shade from multiple levels of vegetation, help to decrease evapotranspirative losses that would normally occur in a warm, highly vegetated region.

By breaking the impact of heavy rains, holding large quantities of water with surface tension and absorption, and thus allowing a slower, more manageable impact to the ground via stem and leaf drip, Hawai‘ian cloud forests not only reduce the erosive impacts of freshets, but also enable higher and more sustained quantities of recharge. The sponge-like ability of the mosses and fern layers, as well as root-zone soil strata, help to facilitate recharge and minimize water loss during dry periods, holding moisture and keeping the ground shaded.

Hawai‘i’s watershed forests contribute to the high quality of the islands’ waters. Forests have been compared to the kidneys in the body, which filter impurities out of the blood. Particles are removed by adhering to leaves, stems and soils. Certain compounds, especially nutrients, can be absorbed by leaves or root systems. Leaf matter and well graded soils also help filter particles of water.

Hawai‘ian cloud forests are particularly good water managers, and perform the five functions discussed above, namely: 1) collection of water, 2) storage of water, 3) regulation of the discharge of water, 4)erosion control and 5) improving water quality.

Collection of Water

As moisture laden air travels over the ocean and up the mountains, it comes into contact with the abundant plant cover in the forest. The moisture condenses, adheres to, and is absorbed by vegetation and forest litter. Every stem, leaf, twig and bit of moss helps to collect water.

Storage of Water

Hawai'ian forests are characterized by a dense understory of ferns and mosses, and by multiple levels of plant surfaces. The multidimensional layers and dense understory, and especially the carpet of moss and ferns that typify Hawai'ian watersheds serve, not only as excellent collection systems but also as storage reservoirs for water. Abundant surface area and multiple surface layers help to absorb and hold more water and to reduce evapotranspirative losses even where large amounts of plant materials are present. Mosses, lichens and ferns are also able to hold large quantities of water.

Regulation of the Discharge of Water

During a heavy rain, the forest canopy and dense under- layers break the impact of falling raindrops, while the sponge-like abilities of mosses and forest floor plants, as well as root-zone soil strata help to hold the water. The understory and groundcovers also help to keep the air and soil in the watershed moist, while facilitating continued recharge and minimizing water loss during dry periods.

Control of Erosion

Erosion control results from the ability of the canopy and other vegetative layers to break the impacts of heavy rain, as well as from the soil holding capacities of the roots. The roots and dense growth serve to keep soil aerated and penetrable, helping to prevent run off, and also preventing the soil from becoming so dry and exposed that it becomes powdery and blows away. In this way, the healthy forest cover helps to promote recharge and minimize soil loss.

Improvement of Water Quality

The watershed forest helps to keep water clean. Impurities in water are removed by adhering to leaves, stems and soil particles. Certain compounds, especially nutrients, can also be absorbed or taken up by both leaves and root systems. The leaves and well graded soils found in a healthy watershed also help to filter particles out of the water.

The effects of Hawai'ian forests on island recharge are profound. Perhaps the most dramatic example is the island of Lana`i, one of the least forested of all the main islands, with relatively low rainfall and a sustainable yield of only 6 MGD.

FIGURE 6-2 Role of Forests in Hydrologic Cycle

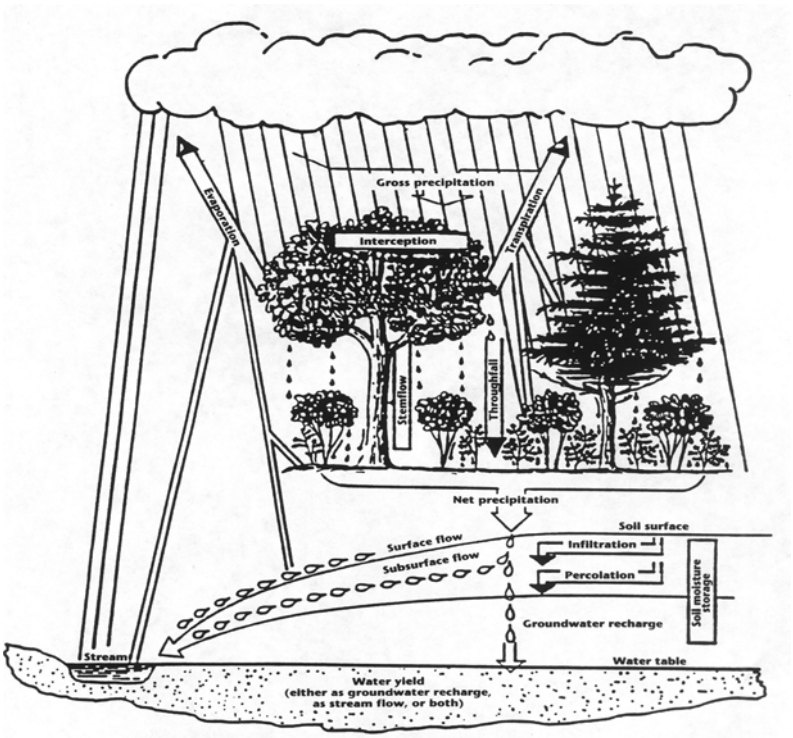

Illustration of the role forests play in the hydrological cycle and watershed protection. (Source: Cassells, Hamilton & Saplaco)

A 1967 State Land Bureau study investigated soils and vegetation on Lana‘i Hale and concluded that they were more typical of an area receiving 60" / year of annual rainfall - or nearly double the amount received on most of Lana‘i - than of the 35-40” that actually fall on Lana‘i Hale. More recently, *A Numerical Groundwater Model for the Island of Lana`i, Hawai‘i* (CWRM-1, Hardy, ‘96) estimated that over 65% of the recharge in the primary high level aquifer for Lana‘i was attributable to fog drip, and that the loss of fog drip from Lana‘i Hale would lead to the loss of over 50% of the water levels in the Central aquifer, essentially the only viable water source for the island. Lana`i is unusually dependent upon fog drip. Estimates from studies elsewhere indicate that fog drip interception by mountain forests increase precipitation by as much as 30%, and recharge by 10-15%.

The mauka cloud forests are as vulnerable as they are important to the water budget of the islands. Hawai‘ian forest ecosystems evolved in extreme geographic isolation, over 2,400 miles from the nearest continent, with an estimated species introduction rate of one in every 10,000 years, Hawai‘ian species were not exposed to the same pressures and competition as continental species. The result is that many Hawai‘ian species are not well equipped to defend against invasive weeds from more competitive environments, nor from exotic animal pressures such as grazing, browsing, trampling and imported diseases, pests and pathogens. Introduced species can over-run native ecosystems.

Lana`i has suffered the ravages of such introductions. In his 1993 article, "Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawai'ian Island"; (*Pacific Science*; Vol.. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993), Robert Hobdy estimated that, of the original plant communities on Lana`i, more than 2/3 have been lost. This circumstance is particularly worrisome on Lana`i, where sustainable ground water yield is less than 10% that of Molokai, and less than 2% that of Maui.

Theoretical, empirical, anecdotal and modeling evidence indicate that loss of forest cover, and associated loss of fog drip, has likely impacted water recharge on Lana`i.

The State Land Study Bureau (Sahara et. al '67, quoted from CWRM-1, Hardy '96) studied the vegetation and soils on and around Lana`ihale and concluded that the vegetation and soils of the forest were more typical of one receiving 60" per year than 35 or 40". They attributed this apparent anomaly to the continuous cloud cover. Hardy, in *A Numerical Ground Water Model for the Island of Lana`i, Hawai'i*, describes several such investigations into fog drip on Lana`i. Given repeated, essentially undisputed conclusions that the forest cover contributes to fog drip, it is a short step to the conclusion that loss of forest cover will alter effective precipitation, and hence, via the water budget, recharge.

In "*The Hydrological Importance of a Montane Cloud Forest in Costa Rica*", (Chapter 2.3 of Tropical Agricultural Hydrology, John Wiley & Sons, ©1981), F. Zadroga describes preliminary data from a 5 year experimental catchment research project in the Monteverde Cloud Forest Reserve. Comparing rich montane forest cover with deforested watersheds, he notes a differential effect in wet season direct run-off as compared to dry-season flows. Deforested areas experienced higher run-off during wet seasons, but were unable to sustain flows during dry seasons. On the other hand, forested watersheds continued to yield flows above "rainfall" levels even during the dry season. Areas lacking in forest vegetation had substantially lower yields in terms of percent of direct rainfall over time. The preliminary findings seemed to indicate that the presence of montane cloud cover makes a significant contribution to sustained flows / recharge. Potential reasons mentioned for increased ability to sustain flows in forested areas included increased precipitation from cloud mist or cloud droplet catchment in forested areas, low evapotranspiration due to low insolation from closed canopy, high air-moisture content, and increased ability to intercept clouds.

This finding seems to echo Lana`i's experience as summarized by Hobdy ('93). In an excellent chronology of human activities leading to denudation of the slopes, he describes accounts and observations of witnesses in the late 1800s and early 1900s, and early efforts to preserve or recover forest. *(This narrative is summarized in the timeline/Figure following this introduction.)* Lawrence Gay, in his *True Stories of the Island of Lana`i* noted that the Maunalei stream traveled a mile from its source, but that older Hawaiians remembered it flowing all the way to the sea. In the late 1800s, taro production in Maunalei had to be discontinued, because goats on the cliffs above had denuded the land to such a degree that it had become dangerous to work below. Traditional wetland taro terraces, or lo`i may still be found in Maunalei Valley. George C. Munro, in *Story of Lana'i*, also described hearing from an old Hawai'ian that Maunalei Stream once ran all the way to the ocean. Stearns noted that Maunalei Gulch was perennial prior to the development of Maunalei Tunnel around 1940, although apparently it was not perennial all the way to the sea. Combined, these comments give us the picture that flows at Maunalei Stream had once been sufficient to support taro, and that flows had diminished even before the remainder was essentially eliminated with development of the tunnels. Bowles ('74) and Hardy ('95) both indicate that the loss of recharge resulting from loss of forest cover may have contributed significantly to drawdowns in the wells (CWRM-1, Hardy, '96, pg. 125).

Such conclusions are also supported by Hardy's *Numerical Groundwater Model for the Island of*

Lana`i, Hawai'i (CWRM-1, Hardy, 1996). The model uses a fog drip to rainfall ratio of 0.72, arrived at by averaging studies quantifying precipitation collected in open areas as compared to under forest cover. It uses empirical and / or calculated data for elements such as rainfall, direct run-off, evapotranspiration, and soil characteristics to arrive at water level and draw down estimates assuming various pumping and recharge scenarios. One of the model runs examines the loss of fog drip from the island. The greatest impacts are observed in the areas over 2,000', under which the primary high-level water source is located. In this area it is estimated that 8.87 MGD is attributable to fog drip, vs. a total recharge estimate of 13.5 MGD.

The model scenarios indicate that loss of fog drip alone, with no pumping, would have a greater regional effect on the Central Aquifer Sector than pumping existing wells to 6 MGD (CWRM-1, Hardy, 1996, p. 112). In this high level aquifer area, the loss of fog drip would lead to the loss of over 50% of water levels. Since the model used is unable to account for additional loss of recharge due to erosion and compaction of soils that would be associated with loss of watershed, this may even be a conservative estimate. "...The results clearly indicate that the reduction of forest cover would affect ground water levels drastically,....[and]... make.. a strong case for the maintenance of fog drip efficient vegetation above the 2,000' elevation. "...Recharge should be protected and enhanced to guarantee a reliable ground water resource..."It is important to remember that the overriding factor for governing actual fog drip...is providing the medium upon which fog drip can condense and be harvested from the air. Therefore, changes in the type and density of the forest cover are more likely to change actual fog drip on Lana`i than changes in the surrounding ocean or global climate." (Hardy pgs. 126, 95 & 26)

A recent study by Pacific Environmental Engineering, (Final Report: Lana'i Fog Drip Study, May 29, 2009), found even higher precipitation under Cooke Pine than had been previously estimated. This study did not compare Cooke pine to native vegetation, nor analyze differences in subsurface soil characteristics such as moisture and compaction, but it did highlight the importance of fog drip. While Cooke pine seem to have much to offer in terms of increasing effective precipitation, it cannot and should not be concluded that they are more effective than, nor that they should replace, native vegetation. Nor is this suggested in the Lana'i Fog Drip Study. The concern is raised here because Figure 50 in that document, labeled "Potential Acreage for Cooke Pine Restoration (by Suitability Class)" indicates a candidate Cooke Pine planting area which overlaps the extent of the best remaining native habitat. The map merely indicates areas where Cooke Pine could be effective at fog drip catchment, and where slopes, terrain, wind characteristics, etc. were likely to be suitable for Cooke Pine. This is all valid as far as it goes. It simply does not address the question of native habitat at all. Caution should be taken not to misinterpret this as a recommendation that remaining native vegetation be replaced by Cooke pine.

A more recent article "Hawai'ian Native Forest Conserves Water Relative to Timber Plantation Species and Stand Traits Influence Water Use", Kagawa, Sack, Durate and James, Ecological Applications 19(6), 2009, pp. 1429-1443 studied native 'ohi'a forest versus invaded eucalyptus and evergreen ash, and found that native forest was the better water manager.

Despite abundant evidence pointing to the importance of forested watershed in sustaining the small, susceptible water resources of this island, multiple accounts attest to the fact that Lana`i's watershed has been both degraded and reduced dramatically over the past two centuries. Hobdy ('93) estimated that only 30% or less of the original cloud forest cover in Lana`i remains.

Lana'i Water Advisory Committee Process in Watershed Plan Development

Given that forested watershed is critical to maintaining water availability, and that Lana`i's forested watershed is diminishing, it was determined that the Water Use & Development Plan would not be complete without a skeletal plan for watershed protection and implementation measures. The following section represents a peer reviewed cooperative, consensus effort at developing the basis for watershed protective efforts over the planning time frame.

The group started by identifying two existing plans, the CCR's proposal for a stewardship plan at that time (not the same as the present plan) and a species recovery plan for Lana`i, entitled *Lana'i Plant Cluster Recovery Plan*, published by the US Fish & Wildlife Service, September 1995. These two plans were sent to a panel of over 20 resource managers, most of whom had experience in Lana`i, with the request that each be reviewed as a potential watershed plan to incorporate by reference, and that each panel member offer suggestions for the top priority actions needed to protect the Lana`ihale watershed. Written comments were followed up with a three island skybridge meeting, in which priorities for forest management were discussed. The results of these efforts are incorporated in the proposed plan, by unanimous agreement of the Lana'i Water Advisory Committee.

The proposed plan reflects certain principles to which the Lana'i Water Advisory Committee was committed. Specifically, the group unanimously agreed that any plan should afford maximal protection for the water resource, protecting biodiversity to the greatest extent possible. The group concluded that preservation of native biodiversity would be the most protective for the watershed, given that systems are more stable and able to withstand challenges when their inherent parts are intact.

There are multiple, complex inter-dependent relations between species in any system, and it has been noted that there also appear to be keystone species, without which entire systems unravel. In matters of biodiversity, the committee determined that the most cautious approach for the watershed would be to encourage the maximum preservation of native biodiversity.

Finally, the committee determined that respect for cultural resources and consistency with community values should help to guide the plan. Management of ecosystems has to account for lifestyle and needs of the community. For example, there are roughly 400 hunting licenses out of a population of roughly 2,500 in Lana`i. There are also gathering rights which will be eliminated if the species gathered disappear. Given the need to balance community values, lifestyles and concerns, a series of public meetings were held in which several alternatives were presented and discussed.

Concurrently, a second committee, of which several advisory committee members were a part, met to determine the best path for biodiversity preservation on the island of Lana`i. Although these two groups met separately and for somewhat different purposes, they ended up reaching similar conclusions regarding the management of Lana`ihale, and presented suggestions at a public forum hosted together, and ultimately formed a partnership with other agencies to protect Lana'i's forest and watershed.

Setting

Lana`i is an 89,280 acre (361 sq. km.) island, nearly 2,500 miles (4,022.5 km) from the nearest continent (2,400 miles from California, 4,000 miles from Japan, 2,400 miles from the Marquesas, Samoa & Fiji).

The summit of Lana`i is about 3,370' (1,027.85 meters) high. Lana`i was created by a single shield volcano, built by eruptions at the summit along 3 rift zones, (Stearns & MacDonald, 1983), and possibly a fourth, northern rift zone. (CWRM-1, Hardy, 1996), referring to gravity survey by Krivoy & magnetic

survey by Malahoff). The principal rift zone trends northwest-ward, the other rift zones trend southwest toward Kaholo Pali and Kaunolo Bay; and the last south-southwest-ward, toward Manele. Palawai basin is the remnant of a caldera. Just to the west of Palawai, Miki Basin is a nearly filled pit-crater. Cross sections of several additional subsidiary cones and pit craters have been identified.

Lana`i stone has been dated from 0.81 million to 1.46 million years old. The lavas are *theolitic basalts*. These are igneous rocks composed of calcic plagioclase feldspar and pyroxene, relatively rich in silica, and poor in sodium and potassium. Some contain olivine as well. Basalts are low viscosity lavas that form in volcanoes with gently sloping flanks. Basalt lava flows are the *Pahoehoe*, which means "ropey", and indeed looks like smooth ropes or layers, or *A'a*, which means "hurt" and is sharp and fragmented.

Because Lana`i lies to the lee of Maui, precipitation is low. The summit receives roughly 38" (96.52 cm) of rain per year, as compared to over 400" (1,016 cm) per year on parts of the neighboring island of Maui. This orientation has also given the island a somewhat unusual topology. What would normally be the "windward" slopes of the island are relatively sheltered from wind, precipitation and wave action. As a result, Lana`i does not have the dramatic windward facing sea-cliffs of Maui or Molokai. However, the southwest is fully exposed to both waves and south-westerly storms, which has allowed the formation of high sea cliffs on her "leeward" side, and a wind-formed dune ridge to the southeast. Pinnacled rocks on the north of the island are also the result of erosion by northeasterly winds.

The hydrogeology of Lana`i is unusual in terms of the predominance of high level water, including the presence of high-level brackish water in at least one location, accompanied by geothermal heating. High level water occurs within 3.8 miles (6.1142 km) of the coast line all around the island. In addition, the north west rift zone is quite wide, possibly as much as 4 miles (6.436 km) across at some points. Such features, as well as numerous dike and fault boundaries have introduced some difficulty in monitoring and understanding the shape of the aquifer and fresh /salt water interface. The south side of the island has essentially no cap rock, but thick alluvial deposits or possibly caprock on the north side may serve to deter discharge of water to the ocean and saltwater intrusion.

FIGURE 6-3 Chronology of Land Use Conservation & Water in Lana'i

1400 AD -	Hawai`ians arrived - peak population prior to Cook was estimated at between 3,000 - 3,250 people. Fire, wood, thatch used, some ag - some clearing, some burning for ag and use of wood, etc.
1675 -	Kahuna named Kawelo maintained perpetual bonfire - kept burning for many years, must have cost a lot of trees - the site is one of the worst examples of erosion today
1778 -	Few months before Cook's arrival, warring raid from King of Hawai`i Kalaniopu`u, and his Chief Kamehameha (who eventually united the Hawai`ian islands) (Kamehameha was about 25 yrs old) Kalaniopu`u was upset because he had been defeated by the king of Maui Kahekili. His army descended on Lana`i and destroyed the entire population, ate the food and crops, burned all the houses and other improvements
1778 -	Cook arrived in Hawai`i
1779 -	Clerke recorded Lana`i's existence while departing

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1778 -	Goats and European hogs introduced to Hawai`i
1791 -	Sheep introduced to Hawai‘ian islands
1793 -	Cattle introduced to Hawai‘ian islands
early 1800s -	Goats introduced to Lana`i - causing noticeable damage within 30 years Before the introduction of goats, there was apparently an extensive and unique forest of `akoko covering upland basins of Palawai and Miki (Succulent bark with good moisture, goats stripped the bark - killing the trees. `akoko = (Chamaesyce celastroides, var. lorifolia) At first, goats didn't penetrate the summit - there was plenty of good eating below.
1823 -	First known visit of caucasian to Lana`i - Reverend William Ellis to Hawai`i Estimated population of the island 2,500
1823 -	Lana`i island population about 2,500
1848 -	The Great Mahele in Hawai‘i. Government heard peoples claims for land, and awarded it to chiefs and commoners. Lana`i had 13 ahupua`a
1852 -	First distribution of land to commoners in Lana`i
mid 1800s -	Sheep to Lana`i (probably in connection with small colony of Mormons that settled in Palawai basin) later under Walter Murray Gibson, decision was made to raise goats for skins and sheep for wool
1865 -	Lana`i Ranch started
1867 -	Gibson estimated 18,000 goats and 10,000 sheep on Lana`i.
1867 -	Peck vs. Bailey, 8 Hawai‘i 658 Determined appurtenant rights, right to amount of water used on the land at the time of the Great Mahele.
1870 -	Botanist Dr. William Hillebrand visited Lana`i with J.M. Lydgate. Lydgate described the island as “pretty well denuded of its forest cover:” and observed that “only on the summit of the island ridge was that mantle really intact and undisturbed” (Lydgate 1920)
1875 -	First two Norfolk Island pine planted on Lana`i.
1876 -	Gibson noted that “the isles are becoming naked at a fearful rate”.
1880s	Late 1880s European hogs introduced, but succumbed to a virulent hog cholera epidemic a few years later.
1886 -	Complaint was filed against Gibson by 5 Hawai‘ian families, for placing undue pressure on their livelihoods by charging / limiting access to gathering, fishing and water resources necessary for the subsistence lifestyle of the day. Many water sources were controlled by Gibson, including Waipa‘a. The Waipa‘a Tunnel was not drilled until 1924, so this must have referred to a spring source nearer the shoreline.
1888 -	Gibson passed away and left Lana`i lands to his daughter and her husband, Frederick Hayselden. Hayselden focused primarily on sheep ranching.
1895 -	Lonoaea vs. Wailuku Sugar Co., 9 Hawai‘i 651 (1895) determined prescriptive rights - rights obtained by adverse use of water for statutory period of adverse possession.
1898 -	Munro estimated 50,000 sheep and a large but undetermined number of goats. Lowland already mainly destroyed. Animals wandering up into mesic and cloud forest areas and denuding mid-elevation canyonlands on the windward side. Human population about 174.

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	Attempts made to control rampant erosion by planting Bermuda grass. Eucalyptus and Norfolk pine also planted in Koele.
	WATER RESERVOIRS BUILT AT KOELE AND KAIHOLENA GULCH.
1898 -	Maunalei Sugar Co. started by Heyselden.
late 1800's	Taro production in Maunalei Gulch discontinued because rocks dislodged by goats from denuded cliffs above.
1899 - 1901 -	Epidemic among Chinese workers on sugar plantation reduces company employee population from 710 to 12. This, combined with brackish water helped to guarantee the end of the sugar plantation.
1900 -	GAY WELL A CONSTRUCTED.
1902 -	Heyselden destroyed a local well in KAUNOLU, by damaging the traditional Hawai'ian plaster work. The well went brackish. The wells he depended upon for sugar production in KEOMOKU were also too brackish to continue using for irrigation.
1902 -	Charles Gay purchased ⅔ of Heyselden's holdings at auction.
1902 -	Charles Gay arrived on island and began more controlled operations focusing on cattle and some agriculture. In 1965, Gays eldest son, Lawrence Gay was noted to recall that mid elevations had extensive areas of tree skeletons on the northern plateau and in the central basin above 1000'. (305 m) around the period (1902) they had arrived on Lana`i.
1902 -	Island population less than 100. Droughts resulting from loss of forest cover - brought reduced productivity and famine to Lana`i residents in the first decade of the twentieth century. Gays arrived on the island. Gays began intensive goat and sheep eradication efforts.
1903 -	Gay purchased Hayselden's remaining interests in Lana`i.
1905 -	The two-story company store and hotel at Keomoku was dismantled and floated across the channel to Laha'ina, where it became the Pioneer Inn.
1907 -	Gays purchased Kaa & Kaohai ahupua`a. At this time more than half of the lands of Lana`i were still in the hands of Hawaiians, but this percentage was diminishing rapidly.
1908 - 1911 -	Drought
1910 -	Gays invited Territorial Forester Ralph S. Hosmer to help them with a long term recovery plan. Hosmer wrote a 27 page report, recommending more fencing and animal eradication, followed by tree and grass planting to speed the revegetation on the lower slopes.
1910 -	Gays forced to sell most of their holdings Lana`i Company - formed by a group of bankers Initial plan was to focus on sugar beets
1911 -	Small piggery started at Waiapa`a on the slopes above the Palawai basin. Unsuccessful because of non-dependability of water supply remaining hogs released and became feral Munro noticed signs of forest damage in the summit cloud forest, and mounted a successful effort to rid the island of hogs
1911 -	Lana`i Company hired George C. Munro to run the ranch 799 head of cattle present, but sheep count was estimated at 20,558 Munro recommended transition from sheep to cattle; this recommendation was approved

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1911 -	MAUNALEI TUNNELS 1 & 2 CONSTRUCTED
1911-1921 -	Munro spent much time shooting sheep and goats completed fenceline around the mountain started by the Gays
1911-1937	Munro introduced many species of plants for erosion control and reforestation some of which became pests, choking out native species
	Melinis minutiflora - molasses grass Paspalum dilatatum - dallis grass Panicum maximum - guinea grass Atriplex semibaccata - Australian saltbush Araucaria columnaris - Cook Pine Leptospermum scoparium - manuka Cauarina glauca - longleaf ironwood Myrica faya - firetree
1916 -	By this time large scale sheep farming was finished
1917 -	Baldwins purchased Lana`i from the Lana`i Company of the time Baldwin's focused on cattle ranching. 4,000 head of cattle in 1917.
1918 -	50 acres of Kanepu`u dry forest fenced by Gay et al
1918 -	MOUNTAIN HOUSE TUNNEL DRILLED
1920 -	Two bird species: `akialoa (Hemignathus obscurus lanaiensis), and Lana`i hook-billed finch (Dysmorodrepanis munroi) gone by 1920. Both birds primary habitat had been the `akoko forests.
1920 -	12 axis deer introduced to Lana`i from Molokai. Multiplied in the Palawai basin, hunted for sport and meat. Munro later mentioned that he regretted this. Population at this time estimated at 185.
1920-	GAY TUNNEL CONSTRUCTED
1921 -	By this time, only 208.25 acres out of the entire island were still owned by Hawaiians.
1921 -	First crop of pineapples planted on Lana`i by Gay.
1922 -	Baldwins sold Lana`i to James Dole, who immediately began preparing Palawaii Basin for pineapple growing. Razing and destroying an enormous non-native invasive cactus population in the process.
1922 & 1926	Munroe makes systematic fog drip observations. *Letter to the Editor,* Hawai'ian Forester and Agriulturist 19(2) pp. 45-46. Unpublished analysis by Munro also given to company as late as 1954
1924 -	Dole Company started planting pineapple fields.
1924 -	Waiapa'a TUNNEL CONSTRUCTED
1925 -	By this time over 2,000 laborers, including many immigrants, had moved to Lana`i to work in the pineapple fields. Brought considerable numbers of poultry and other birds with them.
1926 -	First pineapple harvest on Lana`i. Kaumalapau Harbor was opened, and the crop shipped by barge.

Source Water Protection

1927 -	Territorial Forester Charles S. Judd made a visit to Lana`i. Noted that forest was making a substantial recovery under Munro's management.
1929 -	Munro noticed a sudden decline in numbers of forest birds, which had previously seemed to be recovering.
1929 -	Munroe, *Norfolk Island Pine for the Wet Forest*, Hawiian Forester and Agriculturist 26(3), pp 126-127.
1930 -	Hogs eradictaed. Human population had exploded to 2,356, more than 10x the number of a decade before. The vast majority, about 78% were either Japanese or Filipino,. The remaining 22% were a mix of Hawaiians, Koreans, Puerto Ricans, Chinese, Haole and Portuguese (in descending order of population).
1930 -	W.O. Clark recommended tunneling in Maunalei Gulch.
1931 -	Three more species of birds gone: `o`u (Psittirostra psittacea), Lana`i Creeper (Paroreomyza montana montana), and Lana`i Thrush (Myadestes lanaiensis lanaiensis). Munro believed that there must have been an inadvertent introduction of some avian disease against which the native birds had no defense.
1931 -	9 month drought.
1936 -	MAUNALEI SHAFT 1 & 2 CONSTRUCTED
1937 -	`i`iwi (Vesstiaria coccinea) gone
1937	Munro retired. Deer numbers still low at this time, but in 1950 reminiscences, regretted the introduction.
1940 -	H.T. Stearns estimated 6.46 recharge for high level aquifer; 21.26 MGD for entire island. 6,150 acres (24.89 $km^{2)}$ were set aside as the Maunalei Forest Reserve through a surrender agreement between the Hawai'ian Pineapple Company and the Territorial Government.
1945 -	WELL 1 DRILLED
1946 -	WELL 2 DRILLED
1948 -	George Munro wrote a letter to Colin G. Lennox (president of the Board of Agriculture and Forestry) seeking his assistance in persuading Hawai'ian Pineapple Company to additionally fence of the Kanepu`u dry forest to protect it from cattle and deer. He recounted his long efforts to do so, but registered frustration that it "all has been to no effect".
1950 -	Cattle completely gone from the island. (Cattle ranching discontinued when pineapple began).
1950s	Several hectares of pine trees were planted on the summit to enhance fog drip, but little else in the way of forest management was initiated by government or company during this period.
1950 -	WELLS 3 , 4, & 5 DRILLED.
1950 -	KAIHOLENA TUNNEL HOLE 3 CONSTRUCTED.
1953 -	H.T. Stearns estimated sustainable yield at 3+ MGD.
1954 -	Mouflon sheep introduced as potential game animal.

Watershed Protection

1954 -	SHAFT 3 CONSTRUCTED.
1955 - 1958	Fog Drip Study by Ekern, published 1964 Direct Interception of Cloud Water on Lana‘i Hale, Hawai‘i, Soil Science Society of America Proceedings, vol. 28, n. 3, pp. 319-421.
1957 -	Hawai‘ian Pineapple Company rescinded the surrender agreement & terminated forest reserve status.
1959 -	Hawai‘i Water Authority publishes study on development of Lana`i groundwter and fog drip importance.
1960 -	Pronghorn antelope introduced - did not adapt well.
1960 & 1961 -	K.E. Anderson estimated safe yield at 2.2 and 2.3, respectively. Ultimate high level aquifer supply estimated at 3.6 to 4.8 MGD. At the time appreciable amounts of Maunalei Tunnel water flows bypass the water system, are not accounted, and probably flow into the sea.
1961 -	Carlson, N.K.; *Fog and Lava Rock, Pine and Pineapples*, American Forests 67(2); pp. 8-11, and 58-59.
1961 -	Groundwater Use Act , Hawai‘i Revised Statutes, §177.
1963 -	Otto Degener published warning concerning the future of Lana`i's native flora.
1964 -	P.C. Ekern estimates that rainfall precipitation is augmented by 30″ per year beneath a mature Norfolk Pine.
1970s -	Castle & Cooke and State wildlife managers decided to eradicate goats from the island.
1971 -	Spence & Montgomery documented diminishing forest diversity at Kanepu`u dry forest.
1973 -	Hobdy sends report to State Forester documenting diminished forest diversity at Kanepu`u. Document calls for fencing, deer removal, enrichment plantings of rare species.
1973 -	W.M. Adams estimates that optimum drilling sites for high quality water are in the southeast area between Lopa and Naha. Lower quality between Kiolohia and Lopa.
1973 -	McBryde vs. Robinson 54 Hawai‘i 173 N 15.
1974 -	S.P. Bowles estimates infiltration recharge of 6.5 gpd.
1976 -	Last sighting of the `amakihi (Hemignathus virens wilsoni).
1981 -	Goats eliminated.
1983 -	J.F. Mink estimates recharge at 9.3 MGD; sustainable yield of 6 MGD. Sets a primary recharge area of 14 square miles, and a secondary recharge area of 10 square miles.
1982 -	Pronghorn antelope gone.
1983 -	K.E. Anderson suggests that a freshwater supply estimate of 4.1 - 5.5 MGD be used for planning purposes.
1984 -	Heteropsylla cubana - the Leucaena psyllid - infested and defoliated haole koa in lowlands, deer began migrating upland - deer numbers began to increase rapidly.
1985 -	K E. Anderson reviews water supply and concludes existing infrastructure is capable of supplying 2.7 MGD.

Source Water Protection

1986 -	Ordinance 1578 establishes Manele Project District. Initial project configuration includes 395.34 acres of Single Family, Multi-Family, Commercial, Golf Course, Hotel, Park & Open Space Uses.
1986 -	Ordinance 1580 establishes Koele Project District. Initial project configuration involves 468.3 acres of Single Family, Multi - Family, Commercial, Golf Course, Hotel, Park & Open Space Uses.
1986 -	Well 6 DRILLED.
1987 -	Well 7 DRILLED.
1988 -	Government deer census estimated over 3,700 deer on the northern half of the island alone.
1989 -	Lana`i Company publishes Water Resources Development Plan for the Island of Lana`i, Hawai'i, by M&E Pacific.
1989 -	Well 10 DRILLED (aka Lana`i 10) . This was drilled in response to suggestion that an exploratory well be drilled in the southwestern sector of the Palawai Basin, outside the range of the high level aquifer, and outside the primary and secondary recharge zones. This was an attempt to test whether the basal aquifer could deliver any viable supply. If chlorides were low enough it could prove economical to utilize - and if this had been the case, there would have been a viable source outside the high level aquifer. Instead, high level, geothermally heated and highly brackish water was found.
1989 -	Lana`i Company filed a petition with the State Land Use Commission to reclassify 138.577 acres from Rural and Agricultural Designations to Urban in order to develop the Manele golf course and related facilities.
1989 -	K.E. Anderson estimates recharge at 8.89 MGD, S.Y. at 6.22 MGD.
1990 -	State Water Resources Protection Plan by JF Mink includes discussion of Lana`i aquifers. Further update 1993.
1990 -	County Water Use and Development Plan published. Key issues for Lana`i involved how to accommodate the combined resort and pineapple economy with limited water. Alternate water sources for golf-course irrigation were proposed.
1990 -	Petition to Designate Lana`i as a State Groundwater Management Area filed by a group of citizens on Lana`i. CWRM finds that reasonable estimates are recharge: 9 MGD, and sustainable yield : 6 MGD.
1990 -	WELLS 8, 9, 12 & 13 DRILLED. Well 9 is on the border between Mink's "primary" and "secondary" recharge areas. Wells 12 & 13 were a further test to see if the basal aquifer could deliver practical supply. They are located in the island's southeast rift zone. The wells are basal with 4 - 5 feet of head. Chlorides were 900 - 1400 mg/L. Well 12 tested at 100,00 gpd, and Well 13 at less than 42,000.
1990 -	Dole Company announced the closing of pineapple operations.
1991 -	Ordinance 2066 prohibits use of potable water on all golf courses.
1991 -	Land Use Commission issued a Decision and Order, granting the reclassification for Manele, pursuant to several conditions; one of which was that no potable water from the high level groundwater aquifer would be used for the golf course irrigation, and that instead only alternative, non-potable sources of water would be used.
1992 -	Coastal and strand community had been largely destroyed - 3% remained

	Watershed Protection
	Arid grassland & shrubland ~ 20% remained, mostly in N. & E., Much species diversity eliminated Dry forest community - 2% remained Mesic forest community - 3% Cloud forest community - 30% threatened with Myrica, Psidium or Leptospermum thickets, Melinis grass, etc.
1992 -	Ordinance 2132 increases Manele Project District from 395.34 acres to 556.34 acres. Major changes are addition of 201 acres of golf course, and reduction of 25 acres of Open Space.
1992 -	Ordinance 2139 increases Koele Project District from 468.3 acres to 618 acres. Major changes are addition of 332.4 acres of golf course and reduction of 201.5 acres of Open Space.
1992 -	County Water Use and Development Plan Draft - Revisited Lana`i issues given the new economic direction of the island. Key issues were the need for better water auditing and control - there seemed to be wide unexplained swings in consumption, high water losses and overall need for better monitoring and conservation. This recommendation applied not only to systems, but was also put forth with regard to hydrologic data gathering. Dual potable and non-potable water systems were also recommended for the Manele Project District.
1993 -	Council Chair requests stop work at Manele golf course pursuant to violation of condition of County Code §19.70.85 prohibiting use of water from the high level aquifer for Manele. Three months later, council elects to defer, enforcement of §19.70.085 is deferred given certain conditions. 750,000 gpd allowed for the interim, with some restrictions, in Resolution 93-42.
1993 -	State Land Use Commission issued an Order to Show Cause because it believed that Lana`i Co. had failed to comply with Condition 10 of it's District Boundary reclassification for Manele, prohibiting the use of high level water for irrigation of Manele Golf Course.
1993 -	County Council Resolution 93-42 also establishes Lana`i Water Subcommitee, with sunset at the end of the year to monitor the use of water from the high-level aquifer. Subcommittee has 9 members. 3 from company, 3 from Lanai'ans for Sensible Growth, and 1 each from CWRM, Planning Commission and State Water Commision.
1994 -	Bill is proposed to amend §19.70.85 to allow withdrawal of 650,000 gpd. Heard first by Planning Commission. Planning Director recommends total allowance fo 650,000 gpd; and that subcommittee be impaneled as a subcommittee of the Human Service, Water and Ag Committee. Recommended subcommittee composition includes 3 from Company, 3 from Lanai'ans for Sensible Growth, 1 each from CWRM, Planning Commision and State Water Commission as before, with the addition of the Directors of Public Works and of Water Supply.
Mid 1990s -	Goats re-introduced.
1995 -	Council Subcommittee Established with the following membership: 2 from Company, 2 from Lanai'ans for Sensible Growth, 1 Councilmember, Lana`i Planning Commission Chair, Planning Director, Public Works Director, the Water Supply Director as an ex-officio non-voting member, and one additional non-voting member from Lanai'ans for Economic Growth and Stability.
1995 -	Ordinance 2410 increases Manele Project District from 556.34 acres to 872.25 acres. Major changes are additon of 258 acres more single-family development, reduction of 29 acres of golf course, reinstatement of 45 acres of open space and addition of 21.4 acres of multi-family development.
1995 -	WELL 14 DRILLED.
1996 -	State Land Use Commission issued cease and desist order requiring Lana`i Company to stop using water from the high level aquifer for golf course irrigation, and to file a plan with the LUC within 60 days saying how it would comply.
1996 -	CWRM publishes a Numerical Ground Water Model for the Island of Lana`i, Hawai'i ; by Roy Hardy ; CWRM-01.

Source Water Protection

1996 -	An additional Lana'i Water Resources Management Plan is published by the Company, in response to the State Land Use Commissions May 17th 1996 Decision and Cease & Desist Order. It essentially stated that since efforts to develop a practical basal source with wells 10, 12 and 13 had failed, it was impractical to continue to rely on purely non-potable, non-high-level sources. It notes that Time Domain Electrormagnetic Resistivity surveys performed by Black Hawk had indicated that the extent of the high level aquifer was larger than previously expected. It stated that principal recharge to the basal lense is leakage from high level groundwater compartments beyond the rim of the Palawai. The recharge itself was considered too brackish for use. The report concluded that brackish water from the high-level aquifer was the only practical source for alternate irrigation.- A month later, the company filed a supplement with additional cost information. There were no alterations to the conclusions.
1996 -	State Commission on Water Resource Management establishes a Lana`i Water Working Group to try to reach consensus on water issues. Composition is identical to that of the council subcommittee, which was scheduled to dissolve at the end of the year.
1996	Council Subcommittee sunset December 31st.
1997 -	Water Working Group established by the State Commission on Water Resource Management sunsets.
1997 -	In January and again in April, the Board of Water Supply resolves to continue working with the Working Group until the County Water Use and Development Plan is completed, and to consider establishment of ongoing committee to work on unresolved issues. Board continues discussions on pros and cons of this decision and on what form the committee should take until 1999.
1997-	Final Report of the Lana`i Water Working Group established under CWRM is submitted. Board moves to accept this report as the "interim" draft WUDP until the Lana`i WUDP chapter is approved through the usual process.
1996 -	Ordinance 2515 amended County Code Section 19.71.055 relating to irrigation of the Koele Golf Course. Amends section D on Irrigation by changing phrase from no high level groundwater to no high level aquifer groundwater . Then proceded to establish conditions under which the Director of Public Works and Waste Management may authorize use of the high level aquifer for golf course irrigation. Events that trigger such allowance include but are not limited to: chemical contamination of a non-potable source, resulting in chemical concentrations not approved for golf course application; a water transmission line break in the non-potable line; failure of non-potable pumping systems, failure in sewage reclamation systems, draw down of reservoirs and irrigation water features for fire fighting or other emergencies or electrical power failure in delivery facilities. In no case is drought to be deemed an unanticipated event warranting issuance of such permit. Prior to such emergency approvals, the golf course owner shall have provided to the director supporting documentation of relevant facts and events, a plan showing that no continuous physical connection will be made between potable and non-potable systems, a remedial plan to restore non-potable water use including schedule; and a plan detailing how other critical uses will be accommodated, source to be used, distribution priority to residents, etc. Such permit when issued to be valid for only 30 days, with provision for longer lasting permits if deemed necessary by director and council. Failure to comply with remedial plans warrants refusal of extensions, weekly progress resorts must be submitted by golf course owner, amounts not to exceed 250,000 gpd.
1996 -	Ordinance 2516 further amends County Code 19.71.055 by adding Section E, entitled re-seeding or re-grassing, enabling a golf course owner to apply for use of up to 27,000 gpd PER FAIRWAY to supplement non-potable irrigation sources in order to establish new plantings. One fairway to be irrigated at a time. No more than 4 fairways per calendar year. Re-seeding or re-grassing allowable only between May and October; each fairway to be re-seeded or re-grassed NO MORE THAN ONCE under this provision. Reiterates several

	conditions listed above: no permanent interconnections; provision for other priority uses; if irrigation emergency occurs during already-permitted re-seeding or regrassing, the replanting activity may continue, but only such that the combined total of re-grassing or re-seeding and the other emergency use does not exceed 250,000 gpd.
1997 -	Lana`i Water Working Group Report passed February '97.
1998 -	Ordinance 2743 decreases Manele Project District from 872.25 to 868 acres. Major change is reduction of 51 acres of single family, addition of 25 acres of multi-family, addition of about 19 acres of open space, and addition of 6.6 acres to hotel site.
1999 -	Board Resolution No. 5 (1999) establishes the Lana`i Lana'i Water Advisory Committee. Composition: 2 voting members from Lana`i Company, 2 voting members from Lanai'ans for Sensible Growth; 1 voting member from the Lana1i Planning Commission; councilmember from the island of Lana`i, with voting rights; 3 residents of Lana`i who are not affiliated with any of the aforementioned entities; 1 non-voting member from Lanai'ans for Economic Growth and Stability, DWS as the lead agency and staffing source, and other county and state agencies such as Planning, Public Works, CWRM, DLNR-DOFAW or others to participate as desired, but without voting privileges. Executed on March 16th, 1999.
2001 -	Lana`i Forest and Watershed Partnership MOU signed. Efforts to construct fence and management undertaken by multi-entity partnership.
200 -	First increment of Lana'i Hale Summit Fence completed.
2008 -	WELL 15 (briefly aka Well 11) - drilling permit issued. Well is not yet drilled as of 2009 update.
Sources:	Hobdy, Robert; "Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawai'ian Island"; *Pacific Science*; vo. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993 Lana`i Community Plan (1998); prepared for the Maui County Council by the Lana`i Planning Commission; the Maui County Department of Planning; the Lana`i Citizen Advisory Committee; and Consultants; Community Resources, Inc. & Michael T. Munekiyo Consulting, Inc. CWRM; Numerical Ground Water Model for the Island of Lana`i, Hawai'i ; by Roy Hardy; CWRM-01; State Commission on Water Resources Management; well data base dated 2001

Lana`i Plant Communities

Range: The Lana`ihale Cloud Forest ranges from about 2,100' (700 meters) to the summit at about 3,370' (1,023 meters) in elevation, along the ridgetops and gulches of the mountain summit in Lana`i. The Lana`ihale forest covers all or part of the Kealiakapu, Kealia Aupuni, Palawai, Kamao, Kaohai, Pawili, Kaunolu, Kalulu, Maunalei, and Kamuku ahupua`a. Access from town is achieved via the Lana`ihale summit road, and by various 4 wheel drive roads to the northeast end.

Because of the low elevation of this cloud forest, it contains a strong mix of mesic species and is immediately surrounded by mesic forest and shrubland. These communities, where contiguous, are not entirely distinct. Therefore, it is recommended that management measures be extended to the buffering mesic areas. The Lana`ihale mesic forest ranges from 900' (300 meters) to 2,400' (800 meters) in steep gulch lands surrounding the summit cloud forest, and extends into the summit forest.

Plant Taxa and General Plant Community Types:

Native species commonly found in the area include `ohi`a, pukiawe, `olapa, a`ali`i, mamane and uluhe.

A list of flowering plants, indicating endangered, proposed, candidate and SOC (Species of Concern) plants of Lana`i is provided in Figure 6-5. Also provided are lists of the ferns, lichens and hepatics, of Lana`ihale.

Native plant communities have been classified by Dr. Samuel Gon, III of The Nature Conservancy according to an adaptation of the method used by Wagner, Herbst and Sohmer in the Manual of the Flowering Plants of Hawai`i. According to this classification, predominant plant communities in Lana'ihale include a mixture of:

Metrosideros polymorpha / Cheirodendron sp. ('Ohi`a / `Olapa or Lapalapa)
Metrosideros polymorpha / Dicranopteris spp. (`Ohi`a/Uluhe)
Dicranopteris sp. lowland wet shrubland (Uluhe)

Also present are:
Dodonaea spp / Stypelia tameiameiae (`A`ali`i / Pukiawe)
Osteomeles anthyllidifolia (`Uulei)
Acacia koa (Koa)
Diospyros sanwicensis (Lama)
Nestegis sandwicensis (Olopua or Lapalapa)

Loss of Plant Communities

According to Hobdy (93) About 30% of native Hawai'ian vascular plants have been recorded in Lana`i, roughly 345 species. Of these, about 70 have disappeared, including 8 endemics. The Bishop Museum Flowering Plant Checklist lists 205 endemic and indigenous species. The U.S. Fish & Wildlife Service lists 36 endangered, 3 proposed, 3 candidate and 25 "species of concern" (hereinafter SOC).

The attached Figure 6-5 lists these endangered, proposed, candidate, and SOC plants, of which 35 are found in Lana'ihale. Hobdy has developed a user-friendly classification of native plant communities on Lana`i based on moisture, elevation, plant community and soil type. The following Figure, from his 1993 article (*Case Study*), paints a dismal picture of what has already happened to biodiversity on Lana`i. This Figure more or less answers the question "What have we lost so far" (or "what have we not yet lost")?

Vegetation Community	Annual Moisture	Percent Remaining	Percent of Island
Cloud forest	35-50" (875-1250 mm)	30% remains	2%
Mesic forest	27-35" (675-875 mm)	3% remains	7%
Dry forest	20-27" (500-675 mm)	2% remains	36%
Arid grassland & shrubland	8-20" (200-500 mm)	20% remains	49%
Coastal and strand	8-18" (200-450 mm)	3% remains	6%

Source: Hobdy, 1993

Status of Remaining Plant Communities

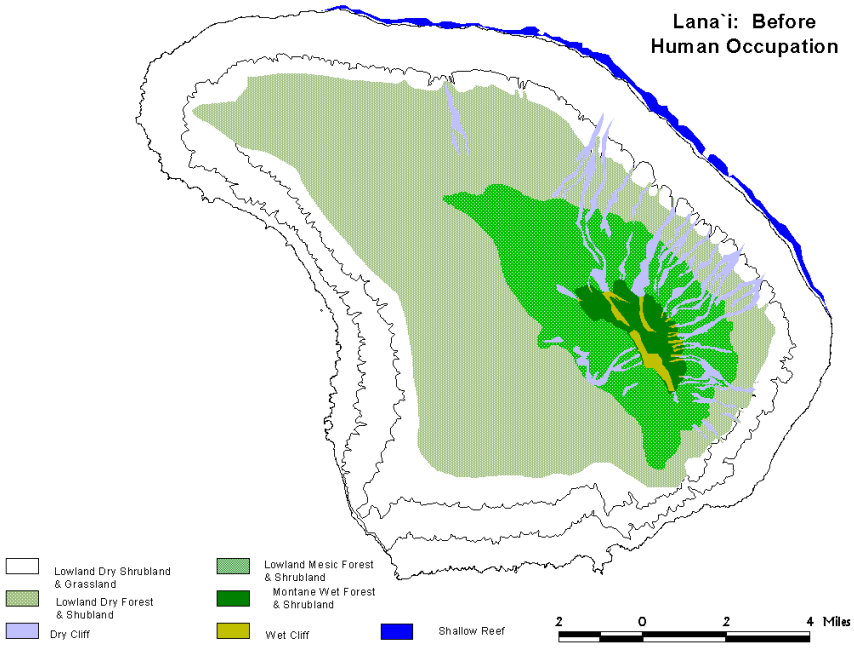
The Nature Conservancy, using a classification with more segregation of categories, but based on the same sorts of considerations, divides the island into seven main types of communities. This Figure does not look at the overall percent of native community remaining, but rather asks the question, within the remaining pockets of native plant communities, what percent of plants is actually native? In other words, the Figure below answers the question "How pristine is the remaining native cover?"

VEGETATION COMMUNITY	ELEVATION RANGE	PERCENT NATIVE
wet cliff	2,700-3,300'(823.5 - 1,006.5 m)	75%
montane wet forest & shrubland	2,800-3,300'(854 - 1,006.5 m)	75%

lowland mesic forest &shrubland	1,500-3,300(457.5 - 1,006.5 m)	50%
lowland dry forest & shrubland	1,600-1,800'(488 - 549 m)	25%
dry cliff	400-3,300'(122 - 1,006.5 m)	75%
lowland dry shrubland & grassland	500-3,200'(152.5 - 976 m)	50%
non-native	0-3,100' (0 - 945.5 m)	5%?

The map below shows estimated ranges of the pre-contact extent of the communities listed above.

FIGURE 6-4 Lana'i Vegetation Before Human Occupation



Threats to Lana'i Hale Plant Communities

Prior to Polynesian colonization, Lana`i was covered with native vegetation. The introduction of Polynesian agriculture and fire modified the vegetation primarily in the coastal and lowland areas. The arrival of Europeans accelerated the destruction, with the introduction of ranching, cattle, sheep, pineapple, cane, goats, pigs, etc, axis deer, mouflon sheep.

Although the Lana`ihale ecosystem is unique, many of the threats to the watershed affect the entire island. The major threats include habitat alteration, invasive plants & animals, erosion, pathogens, human activity and drought. These are further described in Figures 6-7 and 6-8, which follow.

FIGURE 6-5 Flowering Plant Species on Lana`i - Endangered, Candidate, Threatened, Species of Concern

found in Lana`ihale	Status	Family	Genus	Species	SubSpecies (var. if indicated)	Description
	E	Amaranthaceae	Achyranthes	splendens	var. rotunda	
	E	Apiaceae	Spermolepis	hawaiiensis		tiny, seasonal shrub in the Parsley family. found in dry areas 1,000-2,500'
Y	E	Asteraceae	Bidens	micrantha	kalealaha	erect, perennial herb in the Sunflower family. found in dry to mesic forests and shrublands. 1.5-5' tall. Lana`i Hale.
Y	E	Asteraceae	Hesperomannia	arborescens		small, shrubby tree in the Sunflower family, 5-15' tall. slopes and ridges of wet forests. (1,000'-2,200')
	E	Asteraceae	Tetramolopium	lepidotum	lepidotum	white flowered daisy in the Sunflower family found in dry lowland areas (500'-1,000')
	E	Asteraceae	Tetramolopium	remyi		shrub in the Sunflower family found on dry exposed ridges or flats in lowland & dry shrubland areas (500'-2,500')
Y	E	Camapanu-laceae	Clermontia	obliongifolia	mauiensis	terrestrial shrub or tree in the Bellflower family, with dark, smooth glossy green leaves, and white calyx type flowers with white or purple stamens. 6-21' tall. orange berries. mesic valleys to wet forests, 1,200-3,600'.
Y	EX	Camapanu-laceae	Cyanea	lobata	baldwinii	four to seven foot tall palm-like shrub in the Bellflower family. mesic to wet forest (2,000' - 3,000') , extinct. a single plant was found in 1919 by Munro. The same plant was still alive as of 1935. Munro propagated seeds from this plant, and they survived around his home site until at least 1940.
Y	E	Camapanu-laceae	Cyanea	gibsonii		was Cyanea macrostegia gibsonii. palm-like lobeliad tree in the Bell-flower family, 3-21' tall. bird-pollinated, found in wet to mesic areas (2,490-3,180')
Y	E	Campanulaceae	Brighamia	rockii		}lula, h~h~. succulent in the Pink family. has stout, unbranched stem, thicker at base. 3-15' tall. calyx type flower has white corolla with green to yellowish green tube. grows on windward sea cliffs to 1,400'. also found in Maunalei valley.
Y	E	Caryophyl-laceae	Silene	lanceolata		subshrub in the Pink family. small flowers at end of stems, in clusters, with smooth white petals. reddish brown seeds. dry to mesic areas, 900'-5,490'. Maunalei Valley .
	E	Convolvu-laceae	Bonamia	menziesii		
	E	Cyperaceae	Cyperus	trachysanthos		
Y	E	Cyperaceae	Gahnia	lanaiensis		tufted, perennial Sedge, 980'-3,020' range, first described at 2,919' elevation
Y	E	Cyperaceae	Mariscus	fauriei		low-growing Sedge found in mesic shrubland (1,000'-2,500')
Y	E	Fabaceae	Caesalpinia	kavaiensis		uhi uhi, k~wa`u, kea shrub or tree in the Pea family. 12-30' tall, thick rough dark gray bark, pinate (divided) leaves, red flowers. dry to mesic forests 240'-2,760' . Hawaiians made spears and fishing implements from the hard, durable wood.
	E	Fabaceae	Sesbania	tomentosa		prostrate shrub in the Pea family found in lowland coastal areas 50'-1,500'
	E	Fabaceae	Vigna	owahuensis		twining vine in the Pea family, found in dry lowland areas 50' - 1,500'
	E	Gentianaceae	Centaurium	sebaeoides		ephemeral herb in the Gentian family, found in coastal habitats 50'-750' elevation
Y	E	Gesneriaceae	Cyrtandra	munroi		shrub in the African violet family found in lowland wet forest (980'-2,202')
	E	Gooeniaceae	Scaevola	coriacea		dwarf naupaka. prostrate perennical herb in the Goodenia family.
Y	E	Lamiaceae	Phyllostegia	glabra	var. lanaiensis	perennial herb in the mint family lowland mesic to wet forest 2,490' - 3,180' gulch bottoms & sides, steep areas
	E	Malvaceae	Abutilon	eremitopeta-lum		shrub in the mallow family, bird pollinated lowland dry forest, historical range 690'-1,710' currently only at around 1,100'
	E	Malvaceae	Abutilon	menziesii		shrub in the mallow family, bird pollinated found in low, dry shrubland (500-1,400')

	E	Malvaceae	Hibiscus	brackenridgei	brackenridgei	sprawling, deciduous shrub found in dry, lowland areas (500'-2,000')
	E	Poaceae	Cenchrus	agrimonioides	agrimonioides	
	E	Poaceae	Panicum	fauriei	var. carteri	
	E	Portulacaceae	Portulaca	sclerocarpa		perennial herb in the purslane family. pale, grayish-green leaves. clusters of 3-6 flowers at the end of stems, white or pink metals about 10 mm long, with tufts of hair underneath. likes dry habitats, 3,090'-4,890'. Found on Po`opo`o islet off the coast of Lana`i.
	E	Rhamnaceae	Gouania	hillebrandii		
Y	E	Rubiaceae	Gardenia	brighamii		small tree in the coffee family, up to 15' tall. dry forest species. 1,050' -1,560'. Kanepu‘u.
	E	Rubiaceae	Hedyotis	mannii		subshrub in the Coffee family. mesic to wet forest.
Y	E	Rutaceae	Zanthoxylum	hawaiiensis		moderate sized tree in the Rue family. found in mesic forest habitats. 2,000' - 4,500'
Y	E	Santalaceae	Santalum	freycinetianum	var. lanaiensis	small gnarled tree (Sandalwood) w/ bright red flower clusters, bird pollinated, lowland dry to high-elevation mesic, or wet
Y	E	Solanaceae	Solanum	incompletum		pÇpolo kā mai. shrub in the Nightshade family. Up to 9' tall. reddish prickles on stem. mesic to dry forest. 1,800' - 6,100'.
Y	E	Urticaceae	Neraudia	sericea		9' - 15' shrub in the Nettle family. Mesic to dry forest. 2,000'-3,000'.
	E	Violaceae	Isodendrion	pyrifolium		
Y	E	Violaceae	Viola	lanaiensis		subshrub in the Violet family, lowland wet forest to lowland mesic shrubland 2,200' - 3,200'
Y	PE	Loganiaceae	Labordia	tinifolia		k~makahala. Shrub or small tree in the Logania family. 3.5 - 30' tall. Mesic to wet forest, ridges, slopes or understory of open canopy. 900' to 2,300'.
Y	PE	Rubiaceae	Hedyotis	schlechten-dahliana	var. remyi	trailing herbaceous shrub in fern understory. Coffee family. 2,500' - 3,000'
Y	PE	Rutaceae	Melicope	munroi		
Y	C	Caryophyl-laceae	Schiedea	pubescens	var. pubescens	
	C	Fabaceae	Canavalia	pubescens		found in mesic to dry areas, bird pollinated
Y	C	Laminaceae	Phyllostegia	imminuta		sub-erect perennial shrub in the Mint family. mesic gulches of Lana`i Hale. 2,040' - 2,190'
Y	SOC	Asteraceae	Bidens	campylotheca	campylotheca	erect perennial herb in the Sunflower family. 2 ' - 12' tall. wet to mesic areas 300'-3,600'.
	SOC	Asteraceae	Bidens	mauiensis		decumbent perennial herb in the Sunflower family 0.3' - 1' tall. coastal bluffs, dunes and dry slopes. 150' - 1,800'.
Y	SOC	Agavaceae	Pleomelde	fernaldii		small, branched tree in the Agave family w/palm-like leaves mesic to dry forest 1,600' - 3,000'
Y	SOC	Araliaceae	Tetraplasandra	kavaiensis		tallish (24' - 75') tree in the Ginseng family. mesic to wet forest. 1,950' - 4,800'.
	SOC	Asteraceae	Tetramolopium	conyzoides		
	SOC	Brassicaceae	Lepidium	bidenatum	var. owahiense	
Y	SOC	Campanulaceae	Delissea	lanaiensis		four to six foot tall palm-like shrub in the Bellflower family. mesic to wet forest (2,000' - 3,000') , extinct?
	SOC	Capparaceae	Capparis	sandwichiana		
	SOC	Caryophyl-laceae	Schiedea	menziesii		Sprawling subshrub in the Pink family. Found in Maunalei valley. dry forest ledges and cliffs. 90' - 1,020'
	SOC	Euphorbiaceae	Chamaesyce	celastroides	laehiensis	
	SOC	Fabaceae	Acacia	koaia		smallish, gnarled tree in the Pea family. less than 35' high. mesic and dry, open habitats. wood is harder and pods narrower, than those of Acacia koa. 180' - 6,180'
Y	SOC	Gesneriaceae	Cyrtandra	lydgatei		shrub in the African violet family. 2' - 8.5' tall. flowers at ends of stalks, in dense clusters. leaves in unequal pairs. white berries. wet forest (1,500' - 2,700'). Maunalei Valley and Hale.
	SOC	Lamiaceae	Haplostachys	munroi		
Y	SOC	Malvaceae	Hibiscadelphus	crucibracteatus		tree up to 18' tall in Mallow family. rounded crown. trunk about 16 cm. diameter. Puhielelu Ridge in Lana`i about 2,250'.
Y	SOC	Poaceae	Dissochondrus	bifloris		tall, perennial Grass with narrow, spike-like tufted flowers. sharply keeled, flat blades. diverse mesic forests, often on slopes. 1,400' - 3,150'.
	SOC	Poaceae	Eragrostis	deflexa		
	SOC	Poaceae	Eragrostis	mauiensis		
	SOC	Poaceae	Panicum	ramosius		
	SOC	Portulacaceae	Portulaca	molokiniensis		`Ihi. stout perennial herb in the Purslane family. older stems have a pale, corky layer of secondary growth. headlike clusters of flowers with white or pink petals, 10 mm long. dark brown seeds. coastal areas, sea cliffs and steep, rocky slopes. 30-345'.

	SOC	Portulacaceae	Portulaca	villosa		perennial herb in the Purslane family. erect sub-shrub. pale, grayish-green leaves. dark, reddish-brown seeds. clusters of 3-6 flowers at the end of stems, white or pink metals 8- 10 mm long, with tufts of hair underneath. dry rocky or coralline areas, 0-1,200'.
Y	SOC	Rubiaceae	Morinda	trimera		
Y	SOC	Rutaceae	Melicope	hawaiensis		Mokihana, kākae moa, manena. 9' - 30' tall shrubs or trees in the Rue family. smooth, pale brown bark. dry to mesic areas, 1,830' - 3,660'.
	SOC	Santalaceae	Exocarpos	gaudichaudii		Heau, a`u, sandalwood tree. small tree or shrub 4.5 - 21' tall. found on ridges in mesic forest and shrub land. 750' to 1,075'. bears small fruit with hard seed.
	SOC	Solanaceae	Nothocsestrum	latifolium		
Y	SOC	Thymelaeaceae	Wikstroemia	bicornuta		}ki`a, kauhi. straggling shrub to small tree in the }ki`a family. Dark green leaves, lighter on lower surface. 3'-7' tall. 2,700' - 3,150' elevation. wet forest. highest ridge of Lana`i.
	E		Ctentis	squarmigera		endangered terrestrial fern found in Lana`i Hale.

FIGURE 6-6 Two Native Lana'i Species: Kawau and Cyrtandra

The left column indicates whether the species is found in Lana`ihale. Descriptions are provided for Lana`ihale species.
This Figure was compiled from the Bishop Lists, US F&WS list, the Manual of Flowering Plants of Hawai'i (Wagner, Herbst and Sohmer, 1990), with guidance and assistance from Robert Hobdy, formerly of the State DLNR Division of Forestry and Wildlife.

FIGURE 6-7 Threats to Lana'i's Flowering Plant Species

Threat	Explanation of Problems Caused by Threat
Habitat Alteration	The small size of remaining populations of certain species can leave them vulnerable. Loss of numbers can lead to loss of genetic vigor, increased susceptibility to disturbances & diseases and other problems. The small extent of remaining intact ecosystems may prove too small to support certain target species Introduction of exotic species, particularly if these are invasive, can destroy large tracts of land very rapidly Poorly planned management efforts can inadvertently alter habitat.
Invasive plants	A list of invasive plant species needing control in and around Lana'ihale is provided in Figure 8. This Figure also describes some of the problems associated with these plants.
Invasive animals	examples below
Axis Deer (Axis axis)	Axis deer were introduced 1920s. After elimination of goats in 1981, deer moved upland and numbers have increased dramatically. It is possible that a psyllid leafhopper of koa haole contributed to this movement upland, since koa haole had been major source of food for deer in the lowlands. In 1988, the deer population reached 10,000. The majority of deer are noted just mauka of the kiawe belt on the north east side of the island. DOFAW staff also notes that there appears to be evidence that there may be two somewhat distinct populations of axis deer on Lana`i: one makai (in the kiawe belt) and the other mauka (in and around Lana'ihale and upper elevations). This theory is based on observations of game trails that extend upward from the kiawe and downward from the mesic forest, but seem to be discontinuous at or about mid-elevation. Axis deer are considered the primary threat to the watershed at this time, largely due to their behaviours of browsing, trampling and rubbing, described further below.
	Browsing damages or destroys plants by eating green portions
	Trampling removes vegetation, removes leaf litter important to soil-water relations promotes erosion, compacts soils, opens areas to invasive plants and animals (carried as seed in digestive tracts, droppings, fur, etc.)
	Rubbing destroys cambium layer of trees, esp. from bucks rubbing felt off antlers
Mouflon Sheep (Ovis musimon)	Browse on native vegetation, trample, etc. Introduced in 1954. Well adapted to ridge and gully lands
Sheep (Ovis aries)	catastrophically large numbers of sheep around the turn of the century (50,000) Greatly reduced by 1920, eliminated entirely from Lana`i by the late 1950s.

Goats (Capra hircus)	introduced in early 1800s eliminated 1981 trampling, grazing, erosion, etc.
Cattle (Bos Taurus)	eliminated about 1950 trampling, grazing, erosion, etc.
Pigs (Sus scrofa)	first piggery 1911, pigs eradicated in 1930 by George Munro trampling, wallows, grubbing, erosion, etc.

Birds	Loss of native pollinators (birds, insects) causes threat to remaining habitat Introduction of pest birds that feed on native insects that pollinate native plants Introduction of pest birds that compete with native birds for food, nesting sites, etc. Examples include the Japanese White Eye and the Japanese Bush Warbler, which compete for food & nesting sites, or Cardinals, believed to feed on sandalwood fruits. More information is found in Figure 13. Introduction of bird diseases including avian malaria (protozoan), avian pox (virus) Introduction of insects carrying avian diseases, especially mosquitoes, which carry avian malaria and avian pox
Rats (Rattus rattus rattus, Rattus exulans Rattus norvegicus)	Rats feed on fruits, flowers and seeds of native plants, girdle or strip branches, and prey on native birds. Rattus rattus rattus, the arboreal black rat, believed to have had the greatest impact among rats and mice on flora and fauna.
Mice (Mus domesticus)	Like rats, mice feed on fruits and flowers of Hawai‘ian plants, and/or girdle and strip branches. Sandalwoods are especially vulnerable to rodent damage. Predation on seeds reduces reproductive viability.
Slugs	Slug damage and live slugs have been observed on native species, such as Viola lanaiensis). Seedlings and young tender shoots are especially susceptible
Insects	Descriptions of problem insect species are found in Figure 9.
Pathogens	Spike disease - affects sandalwood in India, believed to be in Hawai‘i Santalum heart rot - affects sandalwood (mostly dry to mesic, but some in Lana‘ihale) Santalum seed fungus - affects sandalwood (mostly dry to mesic, but some in Lana‘ihale)
Humans	Human and animal traffic in and around remaining communities Example - roughtly half of the remaining plants of a certain species (Gahnia lanaiensis) grow adjacent to the Munro Trail. conversion of native ecosystems to agricultural uses , pasture Ex: Most of dryland habitat long ago cleared for pasture, harming Abutilon eremitopetalum, Abutilon menziesii, Tetramolopium remyi) pineapple cane vandalism illegal collection fires resulting from human activities or spread by human-introduced species inadvertent damage from poorly executed management efforts

Erosion	Self-perpetuating cycle. Animals lead to compaction of soils, loss of plants, and erosion. Erosion leads to more loss of plants. Loss of plants leads to more erosion
Drought	May be exacerbated by diminishing fog drip. Exacerbated by loss of ground cover in the forest - ground dries quickly & stays dry longer can also lead to viscious cycle . Die back of plants leads to less fog drip. Less moisture leads to more die back of plants. This cycle increases threats from fire and erosion.

A list of invasive plants that pose threats to the watershed is provided in Figure 6-8. Typical invasive behaviors include crowding out other vegetation, displacement of understory, allelopathy or release of compounds that inhibit growth of other plants, and provision of fire fuel or stimulation. Among the more damaging are christmas berry (*Shinus terebinthifolius*), strawberry guava (*Psidium cattleianum*), manuka (*leptospermum scoparium*), guava and *Tibouchina herbacea.*

FIGURE 6-8 Invasive Plants in Lana'ihale and Surrounding Mesic Areas

Genus	Species	Common Name	Description
Andropogon	viginicus	broomsedge	boggy open mesic and dry habitats, releases allelopathic substances. fire stimulated, and fuel for fires. Dormant during rainy season. May enhance erosive properties.
Asclepias	physocarpa	balloon plant	erect shrub in the milkweed family. grows up to about 6' in height. highly invasive in disturbed areas. seeds dispersed by wind.
Hedychium	gardnerianum	kahili ginger	agressive invader of wet forests, especially well lit areas and streambeds. dispersed by birds. also spreads vegetatively. forms large continuous clumps, displaces understory.
Lantana	camara	aggressive grass. crowds out other species. carries fire, fire stimulated. seeds dispersed by wind. affects mostly dryland areas. Introduced to Lana`i in two places, on the north end and on the golf course. Known populations were removed, but follow-up is needed.	thorny shrub, forms impenetrable thickets, crowding out other plants. biological controls have reduced aggressiveness somewhat. especially bad in dry lowland areas. normally does not grow over 15' hight, but can get to 40' if supported.
Leptospermum	scoparium	manuka	New Zealand shrub. Crowds out native vegetation, especially on Lana`i Hale.
Leucacaena	leucocephala	koa haole	nitrogen fixing tree, forms dense thickets, excludes other vegetation, esp bad in low, dryland areas,but also affects mesic to wet areas.
Melinis	minutiflora	mollasses grass	dry mountain ridges, mesic to wet forests. forms dense mat, smothers other plants. fuel for fires. spreads fires.
Myrica	faya	firetree	rapidly growing, invades mesic and wet habitats. Forms dense, monotypic stands. Nitrogen fixing, capable of altering ecosystems. Suspected of allelopathic activity. Grows from 984' to the summit. Colonizing. Lana`i Hale south slope has one of the major infestations in the state.
Panicum	maximum	guinea grass	drougt resistant, allelopathic, carries fire under dry conditions, highly invasive. Especially problematic in dry areas.
Paspalum	conjugatum	Hilo grass	low growing grass. spreads in shady partial openings and occupies distrubed areas in forst understory. not as habitat-altering as molasses grass
Pennisetum	clandestinum	kikuyu grass	invades dry, mesic and wet forest habitats. forms thick mat that prevents reproduction of native taxa.
Pennisetum	setaceum	fountain grass	aggressive grass. crowds out other species. carries fire, fire stimulated. seeds dispersed by wind. affects mostly dryland areas. Introduced to Lana`i in two places, on the north end and on the golf course. Known populations were removed, but follow-up is needed.
Pluchea	symphytifolia	sourbush	forms dense thickets in dry to wet habitats
Prosopis	pallida	kiawe	highly invasive tree to dry areas and lowlands. Overtops other lowland vegetation.
Psidium	cattleianum	strawberry guava	one of the most agressive exotic invasive species. forms dense stands, capable of displacing all other palnt species. Has allelopathic properties. Fruit is dispersed by birds.
Rubis	rosifolius	thimbleberry	low to mid height, weak-stemmed shrub. Has small red berry and prickles on stems. Grows in mesic to wet areas
Schinus	terebinthifolius	christmas berry, brazilian pepper	tree. forms dense monotypic stands. found in Kanepu`u and on the lower slopes of Lana`i Hale. Massive dispersal by birds follows fruiting in Nov.-Dec. Christmasberry invades dry to mesic sites
Tibouchina	herbacea	aggressive grass. crowds out other species. carries fire, fire stimulated. seeds dispersed by wind. affects mostly dryland areas. Introduced to Lana`i in two places, on the north end and on the golf course. Known populations were removed, but follow-up is needed.	wet forest invader, crowds out native species. Especially invasive where native cover has been disturbed

FIGURE 6-9 Native Lana'i Ferns - Amau and Uluhe

Ferns

Native Hawai'ian ferns help to collect and hold water, and to improve water holding capacity of the soils. They help to limit loss of water through evapotranspiration by keeping the forest floor cool.

Native ferns serve as nesting sites for certain native birds. Munro records certain native Lana`i bird species nesting in and amongst ferns, possibly to help hide themselves from the predatory Pueo (native owl).

Like all other species, ferns also contributed to the general biomass and level of soil nutrients.

The following Figure describes some of Lana'i's native ferns.

FIGURE 6-10 Pteridophytes (Ferns) Native to Lana`i

Family	Genus	Species
Psilotaceae	Psilotum	nudum
		complanatum
Lycopodiaceae	Phlegmariusrus	filiformis
		phyllanthus
	Huperzia	erosa
		x. gillettii
		serrata
		x sulcinervia
	Lycopodium	venustulum
	Palhinhaea	cernua
Selaginellaeae	Selaginella	arbuscula
Botrychiaceae	Sceptridium	subbifoliatum
Ophioglossaceae	Optioglosum	petiolatum
		polyphyllum
	Ophioderma	pendula
Marattiaceae	Marattia	douglasii
Gleicheniaceae	Dicranopteris	linearis
	Diplopterygium	pinnatum
	Sticherus	owhyhenis
Schizaeaceae	Schizaea	robusta
Pteridaceae	Adiantum	capillus-veneris
	Coniogramme	pilosa
	Pteris	cretica
		excelsa
		x hillebrandii
		irregularis
	Doryopteris	decipiens
		decora
		subdecipiens
	Pellaea	ternifolia
Vittariaceae	Haplopteris	zosterifolia
Hymenophyllaceae	Gallistopteris	baveriana
	Gonocormus	saxigragoides
	Mecodium	recurvum
	Sphaerocionium	lanceolatum
		obtusum
	Vandenboschia	cyrtotheca
		davallioides
		draytoniana
Cyatheaceae	Cibotium	chamissoi
		glaucum
		menziesii
Dennstaedtiaceae	Hypolepis	hawaiiensis
	Microlepia	strigosa
	Pteridium	decompositum
Lindsaeaceae	Lindsaea	repens var. macroaeana
	Odontosoria	chinensis
Thelypteridaceae	Pseudophegopteris	keraudreniana
	Cyclosorus	cyatheoides
		hudsonianus
		interruptus
		sandwicencis
	Thelypteris	globulifera
Blechnaceae	Dodia	kunthiana
	Sadleria	cyatheoides
		pallida
		souleyetiana
		squarrosa
Aspleniaceae	Asplenium	acuminatum
		x adiantum-nigrum
		aethiopicum

		contiguum
		cookii
		horridum
		lobulatum
		macraei
		nidus
		nomale
		sphenotomum
	Hymenasplenium	excisum
		unilaterale
	Diellia	erecta
Woodsiaceae	Athyrium	microphyllum
	Deparia	fenzliana
		marginalis
		prolifera
	Diplazium	arnottii
		molokaiense
		sandwichianum
Dryopteridaceae	Ctenitis	latifrons
		squamigera (endangered)
	Cyrtomium	caryotideum
	Dryopteris	fusoatra
		glabra
		mauiensis
		sandwicensis
		unidentata
		wallichiana
	Nothoperanema	rubiginosa
	Tectaria	cicutaria var. gaudichaudii
	Elaphoglossum	aemulum
		crassifolium
		paleaceum
		parvisquameom
		pellucidum
		wawrae
	Nephrolepis	cordifolia
		exaltata ssp. hawaiiensis
Grammitadaceae	Adenophorus	abietinus
		hillebranii x. tripinnatifidus
		hymenophylloides
		tamariscinus
	Grammitis	hookeri
		tenella
	Lellingeria	saffordii
	Oligadenos	pinnatifidus
Polypodiaceae	Lepisorus	thumbergianus
	Microsorum	spectrum
	Polypodium	pellucidum
Courtesy of Herbarium Pacificum, Bishop Museum		

Hepatics, Mosses and Lichens

The health of a watershed, and therefore its water catchment ability, can be rapidly assessed by the abundance of pendulous lichens and mosses on the branches of the trees.

Lichens and mosses are excellent interceptors of moisture from fog. Hanging *Thalli* have a high surface area to volume ratio, which means more surface area to intercept rainfall. Mosses and lichens help to keep the temperature in the cloud forest cool, allowing for more water condensation.

The diversity of a healthy epiphyte and bryophyte community also lends stability. A monotypic plant community is ultimately unstable and more vulnerable to outside threats.

Mosses and lichens provided food and home to various species. For instance, *Usnea* species are often inhabited by rare, cryptic spiders. *(Personal communication: Dr. Cliff Smith of UH Botany Dept.)*

Figures 6-11, 6-12 and 6-13 list native mosses, lichens and hepatics of Lana`i, respectively, based on information provided by Bishop Museum. Dr. Christopher Puttock, Collection Manager of Botany for the Bishop Museum, has indicated that the list of hepatics is likely a vast underestimate, and suggests that the true list "will probably be similar to that of Molokai (91 taxa) and perhaps half of Maui (137)".

Threats to Mosses and Lichens and Algae

Threats to ferns, mosses, lichens and algae are largely similar to those facing the flowering plant communities described in the Figure above. Of particular concern for the survivial of these specific communities are:

- trampling, browsing, ungulate traffic
- insect pests such as the Chinese two-spotted leaf- hopper
- exotic weeds
- loss of critical population size / habitat size
- predation by introduced rodents, snails, slugs, birds
- erosion
- fire damage
- introduced pathogens

(Sources: Personal communications, Dr. Cliff Smith of UH Botany Dept., and Dr. Christopher Puttock of Bishop Museum Dept. of Natural Sciences)

FIGURE 6-11 Mosses on Lana`i

GENUS	SPECIES	VARIETY	BAUTHOR	TAUTHOR
Acroporium	fusco-flavum	fusco-flavum	(Par.) Broth.	
Aerobryopsis	wallichii		(Brid.) Fleisch.	
Anoectangium	euchloron		(Schwaegr.) Mitt.	
Baldwiniella	kealeensis		(Reichardt)Bartr.	
Bryum	angustirete		Broth.	
Campylopus	fumarioli		C. Mull.	
Campylopus	hawaiicus	hawaiico-flexuosus	(C. Mull.) Jaeg.	(C.Mull.) Frahm
Campylopus	hawaiicus	hawaiicus	(C. Mull.) Jaeg.	
Campylopus	umbellatus		(Arnott) Par.	
Daltonia	contorta		C. Mull.	
Dicranella	hochreuteri		Card,	
Distichophyllum	freycinetii	freycinetii	(Schwaegr.) Mitt.	
Distichophyllum	paradoxum		(Mont.) Mitt.	
Ectropothecium	sandwichense		(Hook & Arnott.)	
Ectropothecium	viridifolium		Bartr.	
Entosthodon	subintegrus		(Broth.) Miller, H.	
Eurhynchium	vagans		(Jaeg.) Bartr.	
Fissidens	bryoides		Hedw.	
Fissidens	delicatulus		Angstr.	
Fissidens	elegans		Brid.	
Fissidens	hoei		Pursell	
Fissidens	kilaueae		Hoe & Crum	
Fissidens	lancifolius		Bartr.	
Fissidens	nothotaxifolius		Pursell & Hoe	
Glossadelphus	zollingeri	filicaulis	(C. Mull.) Fleisch.	(Fleisch.) Fleisch.
Glossadelphus	zollingeri	filicaulis	(C. Mull.) Fleisch.	(Fleisch.) Fleisch.
Holomitrium	seticalycinum		C. Mull.	
Homaliodendron	flabellatum		(Sm.) Fleisch	
Hookeria	acutifolia		Hook. & Grev.	
Hookeria	acutifolia		Hook. & Grev.	
Isopterygium	albescens		(Hook.) Jaeg.	
Leucobryum	gracile	gracile	Sull.	
Leucobryum	pachyphullum		C. Mull.	
Leucobryum	seemannii	seemannii	Mitt.	
Macromitrium	brevusetyn		Mitt.	
Macromitrium	emersulum		C. Mull.	
Macromitrium	piliferum		Schwaegr.	
Macromitrium	reinwardtii		Schwaegr.	
Palamocladium	wilkesianum	wilkesianum	(Sull.) C. Mull.	
Palamocladium	wilkesianum	sciuroides	(Sull.) C. Mull.	(C.Mull.) Wijk &
Philonotis	hawaica		(C. Mull.) Broth.	
Philonotis	turneriana	turneriana	(Schwaegr.) Mitt.	
Pogonatum	tahitense		Schimp. ex	
Racopilum	cuspidigerum		(Schwaegr.)	

Rhizogonium	pungens		Sull.	
Rhizogonium	spiniforme		(Hedw.) Bruch	
Sematophyllum	hawaiiense		(Broth.) Broth.	
Taxithelium	mundulum		(Sull.) Bartr.	
Thuidium	hawaiense		Reichardt	
Tortella	humilis		(Hedw.) Jenn	
Tortella	tortuosa		(Hedw.) Limpr.	
Trichosteleum	hamatum		(Dozy & Molk.)	
Trichosteleum	bartramii		Mill	
Vesicularia	perviridis		(Angstr.) C. Mull	
Weissia	ovalis		(Williams) Bartr.	
Courtesy of Herbarium Pacificum, Bishop Museum				

FIGURE 6-12 Lichens of Lana`i

GENUS	SPECIES	VARIETY	BAUTHOR
Anaptychia	sorediifera	colorata	(Muell. Arg.) Du Reitz & Lynge
Anthracothecium	sandwicense	convexum	Zahlbr.
Anthracothecium	sandwicense		Zahlbr.
Arthonia	cinnabarina		(DC.) Wallr.
Arthopyrenia	phaeoplaca		Zahlbr.
Arthotelium	macrothecum		(Fee) Mass.
Bacidia	alutacea		(Kremp.) Zahlbr.
Bacidia	alutacea	minarum	(Kremp.) Zahlbr.
Bacidia	choriciae		Zahlbr.
Bacidia	medialis		(Tuck.) Zahlbr
Bacidia	personata		Malme
Bacidia	sandwicensis		H. Magn.
Bombyliospora	domingensis		De Not
Buellia	subcallispora		H. Magn.
Catillaria	cuvatula		H. Magn.
Catillaria	intermixta	trachonoides	(Nyl.) Am.
Catillaria	vacillans		H. Magn.
Chiodecton	perplexum		Nyl.
Cladina	sylvatica		(Hoffm.) Nyl.
Cladonia	angustata		Nyl.
Graphina	sulphurella		Zahlbr.
Graphis	illinata	apoda	Eschw.
Graphis	leptocarpa		Fee
Graphis	lineola		Ach.
Gyrostomum	dactylosporum		Zahlbr.
Lecidea	granifera	leucotrapa	(Ach.) Vain.
Leptogidium	byssoides		(Carrahlbr.)
Microthelia	albidella		Muell. Arg.
Ocellularia	exnthismocarp		(Leight.) Zahlbr.
Ocellularia	multilocularis		Zahlbr.
Ochrolechia	pallescens		(L.) Mass.
Opegrapha	prosodea		Ach.

Opegrapha	subcervina		Zahlbr.
Pannaria	lurida		(Mont.) Nyl
Parmelia	tinctorum		Despr.
Parmentaria	lyoni		Zahlbr.
Phaeographis	dentritica		(Ach.) Muell. Arg.
Phaeophysica	UN		UN
Phaeotrema	rocki		Zahlbr.
Physcia	picta		(Sw.) Nyl
Physcia	picta		(Sw.) Nyl
Physcia	sorediosa		(Vain.) Lynge
Pleurotrema	rocki		Zahlbr.
Pseudocyphellaria	flavicans		(Hook.) Vain.
Pseudopyrenula	octomera		H. Magn.
Pyrenula	sublateritia		Zahlbr.
Pyxine	retirugella	capitata	Nyl.
Ramalina	extenuata		H. Magn.
Ramalina	faurieana	contracta	Zahlbr.
Ramalina	faurieana		Zahlbr.
Ramalina	microspora		Kremp
Ramalina	sideriza		Zahlbr.
Ramalina	subpollinaria		Nyl.
Sphinctrina	microcephala		(Sm.) Nyl.
Sticta	weigelii		Isert
Usnea	australis		Fr.
Usnea	condensata		Mot.
Usnea	dasycera		(Nyl.) Motyka
Usnea	rubicunda		Stirt
Xanthoparmelia	subramigera		(Gyeln.) Hale
Courtesy of Herbarium Pacificum, Bishop Museum			

FIGURE 6-13 Hepatics of Lana`i

GENUS	SPECIES	BAUTHOR
Frullania	neurota	Taylor
Jubula	hutschinsiae	(Hooker) Dumortier
Courtesy of Herbarium Pacificum, Bishop Museum		
* Bishop Museum staff suggest that this list probably under-represents		
Hepatics on Lana`i, and that the true list would probably be more		
similar to those of Molokai (91 taxa) and perhaps half of		
Maui (137 taxa).		

FIGURE 6-14 Native Lana'i Snails

Terrestrial Mollusks of Lana`i

Estimates of the number of species of terrestrial mollusks in Hawai'i vary. Loope ('98) quotes S. Miller of the US F& W Service as stating that there are about 1,263 historically described species of Hawai'ian Land Snails, of which about 900 species, or 71% are extinct. (Mac, M.M.; P.A. Opler; C.E. Puckett Haecker; and P.D. Doran "Status and Trends of the Nation's Biological Resources", 2 volumes; U.S. Department of the Interior, U.S. Geological Survey; Reston, Va.; Chapter on Hawai'i & the Pacific Islands by Lloyd Loope, 1998). A review of the U.S. Fish & Wildlife Service Species List from February 1st, 2000 indicates 640 endangered, threatened, candidate or species of concern snail taxa. Hobdy ('93) estimates that there were once roughly 780 species of snails endemic to the Hawai'ian islands ("Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawai'ian Island"; *Pacific Science*; vo. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993). According to Severns (personal communication 1999), there were 763 species of taxonomically valid species of snails recognized as Hawai'ian, of which all but 2 to 4 are endemic. Most were single-island endemics. An additional 16 species questionably belong to Hawai'i, and a further 14 are possibly senior synonyms (prior descriptions under a different name).

Earlier articles have estimated that there were once 42 species of native land snails on Lana`i. However, more recent work estimates 71 species. (See Figure prepared by Mike Severns, based on Cowie, Catalog of Native Land & Fresh Water Molluscs of the Hawai'ian Islands, Backhuys Publishers, Lieden, 1995 and others. These are listed in Figure 6-15.

Although native snail fauna is among the more diverse groups of native species, some experts

believe that most species of Hawai‘ian snails radiated from members of a single genus of progenitors, *Tornatellides*, which has been found on bird feathers throughout the Pacific islands. (Personal communications, Dr. Michael Hadfield, Mike Severns).

Snails were and integral and abundant part of the original, uniquely endemic ecosystems of Lana`i. Most native snails are single island endemics, existing no where else on Earth. Snails in Hawai‘i mainly eat fungus, lichens and algae off leaves of trees. It is not clear whether this could have any beneficial impact on the trees, or how important this role was. Snails, like other abundant life forms, were part of the nutrient cycle, contributing to the total biomass, soil nutrients, and so forth. They were a dietary component of certain native birds. The endangered Po`ouli (Melamprosops phaeosoma) eats snails (Gon), and it is believed that certain extinct species of large flightless birds ate snails (Severns), although apparently the larger snails were not eaten. (Severns, personal communication; Pilsbry, Manual of Conchology, Storrs & James, Ornithological Monographs 45 & 46, James Juvik, Atlas of Hawai‘i, 3rd Edition).

Severns has explained a phenomenon noticed during the time when sheep were on Lana`i, in which mollusc populations seem at first to increase with disturbance of native communities, though in the long run they may be adversely affected. He believes that invasive mammals, such as sheep ate lower stature plants / trees at the edge of the forest, exposing large, shallow-roooted `ohi`a trees to winds which they were not capable of withstanding. When the trees fell, they extended the range of the fringe (semi-forest, semi-scrub) habitat, and certain populations adapted to inhabit fringe areas expanded.(Severns, personal communication, information from article in preparation for Pacific Science)

Snail species are described in Figure 6-15.

FIGURE 6-15 Native Snails of Lana`i

Family	Sub Family	Genus	Sub Genus	Species	Preferred Habitat, Food,Habits, Elevation Ranges and Other Notes	Max Size mm	Description
Helicinaidae		Pleuropoma	Pleuropoma				have opercula (trap door)
				kaaensis	Dry land, W. Lana`i	3.10	
				lacinosa		3.20	
				piliformis	Found on Lana'i Hale.	3.50	
Achatinelli-dae	Achatinellae	Partulina	Eburnella		Eburnellas live in Lana'i Hale and fringe forest. live in trees, feed on lichens & algae. nocturnal		
				variabilis	Scrub `ohi`a areas, likes habitat that gets some light, vegetation not too dense, not usually found in the tops of trees. may be adapting to live on guava	18.00	semi-gloss shell
				lactea	Variation of variabilis	22.00	
				semicarinata		18.00	
				hayseldeni	Variation of semicarinata	18.00	well defined, sharp ridge around body keel that runs around periphery of the last whorl.
			Partulina		Lana'i Hale & fringe forest, uluhe & scrub `ohi`a areas feeds on lichens and algae, nocturnal, lives in trees. lives at somewhat lower elevations than other Partulinas (2,000-4000' on W. Maui) , but found on Hale		dull, rough shell,
				crassa		22.00	
	Auriculelli-nae	Auriculella			Tree dweller, feeds on lichens and algae, nocturnal.		
				brunnea		8.00	
				lanaiensis		5.80	
	Pacificellinae	Lamellidea	Lamellidea				
				gracilis		3.75	
	Tornatellidi-nae	Tornatel-laria					
				cincta		5.00	
				trochoidea		4.00	
		Tornatel-lides	Tornatel-lidides				
				acicula		3.00	
				macromphala		2.75	
				perkinsi		3.00	
				procerulus		3.50	
				terebra		3.00	
Amastridae	Amastrinae	Amastra	Amastra		Lana`i once had large Amastras. These tend to be more ground-dwelling. They live under rocks, under ferns and other ground vegetation, and in leaf litter. Can live in mesic and fringe, down to dry-forest. Somewhat lower elevation than Partulinas, but lived in Hale.		
				aurostoma		25.00	

				balteata		23.60	
				biplicata		23.00	
				durandi		20.00	
				grayana	Found in Lana`i Hale on ground	21.50	
				longa	Disappearance noted in 1912.	12.00	
				magna		36.00	largest known Amastra in Amastra genus. (Corelia is in a different genus)
				moesta		15.80	
				nucula		12.00	
				obscura		16.50	
				pusilla		8.50	smallest amastra on Lana`i
				rubristoma		19.30	
		Amastra	Heteramas-tra	fraterna		10.00	
		Laminella			Tree dwellers, feed on lichens and algae, nocturnal		
				concinna	Found on koele side of summit, about 3,000'	11.20	
				circumcinta	Color variation of concinna	12.00	striped. this is the only striped Laminella.
				gracilor		15.50	
				remyi	Very similar to tetrao. Found behind koele.	14.00	
				tetrao	Very similar to remyi. Found behind koele.	17.20	
		Tropi-doptera					
				alata	Found behind koele	8.50	
				lita		10.00	
	Leptachatini-nae	Leptacha-tina	Leptachatina		Fringe to grassy areas	14.00	bullet shaped, shiny shells
				impressa	Found behind koele	7.00	
				lanaiensis		8.00	
				longiuscula		10.50	
				perkinsi	Found on ridges of gulches	10.50	
				semipicta	Found behind koele	8.00	
				smithi	Found in mountains behind koele	9.25	
				subovata	Was once abundant	7.30	
				supracostata		6.30	
Pupillidae	Nesopupinae	Lyropupa	Lyropupa				
				lanaiensis		2.50	
				rhabdota		2.50	
			Lyropupilla				
				sparna		2.20	
			Mirapupa				
				costata			
		Nesopupa					
			Limbatipupa				
				newcombi		1.65	
			Nesodagys				
				rhadina	Likes damp rocks, smooth, barked trees	1.95	
				thaanumi	Found in moss on tree trunks	2.75	
				wesleyana	Likes damp rocks, smooth, barked trees	2.00	

			Nesopupilla				
				baldwini	Found on top of Lana`i Hale	2.50	
				dispersa	Found freshly dead in mahana gulch	1.53	
		Pronesop-upa					
			Pronesopupa				
				boettgeri			
				hystricella			
Endodontidae		Cookecon-cha			Found on the ground, live in cracks between rocks, fallen logs, etc.		
				lanaiensis	Found in Koele and on Hale	4.77	flat rounded spire
				ringens	Likes wet forest. Found on Koele and on Lana'ihale	4.61	
		Endodonta		concentrata	Found on the ground, live in cracks between rocks, fallen logs, etc.	5.43	flat angular spire
Succineidae	Succineinae	Succinae	Succinae	caduca			
		Succinea	Truella	rubella	Fringe to drier areas		fingernail-thin
Helicarioni-dae	Euconulinae	Euconulus	Nesoconulus				
				kaunakakai	Under talus	2.33	
				subtilissimus	Ground dwelling	2.36	
	Mycrocysti-nae						
		Hiona	Hionella				
				perkinsi	Likes ground moisture, high elevations	6.50	
		Philonesia	Haleakala		Live in wet forest, like forest understory, very susceptible to dessication, typically likes higher elevations and wetter areas than Partulinas.		have thin, almost transparent shells, charcoal gray to black,
				diducta	Found under lichens on a`alii shrubs	4.81	
				interjecta		6.28	
				turgida	Found under lichens on trees	5.50	
			Philonesia	maunalei	Found in talus under kukui tree	6.33	
Zonitidae	Gastrodonti-nae	Striatura	Pseudohy-alina	discus		3.40	
	Zonitinae	Nesovitrea		pauxilla		5.00	
		Philonesia	Haleakala		Live in wet forest, like forest understory, very susceptible to dessication, typically likes higher elevations and wetter areas than Partulinas.		have thin, almost transparent shells, charcoal gray to black,
				diducta	Found under lichens on a`alii shrubs	4.81	

Figure courtesy of Mike Severins

Sources: Cowie, Catalog of Native Land & Fresh Water Molluscs of the Hawai'ian Islands, Backhuys Publishers, Leiden, 1995, and others

Threats/ Concerns to Native Snail Populations

Threats to snails in Lana`i include predation by rats, other snails, and possibly birds; altered and diminished habitat, introduced pathogens, and the risk of damage from human activities. These threats are delineated below. (*Source:Personal communications, Dr. Michael Hadfield and Mike Severns*)

- **Predation by other snails**

Oxachilus aliaris

Introduced predatory snail, eats natives.
Believed by Severns to have been introduced during WWII.
By the 1960s, most ground-dwelling snails were extinct.
Mucous coating smells of garlic.
Eats young snails when hatched.

Euglandina Rosea

Introduced predatory snail from the Florida swamps.
Not yet reported on Lana`i ,
Due to its agressive nature, forest managers should be on the alert
for this predatory snail.
Introduced to the islands intentionally in 1958 to
control another species of introduced snail.
A comparison of the life cycle of the predatory *Euglandina* to that of native snails such as *Achitinella* and *Partulina* highlights the vulnerability of the native snails. Whereas Achitinella and Partulina mature slowly (6-7 years), and live to a maximum of about 20 years, producing only 1 to 7 offspring per year, the introduced Euglandina takes less than a year to mature, produced more than 600 eggs per individual per year, and has a life span of up to 5 years. (Loope, 1998, in Mac, M.M.; P.A. Opler; C.E. Puckett, Haecker; and P.D. Doran *Status and Trends of the Nation's Biological Resources*, 2 volumes; U.S. Department of the Interior, U.S. Geological Survey; Reston, Va..; Chapter on Hawai'i & the Pacific Islands by Lloyd Loope, quoting Mike Hadfield et al 1986) - (Hadfield, M.G.; *Extinction in Hawai'ian achetelline snails*; Malacologia; 27:67-81; 1986)

- **Possible predation by other animals such as introduced birds**

- **Habitat of choice:**

Native snails remaining are found living in low vegetation. This makes them more vulnerable to predators loss of natural habitat and possible introduction of diseases by introduced snails or slugs.

- **Invasion of non-host plant species**

For example, Eucalyptus or other species that eliminate natural habitat species and which do not provide host for native snails.

- **Poorly planned management efforts**

Even well-intentioned attempts to help retain and enhance habitat could pose a threat. Proposed fence lines or other forest management facilities should be surveyed to insure that snail populations are not disturbed.

FIGURE 6-16 Native Birds of Lana'i

Family	SubFamily	Genus	SubGenus	Species	Sub species	Common Name	Description
Fringillidae		Himatone		sanguina		apapane	Only remaining endemic forest bird in Lana`i. adult has crimson body with white belly and under-tail coverts, and black tail and wings. first plumage on the young is brown. strong flier, flies high in small groups from one part of the forest to another. keeps mainly to tree tops. wings vibrate loudly in flight. active in tree tops, hopping from one flower to another. food, nectar, insects and caterpillars.
Fringillidae		Paroreomyza	maculata	montana		Lana`i creeper, alauwahio	Wilson called this Paroreomyza maculata montana. Hawai'ian names: Alauwahio, Alauwi, Lauwi. short flights, food in bark of tree trunks and branches. pretty, chirping call. yellowish green upper body with lemon-yellow under body. about 5" long. nest was compact ball of fine grass stems and skeleton leaves, 1.75" across the bowl, 0.75" deep, 0.5" thick. last seen in 1937 per Munro.
Antidae		Branta		sandwicensis		Nene	Listed as Nesochen sandwichensis by Munro, but not mentioned by him as being on Lana`i. Ornithological monographs list as Branta sandwicensis. Both refer to it as nene. black, brown and buff with greyish parts. hind neck, cheeks, chin and throat black, also black ring around lower throat. 23"-28". webs on feet smaller than other geese. feeds on berries. lived and fed mainly in dry upland country; wintered and raised young in lowland lava flows. noted as living from sea level to 2,200' by Munro. nest was a hollow in the ground, or eggs laid on surface and surrounded by pieces of brush. Munro reported laid 3 to 6 cream white eggs. eggs 3.36"x2.35", but usually only 2 chicks. Nene on Maui typically lay about 4 eggs. Hawaiians used to hunt nene for food, esp. during molting season.
Fringillidae		Dysmorodrepanis		munroi		hookbilled finch	Perkins called it Dysmorodrepanis munroi. Not clear if Munro thought it was finch or drepanid? Endemic to Lana`i. nearly extinct per Munro in 1944. bird found in 1913 by Munro had upper body light grey with tinge of green, white mark over the eye, but it was molting. found in Kaiholena Valley in 1913, and later in Waiakeakua. beak unusual in that mandibles curved toward each other so that only the tips touched. Retiring bird. Munro believed that this bird used to live in the akoko forest (Euphorbia lorifolia) that originally covered the Lana`i plains. Munro took one feeding on the fruit of an opuhe (Urera sandwichensis), which has fruit about the same size. lived in upper forest and plains of Lana`i. between the islands.
Fringillidae		Hemegnathus		obscurus	lanaiensis	Akialoa	Munro calls it Hemignathus obscurus lanaiensis (Rothschild). Rothschild described male as black olivaceous green, with dirty yellow breast and cream white under tail covers. However both Munro and Perkins thought that this must have been either a younger bird or if an adult, one not in its breeding stage, as they found it to be quite yellow. The female was a dull greayish olive, with yellowish abdomen. By 1944, Munro felt it was probably extinct, as it had not been seen in many years. It was seen hunting for insects on an o`hi`a. Munro believed it had also inhabited the akoko forest. it hunted for insects on the trunks and limbs of trees, and Perkins noted that the one he saw seemed rather tame, continuing to hunt for food at times not 5 yards distant.

Fringillidae		Hemignathus		virens		Amakihi, honey creeper	Bishop museum printout lists Hemignathus virens. Ornithological monographs list Loxops virens. Munro calls it Chorodrepanis virens chloroides. Known as the Lana`i amakihi. Type of honeycreeper. Looks not described specifically, but Munro mentions that the species vary little in size, with total length varying from 4.2 to 4.75 inches. He noted that Perkins felt that the species inhabiting Hawai‘i, Molokai, Maui and Lana`i were essentially the same. He describes the Kaua‘i and Hawai‘i amakihis, and foregoes description of the appearance of the Molokai, Maui or Lana`i species. The Kaua‘i species had bright green upper parts, with yellowish under parts. The Hawai‘i species was described as being much yellower than the Kaua‘i species, with a smaller bill. Kihi means curved, and describes the shape of the bill. One assumes that the Lana`i species was also green on top and yellow underneath. The Lana`i amakihi was once very common in the forest, but numbers were reduced by introduction of bird diseases. Munro says that they were plentiful prior to 1923, when the town was built. By the writing of his 1944 book, he says that they were very much reduced in numbers as of a few years ago and their chance of survival slight. The forest was small and of no considerable elevation, and its proximity of the town lent little protection through isolation. Munro observed a nest and noted that it was 3.75" wide by 3.5" deep, with a 1.75" hollow at the top, with the characteristic odor of the Drepanine birds. The Lana`i amakihi had this odor so stronly that, "A bird flying past to windward left the odor plainly perceptible in the air." Munro saw a nest in a small tree 12' from the ground. The female approached and tried to lure him away by scolding and fluttering. The nest overhung the steep valley side, but was hidden by the trees above from owls. It was made of grass and fiber from the ieie vine, and lined with rootlets and some sheeps wool.
Fringillidae		Loxops		virens		Amakihi, honey creeper	
Fringillidae		Psittirostra		psittacea		O`u	Munro lists as Psittacirostra psittacea (Gmelin). Bishop lists as Psittirostra psittacea. Munro notes that Temminck, Rothschild and Henshaw all referred to it as Psittirostra. He seems to credit Temminch with the name, but states that Psittacirostra as used by Perkins is more grammatically correct. Munro states that the male was known as the O`u poolapalapa, or yellow-headed O`u; and the female as O`u laueo, or leaf green O`u. The bird has a bright green body, and the male of the species has a yellow head. The female and young did not have a yellow head, and the younger birds were not quite as bright. The bill was parrot-like and hooked, possibly facilitating scooping fleshy flower bracts and picking ripe fruit from the upright spadix of the ieie vine. The O`u had a beautiful voice, with clear whistling notes leading in to a plaintive call. Munro noted that the birds were common in 1923 and seemed to be doing well, but by 1944 he felt that they were near extinction. O`u naturally fed on the fruit and flowers of the ieie vine, and on the berries of arborescent lobelias, and other upland fruits but they were also seen feeding on guava and mulberries. Unfortunately, Munro believed this is part of the reason they became extinct. The O'u had a habit of coming to the low level areas for food, which exposed the species to introduced bird diseases which they could then carry back to their forest habitat. No nests were seen. Munro thought they were probably well hidden in staghorn ferms and ieie vines. O`u feathers were used in Hawai‘ian featherwork..

Fringillidae		Vestiaria		coccinea		I`iwi, honey creeper	Munro lists as Vestaria coccinea (Forster). Type of honey creeper. Bright scarlet wings and tail. Also black wings. Rose colored bill. 5.75" long. According to Munro, in 1891 the i`iwi and apapane were so numerous that they raised a continual buzz. Lived in `ohi`a and Pelea trees. Lived at all elevations from the seashore to the mountaintop, whereever flowering ohi`a forest reached. Munro noted, "It semed to me that the `ohi`a honey had a stimulating effect as these birds were full of life and gaiety when frequenting the profusely blooming ohi`a trees." I`iwi fed on nectar, caterpillars and insects. They flitted from flower to flower and hopped among twigs and leaves in search of caterpillars. The call apparently varied. When feeding it was a sharp chirp, at other times a longer call. Munro described it as "like the creaking of a wheelbarrow, but a little more musical". Apparently the call was more discordant in lower elevation trees, and more musical among the treetops. Munro also noted, "...in a great assembly of birds the medley of sounds produced by hundreds of apapane, i`iwi and other birds produced a pleasing chorus and cheerful effect." Although I`iwi liked `ohi`a nectar, the main food was thought to be caterpillars. Nests were built of dry stems, leaves and rootlets, and some skeletonized capsules of Poha. They were usually placed in tall ohi`a trees. The feathers were used in Hawai‘ian featherwork.
Muscicapidae		Myadestes		lanaiensis		Lana`i thrush, Amaui, (olomau - molokai species)	Munro lists as Phaeormis obscura lanaiensis. Bishop Museum and Ornithological Monographs list as Myadestes Lanaiensis (family Muscicapidae). Munro quotes Wilson as noting that the Lana`i Thrush "resembles P. obscura and P. myadestina, but is smaller than either while the bill is distinctly intermediate in size between those of the two species.". The outer pair of tail feathers have slight white markings at the tip, while the abdomen and undertail feathers are nearly pure white. Top was brown. Wing from carpal joint to tip was 3.65". Lana`i thrush differed from those of the other islands in its call. The other thrushes were great singers, but the Lana`i thrush had only 2 or 3 notes which it used constantly. It inhabited the forest and frequented the low trees and underbrush. It nested in the thickest underbrush amongst ‘ie‘ie vine and staghorn fern. It was a retiring species, more often heard than seen. It ate berries and insects. Munro also reported finding a small landshell in one. The thrush had the habit of trembling and quivering its wings when approached or excited. When disturbed, it flew upward into the trees. Munro believed the Hawai‘ian name for all of the thrushes was Amaui (from Manu a Maui?). The Hawai‘i thrush was called Omao or Amaui. The Molokai thrush was called Olomau or Amaui. Munro cites as his source "the very old Hawai‘ian whom Perkins consulted".

Procellarii-dae		Pterodroma		phaeopygia		U`au, dark-rumped petrol	Only remaining Munro lists as Pterodroma phaeopygia sandwichensis (Ridgway). Hawai‘ian name was Uau, Uaau, or Uwau. The back was a brownish slate, with darker wings and tail. The forehead, cheeks and underparts were white, and the head was black. Length was about 15.5". The call was a long drawn out u-a-u. The flight was a darting zig zag, interspersed with sailing. It nested in the mountains of all the main islands, in holes under the roots of trees and stones at elevations ranging from 1,500' to 5,000' (the latter obviously not on Lana`i.). It was killed off the mongoose in Hawai‘i, Maui and Molokai. Munro believed that cats and pigs killed it on Lana`i. The eggs were glossy white and laid in April - May. The young birds were considered a delicacy by Hawaiians, and were kapu to common people, reserved for chiefs. Older birds were eaten after they had been salted. By 1944 Munro commented that it was in danger of extinction, though it seemed from his text that it was already gone completely from Lana`i.

Recurviro-stridae		Himantopus		mexicanus		Hawai‘ian stilt	Listed by Munro as Himantopus himantopus knudseni. Listed by Bishop museumas Himantopus mexicanus. not listed in ornithological monograph. Hawai‘ian names `Ae`o, and also kukuluaeo (Kukuluaeo was the word for stilts, or for a person walking on stilts. it signifies one standing high or set up like an aeo). The back and upper body are blue-black, the underparts white, the tail smoky gray, with white markings over the forehead and around the eye and long thin pink legs. The young are brown/grey above and lighter below. The length is about 16.5". The flight is flapping with legs stretched out behind. Feeds on larvae of dragon flies, small fish, worms, seeds and roots of water plants. The cry is short and sharp. The nest is a hollow in dry mud bordering shore lagoons in summer. Eggs are laid in May with 8-12 in a clutch. Eggs brown with large black spots, 1.9"x1.36", thicker at the large end, pointed at the small end, and ovoid. Adult birds are very agressive at trying to lure intruders away from nest and young.
Strigidae		Asio		flammeus		Owl	Asio flammeus sandwichensis (Bloxam) per Munro. Hawai‘ian name Pueo, probably from one of its calls according to Munro. Tawny ocraceus to buffy white, plentifully striped with dark brown. Immature birds are much darker. The birds are about 15.25" long. The Hawai‘ian owl was spread through all the islands, and numerous in open grassy country. Though a day hunter, it is more active at dusk or in early morning. It was common in the late nineteenth century on Lana`i, but by 1944 Munro commented that its territory had been so taken over by agriculture that numbers had decreased. Nests in grass tufts in a hollow in the earth. Eggs are white and almost round. The Hawai‘ian owl eats mostly mice, but it also eats smaller birds. On Lana`i some hunted over trees in the forests, searching for other bird nests. Most Lana`i species of birds hid their nests from owls. The owl has several cries. The cries of the yound sound something like hissing, and the cries of the old can sound like a muffled dog bark. The owl will spread its wings when approached in a threatening manner. It is fierce enough with its claws that it will fight off cats and dogs.
		Thambe-tochen					

Native Birds on Lana`ihale

FIGURE 6-17 Apapane

Sixteen species of native birds have been recorded in Lana`i, not including non-resident seabirds and seasonal migrants.

Of eight species of native forest birds once known to inhabit Lana`i, the only one known to remain is the apapane (*Himatone sanguinea*). The apapane eats both nectar and insects. Its primary food source is `ohi`a blossom. The amakihi is believed extinct, but a systematic survey should be undertaken to determine status.

Lana`i also has two native seabirds, the Newell's shearwater, and the endangered Dark-rumped petrol. Dr. Fern Duvall recently found a fresh-killed carcass (cat-kill) in Kaiolena gulch while looking for *Hedyotis schlechtendahliana var. remyi* with Bob Hobdy.

Many species casualties among native birds were associated with specific ecosystem niches. The o`u was closely tied with mesic `ie`ie (*Freycinetra arborea*) forest areas. (`ie`ie is a climbing pandanus found in mesic areas) The Lana`i hookbill and akialoa were once plentiful in lowland *akoko* forest (*Chamaesyce celastroides v. lorifolia*). The i`iwi, extinct from Lana`i, was associated with endangered lobeliads. These endangered, bird-pollinated lobeliads in turn were required food for the i`iwi.

The decline of visiting sea bird populations may also have adverse impacts to the Lana'ihale forest. With loss of native trees and habitat, visiting sea birds don't come to Lana`i as much. Bird guana from these birds was thought to once have been an important source of forest nutrients in the islands. Fewer visits by these birds in turn causes diminishing forest nutrients. With diminishing nutrients, forest maintenance and recovery become more difficult. (*Source: Personal communication, Dr. Fern Duvall, 2005.*)

Various species of birds known from fossil records or historical accounts are also gone from Lana`i. Lana`i once had a flightless Ibis species, believed to have lived in Lo`ulu palm habitat. It also had a Moa nalo, a large, flightless grazing bird with a turtle-like head. The extinct Lana`i Hookbill was so fantastic looking that when it was first discovered, its authenticity was questioned. Apparently at some point in history the Hawaiians developed a pastime of sewing skins of different birds together to make fantastic creatures, and upon first discovery, the Lana`i Hookbill was believed to have been one such creation. There were also two species of flightless rail, a flightless owl, a nene

and two relatives of the nene. (*Source: Personal communication, Dr. Fern Duvall*)

A list of the bird species once found in Lana`i is found in Figure 6-18 This Figure contains observations by the naturalists of the time on possible causes of extinction.

Importance of Birds In Lana`ihale

Birds serve(d) several important & specific functions in the watershed on Lana`i, including:

- direct pollination of native plant species
- seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces)
- source of nutrients (especially from sea-bird feces)

Nutrient cycles, especially as affected by seabirds, are now being understood to effect soil and plant health more than previously recognized . It is believed that a contributing cause of progressive degradation of the forest is the loss of sea birds returning nutrients to the soil via guano (Dr. Fern Duvall, referring to research by Storrs Olsen of the Smithsonian Institute).

Birds were an integral part of the pristine ecosystem, so there may have been additional functions which we would not be able to study in the absence of the system intact.

Bird Species Descriptions

A list of native birds once found in Lana`i is provided in Figure 6-19. This list was compiled from the Bishop Museum Bird Checklist, Birds of Hawai‘i (George C. Munro, 1960, 1982), and communication with Dr. Fern Duvall of the State DLNR Division of Forestry & Wildlife.

Threats to Birds on Lana‘ihale

One of the primary threats to remaining birds on Lana`i is the loss of habitat. Although threats to birds are listed below, it should be noted that the threats to plant communities listed above are also among the key threats to bird populations.

FIGURE 6-18 Threats to Birds in Lana‘i Hale

Loss of habitat	Examples, akoko, lobeliads, etc. Direct loss of food source Inadequate space to support and sustain healthy breeding populations If `ohi`a is lost, apapane would probably be lost also
Loss of native pollinators	Loss of pollinators of habitat, (birds, insects) causes threats to remaining habitat. Introduction of pest birds that eat native insects that pollinate native plants.
Introduction of pest birds	Competition with native birds for food, nesting sites. Destruction of native pollinators Introduction of bird diseases including: avian malaria (protozoan), avian pox (virus) Direct agression Examples: White eye - competes for food, nesting sites Japanese bush warbler - compete for food, nesting sites Cardinals - feed on sandalwood fruits Java sparrow

Rats, Cats	Predation. Rats & mice also eat seeds of native habitat trees & plants.
Introduction of insects	Carry avian diseases, for example, mosquitoes carry avian malaria and avian pox. Compete with native insect pollinators.
Diminished population	Remaining population sizes may not be adequate to insure sustainability. It is estimated that in order to sustain a population, there should be a minimum "effective population" size of no less than 500 pairs. By "effective population" it is meant excluding juveniles, aged, or unpaired birds. There also needs to be adequate habitat extent to support such population. In 1980 it was estimated that there were: 540 ± 213 apapane in a transect area of 20 sq. kilometers on Lana`i 15,825 ± 1,129 in a transect area of 44 sq. kilometers on West Maui 94,000 ± in a transect area of 404 sq. kilometers on East Maui

FIGURE 6-19 Problem Birds on Lana'i

Common Name	Latin Name	Comments
Japanese White Eye	Zosterops japonicus	Competes for food and nesting sites. Present on all main islands. Common.
Japanese Bush Warbler	Cerria diphone	Competes for food and nesting sites. First recorded on Lana'i in 1980.
Northern Cardinal	Cardinalis cardinalis	Feeds on sandalwood fruits. Present on all main islands. Common.
Java Sparrow		
Erckel's Francolin	Frncolinus erkelii	Common.
Gray Francolin	Francolinus pondicerianus	Very Common.
Spotted Dove	Streptopelia chinensis	May feed in native forest. Common.
Warbiling Silverbill	Lonchurra malabarica	Common. First recorded on Lana'i in 1979.
Chukar	Alectoris chukar	Very common. Introduced in 1923.

Native Insects in Lana`ihale

The Bishop Museum arthropod list contains records of 472 endemic and indigenous arthropods from Lana`i. Even this number is thought not to be complete. Bishop Museum's checklist lists 11 extinct species, 2 Candidate 1 level species, and 25 Candidate 2 level species. No species are listed as endangered or threatened. Hobdy ('93) estimated that 30% of insect species on Lana`i were believed to be endemic, and that roughly 10% of the native insect species in Hawai'i were on Lana`i. Even with so many species recorded, it is believed that records for insects are lacking. A partial list of arthropod species native to Lana`i follows in Figure 6-20. Rather than attempt to provide descriptions for all of over 400 species, only those listed as candidate species or species of concern are covered.

Insect endemism is not as high as plant endemism, in part because insects can fly and are able to move between the Maui Nui islands. However, in terms of numbers of species, the majority of native species were insects. There are or were native species of spiders, wasps, flies, fungus gnats, beetles, leaf hoppers and true bugs, among others. Endemic Lana`i insects include species of bee-

tles *(Coleoptera)*, flies (*Diptera)*, bugs *(Hemiptera)*, true bugs (*Homoptera)*, bees & wasps (*Hymenoptera)*, moths and butterflies (*Lepidoptera*), and others.

Most Lana`i insect species are very host-specific in feeding & breeding requirements, and are closely interrelated to vegetation communities (Hobdy, 1993). This means they were likely to have fulfilled many key roles in ecosystem integrity, including pollination, etc. Insects also contributed to nutrient cycle, biomass, organic material, and litter component. Native insects were often important as pollinators of specific plants, or because they provided food for birds that were pollinators of specific plants. Insects were also predators, detritivores, soil processors and wood borers, contributing to the food cycle, the breakdown of dead trees and leaves, to soil nutrients, etc.

Examples of some interesting native Lana`i insects include the Nesoprosopis bees and Pomace flies. Over 50 species of Nesoprosopis bees have been found in the islands. Dr. Sam Gon III, of The Nature Conservancy, estimates that there were about 17 on Lana`i, several of which were only found on Lana`i. Nesoprosopis bees, also known as yellow-face bees are smaller and thinner than honeybees, and more solitary. They feed on tiny flowers.

Pomace flies are one of the best examples of adaptive radiation. Over 800 species of native Hawai‘ian pomace flies have been described, and almost all are host-specific. Pomace flies are often called fruit flies, but they are actually part of a different family of insects.

Threats to Lana‘i Hale Insects

Primary threats to remaining native insect populations in Lana`i include:

- Loss of habitat such as nesting sites or food sources necessary to maintain populations.
- Introduced insects may prey on or compete with other insects, damage plants, or carry disease A few of these problem insects are desribed in the Figure 6-21.
- Many insects were brought in with cane or pineapple crops to manage insect pests, but instead turned out to be generalist and fed on native insects and plants.
- Loss of native insects in turn can equate to loss of critical habitat elements, such as pollinators or food source, for other species.
- Introduced Pathogens.

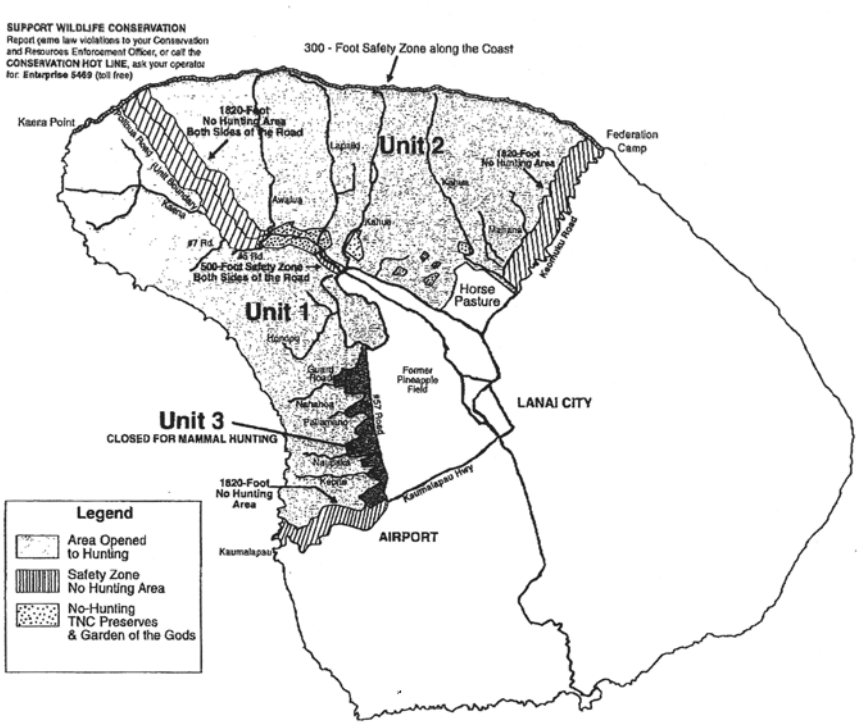
FIGURE 6-20 Lana`i Arthropods - Endangered, Proposed, Threatened, Candidate and Species of Concern

US FWS	Bishop L				#	#	# Lana`i		
					Spp in	Spp on	Spp		
Status	Status	Order	Family	Genus	Genus	Lana`i	Listed	Species	Description
E		Heteroptera	Scutelleridae	Manduca				blackburniae	Blackburn's sphinx moth
C2	C1	Odonata	Coenagrionidae	Megalagrion	22	8	3	pacificum	damselfly - Pacific megalagrion
C8	C1	Odonata	Coenagrionidae	Megalagrion				xanthomelas	damselfly - orange-black megalagrion
SOC	C2	Archaeognatha	Machilidae	Neomachilis				heteropus	Hawai'ian long-palp bristletail
SOC		Coleoptera		Rhyncogonus				freycinetiae	Weevil, `Ie'ie rhyncogonus
SOC	C2	Coleoptera	Curculionidae	Rhyncogonus	34	3	2	lanaiensis	Lana`i rhyncogonus weevil
	C2	Coleoptera	Elateridae	Hyaleus				plebius	
SOC	C2	Coleoptera	Cerambycidae	Plagithmysus	139	4	2	lanaiensis	Long-horned beetle, Lana`i `Ohi`a beetle
SOC		Coleoptera		Plagithmysus				platydesmae	Long-horned beetle, Pilo Kea
SOC	C2	Coleoptera	Elateridae	Eopenthes	33	4	2	arduus	Click beetle , arduus eopenthes
SOC		Coleoptera		Eopenthes				plebius	Click beetle, common eopenthes
SOC		Coleoptera		Proterhinus	72				Hawai'ian Proterhinid beetles
SOC	C2	Diptera	Drosophilidae	Drosophila				lanaiensis	Lana`i pomace fly
SOC	C2	Heteroptera	Scutelleridae	Coleotichus	1	1	1	blackburniae	Koa bug
	C2	Heteroptera	Miridae	Kalania	1	1	1	hawaiiensis	
	C2	Heteroptera	Pentatomidae	Oechalia	14	2	1	grisea	
SOC	C2	Heteroptera	Rhopalidae	Ithamar	2	2	1	hawaiiensis	Hawai'ian rhopalid bug
SOC	C2	Homoptera	Psudococcidae	Phyllococcus	1	1	1	oahuensis	mealy bug - opuhe gall
SOC	C2	Hymenoptera	Colletidae	Hyaleus	60	15	11	anthracina	anthracinian yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				assimulans assimulans	assimulans yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				caeruleipennis	blue-wing yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				difficilus	difficult yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				facilis	easy yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				filicum	fern yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				laeta	laetan yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				longiceps	longhead yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				obscuratа	obscuratan yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				satelles	satellus yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				volatilis	volatile yellow faced bee
SOC	C2	Hymenoptera	Vespidae	Odynerus	100	11	1	nigripennis	black-winged odynerus vespid wasp
SOC	C2	Lepidoptera	Crambidae	Omiodes	23	4	1	monogona	Hawai'ian bean leaf roller
SOC		Lepidoptera		Helicoverpa				confusa	Moth, confused helicoverpan noctuid
SOC		Neuroptera	Distolean	Eidolean				perjurus	Molokai Antlion
SOC	C2	Odonata	Coenagrionidae	Megalagrion				nigrohamatum nigrohamatum	damselfly - nigrohamatum megalagrion

FIGURE 6-21 Insect Pests in Lana`i

Genus	Species	Common Name	Description
Sophonia	rufofascia	Chinese leaf hopper, two-spotted leaf hopper	Destroys uluhe stands, `ohi`a lehua trees. Worse when plants are under stress from drought or etc. Suck the juices out of leaves, leaving yellow spots. Can stress trees to death. Typical scenario: deer move in, eat ferns and other understory, then plant is exposed and ground becomes dry. When drought hits, plants are more stressed and leaf hopper creates more damage.
Adoretus	sinicus	Chinese rose beetle	Feeds on leaves of native plants, incl. Abutilon menziesii. Affects mostly dryland and some mesic plants. Less of a problem than the leaf hopper.
		Hibiscus snow scale	Affects mostly dryland areas, and mostly Hibiscus, (including Abutilon and ilima).
		Mosquitoes	Introduce and carry avian malaria, avian pox and other diseases that destroy bird populations, some of which may have been pollinators.
		Ants	There are no native ants in Hawai`i. Ants prey on and compete with native insects for food, nest sites, etc. There have been many extinctions of native insect species due to ants.
		Yellow jackets, vespula wasps	Very predatory, and very disruptive to native ecosystems. Yellow jacket entry would be difficult to prevent, as a queen could make it from another island across to Lana`i, so measures need to include monitoring and removal.
		Small parasatoid wasps	Several types of small parasatoid wasps have been introduced. These lay their eggs in the eggs of spiders and other native insects, killing the young of native insects before they hatch.
		Black twig borer	Pest brought in with coffee. Attacks native plants. Affects dry areas and mesic areas surrounding Lana‘ihale.

FIGURE 6-22 Game Management Units on Lana‘i



Existing Conservation Efforts

Existing conservation efforts include game management and monitoring efforts run by both Castle and Cooke Resorts, LLC and the State, volunteer planting efforts run mostly by the company, Rare plant exclosures supported by the Company and the US Fish & Wildlife Service, and ex situ collections of various species.

Game Management & Monitoring

The State DLNR runs hunting primarily on the north and western sides of the island, while CCR manages the south and east portions. Different hunting periods and areas are allotted for use of rifle, muzzle loader, and archery hunts. Success rates vary with animal populations, weather, hunter skill and etc. Company-run hunts include paid hunts by hotel guests, as well as resident damage control hunts on Lana‘ihale, night hunts, and license hunts on former agricultural lands. Damage control hunting is sometimes undertaken around the resorts, golf courses and other infrequently hunted areas when complaints are raised. However, animal management that close to hotel grounds is generally restricted to hotel employees.

At one time, the Nature Conservancy also managed animal populations in its Kanepu‘u preserve and nearby exclosures, in partnership with the State Department of Land & Natural Resources,

Division of Forestry and Wildlife (DOFAW). The Nature Conservancy prepared and implemented six year management plans, funded by a TNC - State match. Management efforts included ungulate control (hunting and fencing), weed control, dry forest restoration, research and monitori ng, and fire control. Although most of these efforts did not take place on Lana‘i Hale, they did help to protect the Lana‘i Hale ecosystem.

The State Division of Forestry and Wildlife monitors animal head counts along established transects annually. These transects have been mapped using global positioning system(GPS) equipment .

State Game Management Area Units 1 & 2 are monitored together in 31 transects at half-mile intervals. CCR Management Units are monitored in 28 transects at half mile intervals. Transects taken at 40 mph along established transect routes at ½ mile intervals, flying at a relative altitude of 300 feet.

This flight path protocol provides coverage of over 1/3 of the area. Total estimated population numbers are extrapolated from these observations. Thirty percent coverage is quite good. Many U.S. mainland game management area monitoring operations are only able to fly about 1/10 of the area for their extrapolations.

Some uncertainty is inherent in any extrapolation method. However by repeating the census annually according to consistent methods and transects, this method yields fairly reliable population trend data, and may be considered a reliable indicator of whether deer and mouflon numbers are growing or decreasing.

Current Game Management Areas:

The areas outlined in green are managed by the State, and those in gold by the company. The purple and cyan areas indicate the Kanepu‘u preserve and more recent plant exclosures established by the company with funding assistance from the US Fish & Wildlife Service.

In providing information for the Tables 6-24through 6-30 on the following pages, DOFAW staff asked that the following caveat be given along with the data.. “The use of the term ‘estimated population’ is liberal. A more specific term utilized in wildlife management is “trend”, which reflects the upward or downward movement of the numbers of animals observed or projected to be observed over the given survey area. These trends, when used in conjunction with harvest data for the previous year, are invaluable in the setting of bag limits and seasons. Without prior harvest data to compare with the trends, no conclusion can be drawn as to future hunter success”.

FIGURE 6-23 Game Management Areas and Plant Exclosures on Lana'i

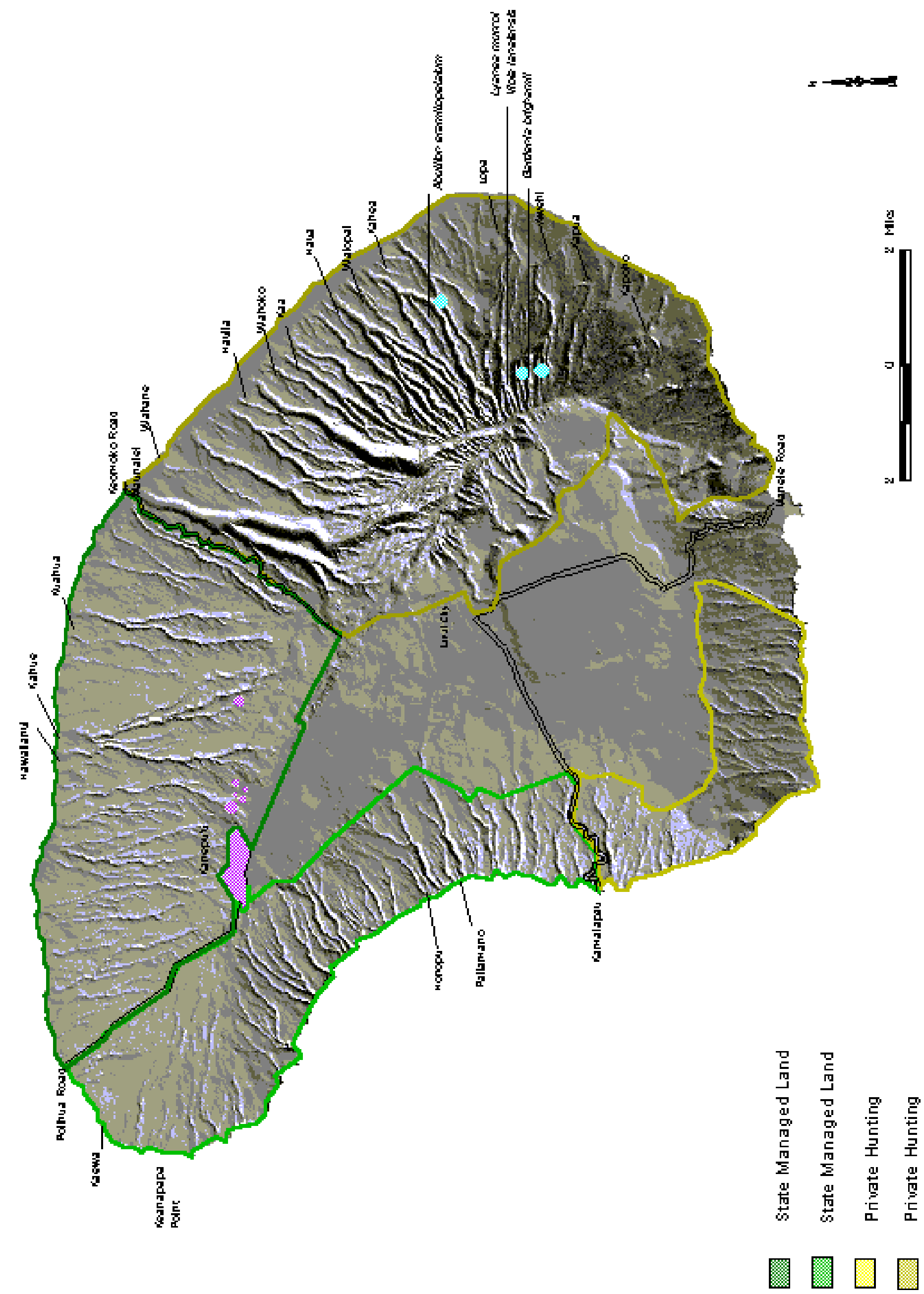


FIGURE 6-24 Lana'i Company Game Management Area - Deer Counts

	Buck	Doe	Fawn	Unclass	Total	Estimated Population*
1994	41	321	22	46	430	959
1995	34	323	19	60	436	972
1996	22	191	8	159	380	848
1997	39	260	9	91	399	890
1998	47	278	32	113	470	1048
1999	22	152	16	57	247	551
2000	14	134	9	71	228	508
2001	9	42	15	25	91	432
2002	9	93	7	11	120	268
2003	No Survey					
2004						
2005	38	164	13	28	243	654
2006	25	244	19	73	361	971
2007	61	351	23	136	571	1,536
2008						

(Projection Index = 2.23) Lana'i Company Area = 30,000 acres

FIGURE 6-25 Lana`i Game Management Area - Deer Counts in Lana`ihale

	Hale Count	General Habitat Conditions Over Entire Area
1994	55	66% increase over '93 Habitat dry & stressed
1995	46	Habitat dry & stressed
1996	21	Bad weather / flew 50 mph Habitat indicated mild summer
1997	28	Looked like start of drying period
1998	52	Extreme drought stress
1999	26	Moderate to severe drought
2000	34	Continued severe drought
2001	10	Prolonged severe drought
2002	17	No improvement from spring rain.
2003	No Separate Survey Data Available After 2002	
2004		
2005		
2006		
2007		
2008		

FIGURE 6-26 Lana'i Company Game Management Area - Mouflon Sheep Counts

Year	Mouflon Sheep Noted
1994	79
1995	16
1996	12
1997	51
1998	72
1999	10
2000	7
2001	11
2002	34
2003	No Survey
2004	
2005	69 Total / 186 Estimated
2006	120 Total / 323 Estimated
2007	186 Total / 500 Estimated
2008	N/A

FIGURE 6-27 Lana'i Cooperative Game Management Area - State Managed Area Counts

	Buck	Doe	Fawn	Unclass	Total	*Estimated Population
1994	111	567	59	176	913	2,438
1995	103	607	30	75	815	2,176
1996	104	537	24	116	781	2,085
1997	119	405	8	181	713	1,903
1998	108	561	101	75	845	2,256
1999	123	503	55	105	786	2,098
2001	87	363	52	174	676	1,805
2002	59	297	39	89	484	1,293
2003	51	261	30	32	374	1,006
2004	39	151	35	169	394	1,060
2005	74	359	42	84	559	1,504
2006	113	476	25	175	789	2,125
2007	93	545	20	273	931	2,512
2008						

Projection Factor: 2.67

Assumptions: buck to doe ratio applies for unclassified... but fawns are assumed equal boy/girl

FIGURE 6-28 State Managed Area - Axis Deer Hunt Statistics

	Estimated Population*	Total Harvest	Total Hunters
1994-1995	2,438	767	2,118
1995-1996	2,176	678	2,632
1996-1997	2,085	462	1,919
1997-1998	1,903	288	1,497
1998-1999	2,256	655	1,687
1999-2000	2,098	698	1,795
2000-2001	1,805	500	1,717
2001-2002	1,293	377	1,709
2002-2003	1,006	338	1,508
2003-2004	1,060	307	1,472
2004-2005	1,504	294	1,357
2005-2006	2,125	384	1,433
2006-2007	2,512	633	1,679
2007-2008		563	1,798
2008-2009		613	1,702

FIGURE 6-29 State Managed Lands - Mouflon Census

	Ram	Ewe	Lamb	Unclass	Total	Estimated*
1994	82	565	0	191	838	2,237
1995	74	617	0	57	748	1,997
1996	110	487	1	70	668	1,784
1997	156	450	1	76	683	1,823
1998	116	518	6	56	696	1,858
1999	110	525	1	6	642	1,714
2000	68	438	11	133	650	1,735
2001	68	371	15	48	502	1,340
2002	23	269	4	55	351	944
2003	50	367	5	36	458	1,232
2004	40	243	6	84	373	1,003
2005	119	535	2	56	712	1,915
2006	98	501	5	168	772	2,077
2007	189	898	1	315	1,403	3,774
2008						

FIGURE 6-30 State Managed Area - Mouflon Sheep Statistics

	Estimated Population*	Total Harvest	Total Hunters
1994-1995	2,237	722	1,727
1995-1996	1,997	435	1,192
1996-1997	1,784	293	944
1997-1998	1,823	640	1,496
1998-1999	1,858	641	1,351
1999-2000	1,714	455	1,298
2000-2001	1,735	445	1,148
2001-2002	944	396	1,115
2002-2003	1,232	441	1,108
2003-2004			
2004-2005	1,003	359	1,015
2005-2006	1,915	408	939
2006-2007	2,077	614	1,226
2007-2008	3,774	694	1,316
2008-2009		225	661

FIGURE 6-31 Observations on Habitat Conditions

	Habitat Condition
1994	Dry Summer effects showing but off-season rains helped
1995	Dry , stressed
1996	Mild summer w/off-season rains
1997	Looked like beginning of dry period
1998	Severe drought Vegetation dessicated
1999	Conditions indicated extremely dry weather
2000	Prolonged dry weather
2001	Conditions very dry
2002	Conditions same - dry with spring rains
2003	Dry range conditions
2004	
2005	Dry range conditions.
2006	Moderate drying of vegetation.
2007	Moderate drying of vegetation.
2008	Dry range conditions.

Existing Planting & Plant Exclosure Efforts

CCR runs periodic volunteer planting programs with volunteer groups and organizations such as the Lion's Club and the Boy Scouts. These are supported by the company's nursery. In recent years, the CCR Conservation Division has been expanded to include staff for regular forest management. This enables CCR to increase its efforts toward watershed preservation: weed removal, plantings, funding development and other functions above and beyond those already performed by its animal management crews.

Four exclosures exist in the Lana'i Hale and surrounding areas. These are indicated in Figure 6-9 above. The exclosures protect small populations of Gardenia brighamii, Abutilon eremitopetalum, Cyanea munroii and Viola lanaiensis. Two additional exclosures are proposed. The Puhielelu exclosure is sited to protect a variety of native plants in the Lana`ihale area, and an additional un-named exclosure is planned to protect critical wet forest habitat for certain snail communities.

Ex-Situ Collections & Reintroduction
Ex-situ collections of plants, plant tissue and seeds exist at various locations, including the National Tropical Botanical Garden & Center for Plant Conservation; the Waimea Arboretum & Botanical Garden, the Amy Greenwell Ethnobotanical Garden, the Honolulu Botanical Garden and others. Collections include Abutilon eremitopetalum, Abutilon menziesii, Cyanea macrostgia ssp gibsonii, Cyrtandra munroii, Gahnia lanaiensis, Phyllostegiat glabra var. lanaiensis, Santalum freycinetianum var. lanaiensis, and others.

The University of Hawai'i at Manoa is raising certain native snail species with the hopes that these can be re-released at some point. *(Sources: Thomas et al, Lana`i Plant Cluster Recovery Plan, 1995; and personal communication, Dr. Mike Hadfield, UH Professor of Zoology & Director of Kewalo Marine Laboratory)*

Necessary Actions

Fencing

If the Lana`i watershed is to have a realistic hope of recovery, there should be no herbivores within the protected area. This is the most important and highest priority management strategy. This has been supported as a priority, both by the peer review panel of resource managers, who reviewed various proposals and unanimously concluded that this was the most fundamental measure that needed to be taken, and by the advisory groups consulted.

Given the relative importance of this measure, several options were considered both within the Lana'i Water Advisory Committee, the Biodiversity Committee and with the public. A copy of presentation made to the public is included as an appendix in this plan. In general, options considered included fencing off either a large area of the island's northeast quarter, a somewhat smaller area encompassing the upper elevations of Lana'ihale, limiting fencing to small exclosures, or a combination of the above.

The larger fence was considered the most protective, and had various advantages such as being easier to maintain, since it was aligned along pre-existing roads on accessible, moderate terrain. This terrain would also limit fence wash-out problems. The larger fence also protected a larger slice of both biodiversity and potential recharge, benefitting more rare taxa. However, the larger fence was deemed unrealistic and overly drastic for a number of reasons. First, the community relies extensively on hunting in Lana`i, and it was thought that this fence would have an adverse impact on local residents. Also, some

of the very advantages of the fence, were also disadvantages. Its accessibility would make it prone to vandalism and breakage, and its large extent would make it more of a monitoring and repair task. Finally, it was felt that the area to be enclosed was too large to realistically manage right from the beginning, and that if such a fence were ever to be built it would have to be with community support, built after time and a track record of success with a smaller project.

Exclosures and smaller fence areas were considered, but this postage-stamp model was rejected. While exclosures for enhanced protection of the most rare species may still be necessary outside or even inside a larger fence, exclosures alone would do little to protect the watershed. However, exclosure fences were still considered appropriate for certain areas. Where utilized, it is recommended that these be a mininimum of 50 meters (about 165') away from nearest target plant.

The selected fence was the one enclosing Lana‘ihale. This was selected because it both protected the key recharge area of Lana‘ihale as well as many of the more critical plant species, had lower impact on hunters, and achieved community buy-in more readily. The following pages further describe the fence options considered by the advisory group and the public.

Consideration was also given to survey of proposed fence lines to insure that no rare or endangered communities of insects, snails, plants or other native flora or fauna would be harmed. This was done for Increments I and II, although there was some discussion as to whether such surveys were sufficiently thorough. The same should be done for Increment III.

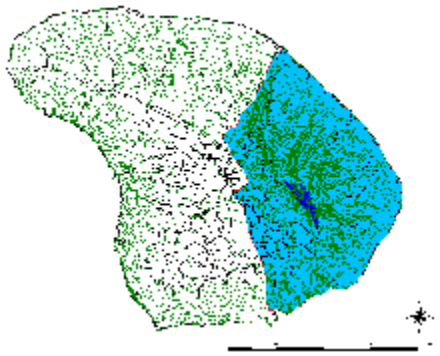
The fencing option chosen was option # 4 in Figure 6-23 and Figure 6- 10. This was subsequently modified to allow for construction in phases. A map of the current alighment is presented in Figure -6-11.

FIGURE 6-32 Fenceline Options Discussed with Panel of Experts and With Community

Option	Enclosed Acreage	Miles of Fence	Cost to Insstall Est.	Advantages	Disadvantages
1 - Keomoku	32,055	13.9	410,000	Protects largest area fastest, Protects more plant communities , Cheapest per area protected Easier maintenance on roads	Large impact on hunters, Exposure to vandalism
2 - Keomoku2	26,555	14.7	450,000	Protects large area more plant communities Cheap per area protected easier maintenance on roads	Large impact on hunters Exposure to vandalism?
3 - "Old Pipeline"	22,807	23	1,100,000	Pprotects large area more plant communities Cheap per area protected	Large impact on hunters, Exposure to vandalism, Low side expensive to maintain Cost per area higher
4 - "Fish"	3,588	12.1	680,000	Protects critical recharge area, Less impact on hunters	Cost per area a bit higher, Protects less plant communities
5 - "½ Fish"	1,835	11.5	400,000	Least impact on hunters	Will not protect key area Protects few plant communities Cost per area a bit higher
6 - No Fence - Eradicate	N/A	0	N/A	Most protective option Less on-going maintenance	Largest impact on hunters
7 - No Action	N/A	0	N/A	Least short-term investment	Loss of recharge Loss of Lana`i biodiversity
8 - Phased 1 -Exclosure 2 -Keomoku 3 -Makaiwa	Step 1 - depends Step 2 - Step 3 -			On second page of Figure 6-10. Protects largest area long term More plant communities protected.	Large impact on hunters Delays to step 2 could result in loss of everything beforefence is built Most expensive program
9- Modified Phased	1- "Fish" 2 - add selected gulch(es) / a'apuaa			Protects larger area than fish Protects down to sea along at least one or two gulches Less impact on hunting than larger options	Higher cost than most options Larger impact on hunters than fish or ½ fish
10 - "Big Fish"				Following road below bench field on SW for top of fish Would make that end less $ / / ft enlarging bottom somewhat wld include major snail and seabird colonies, still less impact on hunters than larger options.	High cost and difficult terrain on lower half. less protective than larger options. Still does not protect all ecosystems.

FIGURE 6-33 Fencing Options Considered - Presented Left to Right In Order of Figure Above

1



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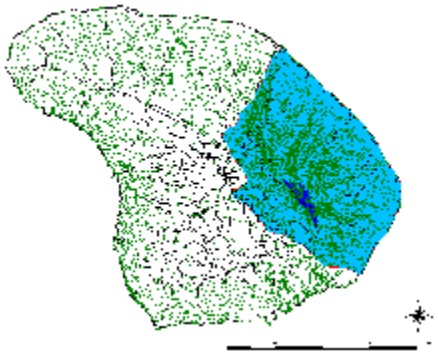

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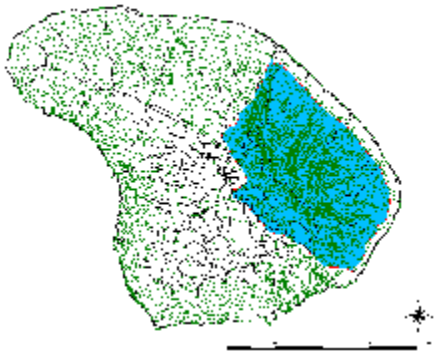

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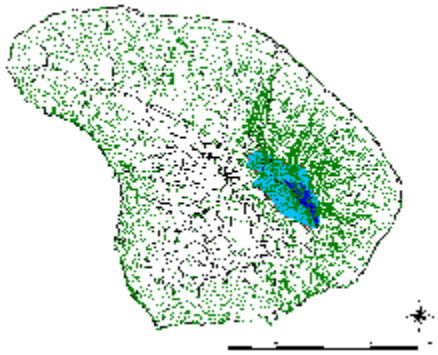

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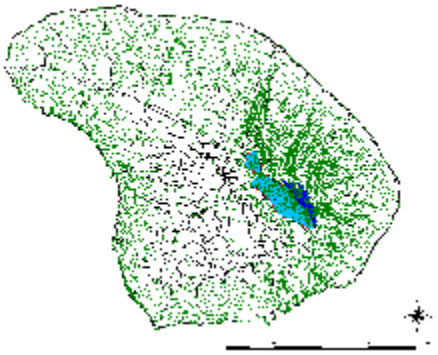

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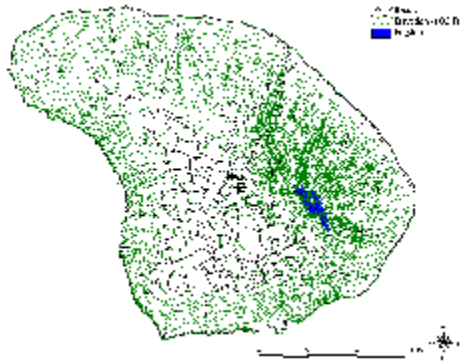
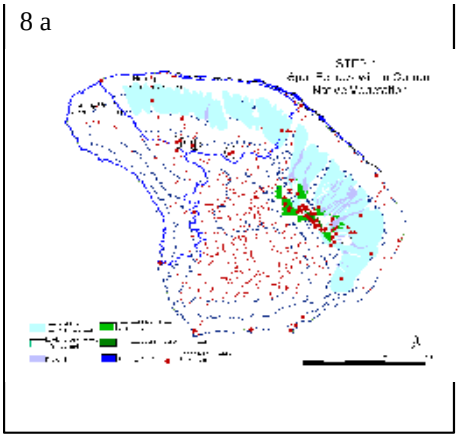


FIGURE 6-34 Fencing Options Considered - Continued

8 a



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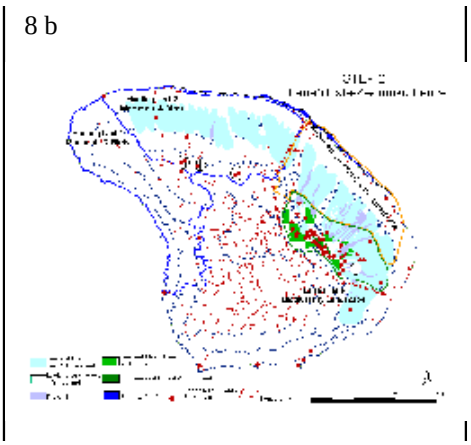

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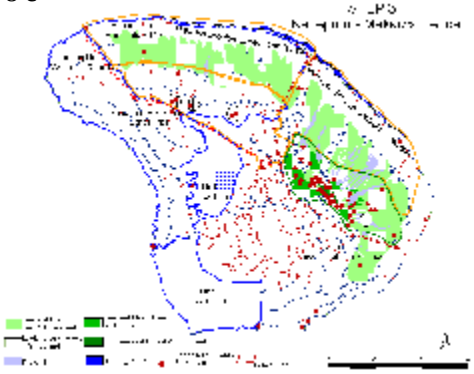

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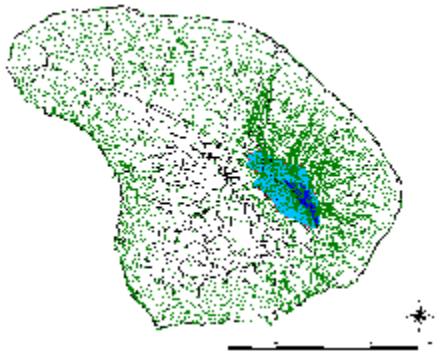


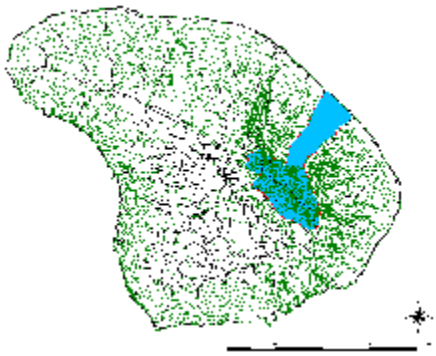
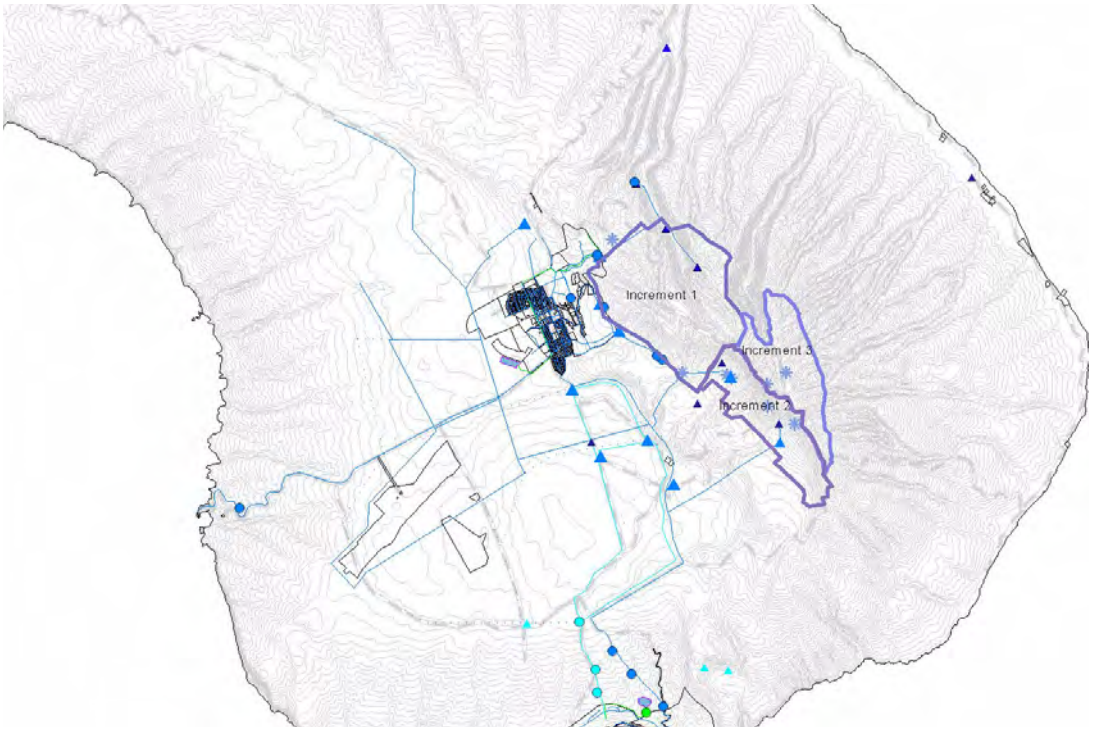


FIGURE 6-35 Current Alignment and Increments of Fence



Watershed Skybridge

Committee members received written testimony on watershed management considerations, and in response to certain unknowns and potential controversy, the committee also took the unusual step of convening a "skybridge" multi-island conference call between forest experts on Oahu, Maui, & Lana`i to receive further testimony and allow experts to discuss issues (One Big-Island expert was kind enough to be present in Oahu also) .

The results of this conference were unequivocal. Fencing was the measure of primary importance, without which all other measures were likely to fail. In further discussions, the Lana'i Water Working Group / Lana'i Water Advisory Committee determined that the issue was important enough and had enough potential to effect subsistence hunters and others, that a series of public informational meetings and discussions should be held.

The results of the public meetings were broad acceptance of the fence as a necessity. The community collectively has great concern for the health of its water systems.

Additional Measures

The Lana'i Water Advisory Committee had many long discussions about how best to protect the watershed. Fencing was clearly considered the most important management measure, but it was not the only one deemed important. Additional measures are described below.

Fencing and other management must be performed in concert - i.e. fencing must be backed up with management of animal populations, appropriate weeding activity and so forth. The LWAC spent some time going over probable cost items, such as survey, herding hunting, ammunition, campsites, shelters, training, liability, and most importantly construction of the fence.

Removal of feral ungulates from inside fenced areas

LWAC agreed on the protocol of hunting to elimination within fence for protection of watershed, but maintaining managed populations outside of the fence for food and sport. Residents were to be the first allowed to hunt within the fence - followed by ongoing staffed hunts if needed. The possibliity of a non-kill herding effort, using men on foot, helicopters, spotlighting and so on to move deer out of the fenced area before it was sealed was also discussed. Once completed, if hunting proved unsuccesful in a given area within the fence, snares, traps or any other means necessary would be used to complete elimination, especially in remote areas. Other means discussed included repellants, non-forage distasteful plants, along buffer strips and other possible means to discourage deer or sterilization, capture and transport, or other non-lethal means of controlling them. At the time it was deemed that none of the alternate methods in literature had been sufficiently developed to be both practical and safe for consumers of hunted meat, nor would they have the necessary impact on populations in time to save the watershed.

Management of Feral Ungulates Outside Fenced Areas

Lana‘i has an unusually active contingent of subsistence and food hunters. In respect for these community values, consideration was given to possible enhancement of hunting outside of the fence to make up for opportunities that could be lost by elimination of deer within the fenced area. Provision of water or salt licks was discussed, but ultimately rejected as having the reverse effect on populations than was desired.

Fire Protection

Lana‘i Hale plants are not well adapted to fire. Some of the more prevalent and invasive weed species found on the hale are fire inducting. The Lana‘i Hale watershed is susceptible to fire, and fire could damage recharge on the island. For this reason, once the fence is in and animal management is showing results, it was deemed important to take certain precautionary measures:

- Survey susceptible areas, including lands taken out of pineapple to identify ways of minimizing fire risk
- Create firebreaks in key areas to prevent spread of fires.
- Create buffer zones to prevent spread of fires to important areas.
- Designate fire-free zones for human use to prevent indadvertent start of a fire.
- Remove, control and /or eradicate fire-inducing weed species as much as possible. At the very least, remove them from the most sensitive areas.
- Prioritize measures to protect areas where small populations mean that a single catastrophic fire could eliminate all remaining population of a species. (Ex. Tetramolopium remyi)
- Heighten public awareness of the dangers and implications of fire. Not just immediate destruction, but potential for longer term loss of recharge.
- Develop a prioritized species response plan, to mitigate damage in the event of a fire (protecting rarest species first).

- Inventory equipment necessary to protect the Lana'ihale from fire and to protect it during a fire. Obtain necessary emergency equipment and /or seek funds to make this acquisition possible (helicopters/strategically placed reservoirs, water trucks, etc.).
- Provide training for Conservation staff and fire fighting staff on special needs within the Lana'ihale area, and on response plan priorities.

Removal of Non-desirable Species

- Certain weeds diminish the forest's ability to recover after disturbance. Identify and remove such weeds.
- Certain rodents and other small animals also impair the forest's ability to recover from disturbance. This can be especially so during the fruiting or seeding time of threatened or endangered native plants. Remove rodent species likely to feed on native plants.

Protection of Sensitive Desirable Species

- Ferns, mosses, lichens, native birds, snails, and certain plants are very sensitive to disturbance. Communities and individuals of sensitive species should be identified and protected.
- Prevent trampling by spreading populations of feeding ungulates
- Prevent invasive weeds or remove them before they become established
- Take measures to reduce erosion.
- Develop a fire, prevention response and prioritization plan.
- Construct exclosures to protect sensitive species where approrpriate.

Monitoring, Mapping and Documentation

- Establish regular transects, using standard methods (point-line intercept or etc.) to monitor the status of target communities, and effectiveness of control measures.
- Perform scheduled field checks and document results.
- Perform additional checks after unusual events, catastrophes, etc. to see what changes have occured in target communities and identify mitigative measures necessary.
- Map monitoring plots, size and class of plants inside each plot (desirable and non-desirable).
- Maintain photographic documentation of plots - especially plant communities - to monitor recovery or loss.
- Establish water and soil moisture gauges to evaluate and track habitat characteristics and quality.

Control Incoming Species

- Establish adequate screening and quarantine for incoming agricultural goods and plants.
- Educate public, landowners, hunters and hotel guests about the dangers of exotic species, potential contaminants, etc.
- Set up procedures to avoid introduction of non-desirable plants and plant pathogens

- set up procedures to avoid introduction of non-desirable insects or insect pathogens

Eliminate or Mitigate Insect Pests

- Identify species to target for elimination, such as chinese rose beetle, chinese leaf hopper, and others.
- Determine protocols, spraying or other schedules, necessary equipment, etc.

Restore Native Populations of Insects, Forest Birds, Sea Birds, Snails, etc.

- Restoration of native species has several benefits for general forest health. Among these are the restoration and improvement of the natural nutrient cycle of the areas soils, establishment of a healthy litter layer, etc.
    - Native snails and insects evolved to be suitable with native plant communities. They also provided important quantities of biomass, nutrients to soils.
    - Sea-birds provided nutrients such as nitrogen, phosphorous, etc. in the form of guano.
    - Some native insects aid in decomposition and soil amendment.
- Restoration of native insects and birds helps to restore and improve pollination opportunities. Forest birds and insects provided important pollinators, the loss of which can exacerbate loss of forest plants.

Control Erosion

- Select realistic / effective areas for management
- Eliminate animal stresses that perpetuate the erosion cycle
- Establish strategic plantings to prevent soil loss
- Construct wattles or other soil trapping devices
- Establish native plants on newly trapped soil
    - Mycorrhizal inoculants can aid the establishment of outplanted seeds
    - Can outplant species grown ex situ.
    - Can broadcast seeds

Protect Species Prone to Gathering By Humans

- For example, sandalwood, due to its high economic value, was subject to removal by individuals seeking the heart wood. Identify species which are likely to be tampered with, and take effective measures to protect them.

Identify Plant Pathogens or Diseases of Concern and Take Measures To Protect Native Plants:

- Using the example of sandalwood
    - "Spike disease" - harmful to sandalwoods in India, believed to be in HI
    - Santalum seed fungus - destructive to viability of seeds (sandalwood)
    - Santalum heart rot

- Possibly others

- Inventory disease problems affecting key species, as well as known management strategies.
- Enhance quarantine & inspection of carrier plants to prevent further introduction of problems.

Internal and Peer Review of Management Plans to Prevent Problems

- Even forest management experts can overlook protective measures or even adverse impacts of protective measures. Once a management plan is drafted, review it internally and invite outside experts to peer review, to eliminate possible ommissions or errors or identify necessary precautions.
- Examples of such errors can include:
  - fencing without adequate monitoring,
  - fencing without weed removal
  - over collection of seeds
  - damage or spread of pathogens by incorrect collection of tissue cultures,
  - careless management on part of humans (human trampling, unmonitored actions, etc.)
- Include proper forest entry practices in all management work.

Collection and Maintenance of Genetic Material

- Seeds, live plants, and plant tissue from threatened areas can be preserved and /or propagated in ex-situ populations. Curators of such collections should take care to avoid in-breeding or cross contamination of genetic material with other variations of a given species. Collectors of seeds or plant tissues should avoid the collection of genetically weakened specimens.
- Ex-Situ Collections - certain plant seeds and individuals exist in collections by
  - National Tropical Botanical Garden,
  - Waimea Arboretum & Botanical Garden
  - Amy Greenwell Ethnobotanical Garden
  - Hawai‘i Plant Conservation Center

Selective Augmentation and Re-introduction of Species from Existing Populations or Ex-situ Collections

- Avoid cross breeding or cross contamination of genetic material.
- Be sure plants have been properly collected, and seed sources appropriately identified.
- Be careful to avoid cross contamination in nurseries or germination media, and exposure to some plant materials.
- In preparation for outplanting, care must be given to proper handling, equpment and training.
- Once out-planted, care must be given to plant care and maintenance until established.

- Survey out-planting sites in advance.
- Prepare necessary protection, possible exclosures, monitoring & maintenance schedules and plans for out-planting sites.
- If necessary, construct camp sites or shelters in advance.

Additional Research on Targeted Plant Communities

The following additional research has been identified as desireable for target plant communities.

- Associated ecosystem components
- Relations between native plant communities / birds / insects (pollination, feeding, etc.)
- Critical habitat size / population size for species viability
- Growth and mortality at various stages of plant life, seasonal changes
- Optimum conditions for reproductive vitality, flowering/seeding conditions
- Light requirements at various stages of life
- Water, soil & nutrient requirements at various stages
- Pollination vectors, seed dispersal
- Means to compensate for missing pollination vectors or other keystone habitat concerns
- Minimum numbers needed for populations to be stable
- Susceptibility to inbreeding

Management Recommendations to Preserve Native Birds

- Protect habitat - including steps to preserve plant communities, snails, insects, etc.
- Prevent predator entry - adequate quarantine, fencing, baiting predators, etc.
- Remove rats and cats from native bird habitats - catch, bait, etc.
- Prevent entry of non-native birds - (avoid disease, competition)
- Prevent entry of mosquitoes and other problem insects
- Control mosquitoes at breeding sites - insecticides, sterilizers, introduction of sterile or non-carrier mosquitoes
- Specific strategic management of existing seabird colonies for enhanced protection.
- Construct feral ungulate fencing in such a way as to avoid harming native bird populations.
    - fence must be visible to prevent birds from crashing during night landing
    - white flagging or tape on top can help
- Establish rat, cat and other small mammal control within the watershed.
- Consider carefully managed re-introduction programs for amakihi, i`iwi, maui creeper, others
- Preserve Lana`i specific genetic material
- Consider minimum habitat size for sustainability of bird populations in deciding fence or othe rman-agement options

Benefits of Protecting Remaining Bird Species and/or Restoring Bird Populations:

- Birds serve(d) specific functions in the watershed on Lana`i
  - direct pollination of native plant species
  - seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces)
  - source of nutrients (esp from sea-bird feces)
  - possible additional non-identified roles, as birds were integral part of ecosystem
- Rare native plants would benefit from having native pollinators and spreaders of seeds restored.
- Nutrient cycles, especially as affected by seabirds, are now being understood to affect soil and plant health more than previously recognized (*Source: Personal communication with Dr. Fern Duvall descrbing paper by Storrs Olson of Smithsonian, indicating that one of the changes in the forest could have come about by loss of sea birds returning nutrients to soil.)*
- Encourage sea birds to return by establishing safe, predator-free sites for them
- In order to successfully maintain existing apapane and seabird populations, and /or to restore previously existing species with close approximations (Maui equivalents) - adequate disease free habitat extent will be required.

Management Recommendations to Preserve Native Snails

- Preserve native snail habitat, especially the upper elevation Lana‘i Hale forest.
- Encourage reforestation with native species, as many non-natives, including Cook pine and Eucalyptus, are not good hosts for native snails (although snails have been found on some non-native plants where they are intermixed with natives). (*Source: Personal communication, Mike Severns*)
- Establish and enforce a ban on collecting.
- Educate the public on damage caused by collecting.
- Eliminate predation by rats and other animals..
  - Construct exclosures to protect snails from predation.
  - Exclosures for snails are roughly waist high. They are constructed of painted, corrugated aluminum roofing. A trench is dug, and in that trench the fence is installed with its foot buried about 6" into the ground, at the top of the fence is a shed-like “roof” that protrudes to either side. Under that “roof” are two additional barriers, a trough of large crystal salt, and a 2-wire electric fence, constructed of two thin wires spaced 8mm apart. The electric wires are powered by solar panels mounted on the inside of the exclosure.
  - The largest such exclosure currently existing is about 40x25 meters.
  - Rat bait boxes may be placed on the outside of the exclosures for further protection
  - Tree limbs and other branches should be prevented from touching the fence exclosure structure , as they may provide a path for predators

- Prevent or eliminate predatory snails, as applicable
- Prevent entry of non-native snails & slugs to avoid possible introduction of diseases
- Snails may be subject to captive rearing and reintroduction as appropriate.
- CARE must be exercised in designing control of slugs.
    - Slugs don't generally hurt snails, but there are no native slugs in Hawai'i, and there is some chance that they could be a source of introduced disease. (Source, Personal Communication, Dr. Hadfield)
    - Any poisons designed to eliminate slugs would also be likely to affect snails.
    - If any poison or bait were used to control snails, it should be limited to extremely LOCAL applications in areas where it was fairly certain no native snails were present.
- Consider careful removal of non-native plant species where appropriate, and replacement with native species. (This measure requires exercise of care to insure that no snails are sitting on the plants to be removed).
- Some species of native snails seem to be adapting to certain introduced plants. In cases where this has occurred, consider selective use of non-native plants that the snails are adapting to.
    - Partulina variabilis
    - Partulina semicarinata

Management Recommendations to Preserve Native Insects

- Protect native habitat on which native insects rely, especially host plants.
- Eliminate non-native predator insects, especially yellow-jackets and ants.
    - Establish pheremone traps for predators.
    - Find and destroy nests with freezing or insecticides
    - Bait ?
- Develop improved quarantine measures and other controls to prevent entry of non-native insects
- Monitor native insect populations to determine species requirements, critical habitat, population size, etc.

Other Prevention Protocols

Through wind dispersion and other means, plants introduced in only a few sites well outside the watershed can and do spread to the watershed.

- A database of cultivated and naturalized non-native species on the island of Lana`i should be developed through survey of nurseries, botanical gardens, parks, hotel and other public landscape and other likely introduction sites.

- The best predictor of invasiveness for most taxonomic groups is a record of invasiveness in similar climates elsewhere in the world. The databases of historically invasive plants and non-native plants present in Lana`i should be cross-checked to identify species of concern.

- A series of species reports should be developed for targeted species, summarizing both literature and field research, and include results fromGPS data collection and distributional mapping, as well as information on attributes of other invaded ecosystems, control data, and so forth. A protocol for obtaining and structuring such information has been developed and implemented in Maui.
- Many of the key corridors by which invasive alien species are introduced are not the same areas where active management transects are located. Efforts need to be directed toward monitoring likely introductory routes such as roadsides, parks refuse sites, vacant lots, harbors, airports and residential areas.
- Through active identification efforts, plants may be detected at earlier stages of naturalization, or even prior to naturalization, avoiding widespread damage.

Education of Land Owners, Residents, Guests, Hunters

- Rare plants and their value
- Importance of watershed / importance of biodiversity
- Non-desirable plants and the threats posed by them
- How to enter the forest and other sensitive areas while causing minimal risk of doing harm
- Dangers of open flames, especially. in certain areas
- Plant walks outside critical areas

Legal & Regulatory Protections

- “It is illegal to remove, cut dig up, damage or destroy an endangered plant in an areas not under Federal jurisdiction in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law (ESA §9(a)(2))
- Hawai`i State law prohibits taking of endangered flora aand encourages conservation by State governement agencies. “Take” means to harass, harm, collect, uproot, destroy, injure or possess endangered species of land plants, or to attempt to engage in any such conduct (HRS 195D-5(d))

Enforcement of Protective Measures

- Make effort to discourage and enforce prohibitions on collection of special species.
- Limit and or manage access to critical areas, as well as activities within those areas.
- Enforce proper forest entry practices for those who do enter.
- Ensure that any uses in sensitive areas are compatible with protecton goals .
- Maintain a regulatory presence in the watershed, manage public activities and education.
- Obtain assistance from agencies or other partnerships if needed.
- Develop a recreational use plan for guiding human activities in the watershed without damage to sensitive areas.

Community Outreach

- Educate the public regarding
  - Importance of watershed
  - Importance of Biodiversity
  - Plants of concern
  - Appropriate forest entry practices
  - Field volunteer training
- Establish a workshop and lecture series
  - Uses of plants in native culture
  - Value of native resources
  - Importance of watershed and connection with native vegetation
  - Plant, animal and bird identification
  - Threats and long term effects of unabated threats (Rapa Nui lesson)
- Solicit community input and partnering
  - Link w/ other environmental agencies and groups. Develop partnerships.
  - Create a pool of docents
  - Develop a guided hike program
  - Offer field trips to biological and cultural sites.
  - Utilize trained docents from partners as leaders.
  - Provide them with / partner to develop prepared informational materials
  - Partner to ensure adequate vehicles and logistical support
- Prepare interpretive materials for use in both community and by visitors
  - booklets, pamphlets
  - web sites
  - public access programs
  - develop native resources curriculum for the schools
- Identify and implement volunteer projects
  - Weed control
  - Restoration activities - outplanting, nursery, maintenance, erosion control
  - Fence building and repair
  - Hunting
  - Construction of wattles to retain soil
- Communicate progress
  - establish media contacts for coverage of projects both local and statewide dissemination

- regular means of communicating relevant information to the community
- utilize existing community special events as venue for promoting education and increasing viability of projects:
  - Aloha Festival
  - Health Fairs
  - Pineapple Festival
  - Other Cultural Events
- Develop and implement long-term alien species awareness and prevention program
- Seek grant funding to develop a video
- Develop a tie-in with the local business community

Coordination with Existing Conservation Efforts

- CCR
  - Some managed hunting and effort to reduce deer on the hale
  - committing funds and developing activities to manage invasive species on Hale
- USFWS
  - ecosystem conservation planning efforts / ongoing work projects
- DOFAW
  - game management areas
  - monitoring census
  - fencing projects on hale and elsewhere
  - endangered petrel project
  - helps to fund Kanepu‘u through NAPP
  - Considering re-intro of nene in conjunction with Hui Malama Pono O Lana`i?
- Kanepu‘u Volunteers
  - Community workdays and volunteer projects in Kanepu‘u
- Maui County BWS
  - WUDP, Lana‘i Water Advisory Committee process
- Certain plant seeds and individuals in collections by
  - National Tropical Botanical Garden,
  - Waimea Arboretum & Botanical Garden
  - Amy Greenwell Ethnobotanical Garden
  - Hawai‘i Plant Conservation Center

FIGURE 6-36 Partial Implementation Matrix - Watershed

Feral Animal Control - Action	Fence Why	By When	By Whom	Cost Estimate
Obtain funding for fence Increment III, or establish rate structure to cover it.	Up-front capital expenditure too great for one entity	within next two years	CCR	$900,000
co-fund grant sources	up-front capital too great for one entity alone - but company will bear partial cost with help from public sector	within next two years	CCR	
Interim - determine whether / where exclosures need to be built while awaiting funds for fence	for some species, the time it takes to obtain public funding for large-scale fence may prove too long...this question needs to be examined and considered	begin immediately determination within 6 months - begin construction for key areas as soon as identified	CCR, DOFAW, LF&WP	Depends upon need.
Survey fence-line	identify best route, potentially affected communities, etc.	within 6 months of funding approvals	CCR in conjunction with DOFAW, US F&WS	Should be included in estimate above
Construct fence	major threat to remaining watershed and other ecosystems is deer	by schedule to be developed but w/in 2 yrs of funding	CCR with help from partners and agencies as needed.	Should be included in estimate above
Maintain Fence and surrounding buffers	without proper maintenance, fence will not work	entire fence perimeter should be checked ... (semi-annually?) to insure integrity	CCR crew	$100,000 per year crew to maintain materials for repairs vehicles, equipment, etc. should also cover some of related expenses
Small exclosures w/in fencelines for snails, seabirds, etc.	target specific areas: nesting sites, known communities, etc.	Can begin inventory of desired sites now, build as indicated	CCR with help from DOFAW, biodiversity committee, etc.	same public / private mix?
Feral Animal Control -	Animal Removal			
Manage Hunting inside and outside of fenced area	hunt to elimination inside fence. This may have to include judas-deer, night hunts, use of lights, use of snares or traps, etc. Manage hunting and access outside of fence	on-going elimination of deer inside fence to begin immediately upon completion of each fence increment.	CCR w/ help from DOFAW, public hunting groups, etc.	part of CCR budget (100,000 per year).
Determine whether deer repellant, non-invasive plant species that taste bad to deer, or other additional measures are desirable to add insurance to buffer zone along outside of fence	additional means of controlling deer may not be adequate by themselves, but may help to enhance the effectiveness of fencing	periodic update of recent research.	DOFAW, Lana`i Co., LWAC, Hui Malama Pono O Lana`i, etc.	Part of other proposed budgets? If desired, planting can be part of volunteer program ?

Determine & implement appropriate predator removal strategies, and implement on-going (rats, cats, etc. - prey on birds & seeds) baits, traps, buffer zones around exclosures, (for ex. see snail exclosure fence design in text)	rats and cats prey on native birds, rats also eat seeds of native plants this may involve controversial issues such as baiting, trapping, etc. Look for repellants too?	within 5 years	DOFAW, CCR. and LWAC	CCR. forest management budget..)
Feral Animal Control -	Monitoring			
Monitor deer & sheep populations maintain regular transects, scheduled field checks, additional checks after unusual events, etc.	determine effectiveness of measures	annually	DOFAW & CCR with enhanced communication with company.	DOFAW & CCR
Fire Protection				
establish fire protective measures:	fire is major threat to watershed and to habitat of all remaining species.	can be started immediately, regardless of fence status	DOFAW, Fire Dept., Company, LWAC, Kanepu‘u group, Boy Scouts, others?	CCR. forest mangement budget...
Inventory worst risk areas				
Fire breaks & Buffer zones				
Remove fire-inducing weed species				
Inventory & obtain emergency equipment as needed				
Develop prioritized response plan				
Develop and implement education program			Volunteer Assistance?	
Weed Removal				
Selective removal of non-desirable plant species - prioritize & implement fire hazard weeds invasive weeds listed elsewhere in report	reduce threats of fire, habitat loss, erosion, etc.	immediately and on-going	CCR DOFAW Volunteers Assistance from LWAC? Assistance from Hui Malama Pono O Lana`i?	On-going CCR. annual budget? (part of $100,000 K annual?) Additional assistance to be sought from Fed, State agencies?
Insect Mitigation				
Mosquitoes identify promising methods (eg: enhanced quarantine measures, selective spraying at breeding sites, or selective intro of sterile or genetically non-avian-disease carrying mosquitoes to reduce threat of avian malaria, pox, etc.) -	reduce threats to pollinators, plant species	efforts can begin immediately & continue indefinitely	CCR. with assistance from DOFAW, Dep’t of Ag, others?	ongoing budgets of listed agencies? additional assistance to be sought in over-all grant request?

Yellow jackets locate nests eliminate with freezing or insecticides	powerful predators on native insects	efforts can begin immediately and continue indefinitely	CCR. with assistance from DOFAW, others	ongoing budgets of CCR and DOFAW?
Mitigate Human Impact				

Enforce bans on collecting native species, snails, seeds, etc.	reduce loss of threatened species	immediately and on-going	CCR, DOFAW, others?	ongoing budgets of listed agencies?
Education on proper forest entry				
Education on Watershed values				
Improved Quarantine & Inspection Protocols	Prevent entry of birds, insects, pathogens, plants	Review can begin immediately Implementation depends upon review	Dep't of Ag, DOFAW, USGS-BRD can review	?
Erosion Control				
Strategic Planting				
Wattles, Other Soil Trapping				
Animal Mgmt				
Reintroduce/Augment	Selected Species			
Bird Pollinators				
Native Plants				
Others?				

Source Water Protection

CHAPTER 6-B

Wellhead Protection

Wellhead Protection Project Summary

The Maui County Department of Water Supply (DWS) is working with stakeholders, private water purveyors and land owners to develop a wellhead protection program for Maui County, which includes Moloka'i and Lana'i. The goal of this project is to establish effective wellhead protection through implementation of a local ordinance aimed at reducing` the risk of contamination in drinking water wells from potential contaminating activities (PCAs). The national Wellhead Protection Program was established under the 1986 Safe Drinking Water Act (SDWA) amendments. The law specified that certain program activities, such as delineation, contaminant source inventory, contingency planning and source management, be incorporated into state Wellhead Protection Programs, which are approved by EPA prior to implementation. State Wellhead Protection Programs vary greatly. Some states require municipal water systems to develop management plans. The State of Hawaii Wellhead Protection Program was approved by EPA-in 1995. The program provides guidance for development of protection measures but does not require local implementation. The SDWA Amendments of 1996 required states to develop and implement source water assessment programs (SWAPs) to analyze existing and potential threats to the quality of the public drinking water throughout the state. DOH has completed a SWAP report for Lanaʻi Company's wells. The report is still under revision. With the support from DOH, DWS continues to develop and implement a Wellhead Protection Program for the DWS water systems, and a protection incentive program. DWS has collected data followed by field surveys of wellhead protection areas (WHPAs) for Lanaʻi Company wells in preparation for future protection efforts. A first report was drafted for Lanaʻi in May 2004. This report serves as an update through addition of suggested protection strategies. DWS has drafted a county-wide ordinance based on strategy plans and input from stakeholders for continued review.

In summary, the Wellhead Protection Project consists of the following tasks:
Delineation of Wellhead Protection Areas (WHPAs). Land areas that could contribute water and pollutants to the water supply were mapped by University of Hawaii Water Resources Research Center as part of the State Source Water Assessment Program.

A review and documentation of the range in wellhead protection that is undertaken by utilities, counties, cities, districts and state agencies in the U.S. The research included the collection of 59 references and the preparation of an annotated bibliography. Programs and ordinances were reviewed and annotated, followed by a questionnaire to help evaluate the efficiency of each program.

Wellhead Protection

An inventory of land uses and PCAs in WHPAs. Land uses, facility type, nature of activities and site specific information were documented and mapped in GIS.

An inventory of contaminants typically associated with identified PCAs. Potential and confirmed contaminants are documented in databases, including descriptions of the environmental transport characteristics and toxicity.

Identification of best management practices for pollution prevention of PCAs, including checklists for public education

A review of the land use control structure and ground water protection programs in effect in Maui County.

With public participation, develop a wellhead protection strategy for Maui County. The Water Advisory Committees on Maui, Moloka'i and Lana'i have voiced support for an overlay zoning ordinance. DWS continues to solicit public input and participation throughout development of the Wellhead Protection Program.

Acronyms

AST	Above ground storage tank
BMP	Best Management Practice
CERCLA	Comprehensive Environmental Response, Compensation, And Liability Act
CWA	Clean Water Act
CWRM	Commission on Water Resource Management
DWS	Department of Water Supply
DOH	Department of Health
EPA	U.S. Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HAR	Hawaii Administrative Rules
HISWAP	Hawaii Source Water Assessment Program
HRS	Hawaii Revised Statues
NPDES	National Pollution Discharge Elimination System
PCA	Potential Contaminating Activity
PUD	Planned Unit Development
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SDWB	Safe Drinking Water Branch
SHWB	Solid and Hazardous Waste Branch
SUP	Special Use Permit
SWAP	Source Water Assessment Program
TSRA	Toxic Substances Control Act
UIC	Underground Injection Control
USGS	United States Geological Survey
UST	Underground storage tank
WHPA	Wellhead Protection Area

Aquifers & Well Sites

The Lanaʻi Company wells delineated and GPSd in this project are described in Table 1. The table includes wells that are developed for current or potential future potable use. Well 1, 9 and 14 are currently for irrigation use. All wells are overlying the Leeward and the Windward aquifers in the Central Sector. Well 6 overlies the Windward aquifer and the remaining wells overly the Leeward aquifer. The aquifers are high level, where fresh water is not in contact with seawater. Both are unconfined aquifers in dike compartments. Salinity is considered fresh (<250 mg/l Cl-) except for the South leeward aquifer where the salinity is high (250 – 1,000 mg/l Cl-). Both aquifers are classified as high sensitivity. Aquifer sensitivity is defined by the U.S EPA as "the relative ease with which a contaminant applied on or near the land surface can migrate to the aquifer of interest". It is determined by the characteristics of the geologic materials of the aquifer. Aquifers in Hawaii are described by Mink and Lau as either vulnerable or not vulnerable to contamination, based on geographical limits of the resources, confining conditions and the relatively rapid time of groundwater travel. (Mink and Lau 1993: "Aquifer Identification and Classification for Lanaʻi: groundwater protection strategy for Hawaii", Technical Report No. 190) When combined with factors of land use and contaminant characteristics, the aquifer's vulnerability to contamination can be further evaluated. Well information about each delineated well was gathered from State databases and from visual survey of the well sites. An example of well information for Lanaʻi 8 well is documented in Figure 1.

Table 1 – Lanaʻi Company Wells Delineated in SWAP

Well Number	Well Name	Year Drilled	Well Type	Casing Diameter	Ground Elevation	Well Depth	Solid Case	Perf Case	Use	Use Year	Init Water	Init Cl	Pump_ GPM
4852-02	Lanaʻi 5	1950		18	2296	1122	630	1120	MUNPR		1548.0	0	900
4853-02	Well 1	1945		12	1265	1274			IRR		876.0	0	700
4854-01	Lanaʻi 9	1990	ROT	14	1411	1451	510	766	IRRGC	94	803.0	0	300
4854-02	Lanaʻi 14	1995	ROT	14	1193	950	650	950	IRRGC	95		700	0
4952-02	Well 4	1950		18	2327	1178	669	1170	MUNPR		1576.0	0	900
4953-01	Well 2	1946		18	1510	609			MUNPR			0	1400
4954-01	Lanaʻi 3	1950		18	1850	1199	442	1189	MUNPR		1078.0	0	300
4954-02	Lanaʻi 8	1990	ROT	14	1902	1490	942	1485	MUNPR	95	1014.0	0	800
5054-01	Kaiholena TH-3	1950									1064.0	0	0
5055-01	Lanaʻi 7	1987	PER	8	2100	1650			MUNPR			67	500

FIGURE 6-1. Well Information

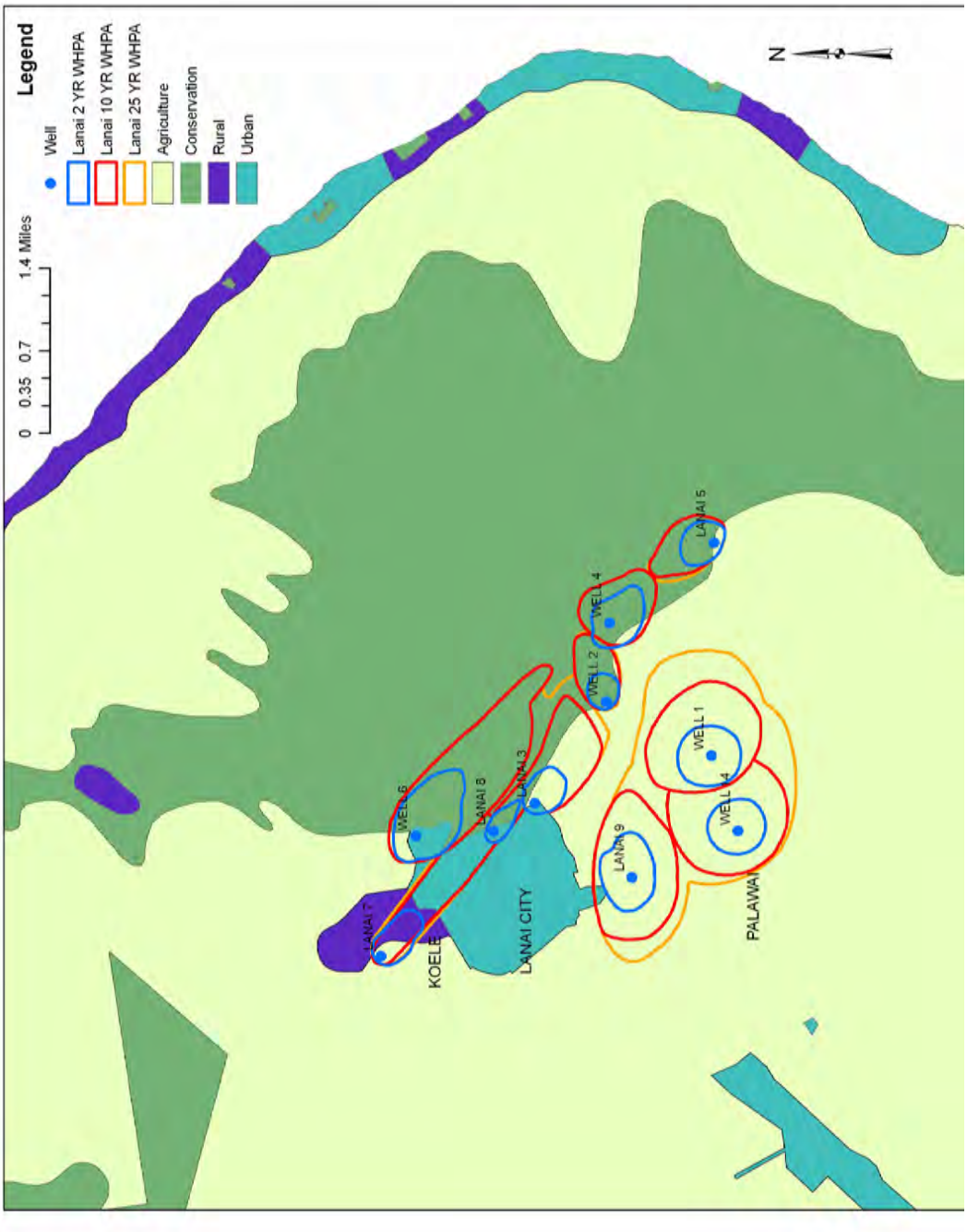
WELL NAME	Lanaʻi 8
WELL NUMBER	4954-02
OWNER/USER:	Lana'i Company
USE	Drinking water
AQUIFER SYSTEM	Leeward
AQUIFER HYDROLOGY	High Level : Fresh water not in contact with seawater
AQUIFER TYPE:	Unconfined
GEOLOGY:	Dike: Aquifers in dike compartments
DEVELOPMENTAL STAGE:	Currently used
UTILITY:	Drinking
SALINITY:	Fresh (<250 mg/l)

Wellhead Protection Area Modeling

Wellhead Protection Areas (WHPAs) for Lanaʻi Company wells were delineated by University of Hawaii Water Resources Research Center for the State SWAP. A WHPA is defined by the 1986 Amendments to the Safe Drinking Water Act as "the surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field". The SWAP modeling uses MODFLOW, a three-dimensional numerical groundwater model, and MODPATH, a particle tracking program. WHPAs were delineated for a 2-year, 5-year, 10-year, 15-year, 20-year and 25-year time of travel. SWAP designates a 50 feet fixed radius around each well to provide protection from direct contamination from vandalism or accidental spillage of chemicals or microbes. DWS added a 1,000 foot fixed radius to account for existing regulatory setback from wells for certain PCAs. The 2-year time of travel zone is intended to designate a conservative estimate of the surrounding area which may contribute bacteria and viruses to the wellhead, based on typical survival times for bacteria and viruses in soil and groundwater (HISWAP Report Volume I, November 2006). The 10-year and higher time of travel zones would allow protective measures in the event of a contaminant spill. Any land use management in this zone needs to address hazardous and persistent contaminants. However, bacterial and viral risks may still be a concern. MODFLOW is a reliable and well documented model that allows new sources to be added to the model fairly easily. MODFLOW WHPAs based on 2-, 5-, 10- and 25-year time of travel are illustrated in Figure 2.

Wellhead Protection

FIGURE 6-2. Delineated MODFLOW Wellhead Protection Areas



Potential Contaminating Activities Inventory

To identify the PCAs within the delineated areas, an in-office survey using public records and other information sources was completed, followed by field survey for visual inspection. Land uses considered PCAs are those facilities that typically use, produce, or store contaminants of concern, which, if managed improperly, could find their way to a drinking water source. Activities to be inventoried were selected referencing U.S. EPA and State WHP guidelines. Appendix A lists PCAs, categorized as Agricultural, Commercial – Industrial, Municipal or Residential. Contaminants of concern are chemicals and other material that can leach into and contaminate groundwater sources and that are commonly associated with PCAs. Those contaminants are in accordance with standard lists prepared by DOH and EPA. Less than half of these contaminants are regulated under State or Federal drinking water standards and monitored. Unregulated contaminants of concern include those on the EPA Drinking Water Contaminant Candidate List. Unregulated contaminants are known or anticipated to occur in public water systems, and may require regulation under the Safe Drinking Water Act, including so called emerging contaminants. Unregulated contaminants that are not subject to testing at the source can still be of concern if the PCAs they are commonly associated with are present, or could potentially be located within WHPAs. Contaminants of concern are listed in Appendix B.

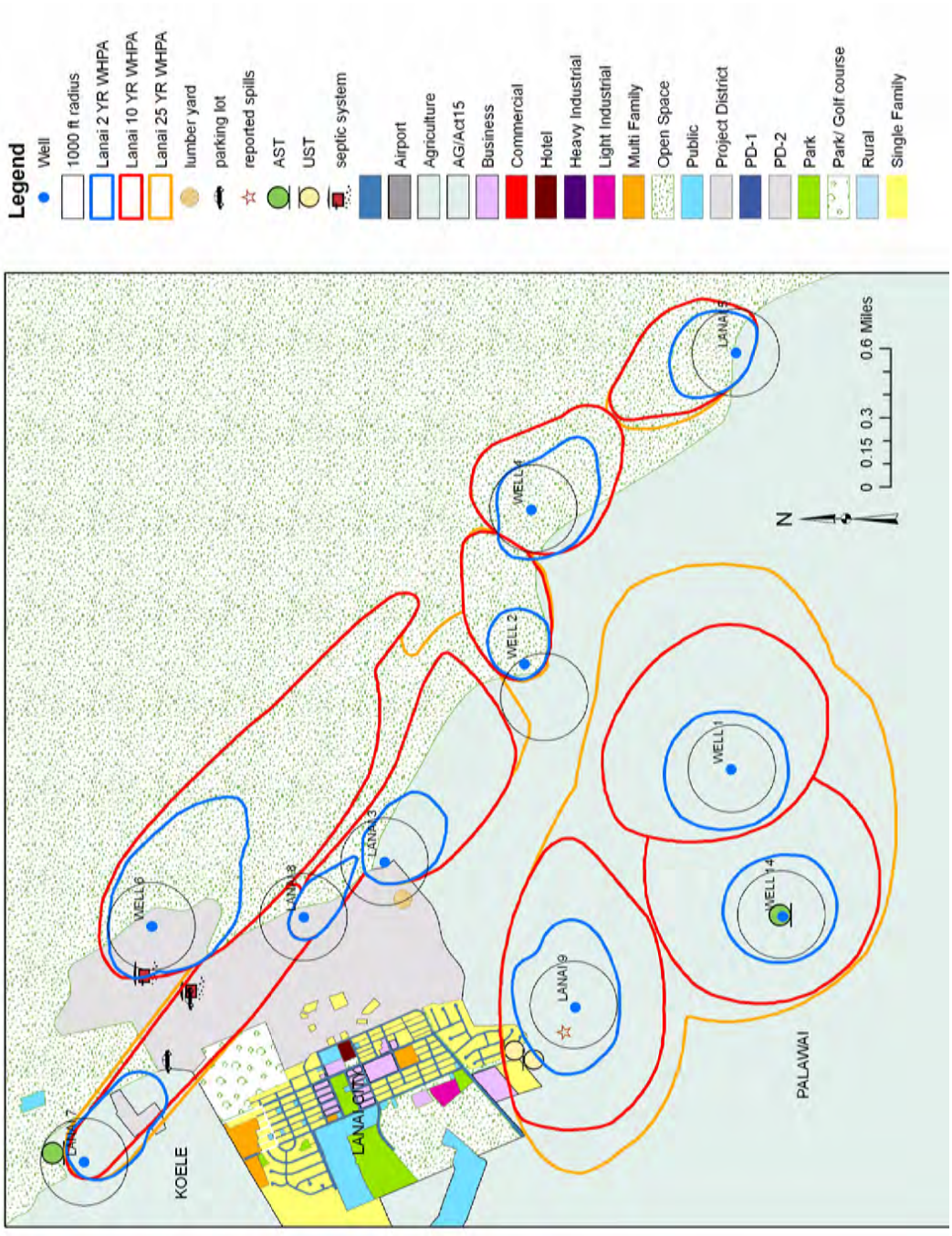
Staff performed field surveys with assistance from Lanaʻi Company to verify PCA locations and to identify any additional PCAs in 2004. DWS staff updated the PCA inventory in April 2010. Mapped PCAs are illustrated in Figures 3 – 4.

Pollution potential is based on, but not limited to, the type and quantity of chemicals used or wastes generated by an activity, and the behavior and mobility of the pollutants in the soils and groundwater. The characteristics of chemicals and the processes associated with the presence of PCAs were researched during data collection for the island of Maui, including mobility (solubility in water and potential for a contaminant to adsorb to soil), persistence (the time it takes to lose chemical potency by 50%) and rated leachability (ability to dissolve out into soil or water). The chemical and biological processes that control contaminant movement are a function of the contaminant composition, reaction with other compounds present in groundwater, and the conditions of the aquifer system. Examples of these processes are sorption (to take up and hold by either adsorption or absorption), biodegradation (capable of being broken down especially into harmless products by the action of living things), and volatilization (to cause to pass off in vapor). Organic contaminants that are discharged to groundwater may adsorb (to take up and hold) more or less to organic material present in the water, and affect the rate the contaminant moves through the aquifer and the amount of contaminants dissolved in the groundwater. Biodegradation can reduce contaminant concentrations and slow movement of contaminants through the aquifer. Volatilization is the migration of contaminants in the gas phase to the atmosphere and may reduce the volume of a contaminant reaching the aquifer. The inventoried data can in conjunction with site-specific factors such as soil type, amount of rainfall, water table level, and topography be used in the susceptibility analysis.

Known contaminant detections in delineated wells were inventoried and federal and state drinking water standards identified. The Maui data inventory also researched health effects resulting from exposure through drinking water to contaminants.

Wellhead Protection

FIGURE 6-3. Potential Contaminant Activitie



Lana'i 7

Lana'i 7 is a closed well not currently in use, but recommission of this well is an option included in the Water Use and Development Plan. It is located in brush area of a former pineapple field. Large-scale pineapple cultivation was largely phased out by the 1970s throughout the island. A rusting aboveground storage tank, likely formerly for fuel is within the 50 ft radius of the well. The entire 1,000 ft radius is former pineapple land, currently mowed pasture. PCAs at the Koele Lodge include: the golf course, commercial septic system, sewer lines, parking lot, and a horse stable. Reclaimed water irrigation of the golf course is R-1 quality, which is considered a medium risk PCA. The reclaimed water facility is located outside WHPAs. Roads and resort development are other PCAs. Historic applications of so called legacy pesticides on former pineapple fields in the immediate area surrounding the well should also be considered a PCA.

Lana'i 8

The well site is in a wooded area. The fixed 1,000 ft radius extends over portions of the Koele golf course. No other current PCAs were identified. However, former pineapple fields are in the 2 and 10 year WHPAs. The area may be subject to new residential development.

Kaiholena TH-3/Well 6

The well site is fenced and located in the wooded area. Portions of the Koele golf course are within the West section of the WHPA. A septic system located at the 7th tee is within the 2-year time of travel zone.

Lana'i 3

The well site is in a wooded area. No current PCAs were identified within any time of travel zone. A closed down lumber yard is found within the 1000 ft radius. Some metal and wood scrap remains at the site. The West portion of the WHPA was former pineapple cultivation and may be subject to future development.

Lana'i 9

The well is brackish, not used for potable consumption and is therefore not subject to wellhead protection under the proposed ordinance. The well is situated on a cement pad in a fenced grassed area. It sits below a former fill site. The South and West portions of the WHPA is former pineapple land. An underground storage tank in use for a wastewater pump station is located in the residential area within the 10-year time of travel zone. A permanently closed underground storage tank is located somewhere at field 5305, possibly within the WHPA. The tank was reported as leaking and site cleanup is completed. Alleged spills and/or dumping at former DDT storage tanks within the WHPA were reported to not require further action as DDT is known to degrade to the less toxic DDE, according to DOH Solid and Hazardous Waste Branch records. Other PCAs are retention ponds, roads, including Manele road, and a residential area with a sewer system.

Palawai Exploratory Well/Lana'i 14

The well is not used for potable supply. Surrounding land is former pineapple cultivation. The Western portions are possibly used for cattle grazing. There is a former hog farm located just outside the 25-year time of travel. The Manele road traverses the WHPA.

Well 1

Well 1 is a high-producing irrigation well, with chlorides in the 300 mg/l range. The well is not used for potable supply. Former pineapple cultivation is primarily at lower elevations than the well site. Historic water quality sampling data show Atrazine detected at 0.40 ppb in 1988, below the MCL set at 3 ppb (0.003 ppm). Current sampling does not show any contaminants detected at this site.

Well 4

This well is the primary source for Manele. The entire WHPA is in forested area. No PCAs were identified.

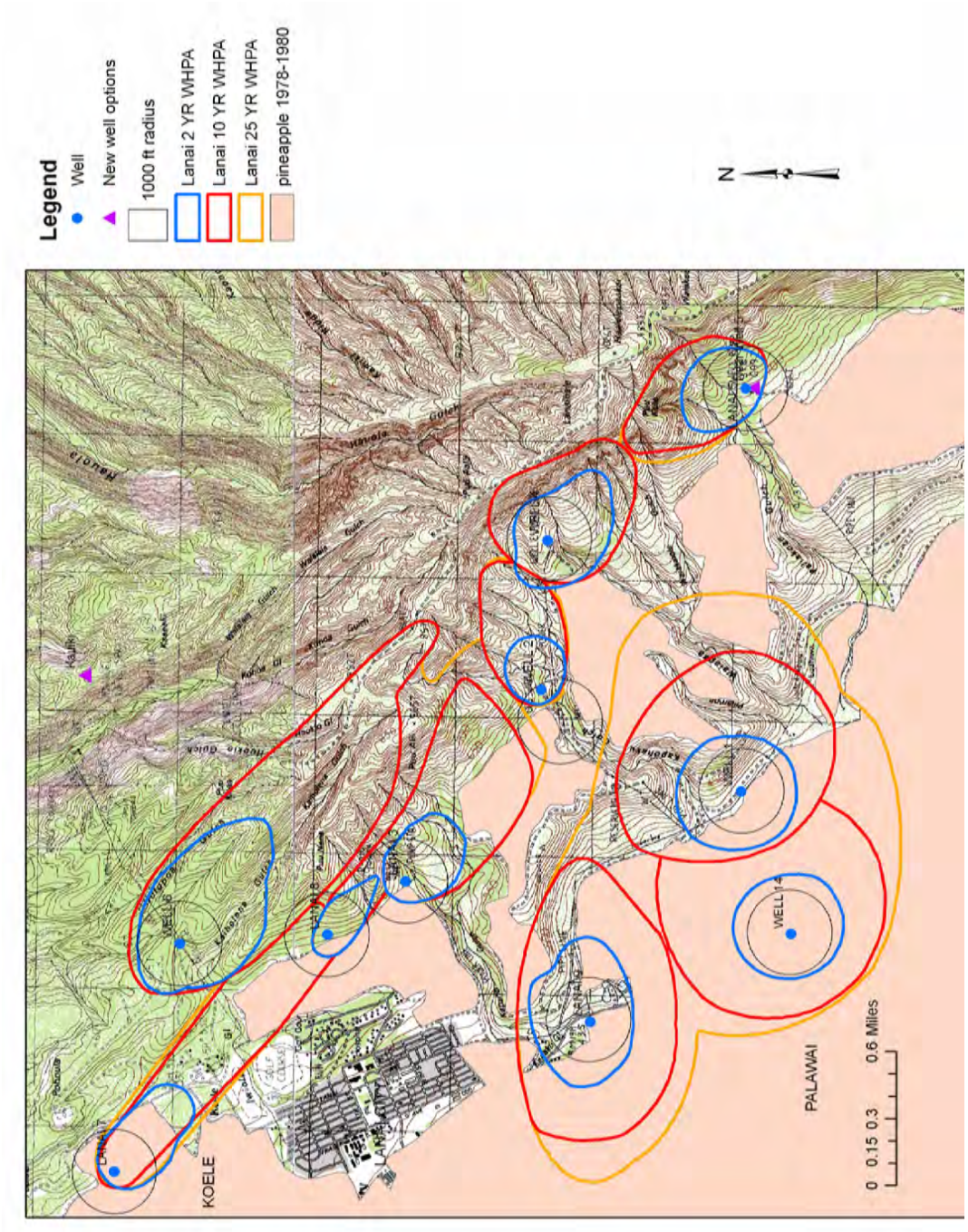
Well 2

The well is currently in use and located in a wooded area. However, the site delineated for SWAP is the old well site up situated approximately 800 ft North East. Should the WHPA be extended further South, no current PCAs are likely to be found, but former pineapple cultivation is immediate upgradient of the new well site.

Lana'i 5

This is currently a monitoring well that collapsed and needs to be re-drilled. The Department was not able to GPS this location. It is situated in an area of overgrown pasture and forest. The WHPA mauka of the well is all forested.

FIGURE 6-4. Historic Pineapple Cultivation

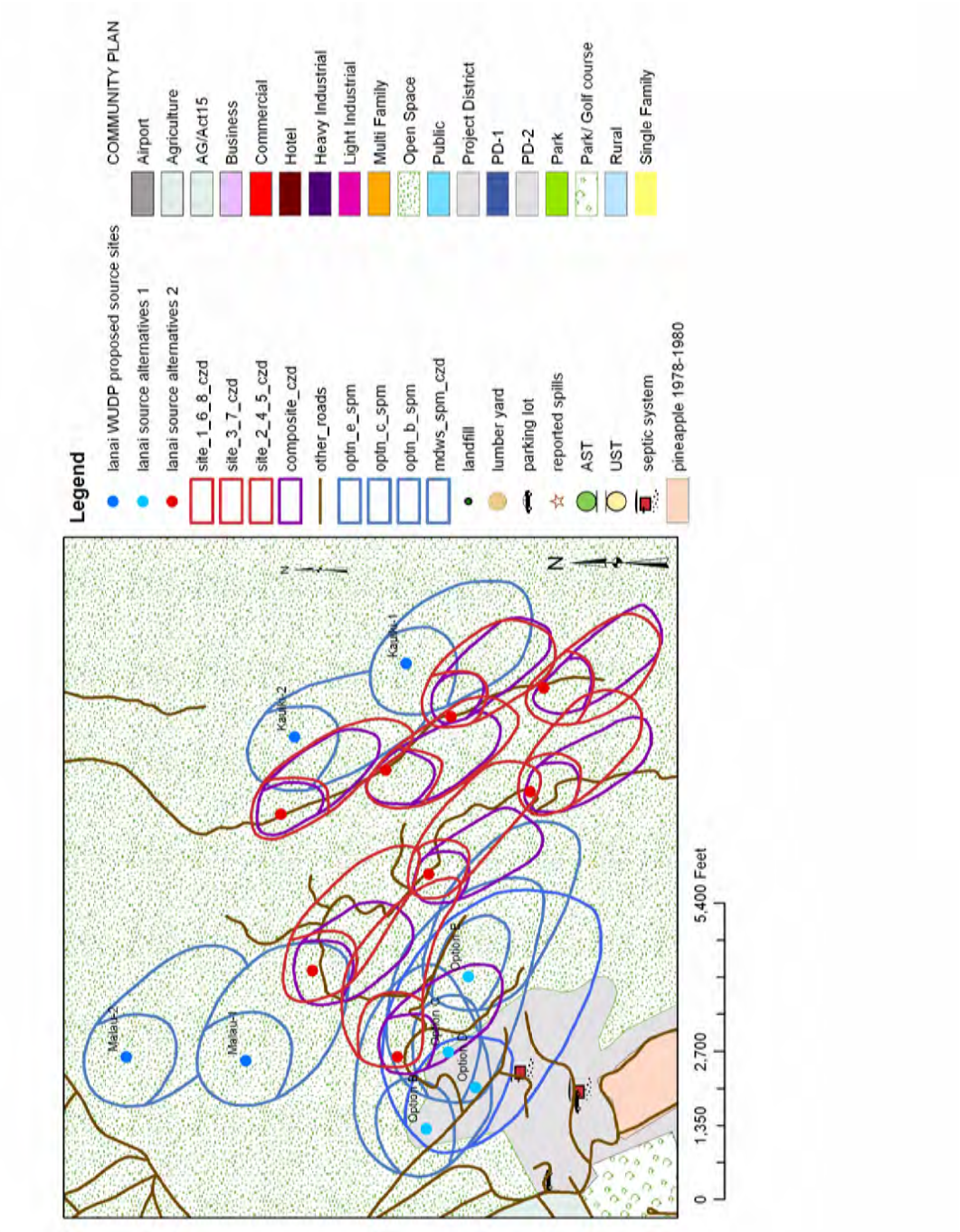


Potential Future Well Sites

Potential new well sites were identified and characterized in Chapter 5 of the Water Use and Development Plan Lanaʻi Chapter. There are 10 wells at 7 different well fields identified for potential potable use, including: Leeward High Level Potable Well Development (near Hi'i Tank), Leeward High Level Potable Well Development (near Well 5), Well 2-B at Shaft 3 Site, Windward wells at Malau, Windward wells at Maunalei Shaft and Tunnel Sites, Windward wells at Kauiki, and Windward well at Kehewai Ridge. Eight alternative sites were also proposed by Lana'i Company in May 2010. WHPAs for all potential future well sites were delineated by the U.H. Department of Geology and Geophysics. DWS staff inventoried PCAs for the first 10 well candidate sites and intends to expand the inventory to all proposed well sites. None of the potential new sites are proposed on lands in former pineapple cultivation. WHPAs for proposed well sites and PCAs identified in the areas to date are illustrated in Figure 5 and 6. WHPAs for the 10 well sites originally proposed in the WUDP and sites B, C, D and E supplementing/amending these are shown in blue. WHPAs for the 8 well sites most recent proposed by Lanai Company are shown in red. The "composite capture zones" shown in purple were modeled with all of the wells pumping. Other WHPAs are modeled with only the subject well's assumed or actual pumpage. Roads extend through most of the WHPAs. At Malau Site Option B there were dump sites of vehicles and mopeds and other debris along the road. A septic system is located in the WHPA of Well Option D. The Koele Golf Course extends into the WHPAs of Well Option B, C and D. The exploratory well sites were difficult to GPS because of trees and ridges surrounding the sites. Most exploratory sites were not reachable and therefore not possible to GPS. Satellite accuracy was also low for those readings that did register. As these sites are further refined, additional GPS surveys are needed.

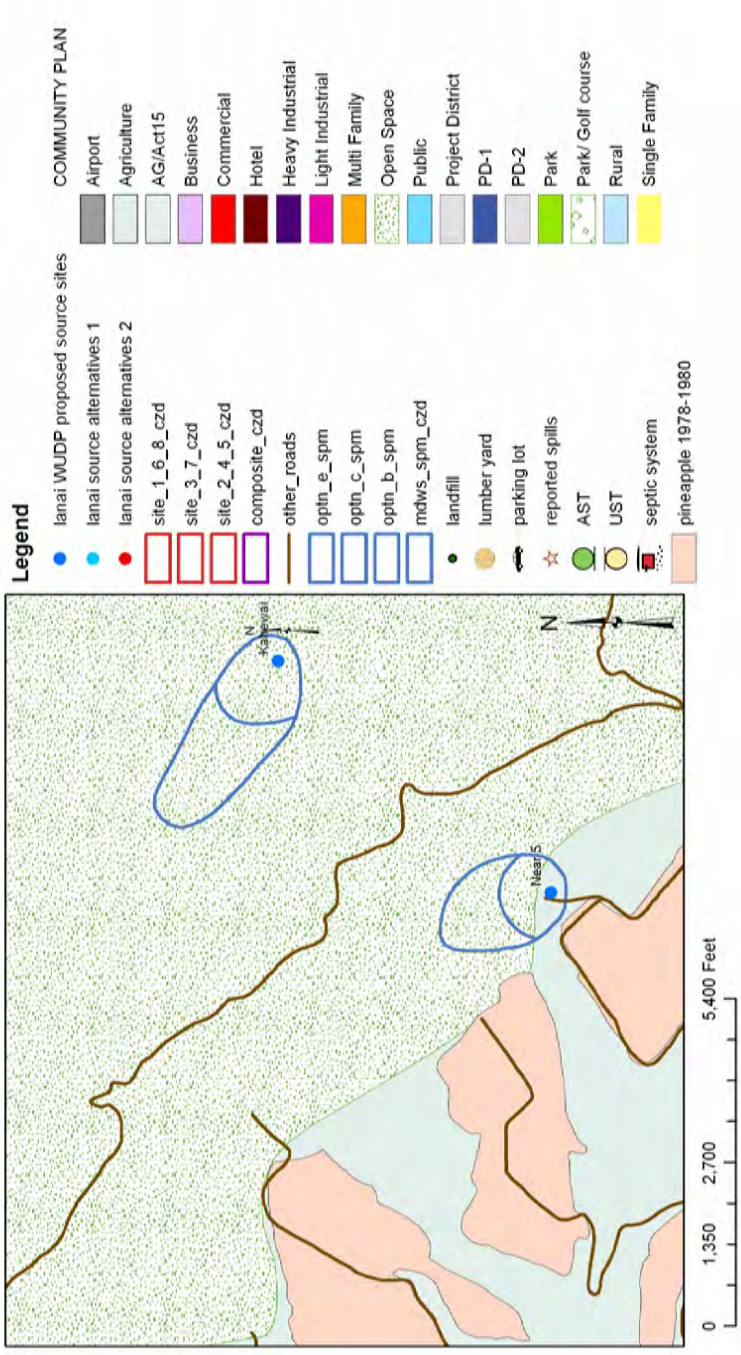
Potential Future Well Sites

FIGURE 6-5. Wellhead Protection Areas and Potential Contaminant Activities of Proposed Well Sites



Wellhead Protection

FIGURE 6-6. Wellhead Protection Areas and Potential Contaminant Activities of Proposed Well Sites "Kahewai" and "Near Well 5"



Land Use Changes

Land development must be consistent with the State Land Use Districts, the Community Plan and County zoning designations. The State Land Use districts are shown in Figure 2. The 2001 Lanaʻi Community Plan designations are depicted in Figure 3. Potential new residential development adjacent to the Koele golf course is shown in purple. Residential parcels are considered medium risk. Additional PCAs associated with residential development include vehicle parking, sewer systems, roads and storm drains.

Historic land use is primarily identified through land use GIS coverages from 1970s and 1980s, history recounts in the 1998 Lanaʻi Community Plan and personal communications. The phasing out of pineapple may be the major change potentially affecting water quality. The pineapple cultivation as of 1978-1980 is shown in Figure 4.

Potential Contaminating Activities Analysis

SWAP conducted a susceptibility analysis, defined by EPA guidance as "the potential for a Public Water System to draw water contaminated by inventoried PCAs at concentrations that pose concern." Susceptibility takes into account both site specific geologic/hydrogeologic factors (aquifer type) and characteristics of the PCA (e.g., nature of the activity, contaminants found in the well, distance from source, areal extent). The SWAP analysis incorporated five criteria in order to rank the potential of each PCA to adversely impact the water quality of each well:

1. Type of PCA: SWAP established PCA categories based on their potential to contaminate a drinking water source. A PCA was defined as very high, high, or medium risk based on specific characteristics of the PCA, namely, the nature of the activities, contaminants associated with the activities, and past history of contamination.
2. The distance of the PCA from the source: the closer a PCA is to the well, the higher the likelihood that a contaminant released would adversely impact the well.
3. The area occupied by the PCA: in general, the larger the spatial area that is impacted, the higher the potential for contamination. For PCAs such as cesspools, residential parcels, septic systems, sewer lines and parks, the scoring was assigned by the density.
4. Detection of potential contaminants commonly associated with PCA at the source: past detection demonstrates definite contamination risk. Scores were given on whether a contaminants is detected at concentrations above the MCL, detected at concentrations below the MCL (or has no MCL), not detected, or detection is unknown because contaminant is not monitored.
5. Aquifer sensitivity: The vulnerability of the geologic/hydrogeologic setting was discussed under the section "Aquifers and Well Sites". The aquifer sensitivity was rated as high, moderate and low. High sensitivity is characterized by basal and high level aquifers that are unconfined and may include aquifer types that are flank, dike, sedimentary, or a combination.

A numerical scoring system was used to relatively rank the susceptibility of the drinking water source to each PCA. The general concept is that the higher the score, the higher the potential for contamination from that particular PCA. (Hawaii Source Water Assessment Program Report Volume I, Approach Used

For the Hawaii Source Water Assessments. November 2006). The purpose of the analysis would be to indicate where source protection may be most needed and what PCAs should be targeted. The susceptibility analysis was included in Lanaʻi Company's SWAP report.

Protection Strategies

Lanaʻi has few current PCAs compared to more urban and developed areas. PCAs that are currently located in Lanaʻi WHPAs are discussed below. A regulatory approach can prevent undesirable and high risk PCAs from being located within WHPAs, while non-regulatory approaches may best address existing PCAs, such as best management practices education and agreements. Inventoried PCAs may in fact pose no or very little concern because of regulations and best management practices already in place. The regulatory framework of ground water protection was reviewed in the Maui process. State legislation and federal mandates provide for groundwater protection through land use and natural resource planning and programs specifically dealing with groundwater protection. A table of programs in place is provided as Appendix C. PCAs are administered by a range of state, federal and county regulations. Identified regulations of PCAs that directly or indirectly provide for ground water protection are described in Appendix D.

Cesspools and septic systems

Contaminants commonly associated with septic systems include nitrate, nitrite, viruses and bacteria as well as various household chemicals. Lanaʻi City is served by municipal and private sewer lines. HAR 11-62 regulates individual wastewater system siting, distance from groundwater table, design and installation. Septic tank effluent disposal systems must be located at least 1,000 feet from a drinking water well and at least 5 ft above groundwater table. Septic systems are allowed for new residential developments comprised of single-family dwelling units on a minimum lot size of 10,000 square feet, but hookup to sewer system is mandatory if available. Two septic tanks are located on parcels that could extend into the WHPAs of the Lanaʻi 7 and Lanaʻi 8 wells. Cesspools are used to receive untreated wastewater. Solids are retained in the cesspool and the liquid percolates into the surrounding soil. Virtually no treatment occurs that would protect the ground water. Installation of new cesspools is no longer permitted in unsewered areas. Large capacity cesspools – those designed to serve 20 or more people per day – have been banned. All WHPAs are in established Critical Wastewater Disposal Areas (CWDAs) where the director of DOH may impose more stringent requirements for individual disposal systems. Maintenance of the private wastewater systems are not monitored or enforced.

Suggested Protection Strategy:

In the event a cesspool would be identified within 1,000 ft of a drinking water well, an upgrade to septic tank would be required should a building permit be sought for the property. Development guidelines are proposed for all WHPAs that set a recommended minimum density of 1 septic unit/2 acres for new development in any unsewered areas. DWS could in cooperation with DOH Wastewater Branch distribute public education material to ensure proper maintenance and prevent use of improper septic tank cleaners.

Household hazardous products

Household chores involve a range of hazardous and non-hazardous products such as paints, solvents, synthetic detergents, pesticides, medicines, fuels, disinfectants, pool chemicals, oils, and batteries. These items can potentially enter groundwater sources when improperly stored through garage floor drains, spills and flooding, through disposal down household drains or through dumping and disposal on the ground. Pesticides, herbicides and fertilizers are sometimes over-applied on lawns and in flower and vegetable gardens and may infiltrate groundwater. Household hazardous products are exempt from hazardous waste and storage regulations, and can therefore be considered potentially significant PCAs.

Suggested Protection Strategy:

Public education for household practices should continue, including newspaper and radio advertisement, and public pollution prevention workshops. The potential contamination load would also be reduced with residential development density restrictions.

Pesticide application

There are no current large scale agricultural operations in WHPAs on Lana'i but pesticides are probably applied in small scale farming and home gardens. Applicators of registered pesticides must be licensed with DOA/EPA. The use of a pesticide can be cancelled, suspended, or restricted or limited to areas to protect groundwater, if it is determined that a particular pesticide or practice appears detrimental.

Suggested Protection Strategy:

Public education and workshops in coordination with the University of Hawaii College of Tropical Agriculture and Human Resources (CTAHR) or other appropriate agency can address Integrated Pest Management (IPM) practices. Application of pesticides and fumigants with high leachability should be avoided in the 2-year time of travel zone or, where no alternative pesticide is available, applied as part of an IPM program.

Pesticide storage and disposal

No pesticide storage was located within WHPAs, but storage could occur with small scale farming in agricultural and residential areas. Pesticides are commonly stored in above ground storage tanks. Unregulated tanks may pose a risk of contamination if not properly maintained. Tanks containing less than 660 gallons of non-hazardous chemicals are not regulated; therefore, the potential for greater hazards may exist. Larger storage must be labeled, and leak free containers and pesticides may not be disposed of except through regulated hazardous waste facilities. Pesticide wastes include leftover pesticides, unusable pesticides, pesticide containers, and rinse water Pesticide leftovers may not be accumulated by large quantity handler (>5000 kg/year) for more than one year. Empty containers must be triple rinsed and taken to landfill, or buried 1 ft deep in ground.

Suggested Protection Strategy:

Where possible, pesticide storage and mixing areas should be located outside WHPAs in order to prevent leaks and spills. Where location outside critical areas is not feasible, best management practices including a secondary containment system should be required.

Golf course

The Koele Golf Course extends into the WHPAs of Well 6 and Well 7. Contaminants commonly associated with golf courses are nutrients applied to the soil, primarily Nitrogen (N), Phosphorus (P) and Potassium (K) and pesticides, including herbicides, insecticides and fungicides. Without proper management, these contaminants may leach into groundwater. In a survey of 37 golf courses in Hawaii, researchers identified 30 different pesticides in use (Brennan et.al. 1992).

Suggested Protection Strategy:

Golf courses is a medium risk PCA. The Draft Wellhead Protection Ordinance prohibits new golf courses in the 2-year time of travel zone. Within the 10 year time of travel zone golf courses are prohibited unless they meet performance standards outlined in the ordinance. The existing golf course should meet "Golf Course Management Measure" outlined in Hawaii's Coastal Nonpoint Pollution Control Program Management Plan. Appropriate BMPs include:

Nutrient management:

Schedule fertilizer application so that the chance of leaching and run-off of soluble fertilizers is minimized

Apply slow release fertilizers that will release nitrogen at a rate comparable to the rate at which it is used by the turf

Apply slow release nitrogen fertilizer in an insoluble form. Calibrate fertilizer application equipment regularly.

Calibrate fertilizer application equipment regularly.

Implement an integrated pest management (IPM) plan that includes, among other things:

Emergency response procedures to be undertaken in the event of a spill or accident.

Avoid applying pesticides in areas where there is a high potential for leaching.

Avoid locating greens and tees that may require high amounts of pesticides within WHPAs

Avoid applying pesticides near well heads.

Apply pesticides when runoff losses are unlikely.

Ensure proper storage of pesticides, located away from wellheads, and if possible from WHPAs.

Well sites

Wells provide a pathway for contaminants associated with land uses around the well. Wells that are not serving a public water system are not subject to the same contaminant monitoring requirements or sanitary surveys as public water system wells. Private wells are often surrounded by farming and other business activities. Permit and registration with the Commission on Water Resource Management (CWRM) is required for new wells. Groundwater quality is not addressed through standard conditions but on a case-by-case basis. Abandoned wells require casing, plug back, cap, or cement fill and seal well in order to prevent seepage of contaminants directly into drinking water supplies. Abandoned or improperly sealed wells present a conduit effect for contaminants to enter an aquifer. DWS are investigating potential abandoned or unused wells during PCA field surveys. With the exception of Shaft 3, all delineated wells are owned by Lana'i Company.

Suggested Protection Strategy:
Siting of new wells should be preceded by delineation of a WHPA around the well, PCA identification and consultation of development plans in the WHPA to identify the impact of future land use and any need for land use controls to protect the well.

Overlay Zoning Regulation

Several existing PCAs may individually and cumulatively pose considerate threats to the underlying water supply. The Maui advisory committee suggested considering density of PCAs rather than individual sources. Clusters of small-scale businesses such as auto body shops and services, whose practices are not regulated by federal or state laws, use significant quantities of hazardous materials such as solvents. Lana'i fortunately has very few high risk PCAs. Although high risk PCAs are unlikely to locate in Lana'i WHPAs in the near future, prohibiting or restricting possible location of undesirable PCAs in WHPAs is recommended due to the nature of the activities, contaminants associated with them and past record of contamination elsewhere. Regulation by complete prohibition (no chemical use or storage in a WHPA) is consistent with most wellhead protection ordinances, regardless of site-specific history of contamination, to provide the greatest assurance that inadvertent discharge of pollutants into the groundwater supply will no occur. The prohibition list should represent changes in knowledge and technology so that as other polluting uses are discovered or as the employed technology reduces pollution potential, uses can be added or eliminated from the list.

There is currently merely a sliver of land zoned business within Well 9 WHPA. Business zoning could allow new establishments of automobile service businesses, printing shops, and other medium – to high risk uses, while light industrial zoned areas would potentially allow a range of high-risk uses. An overlay zoning district based on the delineated WHPAs could restrict uses that are incompatible with groundwater protection without changes to the underlying zoning districts. An overlay zoning ordinance would typically allow existing non-complying uses to continue operating, but subject to land use restrictions if any change in use is proposed. A Draft Wellhead Protection Ordinance for Maui County prepared in cooperation with the Maui Advisory Committee is attached in Appendix E. Regulatory and non-regulatory management approaches are illustrated in light of legal and administrative considerations in Appendix F.

Public Education

BMP education and compliance with applicable regulations in place should be further promoted. On Maui, DWS has distributed targeted pollution prevention material through direct mailings to businesses and residences, newspaper and radio advertising and workshops. A continued pollution prevention campaign in radio and newspaper media will continue that is expected to benefit the Lana'i water system as well. Targeted BMPs are recommended for identified PCAs such as integrated pest management for roadside weed control by Lana'i Company in WHPAs and by the County Department of Public Works.

Project district, mixed use & residential development design
While open space and low-intensity land uses are desirable in protection areas, these goals can pose conflicts with proposed land and resource use. Residential uses generally pose a low risk to water quality, but may not be desirable in protection areas unless appropriate sewer systems and design standards to minimize contamination are provided. Nitrates are commonly associated with septic systems and lawn fertil-

izing. An increase in residential density also brings along increased road runoff and use of household hazardous products.
The Lana'i Project District 2 (Koele) extends into the WHPA of Wells 6, 7 and 8. Permitted land uses in the project district include residential, multifamily, hotel, public use, park and golf course.

New development design could incorporate groundwater protection in the WHPAs in several ways, such as locations of park and storm water detention areas, as well as limiting residential densities. Low residential and commercial density in WHPAs is suggested to maintain groundwater recharge, prevent overloading of household hazardous products and septic systems and keep runoff basins outside WHPAs where feasible. Large-lot zoning is used to reduce the impacts from residential development by limiting number of units within WHPA. A minimum lot size of 2 acres for residential development has been reported to maintain compliance with nitrate standards (Stevens Point Whiting-Plover Wellhead Protection Program). On-site septic system density control should be provided at a minimum in the 2-year microbial contamination zone to prevent future contamination from viruses, bacteria and other contaminants typically associated with on-site septic systems. Maximum overall net density for single family development in the Koele Project District is two and one-half units per acre. Only un-sewered development would be subject to the density restrictions.

The following design guidelines are suggested for all new commercial, residential or mixed use development projects, excluding residential subdivisions of 2 lots or less, throughout the WHPAs:
2-year time of travel WHPA:
Commercial and high-density residential development should be minimized.
Appropriate uses are open space, parks, schools and low density residential (minimum 2-acre lots
for septic systems)
Projects should be designed such that more intense uses are as far as possible from the wellhead while areas closer to the wellhead are reserved for less intensive uses.
Storm-water infiltration basins should be located outside the WHPA where feasible.

10-year time of travel WHPA:
High risk commercial and high-density residential development should be minimized.
Appropriate uses are open space, parks, schools, low risk commercial and low density residential (minimum 1-acre lots
for septic systems)
Projects should be designed such that more intense uses are as far as possible from the wellhead while areas closer to the wellhead are reserved for less intensive uses.
Storm-water infiltration basins should be located outside the WHPA where feasible.

2-year and 10-year time of travel WHPA:
Proposed development entirely within the WHPA should be grouped and sited on the subject parcel at as far distance as possible from the wellhead.
Where development is proposed on property extending both inside and outside the WHPA, and where sufficient buildable land area exists on the portion of the property outside the WHPA boundary to accommodate the proposed development, and where applicable setbacks permit, that area in its entirety should be utilized before any land within the WHPA should be used. Where insufficient buildable land area exists on

the portion of the property outside the WHPA to accommodate the proposed development, as much of the development as possible should be sited outside the WHPA.
Expansions of existing uses should at least conform to these guidelines where
the use is expanding beyond its property boundaries.
Vegetative cover should be provided on all disturbed land areas, excluding fallow agricultural fields, not covered by paving, stone or other solid material. The maintenance or use of native plant materials with lower water and nutrient requirements is encouraged.

Program Implementation

Legal Issues and Potential Conflicts

The Maui advisory committee discussed whether siting of new wells down-gradient of private land could potentially reduce land value and utilization due to land use restrictions. This also raised the issue of takings. Restrictive government decisions may constitute a taking in cases where the regulation interferes with reasonable investments made prior to general notice of the regulatory program, where the regulation deprives the landowner of all, or substantially all economically viable uses for the property with no offsetting reciprocal benefits. A regulatory approach would need to consider existing uses and proposed projects under current zoning to ensure that no restrictions will constitute a taking of private property. In prohibiting certain land uses, there is a potential impact on businesses, farms and "the little guy". The Maui advisory committee commented that many land owners are already conscientiously implementing BMPs and are concerned that costly additional restrictions would be set. Technical and, where possible, financial assistance should be provided for implementation of BMPs so as not to overburden existing users. However, the overall impact and the benefits to the community must take precedence. The benefits of wellhead protection include public health, reducing liability from leaks and spills, decreasing emergency response costs, a safe and viable water supply, avoiding costly treatment systems to treat contaminated drinking water, replacing wells due to contamination and remediation costs to remove the source of contamination.

Administration & Financing

Implementation of an overlay zoning ordinance should rely on existing administration and staff for processing zoning requests. Non-regulatory management, such as BMPs and land use agreements requires coordination between DWS and the appropriate agencies for administration and technical assistance. Farming BMPs should be coordinated with the Natural Resource Conservation Service (NRCS); chemical use, handling and waste with the Department of Health offices and the County Department of Environmental Management; and individual PCAs with the appropriate agency as defined in the Appendix E. If an ordinance stipulates mandatory performance standards in addition to existing state and federal requirements, coordination and inspection by the approving agency will be necessary. An overlay zoning ordinance would be enforced, as other zoning, by the Police Department.

Wellhead Protection

CHAPTER 6-C

Well Operating Guidelines

On January 31, 1990 the Commission "authorized the Chairperson to reinstitute water management area proceedings and re-evaluation of groundwater status when: a. the static water level of any production well falls below one half of its original level above sea level, or b. any source or any alternative source of supply contained in the Company's water development plan does not materialize and full land development continues."

In 1996, voluntary well operating mangement guidelines (VWOMG)[1] were submitted by CCR to the State Commission on Water Resource Management. Based upon this review the Water Working Group at the time recommended revisions and further recommended that the guidelines, once revised, be made mandatory.

These guidelines set "action levels" as well as specified limits or "lowest allowable levels" of water for each well. When an action level is reached, data on pumping is to receive thorough public and scientific review, with the aim to evaluate whether new source should be developed and pumping on the well reduced.

When the lowest allowable level is reached, pumpage on a given source should stop altogether, pending new source development or recovery. In event that it is not possible to stay within the limitations set for potable wells, LCI will develop new wells and/or outfit Well 7, whichever is most hydrologically appropriate. [2]

1. Lana 'i Water Resources Management Plan, Prepared by Lana 'i Company, Inc., August 1996
2. Resolution 93-42. Relating to the use of non-potable water for the construction of the Manele Golf Course. County of Maui, 1993.

According to these guidelines, pumpage shall be distributed among well sources so as to maintain their water levels within the specified limits delineated in the table below:

TABLE 7-35 Action levels for groundwater sources.

Potable Well	Initial water level (ft elev)	2009 P7 Water level (ft elev)	Action Level* (ft elev)	Lowest allowable level (ft elev)	CWRM Trigger (Half Initial Head, Jan. 31, 1990)
2	1544	1,441	1050	750	772
3	1124	992	750	562	562
4	1589	1,495	1100	750	794.2
*5	1570	1,491	1100	750	735
6	1005	924	750	500	502.5
8	1014	944	750	500	507
Brackish Wells					
1	818	575	550	410	409
9	808	650	550	410	404
14	?	497	400	292	

*Requires public review of all pumpage, water level, and water quality data for possible changes in the resource management procedures, policies, and plans.

** Well 5 is not in operation

CHAPTER 7

Policy Issues

Sustainable Yield

Lana'i has a very low sustainable yield. At 6 MGD, it is less than 1/10 that of any other major island. Unlike the other islands, Lana`i also has no flowing streams or utilizable surface water. Figure 7-3, below, shows the relative sustainable yields of the main inhabited Hawaiian Islands for comparison. Note that the recent update of the State Water Resources Protection Plan reduced sustainable yields from the 1990 estimates on virtually every island but Lana'i, although these reductions were less than initially proposed. In many cases, such decisions resulted from pumpage beginning to approach initial sustainable yield estimates, only to find that such estimates were either overly optimistic, or that distributions of withdrawals had to be increased substantially to realize them. It is not unreasonable to posit that Lana'i might one day find itself in a similar situation.

FIGURE 7-1. Sustainable Yields of Hawaiian Islands

Island	1990 WRPP Sustainable Yield MGD	2007 Draft WRPP Update Sustainable Yield MGD	June 2008 Final WRPP Sustainable Yield MGD
Hawaii	2,431	2,175	2,410
Kauai	388	306	310
Lana'i	6	6	6
Maui	476	386	427
Molokai	81 / 38 Dev	71	79
Oahu	446	419	407

Need for Improved Distribution of Withdrawals

Policy Issues

The document *A Numerical Groundwater Model for the Island of Lana'i, Hawaii* (CWRM-1, Hardy, 1996, pg. 126), "shows that **many more wells** would be necessary to achieve pumpages near the current CWRM sustainable yield estimate of 6 MGD, assuming that long term recharge conditions in the regions above 2,000' remain stable" [emphasis added].

This model assumed withdrawal of water was distributed between thirteen sources, of which two, the Upper and Lower Maunalei Tunnels were passive. Pumping was distributed among eleven sources, as shown in Figure 7-4. Pumping is currently distributed primarily among only six sources, with a seventh contributing an average of only 2,418 GPD.

More than 85% of 2008 water withdrawals on Lana'i, 1,913,310 GPD out of 2,241,222 GPD, came from the Leeward aquifer. All near term plans of LWCI or LHI to develop water are also in the Leeward aquifer. The only pumping well in Windward aquifer is Well 6, with an average 2008 withdrawal of 328,000 GPD. It is unlikely that more pumpage could be distributed to this well, because its water levels are already declining.

FIGURE 7-2. Modeled Distribution of Pumping Versus Present Distribution of Pumping

	AS MODELED IN 1996 CWRM MODEL	CWRM MODEL WELLS IN USE NOW	2008 MAV	* MOST RECENT ACTUAL MAV	* OTHER RECENT ACTUAL MAV	AVG OF NON-ZERO MAVS OVER PUMP RECORD	Comments
Maunalei Shaft 2	500,000	0	0	0	557,385	525,980	*MAV period 13 1994. In the late 1980s, more than 600 KGal came from Maunalei sources. Shaft 2 operated until 1995 with a running MAV of around 526 KGal. Stopped in early 1995.
Well 1	270,000	270,000	393,981	378,074		291,173	*MAV period 7, 2009. Water levels appear to be declining at current pumping rates.
Well 2 / Shaft 3 future "2-A"	300,000		2,418	0	302,468	228,523	*302,468 was MAV period 13, 2006. However, there have not been 13 straight periods of pumping since 1997. Period 8, 1997 MAV was 157,140 GPD.
Well 3	300,000	0	0	0	233,991	191,281	*MAV period 6, 2006. Last 13 period with continuous non-zero pumpage.
Well 4	400,000	400,000	683,867	598,677		532,729	MAV period 7, 2009.
Well 5	400,000	0	0	0	120,030	153,557	*MAV period 12, 1992. This well started in the 200-300 KGal range for 2 years, and then dropped steadily. Period shown is last continuous non-zero MAV use.
Well 6	300,000	300,000	327,912	303,118		432,557	MAV period 7, 2009.
Well 7	200,000	0	0	0			No continuous pumpage record. One monthly number in 1992.
Well 8	300,000	300,000	276,890	255,469		121,459	*MAV period 7, 2009.
Well 9	270,000	270,000	151,440	127,851		224,302	*MAV period 7, 2009.
Well 12	0	0	0	0	14,305	10,316	*MAV period 13, 1995. Started at 17.8 KGal & declined continously. Use stopped in 1997.
Well 14	280,000	280,000	404,714	323,302		336,913	*MAV period 7, 2009.
	---	---	---	---	---	---	
	3,520,000	1,820,000	2,241,222	1,986,491	1,228,179	3,048,790	Average over pump record is high. These wells have not pumped at same time. Difference between 2,238,804 and 2,241,222 is less than 1%, and results from different averaging method.

As modeled in CWRM-1, Hardy, 1996. Modeled scenarios were based on pumpage at the time and various pumpage scenarios that had been proposed at the time.

Declining Water Levels

At 2008 pumpage rates, water levels in several wells are declining (Wells 1, 9, 14, 6 and 8). Pumps have been lowered recently in several wells with Well 9 showing particular stress. Since 2003, the pump in Well 9 has been lowered 442 feet. Water levels are within 48 feet of the "Action Level" in CCR's proposed operating guidelines, and continue to decline. Chlorides have also been rising in the 15 MG reservoir. This is not due to rising chlorides in the wells, but rather to increased use of the higher chloride Well 14 to supplement Wells 1 and 9. However, it does affect the amount of salt that is introduced in irrigation at Manele. LHI is taking action on this situation, by drilling an additional well, Well 15, to distribute withdrawals. How much water and at what quality this well will produce remains an open question. While a certain amount of decline in water levels is to be expected, caution and circumspection would still seem warranted.

Water levels in the wells mentioned are plotted below. In each of these graphs, the green line represents the initial water level. The yellow line is the action level set in the LWCI operating guidelines. The red line is the lowest allowable level in the LWCI operating guidelines. A pink line is plotted, and is the CWRM trigger for designation proceedings, but it is so close to the red line that the two are not distinguishable. The dotted black line is the pump level. The thick blue line is the low water level and the thin blue line is the high water level.

FIGURE 7-3. Water Levels - Well 1

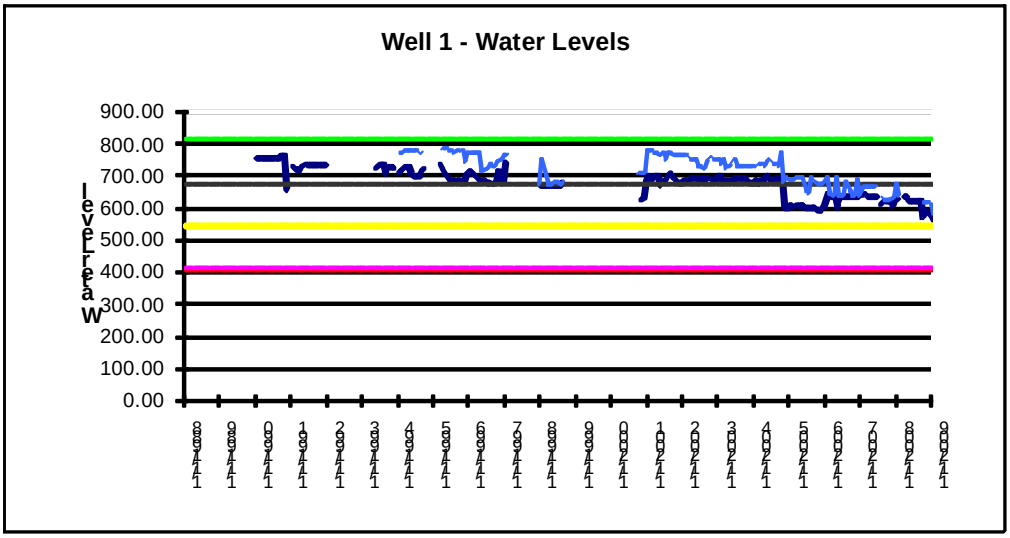


FIGURE 7-4. Water Levels - Well 9

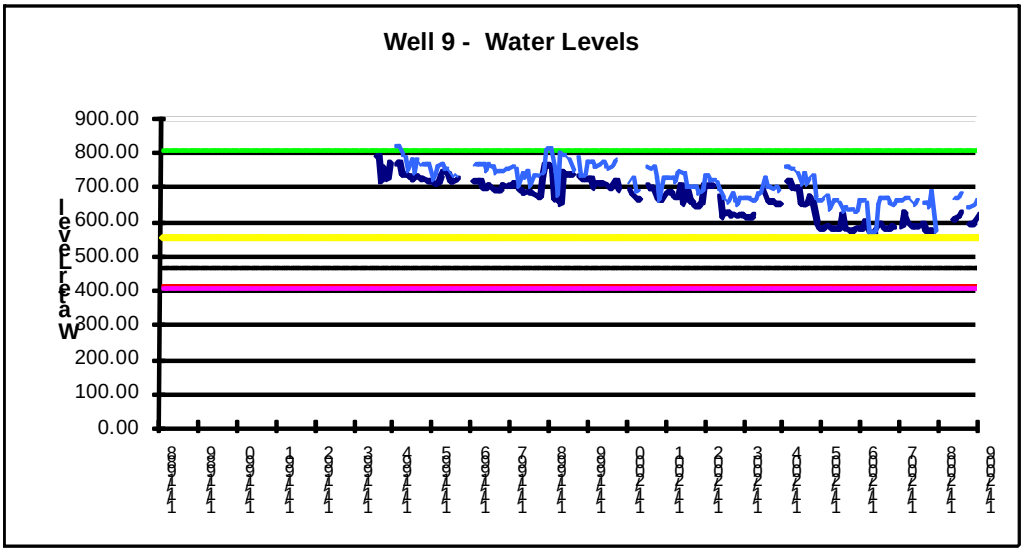


FIGURE 7-5. Water Levels - Well 14

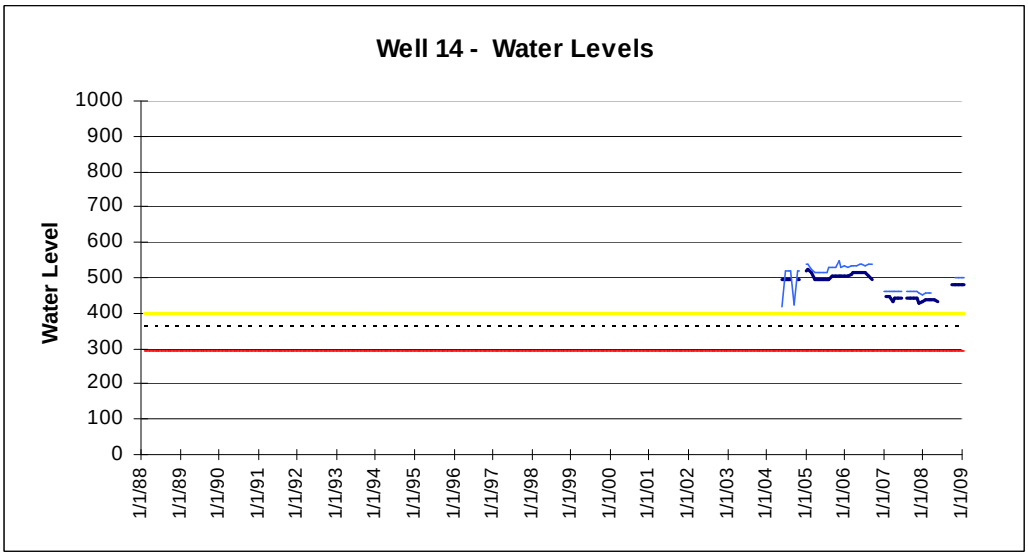


FIGURE 7-6. 15 MG Brackish Reservoir - Chloride Levels

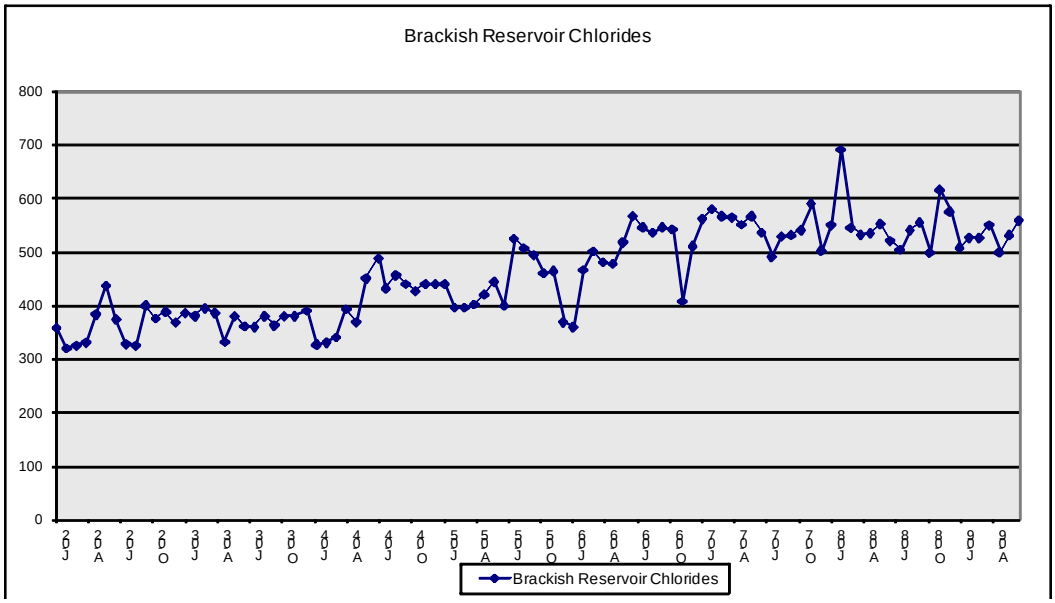


FIGURE 7-7. Well 6 Water Levels

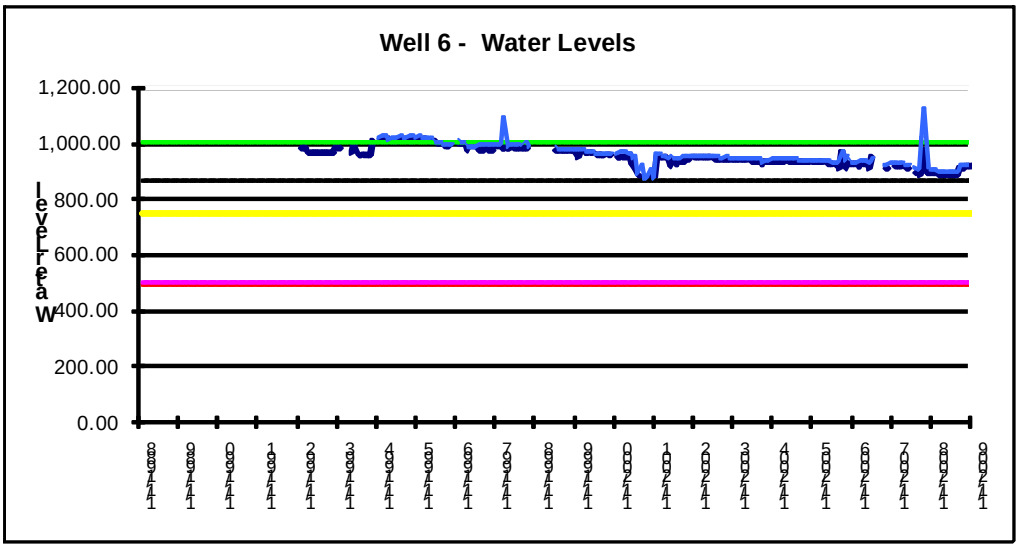
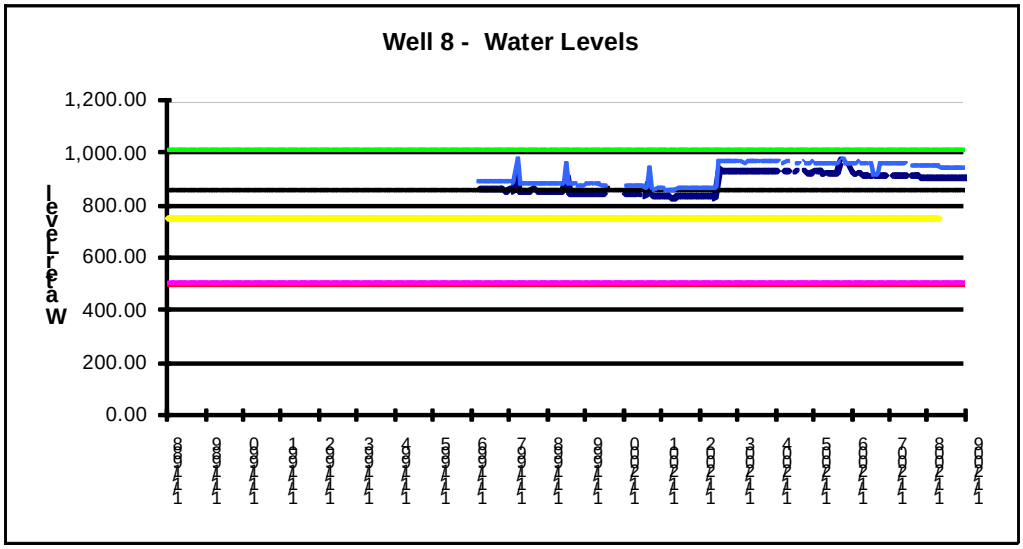


FIGURE 7-8. Well 8 Water Levels



Green - Initial Water Level; Yellow - Action Level; Red - Lowest Allowable Level; Pink - Trigger for Designation Proceedings; Dotted - Pump Level, Thick Blue - Low Water Level; Thin Blue - High Water Level

Importance and Condition of the Mauka Watershed Forest

The *Numerical Groundwater Model for the Island of Lana'i Hawaii* (CWRM-1, Hardy, 1996) "...predicts that the reduction of forest cover would affect ground water levels drastically." (pg. 126) The model indicates that fog drip is a major contributor of recharge to the primary high level aquifer. Fog drip is estimated to contribute 8.87 MGD of a total 13.5 MGD in estimated recharge (65.7%). Loss of fog drip from the forest, even with zero pumpage, would result in a severe drop in water levels, on the order of 25% to 30%. With 6 MGD pumpage, that drop would be even more severe, with water levels dropping 50% within the modeled period. (CWRM-1, Hardy, 1996, pgs. 44, 105 & 112 - described in Chapter 3 of this document).

The mauka watershed forest is exceedingly compromised. By 1993, two thirds of cloud forest vegetation had been lost. (Hobdy, 1993). Despite efforts to install fencing and manage feral ungulates, the Lana'ihale watershed continues to decline. (Hobdy and Penniman, minutes of 5/30/2008 meeting). Increment I of a three-phase project has been completed. However, fencing for the most critical habitat area must wait for Increment III. This is still years away, and funding is uncertain. Whether or not cost recovery for this increment is folded into the final rates of the LWCI, additional major entitlements for CCR should be conditioned upon continuing watershed protection, and most especially upon construction of Increment III of the fence.

Historical Water Allocations

Hawaii Revised Statutes (HRS) §174-C-31 (a)(2) states that the Water Use and Development Plans for each county shall set forth the allocation of water to land use in that county. However, the statute is not prescriptive about how such allocations should be made. Conceivably, allocations could be made in any number of ways, from broad-brush statements about general priorities for each type of water, to accommodating land use forecasts for each sector, to specific and explicit review of every planned use and source. Similarly, such allocations could address the "bottom line" at the end of the planning period and ignore timing, or could address the pace and schedule of resource use.

Regardless of the manner in which allocations are set, they must be set within certain parameters. They must be consistent with Community and General Plans. They must incorporate the current and foreseeable development and use needs of the Department of Hawaiian Homelands. They must reflect the responsibility of the counties set forth in Article XI of the constitution that the State *and its political subdivisions* have the responsibility to protect and conserve resources. In other words, protection of resources is a public trust obligation for which the State has primacy, but from which the counties are not exempt. Given a public trust obligation, a precautionary principle is warranted where applicable in setting water allocations.

1997 Allocation Agreement

Source water use estimates from the 1997 Water Working Group Report are presented in Figure 7-1. These were the starting point for allocation discussions by the Water Advisory Committee for this update. Two key points of the 1997 consensus were:

- Total potable and brackish water use for the Manele Project District should be limited to 1.03 MGD, regardless of any approvals that would result in a higher build-out. High level brackish water use is limited to 650,000 GPD, to be decreased as increasing reclaimed water becomes available. Use of reclaimed water for irrigation should be maximized.

- No high-level water should be utilized to irrigate the Koele Golf Course, with the exception of the special conditions provided for in Ordinances 2515 and 2516, described in Appendix B.

The 1997 allocation agreement remained the consensus agreement of the LWAC until 2002.

Island-wide water use, at 2.24 MGD in 2008, was considerably less than the projected 3.72 for 2010.

Consumption for the Manele Project District area reached 1,082,999 GPD in 2008. Only a small portion of the Project District has been built. Of 282 Single Family units permitted under the Project District Ordinance, only 17 units have been built. Half the hotel units have been built. The project is not even close to full build-out. Similarly, in Koele Project District, only 13 of 535 eventual single family units have been built.

FIGURE 7-9. Water Use Allocations from 1997 Water Working Group Report

LAND USE CATEGORY	Present (97) mgd	2010 mgd	Future mgd	Source of Wate
Residential	0.274	0.414	0.494	Primary
Agriculture	0.219	0.50	1.50	Primary
Commercial & Institutional (10 addditional acres)	0.379	0.439	0.439	Primary
Light Industrial (15 acres)	0	0.09	0.09	Primary
Kaumalapau Harbor	0.009	0.01	0.01	Primary
Lanai Airport	0.004	0.005	0.005	Primary
Manele Project District	0.078	0.68	1.03	Primary & Seco
Manele Golf Course	0.51	0.65	0.65	Secondary
Manele Effluent	0.05*	0.07*	0.14*	Effluent
Koele Project District	0.096	0.20	0.42	Primary
Koele Golf Course	0.25*	0.25*	0.25*	Effluent
Subtotal Groundwater	1.569	2.99	4.64	Primary & Seco
System losses 12% future	0.134	0.41	0.63	
Subotal Groundwater	1.703	3.40	5.28	
Total Effluent	0.3	0.32	0.44	
Total Water Demand	1.73	3.72	5.72	

*Reclaimed wastewater effluent

**Sources of Water:
Primary= Wells 2,3,4,5,6,8, Maunalei

Secondary=Palawai (Wells 1,7,9,10) and beyond

Effluent=reclaimed water

Water Demand Associated with Build-out of Entitled Projects

Build-out of Existing Approvals / Partial Entitlements Could Create Demands Exceeding Sustainable Yields

Absent measures to mitigate withdrawals, existing partial entitlements in the form of Project District approvals, could cause demands to meet or exceed the sustainable yield of one or both aquifers. This is shown in Figures 4-59 and 4-60 of the *Demand Analysis* Chapter. Project Districts plus additional entitlements requested in the CCR proposals, plus non-company projects, would lead total demands to exceed the sustainable yield of the aquifer, as shown in Figures of the *Demand Analysis* Chapter. Build-out of the portions of Project Districts which already have Phase II approvals will lead to a total withdrawal of about 3.66 MGD. This assumes unaccounted-for water could be cut to 15% in the Manele Project District and Palawai Grid areas. At current island-wide unaccounted-for water rates, build out of the Phase II entitled portions of the Project Districts, without additional development in the Windward aquifer, could lead to exceedence of sustainable yield in the Leeward aquifer. These estimates are tallied in Figure 4-76 of the *Demand Analysis* Chapter.

CCR Proposals Include Project Elements Beyond Those In The Approved Project Districts

The CCR proposals indicate additional project elements beyond those already entitled or partially entitled. It also does not include all of the partially entitled project elements in the PD. Differences between build-out of proposals and project district entitlements are delineated in Figure 4-75 of the *Demand Analysis* Chapter. The 2006 proposal for Koele includes 90 Multi-Family units, 425 Single-Family units and 250 Hotel units, while the PD allows for 156 Multi-Family, 535 Single-Family and 253 Hotel units. In Manele, the proposal calls for 200 Single-Family units, 300 Multi-Family, 400 Hotel units, and 10 acres of Commercial area, while the PD allows for 282 Single-Family units, 184 Multi-Family units, 500 Hotel units, and 5.25 acres of commercial. CCR was asked in discussions whether it would be willing to trade additional elements noted above for project elements not included in its proposal. CCR personnel responded that they preferred to reserve the full PD approvals, even though these may not be built-out within the planning time frame. For example, the 2006 proposal raises the count of MF units in the Manele Project District from 184 to 300. At the same time, it omits 82 of the SF units allowed in the Project District. In this scenario, the full count of 200 single family units would still be built, so the net effect would be the addition of 116 MF units. The problem with this logic for Lana'i is that the existing approvals and the proposed approvals both have the ability to render demand higher than sustainable yield. Adding additional entitlement without benefit of clearly identified source raises concerns regarding sustainability of the aquifer. While it is understandable that any business would want to maximize the flexibility of its options, in this case it is recommended that such flexibility be obtained by trading some entitlements for others, rather than by adding more, until more is known about the response of the aquifer to build-out of existing entitlements. This will require interagency coordination. Figure 4-61 is a table of current Project District build-out status. Figures 4-65 and 4-66 are attempts to map this status into Phase I, Phase II and Phase III approvals. Some difficulty was encountered in mapping, as certain unit counts were not tied to specific counts on Project District maps. It is both recommended that this be addressed, and hoped that it may be already being addressed in preparation for the Community Plan process. In any case, discrepancies between proposals and Project Districts as approved, plus the addition of other projects not part of the Project Districts point to the need for both clear allocations and for convenient tracking mechanisms such as the maps described.

Demand Generated From Project Approvals Is Not Immediately Apparent

There is a time lag between when projects are approved and when their full water consumption is reached. Even once projects have been built, there is a time between construction and full occupancy. Therefore, it is possible that additional approvals could be issued before the full impact of already-approved developments is accurately known and gauged. A reviewing governmental body may ask for a comparison of present consumption figures, and incremental additional use represented by the project, without being fully aware of or able to visualize the magnitude of demand still pending. One way to limit the probability of this becoming an issue is to identify sources for each approval, including all existing and planned project elements anticipated to rely on those sources, and to proceed slowly and deliberately with regard to build-out.

Econometric Trends from General Plan Update Data and Time Trends Both Indicate that the Natural Pace of Growth Would Be Slower Than That Proposed

Forecasts range from 2.43 MG to 5.03 MGD, with the base case between 2.6 and 3.5 MGD. Build-out analysis, on the other hand, ranges from 6.08 to 7.13 MGD, or 5.66 MGD for Phase II. The recommended allocation is consistent with the SMS base case forecast at an elasticity of 1.5, allowing slightly

more consumption than the base case and elasticity calculated for other communities on Maui, but not so much as full build-out.

Proposed and Empirical Unit Consumption Are Considerably Higher Than Standards

Both proposed and actual demands in the hot, dry Manele area exceed *System Standard* guidelines. However, in some cases hundreds or even thousands of gallons per day of brackish water are used, even when potable consumption is at or near zero. This and other observations led to the impression that occupancies of these single and multi-family residences can be low, while most of the water goes to irrigation. In turn, this would lead to a lower available return of reclaimed water per unit of build-out. The question was raised by LWAC and discussed at length as to whether per-unit consumption rates exhibited and proposed were reasonable. Water consumption by single family lots in Manele Project District averaged 3,700 GPD in 2008, with a high of over 9,000 GPD. Most of these are half-acre lots. Among the recommended measures are a tiered rate structure and a landscape conservation program with the objective of reducing per-unit consumption.

Conservation Potential

System wide unaccounted-for water averages about 0.633 MGD, or 28.36% of total production. There are several potential sources of such unaccounted-for water. Pipelines in the Palawai Irrigation Grid are old, deteriorated, and subject to high pressures. Leak detection has been performed by visual inspection, "walking the lines", for years. This generally indicates an old system in poor repair. A leak has to be either quite large, or to continue for a long time, or both, before visible signs reach the surface. Other lines are old and sub-standard as well, such as the Kaumalapau line. There is a 15 MG uncovered reservoir where evaporation and other losses are suspected to be high. Also on the brackish system, some unmetered uses were found during the drafting of this document. There is a 1.5 MG covered reservoir which is over fifty years old but lined at the bottom only with old concrete. In addition, end uses demonstrate high per unit consumption, most of which is attributed to landscape. Landscape use is estimated at 1.1 MGD. Per unit consumption rates are high, with much of this going to the landscape. Hotel uses are about 0.27 MGD, roughly half of which is presumed to be outdoor use and included in the 1.1 MGD total. About 485,000 gallons of target savings have been identified in the Supply Options chapter of this document, and are included in the allocation proposal.

Green - Initial Water Level; Yellow - Action Level; Red - Lowest Allowable Level; Pink - Trigger for Designation Proceedings; Dotted - Pump Level, Thick Blue - Low Water Level; Thin Blue - High Water Level

Forest Management and Watershed Protection

Over 65% of the recharge in the primary high level aquifer is attributable to fog drip (Hardy, CWRM, 1996). Forested watershed is critical to maintaining water availability on Lana‘i and yet the native forest on Lana‘ihale is diminishing.

The Lana‘i Water Advisory Committee deemed watershed protection important enough to warrant an entire section of the Water Use and Development Plan. Through several community meetings, a fence alignment and plan to protect the watershed were agreed upon. Other protective recommendations are delineated in the *Source Water Protection* chapter and in the *Implementation Matrix*.

Aside from protective measures identified in that chapter, several policy questions relating to watershed protection were raised in the course of Water Advisory Committee discussions.

Relationship of Forest Protection to Build-out of Entitlements

Continued protection of the watershed, and most particularly construction of Increment III of the Lana‘ihale Fence, were deemed of utmost importance. One way to ensure that such protection continues is to tie continued protection of the watershed forest, and /or specific protective measures, to entitlements. Due to uncertainties as to the timing of construction of Increment III, the enclosure for the best remaining native watershed on the island, it was decided that construction of this fence should be linked to allocation table triggers.

Provision for Forest Protection In Water Utility Rates

Statewide, many utilities have objected to a mandatory provision to address watershed protection in the rates. However, one of the primary reasons has been that drinking water utilities throughout most of the Hawai‘i are not the only, nor even the major users of water, and as such it seemed to be placing an unfair burden on utility customers. On Lana‘i, there are no such complications. All drink from the same source and that source is dependent on the forest. Therefore, the financing plan proposed included watershed protection, specifically construction of the Increment III Fence, deemed crucial to the viability of remaining native watershed.

Aquifer Monitoring and Protection

With a low sustainable yield, declining forest cover, declining water levels and an ambitious build-out proposal, several members of the LWAC expressed concern about extending the life of the aquifer. Such concerns gave rise to the concept of the allocation plan discussed earlier.

In addition to recommended limitations on withdrawals, LWAC members discussed the idea that an allocation plan should include triggers of actions to be taken when pumpage reached certain levels. For instance, total island-wide withdrawals should not exceed those modeled in scenario 6 of Hardy’s numerical groundwater model, without additional distribution of withdrawals or other actions.

The results of Hardy’s numerical groundwater model indicated that the 13 sources modeled should be able to yield 3.52 MGD from the aquifer, without severe water level declines. However, pumpage is currently distributed between only 6 or 7 sources (one source pumps only 2,000 GPD), and, as noted

elsewhere, water levels are declining. Some LWAC members have expressed some concerns about adequate distribution of withdrawals. The implementation chapter lists a schedule of near term, mid term and long term source improvements.

For the planning period, or until new sources can be brought on line to better distribute withdrawals, it is recommended that a minimum 10% resource reserve be maintained in each aquifer. This would enable pumpage impacts on the aquifer to be better evaluated before the full yield is utilized. This recommendation is consistent with other criteria used by the State, such as the criteria for designation of a groundwater management area in §13-171-7 of the State Water Code, which reads, "whether an increase in water use or authorized planned use may cause the maximum withdrawal from the groundwater source to reach ninety percent of the sustainable yield of the proposed water management area." It is also consistent with other CWRM actions, such as the 90% sustainable yield trigger that was set for Iao aquifer. This would limit pumped water to a total of 5.4 MGD, and water pumped from each aquifer to a total of 2.7 MGD during the planning period. A total of 600,000 gallons in resource reserve is included in the allocation plan. However, this amount does not affect other uses within the allocation plan, as each use was escalated separately with the planning time frame.

Key recommendations with regard to source development include:

- New source development should commence at or before the point total pumpage reaches 3 MGD (At current Well 6 pumping rates, this would be 2.7 MGD in the Leeward aquifer).
- Project build-out should take place at a pace that enables continued monitoring of the status of the aquifer and watershed.
- Build-out approvals should be contingent upon continued efforts to protect and preserve the watershed in Lana'ihale.
- Operational guidelines should be followed to avoid over-pumping and ensure adequate distribution of withdrawals.

Wellhead protection was also discussed. Protection of wellheads or potential future wellheads from potential contaminant sources is an important source protection measure. A wellhead protection strategy is presented in Chapter 6 of this document, as well as in Appendix F.

Operational Guidelines

Early LWAC discussions stressed the need for guideposts to help Committee members and water managers know when action must be taken to prevent over pumpage. Guidelines were proposed by CCR and reviewed by CWRM. These are described briefly in the *Source Water Protection* chapter. As stated above, it is recommended that these be followed.

System Monitoring & Maintenance

System monitoring and maintenance was at times a heated topic within the Lana'i Water Advisory Committee. The recommendations here are not strictly policy matters, but arise from the community's desire to have adequate information about the status and condition of the water system.

Maintenance

As demand for water and cost of electricity increase, maintenance will become increasingly important. Unaccounted-for water on Lana'i presents opportunities to provide for demand while still extending the life of the aquifer. Replacement of old degraded pipe, leak detection equipment, pipe repairs, annual unaccounted-for water analysis and other measures are recommended to provide for source availability as well as to save money and resources. These are described in the Supply Options chapter.

Metering and Monitoring

Metering and monitoring have improved in recent years. Previously unmetered uses are now metered, and other improvements have been made. However, LWAC members have raised concerns regarding the Periodic Water Report

Maui County Ordinance 2408 stipulated that the total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range, and other associated landscaping, shall not exceed an average of 650,000 gallons per day, expressed as a moving annualized average using 13-28 day periods rather than 12 calendar months, or such other reasonable method as may be determined by the Maui County Council upon advice from its standing committee on water use. This was likely written to enable the company at the time to continue its 28 day reporting without disruption. Since that time the question of monthly reporting has come up repeatedly. The pumpage record goes back to 1926. For most of that record, either reporting was in fact on a monthly basis, or whoever maintained the data at the State reconciled it back to a monthly basis. In any case, the majority of the available record is recorded on a monthly basis. The system of thirteen 28 day periods started in 1981, continued to 1986, stopped for a time, and then resumed from 1987 to the present. Depending on how this is accomplished, there are some advantages to reporting both pumpage and withdrawals on a monthly basis. Today's meters are capable of recording historical flows, such that the flow at any chosen period can be derived. Unaccounted-for water analysis now requires that billing and pumping records be broken down and re-apportioned to the number of days in a month or period, in order to ensure that pumping and billing are examined for the same period. If flows from the same periods were utilized, then this process would be streamlined. However, there appears to be some hesitancy to make this change, because of the outstanding ordinance.

Another issue raised with the Periodic Water Report has been the break down of water service areas. As discussed in the *Demand Analysis* chapter, the periodic water report has a service area subtotal called "Manele, Aoki Diversified, Agriculture and Ag Activities near the Airport." This was apparently intended to maintain consistent data breakdown, but more accurately re-name what was once simply called "Irrigation" (in the days of pineapple). Based upon today's uses and service areas, this breakdown makes little sense. In terms of pumped water, there are two public water systems on Lana'i, and essentially 5 service district areas, distinguished by sources and tanks serving them and by pressure zones. These are the Koele Project District Area, Lana'i City, Kaumalapau, the Palawai Irrigation Grid, and the Manele Project District Area. The Manele Project District Area is further broken into fresh and brackish service. It would seem that the reports could be clarified by distinguishing these areas. Another item repeatedly desired by the committee was a more discernible breakdown of what amount of brackish water goes to the golf course vs. other irrigation, and what amount of potable water goes to irrigation vs. other uses, most especially in Manele.

Current billing user types maintained in the LWCI data base are shown in Figure 7-13.

FIGURE 7-10. Use Types in Current CCR Database

R. Residential						
C-Commercial						
G-Government						
Z-Community Gardens						
L-Non Resorts (Central, Plantation Homes, Iwiole, Commercial Homes, etc.)						
P-Four Seasons						
V-Development						

A further breakdown of residential multi vs. single family use is provided for Manele and Koele in the district code, but no such breakdown is provided for Lana'i City. Current utility personnel are sufficiently familiar with the system to know which meters are which. The data system is clearly useful for internal accounting and operations, which would naturally be of highest concern to the utility. However, an additional field might be useful for auditing and reporting, as well as for rate-setting. Certain meters are classed in ways that are non-intuitive to an outsider - not incorrectly, but based as much on internal company operations as on the actual use class. For an outside analyst, or even an internal one, to go through and reclass each meter, even based upon personal familiarity with each, is a time consuming effort. For purposes of water audit, data reporting and other uses, it may be beneficial to add a field to the data base that breaks user classes out by more conventional use types. This could be done without any change to the primary breakdown and functioning of the database and may prove to be a useful option. It would be especially so, in fact maybe even necessary, if the proposed rate structure, or one like it, were established. Another value of such a change would be the ability to report more clearly on the status of build-out versus any agreed upon allocation. A more practical breakdown for planning purposes might be:

Single Family
Multi-Family
Commercial
Industrial
Hotel
Government
AgriculturalIrrigation
Other Irrigation

Rate Equity

While LWAC members had no objection to the use of desalinization as a major water source, some expressed concern that the expense of new source development to accommodate project district build-outs not burden the existing residents of Lana'i, or that long-time residents not have to experience fees raised to a level to accommodate build-out growth.

The rate and fee structures proposed in the Supply Options chapter are designed to keep rates low for low water users, and to encourage conservation by sending a pricing signal to high water users. New source would be paid for by new meters or by the company.

Conservation Measures and Milestones

The Lana'i Water Advisory Committee spent much time discussing high consumption rates per unit, system losses, unaccounted-for water, and the need for conservation. A few iterations of a draft conservation ordinance have also been presented to the LWAC. The most recent of these is attached as Appendix I. System wide unaccounted-for water in 2008 was roughly 28%, with about 13.5% in Lana'i City, 45% on the potable Manele / Palawai Irrigation Grid system, and 19% on the Brackish system. A target program was developed that included the following measures and targeted savings:

FIGURE 7-11. Targeted Conservation Savings

	Manele & Grid Fresh	Manele Brackish	Lanai City Koele & Kaumalapau	
Palawai Grid	200,000.0			200,000
Landscape	50,000.0	50,000.0	11,000.0	111,000
Fixture Replacement	20,000.0		80,000.0	100,000
Leak Detection & Repair	15,000.0	13,000.0	12,000.0	40,000
Hypalon Cover		14,000.0		14,000
Hotel & Landscape Incentives	12,000.0	6,000.0	2,000.0	20,000
Rate Structure				0

These measures may still fall short of achieving targeted unaccounted for water rates in one or more areas, particularly in the service area of Wells 1, 9 & 14. Additional reductions should be possible through additional landscape savings beyond the modest 10% prescribed or additional leak identification. Metering of previously unmetered services will also help to reduce UAFW, though it may not help to reduce pumpage.

Agricultural Reserve

There is strong conviction among certain community members that preservation of agricultural opportunities should not be lost. LWAC members expressed concern that build-out of the project proposals by CCR could preclude there being enough water for the planned Agricultural Park. Agricultural lands offer many benefits, including increased food security, and economic development opportunities. The recommended allocation plan includes a 500,000 GPD agricultural reserve, which is assumed to be actually withdrawn from the aquifer, as opposed to the resource reserve, which is not assumed to be pumped. Neither reserve affects water allocations to other uses within the planning time frame, as each class of use was escalated separately, and there was adequate water to cover uses and reserves based on the forecast coefficients used.

Issues Pertaining to Specific Supply Options

Selecting new source options always involves some trade-offs. Lana'i is no exception.

Several good Leeward locations have been identified for new source, but at some point, these will start to provide only distribution of withdrawals, rather than additional source.

Development of a windward well is recommended, but this is not without challenges either. On the windward side, whether Maunalei or Kehewai are chosen, the transmission route will be long and expensive. The transmission route to Kehewai was designed in such a way to avoid damage to crucial habitat.

On the other hand, both the Maunalei and Kauiki options are in the greater ahupua'a of Maunalei. During the Mahele of 1848, 19 individuals made 20 claims for property rights in the ahupua'a of Maunalei. The entire ahupuaa was granted to Pane Kekelaokalani, a chiefly awardee (who filed two separate claims). At the close of the Mahele in 1855, at least 11 commoners claims were also granted. The clustering of kuleana lands deep in the valley of Maunalei include the claims for lo`i kalo (taro pond fields) and the associated water rights as protected by the Kuleana Act of 1850. At the time of this writing, it is unclear if any native claims remain to kuleana lands and water resources in Maunalei. It is noted that company maps dating from 1929 to 1993 still identify possible lots in the valley to which such water rights might appertain. It is suggested that a definitive study on the native tenant rights and disposition of land ownership be determined prior to final settling of water usage in Maunalei.

Desalinization is still expensive, and proper disposal of brines can prove difficult. CCR will need to accommodate the fact that marine waters surrounding Lana'i are Classed AA under HAR §11-54-3. The objective of Class AA waters is that they remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused sources or actions. To the extent practicable, the wilderness character of these areas must be protected. No zones of mixing are permitted in this class.

Community Plan Consistency

The Maui County Charter, §8-11.2(3) requires that the Water Department's Long Range Plan conform with the County's general and community plans. The last version of the Lana`i Community Plan was adopted by the Maui County Council on December 8th, 1998. An update of the plan is expected shortly, However, some of the goals, objectives, policies and implementing actions that pertain to water issues within the old plan are attached as an Appendix J, with comments as to how this WUDP addresses those items.

CHAPTER 8

Implementation

The Matrix below identifies a categorized list of impelementing actions that could further the intent of the Lana‘i Water Use and Development Plan

Abbreviations used in the Implemenation Matrix are as follows:

CCR	Castle & Cooke Resorts, LLC.
DOE	Department of Education
DOFAW	DLNR - Division of Forestry and Wildlife
DOT	State Department of Transportation
DWS	Department of Water Supply
LF&WP	Lana‘i Forest and Watershed Partnership
LWAC	Lana‘i Water Advisory Committee
LWCI	Lana‘i Water Company Inc
MCC	Maui Community College
USDA	United States Department of Agriculture
US F&WS	United States Fish & Wildlife Service

FIGURE 8-1. Implementation Matrix

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
I. INFRASTRUCTUREMAINTENANCE, OPTIMIZATION & SUPPLY-SIDE MANAGEMENT STEPS			
	Develop or update storage inventory. Size, volume, geometry, age, materials, condition, fill cycle issues, leaks, estimated remaining useful life, potable or reclaimed, service zones, controls and call levels, inside lining, existing maintenance schedules, etc.	LWCI	Annual Update
	Evaluate costs and create or update ongoing tank and reservoir refurbishment schedule -annual, 5 year, Longer. 5 year storage CIP.	LWCI	Annual Update
	Develop or Update Pump Facilities Inventory. Model, Speed, Rated Head, Motor HP, Performance against manufacturers curves (efficiency), Control Configurations, Well or Booster, On-Off calls, Chemical Feeds (chlorine, corrosion control, other), Backup Power source, land use for source pumps, chlorides, water level fluctuations, etc. Last Replacement, Next scheduled maintenance, etc.	LWCI	Annual Update
	Compile 5 year pump maintenance & replacement schedule, including updated pump efficiency curves and calibrated efficiencies.	LWCI	Annual Update.
	Develop and /or update inventory of transmission and distribution lines in the system; from and to points, diameter, material, install dates, leakage or breakage problems, pressure and flow status, etc. leak or breakage history, etc.	LWCI	Near. Ongoing.
	Identify replacement and upgrade priorities for line repair and replacement and compile 5 year schedule	LWCI	Regular Updates

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Implement hydrant maintenance program: operate, flush periodically, check drain rate, lubricate when needed, check, pressure, replace older hydrants as needed	LWCI	Annual Update.
	Perform or maintain similar inventory and maintenance schedule development for all system elements as well: valves, meters, treatment facilities, generators, etc.	LWCI	Annual Update
	Acquire leak detection equipment and or borrow/ rent same. Perform& document regular leak detection on system.	LWCI	Near
	Perform annual unaccounted-for water audit.	LWCI / Possibly help from DWS.	Near
II. INFRASTRUCTURE & CAPITAL & MAINTENANCE PROJECTS			
	Replace Deteriorated Palawai Grid Pipeline	LWCI	Near
	Install Floating or Hypalon Ball Cover on 15 MG Brackish Reservoir	LWCI	Near
	Replace old asbestos segments in Lana‘i City	LWCI	Near to Mid
	Replace deteriorated Hi‘i Tank and 50 year old concrete lined Hi‘i Reservoir with new 2 MG Tank	LWCI	Near to Mid
	Replace Old Substandard Pipeline to Kaumalapau	LWCI	Mid
	Replace Old Steel Line Segments in Lana‘i City	LWCI	Mid
	Drill Well 15 to distribute brackish withdrawals	LWCI	Near term
	Replace Well 2-A to increase ease of operability and for better reliability.	LWCI	Near to Mid

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Replace Well 3 or drill new well that will serve same purpose for improved reliability and distribution of withdrawals.	LWCI / LHI	Near Term
	Replace Old Line Segments in Northwest End of Irrigation Grid	LWCI	Mid-Long
	Improve pump system to reclaimed reservoir especially around lower 9 at Koele. (can't pump out of reservoir as needed)	CCR	Mid
	Evaluate possible improvements to reclaimed water treatment facility and storage. Make any necessary improvements	CCR	Mid to Long
	Install additional wells for distribution to prevent declining water levels or over-use of either aquifer. Options identified in Chap 5.	LHI	Near, Mid & Ongoing
III. DEMAND-SIDE MANAGEMENT STEPS			
	Retrofit indoor fixtures including but not limited to 1.28 GPF toilets, showerheads, faucets, efficient clothes washers.	LWCI	Replacement in Proposed rate structure. Near to Mid term.
	Implement water conservation measures aimed at reducing outdoor usage (Conservation measures are more cost effective the earlier they get done.)	CCR; LWAC	Near and Ongoing
	Establish additional ET/weather stations for improved drought prediction, fire prevention and conservation.	LWCI, CCR, DLNR	Some existing. Additions Near and Mid.
	Review & update design guidelines and plant list	CCR; Planning Dept.	Near to Mid term
	Support establishment of certification program, and of certified source of native stock to protect existing communities of appropriate plants	CCR LWCI;	As Appropriate

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Identify and map areas where turf or other high-water-use plants are featured, and prioritizing them for retrofit - i.e. seeking places that can be converted to less thirsty plants.	CCR; Hotels, LWCI,	Near to Mid term included in rates
	Maintain and expand native plant nurseries; possibly with grant funding assistance -also establish or help other "certified" nurseries - as may be established, for example by Hui Malama, MCC or others.	CCR, LFWSP, DLNR, FWS	Increase focus on native & drought-tolerant non-invasive plants. Near to Mid term.
	Annually examine "per-unit" water use information; by customer class, location, size of meter, end uses; etc. Develop targets for reduction.	CCR;	Near to Long
	Develop tiered rate structure to encourage conservation, leave rates low for base "life-line" amount; increased rates for excessive use.	LWCI, LHI, CCR, PUC, Public	Proposed in Plan, PUC case in Near term.
	Revisit and consider conservation ordinance; including county-wide public review;	LWAC, LWCI, Public, Council	Near to Mid term
	Offer incentives and assistance to local hotels and businesses. Assist with pre-rinse spray nozzles, incentives for cooling efficiency improvements, efficient laundries, and other measures mentioned in Chapter 5.	LWCI	Included in proposed rate structure. Near to Mid term.
IV. WATER CONSERVATION OUTREACH & EDUCATION			
	Develop a "walking tour" of native/demonstration landscapes: identifying projects that have been well-landscaped with native plants;	Cultural Center, Conservation Dept., Community Groups, possibly Hotels, Schools	Mid

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Partner with other Community Resources to provide well-rounded education and outreach for landscape and other conservation opportunities.	Conservation, Cultural Center, MCC, Hui Malama and others.	Near Term and Ongoing
	For new developments, utilize native or non-invasive non-native plants to the maximum extent possible in landscaping	CCR other developers incl. government	Near, Mid and Long, Ongoing
	Re-plant selected hotel properties with native plants - secondary to restoring natives on the hale	CCR; Hotels, LWCI assistance program, Conservation Dept., help from Community Groups & Cultural Center as applicable.	Near to Mid and Long term. (should commence near term, and continue).
	Demonstration projects: community gardens, plantings etc. establish demonstration gardens at various sites. Note that the last community plan also stated that this be should done at government sites.	CCR; Conservation Dept., DOE County/State govt., Cultural Center, Community Groups as applicable.	Near and continuing
	Establish set of qualified speakers on various conservation topics. Visit schools & community groups, offer classes.	LWCI; CCR, MCC, Conservation Dept. Partner with others as applicable.	Near
	Conservation ads in Lana‘i newspaper(s).	LWCI, CCR, Other co-sponsors as available.	Near

Implementation Matrix

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Ads for radio, movie screen, other venues	LWCI, DWS	Near. DWS has Many Ads, can share.
	Ads for movie-screen	DWS; CCR	Optional
	Posters	DWS; CCR	Mid
	Information on and periodic distribution of appropriate plant types	CCR, BWS	ongoing arbor day upgrade with nursery Near to Mid & ongoing
	Maintain list of appropriate plant species. Review and update Urban Design Guidelines accordingly.	DWS; Planning Department; DLNR, HEAR Lana`i Planning Commission	Ongoing. Needs improvement. Near
V. SOURCE WATER PROTECTION			
	Conduct additional fog drip studies in order to refine recharge estimates. Update Lana`i Water Model accordingly.	CWRM; UH; USGS; CCR, DWS?	Study on Cooke Pine throughfall completed. No review of native forest.
	Adopt the well operating management guidelines in the plan; monitor performance against same.	CWRM, LWCI CCR	Included in Plan. Implementation Near, Mid & Long.
	Draft wellhead protection strategy and ordinance discussed with LWAC, needs broader community presentation and discussion.	DWS, LWCI, CCR, Public	Near
	Distribute withdrawals such that no more than 2.7 MGD each are pumped from Leeward and Windward Aquifers during plan period.	LWCI, LHI	Near to Long Term

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Establish an ongoing watershed management program with special emphasis on preserving native ecosystems and maximizing the fog drip component of the watershed	LFWP, DWS, US F&WS, DOFAW, County CCR, CWRM, NRCS,	Ongoing Long-term
	Continue to Identify Potential Sources of Funding, Including Appropriations, Assessments, Contributions, Grants, Donations from Public and Private Sources, and Recommend Funding Sources	CCR Conservation, LF&WP	Near term and Ongoing
FENCING			
	Monitor the integrity of existing fences	CCR, LF&WP, USF&WS	Ongoing and Near
	Select appropriate fence materials for new fences or fence segment replacements, such as triple dip galvanized with welded seams, treated against corrosion, alloy, even plastic fence, consider fence materials researched at Kalaupapa, consider increase in height or visual barrier to deter deer	CCR; LF&WP, USF&W	Increment 1 Completed Increment II in Progress Increment III still pending.
	Ground and aerial survey of new Increment III alignment & surrounding areas; set proper alignment vis a vis terrain and rare species communities; survey area to insure that populations of important snail, insect or plant species are not disturbed, or that such disturbance is minimal & mitigated	CCR; LF&WP, USF&W	Increment I completed Increment II Near Increment III Near.
	Resolve access issues. Additional gates needed. Gates at Hi‘i Bench, East and West Hauola. Koolanai and Waiwaiku need gates. Vandalism could lead to more animals in Hale.	CCR; Community	Mid Term.

Goal	Action Item	Key Parties	Time Frame Near Term Mid term Long Term or Ongoing
	Maintain fence regularly	CCR Conservation, with help from other forest partnerships as needed.	Mid to ongoing
	Maintain buffer zones around fence	CCR	Mid to ongoing
FERAL UNGULATE MANAGEMENT			
	Inside Fence		
	Herding effort to move deer out of each new increment of fenced area - foot, helicopter, etc.	CCR, DOFAW	Increment I - Done. Increment II - Near Increment III Near.
	Allow residents to hunt within fence first - ongoing staffed hunts if needed	CCR, DOFAW	Increment I - Done Increment II - Near Increment III - Near to Mid
	Hunting to elimination within fence for protection of watershed,	CCR, DOFAW, LFWP, Community	Mid to ongoing
	IF NECESSARY - Aerial hunts, spotlighting, snares, or traps if necessary in designated elimination areas -esp. remote areas, or where animal numbers are not dropping	CCR, DLNR	last resort only
	Outside Fence		
	Manage populations outside of fence	CCR, DLNR	Near term & continuing
	Investigate use of repellents, non-forage distasteful plants, other methods along buffer strip / corridor on outside of fence to discourage deer from approaching or trying fence	DLNR, USF&WS, CCR Conservation	Mid to Long

	Implementation		
	Continue to investigate other "non-kill" options that may be used with hunting: catch & transport; repellents, sterilizers, habitat alteration, etc.	DLNR, USF&WS CCR Conservation	Mid & continuing
	Provide training or review, as appropriate and necessary for certified volunteer hunters.	DLNR - license CCR - forest entry etc.	ongoing & continue
	Improve harvest reporting protocols and data. Harvest report should go to one central repository, such as DLNR-DOFAW	DLNR, Hunter Advisory Group, CCR	Near
OTHER ANIMAL MANAGEMENT			
RODENTS			
	Survey area to determine priority locations for treatments highly susceptible plant, bird or snail communities signs of excessive rodent activity	DLNR, USF&WS; LF&WP, CCR	Ongoing DLNR Conservation as needed
	Determine appropriate treatment schedule all year, or at least during fruiting/seeding of target native plants?	DLNR, USF&WS; LF&WP, CCR	As appropriate
	Eliminate rodents using traps, bait, other methods	DLNR, USF&WS; LF&WP; CCR	As needed
	Perform follow-up documentation and monitoring to evaluate usefulness	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed
INSECTS			
	Survey as needed to determine priority pests for removal based on threat to remaining target communities: mosquitoes, chinese rose beetle, chinese leaf hopper, others	DLNR, USF&WS; LF&WP; CCR	Mid & continue
	Research other removal experience with target insect pests determine protocols, spraying, equip needed, etc.	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed

	Implement removal protocols	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed
	Perform follow-up documentation and monitoring to evaluate usefulness	DLNR, USF&WS; LF&WP; CCR	Mid & continue as needed

FIRE PROTECTION

	This is especially. important on Lana`ihale, since the native Hale plants are not well adapted to fire. Efforts should also address management of surrounding lands, including those taken out of pineapple.		
	Consult with other fire management agencies to review existing fire plan as related to Lana‘i Hale protection.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid
	Survey plant communities in pristine areas, fire prone areas	CCR	Mid
	Map & prioritize fire prone areas.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid
	Inventory response crews, response times, etc.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid
	Inventory/ obtain as needed emergency equip (helicopters/strategically placed reservoirs, water trucks, etc.)	DLNR, Fire Dept.; CCR	ongoing? re-evaluate? Near to Mid?
	Develop improved access as necessary (careful not to spread weeds).	DLNR, Fire Dept.; CCR	Mid
	Develop and conduct regular training, and/or joint training programs for fire fighting crews.	DLNR, Fire Dept.; CCR	ongoing & continue? or Mid?
	Review and update prioritized response plan as appropriate.	DLNR, Fire Dept.; CCR	ongoing, re-evaluate Near to Mid

	Implementation		
	Construct fire breaks or buffer zones as appropriate	CCR	Mid to Long
	Remove/ eradicate fire-inducing or fire-carrying weed species, especially in areas where small populations mean that a single catastrophic fire could eliminate the entire remaining population of a species. (Ex. Tetramolopium remyi)	CCR	Mid to Long
	Establish "fire-free" use zones	CCR	Mid to Long
	Heighten public awareness of dangers	CCR	Mid

REMOVAL OF NON-DESIRABLE PLANT SPECIES

	Survey area to locate and prioritize weeds for removal, based on aggressiveness of weed species; extent of spread; proximity to rare species; etc. - (ex.guava, eucalyptus, christmas berry, ironwood)	LF&WP; CCR; DLNR	Mid (after fence Phase I completion)
	Remove target weeds from selected areas by hand or mechanical removal; possibly with selective use of herbicides or bio-controls where appropriate	LF&WP; CCR; DLNR	Mid (after fence Phase I completion) to Long & continue
	Follow/up to remove re-germination	LF&WP; CCR; DLNR	Mid to Long and continue

PROTECTION FROM PATHOGENS, DISEASES

	Identify pathogens of concern to Lana`i watershed species communities. Possible examples include but are not limited to: _"Spike disease"- harmful to sandalwoods in India, believed to be in HI _Santalum seed fungus - destructive to viability of seeds (sandalwood) _Santalum heart rot _Others~~?~~	LF&WP; DLNR US F&W	Mid to Long term and continue

	inventory disease problems affecting key species, known management strategies	LF&WP; CCR; DLNR	Long
	enhance quarantine & inspection to prevent further introduction	LF&WP; CCR; DLNR, DOT	Long
	implement treatment options where identified	LF&WP; CCR; DLNR	Long

EROSION MANAGEMENT & REFORESTATION

	Survey & select realistic / effective areas for management	CCR; LF&WP	Mid & continue
	Eliminate animal stresses that perpetuate erosion cycle	CCR; LF&WP	Mid & continue
	Strategic planting	CCR; LF&WP	Mid & continue
	Mycorrhizal inoculants can aid the establishment of outplanted seeds (down side?)	CCR; LF&WP	Mid to Long as appropriate
	Wattles and other soil trapping devices. silt basins?	CCR; LF&WP	Long
	Establish native plants on newly trapped soil	CCR; LF&WP	Long
	Outplant species grown ex situ.	CCR; LF&WP	Mid
	Seed broadcast	CCR; LF&WP	Mid to Long as appropriate

	Perform complimentary actions aimed at restoration of native populations of insects, forest birds, sea birds, snails, etc. These will also help to restore and improve the nutrient cycle of the soil, healthy litter layer, etc. For example, Snails and insects provided important quantities of biomass & nutrients; Sea-birds provided nutrients such as nitrogen, phosphorous, etc. Insects helped to break down fallen trees, aided in decomposition and soil amendment. and provided biomass. restoration of these populations will also improve the health of the soil.		
MONITORING AND EVALUATION			
	Establish & Maintain Monitoring Transects Using Standard Accepted Methodologies (point-line intercept or etc.)	CCR; with help from LF&WP	Mid to Long as appropriate
	Collect Data on Soils, Stream Flows, Rainfall & Other parameters	CCR; with help from LF&WP	Long & continue as appropriate
	Perform aerial and field survey, photography and mapping to inventory and characterize resource health	CCR; with help from LF&WP	ongoing & continue periodically
	Monitor, map and inventory on a regular basis to keep track of changes in plant communities, animal communities, ungulate activity, erosion, etc.	CCR; with help from LF&WP	Mid to Long & continue
	Survey and map major communities, threats, measures	CCR; with help from LF&WP	Mid to Long & continue
	Map monitoring plots, size and class of plants inside (desirable and non-desirable)	CCR	Mid to Long & continue
	Perform scheduled field checks	CCR	Mid & continue
	Perform additional checks after unusual events, catastrophes, etc.	CCR	Mid & continue
	Photo plots - especially plant communities - to monitor recovery / loss	CCR	Mid for baseline & continue

	Water / soil gauges other special equipment for monitoring fog drip, etc.	CCR, LHFWP DLNR/ CWRM, USGS. UH	Mid to Long
	Provide report of quantitative and qualitative data w/ photos and maps	CCR	Mid for base-line & continue

	Implementation		

CONTROL OF INCOMING SPECIES

	Adequate screening and quarantine for incoming agricultural goods and plants	DOT, DLNR, USDA; CCR	Long
	Education of public / landowners on dangers of bringing in exotic species, potential contaminants	LF&WP; CCR; DLNR, DOT, USDA	Mid to Long
	Set up procedures to avoid introduction of non-desirable plants OR plant pathogens	LF&WP; USDA CCR; DLNR, DOT	Long
	Set up procedures to avoid introduction of non-desirable insects or insect pathogens	LF&WP; CCR; DLNR, DOT	Long

PROTECTION FROM HUMAN ACTIVITY

	Protect species prone to gathering by humans. For example, Sandal-wood has been subject to removal by individuals seeking the heart wood, due to its high economic value.	CCR LFF	Long
	Develop and enforce protective measures: no collection of special species limit forest entry in selected areas such as exclosures, etc. proper forest entry practices, maintain a regulatory presence in the watershed, post signs for limited entry or special access concerns manage public activities and education interagency cooperation for these	CCR with help from members of LF&WP	Long
	Develop a recreational use plan for human activities in the watershed	CCR with help from members of LF&WP	Long

	Insure that existing protections are followed, and continue to evaluate the need for and support additional measures as appropriate Existing Legal & Regulatory Protections include the following: "It is illegal to remove, cut dig up, damage or destroy an endangered plant in areas not under Federal jurisdiction in knowing violation of any State law or regulation or in the course of any violation of a State criminal trespass law. (ESA §9(a)(2)) Hawaii State Law prohibits taking of endangered flora and encourages conservation by State government agencies. "Take" means to harass, harm, collect, uproot, destroy, injure or possess endangered species of land plants, or to attempt to engage in any such conduct (HRS 195D-5(d))	CCR with help from members of LF&WP DLNR	Long

	Implementation		
PEER REVIEW MANAGEMENT PLANS & IMPLEMENTATION TO AVOID MANAGEMENT ERRORS			
	Establish a regular system of inter-agency review to help avoid and /or correct errors such as the following: fencing without adequate monitoring, fencing without weed removal over-collection of seeds damage or spread of pathogens by incorrect collection of tissue cultures, careless management on part of humans (human trampling, unmonitored actions, etc.)	LF&WP	ongoing and continue
MANAGEMENT RECOMMENDATIONS TO PRESERVE NATIVE BIRDS Benefits of protecting remaining bird species and possibly restoring bird populations: Birds serve(d) various beneficial functions in the watershed, including: direct pollination of native plant species seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces) source of nutrients (esp from sea-bird feces) possible additional non-identified roles, as birds were integral part of ecosystem rare native plants may benefit from having native birds that served to pollinate and spread seeds restored. nutrient cycles, as affected by seabirds may effect soil and plant health by returning nutrients to soil			
	Protect habitat - including steps to preserve plant communities, snails, insects, etc.	CCR with help from members of LF&WP	ongoing as part of other plan elements.
	Prevent predator entry - fencing (*fencing will not keep out chief bird predators, but may reduce spread of weeds that attract them, reduce disruption of habitat, etc.*) adequate quarantine baiting predators	; LF&WP CCR	 fence ongoing quarantine, Long term baiting, Long term
	Remove rats and cats from native bird habitats - catch, bait, etc.	CCR; LF&WP	Long

	Prevent entry of non-native birds - (avoid disease, competition)	CCR; DLNR, DOT	Long
	Prevent entry of mosquitoes and other problem insects	CCR; DLNR; DOAg; DOT	Long
	Control mosquitoes at breeding sites - insecticides, sterilizers, introduction of sterile or non-carrier mosquitoes	CCR; DLNR, Dof Ag; DOT	Long
	Specific strategic management of existing seabird colonies for enhanced protection	CCR; DLNR, DOT	Long
	Appropriate adjustments to fencing, such as flagging or etc. Fence must be visible to prevent birds from crashing during night landing. white flagging on top can help.	CCR; LFWP DLNR	Mid to Long
	Intensive rat & cat control	CCR; DLNR,	Long
	Consider carefully managed re-introduction programs for amakihi, i`iwi, maui creeper, others	CCR; DLNR, USF&WS	Long
	Preserve Lana`i specific genetic material.	CCR; DLNR, Bishop, NTBG, USF&WS	ongoing, continue and Long
	Consider minimum habitat size for sustainability of bird populations in deciding on deer fence option	CCR; DLNR, USF&WS	Mid to Long with Phases II and III
	Encourage sea birds to return by establishing safe, predator-free sites for them	CCR; DLNR, USF&WS	Long - as part of general plan elements

	In order to successfully maintain existing apapane and seabird populations, and /or to restore previously existing species with close approximations (Maui equivalents) - adequate disease free habitat extent will be required.		
MANAGEMENT RECOMMENDATIONS TO PRESERVE NATIVE SNAILS			
	Preserve habitat, esp. upper elevation wet forest.	CCR with help from members of LF&WP	ongoing as part of other plan elements.
	Encourage reforestation with native species. Many non-natives, including Cook Pines and Eucalyptus, are not good hosts for native snails...(although snails have been found on some non-native plants where they are intermixed with natives).	CCR with help from members of LF&WP	ongoing as part of other plan elements Cook Pine area will be preserved, but extent of Cook Pine area will not be extended
	Enforce ban on collecting	CCR w/ LF&WP members	Long
	Educate public on damage caused by collecting	CCR w/ LF&WP members	Long
	Eliminate rat predation *(see also rodent control section)*	CCR w/ LF&WP members	Long
	Eliminate predatory snails, if applicable	CCR w/ LF&WP members	Long

	Prevent entry of non-native snails & slugs to avoid possible intro of diseases. CARE MUST BE EXERCISED in designing control of slugs. poisons designed to eliminate slugs would also be likely to affect snails. Slugs don't generally hurt snails, but there are no native slugs in Hawaii, and there is some chance that they could be a source of introduced disease, competition or habitat loss. slugs do appear to damage certain native plants If any poison or bait were used to control snails, it should be limited to extremely LOCAL applications in areas where it was fairly certain no native snails were present.	CCR w/ LF&WP members	Long
	Captive rearing and reintroduction as appropriate	DLNR, Bishop, USF&WS,	Long
	Construct and maintain exclosures for snails There are various means of constructing snail exclosures. one example is described here, but the design would be selected by the UH, USF&WS, DLNR or others as appropriate. this exclosure is roughly waist high. they are constructed of painted, corrugated aluminum roofing. a trench is dug, and in that trench the fence is installed with its foot buried about 6" into the ground, at the top of the fence is a shed-like "roof" that protrudes to either side. under that "roof" are two additional barriers, a trough of large crystal salt, and a 2-wire electric fence, constructed of two thin wires spaced 8mm apart. The electric wires are powered by solar panels mounted on the inside of the exclosure. the largest such exclosure currently existing is about 40x25 meters. Rat bait boxes may be placed on the outside of the exclosures for further protection. Tree limbs and other branches should be prevented from touching the fence exclosure structure, as they may provide a path for predators.	DLNR, Bishop, USF&WS, UH, others	Long
	Consider careful removal of non-native plant species where appropriate, and replacement with native species. (again, this measure requires exercise of care to insure that no snails are sitting on the plants to be removed)	CCR with help from members of LF&WP	ongoing

	In cases where native snails seem to be adapting to introduced plants, selective use of these non-native plants may be considered. Snails that seem to be exhibiting adaptation according to Severns (conversation) include: Partulina variabilis, and Partulina semicarinata		
MANAGEMENT RECOMMENDATIONS TO PRESERVE NATIVE INSECTS			
	Protect native habitat on which native insects rely, especially host plants	CCR with help from members of LF&WP	ongoing as part of other plan elements.
	Eliminate non-native predator insects, especially yellow-jackets and ants. Possible methods include: pheromone traps; find and destroy nests with freezing or insecticides; bait as appropriate	CCR w/ LF&WP members	Long
	Develop improved quarantine measures and other controls to prevent entry of non-native insects	CCR; DLNR, Dof Ag; DOT	Long
	Monitor native insect populations to determine species requirements, critical habitat, population size, etc.	CCR; DLNR, USF&WS, others	Long
COLLECTION AND MAINTENANCE OF GENETIC MATERIAL			
	Inventory existing ex-situ populations & identify needs for more, if any	CCR; DLNR, USF&WS, others	Mid to Long
	Involve experts in collection of seeds, live plants, plant tissue	DLNR, Bishop, USF&WS, UH, others	Long
	Maintain ex-situ seeds, live plants, plant tissue, plant populations	DLNR, Bishop, USF&WS, UH, others	Long

	Note: Ex situ collections must be managed with care to avoid in-breeding, collection of genetically weakened specimens, cross-contamination of genetic material with other variations of the species Should be handled by outside experts such as NTBG, Bishop Museum, University, or other qualified organizations.		

SELECTIVE AUGMENTATION / RE-INTRODUCTION OF SPECIES

	See cautions above. It is important that such projects be carried out with close attention to proper collection and identification of appropriate seed sources, as well as care to avoid contamination in nurseries, germination media, plant materials		
	Identify priorities for restoration efforts. Rare species, important species, etc. Restoration of certain plant, bird and insect species may help to restore and improve pollination opportunities. plants provided food for birds and insects, forest birds and insects provided important pollinators. Restoration of these components will help support a healthy ecosystem.	DLNR, Bishop, USF&WS, UH, others	Mid to Long
	Identify appropriate sources (seed collection, ex-situ collections, etc.)	DLNR, Bishop, USF&WS, UH, others	Long
	Identify and obtain necessary equipment	DLNR, Bishop, USF&WS, UH, others	Long
	Survey and prepare out-planting sites	CCR w / DLNR, LFWP Bishop, USF&WS, UH, others	Long
	Protect, monitor and maintain out-plantings. (consider smaller exclosures)	CCR w / DLNR, LFWP Bishop, USF&WS, UH, others	Long

Implementation

PREVENTION & EARLY DETECTION

	Through wind dispersion and other means, plants introduced in only a few sites well outside the watershed can and do spread to the watershed. Through active identification efforts, plants may be detected at earlier stages of naturalization, or even prior to naturalization, avoiding widespread damage.		
	Develop a database of cultivated and naturalized non-native species on the island of Lana`i through survey of nurseries, botanical gardens, parks, hotel and other public landscape and other likely introduction sites.	CCR w / DLNR, LF&WP DOT	Long
	Cross check data on naturalized species in Lana'i with databases of historically invasive plants in similar climates elsewhere. The best predictor of invasiveness for most taxonomic groups is a record of invasiveness in similar climates elsewhere in the world. Cross-checking these lists may help to identify species of concern.	CCR w / DLNR, LF&WP DOT	Long
	Develop and/or refer to existing species reports for targeted species, summarizing both literature and field research, and include results from gps data collection and distributional mapping, as well as information on attributes of other invaded ecosystems, control data, and so forth. A potential protocol for obtaining and structuring such information has been developed and implemented in Maui.	CCR w / DLNR, LF&WP DOT	Long
	Monitor likely routes of introduction, such as roadsides, parks, refuse sites, vacant lots, harbors, airports and residential areas for new communities of potentially invasive species. Many of the key corridors by which invasive alien species are introduced are not the same areas where active management transects are located.	CCR w / DLNR, LF&WP DOT	Long

	ADDITIONAL RESEARCH ON TARGETED PLANT COMMUNITIES **The following have been identified as research items which may help the project over the Longer term. This research may not be performed as part of Lana'ihale management. However, funding of such research would be consistent with WUDP watershed goals.**		
	Associated ecosystem components	DLNR, Bishop, USF&WS, UH, others?	Long
	Relations between native plant communities / birds / insects (pollination, feeding, etc.)	DLNR, Bishop, USF&WS, UH, others	Long
	Critical habitat size / population size for species viability	DLNR, Bishop, USF&WS, UH, others	Long
	Growth and mortality at various stages of plant life, seasonal changes	DLNR, Bishop, USF&WS, UH, others	Long
	Optimum conditions for reproductive vitality, flowering/seeding conditions	DLNR, Bishop, USF&WS, UH, others	Long
	Light requirements at various stages of life	DLNR, Bishop, USF&WS, UH, others	Long
	Water, soil & nutrient requirements at various stages	DLNR, Bishop, USF&WS, UH, others	Long

Implementation

	Pollination vectors, seed dispersal	DLNR, Bishop, USF&WS, UH, others	Long
	Means to compensate for missing pollination vectors or other key-stone habitat concerns	DLNR, Bishop, USF&WS, UH, others	Long
	Minimum numbers needed for populations to be stable susceptibility to inbreeding	DLNR, Bishop, USF&WS, UH, others	Long
EDUCATION AND COMMUNITY OUTREACH			
	Rare plants and their value Importance of watershed / importance of biodiversity Non-desirable plants and the threats posed by them How to enter forest / other areas while causing minimal risk of doing harm Dangers of open flames, esp. in certain areas Plant walks outside critical areas Deer impacts to environment / water resource Importance of watershed / biodiversity Plants of concern Appropriate forest entry practices	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Create pool of docents Field volunteer training Recruiting Reporting	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Workshop and lecture series Uses of plants in native culture Value of native resources Importance of watershed and connection with native vegetation Plant, animal and bird identification Threats & Long term effects of unabated threats (Rapa Nui lesson)	CCR w / DLNR, LF&WP members	Near & continuing upgrade

	Solicit community input and contributions to educational efforts Link w/ other environmental agencies / develop partnerships	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Develop guided hike program / field trips to biological and cultural sites Trained docents as leaders Prepared informational materials Vehicles and logistical support	CCR w / DLNR, LF&WP members	Long
	Prepare interpretive materials for use in both community and by visitors Booklets, pamphlets Web sites Public access programs	CCR w / DLNR, LF&WP members	Mid & continuing upgrade
	Identify and implement volunteer projects Weed control Restoration activities - outplanting, nursery, maintenance, erosion control Fence building and repair Hunting	CCR w / DLNR, LF&WP members	Mid to Long
	Develop native resources curriculum for the schools	CCR w / DLNR, LF&WP members	Near & continuing upgrade
	Develop and implement Long-term alien species awareness and prevention program Seek grant funding to develop a video Develop a tie-in with the local business community	CCR w / DLNR, LF&WP members	Long
	Establish media contacts for coverage of projects both local and statewide dissemination Regular means of communicating relevant information to the community	CCR w / DLNR, LF&WP members	as appropriate

Implementation

	Utilize existing community special events as venue for promoting education and increasing viability of projects: Aloha Festival Health Fairs Pineapple Festival Other Cultural Events	CCR w / DLNR, LF&WP members	Long
	Provide update on status of watershed and protection activities to LWAC and or to the Lana‘i Planning Commission twice per year.	CCR Con-servation	Near and Ongoing

February 25, 2011 DWS Amended Draft

LANA‘I ISLAND WATER USE & DEVELOPMENT PLAN

APPENDICES

Appendices

APPENDIX A

Final Report of the Lana'i Water Working Group

The *Final Report of the Lana'i Water Working Group*, also known as the *1997 Draft Water Use & Development Plan for Lana'i* is attached and incorporated in its entirety.

DRAFT
WATER USE
AND
DEVELOPMENT PLAN
FOR
LANA'I

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February 1997

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The Group also expresses its appreciation to Ms. Rae Loui, Deputy Director, Commission on Water Resource Management for the assistance and encouragement given to the group to pursue the work for updating the Water Use and Development Plan for Lana 'i.

DRAFT
2/10/97

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List of Acronyms

BWS	Board of Water Supply, County of Maui
CWRM	Commission on Water Resource Management, State of Hawaii
DHHL	Department of Hawaiian Home Lands, State of Hawaii
DOA	Department of Agriculture, State of Hawaii
ET	Evapotranspiration
LCI	Lana'i Company, Inc.
LEGS	Lanaians for Economic Growth and Stability
LSG	Lanaians for Sensible Growth
LWG	Lana'i Water Working Group. Includes LWS members and additional members from the community. Members are listed as authors of this report.
LWS	Lana'i Water Subcommittee. First established by Council Resolution 93-42, May 7, 1993.
MG/L, mg/l	Milligrams per liter. In water supply, this is equivalent to ppm, parts per million.
MGD, mgd	Million Gallons per Day
MSL	Mean sea level. Reference point used for groundwater levels.
SFR	Single Family Residential. Term used in county zoning actions.
USGS	United States Geological Survey, Department of Interior
VWOMG	Voluntary Well Operating Management Guideline. Part of the procedures proposed by Lana'i Company to monitor performance of groundwater aquifer.
WUDP	Water Use and Development Plan. Part of the State Water Code.

Introduction

Lana'i has been in transition from pineapple to resort economy for several years. The demographics and land use pattern of the island have been changing. While actual use has declined in the short term, the projected water demand for the resort economy exceeds what was experienced in the pineapple economy. Lana'i's officially recognized sustainable yield of 6 million gallons per day (mgd) is much smaller than any other inhabited island, and the anticipated demand of the resort economy presses closer to the sustainable yield than any other island.

Because the island's water resource planning must be more precise, the community has little tolerance for uncertainty. The adequacy of the water resources of the island is a concern for both company and community leaders. In addition, they are beginning to recognize the importance of a sound watershed management program to protect their groundwater resource.

Planning History of the Lana'i WUDP

This planning effort is the third iteration under the state water code. Two Water Use and Development Plans (WUDP) have been prepared before. The 1990 plan was completed by the Maui BWS and adopted by county ordinance. That plan was subsequently adopted by the Commission on Water Resource Management (CWRM) as part of the Hawaii Water Plan. The plan was revised in 1992, but it remained in draft form with no further action by the BWS, the County Council, and the CWRM. Lana'i Company disagreed with the projections of the task force utilized in the plan and opposed its adoption despite the participation of company officials in the process.

Moloka'i started revising its plan in 1993. Moloka'i has been designated as a water management area by the CWRM, and Lana'i is currently under consideration for designation. The proposed community plan update is incomplete for both Lana'i and Moloka'i.

The 1990 WUDP dealt with the critical issue of resort development competing with pineapple for the limited water resources of the island. The WUDP recommended a strategy of developing alternate sources of water outside the high level aquifer as it was defined at that time. However, the company decided to phase out pineapple altogether and focus its effort entirely to developing the Koele and Manele Hotels and the two golf courses, thus avoiding that competition.

In 1992, the draft WUDP identified the major issue as water supply management and control. Construction was booming and resort was starting up operations. The plan recommended a strategy of a tighter organizational control and the use of dual systems in Manele for potable and nonpotable water.

The projections of future demand for water made in the 1990 and in 1992 plan are different, and both projections are substantially different from the demand experienced in

the pineapple economy. Water use in the previous pineapple economy on Lana'i is shown in Table 1.

Table 1. Water consumption in a pineapple economy.

Water Use	Annual average* (mgd)	% of total
Domestic and Commercial	0.38	13.7
Pineapple irrigation	2.40	86.3
Total	2.78	100.0

*The peak demand periods are in the summer months when daily averages were often greater than 6 mgd and as high as 8 mgd. Domestic and Commercial consumption is the average over 1950 to 1988. Pineapple irrigation is the average over 1983 to 1987.

The prospect of resort development and the added demand especially during the summer months was a serious concern to the plantation. The strategy of alternate sources of water for golf course irrigation was proposed in the 1990 WUDP to alleviate demand on the high level water resource.

The future demand projected in the 1990 and 1992 planning projects are compared in Table 2 below. Projections were made using different assumptions for the same category and new categories of use were added in the 1992 WUDP.

In the 12-month period of 1990-1991, the average annual consumption was 3.01 mgd. Koele golf course used 0.49 mgd of that amount in its start-up phase with wide swings in consumption over the year. The range was 0.15 mgd to 0.78 mgd as 4-week averages with standard deviation of 0.18 mgd, or 37 percent of the average.

The 1992 plan addressed management issues. There were wide swings in water consumption without explanation. Water losses were high, on the order of 23 percent. Consumers were drawing water without being billed for it. Faucets were leaking without any effort to repair them. Landscaping was irrigated in the rain. Conservation measures were not evident in the community. The 1992 WUDP concluded that tighter management control and a strong conservation ethic were needed to minimize the risk of over-extending the limited water resource on the island. The WUDP recommended a tighter organization and management of the water supply. The WUDP also recommended dual water systems for potable and nonpotable supply for Manele, including the reuse of water.

In summary, the 1990 issue was the competing economic interests. The 1992 issue was management.

Table 2. Summary of projected demand from the 1990 and 1992 WUDP for Lana'i. Note the difference between pineapple and resort economy versus resort only. Note also the difference in terminology which reflects changing description of the water resource.

	Projected Demand (mgd) 1990 WUDP with Pineapple		Projected Demand (mgd) 1992 WUDP without Pineapple	
	High Level	Alternate	Potable	Non-potable
Domestic and Commercial	1.25		1.869	
Pineapple	1.80		0	
Koele Hotel	0.18			
Koele Golf Course	0.25			0.4
Koele Project District			0.255	
Manele Golf Course		0.8		0.8
Manele Hotel & Hulupoe	0.38		0.405	0.1
Manele Project district			0.338	0.3
Community gardens and landscape		0.4		
Agricultural Park			0.5	
Diversified Agriculture			1.0	
Total	3.86	1.2	4.4	1.6

Scope of this report

This report is intended to provide consensus recommendations for a new draft of the WUDP. The Water Code requires the County to prepare the WUDP and adopt it by ordinance. Once adopted by the CWRM as part of the Hawaii Water Plan, the Code specifies that the WUDP shall serve as a continuing long-range guide for water resource management. The Lana'i Water Group is also considering recommendations for the implementing ordinance itself.

The Lana'i Water Working Group (LWG) was formed from the Water Subcommittee of the County Council's Committee on Human Services, Water, and Agriculture, with the addition of two Lana'i residents. The CWRM provided the facilitator and technical support.

The Group addressed various issues that have been the subject of conflicting views, and proceeded by consensus to recommendations intended to resolve those issues where possible, and to lay the groundwork for future discussions of the more complex issues.

The specific parameters and actions undertaken by the Working Group are as follows:

1. Develop data on present water use according to land use categories.
2. Evaluate system losses through an input-output model.
3. Develop projections of future water demand by identifying specific projects affecting future land use.
4. Identify issues in water use and development and recommend alternative strategies for resolving conflicts and disputes.
5. Prepare draft WUDP for adoption by the county council and the CWRM.

Summary and Recommendations

RECOMMENDED LANAI WATER PLAN ACTION ITEMS			
	ACTION ITEM	KEY AGENCIES	TIME FRAME
LEGISLATIVE MANDATE AND FORMULATION OF ADMINISTRATIVE POLICY	Create a permanent Lanai Water Committee by ordinance. Define its makeup.	County Council	1997
	Appoint and confirm members of the committee.	Mayor's Office; County Council	1997
	~~Designate a lead agency~~ and define its role in staffing the Lanai Water Committee and in the development, monitoring and implementation of the Lanai Water Use and Development Plan (WUDP).	County Council	1997
	Provide appropriate levels of staffing and funding.	County Council; Mayor's Office	1997
	Develop, adopt, and update the WUDP on a regular planning cycle.	LWG; Lead agency; County Council	1997
	Establish rules for the operation of the committee.	LWG; Lead agency	1997
MONITORING AND ENFORCEMENT	Requirements and Conditions of WUDP.	Lead agency CWRM	1998

RECOMMENDED LANAI WATER PLAN ACTION ITEMS (CONT'D)			
INFRASTRUCTURE	Implement and maintain a dual water system at Manele.	LCI	1997
	Submit to County Council comprehensive storage plan for Koele Golf Course. Pursue action to cover open reservoirs for Manele golf course and landscape.	LCI	1999
COMMUNITY EDUCATION AND OUTREACH	Water conservation and education program.	LWG; Lead agency; LCI	1998
	Distribution of low flow devices.	LCI; Lead agency	1999
	Information and distribution of appropriate plant types.	LCI; Lead agency	1997
SUPPLY-SIDE RESOURCE MANAGEMENT	Establish a watershed management program as an on-going program with special emphasis on preserving native ecosystems and maximizing the fog drip component of recharge in the watershed.	LCI; DLNR;	1998
	Consider desalination when necessary to meet future demand for new hotels and resort facilities at no cost to the residents.	LCI	
RESOURCE PLANNING, RESEARCH AND MODELING	Link Community Plan and WUDP review processes.	Lead agency	1998
	Conduct fog drip studies in order to refine recharge estimates. Update Lana'i Water Model.	LCI; CWRM; Lead agency	1999

RECOMMENDED LANAI WATER PLAN ACTION ITEMS (CONT'D)			
DEMAND-SIDE RESOURCE MANAGEMENT	Adopt the revised well operating management guidelines as mandatory.	LCI	1998
	Implement water conservation measures aimed at reducing outdoor usage as the strategy for meeting future demand.	LCI; LWG; Lead agency	1998
	Retrofit and plan for recycling and reusing water from water features within the resort complex, particularly for landscape irrigation.	LCI	1998
	Establish inventory of all irrigated acreage and monitor appropriate irrigation standards and practices.	LCI; Lead agency	1998
	Maintain list of appropriate plant species.	LWG; LCI; Lead agency	1998
	Continue to reduce system losses.	LCI	1997
	Establish "per unit" water use targets and pricing structure.	LWG; Lead agency; LCI	1998

Present water demand

The base year selected for evaluation is calendar year 1995. It is the latest complete year of record available at the time of this report preparation. Data on present water use are shown in Table 3.

The 1995 consumption determined from billing records was 1.57 mgd. The corresponding pumping (supply) rate was 1.70 mgd. System loss is the amount unaccounted. This was 7.89 percent of the pumping rate. This is a significant improvement over the 23 percent loss in 1993. Lana'i Water Company improved its management of the water system.

The unit consumption for residential units in Lana'i City averages 316 gpd/unit. The unit consumption rate is equivalent to Paia, Maui. This rate appears to be normal for this community that is predominantly of old plantation architecture without extensive landscape development. (See Appendix for typical unit consumption rates for Maui County.)

Koele and Manele Hotel water usage appear low compared to projections, but essential information is not available to fully evaluate demand. The occupancy rates for the year are not available. The hotels will not release that information. Instead, occupancy rates are available for specific periods. They are evaluated and extrapolated over the year.

Manele golf course consumption shown in Table 3 does not include the reuse of wastewater effluent. Manele golf course used less water in 1995 than projected in earlier plans. The long term rate is the key, and it has not been yet been demonstrated by experience.

Koele golf course is currently irrigating with reclaimed water only. However, potable water usage may be allowed under unanticipated conditions defined in ordinance 2515.[1] The director of the Department of Public Works and Waste Management reviews requests and authorizes usage according to law. Ordinance 2516[2] also provides for potable water usage for re-seeding and re-grassing fairways. The maximum allowed is 27,000 gallons per day per fairway. The County Council approves by council resolution. Ordinance 2514[3] requires Lana'i Company to present to the Maui County Council within two years of the effective date, a report detailing the following:

1. a comprehensive plan to develop additional storage of water for Koele golf course irrigation;
2. the time frame within which the plan will be implemented; and
3. steps taken to implement the plan at the time the plan is submitted.

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[1] Effective date: October 17, 1996
[2] Same effective date.
[3] Same effective date.

While ordinances allow potable water usage under prescribed conditions, but they require a plan for additional water storage which serves to minimize reliance on potable water.

Projected Water Demand

The water demand for the future is shown in Table 4. The derivation of the demand figures is given in Appendix A. Line item quantities for the Manele and Koele project districts are combined into one figure. This report is not intended to show approval or disapproval of specific projects within the project districts listed for future development. However, it is expected that adjustments will be allowed within the line item categories shown in Table 4.

Residential water demand.

The present population of Lana 'i is 2,800 residents. Population growth on Lana 'i is expected to be driven by the two resort developments. Secondary jobs will be created in the service sector as a result of the resort growth. Population projection in the draft community plan indicates a population of 4,968 by the year 2010, a 77 percent increase averaging 5 to 6 percent per year. This increase of 2,168 residents would require approximately 1,019 additional housing units. It was the consensus of the working group that the population projected by the draft community plan is too high. The projection in the draft plan came from the socio-economic forecast model done in 1992[4] and has not been formally adopted as policy by the Council.

The various population projections reviewed by the group are presented in Appendix A. From 1980 to 1990, the population growth rate was approximately one percent per year. From 1990 to 1996, the growth rate was approximately two percent per year. The Working Group concluded that a growth rate of two percent per year until the year 2010 is the most realistic estimate. This results in a total population of 3,695 in the 2010, representing an increase of approximately 407 additional housing units.

It is very difficult to determine several years in advance where the additional housing will be constructed and what form it will take. The Working Group agrees that new housing should include a mix of multi-family and single family units. At present, there are several potential projects which may arise for the residents of Lana'i. The potential projects include the affordable housing property (115 acres), Department of Hawaiian Home Lands (DHHL) property (50 acres), Kaumalapau Subdivision (45 units), and the redevelopment portion of the Koele Project District (75 acres or 280 units). Assuming a density of 4.5 units per acre, the total number of housing units that can be constructed is more than 1000 units which is far more than needed for the year 2010.

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[4] Community Resources, Inc., Maui Community Plan Update Program. Socio-Economic Forecast Report, August 1992.

Table 3. Present water demand (1995 data).

Category	Present demand gpd	Number of Meters	gpd/unit	Remarks
Residential	274,200	867	316	Predominantly Lana'i City
Commercial	91,695	46	1993	Inventory irrigated acreage
Government	58,600	20	2930	Inventory irrigated acreage
Lana'i Company	229,015	86	2663	Inventory irrigated acreage
Koele Hotel	37,754	4	*	102 units. 1995 occupancy unknown.
Koele Hotel landscape	48,646	1	*	
Cavendish	9,393	1	*	
Manele maintenance	8,279	2	*	
Manele Hotel	39,847	2	*	250 units, 1995 occupancy unknown. Refer to calculations in appendix.
Manele Landscape	30,227	1	*	
Keumalepau	9,223	1	*	Meter at reservoir
Lana'i airport	4,239	1	*	
Diversified Agr	219,123	32	*	Approximate number of meters
Manele Golf	505,710	1	*	Does not include effluent reuse: 49,737 gpd ave for 1995.
Total consumption	1,565,949			
Total Pumped	1,700,000			
System Loss	134,051			
Percent	7.89%			Improvement. System loss was 23% in 1993.

*This report recommends that all irrigated acreage associated with existing uses be inventoried and evaluated in the water conservation program described later in this report.

Table 4. Present and Projected Water Demand for Lana'i. Manele and Koele Project Districts include all water demand within those boundaries.

(Refer to Appendices for assumptions and details)

CATEGORY	Present mgd	2010 mgd	Total Future mgd	Source of Water**
Residential	0.274	0.414	0.494	Groundwater
Agriculture	0.219	0.5	1.5	Groundwater
Commercial & Institutional	0.379	0.439	0.439	Groundwater
Light Industrial	0	0.09	0.09	Groundwater
Kaumalapau Harbor	0.009	0.01	0.01	Groundwater
Lanai Airport	0.004	0.005	0.005	Groundwater
Manele Project District	0.078	0.68	1.03	Groundwater
Manele Golf Course	0.51	0.65	0.65	Groundwater
Manele Effluent	0.05*	0.07*	0.14*	Effluent
Koele Project District	0.096	0.20	0.42	Groundwater
Koele Golf Course	0.17*	0.25*	0.25*	Effluent
Subtotal Groundwater	1.569	2.99	4.64	Groundwater
System losses***	0.134	0.41	0.63	
Total Groundwater	1.703	3.40	5.28	
Total Effluent	0.22	0.32	0.44	
Total Water Demand	1.92	3.72	5.72	

*Reclaimed wastewater effluent
**Sources of Water:
Groundwater=all wells
Secondary=Palawai (Wells 1,7,8,10) and beyond
Effluent=reclaimed water
***System losses=7.89% for 1995, 12% for future years

The housing requirement for the DHHL shown in the Appendices is based on an assumption of residential development density. It is possible that the property would instead be developed as agricultural homesteads. DHHL has no plans at this time. The agricultural alternative could result in a smaller domestic water demand. Potential agricultural demand has been included in the overall agricultural allotment in this plan.

Plans for the future housing are uncertain at this time. Lana 'i Company, the major landowner, is concentrating its housing efforts on the Lana 'i City Redevelopment Project. State and County agencies are currently waiting to gain a better understanding of the need for future housing prior to proceeding with development of their projects. Therefore, housing densities are flexible and may change. Attention should be given to providing the residents different types of housing.

Rather than attempt to allocate water to each of the potential projects, the working group agreed to provide an allocation of water for the increased population in general. The future homes for these residents will be built on one or more of these potential projects, depending upon the home purchase preference of the community at the time.

The key variable in the population projections is the timing of projected expansion of the hotels allowed under current zoning. The expansion of the hotels will have an impact on the job growth on the Island and will affect the population figures accordingly. The group agreed that the long term average population growth estimate of two percent per year is sufficient including the future of the hotel expansion impact.

Agriculture

Agriculture as defined in this WUDP is all activities including corporate farming, farming in the 100-acre state agricultural park, and subsistence farming that DHHL residents might undertake. The water set aside in this plan for agriculture is 1.5 mgd.

The Lana'i Water Working Group invited the Chair[5], State Board of Agriculture to brief the group on the potential for agriculture on the island. A briefing paper was prepared for the Chair prior to his visit (Appendix B). His comments and conclusions given orally to the working group are summarized as follows:

1. DOA has received no requests from members of the community for land in the 100-acre agricultural park. The high cost of water on Lana 'i compared to other parts of the state is a disadvantage.

[5] James Nakatani, Chair of State Board of Agriculture and Director, Department of Agriculture, State of Hawaii. August 1, 1996.

2. DOA does not intend to develop the park unless there is community interest.
3. The economically viable options include high value niche crops, for example, for the hotels and for papaya in a fruit-fly free zone. Papaya is also disease free.
4. Focus efforts on supplying on-island demand for fresh produce.
5. Consumptive uses depend on the crop, but 3500 gpd/ac can be an average.

While there is no specific proposal for agriculture on Lana'i, the working group agreed that 1.5 mgd should be set aside for agriculture. Allocating water for agriculture is also a specific recommendation of the draft community plan for Lana'i.

Strategy for water use and development

Supply-side Factors

The protection of the island's water resources is a principal concern of the WUDP. The Working Group reviewed background information shown in Figures 1 to 6 and Table 5.

Watershed Management

Watershed management is critical to assure continued recharge of the aquifers. The Working Group has expressed concern for two major issues: fog drip and protection of the native ecosystem.

Fog drip is a particularly sensitive element in recharging the aquifer on Lana 'i, due to limited rainfall and the low sustainable yield. The Group is very concerned that loss of fog-drip vegetation could reduce the available groundwater. The focus of attention is the high elevation area recharging the potable aquifer. Fog-drip first came to the attention of the Lana 'i Ranch manager in 1927, as the ranch sought ways to maximize its land use activities, and subsequent studies have confirmed its significance in augmenting rainfall.

The introduction of pigs, goats, axis deer, and mouflon sheep in successive periods has been detrimental to the vegetation. Pigs and goats have been eradicated and sheep seem to be self-limiting, but the deer population has expanded significantly, contributing to vegetative damage and erosion that has undermined the health of the high elevation native habitat that contributes to recharge of the aquifer. Trees that were planted in the 1920s and 1930s and that contribute to the recharge capacity are reaching old age and are susceptible to the current long-term period of low rainfall. Invasive plant and insect species are adversely affecting native species that are significant in retaining moisture. As elsewhere in the islands, native species have been exterminated or are in retreat.

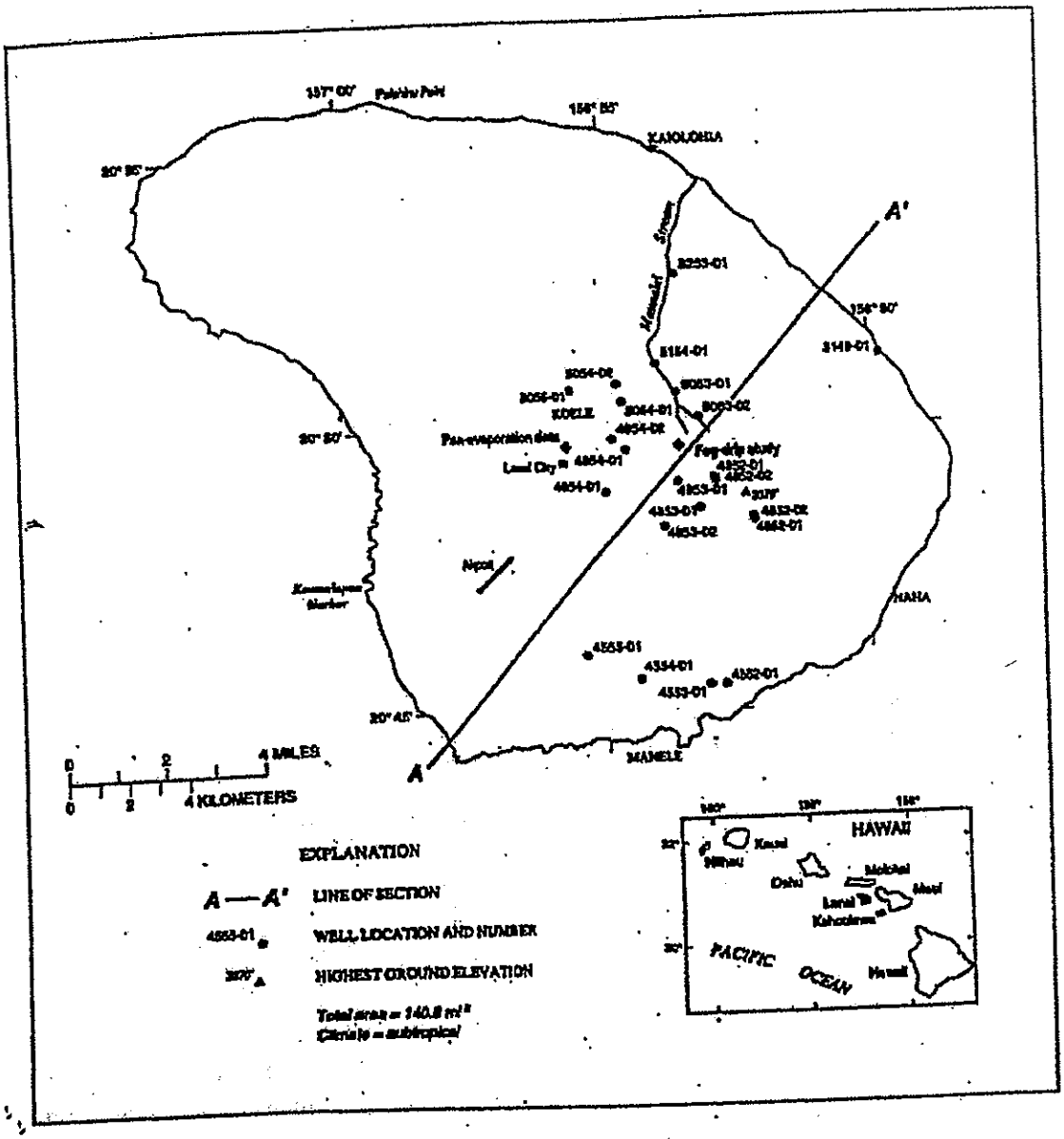


Figure 1. Regional setting for water resources on Lana'i (CWRM, 19 April 96).

Well No.	Well Name	Year Initially Drilled	Initial Water Level Elevation (ft. msl)	Initial Bottom of Well Elevation (ft. msl)
4454-01	Manele	[g]na	2.5	na
4552-01	Well 12	1990	5	-25
4553-01	Well 13	1990.	0	-25
4555-01	Well 10	1989	208	208
4852-01	MH Tunnel	1918	Dry	2,700
4852-02	Well 5	1950	1,570	1174
4852-03	USGS T-2	na	na	na
4853-01	Gay Tunnel	1920	Dry	1,920
4853-02	Well 1	1945	initial head → 818	-3
4854-01	Well 9	1990	[f]806	446
4952-01	Walapaa Tun.	1924	Dry	2,220
4952-02	Well 4	1950	1,589	1,149
4953-01	Well 2	1946	1,544	903
4953-02	Shaft 3	1954	1,553	[i]1,510
4954-01	Well 3	1950	[h]1,124	651
4954-02	Well 8	1990	1,014	412
5053-01	Lower Tunnel	1911	1,103	1,103
5053-02	Upper Tunnel	1911	1,500	1,500
5054-01	USGS T-3	1950	[k]1,064	ground-928.6
5054-02	Well 6	1986	1,005	600
5055-01	Well 7	1987	650	450
5148-01	Gay Well A	1900	2	-44
5154-01	Shaft 2	1936	735	479
5253-01	Shaft 1	1936	2.4	1.4
TOTAL Data	24 wells	na	22	20
AVERAGE	na	na	na	na

Table 5. Identification of wells and characteristics by CWRM code and common name (CWRM 19 April 1996).

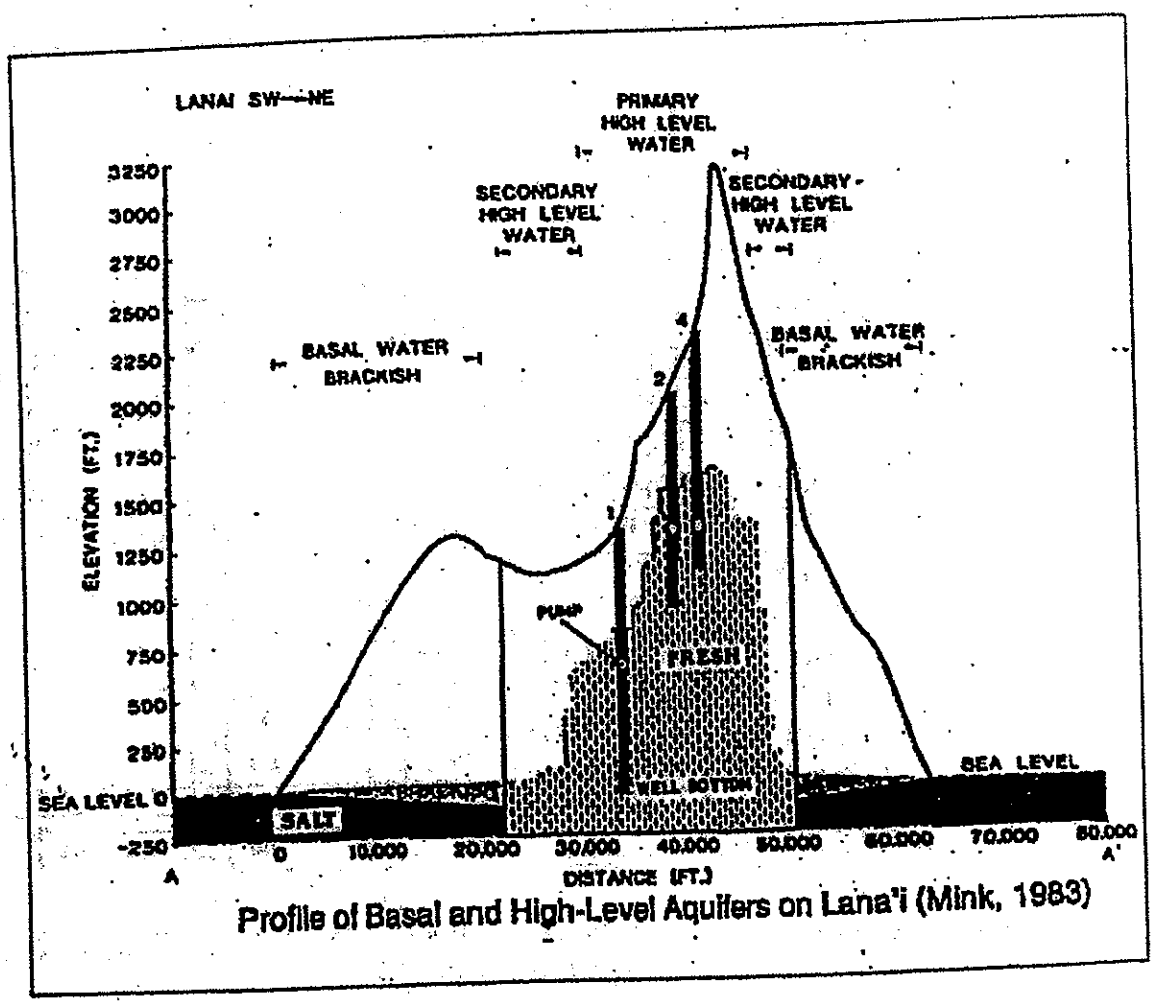


Figure 2. Idealized cross-section of groundwater on Lana'i (CWRM, 19 April 1996).

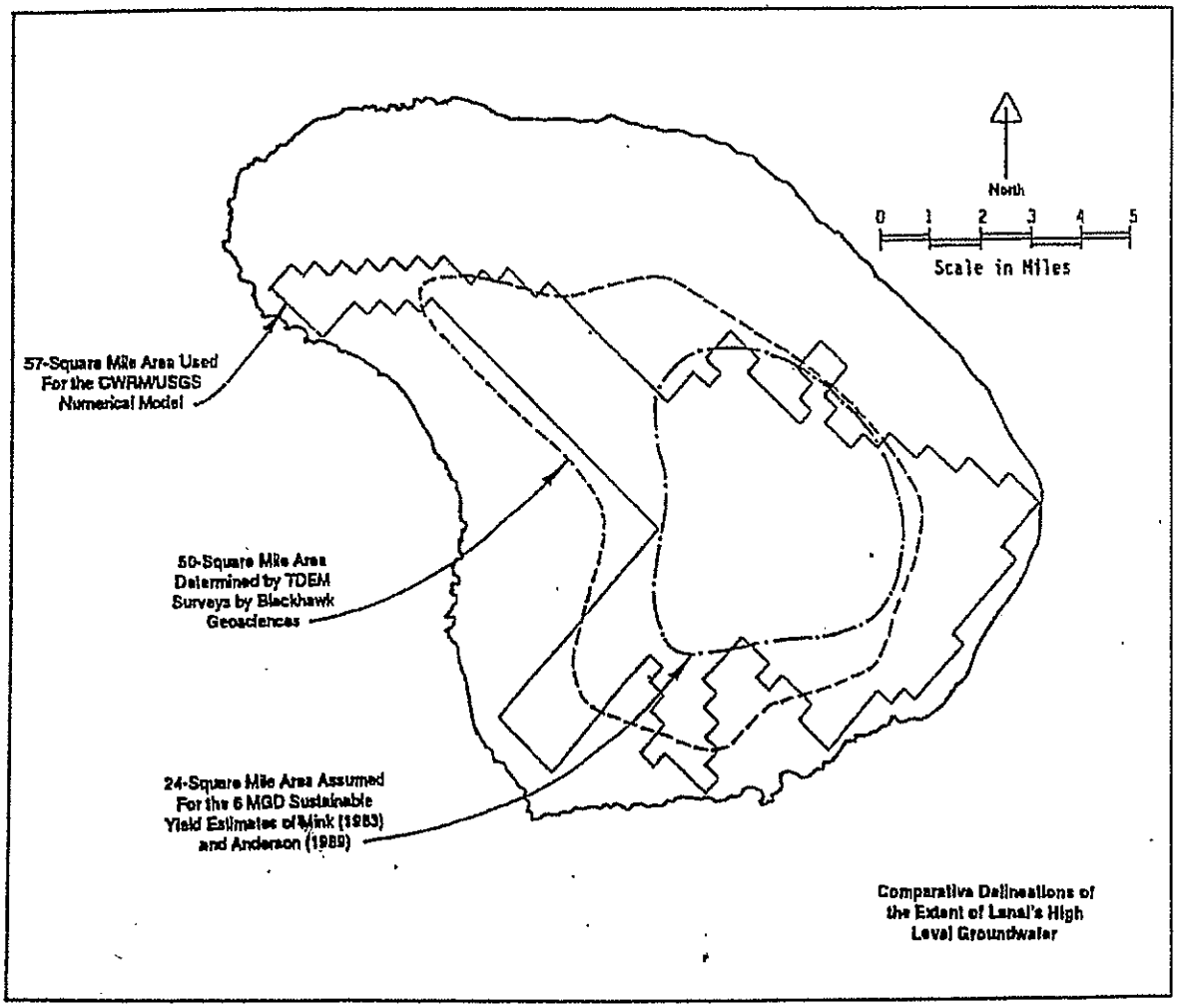


Figure 1. Comparison of different high level areas used in the analysis for recharge and sustainable yield by different investigators (after LCI, Aug 1996). The sustainable yield remains the same at 6.0 mgd for the different recharge scenarios. Water quality is a factor that must be accounted for in each scenario.

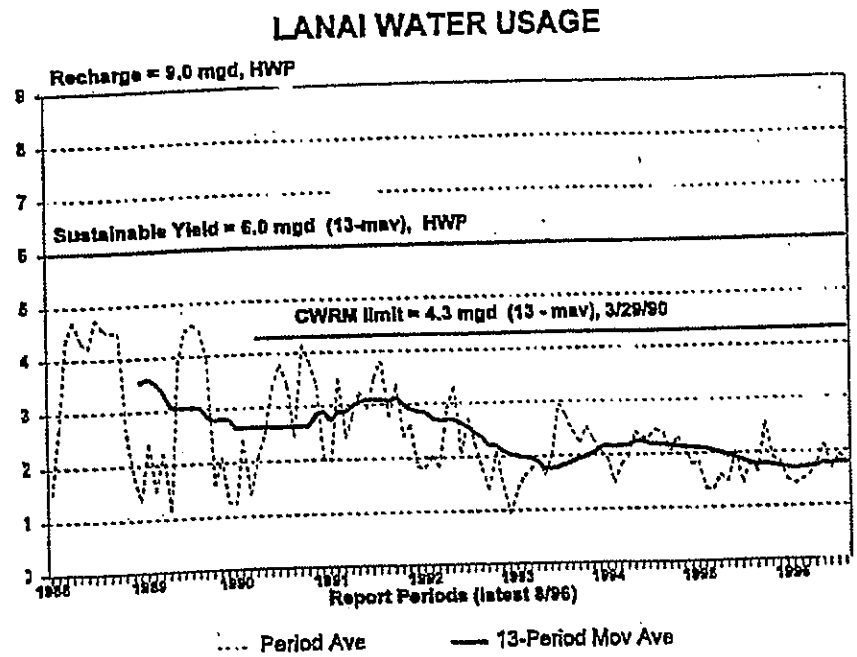


Figure 2. Trend in water usage compared to sustainable yield and CWRM limit (18 Oct 96).

Note the wide swings in water consumption in the different periods prior to 1994. Water consumption steadily declined from 1989 to 1995. Resort construction tapered off and LCI exerted better water supply management. Also, there was a change in water use.

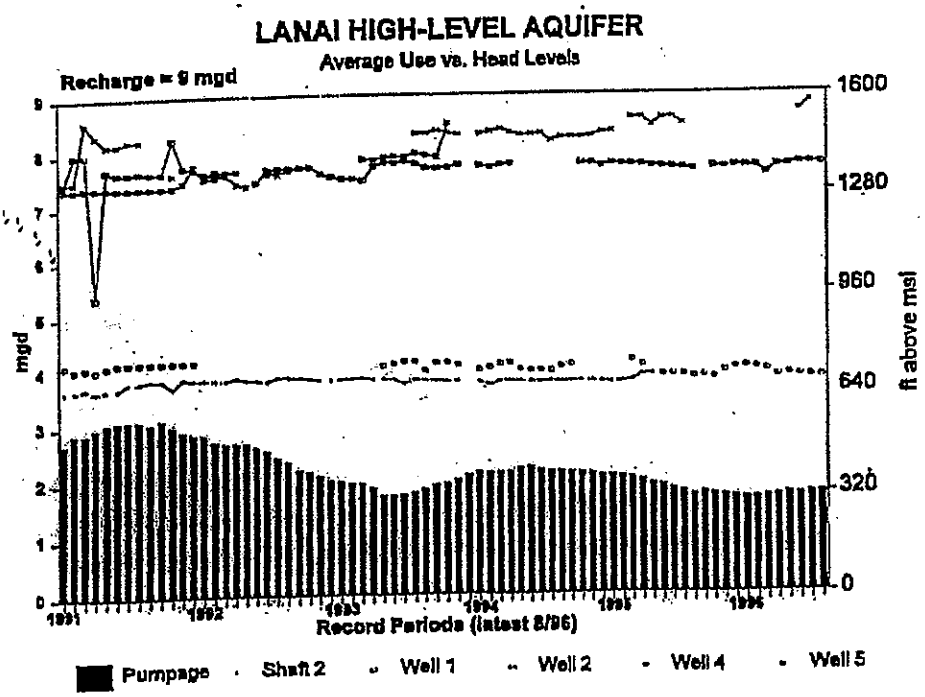


Figure 3. Water levels from 1991 to 1996 (CWRM 18 Oct 96).

Water levels have remained relatively stable since 1991. Well 4 show increase in water level. Pumping has been reduced or stopped in Wells 4 and 5.

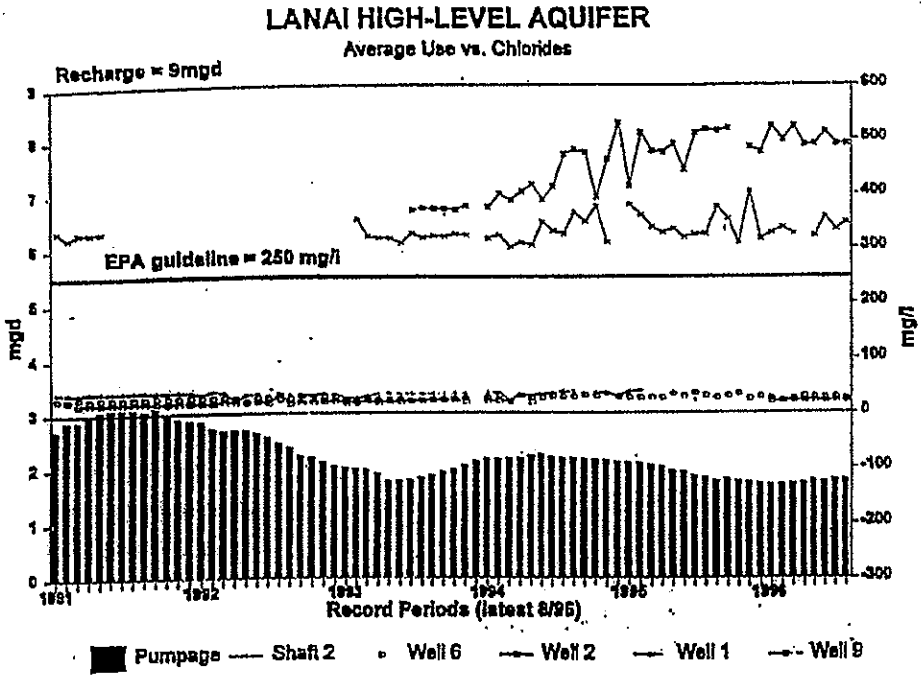


Figure 4. Chloride levels in wells in the Palawai basin compared to other wells (CWRM 18 Oct 96).

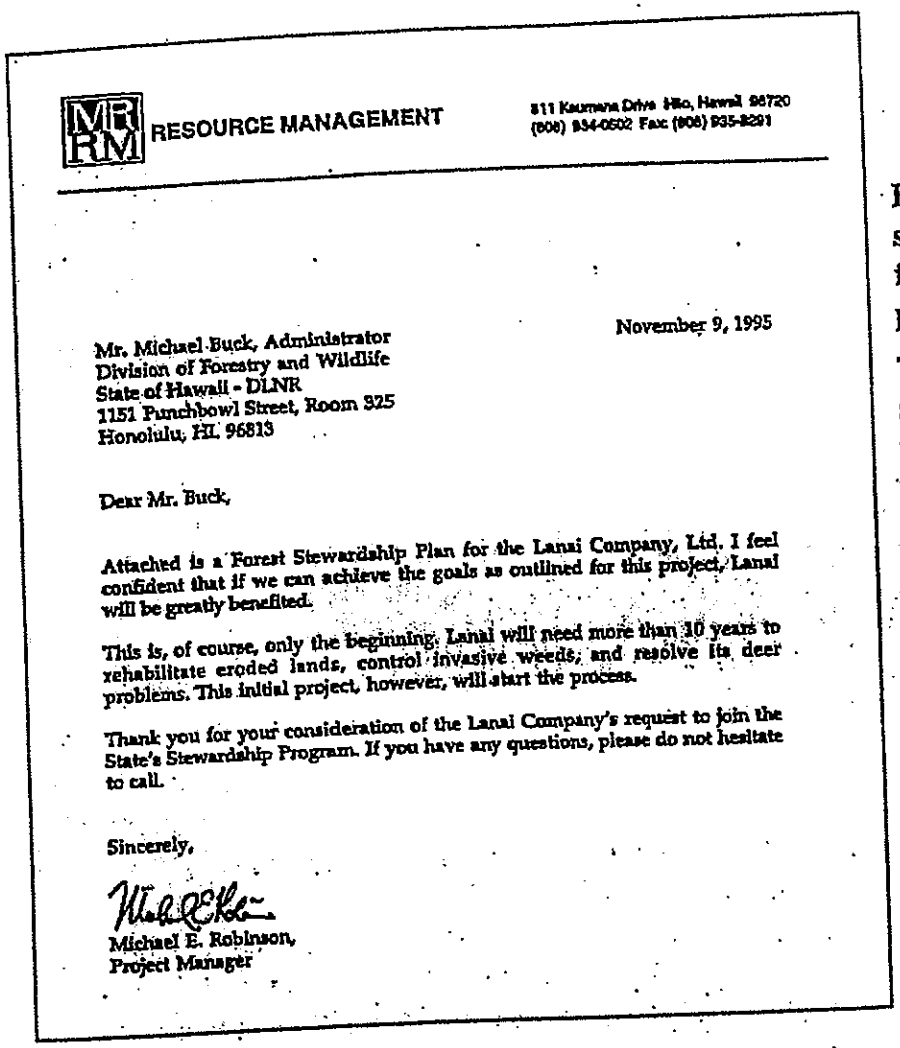
Groundwater in the Palawai basin is brackish. Chloride levels appear to be stable in Wells 1 and 9 at their current pumping rates.

The Working Group agrees that a strong watershed management program is essential to its water resources. There are at least three ways that this matter may be approached. The Tri-Isle (Maui County) Resource Conservation and Development District (RC&D) is a channel for federal-state-landowner cooperative cost-sharing and technical support programs sponsored by the federal natural Resources and Conservation Service (NRCS, formerly Soil Conservation Service); its focus is agricultural land, but it can apply to watershed lands that contribute water resources to the agricultural land. The Forest Stewardship Program is a separate federal-state-landowner cooperative cost-sharing and technical program sponsored by the U. S. Forest Service and administered through the State Division of Forestry and Wildlife. Thirdly, private efforts are a time-honored approach in Hawaii evidenced on Lana 'i by years of volunteer reforestation.

The Group feels that it is imperitive that this plan be implemented and its effectiveness be monitored and the plan be revisted as appropriate. To serve this end, the Group recommends that the CWRM appoint a steering committee to set objectives for a fog-drip study and watershed management program.

A forest stewardship plan[6] has been prepared for LCI.

[6] Forest Stewardship Plan for The Lana'i Company, Prepared by: Resource Management, 811 Kaumana Drive, Hilo, Hawaii 96720, November 8, 1996.



RESOURCE MANAGEMENT

811 Kaumana Drive Hilo, Hawaii 96720
(808) 934-0502 Fax: (808) 935-8291

November 9, 1995

Mr. Michael Buck, Administrator
Division of Forestry and Wildlife
State of Hawaii - DLNR
1151 Punchbowl Street, Room 325
Honolulu, HI. 96813

Dear Mr. Buck,

Attached is a Forest Stewardship Plan for the Lanai Company, Ltd. I feel confident that if we can achieve the goals as outlined for this project, Lanai will be greatly benefited.

This is, of course, only the beginning. Lanai will need more than 10 years to rehabilitate eroded lands, control invasive weeds, and resolve its deer problems. This initial project, however, will start the process.

Thank you for your consideration of the Lanai Company's request to join the State's Stewardship Program. If you have any questions, please do not hesitate to call.

Sincerely,

Michael E. Robinson,
Project Manager

Figure 5. Summary statement of the forest stewardship plan for Lana'i.

This plan is but the start of an on-going process. The goal is to preserve the native ecosystem that fosters groundwater recharge of high water quality.

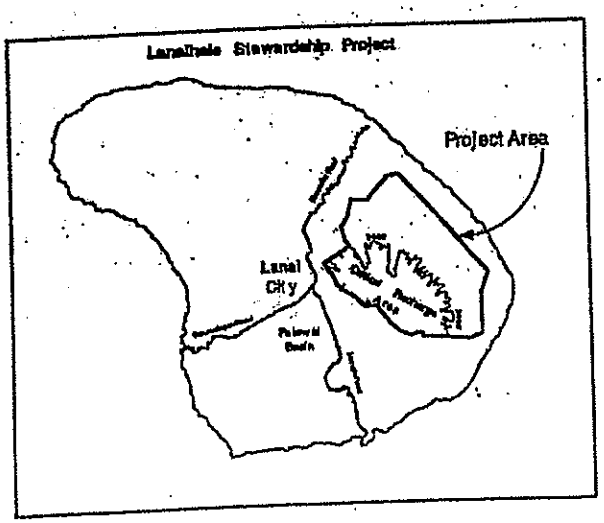


Figure 6. Project area for forest stewardship plan (after Resource Management, 1995).

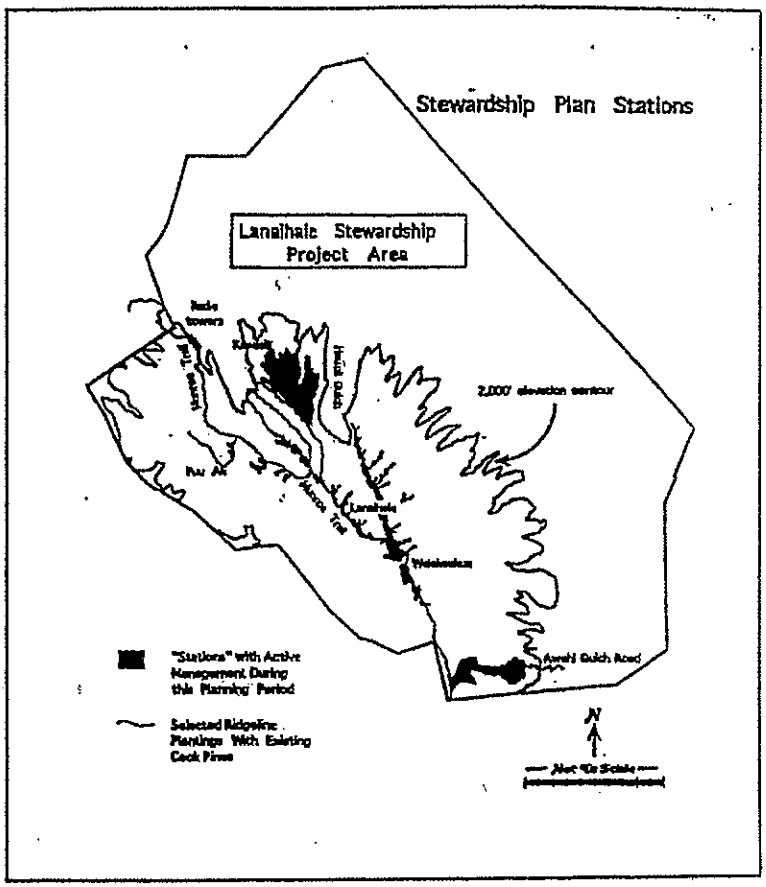


Figure 7. Stations for stewardship plan (after Resource Management, 1995).

Objectives of the plan:

1. Enter into State's Forest Stewardship Program.
2. Improve fog drip, subsurface water quantity, and surface water quality via tree plantings on critical and non-critical planting areas.
3. Protect new and existing plantings from wildlife browsing.
4. Establish vegetative cover which controls erosion.
5. Control undesirable non-native vegetation.

Well Operating Management Guidelines.

LCI developed guidelines for managing groundwater resources and described them as voluntary well operating mangement guidelines (VWOMG).[7] The Working Group recommended revisions and further recommended that the revised guidelines be made mandatory.

1. The moving 12-month average pumpage of high level brackish wells in Palawai Basin which are used to irrigate Manele Golf Course, shall not exceed 650,000 gpd. If other non-potable water becomes available, such as sewage effluent or other brackish

[7] Lana 'i Water Resources Management Plan, Prepared by Lana 'i Company, Inc., August 1996

water, the amount withdrawn from the high level aquifer shall be reduced proportionately.[8]

2. Pumpage shall be distributed among well sources so as to maintain their water levels within the following specified limits:

Table 6. Action levels for groundwater sources.

Potable Well	Initial water level (ft elev)	Current water level (ft elev)	Action Level* (ft elev)	Lowest allowable level (ft elev)
2	1544	1390	1050	750
3	1124	992	750	562
4	1589	1573	1100	750
5	1570	(Not operating)	1100	750
6	1005	998	750	500
8	1014	893	750	500
Brackish Wells				
1	818	748	550	410
9	808	755	550	410
14	?	?	400	292

***Requires public review of all pumpage, water level, and water quality data for possible changes in the resource management procedures, policies, and plans.**

3. In event that it is not possible to stay within the limitations set for potable wells, LCI will develop new wells and/or outfit Well 7, whichever is most hydrologically appropriate.

Desalination and Future Water Development

LCI made a significant commitment to implement desalination for the irrigation of Manele Golf Course in the event the 12-month moving average of total pumpage from the high level aquifer exceeds 70 percent of the sustainable yield for six consecutive months. Desalination incurs a substantial cost in present-day terms, and it will continue to do so in the future despite cost-cutting advances being made in technology. The Working Group understands that the cost for this alternative is to be borne by LCI and not the community. Nevetheless, the Group feels that there are other more cost-effective alternatives to meeting the water demands in the future than desalinating golf course irrigation water. For this reason, the Group does not support the guideline for desalinating irrigation water. This issue will be discussed more fully in the following sections of this report.

[8] Resolution 93-42. Relating to the use of non-potable water for the construction of the Manele Golf Course. County of Maui, 1993.

Demand-side Factors

The consumer-oriented factors are considered here to reduce demand and increase efficiency of water use.

Dual Systems

The 1992 Draft WUDP recommended dual water systems especially for Manele project district for potable and non-potable water. This is a recommendation of this report. It is anticipated that water quality will become a more significant factor in resource management as urbanization progresses in the future.

Conservation measures

There are two basic alternatives to meeting future demand. One is to increase supply. The other is to improve efficiency. Reducing the future demand is often the more cost-effective engineering solution, but it requires changes in habits of people and in traditional uses of water.

The major categories of consumers evaluated here are residential, landscape, and resort. Commercial consumers are specific and require more study to fully evaluate.

Residential (single family units)

The unit consumption averaged 316 gpd/unit in 1995. By comparison, Paia, Maui had 342 gpd/unit in 1991. Both communities started as plantation camps with similar architecture and layout. It is reasonable to expect similar consumption patterns in this case.

However, there are wide differences in average water consumption in Maui County. Climate appears to be a significant factor. The range of values for 1991 in Maui County is shown in Appendix C.

The pattern of residential water use is measurable in terms of indoor and outdoor use. Data developed in the 1992 WUDP[9] show this relationship for the Kihei and Kahului. The result is shown in Table 7. For Kihei, outdoor use is 57 percent. For Kahului, it is 32 percent.

[9] M&E Pacific, Inc., Draft WUDP, Maui, 1992, Prepared for Department of Water Supply, County of Maui, 1992, Table 1.41, p 1-10.

Table 7. Difference in residential water consumption in Kihei and Kahului. The major use in Kihei is outside the dwelling units.

(Draft WUDP,1992)

District	Number of SFR Units	Consumption ave gpd/unit	Outside use* % of ave
Kihei	2520	841	57
Kahului	3404	519	32

*Outside use = [(Potable water in) - (Sewage flow out)]/(Potable water in)
SFR= single family residential

The sewage flow (1995) averaged 0.27 mgd from Lana'i City and 0.05 mgd from Manele Hotel. Therefore, inside usage was 0.32 mgd. That was the total for the island. By comparison, groundwater pumped for delivery island-wide was 1.70 mgd.

Therefore, inside use is a minor part of the overall water use. Table 8 summarizes this situation. Greater returns would be possible by focusing conservation efforts on outside usage instead.

Table 8. Summary of inside and outside uses of water on Lana'i (1995).

Catergory	mgd	Remarks
Water pumped	1.70	Refer to Table 3. Figure includes losses at 7.89% and Manele Golf course irrigation at 0.51 mgd. Koele Golf course uses reclaimed water exclusively.
Lana'i City and Manele Wastewater flows	0.32	This represents inside use of water. Most can be reclaimed for reuse. Current amount reclaimed is about 0.22 mgd.
Outside use, mainly landscape irrigation	1.38	This is 81% which is the predominant use of groundwater on Lana'i. It should be the main focus of conservation efforts on Lana'i.

Landscape

Landscape irrigation is the major water use on Lana'i. Irrigation requirement is fairly predictable based on type of plant or grass, climate, and irrigation efficiency. Turf grass consumes water equivalent to pan evaporation. In contrast, pineapple consumes

substantially less water, about one-tenth of turf grass.[10] Plant type and irrigation efficiency are matters of choice, and they are manageable. Climate is not.

Data on pan evaporation for Lana'i are sparse. Hardy[11] estimated pan evaporation for areas on Lana'i below elevation 2000 feet by extrapolation.[12] Measured pan evaporation data at Lana'ihale was used along with other observations. Pan evaporation for Lana'ihale was 25.63 inches per year. Below elevation 2000 feet, pan evaporation was estimated to be 95.00 inches per year. Details are summarized in Table 9 below.

Table 9. Estimates of pan evaporation (ET) and irrigation application rate for turf grass on Lana'i (after Report CWRM-1).

Characteristic	ET inches	ET gpd/acre	Irrigate* gpd/acre
Areas below Elev 2000 ft (annual)	95	7067	9425
Minimum month (Nov)	3.80	3439	4585
Maximum month (Jul)	9.50	8320	11,093

***Application rate is based on 75% irrigation efficiency and on optimum growth.**

Irrigation of turf grass is greater than 9000 gpd/acre for optimum growth at 75 percent efficiency. By comparison, pineapple cultivation on Lana'i used 240 gpd/acre (2.40 mgd, Table 1, for 10,000 acres).

Drought tolerant plants and grasses can reduce water consumption. Xeriscaping is recommended for Manele. The impact can be significant. For example, the projection for single family residential units in Manele is 1600 gpd/unit. Of that amount, 600 gpd/unit is the estimate for domestic use and 1000 gpd/unit is for outside use such as landscape irrigation. These rates can be reduced with conservation measures. A target of 400 gpd/unit for domestic usage is reasonable. Perhaps more can be done with conservation to reduce total consumption even further.

The projection for Manele project district is 1.03 mgd (Table 4). A likely target for Manele project district is to reduce future demand to 0.53 mgd, a savings of 0.5 mgd.

Resort

Water features are part of the amenities common to hotel-resorts. Swimming pools and ornamental ponds require back-wash, water treatment of some sort, and make-up water. They represent a water demand. Water from these features can and should be reused for irrigation. Some work has already been start to retrofit water saving devices and facilities.

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[10] Ekern, Paul C. and Jen-Hu Chang, Pan Evaporation: State of Hawaii, 1894-1983, Prepared in Cooperation with Hawaiian Sugar Planters' Association, Report R74, Department of Land and Natural Resources, Division of Water and Land Development, State of Hawaii, August 1985, p2.

[11] Hardy, Roy, Numerical Ground-Water Model for the Island of Lana'i, Hawaii, Report No. CWRM-1, Commission on Water Resource Management, State of Hawaii

[12] Eckern, Ibid.

At present, backwash water at the hotels from water features are disposed of in the sewer system. Consumptive use would be a fraction of the total water delivered. However, as in the case of Manele, water reuse from these features is unplanned. It is being discharged to the sewer system, pumped to the treatment plant, and then to the reuse system. With prior planning, it could have been diverted to the irrigation system directly for reuse with minimum effort and cost. Therefore, the issue here is mainly on economics of reuse.

It is recommended that that recycling and reuse of water within the resort be added as a retrofit where possible in existing systems and as a designed feature in future systems.

Recommended Conservation Strategy

Outside usage of water (landscape irrigation) is and will continue to be the predominant demand. Water conservation is a significant alternative to meeting future demand. Therefore, the Working Group recommends the following actions:

1. Reuse water from water features for irrigation within the resort complex to save water and avoid treatment costs.
2. Prepare a plan for a conservation program with the following scope of work:
    - Develop an inventory of current irrigated acreage with type of plant and/or ground cover.
    - Develop a system of monitoring water application rates by month.
    - Set up climatological stations in strategic locations for measuring rainfall, temperature, humidity, evapotranspiration (ET), and other parameters to assist in establishing reasonable irrigation rates.
    - Adjust irrigation application rates according to evapotranspiration rate and type of plant.
    - Develop water pricing system as incentive for water conservation, that is, penalize excessive use based on ET and type of plants.
    - Develop library of drought resistant and salt-tolerant plants and ground cover that can be used in landscaping at Manele.
    - Incorporate drought resistent and non-invasive plants in all landscapes.
    - Set annual targets for adjusting irrigation application rates for different areas based on climatological data and type of plants and ground cover.
    - Set water allocation for each future development.
    - Adjust projections of future demand based on monitoring results and performance of this conservation program.
    - Adjust criteria and procedures for the water conservation plan as part of the WUDP update.
    - Pursue action to cover all open reservoirs.

- Provide additional storage capacity in the water systems as part of the conservation program.

Conclusion

The major issue is community involvement and participation in total water management. What is sorely needed is a company-community partnership in the truest sense of the word, based on trust and cooperation. To serve this end, an on-going organization and forum is recommended.

Recommendations

1. Establish the Working Group by ordinance.
2. Establish watershed management program as an on-going basis with special emphasis on preserving native ecosystem and the fog drip component of recharge in the watershed.
3. Adopt the revised well operating management guidelines as mandatory.
4. Implement water conservation measures aimed at reducing outside use as the strategy for meeting future demand, then consider desalination as required specifically to meet future demand for new hotels and resort facilities. The cost of desalination for hotel and resort activities shall not be passed on to the residential and agricultural consumers on the island.
5. Develop inventory of all irrigated acreage and water application rates as part of the program aimed at water conservation.
6. Retrofit and plan for recycling and reusing water from water features within the resort complex, particularly for landscape irrigation.
7. Implement and maintain dual water systems in Manele.
8. Establish a forum for community involvement and participation in planning for total water management, including the updating of the WUDP and monitoring implementation.

Glossary

Sustainable Yield	A management parameter indicating the amount of water that can be withdrawn without impairing the beneficial use of that source.
Brackish Water	Water that is too salty to drink, generally defined by US EPA as having 250 mg/l of chlorides.
Chloride Levels	Concentration of chlorides which is used as the indicator of salts in the water.
Hawaii State Water Plan	Plan required under the State Water Code.
Recharge	The replenishment of a groundwater source. It occurs naturally from rainfall.
Potable	Water that can be drunk without noticeable salty taste or without being bad to public health.
Desal	Desalination, the process of desalting or removing minerals from water.
Project District	A concept in land use zoning in Maui County which identifies the boundaries of a particular tract of land where development occurs according to Council approved standards and criteria.
Lana'i Water Group	A community group representing the company, government, and the citizens of Lana'i who have volunteered to develop a consensus document for resolving conflicts in water resource issues.
Aquifer	The geologic medium which stores and transports water underground ultimately to the sea.
Fog Drip	The condensation of moisture on plants and other objects like dew drops in sufficient quantity to infiltrate into the ground to groundwater.
Pan Evaporation	The amount of water that vaporizes from a standard container exposed to the weather in the same way that plants and vegetation are. There is a correlation between pan evaporation and the amount plants consume in their life cycle.
Forest Stewardship Progam	This is a cooperative program among federal and state agencies with the land-owners to preserve forestry resources and ecosystem. It is a cost-sharing program sponsored by the U. S. Forestry Service and administered by the State Division of Forestry and Wildlife, Department of Land and Natural Resources.

APPENDICES

Calculation of Projected Water Demand

Note: "Future" water demand represents the fully built-out condition according to authorized zoning. The time period for attainment is unspecified. The "2010" demand represents the foreseeable future.

Table A1. This is Table 4 in report.

LAND USE CATEGORY	Present mgd	2010 mgd	Future mgd	Source of Water**
Residential	0.274	0.414	0.494	Primary
Agriculture	0.219	0.50	1.50	Primary
Commercial & Institutional (10 addditional acres)	0.379	0.439	0.439	Primary
Light Industrial (15 acres)	0	0.09	0.09	Primary
Kaumalapau Harbor	0.009	0.01	0.01	Primary
Lanai Airport	0.004	0.005	0.005	Primary
Manele Project District	0.078	0.68	1.03	Primary & Secondary
Manele Golf Course	0.51	0.65	0.65	Secondary
Manele Effluent	0.05*	0.07*	0.14*	Effluent
Koele Project District	0.096	0.20	0.42	Primary
Koele Golf Course	0.25*	0.25*	0.25*	Effluent
Subtotal Groundwater	1.569	2.99	4.64	Primary & Secondary
System losses 12% future	0.134	0.41	0.63	
Subotal Groundwater	1.703	3.40	5.28	
Total Effluent	0.3	0.32	0.44	
Total Water Demand	1.73	3.72	5.72	
*Reclaimed wastewater effluent				
**Sources of Water:				
Primary= Wells 2,3,4,5,6,8, Maunalei				
Secondary=Palawai (Wells 1,7,9,10) and beyond				
Effluent=reclaimed water				

Table A2. Calculation of projected water demand in Manele Project District

Project	Acres	Reference	Remarks	2010	Future
Manele Hotel Existing		Increased occupancy	250 units, 600 gpd/unit, less exist	0.18	0.18
Manele Hotel II	25	Lanai Co., Feb 1990	150 units, 600 gpd/unit	0.09	0.09
Manele II Landscape	20	Draft WUDP	Ave irrigation 7000 gpd/ac	0.14	0.14
Manele PD SFR	248	Lanai Co. 3/1/90	325 units, 600 gpd/unit	0.08	0.20
			325 units, 1000 gpd/unit	0.12	0.32
Manele PD MFR	27	Lanai Co. 3/1/90	100 units, 300 gpd/unit	0.015	0.03
			100 units, 300 gpd/unit	0.015	0.03
Manele Commercial	5.25	1985 Project District	6000 gpd/ac	0.04	0.04
Manele Golf Course	100	Council Resolution	Included in present usage		
			Total	0.68	1.03

Table A3. Calculation of projected water demand for Koele Project District

				2010	Future
Project	Acres	Reference	Remarks	mgd	mgd
Koele Hotel Existing		Increased occupancy	102 units, 500 gpd/unit, less e	0.01	0.01
Koele PD SFR	138.35	Lanai Co. 6/28/96	254 units, 600 gpd/unit	0.05	0.15
Koele PD MFR	18.46	Lanai Co. 6/28/96	90 units, 400 gpd/unit	0.04	0.04
Koele PD Hotel	21.1	Lanai Co. 6/28/96	250 units, 500 gpd/unit		0.13
			Present Demand	0.096	0.096
			Total	0.20	0.42
Koele Golf Course			Reclaimed water use	0.25	0.25

Table A4. Population and demographic data used in analyzing population and residential water demand.

Parameter	Value	Remarks
1980 Census Population	2119	
1990 Census Population	2426	Approximately 1% growth rate from 1980
1990 Housing units	1007	1990 census
1990 Household size	2.86	1990 census
1988 Total number of Jobs	845	State DLIR
1988 Dole Pineapple	560	
1988 Lanai Company	30	
1988 Koele	8	
1996 Population	2800	LCI
1996 Housing Units	1273	
1996 Household size	2.2	
1996 Total Jobs	1400	State DLIR
1996 Hotel Workers	750	
1996 Other Service	100	
1996 Hotel units	362	Manele=250, Koele=102, Lana'i=10
Population / total job	2.0	Computed values
Service job/hotel job	1.13	Computed
Hotel jobs/hotel unit	2.07	Computed
Population/hotel job	2.27	Computed

Table A5. Projection of residential demand based on different scenarios. New hotel construction is the key driver for population growth.

Scenario (1996 population = 2800)	2010 Population	Population increase	New housing Needed	New Acres needed at 4.5/ac	Increased demand mgd
Community Plan Projection	4968	2168	638	142	0.22
1% Growth Rate (1980 to 1990 growth on Lana'i)	3219	419	190	42	0.07
1% Growth Rate with New Manele Hotel	3672	872	396	88	0.14
2% Growth Rate	3695	895	407	90	0.14
1% Growth Rate with New Manele and Koele Hotels	4805	2005	912	203	0.32

Table A6. Computation of the number of housing units that can be constructed on the land being considered for future housing. DHHL and the County have no plans for development at this time.

Project	Acres**	Remarks	Assumption on maximum density	Units*
In-fill housing		Lanai Co. Feb 96	Net 53 units	53
DHHL Housing	50	LUC Condition. Assuming	4.5 units/ac	225
County Housing	115	LUC Condition	4.5 units/ac	518
			Total	796

*The number of residential housing units possible from the density assumed is more than projected need. A lower density can be considered for future housing developments.
**Refer to Figure A1 for proposed locations of the 115 acres. The County has no definite plans for development. DHHL has no plans for the 50 acres at this time. The site has not been selected.

Table A7. Projection of future commercial demand in Lana'i City.

New Commercial Acres	= 10
Reference	OSP
Standard	= 6000 gpd/acre (County)
2010 additonal demand	= 0.06 mgd
Future demand	=0.06 mgd No further increase anticipated over 2010 demand/

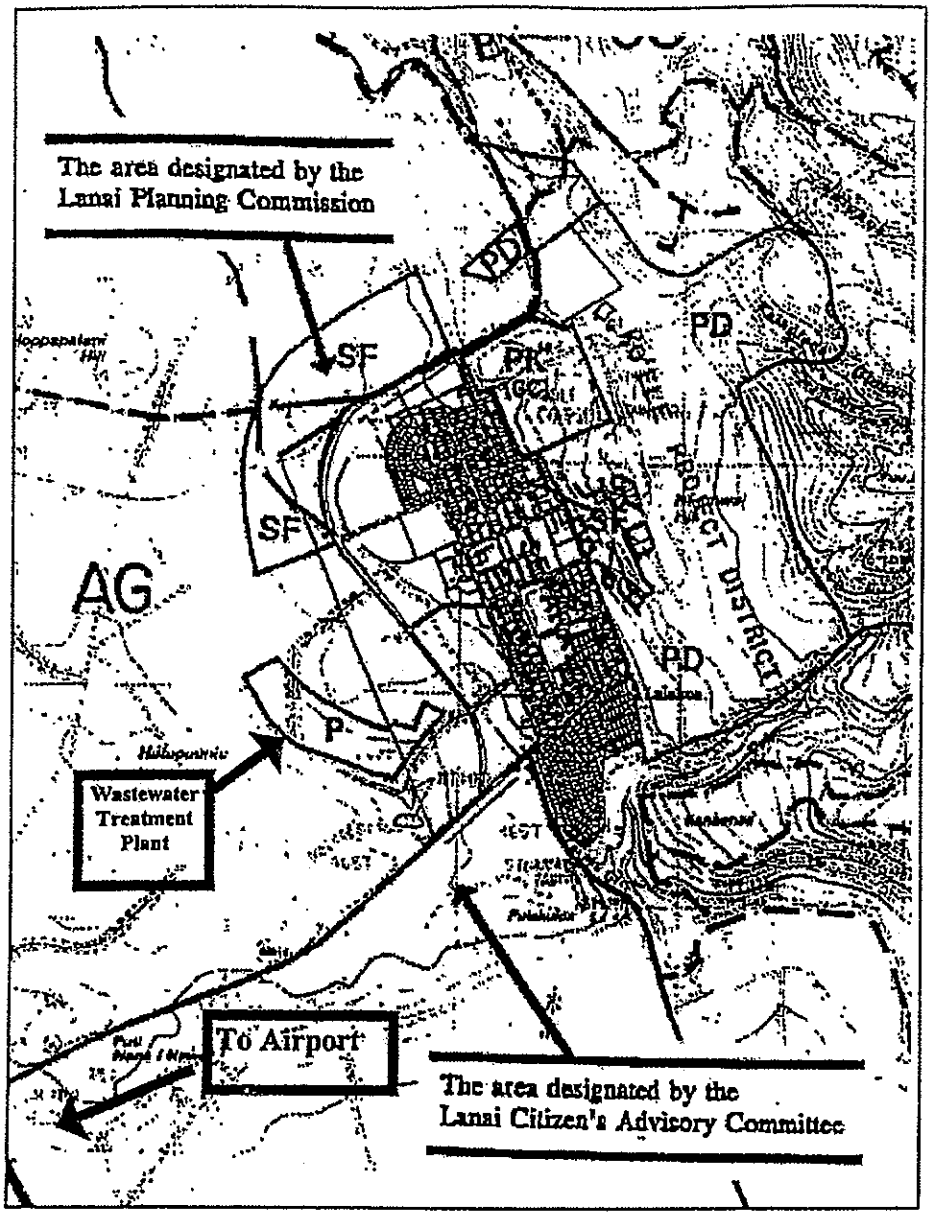

Figure A1. Different sites have been considered for the 115-acre residential development intended for County housing projects. The County has no projects planned. DHHL has no plans at this time for developing the 50 acres. The site has not yet been selected.

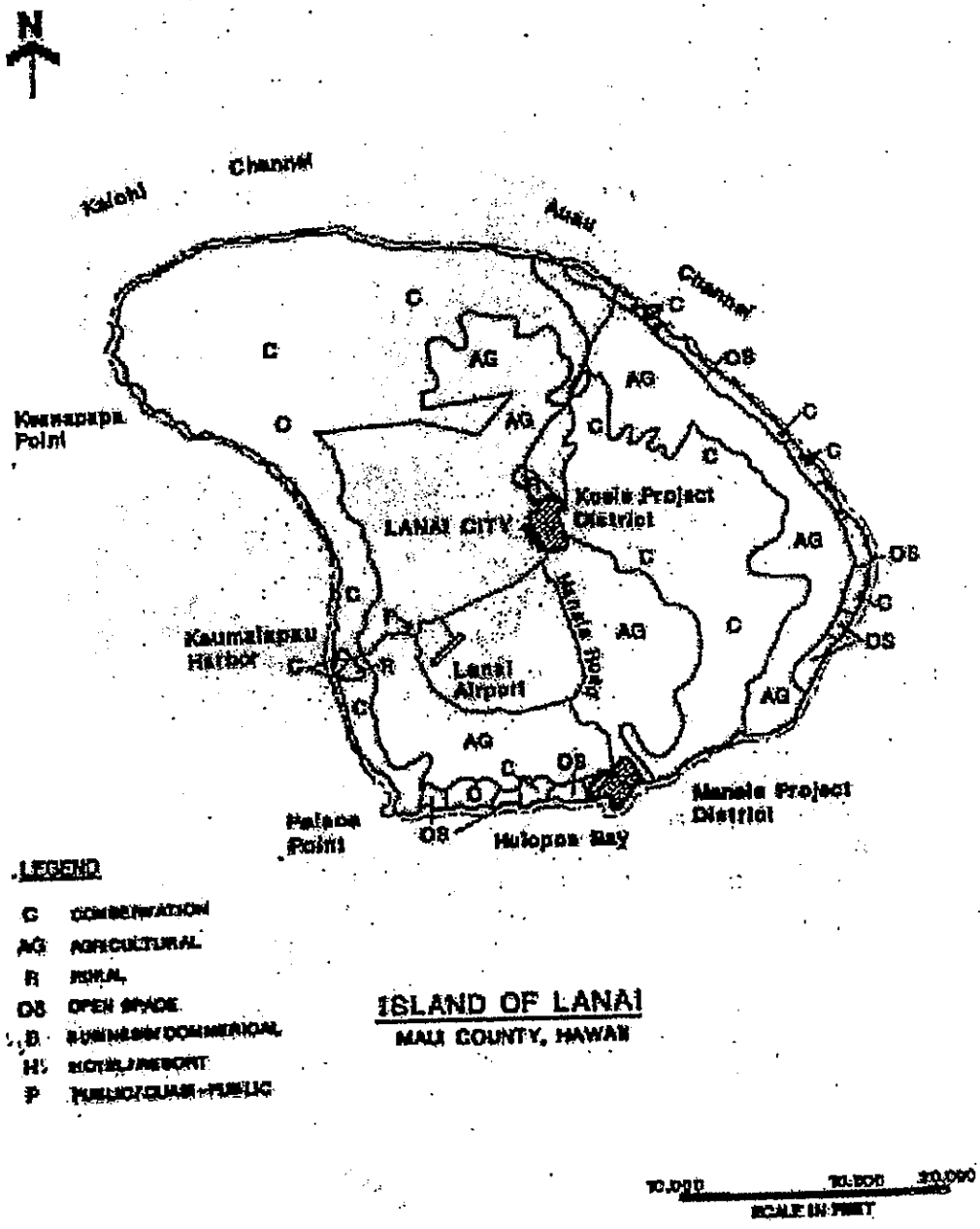

Figure A2. Land use designation for the island of Lana'i. The two major developments planned for the future are the Koele and Manele project districts.

Briefing Memorandum for Chair, State Board of Agriculture

July 22, 1996

MEMORANDUM

To: James Nakatani, Chair
Board of Agriculture
State of Hawaii

From: James Kumagai

RE: Briefing for your meeting on Lanai agriculture

Your meeting with the Lanai Water Working Group (WG) on August 1, 1996, will focus on the potential for diversified agriculture on Lanai. It is a sensitive and controversial issue. You will hear different viewpoints on what agriculture means to Lanai. It is a business. It is a way of life. It is a hope for diversifying a vulnerable economic base. In the end, the WG must pull it all together and decide how much water to recommend as the allocation to diversified agriculture. You can help them decide.

Lanai has a history of change. It has gone from sugar, to ranching, and then to pineapple in this century. Now, Lanai is going out of pineapple altogether and phasing into a resort economy.

Pineapple provided a narrow economic base. It made Lanai citizens feel vulnerable, and they have been calling on government and industry for over two decades to diversify agriculture on the island. The community could do nothing on its own. It had no land and no resources. Lanai Company owned all the land and the infrastructure. Government could help, and the Department of Agriculture tried to create opportunity for the community. It negotiated a 100-acre site with Lanai Company for an agricultural park, but it did not develop it.

Lanai Company tried several ventures, but none proved to be attractive as a business. Data on company projects are given below in this memo.

The Water Use and Development Plan

The WG is dealing with the issue of agricultural water as part of the Water Use and Development Plan (WUDP). The planning process comes under the State Water Code. Ultimately, the County Council and the Commission on Water Resource Management (CWRM) will decide the issue of allocation.

Council must adopt the WUDP by ordinance. CWRM must accept it as part of the state plan.

The process is a bottom-up effort. The WUDP starts at the county level under the principle of home rule. For Lanai, the WG is the planning group. It is made up of county officials, Lanai Company officials, and community members. The WG is an outgrowth of the Water Subcommittee created by the county council.

The WUDP process gives the community a chance to work out its differences in water use and development. In this sense, the community has the means to control its own destiny if it chooses to do so.

The Community Plan is the starting point

The Community Plan is intended as the starting point for the WUDP. It reflects what the community wants for its future. The 1983 Plan is being revised and a draft is now before the council for action.

There is a problem with the process. Revision to the 1983 Plan is overdue. Therefore, all other plans being developed now are either out of sequence or are being delayed. Because of the practical problems of sequencing, more people now are saying that the Community Plan and the WUDP should be developed together. It makes sense when it comes to water. Decisions on land use and water allocation should be made together, not one over the other. Of course, that is only my opinion.

The 1983 Community Plan and the draft of the revised plan both envision agriculture as part of the economy of the island. There are subtle differences in philosophy and expectations of the community.

The 1983 Community Plan for Lanai recommended the following:

1. *Keep pineapple as the primary economic activity and add tourism as the secondary activity.*

2. *Develop diversified agriculture as an economic activity and a source of local food products for the island.*

The 1995 draft currently before the Council for action has these recommendations:

1. *Promote diversified agriculture as a means of establishing job and income stability.*

2. *Establish and reserve a minimum water allocation to meet the needs of diversified agriculture.*

3. *Ensure the long-term availability of low-cost water for agricultural purposes.*

Lanai Company Initiatives

The information presented here came from Steve Snow, the person in charge of diversified agriculture for the company. The date is November 1994. Steve Snow is no longer in charge. More current information should be available from the company when we meet on August 1.

Data on agriculture is summarized below:

Land available for diversified agriculture	14,000 acres
Planned Use (Nov 1994)	
Pasture lands	12,000 acres
Dryland forage crops	2,000 acres
Planned Livestock (Nov 1994)	
Cattle for mainland shipment	800 to 1000 head
Hogs (300 sows)	4,000 hogs/year
Dairy heifers	No estimate
1994 Crops	
Banana	5.5 acres
Papaya	20 acres
Pineapple and herbs	50 acres
Barge Schedule	Once/week
Water consumption (1994 approx)	200,000 gpd
Cost of agricultural water (1994)	$0.96/1000 gal

Lanai is at a disadvantage when competing in the state agricultural market. Barging is only once a week. The shipping schedules and cost are problems to marketing products outside the island.

Cost of agricultural water is higher here than anywhere else. For example, DOA water sells for $0.16/1000 gal. Large users on Maui pay $0.64/1000 gal. I believe farmers using Waiahole water will be paying around $0.35/1000 gal. That was the number being tossed around in discussions among the farmers there. Lanai farmer pays $0.96/1000 gal or greater.

Recent Proposals for Agricultural Water

The community is going through the third iteration of the WUDP. The first was in 1990. It was prepared by the Maui BWS. The second was the 1992 WUDP that remained in draft form. Now, the WG is working on the 1996 WUDP. The agricultural components of the projected water demand are as follows:

Plan	Agricultural Use	Mgd	Remarks
1990 Maui BWS	Pineapple	1.8	1988 usage was 2.4 mgd. Reduction in pineapple.
1992 Draft Maui BWS	Diversified Agriculture (No pineapple)	1.5	Lanai Company disagreed. Company proposed 1.0 mgd.
Present Maui Council	Diversified Agriculture	??	

The decision to phase out pineapple was made public sometime in 1991. The company proposed that diversified agriculture would be somewhere around 1.0 mgd operation. The Department of Agriculture proposed the creation of a 100-acre agricultural park, requiring 0.5 mgd of irrigation water. The water task force recommended adding the 0.5 mgd to 1.0 mgd to get 1.5 mgd as the amount of water to be set aside for diversified agriculture. Lanai Company disagreed, claiming that the 1.0 mgd includes the 0.5 mgd demand for the agricultural park. Besides, the company said, DOA agreed to a lower number of 0.2 mgd for agricultural demand.

There was a problem over the agricultural park water demand. DOA reported to the CWRM in the state projects plan that the demand for the agricultural park of 0.5 mgd. At the same time, it agreed with Lanai Company that it should be lower, at around 0.2 mgd, without telling the WUDP task force or the CWRM about it.

The issue in the 1992 draft boiled down to whether diversified agriculture should be 1.0 mgd or 1.5 mgd operation, a difference of 0.5 mgd. Obviously, there are different philosophies and criteria involved here. That is not surprising. As I mentioned before in this memo, agriculture means different things to different people.

Conclusion

There is no doubt that the issue is complex. I sense that agriculture on Lanai means more than growing crops and getting them to market. You can help the WG and other members of the community sort through the complexities and gain insight into the issue of agriculture on Lanai. In the end, it will be their decision to make.

Call if you have questions.

cc: Members, Lanai Water Working Group

UNIT WATER CONSUMPTION FOR SFR, MAUI COUNTY WATER DISTRICTS.							
(Ref: Water Use and Development Plan, County of Maui, 1992)							
AREA	District	Class	Number Served	Max, gpd/serv	10%-tile gpd/serv	Median gpd/serv	Average gpd/serv
Makena	155	SFR	36	12789	5403	903	2090
Wailea	151w	SFR	93	4512	2496	1334	1455
Maalaea	153	SFR	21	7518	2055	921	1289
Maui Meadows	151m	SFR	561	5559	2151	1153	1229
Ulupalakua	335	SFR	31	6104	1458	342	841
Kihei	151	SFR	2520	6814	1312	655	841
Spreckelsville	173	SFR	88	5126	1521	599	809
Honokowai	513	SFR	209	6405	1310	614	641
Lahaina	511	SFR	1805	4499	1044	501	630
Alaeloa	515	SFR	207	3173	1101	434	556
Lower Kula	333	SFR	577	64888	6767	381	537
Kahului	131	SFR	3404	3290	915	458	519
Kawela-Kaunakakai	711	SFR	533	3036	800	405	454
Ualapue	713	SFR	273	6219	904	290	452
Pukalani	316	SFR	1569	8874	762	359	442
Haliimaile	317	SFR	188	1762	797	374	430
Waihee	113	SFR	142	7112	682	322	428
Upper Kula	331	SFR	1138	6784	789	293	413
Wailuku	111	SFR	3121	4693	759	342	407
Kuiaha	312	SFR	187	6893	707	260	392
Waikapu	115	SFR	202	3178	718	296	391
Lanai	Private	SFR	899	1970	654	333	373
Wailuku Heights	117	SFR	380	0.15	1855	833	367
Kokomo-Kaupakalua	311	SFR	611	2874	712	279	365
Hana	911	SFR	252	3129	707	274	351
Paia-Kuau	171	SFR	634	3323	773	344	342
Makawao	315	SFR	1657	3773	619	279	339
Haiku-Pauwela	313	SFR	514	3416	614	255	334
Honokohau	517	SFR	10	1370	285	217	303
Kalae	715	SFR	88	1058	466	227	251
Halawa	717	SFR	5	562	123	71	174
Makena	155	MFR	6	864	NA	NA	629
Wailea	151w	MFR	4	779	535	476	493
Kahului	131	MFR	26	568	431	415	426
Maalaea	153	MFR	12	408	350	308	293
Lahaina	511	MFR	47	2553	813	309	273
Wailuku	111	MFR	70	16899	448	223	266
Kawela-Kaunakakai	711	MFR	18	530	375	274	261
Kihei	151	MFR	4970units	1345	1191	352	259
Makawao	315	MFR	4	311	288	245	253
Pukalani	316	MFR	6	319	259	164	203
Paia-Kuau	171	MFR	3	348		279	203

UNIT WATER CONSUMPTION FOR SFR, MAUI COUNTY WATER DISTRICTS.							
(Ref: Water Use and Development Plan, County of Maui, 1992)							
AREA	District	Class	Number Served	Max, gpd/serv	10%-tile gpd/serv	Median gpd/serv	Average gpd/serv
Pukalani	316	MFR	6		259	164	203
Honokowai	513	MFR	90	4849	770	113	179
Alaeloa	515	MFR	23	570	405	279	172
Puunene	141	COM	9	76825	33433	14701	21262
Wailea	151w	COM	43	134076	24301	3222	8542
Kihei	151	COM	160	78500	15083	1982	7423
Wailuku Heights	117	COM	7	24066	8230	4112	6842
Honokowai	513	COM	70	31279	19956	1807	5711
Waihee	113	COM	7	38411	463	378	5700
Makawao	315	COM	27		8666	2433	4086
Maalaea	153	COM	6	17153	3499	907	3756
Alaeloa	515	COM	35	12877	9170	2964	3691
Spreckelsville	173	COM	16	9337	7077	1759	3133
Kahului	131	COM	354	55395	7364	818	2918
Lahaina	511	COM	170	25055	8756	438	2173
Wailuku	111	COM	400	34008	3915	449	1675
Upper Kula	331	COM	45	13381	1603	334	1214
Pukalani	316	COM	23	9285	2321	471	1076
Paia-Kuau	171	COM	44	15762	1978	254	1053
Kokomo-Kaupakalua	311	COM	12	4373	4132	462	1041
Haiku-Pauwela	313	COM	13	6181	899	249	755
Kawela-Kaunakakai	711	COM	67	12548	1638	233	740
Lower Kula	333	COM	18	3274	1510	331	678
Waikapu	115	COM	15	2323	696	342	505
Ualapue	713	COM	18	893	532	82	188
Lahaina	511	HOTEL	7	14748	4356	638	3260
Makena	155	HOTEL	4	NA	NA	NA	609
Wailea	151w	HOTEL	4	6836	1389	1449	531
Kihei	151	HOTEL	170units	NA	NA	NA	458
Honokowai	513	HOTEL	960	708		456	392
Alaeloa	515	HOTEL	7	340		310	267
Kahului	131	HOTEL	450 units	NA	NA	NA	206
Kawela-Kaunakakai	711	HOTEL	1	0	0	0	0
Kahului	131	IND	58	90058	25348	3134	8527
Kihei	151	IND	26	33337	18071	4137	6905
Lahaina	511	IND	43	41060	17088	3532	6678
Waikapu	115	IND	3	5764		5769	4829
Honokowai	513	IND	2	6775			4819
Wailuku	111	IND	71	23710	5918	100	2307
Kawela-Kaunakakai	711	IND	7	5844	2688	964	1638
Paia-Kuau	171	IND	10	6836	1452	930	1446

APPENDIX B

Water Conditions of Project Approvals

Ordinances Pertaining to Project District I - Manele

Ordinance #1578(1986) – A Bill for an Ordinance Relating to the Standards for the Project District At Manele, Lanai, and the Procedures for Project Districts

Slopes

12 to <15% slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands –

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses - Restrictions on the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

Ordinance #2132 – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the PD –L-/1 Project District for the Property Situated at Manele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non potable water sources.

Slopes

12 to < 15% slope – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

15 to < 30% slope – No more than 30% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

30% slope or more – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40% shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2133(1992) – A Bill for an Ordinance to Establish Zoning in PD-L/1 (Manele) Project District (Conditional Zoning) for Property Situated at Manele, Lanai, Hawaii

Conditions: (Declarant)

Establish a loan fund of $1M to be administered and managed by the Bank of Hawaii, in consultation with Lanai Resort Partners for the purpose of assisting current Lanai City merchants with improvements of their commercial facilities.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien encumbrances, 115 acres of land adjacent to the Lower Waialua SF site to the County.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien cumbrances, a minimum of an acre of land on Lanai to the County for use as a veterans' cemetery.

Consummate a land exchange with the County for new police station upon terms and conditions acceptable to the declarant and the County.

Use only non-potable water as defined in Ordinance #2066 enacted by the county on 12/17/91, for the irrigation of the golf course in the Manele PD.

Make the Manele Golf course available for play to Lanai residents at a Kamaaina rate of 50% of the standard rate and for Hawaii residents at 60% of the standard rate.

Take appropriate preventive measures so that is development, construction, operation, and maintenance activities in the Manele PD do not cause any deterioration in the Class AA water quality standards currently in existence at Hulopoe Bay and the coastal waters adjacent to the Manele Bay Hotel and the Manele Golf Course.

Provide additional non-potable sources of water as may be needed for Manele Golf Course irrigation after consultation with the State CWRM and DOH.

Comply with the environmental health concerns addressed, entitled "Twelve (12) Conditions Applicable to All New Golf Course Development dtd 1/92 issued by the State DOH. (copy attached)

Ordinance #2408(1995) – A Bill for an Ordinance Amending Chapter 19.70 of the Maui County Code, Pertaining to Irrigation in Lanai Project District I Manele

Effective 1/1/95, no potable water drawn from the high level aquifer may be used for irrigation of the golf course, driving range, and other associated landscaping. The total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range, and other associated landscaping shall not exceed an average 650,000 gallons per day expressed as a moving annualized average using 13-28 day period rather an 12 calendar months or such other reasonable withdrawal as may be determined by the Maui County Council upon advice from its standing committee on water use.

Ordinance #2411(1995) – A Bill for an Ordinance to Establish the Project District Zoning (Conditional Zoning) in PD-L/1 (Manele) – Project District for Property Situated at Manele, Lanai

Conditions:

Water Resource Management Program be developed for the island and the Manele/Koele resorts and be submitted to the Planning Dept. and CWRM. Essential elements of the program shall include:

Study of the water resource which may include monitor wells, electromagnetic resistivity testing, complete and accurate records of the water budgets, rainfall, pan evaporation, consumptive use and pumping from each well source, in order to increase baseline data in regards to the island's geomorphology and the sustainable yield and delineation of high level (potable) and alternative (brackish) sources.

Plan for the use of effluent and desalinized water within the resort.

Greater metering and monitoring of specific water uses in order to establish an island-wide pattern of consumption and to control incidents of unreasonable uses and leakage fro m the storage and distribution system.

A detailed study of the projected water consumption patterns in the Manele Resort along with a detailed management scheme to reduce consumption within the resort, including the use of low-flow devices and offering guidelines for landscaping with salinity and drought tolerant plants and grasses.

Covenants for limits on water consumption and irrigated areas for dwelling units and restrictions on other uses to be included as legally binding instruments on the property owners; and a management program established to administer and enforce the covenants.

The applicant shall request a cooperative monitoring agreement with the USGS, through either DWS of CWRM to enhance data gathering and analysis for the islands water resources.

The commercial use area designated in the project district shall be deleted from the Hulopoe Bay Park shoreline area.

A conceptual archeological preservation interpretation plan, including buffer zones and setbacks shall be reviewed by the Maui County Cultural Resources Commission and the Lanai Archeology Committee, before the Phase 2 Project District approval.

All SF dwelling units shall be used only for long-term residential use. At such time additional hotel units are constructed or provided within the project district, the use of MF units for short-term vacation use shall be discontinued.

The applicant shall provide to the State CWRM its 28 day water usage report of potable and non-potable water for the Manele Project District and shall immediately inform said commission of any withdrawal of potable and non-potable water from the high level aquifer in excess of 70% of the sustainable yield as determined by said commission for the island of Lanai.

The applicant shall defer all applications for any approvals for the development of residential units (SF/MF) in the Puupehe Peninsula and the area east of Manele Road in the Manele Project District until the appropriate use of the peninsula and the area east of Manele Road is determined by the enactment of the pending Lanai Community Plan by the Maui County Council.

The applicant may subdivide the agricultural classified lands in the additional area of the Manele PD pursuant to Section 18.16.270 (large lots) and shall defer all applications for any approvals for the development of the Ag classified area in the Manele PD that have not yet been reclassified to urban by the state Land Use Commission in its decision and order dtd Oct. 24, 1994, except that infrastructural improvements necessary to the residential subdivision in the urbanized area, such as but not limited to, drainage and erosion control, sewer force main, water main and roadways, are permitted until said areas are reclassified to urbanized area by the state Land Use Commission pursuant to the said decision and order and any amendment thereof. In the event of an amendment wherein a portion of the Ag area is reclassified to rural, the applicant shall be permitted to develop the newly reclassified urban area and

shall defer all applications for any approvals for the development of the newly reclassified rural area established by said amendment until said rural area is reclassified as heretofore stated in this condition.

Ordinance #2743(1998) – A Bill for an Ordinance Pertaining to the PD-L/1 Project District Situated at Manele, Lanai, Hawaii

Conditions: numbers 1 though 8 – same as in Ordinance #2411

No dwellings (residential units) on any kind shall be permitted within the open space designation in the Puupehe Peninsula. However, structures to promote cultural resources and preserve archaeological resources, based upon resource management plan for the area developed by the Cultural Resources Commission and the Hui Malama Pono O Lanai, shall be permitted.

Work with the Cultural Resources Commission and the Hui Malama Pono O Lanai organization to limit impacts of the MF project east of Manele Road to achieve the following:

Cultural protection of archeological sites at the Manele area proper.

Creation of a buffer zone at least 200 feet between the closest building the nearest heiau.

Completion of a drainage plan prior to construction, which would include addressing the adequacy of the siltation basin currently used to protect the small boat harbor

Hiring of Kupuna form Lanai to monitor the project's development during construction consistent with the current agreement with the Lanai Archeological Committee.

The designation of the6.6 acre site from SF to hotel use shall not increase the total number of hotel units within the PD in accordance with the density standards provided in the PD ordinance.

Current Manele PD

Land Use Type	Acres	Max Density (units/ac)	= Max Units	Water or Density Conditions in Ordinance
SF - Residential	328.8	0.8576 net units /acre 6,000 sq. ft. lot minimum min width 60'	282	setbacks front 15, side 8, rear 10 for single story <7,500 sq. ft. ; front 20 for lots greater than 7,500 sq. ft.; side and rear 15' for second story of structure.
Multi-family	55	3.34 net units / acre min lot area 1 acre min lot width 120'	184	front 25', side and rear 15' for one story, side and rear 20' for 2 story.
Commercial	5.25	0.5 acres 75' wide min. max 60% coverage structures min 6' setback +		+ setbacks per requirement of adjacent land-use, but not less than 6'
Hotel	56.6	10 units per acre 5 acres 250' wide min. max 50% coverage	500*	front 50', side 30', rear 30' *Ordinance 2743 (1998) stipulated that additional 6.6 acres added to the hotel site should not be construed to mean that more hotel units were allowed.
Park	66.33	10 acres 350' wide min max lot coverage 2% structures min 50' setback		dedication of park required
Open Space	152.02			
Golf Course	172	50 ac. 9 hole, 110 ac. 18 hole structures min 50' setback		No potable water drawn from the high level aquifer to be used for irrigation of golf course, driving range and other associated landscaping. Non-potable water from the high level aquifer not to exceed 0.65 MGD, annualized avg. basis (13, 28-day periods)..except as allowed by Maui County Council upon advice of standing committee on water use.
Roads	32			
OTHER				no more than 60% of existing woodland area in project area shall be cleared. Rest shall remain as permanent undisturbed open space. Also 95% dunes OS, 95% ravines, all wetlands, all bluffs - permanent open space
				xeriscaping “encouraged”, use of recycled water “considered” for irrigation purposes.

Ordinances Pertaining to Manele Land Use - Density and Acreage

	ORDINANCE 1578 1986 DENSITY*			ORDINANCE 2132 1992 DENSITY*			ORDINANCE 2410 1995 DENSITY*			ORDINANCE 2743 1998 DENSITY*		
	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS
SF RESIDENTIAL	137.00	2.50	342.50	121.00	2.84	343.64	379.00	0.86	325.03	328.80	0.86	281.98
MF RESIDENTIAL	18.60	4.00	74.40	18.60	4.00	74.40	30.00	3.34	100.20	55.00	3.34	183.70
COMMERCIAL	5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%	
HOTEL	50.00	10.00	500.00	50.00	10.00	500.00	50.00	10.00	500.00	56.60	10.00	500*
PARK	66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide	
GOLF COURSE	0.00			201.00	min 110 ac 18-hole		172.00	min 110 ac 18-hole		172.00	min 50 ac 9-hole min 110 ac 18-hole	
PUBLIC	4.25	min 2 acs. 50' setbacks		4.25	min 2 acs. 50' setbacks		4.25				min 2 acs. 50' setbacks	
OPEN SPACE	113.91			89.91			133.42			152.02		
ROADS							32.00			32.00		
TOTALS:												
Acreage	**395.34**			**556.34**			**872.25**			**868.00**		
Units:												
SFR			**342.50**			**343.64**			**325.03**			**281.98**
MFR			**74.40**			**74.40**			**100.20**			**183.70**
HOTEL			**500.00**			**500.00**			**500.00**			**500***
Increases:				**161.00**			**315.91**			**-4.25**		
Notes:				although total acreage change reflected is 161, ord. #2133 added only 138.577 acres. zoning map 2607 reason for discrepancy not clear.			although acreage change reflected is 315.91, ord # 2411 established zoning for 319.447 acres. zoning map L26-10 reason for discrepancy not clear.			* ordinance states that addition of 6.6 acres to hotel site shall not increase total # of units land zoning map L-2613. Ord also lists total ac as 868, though sum seems to be 836.		

* for all conditions, see ordinance, units per acre only given here except where noted otherwise

Ordinances Pertaining to Project District 2 - Koele

Ordinance #1580(1986) – A Bill for an Ordinance Relating to Standards for the Project District at Koele, Lanai

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Required Agreements:

A Bilateral agreement requiring the applicant to develop and coordinate a training program for all phases of hotel operations; provided that development other than hotel development within the PD may proceed before the agreement has been executed and

A bilateral agreement requiring the applicant to develop and coordinate an affordable housing program for residents of Lanai; provided that development other than hotel development within the PD may proceed before the agreement has been executed

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

This ordinance shall not be construed to prevent the use of reclaimed water for irrigation and other non-domestic purposes.

Ordinance #2139(1992) – A Bill for an Ordinance Amending Title 19 of the Maui County Code Pertaining to the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources.

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Ordinance #2407(1995) – A Bill for an Ordinance Amending Section 19.71.090 Koele Project District Standards Ordinance, Maui County Code

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Plans

A tract master plan shall be provided showing the building envelope, required setbacks and preliminary drainage plan for each lot within the given tract and shall be reviewed and approved by the Planning Department during Phase III PD review. The Planning Dept. may impose mitigative measures to ensure minimum subsidence and erosion on slopes exceeding 30% and on portions of the tract that are immediately adjacent to ravines. The tract master plan may include all or any part of the given tract, however, Phase III approval shall only apply to that part. Prior to the issuance of a building permit for a dwelling on a lot, the grading and erosion control plan for that lot shall be submitted to and approved by the Department of Public Works and Waste Management, which shall review the final grading plan in accordance with the following criteria:

Drainage

Individual lot drainage shall conform with the approved Phase III preliminary drainage plan

Erosion Control

Erosion control measures to prevent erosion and sedimentation into the adjoining natural drainage way during construction of the home and exterior improvements shall be specified

A plan shall be submitted for re vegetation of all disturbed and exposed slopes. This plan shall show how exposed surfaces will be planted and covered after construction to prevent erosion and sedimentation into the adjoining drainage way; and

The Planning Dept. may require additional information if deemed necessary to support any request for Phase III approval.

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. Furthermore, the use of recycled water is to be considered for irrigation purposes.

Ordinance #2514(1996) – A Bill for an Ordinance Amending Ordinance #2140 Pertaining to a Condition of the Establishment of Zoning (Conditional Zoning) in PD-L/2 (Koele) Project District for Property Situated at Koele, Lanai, Hawaii

The Declarant shall irrigate the Koele golf course with non-potable water, as defined in Ordinance #2066 enacted by the County on 12/7/91 (after the golf course has been operating for 5 years as provided by the Planning Commission on 11/28/89), except as may otherwise be provided by the provisions of the Maui County Code. Within 2 years of the effective date of this ordinance Lanai Company shall present to the Maui County council a report detailing:

A comprehensive plan to develop additional storage of water for Koele golf course irrigation.

The time frame within which the plan will be implemented.

Steps taken to implement the plan at the time the plan is submitted.

Ordinance #2515(1996) – A Bill for an Ordinance Amending Section 19.71.055 of the Maui County Code, Relating to Irrigation of the Koele Golf course (Lanai Project District PD-L/2) Located at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources, except as may be allowed from time to time as follows:

The director of the Dept. of Public Works and Waste Management, after notification of the chairperson and the deputy director of the CWRM, the chair of the Maui County Council, any appropriate subcommittee established under one of the Maui County Council's standing committees to review water related issues on Lanai, the chair of the Lanai Planning Commission, and other state and/or county officials as appropriate, may authorize the use of potable ground water from the high level aquifer if the director finds, in writing, there is an occurrence of an unanticipated even, including but not limited to:

- Chemical contamination of a non-potable source by chemicals not approved for application to golf courses in accordance with the Golf Course Superintendents Association of America standards; or
- Chemical contamination of a non-potable source resulting in chemical concentrations not approved for golf course application by the Golf Course Superintendents Association of America, excluding however, naturally occurring concentrations of chemicals or minerals; or
- A water transmission line break resulting in the interruption in the delivery of non-potable water for golf course irrigation; or
- Failure of the pumping system used to pump non-potable water; or
- A failure in the sewage reclamation systems which provide irrigation water for the golf course; or
- Draw-down of various lakes or reservoirs due to use of that water to fight fires or other similar emergencies; or
- Due to the failure of the main electrical power feed to facilities used to irrigate the golf course with non-potable water; and

Under no circumstances shall drought be deemed in an unanticipated event, such tat a permit may be issued.

Prior to the director approving the use of potable high level aquifer ground water for golf course irrigation, the golf course owner shall have provided to the director:

- Materials, reports and other supporting document setting forth the facts and/or circumstances which gave rise to the immediate need for golf course irrigation with potable high level aquifer ground water;

- A plan showing that no continuous physical connection will be made between potable and non-potable water systems;
- The remedial plan to restore the use of non-potable water in as short a time as possible, and shall include manufacturing and/or shipping times of various items needed for the restoration, as appropriate, and shall further indicate those items will be obtained and/or shipped by the most expeditious means available; and
- A plan detailing how the following uses will be accommodated, including all sources from which water will be obtained (specifically addressing the use of existing reservoirs and lake water) and a watering/distribution plan, with the priority of uses as follows, such as being bases on a daily average of the historical record use over the prior 12 month period immediately preceding the unanticipated event:
    - Residential/domestic consumption (excluding irrigation uses);
    - Commercial, business, and resort consumption where potable water is necessarily used;
    - Agricultural consumption; and
    - Irrigation (including residential and large scale uses such as golf course). This part of the plan shall address the order in which the portions of the golf course shall cease to be watered as the situation continues.

The permit issued by the director shall:

Be issued only one time for any single unanticipated event and shall be valid for a period not to exceed 30 calendar days. The director may propose a longer period to the council and the council, by resolution, may indicate its concurrence with the director's determination that the permit should be issued for a period greater than 30 days. If the council does not concur, the permit shall be valid for a period not to exceed 30 days. The golf course owner is prohibited from applying for a new permit for the same unanticipated event where the original permit has expired and the remedial action has not been completed, and the director is prohibited from issuing any further permits for the same unanticipated event where the original permit has expired and the remedial action has not been completed;

Require the golf course owner to submit weekly reports to the director and the council regarding the status of the situation, efforts made to address the situation, and the amount of potable ground water used for the high level aquifer for that week. Meter readings shall be physically verified by the Dept of Public Works and Waste Management;

Include any condition or restrictions appropriate and reasonably related to the circumstances surrounding the use of high level aquifer potable ground water and the remedial work to be done, and also including the authority to impose a cap on the use of such water based on the historical monthly average of use on non-potable water, in an amount not to exceed 250,000 gpd.

A copy of the permit shall be transmitted to all persons notified pursuant to subsection D.1, above the same day it is issued.

Ordinance #2516(1996) – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the Re-seeding or Re-grassing of the Golf Course Located in the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Re-seeding or Re-grassing

Notwithstanding Ordinance #2066, at such time as the fairways at the golf course are to be re-seeded for re-grassed so as to provide the golf course with more efficient or better quality grass, the golf course owner may make a request of the County Council for the use of potable ground water from the high level aquifer in an amount up to 27,000 gpd to supplement irrigation water from alternative non-potable water sources, Such approval, shall be by resolution of the Council. Such additional water may be used for a period not to exceed 28 days per fairway. Only 1 fairway shall be irrigated with the additional water at any given time. No more than 4 fairways shall be re-seeded or re-grassed during any calendar year. Fairways shall only be re-seeded one time only under the provisions of this section. No continuous physical connection will be made between the potable and non-potable water systems. In determining whether or not to approve the golf course owner's request, the Council shall ensure that an adequate supply of water shall be available for golf course irrigation in accordance with the priority of uses as follows:

- Residential/domestic consumption (excluding irrigation uses);
- Commercial, business and resort consumption where potable water is necessarily used;
- Agricultural consumption; and
- Irrigation (including residential and large scale uses such as the golf course).

If during the re-seeding or re-grassing of a fairway, an unanticipated event occurs for which a permit is issued pursuant to Section D above, the golf course owner may continue to use potable water for re-seeding or re-grassing, but only to the extent that such cumulative total of potable water permitted to be used pursuant to Section D and this section does not exceed 250,000 gpd.

Resolution #01-146(9/7/2001) – Approving the Use of Potable Water from the High Level Aquifer for Re-seeding and Re-grassing Koele Golf Course during September and October 2001, Pursuant to Subsection 19.71.55(E), Maui County Code

Conditions: Castle & Cooke Resorts, LLC shall:

- promptly file with the County Clerk a completion bond for the repair of the sewage-treatment plant that serves the Koele golf course;
- repair the sewage-treatment plant that serves the Koele golf course within one year of this resolution's adoption;
- submit a water-storage master plan to the Council by March 1, 2002;
- install a separate water meter, as approved by the Department of Water Supply, prior to the use of potable water approved by this resolution to gauge such use; and
- allow for meter readings to be conducted and verified by two designated members of the Lanai Water Advisory Committee who are not employees of the Castle & Cooke Resorts, LLC or affiliated entities.

Koele PD History		
Year	**Ordinance/ Approval #**	**Comment**
1985	CIZ for Koele PD	Interim Urban to PD Requirements Included ♦ Resource Study ♦ Maintenance of accurate records ♦ Plans for effluent use & desalinized water ♦ Conservation Plan ♦ Legally binding covenants to limit water consumption ♦ Cooperative aquiifer monitoring with USGS ♦ 28 day periodic water reports ♦ Detailed demand study
1986	1580	Established Koele PD - 468.3 Acres
1991	2066	Prohibits the Use of Potable Water on All Golf Courses
1992	2139	Increased Koele PD from 468.3 to 618 acres Added 332.4 acre golf course Deleted 201.5 acres of open space
1992	Phase II PD	Requirements Prior to Phase III Approval ♦ Detailed monitoring plan for metering - common areas to be metered seperately ♦ Dual system for the GC to be submitted to DWS ♦ Approved xeriscape plan ♦ Use of low flow devices
1995	2407	Amends ordinance for tract master plan requirements Limits density of development on slopes of various grades Use of recycled water for irrigation to be considered No more than 60% of woodland to be cleared Cleared area shld be open space Retain minimum of 35% of tree canopy
1996	2514	Sets conditions in which potable water may be utilized on golf course Requires a comprehensive plan to develop additional storage for the GC Storage plan to include time frame and implementation steps
1996	2515	High level water not to be used for irrigation except as defined Sets triggers & requirements to allow 30 day permits for potable water use Un--anticipated events can be part of a trigger, but it is specified that Drought does NOT meet the criteria for un-anticipated event, Nor does it warrant use of the high level aquifer for GC irrigation
1996	2516	Enables GC owner to aply for up to 27,000 GPD per fairway to supplement non potable irrigation to establish new plantings Stipulates that only one fairway may be watered in this manner No more than four fairways per year to be watered this way Combined use of new fairway establishment and emergencies defined in 2515 should not exceed a total of 250,000 GPD
2001	Res 01-146	Issues temporary permit for use of high level water for re-grassing. Requirements: ♦ Bond repairs to wastewater treatment facility ♦ Implement repairs to WWTF within one year ♦ Submit water storage master plan by March of 2002 ♦ Install separate meter to monitor use of high level water and coordinate with LWAC so that LWAC members can monitor/read it

APPENDIX B

Water Conditions of Project Approvals

Ordinances Pertaining to Project District I - Manele

Ordinance #1578(1986) – A Bill for an Ordinance Relating to the Standards for the Project District At Manele, Lanai, and the Procedures for Project Districts

Slopes

12 to <15% slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands –

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses - Restrictions on the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

Ordinance #2132 – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the PD –L-/1 Project District for the Property Situated at Manele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non potable water sources.

Slopes

12 to < 15% slope – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

15 to < 30% slope – No more than 30% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

30% slope or more – No more than 40% of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of (Public Works) Planning .

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40% shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. The use of recycled water is to be considered for irrigation purposes.

Ordinance #2133(1992) – A Bill for an Ordinance to Establish Zoning in PD-L/1 (Manele) Project District (Conditional Zoning) for Property Situated at Manele, Lanai, Hawaii

Conditions: (Declarant)

Establish a loan fund of $1M to be administered and managed by the Bank of Hawaii, in consultation with Lanai Resort Partners for the purpose of assisting current Lanai City merchants with improvements of their commercial facilities.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien encumbrances, 115 acres of land adjacent to the Lower Waialua SF site to the County.

On a fee simple basis, donate at no cost and free and clear of all mortgage and lien cumbrances, a minimum of an acre of land on Lanai to the County for use as a veterans' cemetery.

Consummate a land exchange with the County for new police station upon terms and conditions acceptable to the declarant and the County.

Use only non-potable water as defined in Ordinance #2066 enacted by the county on 12/17/91, for the irrigation of the golf course in the Manele PD.

Make the Manele Golf course available for play to Lanai residents at a Kamaaina rate of 50% of the standard rate and for Hawaii residents at 60% of the standard rate.

Take appropriate preventive measures so that is development, construction, operation, and maintenance activities in the Manele PD do not cause any deterioration in the Class AA water quality standards currently in existence at Hulopoe Bay and the coastal waters adjacent to the Manele Bay Hotel and the Manele Golf Course.

Provide additional non-potable sources of water as may be needed for Manele Golf Course irrigation after consultation with the State CWRM and DOH.

Comply with the environmental health concerns addressed, entitled "Twelve (12) Conditions Applicable to All New Golf Course Development dtd 1/92 issued by the State DOH. (copy attached)

Ordinance #2408(1995) – A Bill for an Ordinance Amending Chapter 19.70 of the Maui County Code, Pertaining to Irrigation in Lanai Project District I Manele

Effective 1/1/95, no potable water drawn from the high level aquifer may be used for irrigation of the golf course, driving range, and other associated landscaping. The total amount of non-potable water drawn from the high level aquifer that may be used for irrigation of the golf course, driving range, and other associated landscaping shall not exceed an average 650,000 gallons per day expressed as a moving annualized average using 13-28 day period rather an 12 calendar months or such other reasonable withdrawal as may be determined by the Maui County Council upon advice from its standing committee on water use.

Ordinance #2411(1995) – A Bill for an Ordinance to Establish the Project District Zoning (Conditional Zoning) in PD-L/1 (Manele) – Project District for Property Situated at Manele, Lanai

Conditions:

Water Resource Management Program be developed for the island and the Manele/Koele resorts and be submitted to the Planning Dept. and CWRM. Essential elements of the program shall include:

Study of the water resource which may include monitor wells, electromagnetic resistivity testing, complete and accurate records of the water budgets, rainfall, pan evaporation, consumptive use and pumping from each well source, in order to increase baseline data in regards to the island's geomorphology and the sustainable yield and delineation of high level (potable) and alternative (brackish) sources.

Plan for the use of effluent and desalinized water within the resort.

Greater metering and monitoring of specific water uses in order to establish an island-wide pattern of consumption and to control incidents of unreasonable uses and leakage fro m the storage and distribution system.

A detailed study of the projected water consumption patterns in the Manele Resort along with a detailed management scheme to reduce consumption within the resort, including the use of low-flow devices and offering guidelines for landscaping with salinity and drought tolerant plants and grasses.

Covenants for limits on water consumption and irrigated areas for dwelling units and restrictions on other uses to be included as legally binding instruments on the property owners; and a management program established to administer and enforce the covenants.

The applicant shall request a cooperative monitoring agreement with the USGS, through either DWS of CWRM to enhance data gathering and analysis for the islands water resources.

The commercial use area designated in the project district shall be deleted from the Hulopoe Bay Park shoreline area.

A conceptual archeological preservation interpretation plan, including buffer zones and setbacks shall be reviewed by the Maui County Cultural Resources Commission and the Lanai Archeology Committee, before the Phase 2 Project District approval.

All SF dwelling units shall be used only for long-term residential use. At such time additional hotel units are constructed or provided within the project district, the use of MF units for short-term vacation use shall be discontinued.

The applicant shall provide to the State CWRM its 28 day water usage report of potable and non-potable water for the Manele Project District and shall immediately inform said commission of any withdrawal of potable and non-potable water from the high level aquifer in excess of 70% of the sustainable yield as determined by said commission for the island of Lanai.

The applicant shall defer all applications for any approvals for the development of residential units (SF/MF) in the Puupehe Peninsula and the area east of Manele Road in the Manele Project District until the appropriate use of the peninsula and the area east of Manele Road is determined by the enactment of the pending Lanai Community Plan by the Maui County Council.

The applicant may subdivide the agricultural classified lands in the additional area of the Manele PD pursuant to Section 18.16.270 (large lots) and shall defer all applications for any approvals for the development of the Ag classified area in the Manele PD that have not yet been reclassified to urban by the state Land Use Commission in its decision and order dtd Oct. 24, 1994, except that infrastructural improvements necessary to the residential subdivision in the urbanized area, such as but not limited to, drainage and erosion control, sewer force main, water main and roadways, are permitted until said areas are reclassified to urbanized area by the state Land Use Commission pursuant to the said decision and order and any amendment thereof. In the event of an amendment wherein a portion of the Ag area is reclassified to rural, the applicant shall be permitted to develop the newly reclassified urban area and

shall defer all applications for any approvals for the development of the newly reclassified rural area established by said amendment until said rural area is reclassified as heretofore stated in this condition.

Ordinance #2743(1998) – A Bill for an Ordinance Pertaining to the PD-L/1 Project District Situated at Manele, Lanai, Hawaii

Conditions: numbers 1 though 8 – same as in Ordinance #2411

No dwellings (residential units) on any kind shall be permitted within the open space designation in the Puupehe Peninsula. However, structures to promote cultural resources and preserve archaeological resources, based upon resource management plan for the area developed by the Cultural Resources Commission and the Hui Malama Pono O Lanai, shall be permitted.

Work with the Cultural Resources Commission and the Hui Malama Pono O Lanai organization to limit impacts of the MF project east of Manele Road to achieve the following:

Cultural protection of archeological sites at the Manele area proper.

Creation of a buffer zone at least 200 feet between the closest building the nearest heiau.

Completion of a drainage plan prior to construction, which would include addressing the adequacy of the siltation basin currently used to protect the small boat harbor

Hiring of Kupuna form Lanai to monitor the project's development during construction consistent with the current agreement with the Lanai Archeological Committee.

The designation of the6.6 acre site from SF to hotel use shall not increase the total number of hotel units within the PD in accordance with the density standards provided in the PD ordinance.

Current Manele PD

Land Use Type	Acres	Max Density (units/ac)	= Max Units	Water or Density Conditions in Ordinance
SF - Residential	328.8	0.8576 net units /acre 6,000 sq. ft. lot minimum min width 60'	282	setbacks front 15, side 8, rear 10 for single story <7,500 sq. ft. ; front 20 for lots greater than 7,500 sq. ft.; side and rear 15' for second story of structure.
Multi-family	55	3.34 net units / acre min lot area 1 acre min lot width 120'	184	front 25', side and rear 15' for one story, side and rear 20' for 2 story.
Commercial	5.25	0.5 acres 75' wide min. max 60% coverage structures min 6' setback +		+ setbacks per requirement of adjacent land-use, but not less than 6'
Hotel	56.6	10 units per acre 5 acres 250' wide min. max 50% coverage	500*	front 50', side 30', rear 30' *Ordinance 2743 (1998) stipulated that additional 6.6 acres added to the hotel site should not be construed to mean that more hotel units were allowed.
Park	66.33	10 acres 350' wide min max lot coverage 2% structures min 50' setback		dedication of park required
Open Space	152.02			
Golf Course	172	50 ac. 9 hole, 110 ac. 18 hole structures min 50' setback		No potable water drawn from the high level aquifer to be used for irrigation of golf course, driving range and other associated landscaping. Non-potable water from the high level aquifer not to exceed 0.65 MGD, annualized avg. basis (13, 28-day periods)..except as allowed by Maui County Council upon advice of standing committee on water use.
Roads	32			
OTHER				no more than 60% of existing woodland area in project area shall be cleared. Rest shall remain as permanent undisturbed open space. Also 95% dunes OS, 95% ravines, all wetlands, all bluffs - permanent open space
				xeriscaping “encouraged”, use of recycled water “considered” for irrigation purposes.

Ordinances Pertaining to Manele Land Use - Density and Acreage

	ORDINANCE 1578 1986 DENSITY*			ORDINANCE 2132 1992 DENSITY*			ORDINANCE 2410 1995 DENSITY*			ORDINANCE 2743 1998 DENSITY*		
	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS	= UNITS	(units per acre)	= UNITS
SF RESIDENTIAL	137.00	2.50	342.50	121.00	2.84	343.64	379.00	0.86	325.03	328.80	0.86	281.98
MF RESIDENTIAL	18.60	4.00	74.40	18.60	4.00	74.40	30.00	3.34	100.20	55.00	3.34	183.70
COMMERCIAL	5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%		5.25	min area 0.5 ac max lot cov 60%	
HOTEL	50.00	10.00	500.00	50.00	10.00	500.00	50.00	10.00	500.00	56.60	10.00	500*
PARK	66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide		66.33	min 10 acs. 350' wide	
GOLF COURSE	0.00			201.00	min 110 ac 18-hole		172.00	min 110 ac 18-hole		172.00	min 50 ac 9-hole min 110 ac 18-hole	
PUBLIC	4.25	min 2 acs. 50' setbacks		4.25	min 2 acs. 50' setbacks		4.25				min 2 acs. 50' setbacks	
OPEN SPACE	113.91			89.91			133.42			152.02		
ROADS							32.00			32.00		
TOTALS:												
Acreage	**395.34**			**556.34**			**872.25**			**868.00**		
Units:												
SFR			**342.50**			**343.64**			**325.03**			**281.98**
MFR			**74.40**			**74.40**			**100.20**			**183.70**
HOTEL			**500.00**			**500.00**			**500.00**			**500***
Increases:				**161.00**			**315.91**			**-4.25**		
Notes:				although total acreage change reflected is 161, ord. #2133 added only 138.577 acres. zoning map 2607 reason for discrepancy not clear.			although acreage change reflected is 315.91, ord # 2411 established zoning for 319.447 acres. zoning map L26-10 reason for discrepancy not clear.			* ordinance states that addition of 6.6 acres to hotel site shall not increase total # of units land zoning map L-2613. Ord also lists total ac as 868, though sum seems to be 836.		

* for all conditions, see ordinance, units per acre only given here except where noted otherwise

Ordinances Pertaining to Project District 2 - Koele

Ordinance #1580(1986) – A Bill for an Ordinance Relating to Standards for the Project District at Koele, Lanai

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Required Agreements:

A Bilateral agreement requiring the applicant to develop and coordinate a training program for all phases of hotel operations; provided that development other than hotel development within the PD may proceed before the agreement has been executed and

A bilateral agreement requiring the applicant to develop and coordinate an affordable housing program for residents of Lanai; provided that development other than hotel development within the PD may proceed before the agreement has been executed

Ordinance #2066(1991) – A Bill for an Ordinance Pertaining to the Use of Potable Water for Golf Courses

Restrictions:

Permit application shall be transmitted to Department of Water Supply for its review and recommendations. The department shall consider whether potable water will be used for irrigation and other non-domestic purposes.

No permits shall be approved for any new golf course if potable water is to be used for irrigation and other non-domestic purposes.

If the State Commission on Water Resources Management designates as water management are pursuant to Chapter 174C, Hawaii Revised Statutes, withdrawals or diversions shall be pursuant to that chapter.

This ordinance shall not be construed to prevent the use of reclaimed water for irrigation and other non-domestic purposes.

Ordinance #2139(1992) – A Bill for an Ordinance Amending Title 19 of the Maui County Code Pertaining to the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources.

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control.

Ordinance #2407(1995) – A Bill for an Ordinance Amending Section 19.71.090 Koele Project District Standards Ordinance, Maui County Code

Slopes

12 to <15% of Slope – No more than 40 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

15 to <30% of slope – No more than 30 % of such are shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

30% slope or more – No more than 15 % of such shall be developed, re-graded, or stripped of vegetation unless approved by the Director of Public Works

Plans

A tract master plan shall be provided showing the building envelope, required setbacks and preliminary drainage plan for each lot within the given tract and shall be reviewed and approved by the Planning Department during Phase III PD review. The Planning Dept. may impose mitigative measures to ensure minimum subsidence and erosion on slopes exceeding 30% and on portions of the tract that are immediately adjacent to ravines. The tract master plan may include all or any part of the given tract, however, Phase III approval shall only apply to that part. Prior to the issuance of a building permit for a dwelling on a lot, the grading and erosion control plan for that lot shall be submitted to and approved by the Department of Public Works and Waste Management, which shall review the final grading plan in accordance with the following criteria:

Drainage

Individual lot drainage shall conform with the approved Phase III preliminary drainage plan

Erosion Control

Erosion control measures to prevent erosion and sedimentation into the adjoining natural drainage way during construction of the home and exterior improvements shall be specified

A plan shall be submitted for re vegetation of all disturbed and exposed slopes. This plan shall show how exposed surfaces will be planted and covered after construction to prevent erosion and sedimentation into the adjoining drainage way; and

The Planning Dept. may require additional information if deemed necessary to support any request for Phase III approval.

Wetlands

Areas such as swamps, marshes, bogs, or other similar lands shall remain as permanent undisturbed open space

Woodlands

No more than 60% of existing woodland area shall be cleared. The remaining 40 % shall be maintained as permanent open space that may be enhanced by landscape planting as approved by the Planning Director.

Landscape Planting

Landscape planting is to be considered as an integral element to be utilized for visual screening, shade definition, and environmental control. Furthermore, the use of recycled water is to be considered for irrigation purposes.

Ordinance #2514(1996) – A Bill for an Ordinance Amending Ordinance #2140 Pertaining to a Condition of the Establishment of Zoning (Conditional Zoning) in PD-L/2 (Koele) Project District for Property Situated at Koele, Lanai, Hawaii

The Declarant shall irrigate the Koele golf course with non-potable water, as defined in Ordinance #2066 enacted by the County on 12/7/91 (after the golf course has been operating for 5 years as provided by the Planning Commission on 11/28/89), except as may otherwise be provided by the provisions of the Maui County Code. Within 2 years of the effective date of this ordinance Lanai Company shall present to the Maui County council a report detailing:

A comprehensive plan to develop additional storage of water for Koele golf course irrigation.

The time frame within which the plan will be implemented.

Steps taken to implement the plan at the time the plan is submitted.

Ordinance #2515(1996) – A Bill for an Ordinance Amending Section 19.71.055 of the Maui County Code, Relating to Irrigation of the Koele Golf course (Lanai Project District PD-L/2) Located at Koele, Lanai, Hawaii

Irrigation

No high level ground water aquifer will be used for golf course maintenance or operation (other than as water for human consumption) and that all irrigation of the golf course shall be through alternative non-potable water sources, except as may be allowed from time to time as follows:

The director of the Dept. of Public Works and Waste Management, after notification of the chairperson and the deputy director of the CWRM, the chair of the Maui County Council, any appropriate subcommittee established under one of the Maui County Council's standing committees to review water related issues on Lanai, the chair of the Lanai Planning Commission, and other state and/or county officials as appropriate, may authorize the use of potable ground water from the high level aquifer if the director finds, in writing, there is an occurrence of an unanticipated even, including but not limited to:

- Chemical contamination of a non-potable source by chemicals not approved for application to golf courses in accordance with the Golf Course Superintendents Association of America standards; or
- Chemical contamination of a non-potable source resulting in chemical concentrations not approved for golf course application by the Golf Course Superintendents Association of America, excluding however, naturally occurring concentrations of chemicals or minerals; or
- A water transmission line break resulting in the interruption in the delivery of non-potable water for golf course irrigation; or
- Failure of the pumping system used to pump non-potable water; or
- A failure in the sewage reclamation systems which provide irrigation water for the golf course; or
- Draw-down of various lakes or reservoirs due to use of that water to fight fires or other similar emergencies; or
- Due to the failure of the main electrical power feed to facilities used to irrigate the golf course with non-potable water; and

Under no circumstances shall drought be deemed in an unanticipated event, such tat a permit may be issued.

Prior to the director approving the use of potable high level aquifer ground water for golf course irrigation, the golf course owner shall have provided to the director:

- Materials, reports and other supporting document setting forth the facts and/or circumstances which gave rise to the immediate need for golf course irrigation with potable high level aquifer ground water;

- A plan showing that no continuous physical connection will be made between potable and non-potable water systems;
- The remedial plan to restore the use of non-potable water in as short a time as possible, and shall include manufacturing and/or shipping times of various items needed for the restoration, as appropriate, and shall further indicate those items will be obtained and/or shipped by the most expeditious means available; and
- A plan detailing how the following uses will be accommodated, including all sources from which water will be obtained (specifically addressing the use of existing reservoirs and lake water) and a watering/distribution plan, with the priority of uses as follows, such as being bases on a daily average of the historical record use over the prior 12 month period immediately preceding the unanticipated event:
    - Residential/domestic consumption (excluding irrigation uses);
    - Commercial, business, and resort consumption where potable water is necessarily used;
    - Agricultural consumption; and
    - Irrigation (including residential and large scale uses such as golf course). This part of the plan shall address the order in which the portions of the golf course shall cease to be watered as the situation continues.

The permit issued by the director shall:

Be issued only one time for any single unanticipated event and shall be valid for a period not to exceed 30 calendar days. The director may propose a longer period to the council and the council, by resolution, may indicate its concurrence with the director's determination that the permit should be issued for a period greater than 30 days. If the council does not concur, the permit shall be valid for a period not to exceed 30 days. The golf course owner is prohibited from applying for a new permit for the same unanticipated event where the original permit has expired and the remedial action has not been completed, and the director is prohibited from issuing any further permits for the same unanticipated event where the original permit has expired and the remedial action has not been completed;

Require the golf course owner to submit weekly reports to the director and the council regarding the status of the situation, efforts made to address the situation, and the amount of potable ground water used for the high level aquifer for that week. Meter readings shall be physically verified by the Dept of Public Works and Waste Management;

Include any condition or restrictions appropriate and reasonably related to the circumstances surrounding the use of high level aquifer potable ground water and the remedial work to be done, and also including the authority to impose a cap on the use of such water based on the historical monthly average of use on non-potable water, in an amount not to exceed 250,000 gpd.

A copy of the permit shall be transmitted to all persons notified pursuant to subsection D.1, above the same day it is issued.

Ordinance #2516(1996) – A Bill for an Ordinance Amending Title 19 of the Maui County Code, Pertaining to the Re-seeding or Re-grassing of the Golf Course Located in the PD-L/2 Project District for Property Situated at Koele, Lanai, Hawaii

Re-seeding or Re-grassing

Notwithstanding Ordinance #2066, at such time as the fairways at the golf course are to be re-seeded for re-grassed so as to provide the golf course with more efficient or better quality grass, the golf course owner may make a request of the County Council for the use of potable ground water from the high level aquifer in an amount up to 27,000 gpd to supplement irrigation water from alternative non-potable water sources, Such approval, shall be by resolution of the Council. Such additional water may be used for a period not to exceed 28 days per fairway. Only 1 fairway shall be irrigated with the additional water at any given time. No more than 4 fairways shall be re-seeded or re-grassed during any calendar year. Fairways shall only be re-seeded one time only under the provisions of this section. No continuous physical connection will be made between the potable and non-potable water systems. In determining whether or not to approve the golf course owner's request, the Council shall ensure that an adequate supply of water shall be available for golf course irrigation in accordance with the priority of uses as follows:

- Residential/domestic consumption (excluding irrigation uses);
- Commercial, business and resort consumption where potable water is necessarily used;
- Agricultural consumption; and
- Irrigation (including residential and large scale uses such as the golf course).

If during the re-seeding or re-grassing of a fairway, an unanticipated event occurs for which a permit is issued pursuant to Section D above, the golf course owner may continue to use potable water for re-seeding or re-grassing, but only to the extent that such cumulative total of potable water permitted to be used pursuant to Section D and this section does not exceed 250,000 gpd.

Resolution #01-146(9/7/2001) – Approving the Use of Potable Water from the High Level Aquifer for Re-seeding and Re-grassing Koele Golf Course during September and October 2001, Pursuant to Subsection 19.71.55(E), Maui County Code

Conditions: Castle & Cooke Resorts, LLC shall:

- promptly file with the County Clerk a completion bond for the repair of the sewage-treatment plant that serves the Koele golf course;
- repair the sewage-treatment plant that serves the Koele golf course within one year of this resolution's adoption;
- submit a water-storage master plan to the Council by March 1, 2002;
- install a separate water meter, as approved by the Department of Water Supply, prior to the use of potable water approved by this resolution to gauge such use; and
- allow for meter readings to be conducted and verified by two designated members of the Lanai Water Advisory Committee who are not employees of the Castle & Cooke Resorts, LLC or affiliated entities.

Koele PD History		
Year	**Ordinance/ Approval #**	**Comment**
1985	CIZ for Koele PD	Interim Urban to PD Requirements Included ♦ Resource Study ♦ Maintenance of accurate records ♦ Plans for effluent use & desalinized water ♦ Conservation Plan ♦ Legally binding covenants to limit water consumption ♦ Cooperative aquiifer monitoring with USGS ♦ 28 day periodic water reports ♦ Detailed demand study
1986	1580	Established Koele PD - 468.3 Acres
1991	2066	Prohibits the Use of Potable Water on All Golf Courses
1992	2139	Increased Koele PD from 468.3 to 618 acres Added 332.4 acre golf course Deleted 201.5 acres of open space
1992	Phase II PD	Requirements Prior to Phase III Approval ♦ Detailed monitoring plan for metering - common areas to be metered seperately ♦ Dual system for the GC to be submitted to DWS ♦ Approved xeriscape plan ♦ Use of low flow devices
1995	2407	Amends ordinance for tract master plan requirements Limits density of development on slopes of various grades Use of recycled water for irrigation to be considered No more than 60% of woodland to be cleared Cleared area shld be open space Retain minimum of 35% of tree canopy
1996	2514	Sets conditions in which potable water may be utilized on golf course Requires a comprehensive plan to develop additional storage for the GC Storage plan to include time frame and implementation steps
1996	2515	High level water not to be used for irrigation except as defined Sets triggers & requirements to allow 30 day permits for potable water use Un--anticipated events can be part of a trigger, but it is specified that Drought does NOT meet the criteria for un-anticipated event, Nor does it warrant use of the high level aquifer for GC irrigation
1996	2516	Enables GC owner to aply for up to 27,000 GPD per fairway to supplement non potable irrigation to establish new plantings Stipulates that only one fairway may be watered in this manner No more than four fairways per year to be watered this way Combined use of new fairway establishment and emergencies defined in 2515 should not exceed a total of 250,000 GPD
2001	Res 01-146	Issues temporary permit for use of high level water for re-grassing. Requirements: ♦ Bond repairs to wastewater treatment facility ♦ Implement repairs to WWTF within one year ♦ Submit water storage master plan by March of 2002 ♦ Install separate meter to monitor use of high level water and coordinate with LWAC so that LWAC members can monitor/read it

APPENDIX C

Public Process

Documentation of Public Participation and Partial History of Community Water Committees on Lanai

03/03/89 Petition from concerned citizens on Lana`i to the State Commission on Water Resource Management (CWRM) to designate the aquifer as a groundwater management area.

08/29/89 Public hearing held on Lana`i. CWRM staff recommended not to designate.

03/29/90 CWRM decided not to designate any of the aquifer systems on Lana`i as groundwater management areas. However, in lieu of designation, the Commission required data monitoring, submittal of a water shortage plan, and annual October information status hearings. CWRM also retained the authority to re-institute designation proceedings if specified conditions were met.

10/23/90 First annual public informational meeting held on Lana`i.

01/17/91 Lana`i Company Water Shortage Plan approved. *(by whom? staff has not seen it.)*

02/17/93 Council Chair requests stop-work at Manele golf course pursuant to violation of condition of county code §19.70.085 prohibiting the use of water from the high level aquifer for Manele golf course.

05/7/93 Council Resolution 93-42 defers enforcement of county code §19.70.085 given certain conditions. Allows use of 750,000 gpd for the interim, with restrictions. Establishes Lana`I Water Subcommittee until 12/31/93 “to monitor the use of water from Lana`I’s high level aquifer. Subcommittee has 9 members:

1 from CWRM
1 from Lanai Planning Commission
1 Lanai Council Member
3 Lanai Company
3 Lana`ians for Sensible Growth

06/17/94 Proposed bill amending §19.70.085 to allow withdrawal of 650,000 gpd considered by Planning Commission.

09/22/94 Planning Director recommends a total allowance of 650,000 gpd MAN of 13-28 day monitoring periods, to be monitored by council standing committee. Recommends that subcommittee be impaneled as subcommittee of Human Service, Water & AG committee. Proposed subcommittee composition:

3 Lanai Company
3 Lana`ians for Sensible Growth
1 Lanai Council Member
1 Lanai Planning Commission Director
Pubic Works Director
BWS Director
CWRM Representative

09/28/94 Referred to council. Hearing deferred until 4/17/95

10/07/94 State Commission on Water Resource Management (CWRM) receives request from Lanaians for Sensible Growth to "reconsider its initial refusal to designate Lanai as a water management area in view of the serious disputes that have arisen over the future use of the islands's very limited water resource."

01/25/95 CWRM defers action on the petition to designate Lana`i until it can meet on Lana`i in October. Requests quarterly status updates on community plan and Water Use & Development Plan.

05/15/95 Council Subcommittee Established (Bill #13, 1995, Committee Rpt 95-79) Membership:

2 LSG
2 Lanai Co

1 Lanai Council Member
1 Lanai Planning Commission Chair
Planning Director
Public Works Director
1 LEGS - Non Voting
BWS Director - Non Voting

9/13/95 *A Numerical Groundwater Model for the Island of Lana`i, Hawaii* approved by CWRM.

10/24/95
01/10/96 On both these dates, CWRM defers action on petition to designate to allow more time for public and peer review of the document *A Numerical Groundwater Model for the Island of Lana`i Hawaii*.

04/96 CWRM Establishes Lanai Water Working Group as successor of Subcommittee. CWRM adopts final draft of *A Numerical Groundwater Model for the Island of Lana`i, Hawaii* CWRM defers action on the petition to designate until October 1996.

06/27/96 Water Subcommittee Meeting. Concluded that the housing projection of 1,019 additional units by 2010 was unrealistic. Discussion of per-unit allocations at Manele and Koele. Recommended 1,600 gpd per unit - with 600 potable and 1,000 non-potable. 600 gpd for hotel. Higher than generally used per-unit standards and should be reviewed further. For Koele, 1000 gpd / unit was questioned. As per 1992 Draft WUDP, dual system under construction for Manele. Committee elected to add “Agricultural Reserve” as a line item and to discuss further with Dept. of Ag. Discussion of Working Group Report / Draft WUDP policy document - using 1995 data as base year. Mechanism for home rule and to forge consensus on resource issues.

08/01/96 Water Subcommittee Meeting. Discussion of diversified agriculture on Lanai. Introduction of James Nakatani, Chair of the Board of Agriculture. Background: Workiing Group Report in progress based on last approved community plan from 1983. With community plan overdue, other plans are out of sequence. 1983 Community Plan recommended that pineabple continue to be primary economic activity and tourism secondary. Not consistent with what’s happening now. Draft 1995 Community Plan recomends promotion of diversified agriculture, establishing a reserve for agriculture, and ensuring the long-term availability of low cost water for

agriculture. 14,000 acres available for diversified agriculture per document form Steve Snow, who was in charge of diversified agriculture for the company in November 1994. At that time planned acreages were: 12,000 ac pasture, 2,000 ac dryland forage, 5.5 acres banana, 20 acres papaya, 50 acres pineapple and herbs, with an estimate of 200,000 gpd at 96 cents per 1000 gallons. 1990 WUDP proposed 1.8 MGD for ag. The end of pineapple was announced in 1991. The 1992 Draft WUDP proposed 1.5 MGD for diversified ag. At that time, the Dept of Ag had proposed the creationof a 100 acre agricultural park to use 500,000 gpd. The water task force at the time recommended increasing that set-aside to 1.5 MGD, although the company was initially in disagreement, recommending an Ag reserve of 1.0 MGD. Issue still under discussion for Working Group Report. DOA has as yet received no proposals for Ag park. Will develop only if there is community interest. Suggests focus on high-value niche crops. Waiahole consumptive use about 3,500 gp acre. More discussion on development proposals, criteria, projections and analysis, 1995 demand data and plans for Working Group Report. Lana'i Co. suggested 2% per year growth projection as more realistic than Community Plan. Committee to consider. Roy Hardy summary: 9 MGD recharge, 6 MGD sustainable yield, 4.3 MGD 13-MAV limit for designation proceedings, 3.6 13-MAV trigger for deepening wells, declining water levels to 50% also trigger for CWRM action. Company reports working on watershed plan as recommended previously. Conservation - largest potential savings in Manele PD area. Hotel water features, landscaping, leak detection, improved monitoring, promotion of conservation. Committee to discuss timelines for demand.

08/29/06 Water Subcommittee Meeting. Discussed alternate projections of water demand for residential, agricultural and other sectors. Discussion on alternative startegies, supply and demand side management, public participation, etc.

9/26/96 Water Subcommittee Meeting. Reviewed allocations proposal for Working Group Report. More discussion on alternative strategies, demand-side and supply-side management, conservation, watershed protection, governance and public participation.

10/18/96 CWRM Public Informational Meeting on Lana'i. Commission votes to proceed with designation process based upon the prospect of serious disputes. Instructs Lana'i Water Company and Workiing Group to prepare

a Working Group Final Report, prepare a schedule nd procedure or adoption, and identify any differences between teh consensus report and the company's findings in their Water Resources Management Plan, and to attend the public hearing in February.

10/31/96 Letter from Lanai Subcommittee Chair, requesting to extend subcommittee to 02/97

11/29/96 First Draft Subcommittee / Working Group Report - Working Draft and Policy Core of WUDP Update.

12/17/96 Water Subcommittee / Working Group Meeting. Discussion - Nov 96 Draft Report was submitted to CWRM in lieu of a final report. Discussion centered on comments and review of draft. Also discussed Ordinance 2408, Bill 13 1995 - the ordinance allowing withdrawal of 650,000 gpd from high levvel aquifer and Council Resolution 93-42 clarification of high level water and conditions for withdraawal of high level water for Manele Golf Course, dated May 7, 1993.

12/31/96 Council Subcommittee dissolved - continued under CWRM as Lanai Working Group until 02/97

01/21/97 BWS moves that Lanai Water Use & Development Plan is part of County Water Use & Development Plan, and properly handled by Board. At the request of the Water Working Group, BWS moves to continue working with the Lanai Committee/Working Group until completion of the Water Use and Development Plan.

01/28/97 Board communicates its decision to the Lanai Working Group in a letter from the Director, that the Lanai Working Group shall continue as an advisory committee to the Board for the Development of the Lanai Water Use and Development Plan, that the working group will not sunset until the entire Water Use and Development Plan is finalized and approved, (even though that would be substantially later than completion of the Lanai chapter), that the Board may also be willing to continue to staff an on-going group, but wanted further clarification from the committee as to the purpose, function and role of this group.

02/10/97 Lanai Water Working Group Meeting - Final Report of the Lana`i Water Working Group, also known as the 1997 Draft Water Use & Development Plan, is completed and adopted by the Lana'i Water Working Group. Although this was the last meeting of the LWG under the auspices of the State Commission on Water Resources Management, the Department of Water Supply continued to work with this group until the Lana`i Water Advisory Committee could be established. At this point, LWG begins being referred to as LWG/LWAC. Discusson at the meeting also focused on distribution, implementation and next steps. Notes that at this point the update to the Community Plan is still awaiting review and adoption by the County Council.

02/18/97 CWRM hearing on designation of Lana'i. Elects not to designate subject primarily to continuing efforts to systematize community involvement, continuing efforts to protect the watershed, remaining within the previously established triggers : pumpage less then 4.3 MGD, water level declines not exceeding 50% and wells within approved operational guidelines, continued efforts to conserve.

04/15/97 Board approves Director's report 97-21, resolves again to continue to work with community advisory committees for the completion of the Water Use and Development Plan, and adds to this a resolution to develop and propose to Council an ordinance to County Code §2.88A pertaining to the Water Use and Development Plan, to be submitted upon completion of the WUDP update, and including provision for ongoing community participation in water use and development planning. Board also approves contract with M&E for update of Water Use & Development Plan. Committee now referred to as LWG/LWAC.

04/30/97 LWG/LWAC Meeting. Discussion of Board decision, and proposed Lana`i Company Stewardship Plan. Decides to hold skybridge conference to obtain expert advice on management and protection of the watershed. Committee also agrees that additional capital proposals are needed prior to finalization of the WUDP.

05/20/97 Board received an ordinance proposal, after some discussion, it seemed that Board was more inclined to establish committee by rule than by ordinance. Instructed staff to discuss this idea with committee, and to

draft rule, but deferred further discussion and action to August Tech&Planning Committee meeting. Director's Report 97-36.

06/03/97 Pursuant to committee request, Deputy Director of DOFAW Mike Buck assigns Bob Hobdy to represent the DOFAW as resource person for the Lana`i Water Advisory Committee.

06/09/97 LWG/LWAC continues discussion of establishment of Lana`i Water Advisory Committee. Also discusses company's proposed operational guidelines. Agrees to approve them, and recommends that these be placed in the WUDP and function as mandatory limits. Additional items desired by the committee in the WUDP update as discussed include a capital plan for source development, updated implementation matrix, updated community plan analysis and better system schematics and information.

08/26/97& 09/16/97 Rule drafted but not placed on Board agenda.

10/21/97 Board discussed proposal for a rule and determined that a resolution was a more appropriate vehicle for establishing on-going committee. Instructed staff to discuss resolution with committee and draft resolution.

11/18/97 & 12/9/97 Resolution drafted but not placed on Board agenda. However, testimony received from members of Lanai Water Advisory Committee that establishment of on-going committee is very important to community members and that before deciding on whether to use a rule or a resolution, committee members would appreciate written guidance from corporation council as to what the legal implications would be for such a group were it established by resolution vs. rule.

12/15/97 Letter from Corporation Counsel regarding differences in establishing Lanai Water Advisory Committee by rule vs. by resolution. Paraphrasing: " A Board resolution may be adopted or changed by the Board at any time with proper notice, is non-binding and does not have the force & effect of law.....A Board rule, on the other hand, can only be adopted and changed by going through the rule making process as set forth in HRS Chapter 91. When adopted it is legally binding and has the force and effect of law....."

12/17/97 LWG/LWAC Meeting. Committee reviews letter from Corporation Counsel. Staff reports Board instructions to sound committee out on whether a resolution would be acceptable rather than a rule, and relayed information from Board that if necessary a skybridge meeting would be considered. Committee voted for skybridge and more discussion with Board. Resolution wording also discussed. Status of Lana`i Co. stewardship plan proposal - not funded.

02/17/98 Staff requests permission to schedule skybridge meeting for Board to discuss issues with Lanai Committee re: rule vs. resolution. Board moves that "Lanai Committee to submit a letter to the Board stating exactly what they want to discuss with them. Matter will be placed back on the agenda once the letter is received."

02/25/98 LWG/LWAC Meeting. Decision of Board discussed with Lanai Working Group/Future Lana`i Water Advisory Committee. Group votes that preference is still to be established by rule over resolution. Rather than press for skybridge meeting, decides to reiterate preference for rule and send request to be established by rule.

03/10/98 Letter from Lanai Water Working Group confirming request to have a rule established by BWS pertaining to the establishment of A Lanai Water Advisory Committee. Committee's preference is to be established by rule, because (paraphrasing): resolution can be changed at any time and does not have force and effect of law, whereas rule has force and effect of law and can only be undone through the rule making process.

05/09/98 Skybridge meeting held to discuss protection of Lanaihale watershed. Most important item according to all experts was to construct fence and eliminate feral ungulates in key recharge areas. Hunting to be maintained outside the fence.

06/29/98 LWG/LWAC Meeting. Committee reviews minutes of skybridge and suggestions for watershed. Begins discussion of possible fence alignment proposals. Determines that broader community involvement is needed in fencing decisions.

08/07/98 LWG/LWAC meeting. Attendance list but no minutes. Given date, discussion topics were probably establishment of water advisory committee and fence options.

10/29/98 LWG/LWAC Meeting. Discussed Planning Department projections and other community plan items as they related to the WUDP update. Planning Dept. estimated that 1,019 new housing units would be needed to accommodate a projected population of 4,968 over the next 20 years. Committee members agreed that this seemed a bit high, and did not recommend growing at this pace. (Although per-unit analysis is about 600,000 gallon increase - total build-out would reflect more), and recommended lower values. Also discussed objectives noted in the plan.

Objective: Ensure long term availability of low cost water for agricultural purposes

Objective: Establish and reserve a minimum water allocaiton for diversified agriculture consistent with the WUDP

LWG/LWAC elected to combine set-asides for DHHL and Ag to one large reserve of 1.5 MGD

LWG/LWAC noted the need to re-visit needs for Ag Park, Community Gardens, HHL, Horse Paddock and other potential agricultural efforts.

Objective: Protect, preserve, restore and enhance Lana`i's existing potential recharge areas.

Objective: Forest Management

LWG/LWAC re-confirmed its decision to include a watershed protection chapter in the WUDP update.

Objective: Prohibit the use of the high level aquifer water for golf course irrigation, consistent with the WUDP

Objective: Use recycled and brackish water for irrigation

LWG/LWAC deterimined that there was a need for improved inventory of irrigated acreage and that sources and destinations of irrigation water should be better delineated for the WUDP. Company to provide improved information.

LWG/LWAC made the caveat that the CP should be clarified on prohibiting the use of brackish water and limiting the use of reclaimed water over fresh potable aquifers. Brackish and reclaimed water best considered for Manele Harbor, Kamalapau, other down-gradient

areas where possible.

Objective: Comprehensive planning and management of water resoruces consistent with the WUDP.

LWG/LWAC elected to re-visit allocations for agricultural park, HHL, lands designated for affordable housing, community gardens & Lana`i Horse Owner Associations Paddock to insure that these needs are met.

Objective: Develop alternate sources, xeriscape landscaping, and strict conservation enforcement, especially for Manele Project District area.

LWG/LWAC suggested that alternate sources be considered in the WUDP update, and that the company include these in its capital proposals.

Objective: Develop and utilize a hydrologic model

LWG/LWAC suggested that data for this model might need updating, especially relating to fog drip.

12/04/98 LWG/LWAC discussed LWAC membership and preparations for presentation of fence discussion to community.

12/21/98 Lana`i Community Plan update adopted.

01/21/99 First public presentation and informational meeting regarding fence proposal held at Public Library.

03/16/99 Lana`i Water Advisory Committee Established - from here on committee is referred to as LWAC.

11/19/99 LWAC meets - discusses committee objectives and priorities for WUDP, voting, rules of conduct, agendas, handling of disagreements, rotating chair, etc. Also discussed biodiversity committee and possible formation of partnership to work together for watershed protection, lobbying for fence and other protective funding etc.

01/28/00 LWAC meeting. No minutes. “Rehearsal” / review by LWAC of draft presentation for “fence summit”, large, jointly-sponsored public meeting to be held on fence options.

02/00 State Commission on Water Resource Management approves *Framework for Updating the Hawaii Water Plan* - guidelines on WUDP update.

03/??/00 LWAC discussed watershed management, pumpage report and monitoring & reporting. Certain areas in the reports need clarification. Committee members also discussed regularity of reports.

04/11/00 LWAC Meeting / "Fence Summit" - jointly sponsored meeting (LWAC, biodiversity committee, & company) and company-catered event / meeting to discuss options for fencing the Hale. Afternoon and evening meetings. In afternoon, Manele Spa permit was main topic of discussion. Also discussed Miki Basin, watershed status and periodic water reports. Evening meeting included dinner and presentation on fence proposals to more than 50 community members.

05/26/00 LWAC Meeting. Company presentation on Terraces at Manele project. Maximum allocation for Manele Project overall remains 1.03, regardless of changes to sub-components of that project. . Difficult to separate actual PD use in water reports. Company proposes planning and allocation deduction estimates of 400 GPD potable and 400 GPD non-potable for irrigation, based on irrigation calculations of company consultant. Committee concerns whether estimated estimates are consistent with empirical data for the area. Asked DWS staff to obtain empirical data for similar elevation and climate regions on Maui. Committee also wanted requirement that brackish or reclaimed water be used for irrigation and other non-potable uses, and asked that company provide better documentation of reasons for potable and non-potable estimates. Committee also noted that prohibition on pools should have been included in CC&Rs for the luxury homes. More discussion on pumpage reports, watershed status, possible funding sources. More in-depth introduction of biodiversity committee and LWAC - discussions of jointly sponsored "fence summit meeting" , common goals and of possible formation of "Forest and Watershed Partnership". Draft of watershed chapter handed out to committee members. Also handed out State adopted - Framework for Updating the Hawaii Water Plan, which was approved by the State Commission on Water Resource Management in February, 2000.

09/22/2000 LWAC Meeting. Review of draft response on Manele Terraces based on previous meeting. Presentation on overall Manele Project District status by company. Company consultants explained water use and irrigation calculations. Proposal was still 400 GPD potable and 400 GPD non-potable for MF units. Nothing in CC&Rs of units sold to date indicates any restrictions on water use. Each unit will have two potable hose bibbs. Committee recommended that approval re-iterate 1.03 total limit on Manele PD, set allocation of 400 GPD potable and 400 GPD non-potable water, include these quantities in the CC&Rs for the project - specifically wording the covenant to indicate that potable water use not exceed 400 gpd, the applicant shold be requied to utilize reclaimed and or brackish water for irrigation to the fullest extent possible, and the applicant should implement conservation measures including limits to turf and use of appropriate plants, rain-shutoff devices, regular maintenance, low flow fixtures, etc. DWS staff handed out table on PD densities, units and other conditions of the PD, as well as the empirical data on similar areas in Maui requested at prior meeting. Discussion of re-grassing/re-seeding of Koele GC - result was to recommend filing of the application since rainfall had increased and the question could always be re-opened when necessary. Discussion on grant funding applications for watershed. Pumpage report discussed. Committee member Hokama requested that bulkhead pressure readings at Shaft 3 be included in the reports again. Committee member McOmber requestee an independent non-company entity monitor water levels, chlorides and pumpage. Discussion on status of aquifers and on impacts if water levels should fall. Consultant Dr. Kumagai noted that existing infrastructure not appropriate to deliver 6 MGD and that it should not exceed 3.52 MGD with the current configuration of withdrawals. Also that hydrologists in the past had estimated practical yields more conservatively in past (3.5 Anderson; 4.3 Takasaki).

01/18/2001 Joint CWRM Public Informational Meeting with LWAC meeting. Aquifer status report from CWRM & discussion served as annual Public Informational meeting. Also discussed WUDP - Committee wants to include conditions of approvals section. Staff asked for more data on system infrastructure and conservation measures from company. Committee discussed additional monitoring and reporting requested:

Monitoring
• drive exposed pipelines monthly
• leak detection on old pipes at least once per year
• meter testing sizing and replacement
Reporting
• tank and reservoir levels and pumpage from large storage
• source to use reporting of water - especially better break down of irrigation water use
• status of system - liners, leaks, broken/repaired pumps, etc.
Committee discussed difficulty of including financial plan without company data - but that need to consider realistic factors in capital or other proposals. Need to consider do-ability. DWS staff requested PUC submittal from company. Later received two pages from company staff. Had someone copy additional info at PUC.
Discussion of brackish wells in high level aquifer that could freshen, and company's inability to use those if that occurred.
Discussion of new source development vs. demand. Committee set policy that additional distribution of withdrawals be required by 3.2 MGD total pumpage.
Discussion of possible conservation measures -
• Cover large storage such as 10 MG Koele and 15 MG Manele holding ponds?
• Landscape retrofit at projects to save more water.
• Upgrade irrigation systems to include rain-shutoffs, soil-moisture sensors, etc.
• Need for systematic, reportable maintenance program discussed.
Implementation matrix needs rework w/ tracking items for each measure.
Future Mtg.

05/31/01 LWAC Meeting. Company gave powerpoint presentation on re-seeding and re-grassing of fairways at Koele GC. Requested LWAC support for requets to use high level aquifer for this project and amendment to ordinance to allow it. Customers dissatisfied with status of GC. Committee did not vote. Staff distributed data, referred to in minutes of subsequent meeting. Update that Stewardship plan as revised had been approved for funding.

07/26/01 LWAC Meeting. Discussed proposed ordinance amendment regarding irrigation of Koele and re-seeding re-grassing efforts. Flouridation also discussed. Questions on periodic water report. Committee still not happy with monitoring and reporting.

09/25/01 LWAC Meeting. Presentations by Lana`i Company hydrologists on use of water from the high level aquifer for Koele Golf Course. Reviewed updated implementation matrix. More discussion on pumpage report.

10/10/01 Meeting of LWAC, Biodiversity committee, and other future Lana`i Forest & Watershed Partnership members to prepare for MOU signing.

10/11/01 Formal signing of the Lana`i Forest and Watershed Partnership Memorandum of Understanding. Celebration.

10/26/01 LWAC Meeting / CWRM Annual Public Informational update. Handouts were provided but chair did not call on CWRM staff to speak. DWS staff passed out to committee members for review, ahupuaa map, community plan map, wellhead protection area maps, draft map of Lana`i systems - needs further input and information from company, graph of 50 years pumpage on Lana`i, minutes of 01/18/01 meeting, proposed implementation matrix edits, draft community plan consistency section, chronology of water, biodiversity and land use on Lana`i, reclaimed water production graphs and tables, draft section on conditions of approvals, minutes of May meeting. Committee discussed findings of TDEM studies by Blackhawk GeoSciences. No additional water identified. Committee discussed “borrowing” from potable allocation until additional reclaimed water is available. Opted against it on the theory that it would be hard to actually replace the water once used - that once allowed, it would probably continue until there were other new potable uses proposed for the same water...thereby hastening the pace of the use. Corp counsel indicated that e-mail is acceptable method of notification for LWAC meetings. However, committee wished to continue to have agendas posted. Committee noted that meeting needs to be scheduled to discuss systematic changes to periodic reporting. Discussed WUDP status and data needs. Some of the items passed out for discussion today had been passed out previously (in May), and still needed committee review,

discussion & input. Also needed is better data on company systems and consumption by class and area, GIS layer from Planning for community plan still not finalized, and capital proposals/costs of operations still not provided by company.

12/07/01 Presentations by Dr. Aly El Kadi and Robert Whittier on research for wellhead protection section. Modeling, model parameters and purpose discussed. Discussion of request to utilize high level aquifer for Koele Golf Course irrigation. Committee not yet ready to vote. Discussion again re-iterating need for group review of certain draft elements as well as for additional data under the guidelines. Demand and capital planning data not adequate.

02/20/02 Discussion on proposal to use high level water to irrigate the Koele golf course and proposed amendment to Koele PD to enable that. DWS staff passed out Allocation references, implementation matrix and community plan consistency section passed out for discussion, list of all wells, tunnels and shafts on Lana`i, and conservation materials prepared in Tagalog language. Company passed out proposed revisions to allocation table and SMART plan for Koele GC management. Issues raised included condition of aquifer, effects of drought, relation of forest condition, existing ordinance, agreements and past representations, maintenance issues and island economics. Conditions of approval if the request were granted were discussed. LWAC was unable to reach consensus. A summary of the discussion and both sides to be presented to the Planning Commission. Committee reviewed implementation matrix section of WUDP.

08/01/02 Scheduled workshop between LWAC and Lana`i Planning Commission on Koele PD, status of aquifers, WUDP, etc. - cancelled?

09/27/02 LWAC Meeting. DWS staff passed out updated project-based demand anaylsis tables, and updated population projections based on SMS data for review. Also updated demand regressions, well pumpage,chlorides and water levels and reclaimed water use graphs. Committee agreed not to make any further changes to allocations other than those agreed upon in previous meetings. Suggested 5 year incremental demand projections required under Framework for Updating the Hawaii Water Plan be done proportionally. Did not review project build-out analysis passed out. Also did not comment on

draft pump facilities inventory provided by company. Discussed problems with periodic water reports. Agreed to put 3.5 as the trigger for distribution of withdrawal projects. Not clear whether group realized they had previously set 3.2. at 01/18/01 meeting. In any case - discussed that design for distribution of withdrawal projects to commence at 3 MGD, to be sure it is accomplished in timely fashion.

10/??/02 Rescheduled Workshop between LWAC and Lana`i Planning Commission on Koele PD, status of aquifers, WUDP, etc (need to verify which date this actually occurred).

02/27/03 Passed out draft wellhead protection ordinance for committee review. Discussion on pumpage report design and on wells 1, 9 and 14.

08/01/03 Ground rules reviewed. Committee to meet independently. Agreed to rotating facilitation with Chair to handle agendas. Minutes to rotate as well. DWS staff not present. C&CR presented system status handout and indicated that three new master meters would be installed at Manele, one for residential and two for golf course use. Indicated that once well 14 was up, they planned to pull and repair well 1. Noted that new plans were in progress for storage upgrade at Koele, and that bids had been obtained for floating covers for the 10 & 15 MG reservoirs. Discussed using two rather than four holding ponds at the auxilliary wastewater treatment plant, and converting the other two to storage.

09/05/03 ?

12/ /03 ? Minutes of Jan meeting include review of Dec minutes, but missing.

01/09/04 LWAC Meeting. Low attendance. Discussed primarily system issues and periodic water report. Reservoirs full, Wells 9 & 14 awaiting repairs. RM Towill consultants to work on periodic water report. Fence material for hale fences beginning to arrrive.

02/13/04 LWAC Meeting. RM Towill working on supply and demand data. not yet finalized. Collins Lam recently assigned to run water company. Anticiapates well 14 pump to be re-installed the following week.

Determined that tying together the lakes at the Experience at Koele would not be cost effective. Discussion 20 MG storage pond for overflow and drainage. SCADA budget allocation increased. Will work on standardizing and calibrating to improve data. In the development arena, Manele spa and keiki center to be set aside in favor of a “well being” center.

03/05/04 Reviewed procedures of committee. Committee wants work to date submitted to CWRM as working document to be continually under updated. Staff points out missing elements, including certain requested demand data from company, better capital plan enunciation, certain policy questions. Discussion on revised long term build-out demand proposal from company, still in draft. Discussed system status and ongoing projects. DWS staff repeated request for assistance with completion of meter map that DWS had started for company. Discussed how this map was put together, and gaps in data.

4/2/2004

05/07/04 No minutes

07/14/04 LWAC Meeting. Discussed revised demand criteria and project analysis proposals from Castle & Cooke Resorts. DWS staff reviewed changes in assumptions reflected in these proposals. 1997 WGR allocation tables as amended by subsequent minutes to be included in WUDP as well as regressions and other projections, including revised demand proposals. Framework for Updating the Hawaii Water Plan, as well as earlier contracts stipulate that multiple demand forecasts be considered. LWAC will ultimately need to select allocations as policy matter, and may consider any or all of the demand forecasts.

08/04 LWAC Meeting. First Draft handed out to committee

09/20/04 LWAC Meeting. Review first draft. Various suggestions for content, format and clarification.

02/25/05 LWAC Meeting. Discussedpublic notification and minutes. Need protocol. Lanai Water Company working on verifying and calibrating its meters. All accuratre so far except for the one on Well 4. Plan to change meter. Also working on some safety improvements for Well 2 / Shaft 3. Well 14 having

some startup problems. Residential meter beteween the 15 MG reservoir and Manele Project District installed and operational. Golf Course meter installation pending. Periodic water report discussed. new meters and SCADA should improve some previous inaccuracies. Collins Lam to leave Lanai Water Co. after April 05. Committee disappointed as he seemed to work well with them. Phase I of fence complete. Phase II pending, will be more expensive and slower due to steeper terrain. LWAC made request to Corporation Counsel after January Meeting to clarify ordinance 2408. Awaiting word.

07/28/05 LWAC Meeting. Discussed system status leaks and water loss. Breaker tanks project to start soon. Request for proposal for 2 MG tank has been issued. Initial SCADA field work complete. Constructin 11 buildings with 48 units on 10th and Lanai Ave. Contract issued for water hyacinth removal.

10/25/05 LWAC Meetiing. Low attendance. Discussed need for Fog Drip study, establishing ordinance, and how to use the WUDP. Should be reference for applicatons, determine if application conforms to the plan, if not discuss revisions either to plan or project prior to approvals. Amendments to WUDP to be reviewed by LWAC.

11/22/05 LWAC Meeting. More discussion on how to use WUDP, revisited goals of plan, discussion on various tables within draft.

1/26/06 LWAC Meeting. Discussed the use of R-1 water on the Golf Course at Koele, Draft ordinance to establish LWAC by ordinance, periodic water resport, letter from C&CR attorney on WUDP and allocations. C&CR proposed to use potable water on the golf course. DWS staff agreed that potable water over a wellhead protection area would be a nice idea, and suggested trade-off of equivalent amount of potable water to non-potable water elsewhere in same system area but outside wellhead protection area. C&CR proposes trading off for more reclaimed water use in Manele. Committee members do not agree. DWS staff would agree if trade-off were in area with same mix of potable sources, such as irrigated area immediately makai of Lanai City and surrounds. LSG points out that company has made agreement not to use potable water on Koele GC. Committee concludes that this should not be proposed to council without further discussion within committee. Company opposes ordinance to establish LWAC. Other committee members recall that C&CR initially expressed support for the idea and voted for it. C&CR does not want to

be held to that, nor does it want this incuded in the WUDP. Discussion on periodic report. Committee members have questions on the discrepancies between pumpage at wells 1, 9 and 14 vs. use from the potable reservoir. C&CR says this is natural evaporative loss. Committee expresses concern that it is too much. Discussion on C&CR letter opposing plan. C&CR wrote long letter with many items, including opposition to elements of plan, various policies and statements within plan, and some corrections. Committee points out that C&CR representatives were present for and voted in concurrence on all elements of plan, including ordinance proposal. C&CR wants to know if entire plan becomes ordinance, or what becomes ordinance. Committee points to implementation matrix and policy section. Segways into primary concern of C&CR which all agree is allocation table. Committee agrees unanimously to work together to re-visit allocation table. Discussion on allocation - need agreement on unit factors, C&CR updated proposal not based on system standards, but has some empirical basis. Needs further review. Need better breakdown of existing and proposed uses. Need to spacify allocation to project and to system area. Need explicit allocation for ag park. Need individual information per project distrct.

02/06/06 LWAC Meeting. Discussed agricultural allocation. Brackish wter for residential landscape irrigation at MPD, Project analysis tables in Chapter 4, per unit consumption, consucmption classes. Also posting for new at-large member.

4/06/06 LWAC Meeting. Discussed pubic notice, project build out proposal from C&CR and analysis, allocation table and C&CR attorney correspondence. Also discussed data still missing to enable assignment of location and subdistrict for each meter. Value of disaggregated data in system analysis, conservation planning, etc. Corp Counsel memo indicates tthat sunshine law notification not requried, but does recommend good public notification. DWS points out that since it is no longer creating agendas or schedule it would be better to have someone else do the posting. However, agrees that public notice is important. Chair will post notice at post office and committee member volunteers to inform Lana‘i councilmember’s office. DWS to prepare ad for Lana‘i Times to recruit new at-large member. Allocation table - proposals should be broken down to indicate 5, 10, 15, 20, 25, 30 year anticipated build-out levels. Committee wants triggers defined for when “alternate water source” is requried - so that it can be clear with glance at final allocation table. Discussion of “alternative” water sources, increased wastewater use, desalinaization, run-off, conservation. DWS points out that table 6-2 weighs the cost benefits of some demand and supply side options, while desalt is found in 6-1. Increased wastewater use option not costed as “source” -

existing plants large enough to accommodate additional flow , but it may still be good to add. Discussion of C&CR attorney letter - Committee members express that it goes against the spirit of working with the group to vote one way in a meeting, and then have subsequent representation for the same entity raise these concerns outside the group to a higher body. Lack of continuity in C&CR representation and views is a problem. CWRM reports that fog drip study should begin in late summer of 06.

5/05/06 LWAC Meeting. Reviewed updated demand chapter and policy chapter allocation table. C&CR requests provision to be able to maneuver within a project district allocation, provided that the total remains same. Committee concurs in principple with hte caveat that such allocations be discussed at an LWAC meeting before being finalized. Vote will come when table and associated text are finalized. Discussed 650,000 gallon limit on the use of wells 1, 9 and 14. LSG still interprets this as applying to all use of high level water for Manele. C&CR interprets it as applying only to the Golf Course. Discussed results on the Well 6 oil sheen. C&CR reports that water is safe. Regarding ag reserve, given low sustainable yield, should some additional reserve be set aside to protect aquifer in event of uncertainty ? Committee members note that chlorides in well 1 seem to be decreasing. If this goes fresh, will impact irrigation source for Manele PD. Water levels dropping. Trees on Hale dying. C&CR doesn't think additional reserve is needed. Gradual development, slow development, ag reserve & gradually increasing conservation are adequate. In future de-salt may prove cost effective.

7/ /06 LWAC Meeting. Discussed ordinance establishing LWAC, demand analysis tables and company plans. Company now opposing ordinance. Other committee members want review vis a vis WUDP prior to Planning Commission decisions. Want to be sure Planning Commission receives their comments on water issues. C&CR does not want another layer of bureaucracy or added review time. C&CR confirmed that it had not yet given DWS staff its final table 4-21 (company's proposal), so staff therefore could not complete analysis and comparison. C&CR is revisiting its MF and SF plans for Manele. Considering Increasing MF and decreasing SF.

8/11/06

9/08/06

10/20/06

11/16/06 LWAC Meeting. DWS staff has C&CR final proposal. To make "straw man" revised allocation table using 10, 15, 20, 15, 30 year and build-out.

1/18/07 LWAC Meeting. Two "straw man" allocation tables presented. One based on project build-outs proposed by C&CR with some adjustments based on committee discussions, the other based on econometric forecast numbers - for comparison. Discussed. Some areas in table need clarification.

2/15/07 LWAC Meeting. DWS staff out. Discussed tables, Chair presented alternate format. No votes taken.

4/19/07 LWAC Meeting. Discussed C&CR objection to moving WUDP meetings forward pending results of LUC proceding. Committee members reiterated that it went against spirit of collaboration to present legal challenges rather than raising and discussing concerns in the group. Given disparate positions, difficult to progress. Nevertheless, discussed allocation table. DWS staff wanted some changes to revised allocation table format, to facilitate internal data review - consistent breakdowns by system and region. More work needed to resolve discrepancies between the three tables. DWS noted that assumption for straw-man tables was that build-out would be beyond 2030, but C&CR stated that it intended to build-out by 2027, although this would not be consistent with forecasts.

5/17/07 LWAC Meeting. Discussed membership. Voted to appoint a fourth "alternate" at-large member, to be invited to all meetings and to vote in the even that one of the other at-large members are absent. Discussed Challenge at Manele. Discussed fog-drip study. Dr. Juvick collecting data at eight stations on the Hale. At 6 months of a 2 years study. Progress report scheduled at 12 months. Committee requested C&CR to bring map of Hale showing fog drip stations. Discussed Groundwater study. Tom Nance will formulate parameters for updated model, scope to be reviewed by CWRM and implemented by Howard Endo. Time table of fog drip study may be such that updated data won't get into model update. Model itself won't change sustainable yield estimates, but may provide info on when additional measures might be needed to accommodate various pumping scenarios. Discussed Periodic Water Report. Committee members would like effluent / influent to auxilliary plant included in report. Committee would like monthly vs. 28 day reporting. Need to check with corp counsel re: reporting period under 19.70.085. Discussed period of inconsistent measurement in PWR. Discussed Water

Use & Development Plan. CWRM staff noted that capital plan should be further fleshed out for WUDP. Committee suggested consideration of lining reservoirs. County staff discussed exchange in which reclaimed water would be used for irrigation rather than potable water somewhere outside high level aquifer, enough to enable use of potable water on Koele GC where potable water underlies. Discussed table 5-1. Went from 9 to 13 categories on table and discussed adding subtotals by system area, type of water and pumped vs. other. Discussed controversy over ordinance 2408. CWRM staff asked for Unit Quantity Analysis of assumptions used to determine allocations in C&CR proposal, others. Discussed buildout analysis of C&CR proposal. Discrepancy between proposal and existing project entitlement in that proposal lists fewer units. Either PD should be amended to allow fewer units, or analysis should include all units. First Cut Pace of Resource Use policy proposed by committee member. 2010 3.5, 2015 4.0, 2020 4.5, 2025 5.0 , 2030 5.25 Buildout 5.5. Trigger for new source development 3 and 3.52 reiterated. System status discussed. Committee supports replacement of well #3.

07/12/2007 LWAC Meeting. Discussed Corp Counsel response re: reporting period. Reporting methodology could probably be changed without ordinance, but by a resolution of council. Resolution drafted and presented, as per previous meeting discussion. However, company said it does not support shift from 28-day to monthly cycle. Regarding other changes, company willing but wants clearly delineated list of all changes desired, vs. piecemeal. Discussed Unaccounted-for water. Some committee members concerned re: system losses, particularly from 15 MG reservoir. Some committee members also want more accounting of where water comes from and goes to. Company indicated that systematic leak detection program may be more efficient than revisions to PWR for identifying problems. DWS staff agreed. Started discussion of Unit Quantity Analysis requested at May meeting. C&CR proposal differs from Statewide Standards and existing entitlements in several areas: some items are requested that are not in existing PDs or proposals currently under review, build-out for some items represents less than all entitled units, in some cases consumption estimates are not explained but merely listed as lump sum. These tend to be small, but since there are 13 out of 40 line items in this category, they add up. Finally, some items are adjusted from standards based on empirical data for the area. In some cases these changes are reasonable or allow for more flexibility or even more realistic assessment of demands, but in others they allow for the potential of padding - room for additional approvals not listed. Also, if

entitled projects are not traded or un-entitled in exchange for new proposals, then build-out is likely to be higher than proposal indicates. Minutes include more details of discussion of first page of 5 page unit quantity analysis table.

1/25/2008 (have notes, still have to type up) LWAC Meeting. Presentation from Gordon Tribble of USGS pertaining to the uncertainties of high level dike confined water. (more, need to find).

2/28/2008 LWAC Meeting. Discussed lack of data for forecast. Staff handed out letter from consultant stating that data provided was inadequate to prepare good forecast. Discussed well construction and pump installation permits for New Lanaʻi Well 3 - 4954-03, and for Lanaʻi Well 11 - 4753-01. No vote was taken but committee expressed support for the replacement of well 3 in particular. and slightly more guarded support for distribution of withdrawals with well 11. The concern was expressed that well 11 not be used to further increase pumping of brackish water from the high level aquifer. Discused the need for resource reserve.

4/25/2008 LWAC Meeting. Discussed 8 different scenarios for buildout and pace of resource use policy. Discussed line-item allocations for conservation and “alternate source”. Discussed pros and cons of resource reserve. Discussed triggers for additional distrubution of withdrawal. 3.0 to start 3.52 to be completed. Discussed status of water levels in wells 1,9 & 14 as well as in wells 6 & 8. All declining. Also status of pumps 2 and 3 - both down. Permits for well 3 replacement and for distribution of non-potable withdrawals well 11 have been submitted to CWRM and are being reviewed. were passed out to group at 2/28/08 meeting.

5/30/08 LWAC Meeting. Presantations by Bob Hobdy and Jay Penniman regarding history and status of watershed, concerns re: Increment III alignment, and description of work to preserve Hawaiian petrels. Had been t hought extinct or nearly extinct until about 2001. Now it is believed that several thousand birds remain. The biggest threats to the birds right now are invasive plants that over-run natural habitat and form impenetrable thickets where the birds can not nest. Examples of such problem plants are waiowi (strawberry guava), manuka and tibouchina. Other threats include predation, and flying into the deer fence and meteorological towers. Suggested that white fiberglass eelctric fence tape be woven into the top of the fence wire to enable the birds to see and go over the fence. Also described was a three acre habitat restoration project around the fog drip station. This restoration will make a corridor to Maunalei breeding grounds. . CCR is providing funding as

part of its Habitat Conservation Plan for its potential wind farm. There was strong support for watershed protection by some of the LWAC members. CCR staff agreed to consider the fence line proposed by Hobdy. Discussion of the Implementation Matrix.

06/27/08 Discussion of fence increments. All phases surveyed. However as it may be a while before Increment III is actually constructed, additional survey may be done. CCR outlined the expected timeline for completion of the fencing project; they are currently 2-3 years behind schedule. The costs of materials have almost doubled over the last 4 years. CCR emphasized that it will get completed. Initial results from the 2-year study by Jim Juvik are showing that fog drip is significant on Lanaihale. The new alignment will incorporate suggestions made by Robert Hobdy at the last meeting and in discussions with Conservation personnel. Discucssed capital projects of CCR. Lanaʻi City 2 MG tank done. Improvements made to Well 2/Shaft 3 main from Hiʻi to the bottom of the slope. Other plans include replacement of Well 3 and drilling of Well 15. Anticipated yield on Well 7 was small. Discussion of allocation table.

07/25/08 LWAC Meeting. The pace-of-resource proposal was reviewed. Some billing data is still missing. Also discussed were problems / inconsistencies in the Periodic Water Report. A tiered pricing proposal has been filed with the PUC. Some LWAC members requested that the justification prepared by DWS for the proposed Allocation be included in the WUDP, possibly as part of the Policy chapter as an explanation. The LWAC discussed the status of wells. CCR explained its plans for industrial use development at Miki Basin. Concerns were expressed that the line is very leaky and suggestions to condition approval for the project on fixing the line. CCR said it would be too expensive to put in new line. LWAC members requested continued updates on plans. The group continued discussion on the Implementation Matrix, including tiered rate structure, low flow devices, use of water audits, and importance of education. LWAC members requested that someone from the Fire Department attend the next meeting to address the threat fire poses to the Watershed.

08/22/08 Discussion of whether or not to shut down water source on the west end. Fire Department representative came to discuss concerns. Concerns and possible solutions discussed. Miles of old 10” pipe sitting. Pipe is old, with frequent breaks. Area is fire prone, and water source is needed to be able to fight brush fire. Helicopters alone not enough. Lanaʻi has two fire

engines, one tanker and 6 firefighters. It takes about an hour to get additional manpower. Water is also needed for the Kanepuu project. Discussed cost of Lanaihale fence. No funding yet Discussed breaks in Palawai Grid. Discussed allocation table. Some thought too generous. Raised precautionary principle. One suggested alternate, more stringent proposal. Others thought not generous enough, that LWAC had been close to agreement on CCR proposal. Still others said that regardless of final numbers, setting allocation amounts would not be enough in itself, triggers and actions needed to ensure adequate distribution of withdrawals. Discussed triggers in proposal. Also some discussion of per unit consumption. The group discussed the issues of identifying alternate sources, including a resource reserve, including triggers for future action, applying the precautionary principle.

10/24/08 LWAC Meeting. The group discussed whether the meetings could or should be recorded (video-taped). CCR said it was a public meeting. Others expressed concern about that recording the meeting might limit participants' willingness to speak freely. The group agreed to allow video-taping by CCR, but only if two free copies were made available for the group. CCR has a proposal for an additional swimming pool at Manele. The group agreed to inform the Planning Commission that there was not an opportunity to have a presentation from the Company on the proposal, so request Commission defer action on it. LWAC reviewed what conditions trigger review by the LWAC of major development projects. Also the Planning Commission can request LWAC input on a proposal. The group continued discussion on Table 5-1 (Pace of Resource Use) and the overall timeline for WUDP.

1/30/2009 LWAC meeting. Discussed status of wells, fire protection issues, periodic water report. Discussed allocation table. Discussion included need for a precautionary approach and the need to avoid “paper water”. Additional monitors put in wells 3, 5 and 7. Discussed breaks in Palawai Grid.

2/27/09 LWAC Meeting. Those present discussed possible approaches for when there is no CCR representative at the meeting and suggested sending a letter requesting their regular participation. Agreed to move forward with or without CCR, given need to make progress. The group discussed whether LWAC should take a position on CCR Miki Basin heavy industrial permit application. This involves infrastructure only, not an increase in use; concerns relate to maintenance and fire protection (when draining the lines). LWAC agreed that it wants issues relevant Table 5-1 to come before it. The group discussed CCR's PUC rate case and whether LWAC should take a position. It was

	agreed that given the timing and the inability to discuss with CCR, that no formal letter would be written; individuals could testify on their own about concerns discussed (e.g. lack of conformity with existing covenants). The group discussed the issue of whether the existing water system and rates is fiscally viable. Current rates are estimated to be ¼ of the actual cost. The group also discussed inconsistency of water use with existing covenants and the possibility of a "conservation rate." CCR informed the group that reporting of water use is up to date now and will be current in the future. CCR reported on the status of repairs to the Palawai Basin system
3/27/09	LWAC Meeting. The group reviewed Chapter 2 (Regulatory Framework) and Chapter 3 (Resources) and made some general organizational suggestions. It was noted that Lanai is not currently meeting System Standards in terms of needed resources, but this should reflect more of a Call to Action vs. a panic. CCR said it has plans to move toward meeting those standards. Some wells are closer than others to action levels. LWAC agreed it should watch trends and if approaching action level, do a test. One request was for clear criteria for action level and CWRM designation. Regarding Water Reports and use, CCR presented revised format for reporting. On the PUC rate case for brackish water, there were concerns about how it was costed and whether there was adequate consideration of operating and maintenance costs.
7/31/09	LWAC Meeting. The group was informed that the WUDP needs to be approved by the Board of Water Supply before it is sent to County Council, which then has only 45 days to approve it or reject it. However, Council was looking at amendments to the County Code to change that schedule. DWS reviewed the status of the chapters, with an in-depth review of Chapter 4. The previous calculations were updated with information from 2008. It was suggested that information about Miki Basin should be included in Table 4-23 (4-21), but that it did not equal an "imprimatur" for planning approval. The group also reviewed and discussed the allocation table. A number of LWAC members stated a desire to take a more conservative approach, given the current economy and actual building activity. LWAC also discussed the issue of reporting water use on a 13-period basis and that it would be preferable to have it on a monthly basis.
12/11/09 & 12/21/09	LWAC Meetings. Reviewed 10/19/2009 Review Draft of WUDP for Lanaʻi. Presentation and discussion of review draft.