HILO BAY WATERSHED-BASED RESTORATION PLAN

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1—SUMMARY

Several segments of coastal and inland waters in the Hilo Bay watershed have been on the 303d list of impaired for several years, and Bay waters have been known to exceed state water quality standards since at least the late 1970s. In 2003, EPA Section 319 funds were made available to 1) carry out a community-based assessment of sources of watershed impairment and 2) develop a watershed-based restoration plan. A review of the basis for 303d listing and of the water quality monitoring data available for the Hilo Bay watershed indicates that there are insufficient data to allow identification of the sources of pollution; this is true for nutrients, fecal indicator bacteria, and sediments (the basis on which the waters are listed).

Given the lack of site-specific data along with two major constraints on sediment reduction—the harbor breakwater and high non-anthropogenic sediment inputs from the Wailuku River Basin—the restoration plan developed by the UH Environmental Center in collaboration with the Hilo Bay Watershed Advisory Group (the "HBWAG") therefore focuses on: 1) Locally adapted *non-structural Best Management Practices* (BMPs) and associated *demonstration projects* on a small scale that will serve to reduce nutrient and sediment inputs from a variety of sources immediately following implementation; 2) *formal and informal education* BMPs, and in particular: a) informal education of the Hilo community on general (not Hilo-specific) BMPs that will have a positive effect at low cost regardless of the major sources of pollution, and which simply reflect wise use of resources and smart development and b) improvement of formal education in elementary and high schools as a way of increasing knowledge of science and management issues, and as a way of both increasing the reach of information (to family members) and of providing basic monitoring data for project researchers; 3) *gathering of baseline data* to spatially locate sources of pollution and to understand the Bay ecosystem, followed by dissemination and discussion of research results to stimulate development of a management plan to reduce pollution should it prove to be significant; and 4) *support of county efforts* to manage flood water and wastewater. We propose a five-year initial implementation, baseline data gathering, monitoring and education period, after which a community-wide discussion will result in the selection of additional BMPs to reduce pollutants, targeted at the appropriate land uses that are producing pollution. This Hilo Bay Watershed Based Restoration Plan incorporates comments and corrections to the draft plan submitted to DOH in June 2005. The comments were generated during a public review process coordinated by the Hilo Bay WAG in June-August 2005; these comment, with responses, are also presented in Appendix 6.

The key threats to water quality identified in this Watershed Restoration Plan are (the order does not indicate priority, as there is not enough information available to rank these sources of pollution): urban flooding and erosion due to high rainfall, young geology and inappropriate urbanization in flood zones; conservation area flooding and erosion; lack of enforcement of state and county regulations, and lack of appropriate county level regulations, especially in the area of Grubbing and Grading Ordinances; lack of education / information on the part of the general public and of county and state officials regarding water quality issues and best management practices; the left-over impacts of sugar cane industry; the impacts of the Hilo Bay Breakwater on Bay circulation; incomplete wastewater system and pervasiveness of cesspools and lava tube dumping; and invasive plant and animal species.

This Watershed Restoration Plan recommends that several BMPs and Demonstration Projects be considered for the Hilo Bay Watershed. These BMPs will not only lead to reduction in pollution, they will also generate baseline data and data on hydrology and pollution trends that are needed to better understand the watershed.

<u>Recommended Demonstration projects</u>

1. Restore and monitor Waiakea Pond Wetlands and associated former wetland areas along the Hilo Bay waterfront
2. Manage Nitrogen-fixing invasive species, especially removal of Albizia in lowlands (and monitor impacts on soil and water N content of ongoing gorse removal on DLNR and DHHL lands)
3. Control rooting activities by pigs in parts of the Hilo Forest Reserve, if possible by working with hunters to alter the behavior and movement of pigs; fencing is not recommended in this demonstration project except for small critical areas where it can be shown that rooting by pigs is causing strong erosion impact and it is not possible to deter pigs by other means.

<u>Recommended Structural BMPs</u>

1. Modify the breakwater, if the Army Corps of Engineers determines through modeling that this will in fact improve water quality in the Bay by allowing pollutants to be carried away from shore, without significantly impairing the shipping industry based in Hilo Harbor.

<u>Recommmended Non Structural-BMPs</u>

1. *Community participation*

a-Support community group (WAG) to coordinate process
b-Establish a Memorandum of Understanding with critical outside industries, such as the cruise ship industry, and seek economic support from them for water quality protection in the Hilo area.

2. *Management*

a-Eliminate cesspools in lava tubes, and lava tube dumping (near Wailuku), either by connecting to sewer or by providing alternative individual wastewater treatment systems
b-Educate county and public about need for improving sewer hookups
c-Provide composting toilets in public facilities
d-Maintain flood control channels by removing debris and vegetation
e-Manage fallow / abandoned sugar cane land with vegetation that will reduce soil runoff and minimize nutrient inputs

3. *Planning*

a-Adopt low impact development techniques for planned county projects
b-Adopt integrated floodwater management approaches, at the county and city planning scale
c-Review and amend zoning
d-Ensure that agricultural BMPs are being applied to all agricultural lands, and monitor effectiveness of these BMPs as a way of obtaining baseline data and adaptively changing BMPs when necessary
e-Improve county ordinances and monitoring, especially grubbing and grading
f-Implement contingency planning for hazardous spills in Bay

2—DISCLAIMER

The waters of Hilo Bay are considered quality impaired under current state and federal water quality standards. It is worth noting that these standards were developed to fit all waters in all regions of the US, and do not take into account local ecological conditions in Hawaiian watersheds (tropical climate, flashy streams, Nitrogen fixing native and invasive plant species, very recent volcanic substrate, very heavy rainfall, abundant ground water inputs to costal zones). Because the sources of pollution causing the impairment of the Bay are presumed to derive from the streams draining into the Bay, the DOH has requested the development of a watershed-based restoration plan for the Hilo Bay. The Hilo Bay watershed was therefore defined as the area including all streams that empty into Hilo Bay, and that could potentially contribute pollution to the Bay. In the initial definition of the watershed, underground water sources were not considered; we therefore make the assumption that the watershed as defined by surface waters is large enough to include most underground flow that will affect the Bay.

Land ownership in the watershed is dominated by the Department of Land and Natural Resources (DLNR) and Department of Hawaiian Homelands (DHHL), followed by the Federal Government, Kamehameha Schools, and private landowners. The soil-disturbing practices and the management practices carried out by these major landowners or classes of landowners are likely to be resulting in the largest contributions of pollutants to the Bay. Note that absence of management is considered management here—e.g., fallow agricultural land or roadless forest reserve land is considered to be under a particular form of management, in this case lying fallow or being protected from the well-known negative impacts of roads.

The major pollutants identified in the Bay are sediments and nutrients (primarily N), as well as fecal contamination as indicated by fecal indicator bacteria. For DLNR land we assume that (without having any data to support this, but using logic) the major sources of sediments (and associated nutrients and bacteria) are rooting and other activities by exotic ungulates, natural erosion of streams, and natural runoff from upland soils; we assume that the major sources of nutrients are plant decomposition, N fixation by native and exotic legumes, and animal waste products. For DHHL lands, we assume that the major sources are similar. In suburban and urban areas, we assume that the major sources are runoff, cesspools, sediment runoff from construction sites, leaking sewage pipes, toxins such as arsenic associated with past industrial Canec production, and lava tube dumping. On agricultural lands we assume that the major sources are runoff from fallow and active land, and recent and past pesticide and fertilizer applications. Note that agricultural land is currently dominated by orchards and small-scale cattle pasturing, as well as fallow land and former sugar cane plantation lands, currently undergoing old field succession to shrublands.

The Total Maximum Daily Load process and sampling currently under way by the DOH is not sufficient to define the sources of sediments and nutrients in the Bay, as it will only determine the amounts of pollutants that are in the water at two different points on two different streams, and the streams' capacity to process pollutant loads. Data exist on sediment and nutrient loads in several streams, including the Wailuku River, and on nutrient and fecal contamination of Bay waters. None of the data sets are lengthy. None of the data sets pinpoint the sources of the pollutants by land use type. Therefore to date we do not know the locations where Best

Management Practices should be applied. We can only make assumptions about the sorts and amounts of pollutants that are coming from each land use type, based on studies done elsewhere of the pollutant effects of different land use and land management practices.

Such informed assumptions are therefore what this plan used to select best management practices and monitoring that will help both establish baseline conditions and changes from these conditions following to BMP implementation. In order to properly assess the effect of BMP implementation, we must also assess the background variability in pollutants caused by non-anthropogenic factors, including rainfall variation and soil types. This will allow us to identify synergies between BMPs and local ecological conditions. This background assessment is also necessary due to the high expected levels of non-anthropogenic inputs—i.e., active erosion on newly formed lava flows, nitrogen contributions of the dominant nitrogen fixing trees and shrubs in the area, etc.

This plan recommend BMPs and monitoring, but also spells out the types of research that must be done to understand the hydrology of the Bay and watershed, and to develop bioindicator techniques appropriate to the local conditions. It also heavily emphasizes education as a BMP, because it recognizes that the watershed is currently in relatively good ecological and water quality condition, and that in order to preserve and improve upon these conditions despite planned future development, the community must be aware of the impact of their activities on water quality and therefore on their quality of life. The community must be ecologically literate and informed in order for it to ensure that elected officials move in the direction of Smart Growth and Low Impact Development in the watershed. We expect to find different sources of funding for the different activities recommended actions—e.g., 319 funds and National Science Foundation (NSF) funds for education and other BMP implementation, Natural Resources Conservation Service (NRCS) funds for agricultural BMPs, Army Corps of Engineer funds for assessment of Breakwater modification (the major proposed structural BMP that would affect Bay water quality), and NSF funds for research into ecosystem function.

3—OPPORTUNITIES AND CONSTRAINTS FOR MANAGEMENT, RESTORATION, AND POLLUTION PREVENTION IN THE HILO BAY WATERSHED

Opportunities

1. With the demise of the sugar cane industry in the 1980s and 90s, the inputs of sediments, fertilizers and pesticides into watershed waters greatly diminished. The streams and Bay waters and surrounding soil are therefore cleaner than they were 10 years ago, and the ecosystem is probably still continuing to assimilate and process some of these inputs (e.g., organic matter from bagasse in the Bay, arsenic from Canec plants, sediments from planted fields, N and P from fertilizers). Agriculture is at a low point now, but fruit orchards (e.g. Macadamia nuts) are on the increase. This allows the application of BMPs to smaller scale plantations, smaller pieces of land, and lands that already have more cover and where the cover is not harvested as frequently as sugar cane was.

2. The cruise ship tourist industry is on the rise, and is a potentially good source of revenues for Bay management if they can be retained in the local area.

3. The watershed has low population density

4. The watershed has an abundant water supply

5. There is no industrial pollution in the watershed

6. There are several active community groups in the watershed

7. The University of Hawaii—Hilo has a research focus on aquatic ecology and is an excellent local source of expertise and trained professionals

Constraints

1. The breakwater affects circulation and therefore pollution in the Bay, and it is unlikely to be removed or modified. Therefore, pollution reduction will probably have to occur within the context of a permanent breakwater and the continued functioning of Hilo Bay as a major commercial harbor
2. The Bay contains a major port, the primary point at which fuel and cruise ships are offloaded on the island of Hawaii
3. The watershed is a geologically new and active area, with heavy rainfall, erosion and runoff shaping the land
4. There is an urgent need to manage/control/eradicate exotic species of plants and animals; this plant eradication can lead to soil disturbance and contribute temporarily to pollution in the Bay
5. The waterfront is vulnerable to tsunamis and sea level rise; a balance must therefore be reached between short-term planning that allows economic development and protects the environment, and long term planning that acknowledges the risky nature of the towns location on a low-lying coastal zone

4—PROJECT BACKGROUND

The Environmental Center of the University of Hawaii is under contract to the State of Hawaii Department of Health (ASO Log No.03-017; the "Statewide Watershed Project") to acquire background data on the causes of water pollution and resource degradation in seven key watersheds located throughout the state. The Hilo Bay watershed is one of these. The purpose of this data-gathering effort has been to produce and compile the information necessary to develop meaningful watershed restoration plans for each watershed and sub-watershed pursuant to the directives under U.S. EPA Section 319 Clean Water Grants. Successful and early completion of this process in the Hilo Bay Watershed led to the addition of contract modification No. 2 to proceed with the development of a Watershed Based Restoration Plan for Hilo Bay. This plan is being prepared in accordance with directives from the U.S. Environmental Protection Agency for Watershed Based Plans developed with Clean Water Act 319 funds, and using the background materials compiled for the Statewide Watershed Project along with direct coordination with and involvement of the Hilo Bay Watershed Advisory Group (HBWAG).

4.1—Addressing the 9 elements of an EPA Watershed Based Plan

The initial objective of the Hilo Bay Watershed Based Restoration Plan was to meet the Environmental Protection Agency's (EPA) nine specifically required elements for a Watershed Based Plan as stated in Section 319 of the Clean Water Act. The Hilo Bay Watershed Public Input Final Report, as prepared by the HBWAG in May 2004, was used as a guide to addressing the nine elements required by EPA for the Watershed Based Plan. However, given the paucity of appropriate data available for the Bay, the elements referring to load reductions cannot be completely addressed at this time. Furthermore, the Hilo Bay WAG and community have taken a strong stance in favor of research prior to establishing load reduction guidelines. The community is strongly in favor of improving water quality in the Bay, and stakeholder participation has been high and positive during the community input process. Nevertheless, the community is keenly aware that division and conflict will arise should BMPs and load allocations be assigned to one sector of the economy or community without sufficient data to support the contention that these sectors are actually producing pollution that is contributing to impairment of Bay waters. During the review process, we have found no pre-existing data that pinpoint the source of pollutants—for example, the sediments entering the Bay via the Wailuku river has not been identified as originating on conservation land, ranching land, agricultural land, or completely undeveloped land (non-anthropogenic source). The same holds true for nitrogen (N) inputs into the Bay —although we have strong circumstantial evidence that ground water contributes large amounts of N, we do not know whether it derives from agricultural applications, or from septic systems and cesspools along with other sources of waste water. We also realize that the most detailed evaluations of water quality and hydrology that exist for the area are now 20 years old, and that the closure of sugar mills and abandonment of sugar plantations, concomitant with increases in urbanization and impervious surfaces, have changed the inputs into the Bay in the intervening time. Furthermore, given that several segments of water are listed under 303d based on the visual assessment of nutrients (i.e., visible algae), and that there is little biological data to support such criteria at this time, we believe that better indicators of water quality specific to Hilo Bay must be developed. This is, after all, the area of highest fresh water input in the state of Hawaii, and "the catchment for one of the known, great basal groundwater spring areas of the world" (M & E Pacific 1980). Its hydrology and ecology are therefore not the same as that of other estuaries that have been studied in Hawaii.

The nine elements of an EPA Watershed Based Plan are listed below along with the approach used to address each requirement.

1. *Identify the causes and sources or groups of similar sources (both natural and anthropogenic) that will need to be controlled to achieve the load reductions estimated in this watershed-based plan*:

The Hilo Watershed Advisory Group (HBWAG) identified many of the potential causes and sources of pollutants and watershed impairment to the Hilo Bay Watershed through a series of six public meetings held between July 2003 and January 2004 and by soliciting input with a questionnaire. The list of pollutants, along with other biological, geological, chemical, social and political factors that affect water quality in the watershed, are listed in Table 5 of the Final Report (HBWAG 2004). Following approval of Mod. 2 of the contract, the UH Environmental Center, along with the HBWAG, proceeded to validate this initial input by focusing on the more severe or large-scale sources of pollution through in-depth literature searches, examination of existing data bases, meetings with researchers, county, state and federal officials, and meetings focused on particular sources of pollution. The sources of information are listed and discussed in detail in sections 7 through 9 of this document, as are the data reviewed from existing databases.

2. *Estimate the load reductions expected for the management measures described under element (3) below*:

As described in Sections 7 (criteria under which Hilo Bay waters were placed on the 303d list), 8 and 9 (review of current data availability on Hilo Bay waters), it is at this point impossible to estimate the load reductions needed to remove waters from the impaired list. With the possible exception of the ongoing TMDL estimation process currently under way for two intermittent, seasonal streams in the watershed, data are not available to estimate the current pollutant loads of the waters entering into the Bay (especially for ground water and for the Wailuku River, the largest sources of freshwater input to the Bay). This restoration plan therefore takes a two-phased approach: the first five years of the plan will focus on 1) research and 2) implementation of a few key BMPs and demonstration projects that we are fairly certain will have an impact on sediment, nutrient and fecal indicator reduction (namely cesspool reduction and sewer hookups, improvement of grubbing and grading ordinances, education, management of invasive plant and animal species, wetland restoration, and adoption of low impact development practices). We have estimated, without the use of models, the potential reduction in pollutant inputs that may derive from implementation of the key BMPs and demonstration projects. At the end of 5 years, armed with knowledge about the hydrology of the watershed, the response of nutrient levels and fecal indicator bacteria levels to the BMPs, we will then be prepared to select larger scale BMPs and mathematically estimate load reductions resulting from these BMPs.

3. *Describe the NPS management measures that will need to be implemented to achieve the load reductions estimated under element (2) above and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan*

See above.

4. *Estimate the amounts of technical and financial assistance needed, associated costs, and/**or** the sources and authorities that will be relied upon, to implement this plan*:

Estimated budgets for the recommended research and monitoring, and sources of costs for BMP and demonstration projects are provided, along with the identification of the individuals or authorities most capable of carrying out these actions, or who have already expressed an interest in carrying them out.

5. *Develop an education component that will be used to enhance public understanding of the project and encourage early and continued community participation in selecting, designing, and implementing the NPS management measures that will be implemented*

We have identified three necessary components of education, to take place after plan implementation, and have developed an approach for each:

a) Informal education—a series of video modules addressing specific pollution and water quality/management issues in the Hilo Bay Watershed will be developed; modules will be shown on television, and will be prepared by local film experts; they will emphasize the information that science can provide to managers, the state of knowledge regarding that particular watershed-related topic in Hilo Bay, and the recommended BMPs for the situation

b) Formal education: teachers and students from local high schools and elementary schools will be involved in the restoration plan by contributing to water monitoring efforts; simultaneously, the restoration plan team will seek a Memorandum of Understanding (MOU) with the Department of Education (DOE) and/or individual schools to provide science curriculum materials that include information on aquatic ecosystem function and water resource management (to meet ecology and resource management curriculum requirements).

c) Community education on BMPs—this component will be carried out using standard materials already prepared by other EPA and DOH funded watershed based projects, and materials available through Natural Resources Conservation Service (NRCS), US Environmental Protection Agency (EPA), University of Hawaii at Manoa College of Tropical Agriculture (CTAHR), etc.

6. *Determine a schedule for implementing NPS management measures identified in this plan that is reasonably expeditious*:

The time frame for the restoration plan currently is as follows: A five year implementation and monitoring period starting upon availability of funds, to be followed first by 3-6 months of meetings and community review of information, and then by 3-6 months for elaboration of the research based restoration plan, which will probably involve a 5 to 10 year implementation and monitoring effort, incorporated into the general management activities of the county and of state and federal agencies acting in the watershed. In this document we describe the initial 5-year effort.

7. *Develop interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented as planned*:

For each monitoring and implementation action recommended in the restoration plan, we describe the milestones that should be targeted to evaluate whether a) the time frame is being met, and b) initial steps are successfully leading into the necessary following steps. A formal evaluation protocol will be set in place to determine if and when a certain planned measure is going off-track. Evaluation measures may include: number of school children involved in the monitoring plan, number of schools using watershed based science curriculum, surface area of

Bay that is being monitored, cumulative data production of research projects, key stakeholders brought into the restoration process, personnel hired, etc.

8. *Develop a set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised*:

As part of the restoration plan we recommend a monitoring plan to provide both baseline and continuing data on ecologically relevant water quality parameters. This should be based on biomonitoring using algae and / or coral growth, and on monitoring of specific sites identified after a consideration of the hydrology of the watershed. Monitoring should specifically target storm events for sampling of sediment and nutrient inputs from streams into the Bay, because data are lacking on storm flow (yet what data there are indicate that for Wailuku and Honolii streams at least this in when most surface water enters the Bay and therefore potentially when most sediments—though not nutrients—enter the Bay). This data set cannot be compared against any existing database, to look for changes in parameters. Therefore, through the initial 5-year period and perhaps beyond, plan implementers should also rely on consistent monitoring using the same parameters that the HDOH uses to classify waters for the 303d list, but should ensure that sufficient samples are available each year to meet the criteria of at least 10 samples each in the wet and dry seasons. The DOH criteria are described in section 7 below; they include both regular DOH numeric monitoring and the NRCS visual assessment protocol. Monitoring should not target listed segments; rather, it should provide full coverage of the watershed by dividing it into segments based both on hydrology and accessibility. This means sampling at locations that represent inputs from different land uses, at the mouths of streams, and at locations where fresh water seeps into the Bay. This is the type of monitoring that can be carried out by school groups and canoe clubs and the general public, following adequate training by the restoration team. Note, therefore, that we are referring to two different monitoring plans that have to be developed—one for water quality to detect significant changes in standard water quality parameters, and one that will be developed using the biological community of the Bay waters.

Plan implementers should use a consistent downward trend in the state approved water quality indicator criteria (with the exception of visual assessment for nutrients) over at least a 5-year period as an indication of load reductions. A downward trend over less than five years cannot be indicative of change in water quality, given the variability in rainfall experienced in the Hawaiian islands and the very large within- and among-year fluctuations noted for sediment loads, flow rates, etc. Appropriate statistical techniques should be used to determine whether the variance among years is lower than the variance within years and therefore statistically significant.

Criteria for evaluating TMDL implementation success are being developed by the DOH TMDL team working in the Alenaio and Waiakea basins within the watershed, and are not addressed in this WBRP.

9. *Develop a monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element (8) immediately above*:

See above for standard, DOH-approved criteria. Once plan implementers have developed algae and / or coral based bioindicators of Bay water quality as part of the research plan, these can be used these to monitor ecosystem functions that affect water quality.

5—WATERSHED BACKGROUND

5.1—Boundaries

Two large (Wailuku, Wailoa), one medium (Honolii) and four small (Malii, Pauka, Pukihae, Wainaku) subwatersheds make up the larger Hilo Bay Watershed as defined for the purposes of this restoration plan (Fig. 1). The HB Watershed area covers 463,577 acres and includes agricultural, forest, conservation, urban and rural land uses (Fig. 2).

5.2—Hydrology

Rainfall

Rainfall in this watershed is the highest on the island of Hawaii, ranging from around 120 inches per year on the coast to about 240 inches per year on the lower slopes of Mauna Kea and Mauna Loa (Juvik and Juvik 2002). The watershed includes the northern end of the Waiakea High Rainfall area, as defined by the USGS (Fontaine and Hill 2002). Mean rainfall here ranges from 118 inches per year on the coast to 236 inches per year at 3000 feet elevation. It was this area that received record rainfalls in the so called “November 2000 storm” (more than 30 inches in a single rainfall event) resulting in floods that damaged the Komohana Street bridge over the Alenaio stream (Fontaine and Hill 2002), and which has generated increased concern among Hilo citizens regarding flood control (G. Kuba pers. com., T. Young pers. com.). In fact, a flood control structure was contemplated and cost/benefits assessed by NRCS at the Akolea Road (Young, pers. com., NRCS 2001). The cost-benefit analysis was shown to be negative, and the plan did not proceed. However, the cost-benefit analysis included only the benefits of preventing flood damage to homes and other built structures--it did not consider the indirect benefit of preventing erosion and reducing sediment input into coastal waters. Such benefits should be estimated in future cost-benefit analysis for water management structures and activities in the watershed.

The high rainfall area itself is primarily forested (plantation and native) and former sugar cane land with much decreased agricultural activity. It is an area where commercial logging activities have occasionally been considered (Anonymous 2001) and may be implemented in the future; as such, close attention should be paid to the potential for this area to supply new future sediment and nutrient input to the lower watershed and the Bay.

Surface water vs. ground water inputs

The hydrology and geology (including sediments) of the Bay are described in this section using the Hilo Area Comprehensive Study (M & E Pacific1980) as a source of information, unless otherwise noted. That study did not analyze long term flows from the Wailuku river, but base its estimates of water and sediment flows from a shorter USGS record, and from its own data collection. Hoover (2002) provides an analysis of the long term USGS records for the Wailuku and Honolii streams, with a detailed description of the variability in base and storm flows as well as of the sediment loads and nutrient loads carried by those two streams.

North of the Wailuku, and in the Wailuku itself, most of the fresh water input to the Bay is from surface runoff. The basalt in this area is overlain by a relatively impermeable layer of Pahala ash, limiting percolation. East of the Wailuku, most of the fresh water inputs to the Bay are from ground water, which emerges at the Waiakea pond and then flows through Wailoa river to the Bay, or as seeps and springs right along the coast line (Fig. 3). In this area the surface is made of highly permeable basalts with little overlying ash. Waiakea Pond is the largest single source of groundwater into the Bay (at Reed's Bay).

As noted by M & E Pacific (1980), "Hilo Bay is the greatest sink for fresh groundwater known in the entire Hawaiian Archipelago. Indeed, the Bay is the catchment for one of the known, great basal groundwater spring areas of the world. The flow of fresh basal groundwater to the Bay exudes at a nearly constant rate in comparison with surface runoff and is often the overwhelmingly dominant freshwater component entering the Bay." Therefore research into non-point sources of pollution needs to focus on ground water as well as surface water.

In 1980, the breakdown of fresh water inputs to the Bay was estimated as shown in the following table. The ratios will have changed in the interim due to the increase in impervious surface area in the lower watershed and due to storm runoff and hardening of the Wailoa river channel where it leaves Waiakea pond for flood control purposes.

	Average Flow (mgd)	
Area	**Surface**	**Groundwater**
Wailuku River north to Alealea Point	10-20	10
Wailuku River	300 (range 10 to several billion)	
East of Wailuku and to breakwater	6	500
Puhi Bay	1	100
East of Puhi Bay	1	100

The fresh water input creates an upper fresh water layer lying above a lower salt-water layer. This two-layer system is present year round, but is most marked in the wet season, when the upper fresh water layer is thicker due to higher surface runoff. The lower layer moves in and out with the tide, and the upper layer is pushed toward shore by the easterly and northeasterly winds. Because of low wave energy inside the breakwater, there is little mixing of the layers. Also, the low wave energy allows sediments carried by Wailuku and Wailoa rivers to settle out into the lower salt-water layer, where they can then be carried back inwards with the incoming tides. Tidal velocities are probably too low to resuspend bottom sediments, but suspended sediments will move in and out with the tide. Some of course are also carried out to the mouth of the Bay.

During storm flows, water and sediments from the Wailuku are carried out of the harbor more rapidly.

Most sediments entering the Bay come from the Wailuku. Sediments settle out from the plumes of storm water from the Wailuku, as evidenced by the decreased turbidity of the water as one moves out to the mouth of the harbor during a storm event. In the late1970s, sediments coming from the Wailoa river were marked with arsenic from Waiakea pond, making it possible to track how far the sediments go (M & E Pacific 1980). Arsenic concentration in the sediments at the entrance of the harbor were 96 ug/g dry weight, lower than in the pond but higher than in the northwestern part of the Bay, indicating movement of sediments from the Wailoa river out towards the entrance of the harbor. At the mouth of the Wailuku river, arsenic levels were at background levels, indicating that sediment in this area comes primarily from the Wailuku itself. Despite high arsenic content in the sediments, the water above them does not have detectable levels of dissolved arsenic—i.e., levels do not differ from background levels typical of Hawaii's unpolluted coastal waters.

Silt and organic waste from the sugar mills accumulated near shore in the 1900s. This and continued nutrient inputs made the sediment more Nitrogen rich than in any other estuary in the state: Hilo Harbor sediments had about 1.46 mg per gram dry weight total N, the inner harbor sediments had 1.52 mg/g, and the outer harbor had 1.28 mg/g. These values contrasted with the other urbanized, agricultural and undeveloped coastal areas (Waikiki = 0.324 mg/g; Kahana = 0.299 mg/g, Maunalua = 0.712 mg/g, Kilauea = 0.235 mg/g); again, these are late 1970s levels and will have changed. In contrast, P levels were relatively low in the harbor sediments (0.070 mg/g, 0.079 mg/g and 0.044 mg/g in Hilo harbor, inner harbor and outer harbor, respectively) compared to about 0.5 mg/g for the other sites listed (M & E Pacific 1980).

Dissolved nutrients were also measured in 1978. "The nitrogen data for Hilo Harbor show the highest levels of ground water sources and lower for flood flows. The nitrate levels are especially high in groundwater. In general, the nitrate plus nitrite concentration in Hilo harbor seem unusually elevated during the wet season." These high nitrate levels in ground water may be the result of heavy fertilizer application or of intensive wastewater entry into area where the ground water is recharged. Where cesspools or waste dumping into lava tubes is occurring upslope in the recharge area, this could lead to high nitrate levels.

With respect to phosphorus, levels were higher during the wet season than the dry, indicating surface runoff of phosphorus. This makes sense given that P does not move well through soils because it is sorbed onto sediments and therefore would be retained by the soil and not easily be carried in ground waters. "However, the phosphorus levels in the samples taken from the Ice Pond were unusually high. This may indicate significant groundwater movement via lava tubes or direct discharges of surface runoff or wastewater near the sampling area" (M & E Pacific 1980)

In the late 1970s, levels of suspended solids during storm events exceeded state standards, as did total Kjeldahl Nitrogen and nitrate-nitrite values and phosphorus during normal weather. Chlorophyll a did not exceed state standards. However, the impact of nutrients on plankton growth in the Bay may be limited by the low salinity conditions, especially when some layer mixing occurs during storm events. These conditions are harsh for plankton growth, and would consequently limit nutrient uptake (M & E Pacific 1980). Therefore, measurements of chlorophyll a may not be good indicators of nutrient in the Bay, and nutrients may be there at levels higher than what the plankton or algae can actually use.

Evidence for the movement of nutrients from agricultural land in ground water is supported by contamination of wells near the coast with low levels of residual pesticides, which could have come for the same source (Hawaii Department of Health 2003).

5.3—Biology

There are no long-term studies of the fauna and aquatic flora of the Bay. Some streams in the watershed have been monitored using the DARs Stream Bioassessment Protocol, but data are not currently available in a summarized form or published in reports.

Researchers with the Hawaii Coral Reef Initiative (HCRI) have carried out inventories for invasive algae in Hilo Bay, and some fish monitoring transects outside the breakwater. Results of these surveys are as follows: The mat-forming alien macroalgal species *Gracilaria salicornia* was found in Hilo Bay (Hunter 2003); this species was apparently released during a ballast-empying incident in the bay (L. Basch, pers. com.). The only sites surveyed by the HCRI were outside of (East of) the breakwater. *G. salicornia* is spreading relatively quickly in the state and it regrows rapidly when removed from experimental plots, implying that methods other than manual removal may be necessary to control it should it become more abundant in the Hilo Bay area.

Sites that have been monitored by HCRI for algae, fish and/or coral health are Puhi Bay, Leleiwi point, Onekahakaha, and Richardson's Ocean Park. For Puhi Bay (outside of the Hilo breakwater), P. Jokiel reports that coral and fish surveys were carried out at 17' and 35', the second location being directly out from the Hilo sewer outfall station, 600 feet from the shore. In a pattern opposite to that found in other coastal waters in the state, the temperature at this site increases with depth, due to the cool groundwater seeps that form a freshwater lens at the surface, again emphasizing the unique hydrology of the coastal waters in this area. Surface waters were flowing away from the shore. Coral health seemed good, with high numbers of recruits but no large coral heads; there was no evidence of disease, and 19 different species were documented. Jokiel speculates that the presence of *Porites rus* in the area may be a result of the sewage outfall, as in Guam this species is prevalent in areas of sewage outfall. Fish diversity was recorded as 42 species on eight 25-meter transects at two depths, with *Acanthurus nigrofuscus* (mai'i'i) and *Thalossoma duperrey* (hinalea) the two most common species.

Additional information on planktonic, benthic and fish communities is found in the Hilo Bay Comprehensive Study (M & E Pacific 1980) and might be useful for comparison with up to date data once both water quality and biological parameters are re-monitored in the Bay.

Note that the Hawaii Coral Reef Initiative Research Program's Call for Proposals in 2005 had as one of its focal themes the examination of "how pollution (e.g. toxins, nutrients, debris, point source and non-point source, sediment, hydrocarbons, heavy metals) affects Hawaii's nearshore reefs" and encouraged submission of proposals that would "make practical recommendations for preventing marine pollution that negatively impacts coral reef ecosystems." This approach is complementary to the goals of the Hawaii's Local Action Strategy to Address Land-based Pollution Threats to Coral Reefs, and these programs may be possible sources of funding for research on this topic in Hilo Bay in the future.

5.4—Land Ownership

The major landowner in the watershed is the state of Hawaii with about 314,000 acres (nearly 69 % of the watershed). Two state departments manage most of these lands: Department of Land and Natural Resources with about 254,000 acres and Department of Hawaiian Homelands (DHHL) with nearly 60,000 acres (Fig. 4). The Federal Government owns and manages 68,823 acres in Volcano National Park and Hakalau Wildlife Refuge. Other large landowners are Kamehameha Schools with about 32,119 acres, WU-Hilo with 11,394 acres, and C. Brewer with 10,553 acres. The County of Hawaii owns 675 acres (0.14 % of the watershed). These figures are based on tax acres, not GIS acres. DHHLs Hawaii Island Plan evaluates current status of DHHL land on the Big Island and sets out 20 year plan for development.

5.5—Conservation lands

Three reserves in the DLNR Natural Areas Reserve System are completely or partially within the Hilo Bay watershed area: Mauna Kea Ice Age (3,894 acres) is located in the upper, southern flank of Mauna Kea and contains rare alpine aeolian desert and the only alpine lake in Hawai'i.; Waiakea (640 acres), a montane wet 'ohi'a forest ecosystem, is located on the sloping northeast flank of Mauna Loa and supports succesional communities of ohi'a and other plants on recent lava flows; Pu'u Maka'ala (12,106 acres, of which about half are within the watershed) is located on the eastern flank of Mauna Loa and contains montane wet 'ohi'a and koa forests as well as a montane wet grassland ecosystem (DOFAW brochure). The NARS area thus holds approximately 2.3% (10,662 acres) of the watershed's 463,577 acres. A fenced-off kipuka within the Hilo Forest Reserve also receives additional protection by DOFAW. This is a small kipuka area called "Kipuka Mauna Loa" or Kipuka Mosaic, which protects and makes accessible to the public several native bird species.

Other conservation lands include the Hilo Forest Reserve, managed by the Division of Forestry and Wildlife (DOFAW); the US Fish and Wildlife Service's (USFWS) Hakalau Refuge, where feral pigs are being controlled to reduce invasive plant encroachment through fencing and trapping and hunting. Lands above the Refuge (along Keanakolu Road), which are managed by DHHL, are badly affected by invasive gorse (*Ulex europaea*, Fabaceae). DHHL has not renewed the cattle leases in this area and a program has begun to contain and control gorse. DOFAW and the USFWS are concerned that cattle are not being fenced along stream corridors (L. Hadaway, pers. com. to K. Napoleon). Cattle trespassing from ranches adjacent to the restricted watershed are a source of renewal for the resident population in the Hilo Watershed. Recent emphasis in boundary fencing upkeep and errant cattle removal by DOFAW is to be supplemented by a proposed Feral Cattle Hunt project (R. Bachman, pers. com.)

Protected areas with recreational facilities include Wailuku River State Park (16.3 acres), and Wailoa River State Recreation Area (131.9 acres). Due to high visitation rates by local residents as well as off-island tourists, these parks are excellent sites for educational activities, including self-guided materials such as signs and pamphlets.

DOFAW management activities on conservation lands:
The Division of Forestry and Wildlife feels that the lands they manage are in the best shape of any within the watershed boundaries. They encourage the use of scientific research to determine whether the lands they manage play a role in water quality impairment, and will actively participate in an approved restoration plan if there is evidence that their lands do contribute to water quality problems (S. Bergfelt, pers. com.)

1. Invasive Species: DOFAW actively works on controlling invasive species within the watershed area. DOFAW is currently working on gorse, Himalayan raspberry, *Clidemia*, banana poka, and palm grass using mechanical and chemical methods and biological control (pathogens). The Big Island Invasive Species Committee is working on the control of *Miconia* within the watershed.

2. Threatened and Endangered Species: DOFAW is currently working with the Kau silversword, *Cyanea platyphylla*, *Cyanea shipmanii*, *Clermontia peleana* and Nene.

3. Commercial timber: The Waiakea Timber management area falls within the watershed area. A land license has been issue to Tradewinds to harvest the timber. No harvest has yet begun, but DOFAW will ensure that Best Management Practices will be followed once harvest begins.

4. Hilo Forest Reserve: DOFAW's management activities in the Hilo Forest Reserve are as follows:

Fence line maintenance—within the last year, DOFAW removed trees threatening the Puu OO ranch fence (3 miles of fence line). This will make it easier for the rancher to maintain his fence and keep cattle out of the forest reserve.

Cattle removal—there are feral cattle in the upper reaches of the Hilo Watershed. DOFAW is currently working on a feral cattle removal program. Numbers will be significantly reduced within 3 years.

Trail and road maintenance—DOFAW periodically maintains roads and trails within the watershed boundaries to facilitate access for management as well as for public access for hunting and other forms of recreation.

Fire prevention, pre-suppression and suppression-- DOFAW is an active member of the Big Island Wildfire coordinating group. BIWCG's purpose is to allow the fire agencies on the Big Island to work together more efficiently to provide fire services for the people and resources of Hawaii Island. DOFAW trains and equips 38 personnel for fire suppression activities, and maintains 17 fire vehicles and 2 fire caches on the island for fire suppression.

USFWS management activities in Hakalau Wildlife Refuge:
1. Conservation of native and endangered plants and animals.

2. Restoration of native forest through tree propagation and outplanting.

3. Control and removal of feral pigs and feral cattle.

4. Control of invasive weeds including Florida blackberry, gorse, banana poka and holly.

As noted by Ron Bachman, of the DOFAW wildlife branch, there is synergy between management activities for invasive plants and animals: eradication of feral sheep on the Mauna Kea slopes (Mauna Kea Forest Reserve and adjacent DHHL and Piihonua leases) has led to increase in gorse; increase in gorse in turn provides shelter for feral pigs, which are then harder to control by hunters.

5.6—Hunting Areas

Hunting is allowed on all Forest reserves and game management areas within the watershed. Feral pigs and mouflon sheep are the main game animals. Game birds are also hunted in the upper areas of the forest reserves. Areas open to hunting under different levels of restriction include: the Hilo Watershed Forest Reserve, the Upper Waiakea Forest Reserve, the Waiakea Forest Reserve, the Waiakea 1942 Lava Flow Natural Area Reserve, the Kulani Buffer Zone and the Kipuka Ainahou Nene Sanctuary.

5.7—Urban areas

The Wailoa subwatershed is the most urbanized (Fig. 5). The largest streams in this subwatershed are the Alenaio, Waiakea and Palai, all of which flow into the Waiakea pond, which in turn empties into the Bay via the short, channelized Wailoa river. Alenaio, Palai and Waiakea streams, the pond and the river have been modified as, or contain modifications for, flood control structures. The green area and soccer fields surrounding the pond have been designed as an additional feature of the Alenaio Flood Control system. A planned flood control project on the Palai stream will divert flow into the 4-mile Creek Flood Control structure, which will end at a detention basin rather than in the Wailoa and the Bay (G. Kuba, pers. com.). A partial diversion is also being planned for Waiakea stream above Kupulani Street that would divert peak flows around urban feed areas. Both projects are in the feasibility cost sharing phase of development and are subject to further economic and engineering analysis by the ACOE (G. Kuba, pers. com.).

The Bay itself contains Hilo Harbor, the main port for the island of Hawaii and the unloading point for fuel, cargo and cruise ship travelers. A 10,080-foot long rubblemound breakwater was constructed between 1908 and 1929 (USACOE 2004) to reduce wave energy and facilitate docking by ships at the harbor. It lies on top of Blonde Reef, a natural shallow water area in the eastern side of the Bay. In the late 70s and early 80s there was much research and planning activity related to plans to modify the harbor and breakwater (US FWS 1979, USED 1980, USACOE 1983a, b), but the modifications never took place. Currently there is a new push, supported by the community and by Mayor Harry Kim, to study the Bay and the breakwater again in order to determine whether modifications to the breakwater would improve water quality in the Bay. The Department of Transportation, Harbors Division, is unlikely to allow any such modification, however, if it reduces the functionality of the Bay. The key initiative in this direction is the Hilo Bay circulation modeling study commissioned of the ACOE; the ACOE has now prepared a draft Scope of Services that is available for review.

5.8—Storm water management

Developers must plan for the disposal of their storm water output and follow current county guidelines on the amount of runoff water that the development must be able to retain/handle. They are allowed to maintain pre-development drainage conditions. Small developments that have negligible drainage impacts are not held to the same standards as large-scale developers, so they may not be obligated to have the capability to retain water from a 10 or 25-year flood. There has been some discussion recently of actions to be taken to protect water quality from the impacts of storm water. Actions considered include catchment basins to filter out solid materials before the water enters the storm drain, but this option is being weighed against the cost of maintenance. With the tremendous rainfall in Hilo and the masses of plant litter that are carried by storm water, this would be a huge undertaking. Modifications to storm drains are planned under the Czara New Urban Development Measure. No non-structural BMPs have been tested to date. There is no single map available showing major storm water diversions and channels, but there is a map of storm drains for Hilo town (G. Kuba pers.com., by way of J. Zimpfer). Integrated flood management, as recommended later in this plan, has not been a county strategy to date, and no watershed-wide hydrologic model exists to support such management.

5.9—Grubbing and grading

Appendix 5 describes the current status of grubbing and grading ordinances, and positive criticism for their improvement. The process of revising grubbing and grading laws was started years back but has not reached completion yet. Both the county and NRCS are understaffed to accomplish what are commonly called "grading/grubbing ordinance driven" plans for different reasons. The local Soil and Water Conservation Districts could have a larger role to play but there are linkages that need to be strengthened in order for that to happen (pers. com. S. Skipper).

As an indication of the understaffing that prevents proper monitoring and enforcement of grubbing and grading permits, we examined the dates on 86 grubbing or grading permits that were applied for in 2004 at Hilo county offices. Fifteen of the permits (17 %) were granted or waived after the work had started, (range 1 day to 352 days after work had started) and 13 one month or more after work had started. This is an improvement over the 1991 situation, when 173 of 355 permits (48.7 %) were issued or waived after work had already started; of these, 2 were after work was completed, 71 after work had started at least 30 days earlier, and 5 a year after work had started.

5.10—Agricultural lands

Sugar cane dominated agriculture until 1990, then it gradually phased out, until in 1995 there was only one plantation. The last crop was harvested in 1996 (Research Solutions 2002). The change is very recent, and the economy, society and environment are still in transition. Pesticides and fertilizers were added to these fields, and these may still moving into the ground water, as indicated by well contamination with pesticides. As a result of the ending of sugar cane planting, in the mid to late 90's the Wailuku River drainage basin in particular experienced a drastic change in land use activities. Following the departure of sugar plantation operations and the cessation of continuous harvest and tillage cycles much of the area was stabilized by volunteer cover, modified for residential development and smaller areas were planted to other crops. Overall, annual tilled and open or bare land acreage has been drastically decreased. Water quality and erosion and sedimentation data gathered during the sugar cane period may no longer present a valid picture of agricultural contributions to watershed pollution.

Currently orchards and flower plantations dominate the agricultural landscape, along with fallow land. Along the Hamakua coast north of Hilo, soil loss due to erosion was high in the past due to sugar cane and other plantings on steep, high rainfall areas. Currently less soil loss is probably occurring because orchards and flower plantations have a smaller footprint and include good ground cover. Nevertheless, it is necessary to monitor incoming small land holdings that may require more frequent tilling (Smith 1998). Some cattle ranching occurs along the Hamakua coast, but calves are exported for fattening due to economic constraints. Agricultural and ranching land are shown as cultivated land, grassland and shrubland in the land cover map (Fig. 6)

Erosion and pollution control on agricultural lands are under voluntary management, overseen by NRCS and the Soil and Water Conservation Districts. The NRCS Hawaii Field Office Technical Guide (FOTG) is locally adapted and contains standards and specifications for all conservation practice application. The NRCS National Conservation Planning Procedures Handbook (NPPH) is also used to link and associate practices in a systematic manner for specific types of plans. Planners use these manuals to ensure that practices are appropriate and integrated to apply a "conservation systems" approach in development of the Conservation Plan documents. The Hawaii FOTG is accessible on the web through the NRCS Hawaii website. Conservation practice application effectiveness is well documented. However, if a plan and associated practices are not applied, they cannot be viewed as complete or effective (S. Skipper, pers. com.).

Information on conservation plans on agricultural properties is proprietary information, so that the authros were unable to assess the number, type, potential conservation impact and degree of implementation of management plans. While voluntary compliance with conservation plans is probably a good system, given the strong support provided to farmers through the USDA/NRCS, no data are currently collected on the actual effectiveness of conservation plans in reducing pollution. Without evaluation and monitoring, one cannot assess the value of BMPs or the degree of compliance by landowners, and therefore one cannot determine when practices need to be changed, or how to best adapt practices to local conditions.

Agricultural tourism may become an important even though small part of the Hilo economy— e.g. tourists visiting local orchards and flower farms— especially when linked to the within-Hawaii cruise ship industry (e.g., Norwegian Cruise Lines' week long tours of the islands) (Bishop 2005).

5.11—Wastewater management

Hilo's first sewer system, which delivered raw sewage inside the breakwater (Fig. 7) was completed in 1905-1906. The system was expanded in 1935-1937 to incorporate a longer outfall and to link Waiakea Town. The capacity of the Waiakea segment was too small, and at times raw sewage was discharged into the Wailoa River. In 1952, 3.5 million gallons per day of raw sewage were discharged from the outfall, but most of the town relied on cesspools, not the sewage system. In 1962, the Hilo Sewer System served about 20% of the Hilo population. The sewage system was upgraded in 1966 to include primary treatment, locate the outfall outside of the breakwater (off Puhi Bay), and other improvements. The treatment plant was upgraded to secondary treatment sometime after 1980. The inner Bay outfall was closed, and the current outfall from the 5 million gallon per day treatment plant near the airport is located in the area outside of Puhi Bay (Fig. 8).

Approximately 30-40 % of urban Hilo is currently connected to sewers (P. Boucher, pers. com.) (Fig. 8; Fig. 9). No master plan exists for achieving the maximum possible level of hookups to existing sewer lines. County policy regarding hooking up to the sewer system is as follows: For residential areas, County Code Section 21-5 states that "every lot which is accessible to a sewer and which has a plumbing fixture on it shall be connected to the sewer". For subdivisions, Section 23-85 states that "In a subdivision laid out after December 1, 1966, sewer lines shall be installed where the subdivision is within three hundred lineal feet of the existing sewer system. These lines shall conform to the minimum requirements of the department of public works. In subdivisions where connections cannot be made to an existing sewer system under the requirements of this chapter, the subdivider shall meet the minimum requirements of the State health department relating to sewage disposal." All gang cesspools are referred to DOH for application of current statewide regulations, which call for their total closure and replacement with septic systems.

In 2004 the exemptions for houses built before 1984, and those that would have to pump up to the collection system, were revoked. Homeowners were given 180 days to reach compliance. But compliance has not been monitored (D. Beck, chief of Technical Services, pers. com.). To achieve hookups, any house sold that is not connected must be connected prior to sale completion, if a sewer line is available (J. Zimpfer, pers. com.). Also, customers must pay for the installation of connection lines themselves (which can cost between 5,000 $ and 15,000 $, depending on location and topography), and pay a 27 $ monthly sewerage fee, but there is no additional one-time connection fee.

The exact status of sewer connections is not known due to low monitoring, and there is no current map showing the location of cesspools and septic tanks or their relation with respect to flood zones and underlying hydrology.

5.12—Industrial pollutants

During the height of the sugar cane era, there was a canec plant in Hilo that added arsenic and other pesticides to bagasse to make an insect- and rat-resistant wallboard product used in construction; wastewater from the plant was discharged into Wailoa estuary pond. Similarly, the

Wainaku sugar mill discharged process wastewater and bagasse into the Bay and the Waiakea Mill discharged wastewater from washing cane (with high silt content) into Waiakea pond, some of which would have been carried out into the Bay by the Wailoa River.

In 1978 sediments in Hilo Harbor had the highest concentrations of arsenic of any estuary in the state (675.4 ug/g dry weight, vs. background levels elsewhere of less than 20 ug/g dry weight) (M & E Pacific 1980). This is outside of the Waiakea pond, which presumably is the source of arsenic, which would be resuspended from the sediments during storm flows. However, as arsenic is not very soluble, concentrations in the water column are generally at non-detectable levels, as they were in Hilo Bay in 1978. Although carcinogenic effects due to arsenic have been recorded for workers in factories using inorganic arsenic and for those ingesting water with high levels of inorganic arsenic (EPA standard is 50 ug/l), and high exposure to toxic forms of arsenic can also cause birth defects, these effects are due to chronic exposure to arsenic in the air and water. This is not a concern in the Hilo area, as arsenic levels in water and fish muscle tissue are low. Consumption of fish from areas where arsenic is present in sediments is not a serious health concern, as the forms of arsenic found in fish and crustaceans appear not to have negative health effects (Eisler 1988). Although fish and other marine organisms, including crustaceans, cephalopos, and algae can bioconcentrate arsenic to some extent, arsenic is not biomagnified in the food chain. Fish naturally accumulate arsenic from non-anthropogenic sources into the viscera, not the muscle (arsenic is relatively abundant in the environment and at very low levels may be essential for proper vertebrate growth (Eisler 1988).

We stress this information because there has been concern among Hilo Bay fishermen that studies of arsenic in the Bay may lead to a shutdown of fishing areas due to health concerns (D. Weeks, pers. com.). The above description indicates that this is very unlikely occurrence. We do however need to study the levels and cycling of arsenic in the Bay by the biological community, because arsenic can affect plant growth (agricultural and other), insects, plankton, and other aquatic organisms sensitive to arsenic, and can therefore affect ecosystem function in Bay waters, which in turn can affect nutrient use by the biota. For example, arsenic can be taken up by phytoplankton using the same pathway as phosphorus (T. Wiegner, pers. com.). Arsenic in the Hilo Bay watershed could therefore potentially affect agricultural yields, wetland restoration and function, and overall ecosystem function. It should be studied as part of ecosystem studies in the watershed, but the public should be educated as to the purpose of this research and it should be made clear that there is not current concern about the health effects of eating fish from areas with arsenic contaminated sediments such as Waiakea pond and Hilo Bay.

There was also a gas plant on the shore that discharged petroleum waste into the Bay (Fig. 7; M & E Pacific 1980) and there may be some residues from this time (County of Hawaii 2004).

5.13—Current uses of Bay

Hilo bay is regulated as a class A water; its uses and conditions are described as in Appendix 7 (Definition of Class A waters by Hawaii Administrative Rules)

Fishing

Fish management areas and regulations are described in the Division of Aquatic Resources Web site. Within the Hilo Bay watershed, DAR regulates fisheries in Hilo Harbor (inside of the breakwater), Wailoa River, Wailuku River and Waiakea pond. Data on fish takes are available from DAR. The Hilo Bay Comprehensive Study (M & E Pacific 1980) contains the results of extensive interviews with Hilo fishermen and describes the fisheries at that time. Current concerns of fishermen include keeping the mouth of the Wailoa river open and enlarging the boat harbor in that area. R. Nishimoto, DAR fisheries biologist in Hilo, is interested in managing Waiakea pond as fish nursery, and restoring its vegetated border to increase its quality for fish production. This is consonant with interests in the Hilo community in restoring the former coastal wetlands in Hilo, and with the need to improve habitat quality for endangered wetland bird species in Hawaii.

Canoeing

Canoeing (outrigger canoes) is the main recreational use of the Bay, and has great cultural significance. There are 8 canoe clubs operating out of Hilo, and several of the high schools also have canoe clubs. About 750 paddlers of all ages participate in the clubs. The 2004 International Va'a Federation World Sprints were held in Hilo in August 2004, bringing about 1,500 competitors and many more spectators to Hilo, with an estimated contribution of about 4 million $ to the local economy (Fig. 10). There are six to seven races every summer in the Bay, and every day there are canoes on the Bay for practices and classes. This provides a great opportunity for volunteer and school-based monitoring activities, as the canoeists and students are constantly in the Bay, going fairly far out in their canoes. They have a strong interest in water quality (Dayton 2005), and could easily be recruited to participate in the monitoring and education activities.

Surfing and swimming

Surfing and swimming do take place, but swimming is limited due to the local populace's fear of rashes and staph infections. Hilo Bayfront as it is called is one of the longest and best left hand surfing breaks in the State of Hawaii. It has a narrow swell window and breaks infrequently predominantly from October through February. The surf spot has a long cultural history and is referenced by Isabel Byrd Bishop in her novel "Six Months in the Sandwich Islands". There is a large contingent of dedicated wave riders that use surf based website information to predict the swell events and the spot can accommodate larger amounts of surfers due to the expansive nature of the surfing area (S. Skipper, pers. com.).

Swimming is not uncommon at the Wailuku river mouth but the beach is small. Most of this type of activity would be better termed "wading" especially along the Bayfront Beach or Canoe Beach section of the shoreline and Wailoa Boat Ramp where children often can be seen playing in the shallows on the weekends while parents participate in paddling or fishing activities. A common complaint is water turbidity and skin irritations that have been observed from time to time from some unidentified sea creature(s). Since this popular surfing spot sits at the mouth of the river with largest volume of water in the state, some studies should be undertaken along the reach of the riparian system to locate and quantify potential pollutant/bacterial entry points, as most of the inputs into the marine environment could be traveling into the Bay in or on the waters of the Wailuku. (S. Skipper – pers. com.).

Other water sports

Jet skiers and sailing boats are also present in the Bay. Their impact on, and concerns of their owner regarding, water quality should be addressed.

Cruise ships

The number of port calls by cruise ships and the number of cruise ship passengers visiting Hilo rose from 105 and 75,633 respectively in 2001 to 136 and 234,525 in 2004, respectively. With the addition of Pride of Aloha to the fleet in July 2004, projected visits in 2005 are 164 and 302,560. With the addition of two new domestic flag ships to Norwegian Cruise Line's fleet in 2005 and 2006, projections for the year 2007 are 217 port calls and over 400,000 passengers. The projected revenues for the same year, based on an average expenditure of $ 100 per day by each passenger and considering both Hilo and Kailua Bay ports, are $ 83,380,000 in passenger expenditures, $ 53,366,000 in GSP generated, $ 33,352,000 in household income generated (based on 1,108 jobs generated) and $ 5,669,840 in state and local taxes generated. A bit under half of these monies would be generated by Hilo port calls (information provided by Harbor Master I. Birnie).

The cruise ship industry will play a large role in the economic development (or stability) of the Hilo area in the near future. Hawaii county and the city of Hilo have plans to revitalize the area between Hilo and the cruise ship piers as a greenbelt with connecting greenways and with a shore front park in order to strengthen the cruise ship industry in Hilo (County of Hawaii 2004). While economic analysis has been done of the economic benefits of the industry, the impact in terms of water quality has not been measured, nor has the cost or improving the infrastructure in order to support the growing industry been included in the cost-benefit analysis. Issues such as the environmental impact of increased visitation to Volcanoes Park and Hilo area parks need to be addressed. There is huge potential here for creating a partnership between Hilo and the cruise ship industry, especially with Norwegian Cruise Lines which has demonstrated a strong commitment to Hawaii with its US flagships (Bishop 2005) and to establish an ecological/natural history theme to the cruise ship visits to Hilo.

6—EXISTING MANAGEMENT EFFORTS AND WATER RELATED MASTER PLANS

We are aware of the following management, construction, research and education efforts ongoing in the Hilo Bay Watershed, which provide opportunities for synergy and collaboration with the Watershed Based Restoration Plan (names of contact personnel are given in parentheses):

1. UH Hilo storm water structures—redesign of storm water management on UH Hilo campus

2. Flood control—Palai Stream flood diversion—Department of Public Works; partial diversion for Waiakea stream above Kupulani Street (Galen Kuba)

3. Stenciling urban storm drains—NEMO project (Jeff Zimpfer)

4. Army Corps of Engineers—Honolulu District—computer modeling of circulation in Bay, under different hypothetical scenarios of breakwater modification, based on exiting data with small amounts of water quality data to be gathered; Tom Smith in charge of modeling (E. Williams per. com.)
The County is committed to improving and restoring the Hilo Bay ecosystem and water quality, but rather than focusing on pollutant inputs coming from the watershed itself, it is investigating ways to improve Bay circulation, possibly by altering the Hilo Bay breakwater. This would allow natural flushing to occur and thus minimize accumulation of pollutants trapped by the man-made structure. The one condition on altering the breakwater is that the harbor function not be compromised. To this end, the County administration has approved funds to develop a computer model to study Hilo Bay circulation and look at various alternatives to improve circulation in the Bay. The County intends to hire the Army Corps of Engineers. The County has expressed interest in including UH Hilo in the project, possibly to verify the model. The ACOE also funds channel stabilization in waterways and canals.

5. Waiakea Soil and Water Conservation District—ongoing activities (Thomas Young)

6. Natural Resources Conservation Service— NRCS is involved in ongoing efforts to promote stewardship by development of Conservation Plans for agricultural producers in the Hilo Bay Watershed as well as other areas outside of the watershed. Some of these plans will be associated with USDA Farm Bill cost sharing funds to implement erosion control, grazing management and habitat enhancement and protection programs. In addition there will be a review and selection of watershed areas (some in the WRP area) for participation in the Conservation Security Program (CSP), another Farm Bill Program that targets watershed areas and operators for stewardship incentive payments for applying higher levels of conservation shown in their individual Conservation Plan. The NRCS Field Office (FO) is also responsible for working with the local Soil and Water Conservation Districts to accomplish a GIS based Resource Inventory for the FO work area. This inventory will include soils, watercourses, critical habitat, drought affected grazing lands, coastal ponds, potential water quality problem areas, confined animal sites, wellhead locations, fire hazard areas, noxious species and watershed project areas and many other resource concerns. The Resource Inventory will include a sub-inventory of the Hilo Bay Watershed Restoration Plan boundary area and have several layers of information in that section as well.
The NRCS Big Island Resource Conservation and Development (RC&D) Coordinator and Council are involved in assisting the HBWAG with grant development, grant seeking and fiscal sponsorship of any received funds.

7. Sewer—Hookup incentives, flow study using dye, inspection of treatment plant and outfall permit coming up

8. Fisheries—DAR fisheries area in the Bay and pond—allowing revegetation of area around pond, considering study of Waiakea pond as population source for coastal fish (R. Nishimoto)

9. UH-Hilo:

Chemistry:	Dr. Debra Weeks examining occurrence and behavior of arsenic and copper species in Waiakea pond
Marine Biology:	Dr. Tracy Wiegner and Dr. Richard Mackenzie (USDA Forest Service): Bioavailability of natural and anthropogenic dissolved and particulate organic matter from Hilo Bay ahupua'a
Geology:	Dr. Jene Michaud: Mapping of accessible water sampling sites in Hilo Bay watershed (with T. Wiegner)

10. DLNR/DOFAW—fencing, ungulate control, fire suppression, invasive plant species control, invasive animal species control (L. Hadway, DOFAW-Hilo).

11. Kamehameha Schools—internal efforts towards greater sustainability in land management

12. Department of Hawaiian Homelands: DHHL does not do any more ranching on their watershed lands. However, May start grazing and homesteading in the future. The area south of Saddle Road is on long-term lease with DOFAW. On the rest of their land, DHHL is controlling gorse via spray and reforestation (to shade out gorse)—they have about 4 or 5 thousand acres covered in gorse. They want to plant about one thousand acres in trees. They also use biological control measures, burning and herbicide application. They are estimating it will take 20-30 years for the project to be complete. They have an approved (August 9, 2001) Final Environmental Assessment for controlling gorse, for Koa salvage, and for reforestation. Reforestation in their former sugar cane lands, in the makai area, is meant to both stabilize soil and bring in long-term income through forestry.

13. EPA Brownfields Economic Redevelopment Initiative grant awarded to County of Hawaii; identification and assessment of areas contaminated by past sugar mill use, pesticide storage, plantation dump sites; development of plans for greenways and development on these areas

14. Friends of Downtown Hilo Association—have set priorities and developed mission/vision statement for the revitalization of downtown, have chosen Hilo Bay restoration as one of their key goals.

15. Living on a Hawaiian Stream Community Handbook—in prep by Dr. Michele Sheehan with support from DAR.

16. County of Hawaii Soil Erosion and Sedimentation Control Program; objectives listed in Appendix 1 (Galen Kuba).

17. Plans for Wailoa small boat harbor dredging—contract completed (Scott Sullivan) for study of localized hydrogeology, now seeking funds to do the dredging. Filling in of river mouth is considered an accretion problem with sand coming from Wailuku side, so sand will be replaced

on beach. Sediments already tested (Eric Oasa) and approved for placement on beach (E. William, pers. com.).

18. Hawaii Department of Health Total Maximum Daily Load process for Alenaio and Waiakea streams. (Dave Penn, DOH)

19. USFWS Hakalau Wildlife Refuge: A Conservation Plan covering all management activities (fuel break construction, fence construction, road maintenance, gravel mining, tree planting, weed control, facilities construction, etc.) was prepared by NRCS and approved by the Mauna Kea Soil and Water Conservation District. (Dick Wass, Refuge Manager))

Appendix 3 lists the agencies acting in the watershed with their area of responsibility (regular activities as well as special projects)

7—IMPAIRED WATERS IN THE HILO BAY WATERSHED-- HAWAII'S 303D LIST

7.1—The table below lists the water quality impaired segments in the Hilo Bay watershed, and is modified from Koch's (2004) 3004 303d list of Impaired Waters in the State of Hawaii

Listed Waterbody	Geographic scope of listing	Pollutant	Basis for listing	Standard
Stream				
Alenaio Stream 8-2-61.01.1	Alenaio Stream (Wailoa tributary)	Nutrients	Visual assessment	Dry
Honolii Stream 8-2-56	Honolii stream	Nutrients Turbidity	Visual assessment. Numeric assessment	Dry Dry
Waiakea Stream 8-2-61	Waiakea stream (Wailoa tributary)	Nutrients	Visual assessment.	
Wailoa River 8-2-61	Wailoa River	Nutrients Turbidity	Visual assessment.	
Wailuku River	Wailuku stream	Turbidity	Visual assessment.	dry
Coastal				
Wailoa River 001200	Boat Ramp station	Enterococci	Numeric	Wet/dry
Wailoa River 001132	WR Boat Ramp station	Enterococci	Numeric	Wet/dry
Hilo Bay	Bay inshore of breakwater and near shore waters from Wainaku to Paukaa	Nutrients Turbidity	Visual assessment. Prior listing	
Hilo Bay 001106	Boat Landing station	Chlorophyll a	Numeric assessment	Wet/dry
Hilo Bay 001138	Canoe Beach station	Enterococci Turbidity	Numeric assessment	Wet Wet/dry
Hilo Bay 001102	Exit of Ice Pond station	Total P Enterococci	Numeric	Wet/dry Wet
Hilo Bay 001107	Lighthouse station	Chorlophyll a Turbidity Enterococci	Numeric	Wet/dry Wet Wet
Hilo Bay 001141	Offshore station	Chorlophyll a Turbidity Nitrite/nitrate Ammonium	Numeric	Wet/dry Dry Wet/dry Wet/dry
Hilo Bay 001110	Honolii Cove station	Enterococci Turbidity	Numeric assess	Wet/dry Wet/dry
Leleiwi Beach Park 001121	LBP station	Total P Enterococci	Numeric	Dry Wet/dry
Kolekole Beach 001118	Kolekole Gulch station	Enterococci Turbidity	Numeric	Wet/dry Wet/dry
Richardson's Ocean center	ROC station	Enterococci	Numeric	Wet/dry
Puhi Bay 001130	PB #3 station	Turbidity Chlorophyll a	Numeric	Dry Wet/dry

7.2—Description of Criteria for Listing

Here we describe the basis on which streams were added or their listing modified in 2004; those not described in the text but present in Table 1 are carryovers from the 2002 list, classified using the same methodology described here.

<u>Segments Listed on Basis of Numeric Assessment</u>

Bodies of water in this category are categorized based on existing numeric data gathered by DOH from 1997-2003, for conventional pollutants: nutrients, sediments, and turbidity. Note that sample sizes in all cases were small and sufficient data were never available for any stream to trigger the 10 % and 2% storm event allowances. All descriptions are from Koch et al. (2004).

Priority 1—(waters for which at least 10 samples are available in either the wet or dry season; the geometric mean for each season is compared to the wet and dry season standards, respectively):

1. Honolii stream: Previously listed (2002 303d list) for nutrients and turbidity. In 2004, showed no exceedances of nutrients (NO3, total N, Total P) and turbidity (TSS and turbidity) for the wet standard. For the dry standard, there is not sufficient data to evaluate exceedances, and more monitoring is needed. Note that both nutrients and turbidity were sampled by visual assessment, not by analyzing water samples.

2. Wailuku stream: Previously listed for nutrients and turbidity. In 2004, showed no exceedances of nutrients (NO_3, total N, Total P) and turbidity (TSS and turbidity) for the wet standard. There were also no exceedances of the wet season turbidity standard. For the dry standard, there is not sufficient data to evaluate exceedances, and more monitoring is needed.

<u>Waters Listed Based on Fecal Indicator Bacteria</u>

For inland waters, the fecal coliform standard is used. For marine waters, the enterococcus standard of 7 cfu/100ml is used. Criteria for listing: there must be a minimum sample size of 10, and there are no allowances for 10%, 2% or wet/dry variations. Fecal coliforms are rarely measured in fresh or inland surface waters, so no data on fecal indicator bacteria are available for streams in the Hilo Bay watershed. Therefore no streams are listed for fecal indicators.

There were no new listings in 2004 that did not already exist in 2002. Listed coastal waters are: Wailoa River Boat ramp station, Honolii Cove, Lighthouse Station, Canoe Beach, Exit of Ice Pond; all listed for enterococcus, based DOH data from 1997-2003.

<u>Waters Listed Based on Nutrient Visual Assessment</u>

Visual assessment for nutrients relies solely on an estimate of algal growth on the substrate and greenish color to water. This is interpreted as sign of eutrophication. No species identification of the algae in question is used. No measurements of organic or inorganic N or P or chlorophyll are taken. Scores are as follows:

- Score 2.0 – 1.5: Water clear with no significant algal scum or microalgae; rocks may be slimy but algae not obvious.
- Score 1.0 – 0.5: Large clumps of macroalgae present, or distinctive green/brown scums visible on bottom or sides of stream
- Score 0: Water distinctly green or pea green; or channel choked with grasses

It is unclear what the standard for exceedances is based on this visual assessment.

Waters Listed Based on Turbidity Visual Assessment:

This assessment is based on the depth to which objects can be clearly seen. No filtering of water and measurement of total suspended solids takes place. Scoring is as follows:

- Score 2.0 – 1.5: Very clear, objects visible at depth to the bottom
- Score 1.0 – 0.5: Moderately turbid
- Score 0: Very turbid

It is unclear what the standard for exceedances is based on this visual assessment.

8—Sources of information on water quality in Hilo Bay

8.1—Research Data

There is little current research on the Hilo Bay ecosystem and previous research is scarce at best. A search with the Web of Science search engine failed to turn up a single published peer-reviewed article on aquatic ecology in Hilo Bay. Unpublished reports are few and far between as well. One of the few detailed reports useful in assessing water quality is Dudley and Hallacher 1991.

This lack of published material contrasts with the situation for Kaneohe (multiple papers on algae, diffusion, and nutrient concentrations), Hanalei, Nawiliwili (e.g., El-Kadi et al. 2003, 2004) and the urban bays in leeward Oahu. Those are the watershed now undergoing restoration and continued research, indicating that a strong body of research is required prior to implementation of restoration plans. In all those cases, research was a precursor to restoration. All data available for Hilo Bay derive from consultants completing EAs and EISs, from ACOE evaluations, DOH monitoring and USGS monitoring. None of these efforts are designed at understanding the ecosystem, with the exception of the Hilo Area Comprehensive Study (M & E Pacific 1980). Hoover's (2002) analysis of the long term National Stream Quality Accounting Network (NASQAN) data illustrates the problems of a sampling regime that is not well designed spatially and temporally—trends in the data cannot be pinned down to any source, despite long term, expensive sampling. That review also shows that better monitoring of storm samples is needed, since nutrients and sediments are entering at this time and affecting the ecosystem, even if they are not captured during many non-storm grab samples (i.e., certain organisms may not be able to persist in the Bay due to infrequent but high inputs of nutrients or fresh water or sediments). Any research plan in the future will need a strong scientific coordination to ensure that samples are continuously and constantly gathered, without interruptions or changes in protocol, and with much better spatial coverage than that provided by the USGS automatic samplers or by DOH water quality monitoring.

One key point to keep in mind is that water quality classifications have little to do with ecological conditions in the waters tested, and that sampling is carried out at a spatiotemporal scale that does not allow an elucidation of the processes that produce the “impaired” conditions of the water. The scale of sampling is also inadequate to characterize the nutrient, fecal indicator and sediment content of the water in terms of either average values or peaks and lows in values, because storm events are not targeted, even though this is when the bulk of the inputs occur. On USGS monitored streams, these data are available. For Hilo Bay, monitoring stations are neither numerous nor continuously functioning (e.g., Wailuku data not usable for a number of years) and there is no USGS monitoring of coastal waters which would allow us to understand the linkage between stream inputs and coastal water contents, which would in turn allows us to at least estimate the amount of inputs coming from ground water.

Of the 7 basins or subwatersheds in the Hilo Bay watershed, the best studied are Wailuku, Honolii, and Alenaio/Waiakea. Wailuku is largely unaltered except for one floodwater input and minor water uptakes at three small hydroelectric plants. Alenaio/Waiakea empty into the Waiakea pond, and drain out through the canalized Wailoa river, and the entire urban portion is highly altered for flood control. Honolii has water flow data from NASQAN. Pollutant loads are currently being calculated for four stations on the Alenaio/Waiakea watershed as part of the TMDL process. Once those loads are calculated, load reductions can be determined for that watershed, although they cannot be assigned to specific reaches of the streams. The TMDL process will allocate loads. The Restoration Plan process, in its early research phase, will determine how the loads measured in the streams affect water quality in the Bay—i.e., are they having an impact on Bay waters and Bay ecosystems. That information will assist the TMDL process in allocating loads. Nutrient levels are currently under study at two points in the Wailuku river watershed by Dr. Tracy Wiegner of UH-Hilo—one above the urban area, one below. This study, once complete, will give us an idea of nutrient loads coming primarily from forested lands and the lower urbanized area of the watershed, but not for agricultural areas. Once we have those data, we can calculate needed load reductions for these nutrients. Currently we suspect that large nutrient and other wastewater borne contaminants are coming from fresh water seepage and underground conduit flow in lava tubes into the Bay from cesspools and septic tanks. We are confident enough in this assessment to seek support for the county’s attempts to increase the proportion of households that are hooked up to the main sewer system. Nevertheless, we would like to see tracing studies and output monitoring studies that track the exact source of fecal indicator bacteria and nutrients in the Bay, to verify our hypothesis.

8.2—Community input process

The community input process started in 2003 achieved two key goals of the EPA process for watershed based restoration plans. First, it compiled a list of watershed-related problems; this list provides two kinds of information, both of which are important for watershed management in the area: a) actual, factual physical problems that need to be solved, and b) an overview of the community’s perceptions of what constitutes a problem, with a ranking of what they view as the most serious problems. Second, it established an independent, self-organized, self-governing community group composed of a mix of technical and non-technical, government and non-government people, and other stakeholders and interested community members. This group will serve as an outreach and coordination body for the restoration efforts, and will also carry out independent necessary management and education efforts that may not be included in the restoration plan

The key weakness of the community input process was that the major landowners in the watershed—DLNR, DHHL, US Government, Kamehameha Schools and C. Brewer estates—did not participate actively. Therefore we do not have documentation re their concerns, conservation plans, development plans, willingness to participate in a restoration plan, etc. Additionally, fishers and the DAR were also not heavily involved. On the other hand, participation by all county branches, the NRCS, the SWCD, researchers and private landowners during the community input process was high. The biggest gap is therefore probably with DOFAW and DHHL. Note, however, that DOFAW and DHHL have started coordinating land management efforts. We do know a lot about fishers' needs and opinions from interviews conducted during the Hilo Bay Comprehensive Study and from interviews with Dr. R. Nishimoto, DAR biologist. Needs have not changed much over the last 20 years, focusing on the dredging of the Wailoa river mouth, enlarging the boat harbor at the river mouth, and providing more facilities for fishermen in Waiakea pond. Furthermore, DOFAW personnel gave extensive comments during the review process and prior to the preparation of the final restoration plan. Additional efforts are nevertheless needed to include input from all key stakeholders. A detailed description of the community input process is given in the Hilo Bay Watershed Project Public Input Final Report, submitted to DOH in May 2004.

Stakeholders, landowners and managers are listed with their contact numbers or addresses when possible in Appendices 2 and 3.

8.3—Consultations with experts

Stephen Skipper (NRCS RC&D Coordinator), who has a strong background on Hilo Bay water quality as an NRCS employee and former student coordinator with UH Hilo Bay Water Quality Study (Dudley and Hallacher 1991), has provided us with extensive background on NRCS and SWCD history in the watershed, County Grubbing and Grading Permit process, and NRCS SWCD flood control projects. He has served as the NRCS/RC&D Program Technical advisor to the HBWAG.

Ms. Kaleleonalani Napoleon, MSc. gathered background data and interviewed NRCS, DPW, DOT and DLNR personnel as part of a ground truthing exercise to confirm and refine the information obtained from the community input process.

The WAG itself, and in particular WAG coordinator Mary James continued gathering information as we refined our objectives and specific questions came up during the writing phase.

Jeff Zimpfer—UH Sea Grant Conservation Specialist—worked with the WAG to gather background data.

Kirsten Silvius carried out discussions with UH Hilo researchers Drs. Debra Weeks, Jean-Pierre Michaud, and Tracy Wiegner. Dr. Jene Michaud contributed her expert opinion through direct participation in the WAG.

Dr. Weeks suggests that at least least 50 % of research and clean up efforts be spent on nutrient issues. Dr. J. Michaud recommended focusing on repair and management of the sewer system and wastewater management. Dr. Wiegner indicated that preliminary data from her project show low levels of nutrients entering from the Wailuku river, recommended research to identify sources of nutrients, sediments and bacteria to bay using tracers for particular sources. Dr. J. P. Michaud recommended tracing sediment sources by land use type by identifying the geological signature of the sediments entering the Bay.

8.4—Data available in reports or on the web

These data are described in the next section and in the earlier watershed background section. Key sources of data are:

1. USGS data from monitoring stations, available on their website.
2. DOH water quality sampling—various branches, primarily Clean Water Branch available on the STORET website
3. D. Hoover's analysis of NASQAN data (Hoover 2002)
4. Study of fecal indicators and waste water in Hilo Bay (Dudley and Hallacher 1991)
5. M & E Pacific's (1980) Hilo Bay Comprehensive Survey, commissioned by the USACOE
6. Various Environmental Impact Statements
7. USGS report (e.g., Oki 2004; Fontaine and Hill 2002)
8. Fish, coral and algae sampling by the Coral Reef Initiative in Puhi Bay and Hilo Bay.

The information obtained is not listed here in its entirety. Rather, it is referred to in the appropriate section under implementation, education, institutional review, and research, and references are listed in the bibliography.

9—WATER QUALITY DATA - AVAILABILITY/SOURCES

This section provides an overview of the existing data and current monitoring activities in the Hilo Bay watershed. The purpose of this data review is to determine whether sufficient data exist to establish baseline water quality conditions in the waters within the watershed, and to evaluate the adequacy of the current sampling regime for this purpose. This examination will help guide us in developing a monitoring plan that will allow us to detect changes in the pollutant loads entering the Bay and its tributary streams after mitigating measures have been implemented.

Several agencies have collected and continue to collect data of various types in the Hilo Bay watershed. These include principally the Hawaii Department of Health (DOH), the U.S. Geological Survey (USGS), and the U.S. Environmental Protection Agency (EPA). The types of data available include water chemistry and microbiology, stream flow rates in several of the streams tributary to the Bay, and sediment and tissue chemical data. Most of this data is accessible on the EPA's online STORET databases (http://www.epa.gov/STORET/dbtop.html) and on the USGS' websites at (http://co.water.usgs.gov/sediment/) and (http://nwis.waterdata.usgs.gov/hi/nwis/discharge). The following sections outline the kind and duration of monitoring that these agencies have conducted around the Hilo watershed. There have also been numerous small investigations into water quality in Hilo Bay conducted by university researchers, local government agencies, etc. The data from these is generally of a short duration and directed at meeting the specific needs of the particular activity, therefore not really "monitoring" in the sense of establishing baseline and trends in water quality.

9.1—Water Quality Data—Hilo Watershed Locations

The DOH monitors environmental waters at a number of beach and stream sites in the Hilo watershed for bacteria, physical, and chemical parameters. Data for these sites extends over the last several decades. Monitoring has taken place at more than 30 sites over the years. At some stations the monitoring continued for more than 15 years with hundreds of samples regularly being taken and analyzed. At some stations monitoring only lasted a few years with irregular sampling, and at others the sampling was a one-time effort to obtain a snapshot of conditions at a given point in time.
Most of the monitoring that the DOH does is for their regular program of federally mandated water quality evaluation, other monitoring is done on an irregular basis in response to the need for data for special projects and concerns. This means that the regular sampling regimen is not designed specifically to determine sources of pollutants, but rather to detect exceedances of recreational water quality standards at specific points.

Figure 11 shows the locations of all the DOH sampling sites with data available in the STORET database. Due to budgetary constraints the DOH has gradually ceased sampling at a number of monitoring stations in Hilo Bay. As of this writing, the DOH is sampling for *C. perfringens*, enterococcus group bacteria, pH, salinity, temperature, turbidity, and dissolved oxygen, on a weekly basis at three sites: Canoe Beach (~weekly since ~ 9/02), Honolii Cove (~weekly since ~5/2001), and the Exit of the Ice Pond (~weekly since ~11/2003). Prior to these dates the stations were sampled less frequently. Data up to early 2005 for these 3 sites can be found on the STORET website and newer data are held internally by the CWB awaiting uploading to the STORET site. Appendix 4 summarizes the data available on the STORET system for all DOH monitoring sites in the Hilo Bay watershed.

While the principal focus of the DOH monitoring is on recreational marine waters, DOH has also sampled and continues to sample some fresh water streams in the Hilo watershed for bacteria and the standard chemical/physical parameters. The STORET database contains DOH data for stations on the Wailuku River and Honolii Stream. DOH is currently sampling Pukihae and Maili streams. The sampling in these 2 streams plus that recently done in Honolii Stream and Wailuku River are in support of current TMDL investigations being conducted by the DOH.

The USGS in addition to their well-known streamflow measurement activities, has collected an extensive amount of water quality data at several of their gauge sites in the Hilo Bay watershed. These stations are Wailuku River at Piihonua, Wailuku River near Kaumana, and Honolii Stream near Papaikou. Figure 12 shows the locations of these stations. Parameters monitored at these sites include a long list of chemical, physical, and biological factors (see Appendix 4 for an example of the list of parameters monitored at USGS gauging station on the Wailuku river at Piihonua).

Researchers at the University of Hawaii at Hilo (Dudley and Hallacher 1991) conducted a very thorough investigation of sewage pollution in Hilo Bay in the early 1990s. The investigation included bacterial monitoring at a number of sites between 1988 and 1991. During the three years of the study the researchers monitored fecal coliform, fecal streptococcus, and enterococcus at 15 stations along the shoreline and offshore in Hilo Bay, and several more stations outside of the Bay. This group also looked at several physical parameters, and in addition conducted circulation studies to characterize the pattern of water movement within the Bay.

9.2—Bacteria Data – General

Dudley and Hallacher (1991) contended that "Hilo Bay's waters receive untreated human sewage via both point and non-point sources. Sewage appears to enter the Bay in one of two primary ways: occasional catastrophic malfunctions of Hawaii County's Hilo sewage treatment plant, or chronic input from cesspools of private residences and commercial buildings." However, given the rather poor understanding we have of the relationship between the levels of the currently employed bacterial indicators and the risk of illness from exposure to these levels (Byapanahalli and R. Fujioka 2004, Fujioka 2001) it is important to carefully evaluate the sources of these indicators to ensure that their presence is actually indicating sewage pollution.

Measurement and interpretation of the results of bacterial sampling is tricky. Given the fleeting nature of such contamination results are seldom reproducible. In the available data there are a number of examples of instances where several discrete samples were taken in a short period of time with widely ranging bacteriological results.
Here for example are the results of a set of duplicate analyses for enterococci of samples taken at Canoe Beach 10/19/99 - 10/20/99

date	samples	min (cfu/100ml)	max (cfu/100ml)	avg (cfu/100ml)	st. dev
10/19/99	10	0.3	132	33.7	42.71
10/20/99	25	0.7	124	13.69	29.79

All of these samples were taken from the same spots in the morning between 8:00 and 10:00 on the two days.

A considerable amount of bacteriological data has been collected by the DOH. Over the years the type of monitoring that has been done has evolved along with the advances made in the understanding of bacterial indicators of pollution. In the past total coliform was assayed, but this has been discontinued as it became commonly accepted that fecal coliform, and more recently enterococci and *C. perfringens perfringens* are more meaningful indicators of sewage contamination. Figures 13 through 15 illustrate the minima, maxima, and average numbers of enterococci, *C. perfringens*, and fecal coliform respectively found in samples taken at the DOH stations over the years.

9.3—Bacterial Data – Enterococcus

Enterococcus group bacteria are currently the organisms used as the standard for environmental waters in Hawaii. Aside from the three stations currently being monitored for enterococci by the DOH the available data is old and sparse (Table 1, Fig. 13). Only 40 analyses were done in four years at the boat landing station, and only 96 were done at the Coconut Island site. Use of enterococcus as a sewage indicator was limited before the late 1980s, so sites that were active before then lack this data. Enterococcus densities vary widely in the samples collected over the years by DOH. The numbers are comparable at most of the stations (where the sample size is sufficient to draw comparisons), and no pattern is apparent. In general enterococci survive in salt water better than do the other indicator bacteria, but no difference between the data for fresh, brackish, and ocean water stations is readily apparent.

Between August 1989 and July 1991 Dudley and Hallacher (1991, pg 37) found enterococcus levels ranging from 0 to 4,000 at their sites inside and nearby but outside of Hilo Bay. Based on their results they concluded that “enterococci data from this investigation suggest that virtually all of Hilo’s coastal marine waters will fail to meet State recreational marine water-quality standards.” A summary of the enterococcus data collected by the University of Hawaii Hilo researchers is found in Table 2.

Although this subgroup of the fecal streptococci are more human-sewage specific than the other commonly used indicator organisms, the meaning of enterococcus levels in environmental waters is somewhat unclear due to the fact that these organisms can occur and multiply in soils uncontaminated by fecal matter, suggesting that their presence in recreational waters may be unrelated to health risk from swimming exposure. The levels seen in the available data sets are generally low, but quite variable. Levels are elevated during high rainfall periods when lots of soil washes off the land. Dudley and Hallacher (1991) found a significant correlation between densities of all the bacterial indicators and rainfall during the preceeding 24 hours. They also found a corresponding negative correlation between salinity and bacterial densities. While these researchers concluded that the observed correlations could be due to the rain bringing sewage from cesspools in the drainage basin into the environmental waters, it is also possible that the increases in indicators could be due simply to soil washing into the water and the greater survival of bacteria in fresher waste water (c.f. Fujioka 2001).

9.4—Bacteria Data - *C. perfringens*

C. perfringens is a bacterium that provides a more definitive indication of fecal pollution in water than enterococci. It has greater survival in the environment than other indicators, and is an obligate anaerobe – unlikely to multiply outside of a body. Hawaii DOH has used *C. perfringens* as an adjunct to enterococcus testing as a way of dealing with the uncertainties of the enterococcus standard. Unfortunately the data record for *C. perfringens* in the Hilo Bay watershed is even sparser than that of enterococcus. The use of *C. perfringens* is fairly new in Hawaii and therefore it was never monitored at several of the stations where monitoring has been discontinued, and the period of monitoring is short at those sites were it has been used.

The range of values for *C. perfringens* at the DOH sites is much smaller than it is for enterococci (Table 3, Fig. 14). While *C. perfringens* is not officially recognized as a sewage indicator the State of Hawaii has set a recommended level of less than 5 CFU/100 ml for swimming waters. As with enterococci there is no discernable pattern of *C. perfringens* distribution in the limited DOH data set.

9.5—Bacteria Data - Fecal Coliform

Fecal coliform served as the standard sewage indicator organism group starting in the 1970s when the USEPA recognized that total coliform bacteria, the previous standard indicator, were not very specific for sewage pollution. The DOH collected samples for fecal coliform analysis between the early 1970s and the mid to late 1990s at many of their Hilo Bay monitoring sites (Table 4).

The data record for fecal coliform is rather longer than that of the newer indicators, however it is less meaningful in light of the group's non-specificity to sewage pollution. Some stations definitely stand out as more and less contaminated with fecal coliform, but what else these stations might have in common is unclear and requires additional investigation. The three most contaminated sites on average were the Exit of the Ice Pond, Wailoa River, and Waiakea Mill Pond (Fig. 15). These are all relatively fresh water sites, so it is possible that the lower salinity has been conducive to longer survival by fecal coliforms.

9.6—Bacteria Data - Fecal Streptococcus

Fecal Streptococcus is another fecal organism that has been used as an indicator of sewage pollution in water. Like the other indicators it has been found by researchers to be deficient in this role and is not much used anymore. Formerly the ratio of fecal coliforms to fecal streptococcus was used to determine whether the source of fecal matter in water is animal or human – animal feces containing a higher proportion of the streptococci. This utility has been largely dismissed now due to variable die off rates of the two groups The DOH collected data on fecal streptococcus at a number of their sites for several years. Table 5 summarizes the data set for fecal streptococcus.

9.7—Nutrient Data

In the case of nutrients the extensive DOH data is supplemented by the large USGS collection of data from their stream monitoring stations. A large amount of data on various nitrogen and phosphorous species exists. There are also data sets of chlorophyll values; an indirect measurement of nutrients, for many of the sites. Table 6 summarizes the history of DOH's data collection for different forms of nitrogen.

9.8—Nutrient Data - Nitrogen

The nitrogen water quality standards are exceeded on many occasions in the DOH data (Fig. 16). While the reason for monitoring nitrogen compounds in water is generally to detect the presence of agricultural pollution, the nitrogen seen in the waters in and around Hilo Bay may in fact be the result of seepage of groundwater, which is much higher in nitrogen than seawater. It is well known that Hilo Bay receives massive amounts of groundwater through near and offshore seepage. As in the case of elevated levels of sewage indicator organisms, the significance of high levels of nitrogen in the waters around Hilo Bay needs to be examined before resources are expended to try and clean them up. Nitrogen levels found in the data collected by the USGS at their completely fresh water sources are somewhat higher than those seen at the DOH's marine sites. Table 7 summarizes nitrogen data from the USGS station on Honolii Stream near Papaikou as an example of typical levels seen in fresh water streams. Note that this stream drains an agricultural area, so it is not unaltered or anywhere near its natural state.

The USGS nitrogen monitoring data (Table 8) also displays high results relative to the state standards. The standard for inland waters (as the USGS stations are) is less stringent than the standard for embayments (which the DOH Hilo Bay stations are). Nevertheless the levels seen at the USGS stations regularly exceeded the applicable standards.

9.9—Nutrient Data – Phosphorus

Phosphorus(P) levels seen in the DOH data sets are lower relative to the state standards than are nitrogen levels (Fig. 17, Table 9). Table 10 summarizes USGS P data from the Honolii Stream station, and Table 11 summarizes the availability of P data from USGS stations.

9.10—Chlorophyll

Chlorophyll content provides a useful indication of nutrient enrichment of environmental waters. The DOH has collected chlorophyll data at a number of its Hilo Bay watershed sites over the years. There has been no data collected since 1997, so the data is quite out of date. The chlorophyll readings obtained by the DOH program are high. Station 1141 – Hilo Bay offshore has enough data to be able to lend credence to the results. The average concentration of 41.08 ug/l at this site is very high considering the state standards (Table 12).

The USGS database contains about fifteen measurements of chlorophyll (a and b) taken at various stations in the Wailuku River in 1977 and 1978. This is much too sparse and short a data set to permit an adequate assessment. The method used by the USGS is not readily comparable to that used by the DOH.

9.11—Turbidity

The DOH monitored/monitors turbidity at most of its sampling sites for most of the years they were active (Table 13). Average turbidity values are rather high at a number of the DOH stations, most notably at Canoe Beach, the lighthouse, and Mooheau Park. One might expect that the stations with the highest turbidity values would be those nearest the mouths of the streams entering the Bay. However this did not seem to be the case near the estuaries of Honolii Stream and the Wailoa and Wailuku Rivers. Turbidity, as with other water quality parameters is subject to large variations with time and rainfall.

The USGS also collected a limited amount of turbidity data at its stations (Table 14). This monitoring was not conducted on any kind of a regular schedule, but rather wass done occasionally. In addition USGS switched at some point from the older Jackson turbidity scale to NTU, two not readily interchangeable scales of measurement.

While it is commonly believed that the turbidity seen in Hilo Bay is the result of large quantities of sediment being washed down the Wailuku River and other tributary streams. There is some evidence that this is not necessarily the case. A program of continuous or nearly continuous monitoring of stream flow at various points along the Bay's stream courses coupled with simultaneous measurement of turbidity is needed to truly determine the sources of turbidity in Hilo Bay.

9.12—Sediment Toxicity Data

In the Hilo community a particular matter of concern is the presence of contaminated sediments around the Bay. In addition to the bacteriological and physical parameters that the DOH has monitored in water they have also performed sediment analyses in order to try and better understand the extent of the chemical contamination known to exist in sediments around Hilo Bay based on historical information about previous pollution from a Canec manufacturing plant. For this purpose many samples were taken at multiple sites over a short time frame to get a snapshot of what was there. Between September of 1976 and April of 1987 the DOH carried out a special sampling of 22 sites around the Hilo Bay shoreline and estuaries of the tributary streams. Eighteen of these stations were within the Hilo Bay watershed (Fig. 18). Testing was performed by the DOH for a greater or lesser number of organic chemicals, pesticides, nutrients and metals in sediment samples from these 22 stations. The DOH revisited the sites a few years after the initial survey to see what changes may have occurred between the samplings. A large suite of analyses was performed. Unfortunately there were some problems with the contract laboratory that analyzed the samples and the lab was later closed down by the USEPA. Nevertheless the data is reported to be essentially accurate (personal communication Terry Teruya, DOH CWB, May 2005.

Between 1980 and 1987 the USEPA sampled a Hilo Bay shoreline site right at the bayfront for toxic chemicals and metals in water, sediment, and plant or animal tissue, several times. This data is also to be found in the STORET database.

9.13—Streamflow Data: - Availability/Sources

The USGS has monitored a number of streams in the Hilo Bay watershed from as long ago as 1911 in the case of Papaikou Stream. Table 15 outlines the sampling points and length of record of USGS sampling in the watershed. One can see from the data that the largest stream entering Hilo Bay is the Wailuku River (Fig. 19). Personal communication with Hilo residents indicates that the Wailuku is a major source of sediments when there is a lot of rain. Unfortunately due to the extreme conditions near the mouth of the river it is very difficult to obtain accurate measurements during those times when the data would be most useful from the stadndpoint of estimating pollution loading. The USGS continues to monitor at a number of stations in the watershed, however these are not optimally situated for the purposes of estimating the relative contributions of different reaches of the streams to overall pollution.

9.14—Conclusions

The existing data, though they are quite extensive in time span and quantity, have generally been collected for the purpose of detecting the presence rather than the sources of pollution in Hilo Bay. Data are not comparable between stations, were taken on different dates, at different times etc. Many of the water quality analyses were done using a wide range of parameters using different laboratory methods, yielding results that cannot be easily compared. Without the guidance of an overall plan of comparing like parameters during the same time periods, the data collection has been patchy. Drawing any kind of conclusions about the sources of pollution in the Bay based on this uncoordinated data is difficult at best. There is a need for a sampling/monitoring plan that is designed to address the specific questions of pollutant sources. For example sampling should probably focus on the points where water actually enters the Bay; the stream mouths and places where groundwater is seeping into the Bay.

Water quality is intrinsically variable over time and space. Even the best monitoring schemes usually only obtain a series of “snapshots” of data. Data that are taken only once or twice a month may fail to capture significant trends in water quality. Samples taken 10 feet apart may show completely different results. The case of the multiple analyses performed on samples taken at the DOH’s Canoe Beach site over a two-hour period yielding hugely varying results mentioned above is illustrative. Furthermore, change occurs very rapidly in streams and rivers, particularly in the Hawaiian context. All of this points to the necessity of a high frequency of sampling in a coordinated fashion.

10—OVERALL CONCEPTUAL APPROACH TO RESTORATION

This Restoration Plan takes into account the community's knowledge, perceptions and aspirations as well as the research and best management practices recommended by experts. The Plan acknowledges that some of the problems are institutional and political in nature, and that ecological research and on-the-ground remediation of physical and ecological problems alone are not sufficient for restoration. The Plan suggests several major research efforts and multiple minor ones that must be undertaken to guide restoration, and outlines an educational strategy to involve the community in the restoration efforts. It also recommends a series of demonstration projects and BMPs to be developed and applied in the watershed. In keeping with the EPA's emphasis on adaptive management, the plan proposes milestones and monitoring schemes that will allow evaluation of the efforts along the way so that they may be changed or fine-tuned as the restoration program proceeds.

The Plan focuses on restoring water quality and not ecological rehabilitation/preservation of the whole watershed. However, this Plan does include ecological monitoring components aimed at developing bioindicators for water quality that will make possible the development of ecosystem restoration plans. Ecosystem maintenance is important not only for water quality but for the enhancement of fishery resources that depend on restoration of the primary food chain and on the nursery grounds in the estuaries.

10.1—Objectives of Restoration Plan

1. Obtain funding to establish three demonstration projects that will provide baseline data and data from long-term monitoring on three areas of key concern in the watershed: invasive plant species, invasive animal species, and wetland restoration (Section 13).
2. Encourage the establishment of general BMPs that will solve ongoing regulatory and pollution problems in the watershed (Section 14) and obtain funding to implement these BMPs
3. Determine sources of sediments from Wailuku river basin by land use type (conservation/forest land vs. fallow agricultural land vs. active agricultural land vs. urban and suburban areas vs. resuspension of Bay sediments).
4. Identify appropriate BMPs to reduce sediment input from identified sources in Wailuku river basin where necessary and practicable.
5. Determine sources of nutrient input to Wailuku and Wailoa rivers—i.e., surface runoff vs. ground water vs. autochthonous materials (in situ decomposition of leaf and fruit litter).
6. Determine nature and amount of nutrient inputs to Bay through ground water seepage, separate from ground water seepage into Waiakea pond/Wailoa River. Specifically, determine amount that comes from cesspools, septics and leaking sewer system vs. amount that comes from fertilizer runoff or non-anthropogenic sources.
7. Reduce number of cesspools, require homeowners currently discharging raw sewage into lava tubes or crevices to terminate this practice immediately, and increase the number of buildings hooked up to sewer lines.

8. Increase knowledge in the watershed community about the problems caused by sediments, nutrients, runoff, wastewater, and other point and non point pollution sources and about measures that can be taken by individuals and communities in the watershed, and by State and County of Hawaii and federal agencies to reduce these pollutants.
9. Strengthen the HBWAG as an information center for watershed activities carried out by individuals, NGOs, and city, county, state and federal agencies in the HB watershed
10. Support DOH TMDL implementation through education, coordination and support of low impact development practices.
11. Develop bioindicators for nutrient levels in Hilo Bay to reduce the need for more expensive lab-based sampling in the long term, and to enable trained non-professionals to participate in water quality monitoring; i.e., methods should eventually be usable by volunteers and high school students.
12. Help develop a sound basis in public health, scientific research and economic considerations for future development in the Hilo Bay watershed that will positively impact water quality and watershed resource availability for present and future generations.
13. Improve the institutional management and decision-making process that regulates activities impinging on water quality in the watershed.
14. Describe the hydrology of the watershed in sufficient detail, including the flooding situation in urban areas, to develop a comprehensive drainage and flood abatement program that does not negatively impact the ecology of the watershed and Bay.
15. Assess the potential contributions of wetland restoration to water quality, ecological integrity and economic stability in the Hilo area.
16. Through all of the above, achieve the prime objective: IMPROVE WATER QUALITY IN HILO BAY

10.2—Approach to Achieving Objectives

The following strategies should guide the implementation of activities undertaken by the eventual restoration team, and have already influenced the pre-selection of research, education and immediate implementation activities:

1. Provide support and assistance (expertise and financial) to relevant Hawaii County offices for those situations in which it is needed. Collaborate with the county's efforts at watershed restoration, including potential breakwater modification, development of erosion control measures, and regional zoning. In this respect, for example, the WAG and restoration team members could participate where possible in the County Technical Advisory Committee review of the current sediment and erosion control measures to make them more effective, and could also track and comment on County Planning Department proposed zoning-related projects.
2. Implement BMPs for urgent issues such as cesspool reduction and sewer hook-ups, runoff control, and community education.

3. Carry out longer-term research on key issues for which we do not have sufficient information: sources of sediments, sources of nutrients, status of the Hilo Bay ecosystem, potential for biomonitoring.
4. Carry out water quality monitoring on an appropriate spatiotemporal scale so that the information contributes to our understating of the sources of impairment rather than just to the status of the water relative to state water quality standards. Adapt the watershed monitoring regime to local conditions appropriate for the Hilo area —frequency and location of sampling, parameters sampled, ground water as well as surface water, storm and base flow, etc.
5. Provide sound economic and ecological bases for management decision and development scenarios made by the Hawaii County and State, and Hilo Bay communities. This includes putting the Hilo Bay Watershed /Hilo Bay into the larger context of a) Hawaii Island and b) the State of Hawaii. Key areas to focus on are: cruise ship industry (impacts pollution and the harbor management); agricultural development; forestry development (the latter can be preliminarily assessed from existing EISs and inventories at DOFAW, with additional input from DOFAW as one of the watershed partners) and industrial development and urban/suburban growth in general.
6. Examine the hierarchy of decision-making that regulates watershed management decisions.
7. Use demonstration projects on issues of public and scientific interest: e.g., wetlands and fish stocks in Wailoa pond; economic analysis of cruise ship industry as example of appropriate use of cost-benefit analysis, emphasizing need to include long term environmental costs and benefits of any project as well as short economic costs and benefits.
8. Support wetland restoration as a way of: 1) protecting endangered water birds; 2) regulating sediment and nutrient entry into the Bay; 3) regulating flooding; 4) diminishing the impact of arsenic pollution on the ecosystem. One approach is to carry out a feasibility study on wetland restoration, including all appropriate forms of valuation: ecological services, biodiversity protection, etc.
9. Involve local elementary schools and high schools in restoration and research efforts: incorporate watershed issues into science curriculum (unbiased, fact-based information, as distinct from social and political decisions about management, development and conservation), involve students in monitoring (can be achieved through K-12 NSF grant to UH Hilo professors)
10. Coordinate with TMDL process: provide education for implementation success. Include TMDL information in economic assessments, to emphasize how TMDLs can help guide the development of an area, how BMPs can increase the allocations to any one sector, and how they will link the different economic/management sectors of the community through trading, etc. (proper management of conservation lands to decrease sediments and nutrients, for example, can increase sediment and nutrient allocations to farmers—this provides an incentive for farmers to collaborate with conservation; also, any plans to bring in forestry will have to deal with existing allocations).

11. Identify and then where possible address both current problems (sewer, runoff, low level agriculture, residual sediments in Bay) and future problems (forestry, cruise ships, new forms of agriculture, growth in urban area)
12. Focus on UH Hilo as a way of positive development for Hilo—more money for research will bring more students, which will provide a pool of trained personnel, which in turn will bring in new businesses.
13. Establish a formal partnership, by means of a Memorandum Of Understanding, among the governmental and non-governmental organizations that can work together to oversee the initial 5 year implementation, research and education period and must work together later on do select, develop and implement best management practices and continue water quality monitoring. Potential partner organizations include, among others, Hilo Bay Watershed Advisory Group, Natural Resources Conservation Service, Waiakea Soil and Water Conservation District, Hawaii Department of Health, Division of Aquatic Resources, Division of Forestry and Wildlife, Army Corps of Engineers, diverse County Offices (or simply the County of Hawaii), UH Sea Grant and University of Hawaii-Manoa Water Resources Research Center.
14. Increase the stakeholder base participating in or supporting the restoration plan by incorporating private landowners into planning process (Kamehameha Schools, individual homeowners) and by interfacing more closely with DLNR and DHHL.

10.3—Project Time-line: Five-year initial plan, divided into three elements

1. Immediate implementation of demonstration projects and pre-selected BMPs.
2. Medium term education efforts.
3. Medium term research and monitoring

At the end of five years, the restoration team should review the research, education and implementation process, and evaluate data from the research projects. This evaluation shall be done through a community and stakeholder participation process (e.g. one or two month-long series of meetings in Hilo) to present data and reach consensus on the future needs of the watershed, on long-term education and monitoring efforts, and on best management practices. The restoration team will continue working through and after this period, but this will be the time for critical evaluation of knowledge, success to date, and future budgetary needs.

11—Recommended Best Management Practices

Baseline data obtained prior to the implementation of each of the BMPs described below, and monitoring conducted for 3-4 years following implementation will provide badly needed data not only on the impact of BMP implementation, but on the hydrology of the watershed. For each BMP, monitoring of water quality should be designed to take place upstream of implementation site, immediately downstream of implementation site, at one or more locations between the site and the Bay, and in the Bay itself. Note that monitoring in the Bay itself is already covered by the research and monitoring plan described in Section 14 below. The number of monitoring locations between implementation site and the bay will depend on the distance of the site from the bay, and on the hydrology and topography of the intervening area.

11.1. Eliminate cesspools and lava tube dumping

Background: Elimination of any cesspools in the watershed that are in the path of ground water, along with completion of sewer hookups for the urban and suburban areas, of Hilo should reduce the amount of waste water, and therefore nutrients and pathogens, reaching the Bay. For Hilo Bay as well as for other coastal areas in Hawaii (Kahana, see Michaud 1995 and Garrison et al. 2003; Kaneohe, see Hoover 2002), it is clear that ground water is a large source of nitrogen. This could indicate runoff from fertilizers, but also contamination from cesspools and septic tank leachate. Monitoring of wastewater indicators together with nitrogen at selected areas will help determine the source, as will tracing studies. However, the state of knowledge of the general contribution of cesspool leachate to ground water is sufficient to call for the elimination of cesspools in the hydrologically active areas. It is the goal of the county of Hawaii, the state of Hawaii and of the US Environmental Protection agency to reduce cesspool usage. Contributing to this goal will therefore expedite the process and make more efficient use of resources.

We know from local residents that cesspools opening into lava tubes (essentially lava tubes used as cesspools) are common in the residential areas bordering the Wailuku river. Dumping of non-household wastes into lava tubes is also common. Materials dumped in lava tubes may directly move underground to the bay, or enter the fresh water system in other ways. Such cesspools and dumping have been confirmed by residents (e.g. F. R. Hughes pers. com.) and researchers (e.g. Halliday 2003). See Section 10.5.1 for more detail.

This BMP goes hand in hand with BMP 14.3 below (Sewer Line Completion) and should be undertaken simultaneously

Problem Addressed: Nutrient, toxin, and fecal contamination of freshwater and bay

Expected Outcome: Reduce input of nutrients, human disease agents and toxic wastes into freshwater and bay

Actions Required prior to implementation:

- Evaluate the extent of cesspool and lava tube dump use in the watershed, map existing cesspools, and assess, based on current knowledge of hydrology, the most critical areas to target for elimination of cesspools.
- Determine the actual extent of sewage hook up compliance in the urban areas.
- Determine whether some of the houses can be hooked up to sewer system at owner's expense.

- Identify alternative individual wastewater treatment systems to replace cesspools (e.g., septics) when hookup to urban sewer system is not possible.
- Undertake a study of soils in the watershed to determine which are most appropriate for cesspools, septic systems and which landscapes should have centralized sewage. Some soils may provide adequate filtration for cesspools where others would be more suitable for septic systems. Some soil areas would only be suitable for centralized sewage. Generally the younger landscapes south of the Wailuku River are the most unsuitable for cesspools (S. Skipper pers. com.)
- make available in Hilo area materials re the impacts of cesspools
- provide widespread community information on the rules and incentives and penalties currently existing re cesspools
- produce an educational video module (see education section) on the topic of wastewater systems, including cesspools, septics, sewer, and alternative methods, in the state of Hawaii in general and in the Hilo area in particular

Implementation actions: *Replace cesspools with alternative wastewater treatment system. *Police known dumping sites, cite perpetrators and enforce penalties for dumping

Location to be applied: Prioritized cesspools

Costs to be incurred:

- mapping--$ 5,000 for time spent with cesspool cards and ground truthing
- salary and benefits for one technician to work with the county for two years solely on mapping cesspools, monitoring compliance with regulations, and distribution of printed educational materials— $ 80,000
- print costs for educational materials— $ 5,000
- cost of fuel and vehicles to be used by technician— $ 2,000
- grant for the making of one video module—$ 10,000
- Cost of selected individual waste water treatment systems (septics?).
- Cost of policing known lava tube dumps (for toxic and other wastes).

Milestones by which to measure progress:

- production of cesspool map 2 months after funding is acquired
- hiring of technician no more than one month after funding

11.2. Elimination of gang cesspools (as per EPA regulation and ongoing statewide plans)

Background: Environmental Management Department has received funds from EPA to address/remove gang cesspools

Problem Addressed: Nutrient and fecal contamination of bay

Expected Outcome: Reduce input of nutrients, human disease agents into freshwater and bay

Actions required prior to implementation: Identify gang cesspools and ascertain status of compliance with elimination orders

Implementation actions: As per EPA / state plans

Location to be applied: Location of gang cesspools

Costs to be incurred: labor for locating and mapping cesspools and dumps with respect to known hydrology of the area

11.3. Sewer line completion

Background: The sewer mains in the urban area have not been completed, and part of the urban area within reach of sewer lines is not hooked up (see main text)

Problem Addressed: Provides alternative to cesspool use in urban area; reduces input of nutrients and fecal disease agent to water.

Expected Outcome: Reduction in nutrient and disease agent input to water.

Actions required prior to implementation: *Carry out surveys of both homeowners and county agencies to determine why sewer line completion has not occurred, and why compliance with current hookup requirements is not occurring. *Obtain detailed map from county indicating areas that are within reach of sewer lines but have not been hooked up. Note that we sought such information from the county, but either it does not exist or it was not made available to us. The County Environmental Management Office declined to review the first draft of this plan.

Implementation actions: *Hook up existing houses that are not already hooked up. *Extend sewer lines and hook up additional houses. *Lobby county to proceed with hookups and seek funds from sources such as State Revolving Fund. *Educate household owners as to environmental advantages of hookups, and way to reduce cost of hookups

Location to be applied: At existing sewer lines and ends of such lines, to extend them

Costs to be incurred: *Under 319 funds--education campaign targeted at county and household owners. *Actual hookups to be funded by other sources as accessed by the county

Milestones by which to measure progress:
- 100 % coverage of household in sewerage area 6 months after funding, with 1) information 2) post-information evaluation re changes in attitudes and actual hooking up

- full hookups of all houses that have access to sewer mains 3 years after funding

11.4. Maintenance of flood control channels

Background: Accumulation of debris near narrow areas in streams, at curves, and at bridges and culverts results in flooding during storm events. Flooding continues to be a problem in the watershed in spite of past implementation of flood control projects.

Problem Addressed: Flood and associated flood damage and erosion

Expected Outcome: Reduction in localized flooding during heavy rainfall

Actions required prior to implementation: Map all bridges, culverts and known "clogging" points in watershed. *Review the recommendations found in annual periodic inspection reports for the existing flood control projects in the study area. *Request Corps of Engineers reconnaissance report to see if conditions have changed from past project evaluation reports.

Implementation actions: Routine removal of in channel vegetation and debris. *Maintain existing flood reduction projects in accordance with period inspection recommendations

Location to be applied: At identified at risk locations, and throughout stream channels

Costs to be incurred: Labor for driving/walking streams prior to each rainy season and during rainy season to locate debris. * Labor for removing debris on a regular (? quarterly) basis

11.5. Habitat restoration on fallow sugar cane lands

Background: Much land is currently under grass cover following demise of the sugar cane industry. Nutrients and sediments may be washed off from such lands during heavy rainfall.

Problem Addressed: Nutrient and sediment pollution

Expected Outcome: Reduce nutrient and sediment pollution, reduce erosion, increase nutrient cycling, increase soil quality, put land back into potential forest production, contribute to conservation of native species and reduction of exotic species

Actions required prior to implementation: Determine original vegetation cover prior to clearing for agriculture (i.e., forest vs. scrubland vs. grassland). *Plan restoration according to previous cover and current soil conditions. *On lands for which the zoning allows commercial plantation of exotic species, evaluate the soil and slopes for potential planting with tropical hardwoods which can generate income. *Review forestry BMPs developed by DLNR and available at website, and update as needed for these particular sites and tree species being considered. *Ensure that adequate marketing has been planned for these woods, which would only be available for sale many years down the line.

Implementation actions: Restoration BMPs: removal of exotic grasses and feral cane populations, establishment of nurseries for plant stock, or identification of nurseries with appropriate stock. *Seek partnerships with companies interested in eventual harvesting of native and exotic woods. *Seek partnership with land owners for leasing or other commercial arrangements.

Location to be applied: Former sugar cane lands, now fallow. Maps being produced by NRCS based on aerial imagery will in the near future allow pinpointing of these locations.

Costs to be incurred: Mapping. *Nursery establishment and / or seedling purchase. *Coordination of volunteers for planting. *Equipment for planting. *Transportation and food for volunteers. *Leasing of land if necessary

11.6. Implement locally adapted low impact development pilot projects

Background: Low impact development requirements and guidelines by the County of Hawaii would lead to uniform, low impact construction patterns and materials. This includes strategies such as using pervious pavement, treating storm water *via* an appropriate low-tech filtration devices, and treating waste water in such away that pathogens and nutrients are released in lower concentrations.

Problems Addressed: Flooding, water quality

Expected Outcome: Reduce storm flows and nonpoint source pollution (e.g., runoff polluted with oil from roads, parking lots)

Actions required prior to implementation: Coordination with County of Hawaii and a local landscape Architect

Implementation actions: Coordinate with Hawaii County Public Works and Parks and Recreation.

Location to be applied:
1. Pervious pavement in an urban area--replace pavement in area slated for repair, or in new construction.

2. Storm water filtration near the parking lot that drains into one of the anchialine ponds at Richardson's Beach Park.

3. Maintenance of drywells and catch basins throughout the watershed by removal of accumulated sediment: check current maintenance schedule and increase frequency and efficiency if needed

4. Removal of leaf and litter by increased street sweeping, especially along Banyan Drive, to reduce particulate load to Reed's Bay, Ice Pond, and the greater bay area

5. Installation of sediment removal facilities (check dams or filter fences) at parking lots adjacent to or near the Hilo Bay and nearby drywells such as those located at Keakaha Park, Richardson Park, and along Kalanianiole Ave. to reduce the sediment loading that washes directly into Hilo Bay.

6. Identify all stormdrain outlets along Wailuku, Waiakea, Alenaio, Honolii and Wailoa rivers, and determine potential for construction of sediment removal structures to reduce sediment loading to the bay.

Costs to be incurred: Depends on projects chosen—e.g., area of surface to be paved in pervious materials, etc. *Monitoring of outcome of projects—i.e., obtaining baseline data on runoff quality prior to BMP application, and on load reductions after BMP application. No baseline data currently exist for any potential project locations.

11.7. Develop integrated floodwater management plan for the watershed

Background: There is a need to prepare a detailed and well-coordinated comprehensive watershed plan for the study area. To date flood control structures have been built in response to individual flooding events, rather than on an assessment of the overall hydrology of the area.

Problem Addressed: Exacerbation of flooding at sites other than the flood control structure site

Expected Outcome: Reduce downstream flooding caused by upstream structures that were not planned with the entire watershed in mind.

Actions required prior to implementation: *Develop hydrology model and water budget for entire watershed, or at least for individual sub-watersheds were flood control structures are being planned. *Request Corps of Engineers to prepare a Project Study Plan and reconnaissance level plan for watershed flood management of the area

Implementation actions: *Make such planning a county level requirement. *Allocate funds for such planning, including modeling and water budget. *Ensure future development and flood control structures fit into the watershed wide flood management plan. *Facilitate Federal flood reduction reports to evaluate possible flood reduction projects that might reduce future flooding in the study area.

Location to be applied: County offices (planning); sites of proposed development and flood control structures. *Entire watershed

Costs to be incurred: *Models. *Planning process and legislative change

11.8. Establish and enforce appropriate zoning for watershed

Background: Hawaii County Planning Department (PD) planning and land use decisions can influence the sources that potentially cause pollution. There are two ways to regulate zoning: (1) *Resource/ Location* (e.g. streams, groundwater, hazard areas, zoning, etc), and (2) *Activity* (e.g. grading, wastewater disposal, stream alteration, etc). Hawaii land use is regulated in a hierarchical fashion under 1) the State Land Use Law (under State jurisdiction), 2) the County General Plan, and 3) zoning described within the General Plan. Urban growth is controlled through the General Plan and zoning.

The General Plan identifies three major land categories: *urban, agriculture, and conservation.* County zoning has the following major designations: *urban, rural, agriculture, open* and *project*. The PD approves zoning (e.g. rezoning, variances, use permits, etc.), subdivisions, and certain shoreline activities (Special Management Areas/SMA and Special Shoreline Variances/SSV). People can request to have an area rezoned. There are higher standards for rezoning conservation lands.

There are 'leverage points,' in the County Planning process for zoning where changes can be made, especially in the area of subdivision regulation. Currently there are weaknesses in the regulations, and in particular there is a need to require control of downstream flooding by new subdivisions :

- Discretionary approval early in development process. There are points in the development process where discretionary approvals are made such as rezoning, or attaching conditions to a design. Such actions take place early in the development process and are opportunities to have input on a proposed project.
- Enforcement of mitigation measures through ministerial approvals later in development process such as subdivision approval, grading permits, and/or building permits. Input into permits for such activities can be effective.
- Decision-makers for discretionary approval, that is know who the decision makers are for the various permits. (Planning Director, Planning Commission, County Council).

Problem Addressed: Hawaii County Planning Department (PD) planning and land use decisions can influence the sources that potentially cause pollution. Better planning and proper zoning will help prevent projects that might cause future drainage or pollution problems.

Expected Outcome: Improved and better coordinated PD related-activities that result in better water quality

Actions required prior to implementation: Examine current zoning for watershed and identify areas that may be inappropriately when viewed from the perspective of flood zones, contribution to erosion, and integrated floodwater management.

Implementation actions: Ensure that next zoning process includes data from a hydrological model and water budget for the watershed, and considers the guidelines set out by an integrated flood management planning process.

Location to be applied: Hilo watershed.

Costs to be incurred: Cost to develop hydrological model, water budget for watershed, and cost to develop integrated flood management guidelines.

11.9. Review and analyze existing SWCD Conservation Plans, with a view to implementing NRCS technical standards and specs on agricultural lands that currently do not have conservation plans with associated bmps

Background

Although NRCS maintains an up-to-date list and description of recommended BMPs for agricultural lands, there is no available information on the BMPs that are actually implemented, why they fail to be implemented, which landowners resist implementation, etc. Such information would be useful in achieving more compete implementation of plans on more properties. This review could be done internally by NRCS to find out how well the current voluntary system is working and whether any changes are needed. The information should then be made available to watershed planners. Currently conservation plans are developed by the NRCS staff with review and approval or denial by the respective SWCD board at monthly meetings. NRCS generally supervises the elements of plan installation, but not always if the producers are comfortable installing them. NRCS employees are required to provide designs and specifications for all practices. All programmatic (FARM BILL and other) projects are inspected after installation and need to meet NRCS standards and specifications (as described in the FOTG) before cost share payments are made to producers. All conservation practices in the plan (BMPs) are also designed according to NRCS specifications. Conservation Plans are installed and completed at various levels according to producer need and ability to accomplish. The highest level of Conservation Plan is the Resource Management System (RMS) level plan and it addresses all identified resource concerns at that level. Resource concerns are determined by pre-planning field inventories and producer concerns, goals and operational considerations. Everything from cultural resources, soils, water quality and endangered species are reviewed on standardized inventory check sheets. Conservation Plan implementation is extensively documented in the NRCS Progress Reporting Management System (PRMS) and soil erosion reduction rates, water conservation rates, acres planted to ground cover, wetland acres created, habitat acres created or protected, number of acres planted to buffers are all recorded in the system showing the net savings, gains and quantifying the whole process (S. Skipper, pers. com.). However, with the exception of calculating reductions in soil loss using formulas that take into account the acreage under cover, NRCS does not monitor the outcomes of the conservation plans. We therefore do not know how effective they are in reducing pollutant loads. A review of current level of implementation may suggest effective ways of monitoring the effectiveness of the plans. Monitoring of the effectiveness of conservation plans in the watershed would provide critical baseline data and initial estimation of load reductions achieved by BMPs, and for this reason it is an important source of information for understanding and eliminating of causes of water quality impairment in the watershed. We should keep in mind, however, that agricultural lands constitute a smaller portion of the watershed than other land uses, and that much agricultural land is fallow due to the failure of the sugar cane industry on the Big Island. Our emphasis on obtaining detailed information from Soil Conservation Plans should therefore not be construed as an indictment of agricultural lands as a major source of pollution. Rather, we see them and the NRCS as a major source of information.

Actions required prior to implementation

- Assess all paper work for existing plans, carry out site visits to describe compliance and effectiveness
- Evaluate results of above surveys, and develop better strategies if needed

Costs to be incurred:

- NRCS should be able to do this internally with existing resources; if not, allocate funding for one technician for one year, with evaluation to be carried out the following year—$50,000

Milestones:

- Inform landowners of review process two months after funding
- Carry out plan review and site visits within one year of funding
- Evaluate survey outcomes and develop strategy for new conservation plan implementation within two years of funding

11.10. Establish detailed standards and specs under current Grubbing and Grading ordinance; enforce current G & G ordinance

Background: See section 5-9, section 10.5.2 and Appendix 5 for details. Although the BMP guidelines under the Grubbing and Grading Ordinances have recently been revised, they are not specific enough, nor is there an appropriate system for monitoring and enforcing penalties.

Problem Addressed: Insufficient monitoring, policing, and application of penalties for inappropriate management of sediment runoff from constructions sites. *Lack of specific guidelines for construction site BMPs.

Expected Outcome: Reduced runoff from construction sites

Actions required prior to implementation: *Examine current recommended BMPs (see Appendix 5) and system for regulating application of BMPs. *Reach consensus on best regulatory system (e.g., who is responsible for ensuring application of BMPs—land owner, developer, machinery operator, etc.; one solution might be to make the county responsible for violation of Grubbing and Grading Ordinances, in order to ensure that the County does in fact apply its regulations).

Implementation actions: Establish detailed standards and specifications for different types of construction sites. * Monitor all authorized construction sites on a timely basis. *Apply fines when guidelines are ignored or incompletely applied. *Hire technical staff to monitor and regulate construction sites.

Location to be applied: Hilo watershed urban and suburban areas.

Costs to be incurred: * Hiring of technical staff. * Development of site-specific BMPs, based on zoning area and topography/hydrology, and identified on a map.

11.11. Modify breakwater

Background: A 10,080-foot breakwater was constructed on top of the pre-existing, naturally formed Blonde Reef by the Army Corps of Engineers (ACOE) between 1908 and 1930 to create Hilo Bay harbor. It is believed this breakwater inhibits circulation in Hilo Bay resulting in adverse impacts on bay water quality, ecosystem, recreation and aesthetics.

In an effort to better understand bay circulation and improve bay water quality and ecosystem, Mayor Harry Kim, through the Hawaii County Department of Public Works (DPW), asked the ACOE to investigate and seek a solution to the problem. After much discussion, the County and ACOE agreed the first step in addressing the problem was to develop a computer model of the Hilo Bay circulation that could be used to better understand bay circulation and assess various project alternatives to promote greater water circulation, leading to a better marine environment.

The ACOE submitted a proposed scope of work to DPW in May 2005. The HBWAG and UH Hilo members reviewed and submitted comments to DPW last August. DPW forwarded these comments to ACOE in August and is waiting for a response from the ACOE.

The restoration team should coordinate with the ACOE and their contractors to encourage inclusion of parameters relevant to the evening out in time and space of storm flow from Wailoa River following wetland restoration.

Problem Addressed: The breakwater is believed to inhibit circulation in Hilo Bay leading to adverse impacts on bay water quality, ecosystem, recreation and aesthetics. The circulation model will provide a better understanding of bay circulation patterns and how the breakwater influences circulation. The proposed scope includes the development of a circulation model and evaluation of five breakwater modification alternatives to see if such modifications can improve circulation.

Expected Outcome: The expected outcomes include:

a. a calibrated hydrodynamic model (looking at forces, current, wave patterns) of Hilo Bay circulation leading to a better understanding of bay circulation and how the breakwater influences bay circulation, water quality and ecosystem.
b. an analysis of five alternatives to modifying the breakwater as potential ways to improve bay circulation, water quality and ecosystem.
c. Availability of a model that can be used to evaluate outcome scenarios for BMPs and Demonstration Projects applied in the watershed—i.e., to explore how these changes in pollutant inputs will interact with circulation to affect water quality in the Bay itself

Actions required prior to implementation:

- Coordinator of restoration plan will pull together literature on impacts of wetland on reduction of storm flows, rates of sediment trapping, rates of nutrient trapping, and make these data available to ACOE modeler. If the ACOE process is delayed, data may also become available from a feasibility study of wetland restoration, see below
- The ACOE and County need to agree on scope and cost, and sign a project agreement. Funding sources need to be secured.

Implementation actions: Once a project agreement has been signed and funding secured, the model development can start..

Location to be applied: The location is Hilo Bay.

Costs to be incurred:

- None, funding already being sought by County of Hawaii for the modeling effort, and the restoration coordinator would already be on salary, see section on Management Structure and Funding Needs.
- The County approved $250,000 for the study which covered the original ACOE cost estimate. However after detailing out the project, the cost estimate increased to $325,000. The COE will provide a minimum of $10,000 to start and may be able to provide $10,000/year for some time into the future. The COE prefers a 50:50 (County:ACOE) funding ratio and is seeking an additional $175,000 for the project. A congressional delegation is expected to help secure these funds. The ACOE anticipates an answer on funding by January. If more money is needed, the DPW may consider requesting additional County funds.

Milestones:

- Begin data review within one month of funding, carry out first consultation with ACOE or their contractors within one month of funding, provide data in appropriate form to ACOE or their contractors within six months of funding.

11.12. Maintain viable local Watershed Advisory Group

Background: The Hilo Bay Watershed Advisory Group (HBWAG) is a community-based, volunteer organization formed in July 2003 during a public input process that was part of the EPA grant program to bring Hilo Bay and its tributaries in compliance with certain State water quality standards. The UH Manoa Environmental Center has acted as project manager for this effort during this time. A significant amount of progress has been made over the last 27 months.

The HBWAG is a very dedicated group as indicated by the countless number of volunteer hours that have been poured into the Hilo Bay watershed effort from community members. The HBWAG has had a coordinator that was paid half-time due to limited funding but who found it necessary to work close to full time to really make a difference. In addition, for six months of the project the coordinator worked as a volunteer, without pay, just to ensure that the community momentum was not lost.

Over the life of the project the HBWAG has grown and includes a large number of community members with representation from many key stakeholders. The WAG has a nine-member Steering Committee composed of professional community members. In addition there are four subcommittees. With bare-bones resources, the HBWAG has established a rudimentary outreach and education program that includes making presentations by request to grade and high schools, UHH class, and various community organizations. The WAG has also led several clean ups, stenciled numerous storm drains, and developed a display that has been used at various events.

The HBWAG's long-term goal is to develop a comprehensive watershed management plan for the Hilo Bay Watershed.

Problem Addressed: EPA grant funds for the current part-time coordinator position expired in October 2005. The HBWAG Steering Committee has applied for grants funds for a coordinator and operating expenses but has not been able to secure funding. Therefore, funding for coordination activities are needed to maintain current efforts as well as begin implementation of priority objectives outlined in the Hilo Bay Watershed-Based Restoration Plan and the HBWAG's Hilo Bay Watershed Project Public Input Report dated May 2004.

Expected Outcome: A paid coordinator will allow the HBWAG to continue its progress in educating the community, improving the watershed, and bringing in more key stakeholders and community members.

Actions required prior to implementation: Obtain funding

Implementation actions: *Fund salary for full time watershed coordinator. *Fund materials for Watershed Group activities, including conference visits, grant writing, office equipment and supplies

Location to be applied: Hilo watershed

Costs to be incurred: Salary, operating costs (phone bills, print costs, travel costs), and office materials, equipment (computer, printer, power point projector)

11.13. Establish MOUs with outside industries that impact the watershed, such as cruise ship industry, tourist industry

Background: Cruise ships lead to maintenance of breakwater and its associated circulation impairment problems, harbor facilities, increase road use, increase sewer system use, increase stress National and local parks and facilities, lead to increased demand for infrastructure that further stresses environmental services. Cruise ships and/or their passengers should pay a local tax that stays in the area of the port of call and can be used to address the local environmental impacts of the cruise ship industry.

Problem Addressed: Lack of funding for planning and environmentally sound infrastructure

Expected Outcome: Increased funding and awareness

Actions required prior to implementation: Discussions between citizen groups, cruise ship companies, and county and state officials. Note that these discussions between the community and the primary cruise ship company calling at Hilo, Norwegian Cruise Lines, have already started, but with a focus on increasing cruise ship passenger visitation to downtown Hilo businesses (Sur 2005)

Implementation actions: Pass legislation with respect to cruise ship tax

Location to be applied: Hilo, county

Costs to be incurred: None, costs of meetings will be covered by interested parties

11.14. Informal community education

See section 13 (Education Plan)

Additionally, increased funding is needed for storm drain stenciling, and for a monitoring plan to determine how well the stenciling is working, so that the method can be improved (focus on key locations, try out different messages, etc.), and water quality testing kits for volunteers and for special occasion field efforts should be purchased.

11.15. Formal education

See section 13 (Education Plan)

11.16. Long-term planning for coastal zone adaptation to climate change

Background: Climate change models predict that ENSO like conditions will prevail in Hawaii year round, with more extreme conditions during actual ENSO events. This means that warmer waters between the California coast and Hawaii will result in the maintenance of Pacific Hurricanes, increasing the probability that they will reach Hawaii as hurricane force storms rather than losing force over the usually cooler Pacific waters.

Implementation actions: Begin community, county and statewide discussions on adaptation to climate driven coastal zone changes and disasters (erosion, hurricanes, sea level changes, long-term or ENSO associated changes in rainfall patterns)

12-- RECOMMENDED DEMONSTRATION PROJECTS

Baseline data obtained prior to the implementation of each of the demonstration projects described below, and monitoring conducted for 3-4 years following implementation will provide badly needed data not only on the impact of project implementation, but on the hydrology of the watershed. For each restoration project, monitoring of water quality should be designed to take place upstream of implementation site, immediately downstream of implementation site, at one or more locations between the site and the Bay, and in the Bay itself. Note that monitoring in the Bay itself is already covered by the research and monitoring plan described in Section 14 below. The number of monitoring locations between implementation site and the bay will depend on the distance of the site from the bay, and on the hydrology and topography of the intervening area.

12.1. Removal of *Falcataria molucca* ("Albizia"), an invasive, Nitrogen-fixing tree, from the watershed

<u>Background and Rationale</u>
There is now abundant evidence that several invasive, Nitrogen-fixing tree species in Hawai'i increase the nitrogen content of the litter, the soil and of other plants relative to nearby or similar sites supporting predominantly native forests (Vitousek and Walder 1989, Binkley and Ryan 1998, Kay et al. 2000, Hughes and Denslow in press). Current work in the Hilo Bay Watershed and nearby shows that these increased N levels and rates of N cycling by stands of *Falcataria moluca* translate to higher N levels in streams moving through these stands (K. Bishaw and R. F. Hughes, unpublished data). For example, in Kolelole stream, the nitrate concentration in the water just below an Albizia stand (at about 50 m above sea level) showed a 30 % increase over the concentrations in the stream just above the stand (100 m asl) and in the stream at 1700 m asl. In Ainako stream, well within the Hilo Bay watershed, the increase was 40 %. In this second case, it is important to note that N levels measured after the stream level passed a residential area were not higher than before the residential area, and the 40 % increase can be attributed to collection of nutrients primarily from the Albizia stand. In the Kolekole area, there is no concentrated residential development, indicating that the nitrates cannot be coming from urban runoff.

<u>Location</u>
Ainako stream, Albizia stand at about 340 m asl.

<u>Estimated pollutant reduction</u>
Removal of the trees and associated litter should reduce nitrate inputs to the stream by about 30 %. The reduction factor of this nitrogen as it is used by the biological community before the water reaches the bay is not known, and so the reduction in levels of N entering the bay cannot be estimated at this time. Monitoring of N levels after tree removal at several points below the implementation point and at the nearest estimated point of entry into the bay will provide us with this information.

<u>Potential Implementation Partners</u>
Dr. Flint Hughes, Institute of Pacific Islands Forestry, USDA Forest Service, 23 East Kawili Street, Hilo, HI, 96720; fhughes@fs.fed.us

Estimated costs
Labor to cut and remove trees: 100 person-days
Truck rental and fuel for removal of plant matter from site
Implementation of BMPs during clear-cutting to prevent erosion and both soil and plant matter input into the stream
Destruction of vegetative and reproductive Albizia parts to prevent spread of the plant at the disposal site
Monitoring of N levels and flow rates at 5 points associated with removal site

Potential impacts
Erosion, N inputs at tree disposal site,

Relevant literature

Hughes, R. F. and J. S. Denslow. In press. Invasion by a N2-fixing tree alters function and structure in wet lowland forests of Hawai'i. Ecological Applications

Vitousek, P. M. and L. R. Walker. 1989. Biological invasion by *Myrica faya* in Hawai'i: plant demography, nitrogen fixation, and ecosystem effects. Ecological Monographs 59: 247-265.

Kaye, J. P., S. C. Resh, M. W. Kaye, and R. A. Chimmer. 2000. Nutrient and carbon dynamics in a replacement series of Eucalyptus and Albizia trees. Ecology 81: 3267-3273

Binkley, D., C. and M. Ryan. 1998. Net primary productivity and nutrient cycling in replicated stands of *Eucalyptus salvigna* and *Albizia falcataria*. Forest Ecology and Management 110: 101-112

12.2. Control of rooting by feral pigs (*Sus scrofa*) in the Hilo Forest Reserve and other forested areas of the watershed

Background and Rationale
There is evidence from studies in the mainland US, in Australia, in Central America, and in Hawai'i, that rooting by feral pigs in different habitat types can result in "plant and root death, mixing of soil horizons, increased rates of nutrient mineralization, and decreased rates of nitrogen retention" (reviewed by Mack and D'Antonio 1998). In forested communities such as those that are of concern in the Hilo Bay watershed and elsewhere in the Hawaiian Islands, soil disturbance and loss of the understory due to rooting can be associated with nitrogen and base cation leaching from the soil (reviewed by Mack and D'Antonio 1998). In temperate deciduous forest, ground water in pig-rooted watersheds may have elevated Nitrogen levels (Singer et al. 1984). It is important to point out that to date there are no published studies of rates of soil erosion or nutrient leaching that can be attributed to pig rooting in Hawai'i. However, the literature from other sites suggests that pig rooting may be contributing to both these factors in Hawaiian watersheds, and that therefore controlling pig rooting may lead to a decrease in sediment and nutrient inputs to streams and eventually to coastal waters. Research in Australia indicates that pigs tend to root in moister areas there (Hone 2001). Whether or not this is true in

Hawaii, any rooting near water courses or on slopes draining immediately onto water courses should lead to the highest soil inputs into water.

Pigs are abundant in the Hilo Bay Watershed, and have been so for many decades (Giffin 1972). Hunting is allowed in large sections of the Hilo Forest Reserve and elsewhere in the watershed. Hunting groups and individual hunters work with federal and state agencies in public hunting efforts within protected areas, and also report their hunting activities within areas managed for enhanced hunting opportunities. After identification of areas with heavy rooting activity near waterways, and especially in the rainy season, hunters could hunt in a controlled way to "harass" pigs and deter their presence in these areas. Pigs will leave areas where they are persistently hunted (Hone 2002), allowing for this type of behavioral control on their activities. To supplement this form of management, especially disturbed patches near waterways could be fenced off to prevent access by pigs (small, localized areas, of a hectare or so in extent at most, which will not limit the amount of land areas available to hunters). Sediment and nitrogen levels at several points above and below the location of implementation should be monitored during a year before and for at least a year after implementation.

<u>Location</u>
Pick one subwatershed area to work with in the Hilo Forest Reserve, or work with Hakalau Widlife Refuge to add this type of manipulation and monitoring to their ongoing pig management activities (however, it would be good to have a lowland site as well as an upland site in Hakalau, and also a site without extensive cover by invasive grasses, as is the case in Hakalau)

<u>Estimated pollutant reduction</u>
For a volcanic island in Costa Rica, Sierra (2001) showed that over an 8-month period, forested areas with pig rooting released 2.9 times as much soil on average as sites without rooting. Therefore, by preventing rooting in sensitive areas near streams or other areas that drain into streams, the inputs of sediments and associated nutrients could be reduced by up to a factor of 3. How much of the sediments and nutrients that enter a stream at the source actually make it to the bay waters is not currently known, but by monitoring at multiple sites downstream of the implementation point such load reductions can be determined.

<u>Potential Implementation Partners</u>
Dr. Richard Mackenzie, USDA Forest Service, 23 East Kawili Street, Hilo, HI, 96720; fhughes@fs.fed.us
Dr. J. Fragoso, Botany Department, UH-Manoa and PCSU
Dr. Kirsten Silvius, Environmental Center, UH-Manoa
Dr. Dick Wass, Hakalau Wildlife Refuge Manager
Mr. Edwin Johnson, State Hunting Coordinator, DOFAW-Honolulu

<u>Estimated costs</u>
Support for informational meetings with hunters
Data sheets for hunters, ideally also maps and GPS units (10 GPS, 10 maps)
Aerial photographs of watershed (available from NRCS or DOFAW or Forest Service)
Support for MS student to coordinate hunter monitoring

Support for hunters (taking them to areas where pig harassment is needed)
Fencing materials for small areas—estimate max one mile fencing to be used on multiple small longitudinal barriers and/or exclosures along waterways

Potential impacts
Movement of pigs into other areas where they are not wanted
Conflict with the hunting community
Conflict with DOFAW

Relevant literature
Sierra, C. 2001. El cerdo cimarrón (*Sus scrofa*, Suidae) en la Isla del Coco, Costa Rica: escarbaduras, alteraciones al suelo y erosion. Revista de Biologia Tropical 49 (3-4)

Department of the Environment and Heritage, Australia Government. 2005. Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs. Commonwealth of Australia, Department of Environment and Heritage.

Mack, M. C. and C. M. D'Antonio. 1998. Impacts of biological invasions on disturbance regimes. Trends in Ecology and Evolution 13: 195-198

Hone, J. 2002. Feral pigs in Namadgi National Park, Australia: dynamics, impacts and management. Biological Conservation 105: 231-242

Singer, F. J., W. T. Swank and E. C. Clebsch. 1984. Effects of wild pig rooting in a deciduous forest. Journal of Wildlife Management 48: 464-473

Kotanen, P. M. 1995. Responses of vegetation to a changing regime of disturbance: effects of feral pigs in a Californian coastal prairie. Ecography 18: 190-199

Vtorov, I. P. 1993. Feral pig removal: effects on soil microarthropods in a Hawaiian rain forest, Journal of Wildlife Management 57: 875-880

Aplet, G. H., S. J. Anderson and C. P. Stone. 1991. Association between feral pig disturbance and the composition of some alien plant assemblages in Hawaii Volcanoes National Park. Vegetatio 95: 55-62.

Russell-Smith, J. and D. J. M. S. Bowman. 1992. Conservation of monsoon rainforest isolates in the Northern Territory, Australia. Biological Conservation 59: 55-63

Giffin, J. 1972. Ecology of the feral pig on the island of Hawaii. Division of Fish and Game, Department of Land and Natural Resources, State of Hawaii.

12.3. Waiakea Pond and Wetland Restoration

Background and Rationale

Wetlands are known to retain sediments and nutrients, preventing them from entering coastal waters. Constructed wetlands are designed specifically for this purpose (e.g., Perry 2004). They are also known to store floodwaters and release them slowly, thus reducing the intensity and impact of flooding caused by heavy rainfall and hurricanes (Sipple, W.S. 2004). They trap heavy metals in the sediments, and allow them to be processed by vegetation (de Barry 2004). Additionally, wetlands provide habitat for wildlife and endangered wading bird species, and serve as nurseries for fish species of economic and ecological value. In the Hilo Bay watershed, the costal wetlands have been reduced, with hardened channels in the Wailoa river and short grassland vegetation and impervious surfaces (parking lots, roads) surrounding Waiakea pond and separating it from the coastline. Waiakea pond has been identified as a critical primary wetland for water bird conservation in the Hawaii Water Bird Recovery Plan (Henson 2002).

A demonstration project (BMP application, monitoring, and community education) should be carried out at Waiakea pond in collaboration with the Division of Aquatic Resources, (DAR) focused on wetland roles in controlling sediments and nutrients, and also on the role of this particular site as a fish nursery. This project should be linked to or lead to a plan for the restoration of the coastal wetlands in this area, including social, economic, ecological, and biodiversity assessment. Activities will include experimental alterations of vegetation, with monitoring of nutrient and sediment outputs (and perhaps other pollutants from runoff) at the input and output points during rainfall/flood overflow events; fish stock monitoring by fishermen (self-reporting of what is caught and seen); as well as regular monitoring by DAR. The US EPA has produced numerous materials to guide the design and implementation of such a demonstration project (e.g. US EPA 1996, 2002 a, b, 2003, among others)

Location

Waiakea pond and surrounding flood control areas (soccer fields, etc.)

Estimated pollutant reduction

Sierra Club estimates that wetlands can reduce street runoff pollutants by up to 90 % (Townscape 2003)

Potential Implementation Partners

Dr. Richard Mackenzie, wetlands ecologist at USDA Forest Service
Army Corps of Engineers
Division of Aquatic Resources (Robert Nishimoto)
Ducks Unlimited
Department of Land and Natural Resources
US Fish and Wildlife Service

Estimated costs

Graduate student to monitor inputs and outputs, potentially supported through DAR
Sampling materials for nutrients and sediments
Preparation of safe harbor agreements

USFWS estimates from 500 to 1500 $ per acre of wetland for the physical aspects of wetland restoration (Townscape 2003)
Construction of sediment removal structures (e.g. installation of geotextile fabric) at storm drain outlets near Waiakea boat ramp and at several other locations around the pond.

Funding may be available through Ducks Unlimited, EPA Wetlands program, DLNR, or the Fish and Wildlife Service, and the EPA State/Tribal Environmental Outcome Wetland Demonstration Program Grant Pilot (WDP)

<u>Potential impacts</u>
This wetland restoration plan runs counter to plans by the County of Hawaii Department of Parks and Recreation, which would like to acquire the Waiakea State Park from the state to include the area into its envisioned greenway from the docks to down town Hilo (Takemoto 2002). The two contrasting visions of the area should be presented to the community and discussed in community meetings.

<u>Relevant literature</u>
Sipple, W. S. 2004. Wetland functions and values. EPA Watershed Academy. http://www.epa.gov/watertrain

Perry, W. 2004. Elements of South Florida's Comprehensive Everglades Restoration Plan. Ecotoxicology 13: 185-193.

Townscape, Inc. 2003. Ala Wai Watershed Analysis. Final Report. Department of Land and Natural Resources, State of Hawaii

U.S. EPA. 2002a. Methods for Evaluating Wetland Condition: Introduction to Wetland Biological Assessement. Office of Water, U.S. Environmmental Protection Agency, Washington, DC. EPA-822-R-02-014.

U.S. EPA. 1996. Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices. Office of Water, U.S. Environmmental Protection Agency, Washington, DC. EPA-843-b-96-001.

U.S. EPA. 2002b. Methods for Evaluating Wetland Condition: Volunteers and Wetland Monitoring. Office of Water, U.S. Environmmental Protection Agency, Washington, DC. EPA-822-R-02-018.

U.S. EPA. 2003. Methods for Evaluating Wetland Condition: Wetland Biological Assessment Case Studies. Office of Water, U.S. Environmmental Protection Agency, Washington, DC. EPA-822-R-03-013.

Interagency Workgroup on Wetland Restoration. 2000. An Introduction and User's Guide to Wetland Restoration, Creation and Ehancement. IWWR, Washington, DC

13—EDUCATION PLAN (EDUCATION AS A BEST MANAGEMENT PRACTICE)

In addition to addressing immediate needs of education in the watershed re existing pollution and management problems, regulations and BMPs, the education plan should also address the topic of ecosystem function of bays and estuaries, and why certain features not seen as beneficial by humans may actually provide useful services—e.g. flood control and nutrient retention function of wetlands, providing appropriate conditions for coral and algae growth, thus enhancing fisheries, also estuaries as sources of fish populations, why the benefits of not dredging a river mouth may outweigh the benefits of dredging it, etc. Essentially, education should emphasize the need to value long-term ecosystem services that depend on ecosystem function.

The three primary approaches of the education plan are:

Informal education—A series of video modules will be developed addressing specific pollution and water quality/management issues in the Hilo Bay Watershed. The modules will be shown on television, and will be prepared by or under the direction of local film makers. They will emphasize the information that science can provide to managers, the state of knowledge re that particular watershed related topic in Hilo Bay, and the recommended BMPs for the situation. Ideally, the modules will be produced by local film-makers or students at Hawaiian film schools. They could be funded through a competitive grant process (lay out the required contents and approach, and ask for proposals from interested film makers, set a budget limit, film equipment would have to be available already to the film maker, but grant could cover materials. Kimberlee Bassford, owner of Making Waves Films LLC, in Honolulu, is an award winning documentary film maker with extensive experience in educational videos who could serve as consultant to organize and guide the call for proposals, help define the topics and themes, and oversee actual film production and final products. The Watershed Advisory Group has already identified other individuals and organizations who may be able to participate in this process: Darcy Bevens at UH Hilo; Mari-Lyn Video Production; Na Aleo; Ackerman Black. The videos will show sites in the watershed, and will contain interviews with residents, managers and researchers from the watershed, although they will also provide general background on the science behind each issue and what is being done elsewhere. Modules will be available to schools, the media, community groups, and special interest groups. The videos will essentially be a combination of exposé and education, highlighting what research has to tell us about each of the module topics. Funds may be sought through the National Science Foundations Informal Science Education Program, as well as through the US EPA. An attempt will be made to produce the videos in Hawaiian as well as in English, or to combine the two languages with the judicious use of subtitles. The documentary film consultant will be able to help here. The impact of video modules will be evaluated by formal social science research techniques to assess changes in knowledge and changes in attitudes before and after showing the video. A graduate student in sociology or education could be recruited to work on the evaluation as part of their thesis research. The videos will be available for use throughout the state of Hawaii once completed.

Potential module topics will be evaluated with the help of the video consultant, but could include:

1. *Hydrology of Hilo Bay*—a geography, geology emphasis—how much rain, where does it go, where are the seeps, what are the fish, where are the tubes (available from the Hawaii Speleological Survey of the National Speleological Society), how does water move through them, where were the historic wetlands, how did they function? Include ahupua'a and traditional boundaries. Consult with Jene Michaud and James Juvik at UH Hilo can help refine these topics. This could actually take up two modules.

2. *Waste disposal (garbage*) in Hilo area: How much, what kind, where does it go (landfill), what happens when it enters into streams accidentally or intentionally (e.g. dumping in lava tubes). Issues of toxic substance disposal, and recycling: what options are currently available in Hilo?

3. *Flood issues*: how does zoning and building currently deal with flood threats? What is the 10-year flood zone? 100 year flood zones? Whose houses are located in these zones? What are potential solutions? Runoff from impervious surfaces?

4. *The legacy of the sugar industry*: canec, arsenic, fertilizers, erosion, etc. Potential for bioremediation, future uses of old sugar cane land, what have other islands, countries done with similar lands?

5. *Freshwater and estuarine communities in Hilo Bay watershed*: fish, algae, trophic interactions, impacts of habitat modification and pollutants.

6. *Fertilizer impacts on nutrient cycling in freshwater and estuarine system in Hilo Bay watershed*—describe normal nutrient cycles, as well as impacts of N and P addition. Propose a self-monitoring system, in which landowners keep track of how much of each product they apply and report the data anonymously (through a web site or mail in system with no return address, or by drop off box at grocery stores and schools)

7. *Sediments in Hilo Bay watershed*. Why sediments are a problem. How the following can contribute to increased sediment loads: land clearing activities, natural runoff, grubbing and grading laws, feral ungulates.

8. *History of water management issues in Hilo Bay area*, including which agencies have jurisdiction over what. Also, breakdown of who contributes what to pollution: individual landowners, agriculture, industry, tourists, conservation areas, military, etc.

9. *Human waste*—cesspools, septics and sewer lines in Hilo—capacity, leaks, consequences, jurisdiction, impacts, potential fixes, costs.

Funding needs:

- about 10,000 $ per module for six modules over a three year period = 60,000 $ (two already counted in previous section on implementation)
- 15,000 $ to retain consultant

Milestones:

- Contract with consultant one month after funding
- advertise grant program within 4 months of funding
- select documentary makers within 8 months of funding

- produce at least 2 videos per year for the next three years, with first video produce 1.5 years after funding.

Formal education: Teachers and students from local high schools and elementary schools will be involved in the restoration plan by contributing to water monitoring efforts (under the monitoring regime described below); simultaneously, the restoration plan team will seek a Memorandum of Understanding (MOU) with the Department of Education (DOE) to provide science curriculum materials to elementary schools and high schools that include information on aquatic ecosystem function and water resource management (to meet ecology and resource management curriculum requirements). The Ecological Society of America's program in Schoolyard Ecology and ecology in the curriculum will be used as guidance. Success of the curriculum will be evaluated through impact on science grades and through standard course evaluation used by the schools.

Funding needs:

- Look for DOE funding or grants for education; estimate $ 15,000 to get the project off the ground—produce initial materials for one high school course and one elementary school course (web based, print outs by school as needed, can be designed in modules so that teachers can modify them as needed).
- The CANON Envirothon, funded by the National Association of SWCDs, is a potential source of funding. With planning supported by the Restoration Plan process, Big Island schools could successfully compete for this funding on an annual basis.

Milestones

- initiate discussion with DOE three months after funding
- establish MOU within 6 months of funding
- produce initial materials and start using them in classroom two years after funding

Community education on BMPs—this component will be carried out using standard materials already prepared by other EPA and DOH funded watershed based projects (e.g. West Maui Watershed Management Advisory Committee 1997), and materials available through Natural Resources Conservation Service (NRCS), US Environmental Protection Agency (EPA), University of Hawaii at Manoa College of Tropical Agriculture and Human Resources (CTAHR), etc.

Funding needs:

- print costs for booklets and pamphlets, will depend on number needed—check with West Maui Watershed Advisory Committee re cost, and also get data from their evaluation of the impact of the use of this manual (assuming they did a follow up study). Estimating $ 15,000

Note that the Edith Kanakaole Foundation (http://www.edithkanakaolefoundation.org/) is already doing education on waste management by and for native Hawaiians—the education program of the restoration plan should interface with them to ensure inclusion of methods tested for effectiveness among native Hawaiian communities. They include formal education in their charter schools as well as informal education.

14—Critical Monitoring Needs

The most effective approach to research on Hilo Bay non-point source pollution is to fund researchers at the University of Hawaii-Hilo to design and carry out the required research and monitoring projects with the assistance of their graduate students. In this way, in addition to data collection, training and science education will also be fostered in the area. Furthermore, through this linkage it may be possible to leverage research funds through the National Science Foundation and other federal initiatives that support student research. Researchers based in Hilo know the area and its resources well. It is likely that if consultants are contracted to carry out work on the restoration plan, they would subcontract at least part of the work to the University, increasing the overall indirect costs of the project. Faculty members can be supported through partial salary buy-out during the academic year, which would allow them to reduce their teaching loads and concentrate on research, and/or through full time summer salaries (all faculty members have 9 month positions and are unsalaried for the three month summer break in the academic year). Salary support should already be provided during the time that researchers are developing the final, detailed monitoring proposals that will be supported by the restoration plan. Additionally, programs such as the UHH Marine Option Program Student Research Projects and the summer Quantitative Underwater Environmental Survey Techniques Program already exist, and can be used to support research needs of the WRP.

UH-Hilo researchers and their collaborators that come to mind as potential project participants are:

1. Dr. Tracy Wiegner, Department of Marine Sciences (nutrient inputs to estuaries): can coordinate research on nutrient inputs from Wailuku river, ground water seeps, and in the Bay waters.
2. Dr. Mike Parsons, Department of Marine Sciences (oceanic eutrophication, plankton dynamics); can coordinate research on community structure in the Bay.
3. Dr. Jene Michaud, Department of Geology (hydrology); can coordinate research on flow levels from surface and ground water.
4. Dr. Jon-Pierre Michaud, Department of Chemistry (biochemistry/toxicology); can coordinate research on sediment inputs to the Bay.
5. Dr. Debra Weeks, Department of Chemistry (metal chemistry and pollution); can coordinate research on wetland function in retaining toxins, sediments and nutrients in Waiakea pond/Wailoa river.
6. Dr. Jeff Zimpfer, UH Sea Grant Extension Agent (non-point source pollution, with specialization in microbial ecology); can coordinate research on fecal indicator bacteria.
7. Dr. Leon Hallacher, Department of Marine Sciences (ichthyology)

8. Dr. Walter Dudley, Department of Oceanography
9. Dr. Randy Schneider, Department of Chemistry
10. Dr. Lisa Muehlstein, Microbiology
11. Dr. Jim Beets, Marine Science (Icthyology)
12. Dr. Richard Mackenzie, USDA Forest Service (wetlands ecologist)
13. Dr. Jason Turner, Marine Science (food web ecologist)
14. Dr. Fred Mackenzie, UH-Manoa (water chemistry; teaches in marine science at UH-Hilo)

A two-to-three day workshop should be held in Hilo as soon as possible to bring together these researchers and to co-ordinate proposal development and monitoring design.

Funding needs for ecological monitoring:

- $ 3,000 for workshop.
- Buy out time for three faculty members at UH Hilo per year, for three years, at 1/2 time: $ 25,000 plus benefits x 3 x 3 = $ 225,000 plus benefits plus scheduled annual salary increases. (Or, alternatively, summer salary for 3 faculty members for 3 years, full time: $ 17,000 x 3 x 4 = 204,000 plus benefits plus allowance for annual salary increases)
- equipment and training costs are described separately under each research project

Objectives of Ecological Monitoring and Baseline Data Gathering

1. Identify sources of nutrients, fecal indicators and sediments to Bay waters, focusing on the relative contributions of ground water vs. surface water, and of storm flows vs. base flows in surface water.
2. Develop biological indicators that can be used as surrogates for sediment and nutrient levels in Bay waters and can be monitored by students and volunteers.
3. Obtain baseline data on the current community structure in the Bay waters, with a focus on trophic webs and nutrient cycling; monitor changes that occur following BMP and Demonstration Project implementation (for example, such baseline data and monitoring will allow us to determine the role of restored coastal wetlands in reducing sediment and nutrient input to the Bay).
4. Develop a detailed spatio-temporal monitoring regime for water quality parameters, based on an initial map of the estimated hydrology patterns. Dr. Jene Michaud and a student assistant at UH Hilo have identified a preliminary set of sampling locations that can be attained with existing facilities, equipment and personnel. This monitoring plan, along with comments provided by reviewers of the plan, is available upon request. The plan needs to be expanded to incorporate a much larger, landscape-scale coverage of the watershed, and to place a much greater emphasis on storm sampling. We recommend that Drs. Michaud and Wiegner (UH-Hilo) be retained to continue developing the much more detailed monitoring plan required by the size and complexity of this watershed.

Objectives of Socio-economic Research

1. Determine the contributions of the cruise ship industry to economic status and environmental quality of Hilo Watershed.
2. Identify the barriers and opportunities to effective watershed management in the current management structure in Hilo Bay.

Recommended Ecological Monitoring Projects

Nutrient and sediment loads in the Wailuku river

Nutrients may be dissolved, incorporated into sediments (sorbed or mixed in the matrix) or arrive as particulate matter. It is unclear which type of nutrient is more bioavailable, and which land use type produces more of these bioavailable nutrients. There is evidence that both N and P arriving in sediments are highly bioavailable in the tropical Pacific (K. Chaston pers. com.), and also that dissolved organic nitrogen derived from soil erosion is less bioavailable than that deriving from storm overflow and sewer overflow in urban areas (T. Wiegner pers. com.). Furthermore, it is the relative availability of P, N and C that determines effects such as eutrophication, and in Hilo Bay issues of salinity will also affect plankton and macroalgae growth. In the absence of abundant large herbivores, and given the dense monospecific forests established by invasive plants in Hawaii, nutrient input may also come from invasive plants dropping leaves, fruits and seeds along certain stretches of the river, and this input needs to be properly quantified (Hughes and Denslow in press, Larned 2000, Larned et al. 2001). How these relationships play out may be very site-specific and therefore need to be studied at Hilo Bay and its tributaries themselves. These questions need to be resolved for two reasons: 1) to apply reductions where they will be really effective, and 2) to assure the community that the cost of input reduction is being borne by the appropriate sectors, and that the BMPs applied have a high likelihood of being effective in improving water quality. It will do no good to reduce sediment inputs from natural erosional process in the geologically young Hilo watershed landscape, while not reducing wastewater and storm water runoff and percolation. Furthermore, we need baseline data on the relative importance of nutrients derived from agricultural lands (planted and ranching) vs. urban runoff, in order to properly allocate total maximum daily loads. We also need to know the direction and pathways of water flows throughout the basin, to know which waters are reaching the Bay with pollutants in them, and we need to pin down the relative contribution of surface flow in streams vs. ground water flow, as ground water may in fact be more important than surface flow (Michaud 2003, Garrison et al. 2003, Hoover and Kinzie 2002). We already know that storm flow is more important than base flow in terms of the amount of water carried into the estuary and Bay for the Wailuku and Honolii streams as well as for other areas in Hawaii (Hoover 2002).

Baseline data gathering will focus initially on inputs from the Wailuku river, until the results on the TMDL process in the Alenaio and Waiakea streams are available. At that point it may be determined that more data are needed from those watersheds. Inputs to the Waiakea pond and outputs from the pond through the Wailoa river will also be monitored as part of the demonstration project described earlier.

Baseline data gathering in the Wailuku river sub-watershed will address the contributions of the different land use types in the sub-watershed: alpine/conservation, forest/conservation, abandoned cane fields, active agriculture, homesteads/small scale agriculture, suburban, urban, and re-suspension of Bay sediments (the latter through cores, experimental re-suspension, and observations of re-suspension during natural storm/wave events and other forms of disturbance). Steps to be taken are 1) identification of land use types using the best available satellite imagery currently being used by USGS, DLNR, NRCS and other federal and state agencies, and by ground truthing these images in accessible areas of the watershed; 2) mapping of any cesspool locations that may contribute nutrients to the river; 3) identification of accessible sampling sites along the main river within each land use type, and at the confluences of tributaries with the main river; 4) collection of water samples to be analyzed for sediment and nutrient content under both base flow and storm flow conditions; sampling during storm flow and heavy rain conditions will be maximized by targeting sampling at accessible sites during or immediately after these conditions in addition to using automated samplers; 5) identification of sediment types deriving from different substrate/land use combinations, to test whether they can be identified as they settle out along the river and in the estuary; 6) simultaneous collection of water samples in the river and its tributaries and in the Bay (mouth of river and elsewhere), ideally as part of the regular monitoring effort described below. Sampling in the river will be carried out by UH Hilo PIs and their graduate student assistants, while sampling in the Bay can be carried out by students, volunteers and DOH personnel. Once baseline data gathering is concluded (at least three years of sampling), sampling will continue at a reduced number of locations for permanent monitoring purposes.

Funding needs:

- satellite images, ground-truthed or not (potentially cost-shared with DLNR, NRCS or USGS)
- stipend support for faculty and graduate students (estimated above, all stipends for ecological research are grouped together)
- six storm flow samplers (to be suspended from bridges or other structures overhanging the river) (~$10,000 each x 6 = 60,000 $)
- twelve manual samplers for nitrogen, phosphorus
- sampling materials for *C. perfringens*, including coolers; costs of lab analysis of *C. perfringens* samples (potentially cost shared with DOH).
- sampling materials for suspended sediments (collection jars, filter paper, dryers, etc.); cost to be estimated after final monitoring and sampling design is determined
- analytical services (nutrient analysis)
- 4-wheel drive vehicles (at least 2) for field work, plus fuel and maintenance
- boat, with trailer, plus fuel and maintenance, for bay sampling

Sampling/monitoring in the Wailuku River and Wailoa mouths and the Bay will focus on TSS, *C. perfringens*, N and P at permanent sampling spots in the river and in the Bay. In the river, sampling will cover waters derived from each land use type, with replication; currently we are estimating 6 land use types, with at least three replicate sites per land use type for grab samples and only one replicate for permanent storm flow samplers. Locations of sampling in the Bay will include all major fresh water seeps (approximately 6 sites), the mouths of the all streams/rivers entering the Bay, and the surface and bottom layers of water at incremental distances from the shore (at least three distances before reaching breakwater, and an additional site at the entrance to the harbor. It may be necessary to sample for silica and/or salinity to properly identify the source of water being sampled (fresh vs. ocean, ground vs. surface). Additionally, since some of the sediment in Hilo Bay is biogenic in origin (carbonate sand from coral and coralline algae), biogenic sediments should also be monitored. Although permanent sampling probes have been developed by the HCRI for use in Kaneohe Bay (Hoover and Kinzie 2002), maintenance and training costs will be high for these and we prefer to work with single or few parameter probes deployed only at the time of sampling. This increases person-hours needed for sampling, but with access to students and canoe club volunteers, this does not present an obstacle or added cost. The temporal sampling regime will require sequential sampling in the Bay following sampling in the streams, with a time frame estimated from the expected rate of water flow into the Bay for both base flow and storm flow. The initial coordination of this multiple sampling regime may seem daunting, but once in place it should function well, and we can build in redundancy and replication to reduce the statistical impact of missed samples. Sites should be chosen to maximize information return while minimizing costs, based on current knowledge of water flow. Final instrument selection will occur in consultation with D. Hoover and the CRI team that carried out water quality monitoring in Kaneohe Bay in 1998-2002.

During the first 5 years, monitoring will also take place for the parameters traditionally covered by DOH and on the basis of which the Bay waters were placed on the 303d list: turbidity (visual assessment), nutrients (visual assessment), chlorophyll a, and *C. perfringens*. The number of sites will be smaller, will correspond to sites previously monitored, and will overlap with sites being sampled in more detail. Monitoring can be carried out by DOH staff with the assistance of project volunteers. This monitoring will; 1) allow continuity with existing data to detect any changes in parameters as a result of project implementation; 2) allow us to determine whether a correlation actually exists between these visual criteria and the lab based criteria; 3) allow for calibration of the visual assessment criteria against the chemical, instrument or lab based criteria should a correlation exist; and 4) allow us to determine whether there is a correlation between chlorophyll levels and the status of the plankton community in the Bay that is actually useful as an indicator of community status.

Once sampling sites in the Bay are chosen, monitoring under calm weather and ocean conditions in the Bay will be carried out with assistance from high schools, canoe clubs, UH-Hilo class participants, and volunteers. The WAG coordinator will develop a schedule based on availability of students, club members and volunteers. Initially, the project or the WAG will have to hire technicians to carry out monitoring and train students and other volunteers, who will then continue the data gathering, monitored by the WAG. Data will be entered on a website data base maintained by WAG. Schools could enter data themselves, but we will need hard copies and controls, with random checks of their data quality at regular intervals.

Funding needs:

- salary for technician to work with DOH should that agency lack sufficient personnel to carry out increased monitoring or, more likely, lab analysis
- cost of lab analysis for *C. perfringens* samples
- training of volunteers (copies of sampling methodology, sampling materials to be used during training)

Biological baseline data

Characterize community structure of benthic and water column organisms in Hilo Bay (phytoplankton, algae, zooplankton, invertebrates, vertebrates) and correlate changes in community structure over the long (seasonal) and short term (daily) with above monitoring of Wailuku and Bay waters. The initial work would be done by a graduate student for his/her thesis, then incorporated into regular monitoring. Faculty members at UH Hilo (e.g., Drs. Jason Turner, Jim Beets, Karla McDermid, and Mike Parsons) might be the best persons to carry out this work.

Coral growth and fish populations will be similarly monitored by volunteers using the protocols developed by the Coral Reef Initiative. This will allow detection of impacts of pollution and the reduction of pollution on the marine fauna, and may lead to reliable biological indicator species for the Bay, reducing the need for continuous water sampling once the research phase is over. Invasive algae cover can also be monitored in this way. Misaki Takabyashi, in the UH-Hilo Marine Sciences Department, is a coral specialist who could help guide this work.

Funding needs:

- Stipend support for faculty member at UH Hilo and for graduate student (included in overall estimate of faculty/student costs)
- Research materials—to be estimated

Fecal indicator bacteria

Analysis for fecal indicator bacteria and especially *C. perfringens* will be carried out by DOH personnel, but we will need to provide them with more trained personnel to collect the samples and preserve them properly, in order to get broad coverage across the Bay under different weather conditions. Currently sampling is restricted to three sites at regular intervals rather than to coincide with storm and base flow, which does not allow us to test the hypotheses that there is considerable input from cesspools to the Bay. After mapping out the current location of cesspools and of sewer lines (with potential leaks) in relation to the best available estimate of water percolation into the Bay (see BMPs, Sections 11.1, 11.3), we will select sampling sites that will allow us to test the hypothesis that cesspool leachate is entering through ground water rather than stream flow. We will use *C. perfringens* rather than traditional fecal indicators to avoid the possibility that bacteria from the soil are contaminating the water.

Funding needs:
- cost of sample analysis and cost of training volunteers in proper collection techniques; cost of sample bottles and coolers.

Social and Socioeconomic studies

Addressing Health Concerns in Hilo Bay

Bay users, and especially canoeists, complain of frequent rashes after entering the water, and also believe that staph is prevalent in the waters. A collaboration with doctors and outdoor groups to document incidences of "rashes" and "staph infections" anecdotally reported by Bay users could do much to either confirm or dispel the concerns, leading to greater comfort for Bay users if no disease pattern is found, or alternatively leading to further monitoirng and a solution if support is found for anthropogenic causes of rashes and infections (as opposed to stinging by jellyfish and/or algae).

Funding needs: minimal, forms to be posted in canoe huts and club house, and forms for doctors to fill in; $ 1,000

Economic and Environmental Assessment of Cruise Ship Industry Impacts

Estimate the benefits to local economy, to island economy, to state economy, and costs to each of these three (who is bearing the burden, who is getting the benefits), as well as impact on water resources (direct through pollution in Bay, indirect through wastewater increase at Volcano park and in town, indirect through need to maintain breakwater). This will also serve as a demonstration project for cost-benefit analysis that includes ecological services and other costs not usually considered.

Funding needs:
- graduate student in economics at UH Manoa; one semester RAship at 8,000 $
-

Institutional barriers to and opportunities for efficient water resource management

A review is needed of the current governmental structure controlling watershed management, conservation, granting of permits, etc., at county, state and federal level as it applies to Hilo. This study should describe the barriers and opportunities for improving permitting, enforcement and monitoring of existing regulations related to watershed management and pollution issues in the Hilo Bay Watershed. What is the current procedure for any of the relevant processes? Where are there contradictions and redundancies? What cultural, historical, political, legal and procedural factors currently prevent the implementation of best management practices for environmental quality in the area? Note that these extend all the way up to the State of Hawaii legislative system, and the review will be applicable to watershed management in general rather than just to Hilo, though there may be some historical and cultural factors that apply just in the Hilo area.

Funding needs:

- sociology or geography or related area graduate student one year RAship at 17,000 $; there is strong interest at the federal level in understanding decision making process in management, and the ways in which scientific knowledge is incorporated into policy; this would therefore be a likely topic for a research proposal to the National Science Foundation.

15—PROPOSED MANAGEMENT STRUCTURE, PHASE 1 OF RESTORATION PLAN (Initial Five-Year Research, Monitoring and Evaluation Period)

- PI based at UH Manoa or UH Hilo (use ¼ of PI salary time as match—no additional cost)
- co-PI at Hilo to oversee day to day activities, work on grants, and coordinate both science and education aspects of plan (e.g., Jeff Zimpfer, UH Sea Grant. Full time, cover his salary and benefits, paid through EC or whichever department ends up coordinating the plan)--50,000 $ plus benefits x 5 years = $ 250,000 plus benefits
- Cost sharing—can be cost-shared with UH Sea Grant
- Full time WAG coordinator position—provides linkage between community and project, participates in outreach, coordinates volunteer researchers and students (e.g., Mary James)--$ 40,000 plus benefits x 5 years = $ 200,000 plus benefits
- Faculty members and graduate students at UH Hilo and UH Manoa carry out research and oversee data collection, analysis and presentation.
- School teachers—are trained to pass information on to students
- Students and canoe club volunteers and other volunteers—collect monitoring data, are coordinated by WAG and Project director
- Collaborators in research and monitoring: DAR, DOH, USGS, USDA Forest Service, UH-Hilo

The Restoration Plan will need at least one full time coordinator, but ideally there would be one Science Coordinator and one Education Coordinator. However, if the WAG continues functioning and a coordinator is funded through the Restoration Plan, then the WAG coordinator can assume some of these functions. The project coordinators could be housed within UH Manoa, UH Hilo, or the WAG. If housed within a University, then University facilities will be available to the project (computer, phone, fax, scanner, etc.). If housed within the WAG, all these facilities, in addition to office rental, will have to be funded for the WAG. The management personnel should be funded for the first five years. By that time the WAG and the researchers will have raised additional funds on their own, and after the 5-year evaluation period the new budget will be developed. The project coordinator will follow an evaluation protocol to evaluate success/failure on a yearly basis of overall restoration plan. He/she will oversee/coordinate the work of UH Hilo researchers, consultants, school programs, module producers, etc.

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FIGURES

Figure 1, Hilo Bay Watershed

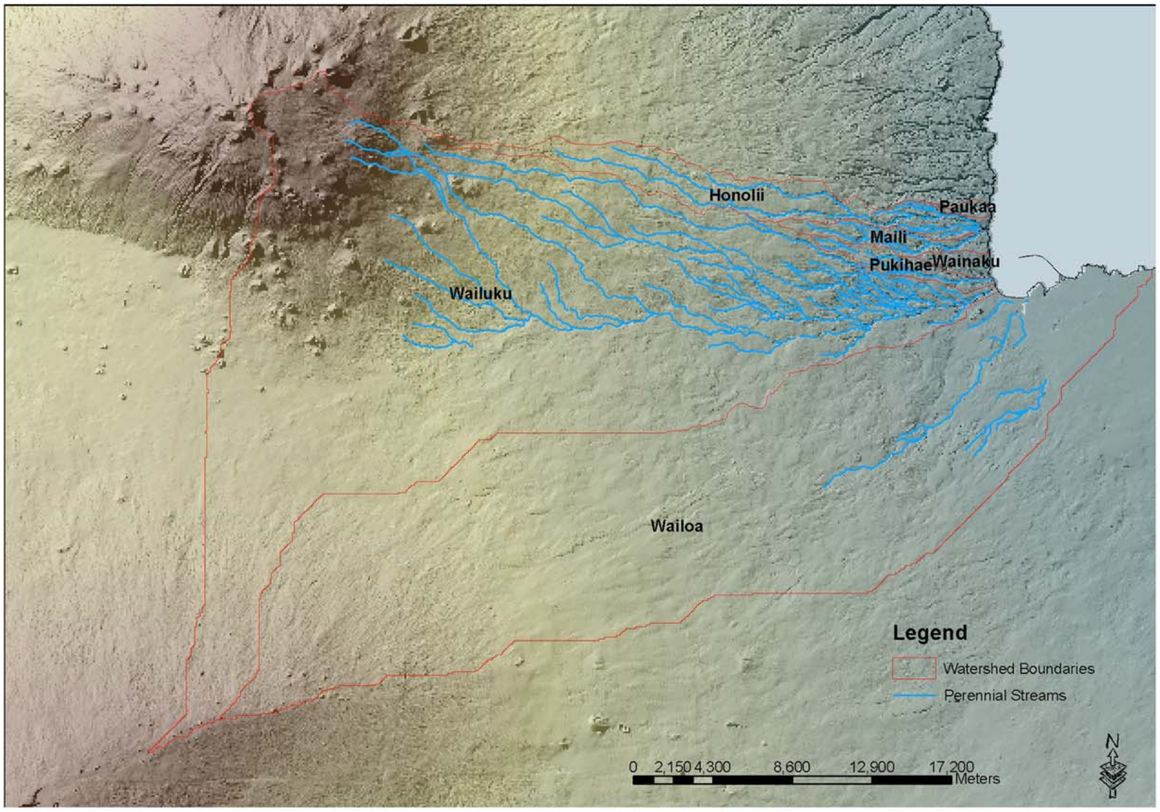
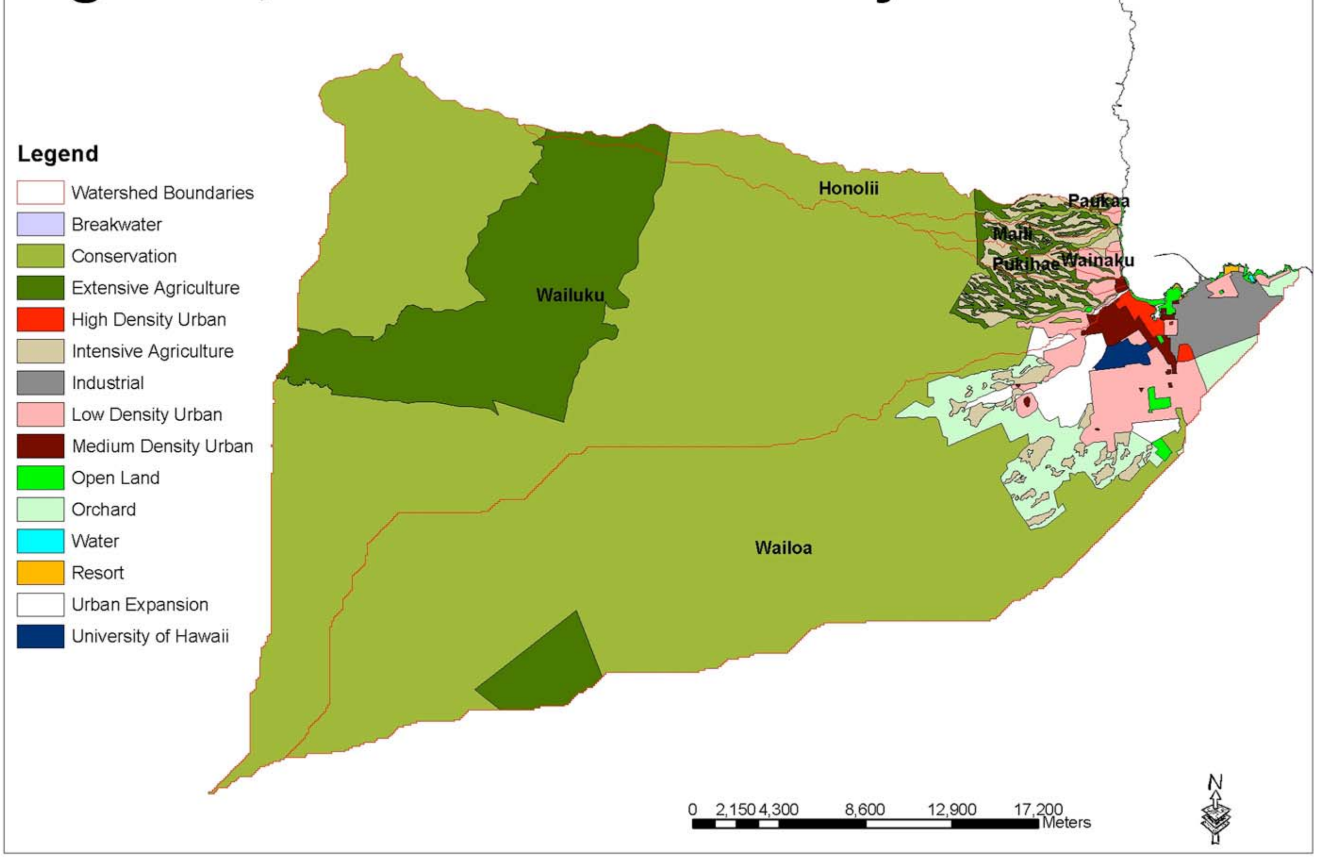


Figure 2, Land use in Hilo Bay Watershed



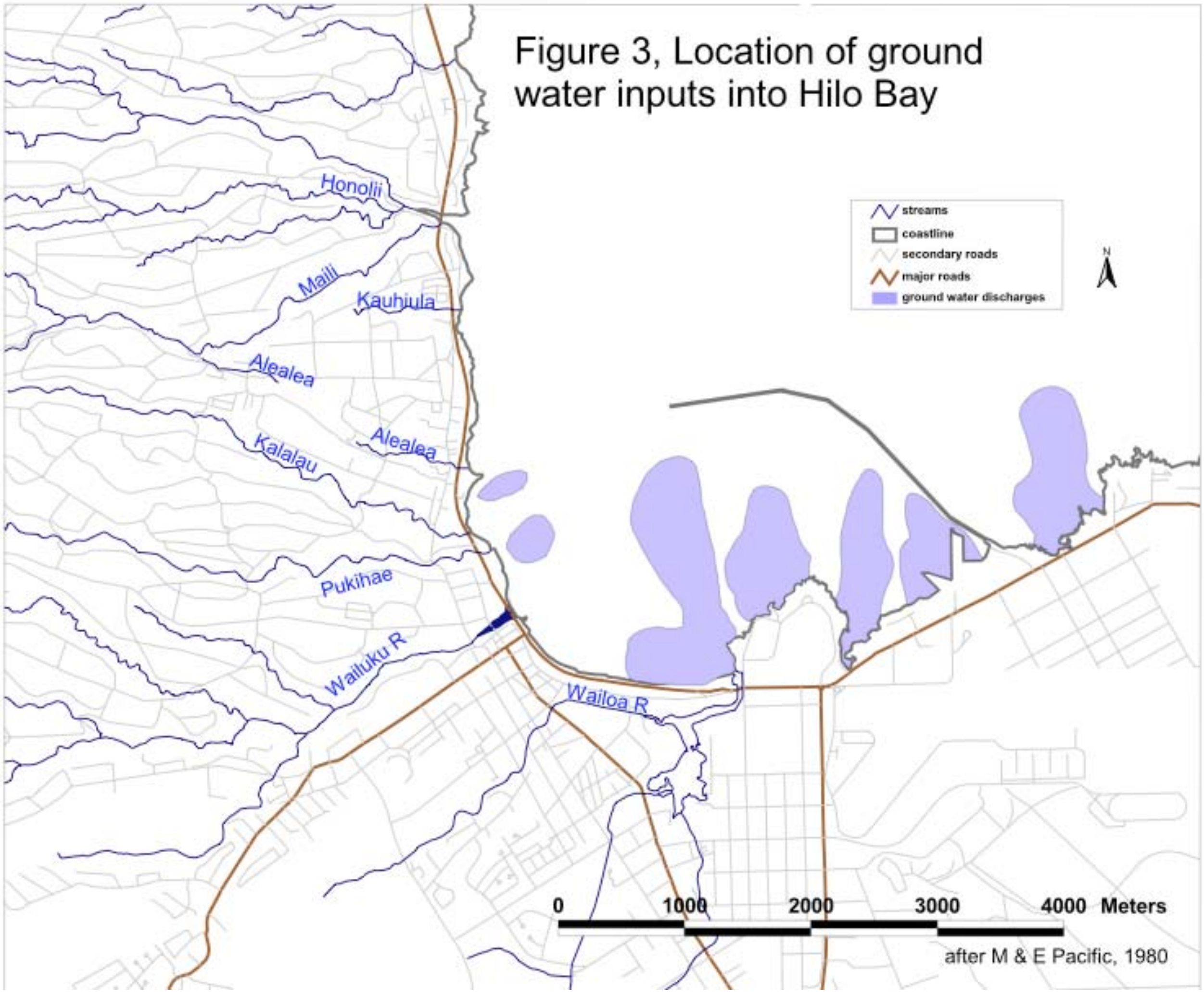


Figure 3, Location of ground water inputs into Hilo Bay
streams
coastline
secondary roads
major roads
ground water discharges
N
Honolii
Maili
Kauhiula
Alealea
Kalalau
Alealea
Pukihae
Wailuku R
Wailoa R
0
1000
2000
3000
4000 Meters
after M & E Pacific, 1980

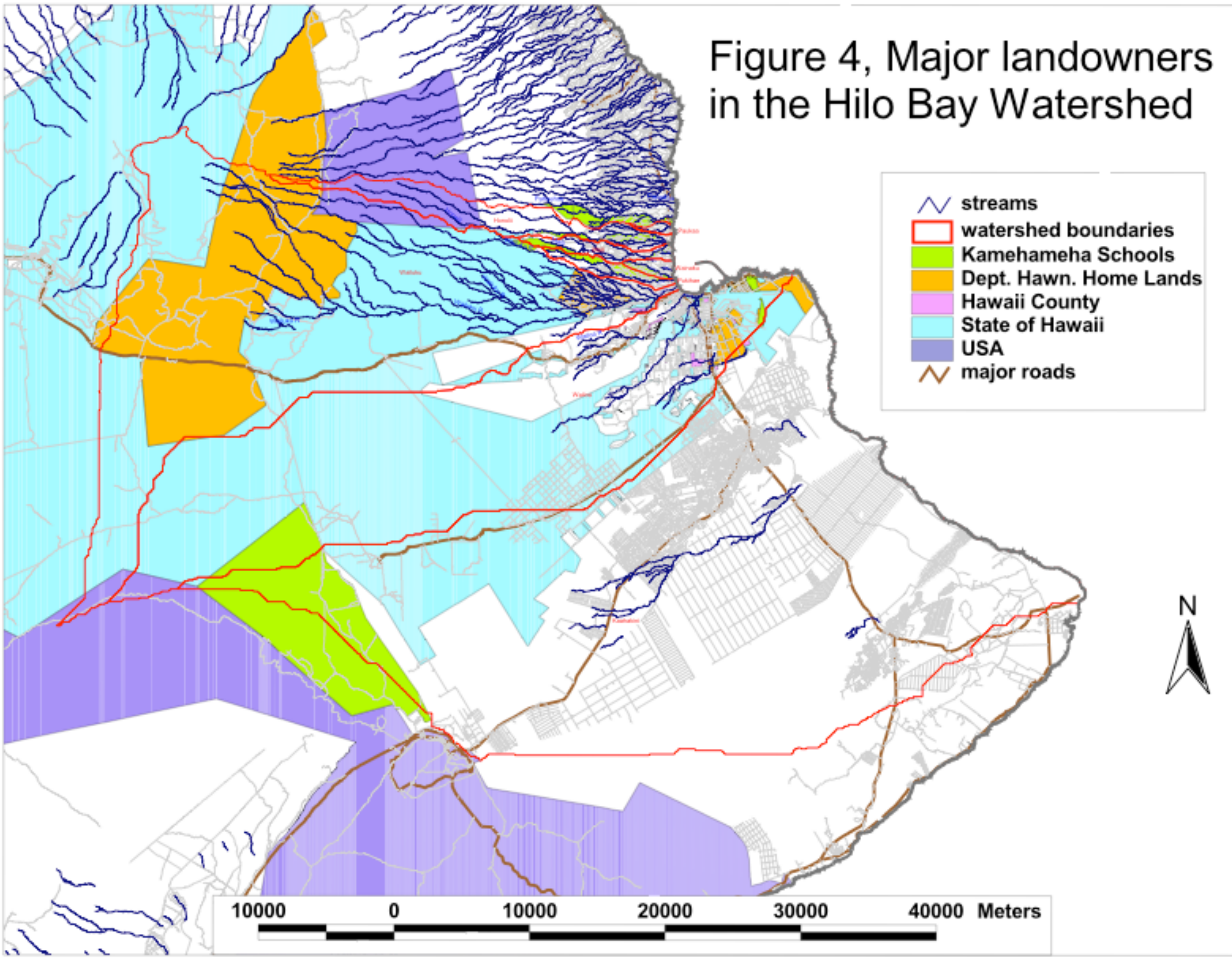


Figure 4, Major landowners
in the Hilo Bay Watershed
streams
watershed boundaries
Kamehameha Schools
Dept. Hawn. Home Lands
Hawaii County
State of Hawaii
USA
major roads
N
10000
0
10000
20000
30000
40000
Meters

Figure 5, Land use urban Hilo area

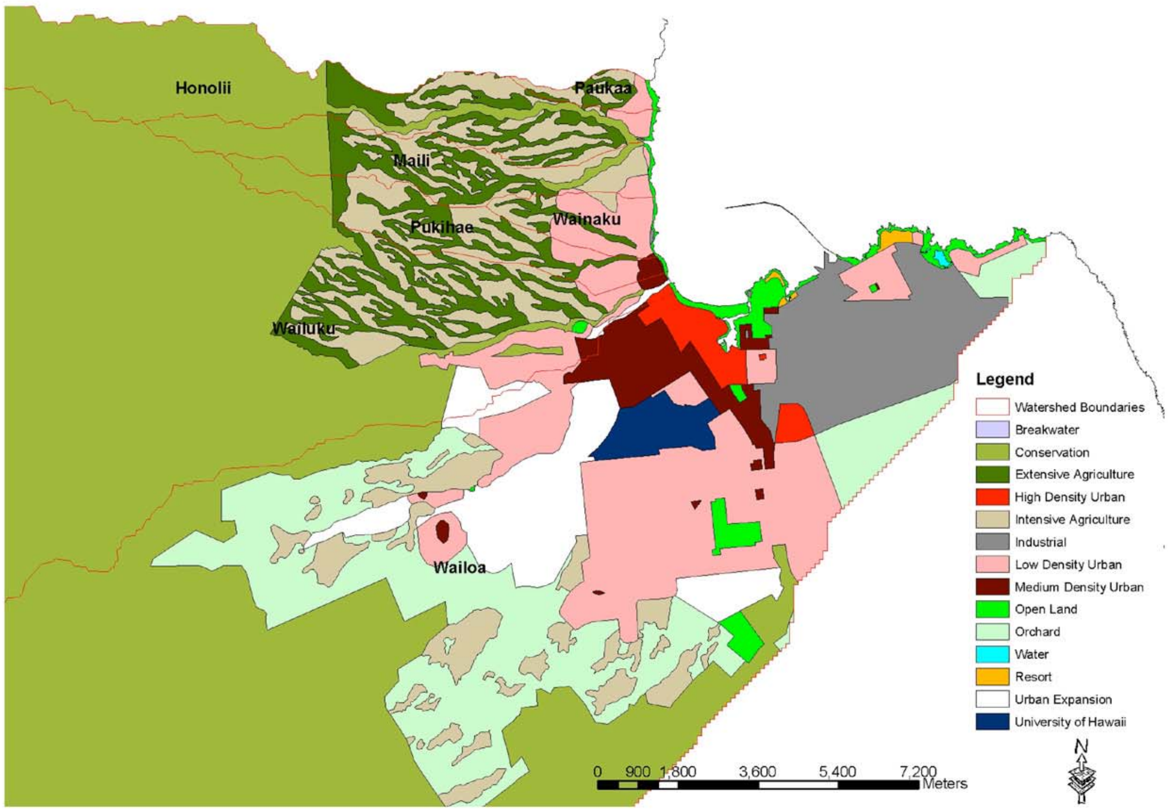
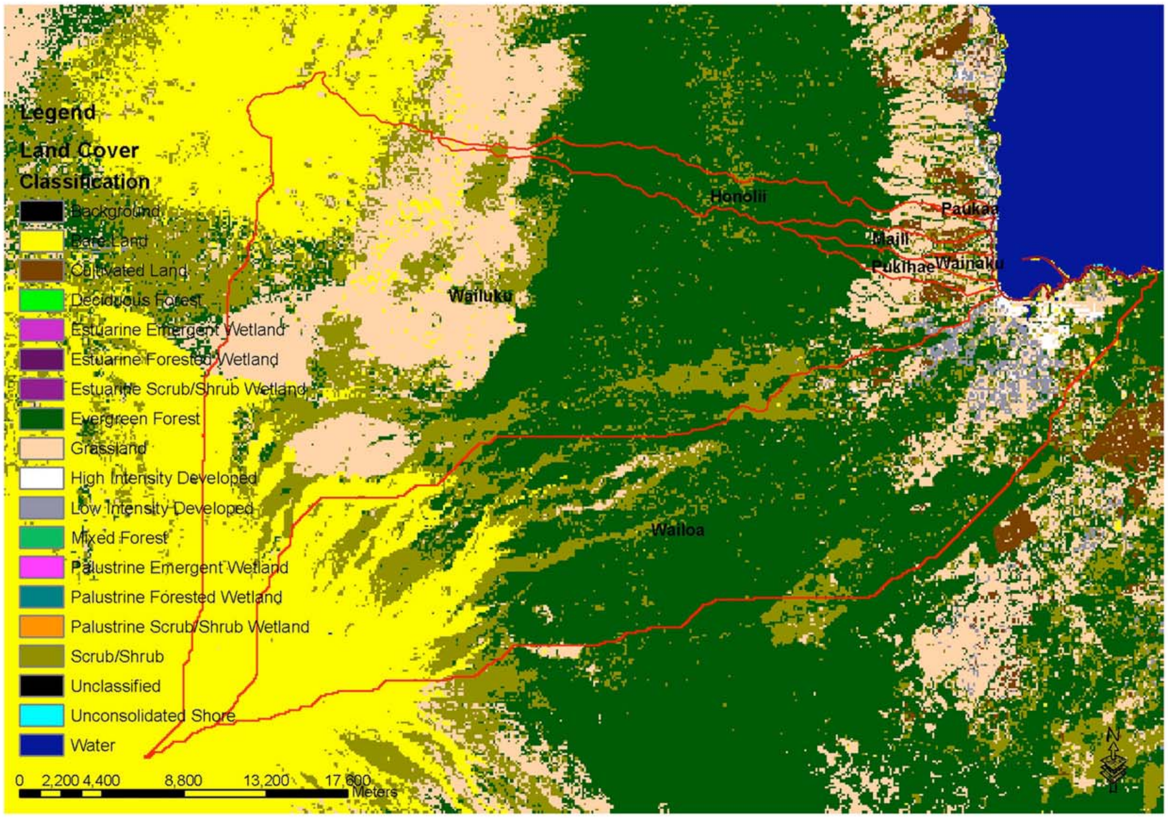


Figure 6, Vegetation/land cover in Hilo Bay Watershed



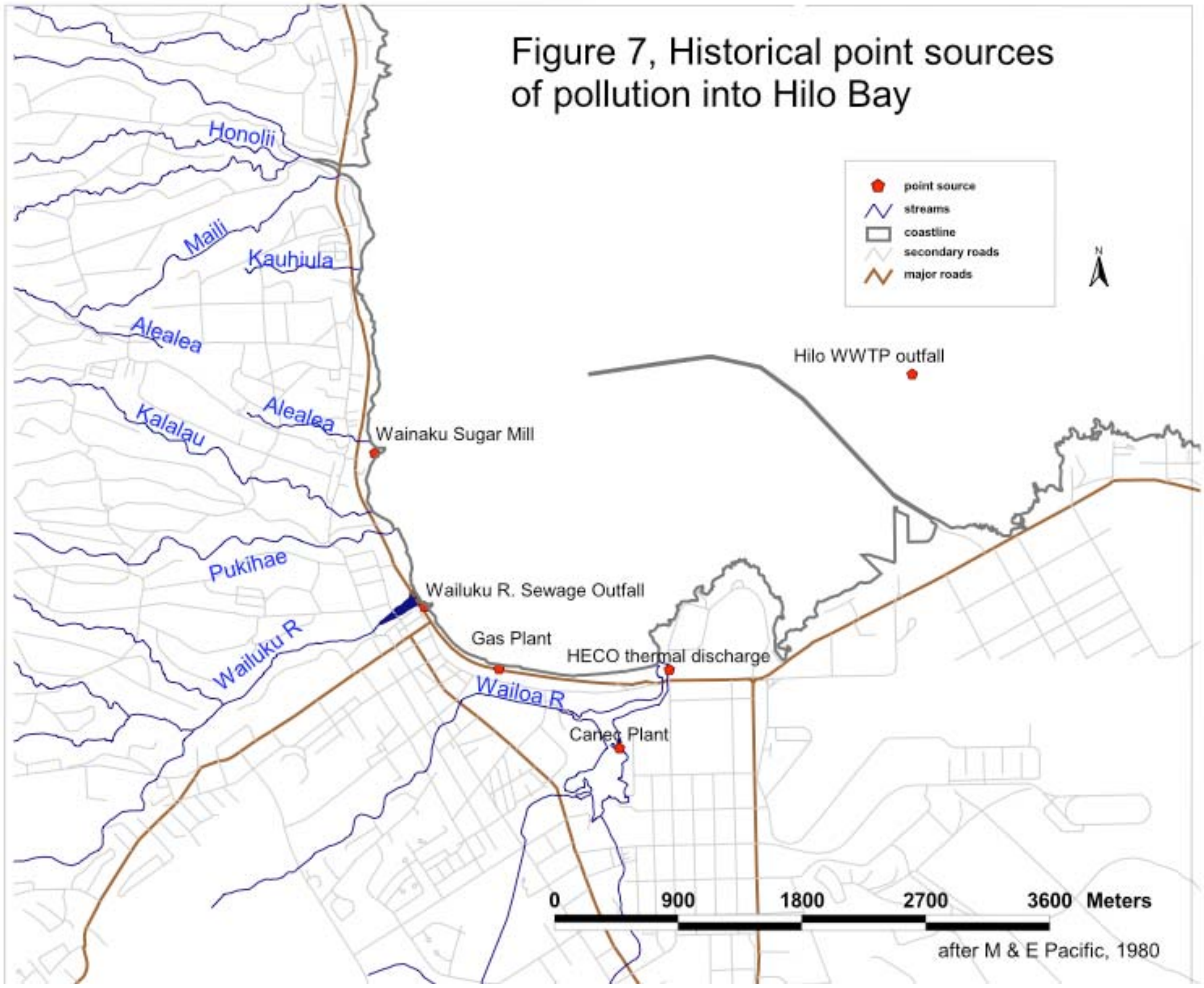


Figure 7, Historical point sources of pollution into Hilo Bay

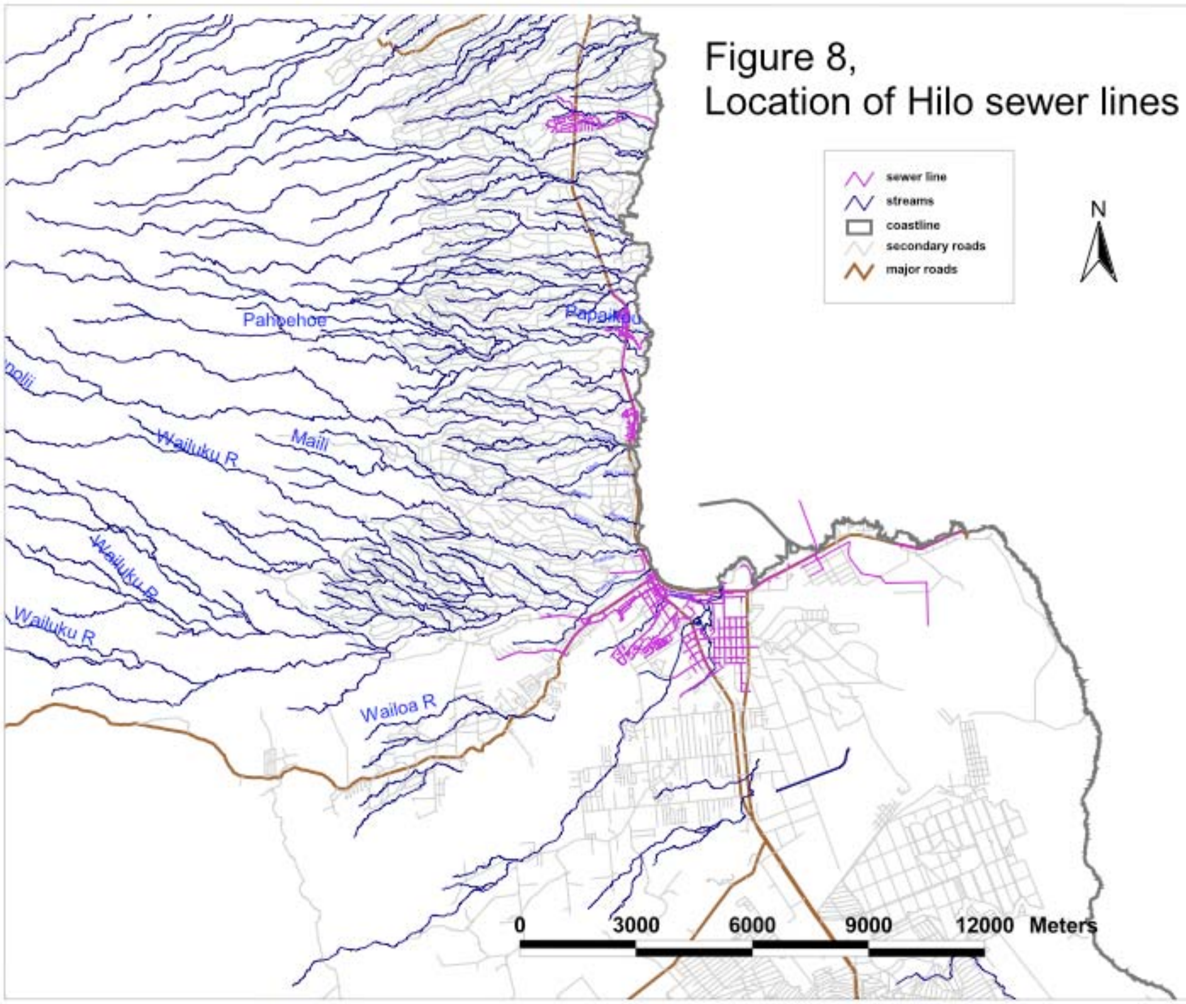


Figure 8,
Location of Hilo sewer lines
sewer line
streams
coastline
secondary roads
major roads
N
Pahoehoe
Papaikou
Wailuku R
Maili
Wailuku R
Wailuku R
Wailoa R
0
3000
6000
9000
12000
Meters

Figure 9, Areas of Hilo currently hooked up to the sewer system

Figure 10, Outrigger canoe racing in Hilo Bay

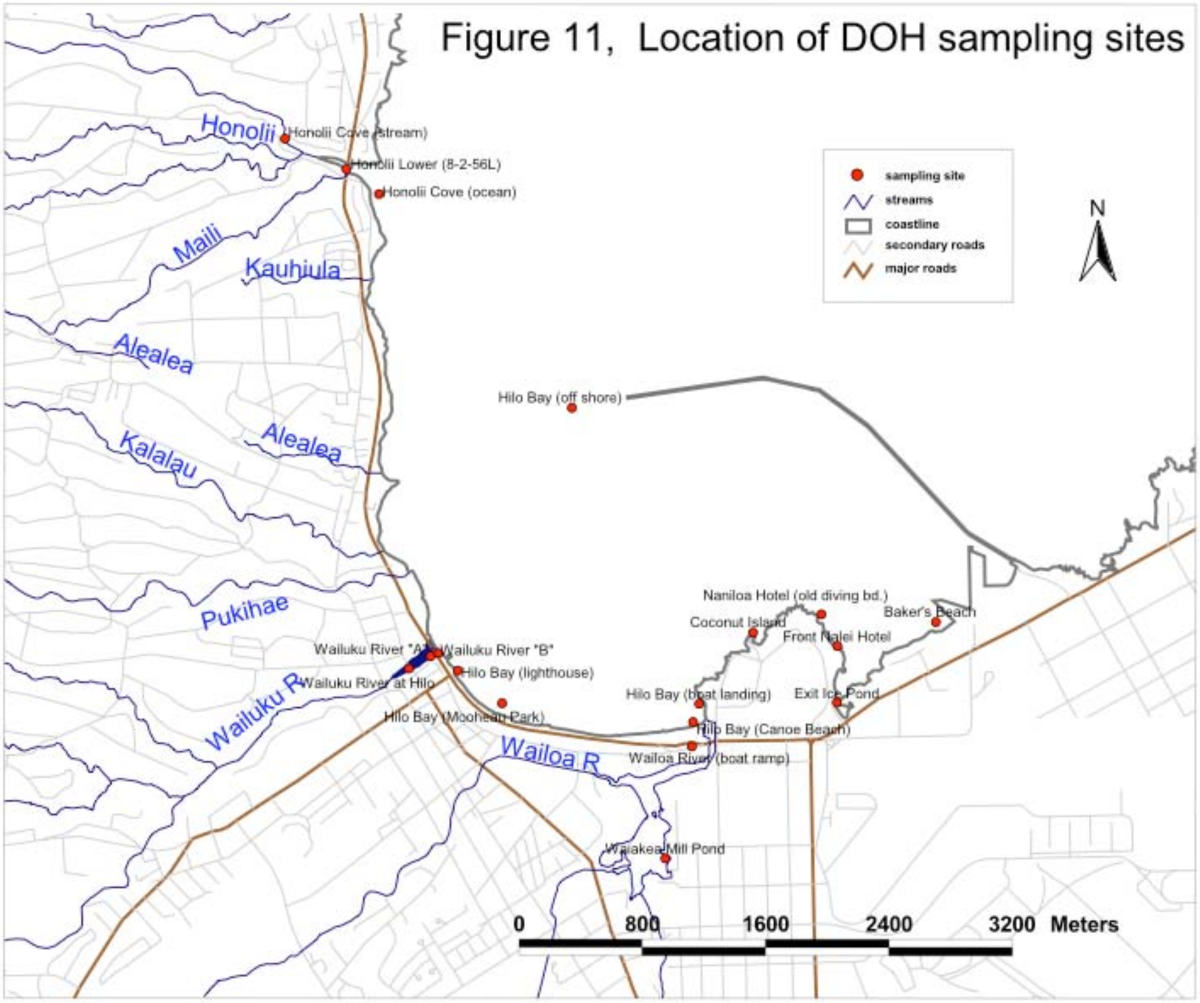


Figure 11, Location of DOH sampling sites
sampling site
streams
coastline
secondary roads
major roads
N
Honolii
Honolii Cove (stream)
Honolii Lower (8-2-56L)
Honolii Cove (ocean)
Maili
Kauhiula
Alealea
Alealea
Kalalau
Hilo Bay (off shore)
Pukihae
Wailuku River "A"
Wailuku River "B"
Hilo Bay (lighthouse)
Wailuku River at Hilo
Wailuku R
Hilo Bay (Mooheau Park)
Wailoa R
Naniloa Hotel (old diving bd.)
Coconut Island
Front Nalei Hotel
Baker's Beach
Hilo Bay (boat landing)
Exit Ice Pond
Hilo Bay (Canoe Beach)
Wailoa River (boat ramp)
Waiakea Mill Pond
0
800
1600
2400
3200 Meters

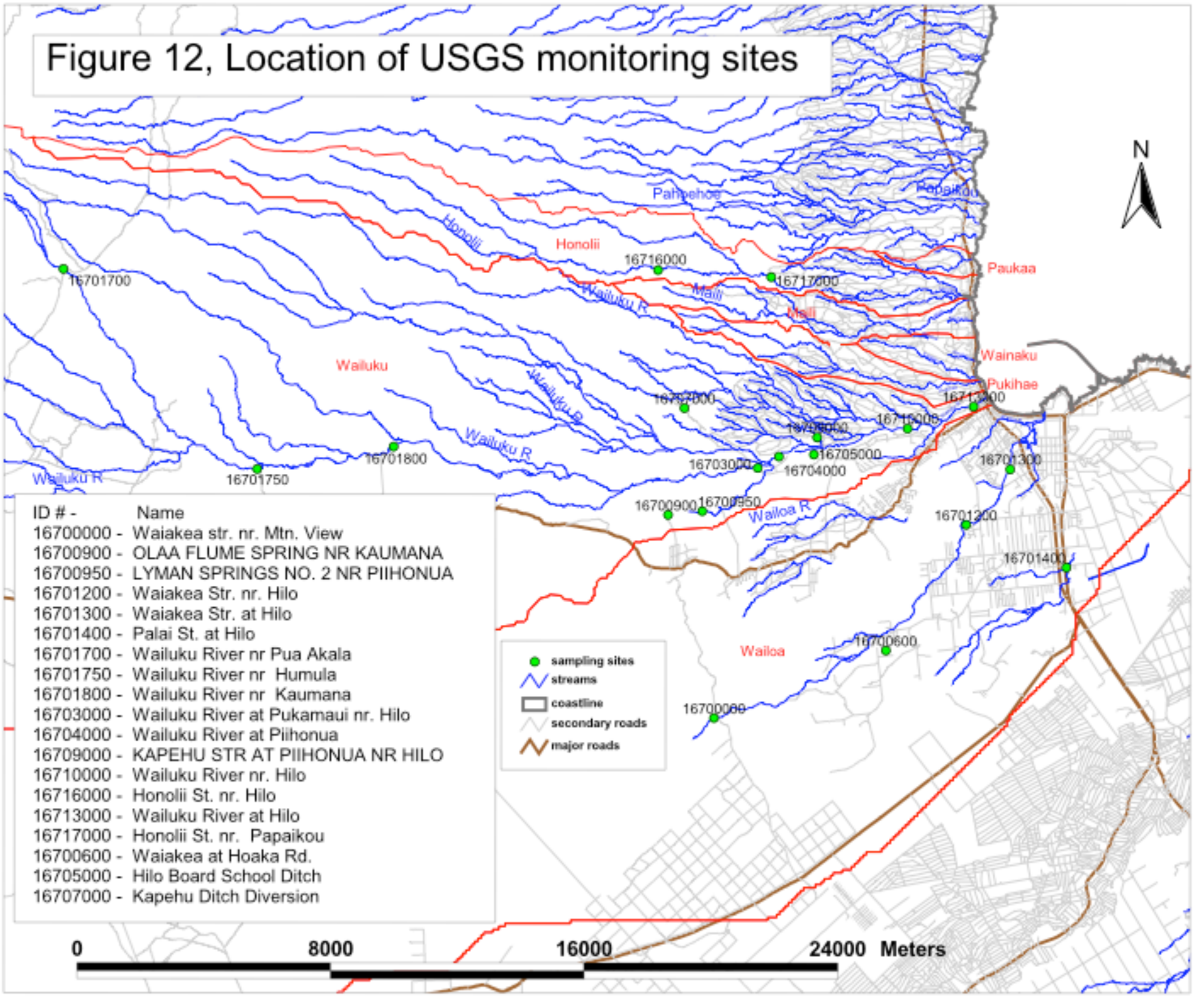


Figure 12, Location of USGS monitoring sites

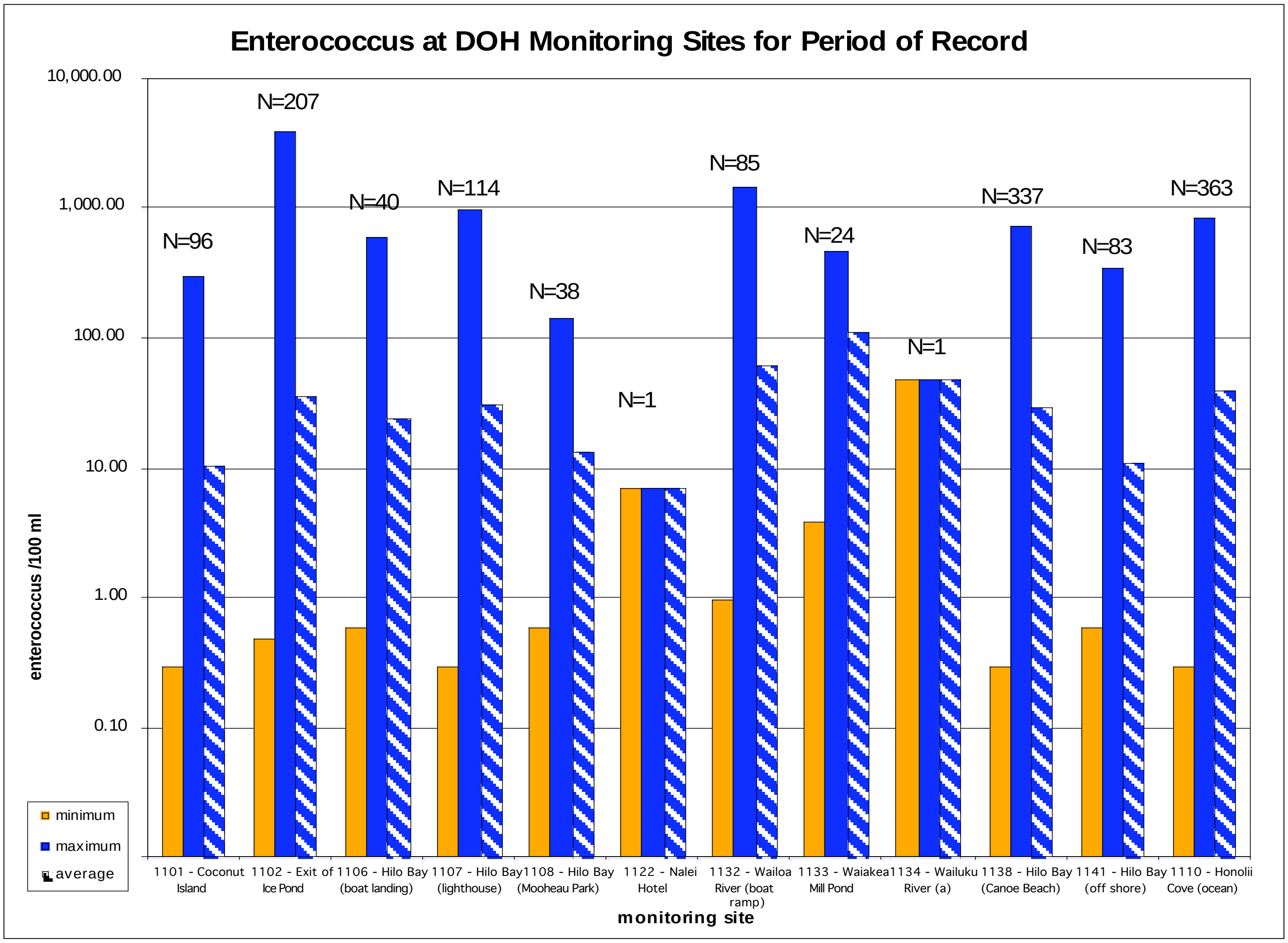


Figure 13, Results of enterococcus monitoring at DOH sampling sites in Hilo Watershed

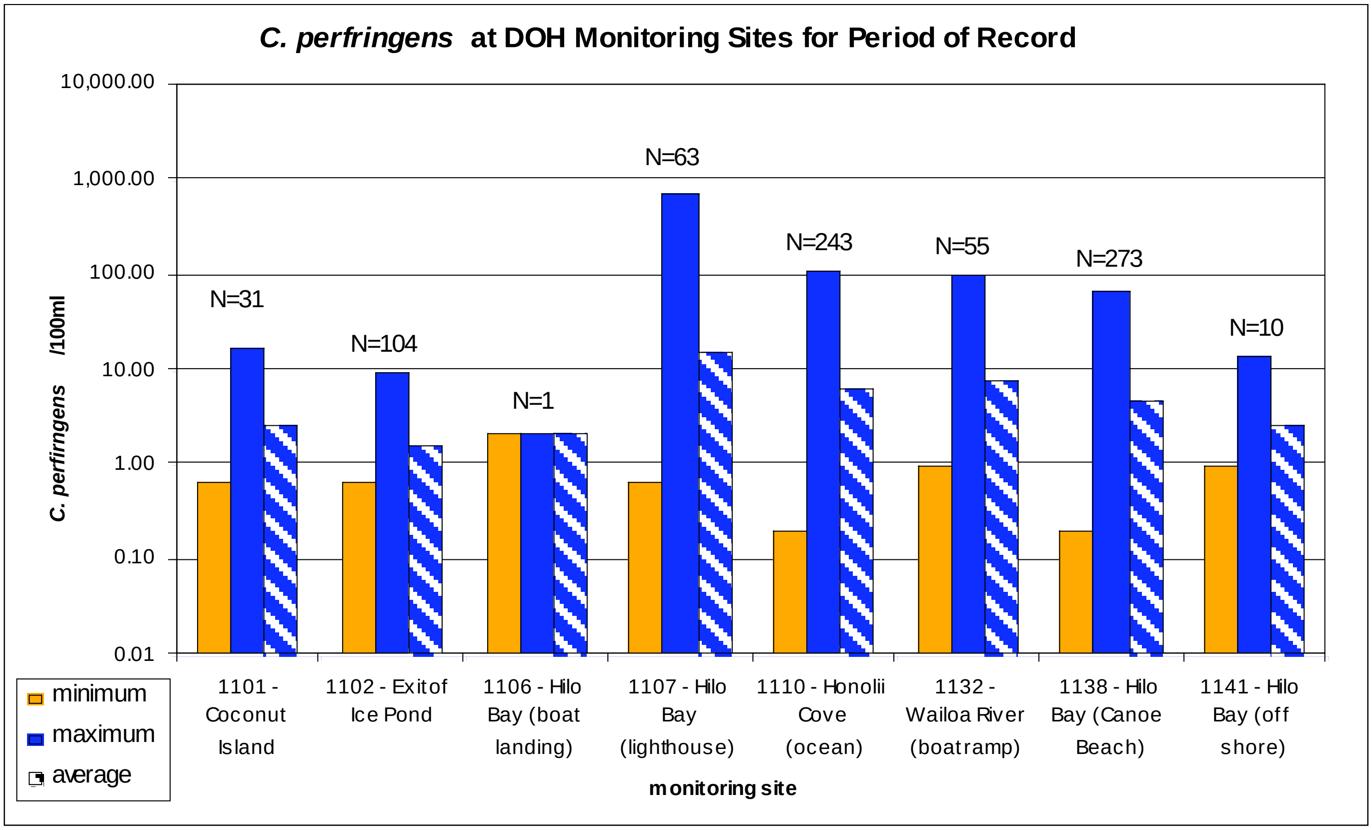


Figure 14, Results of *C. perfringens* monitoring at DOH sampling sites in Hilo Watershed

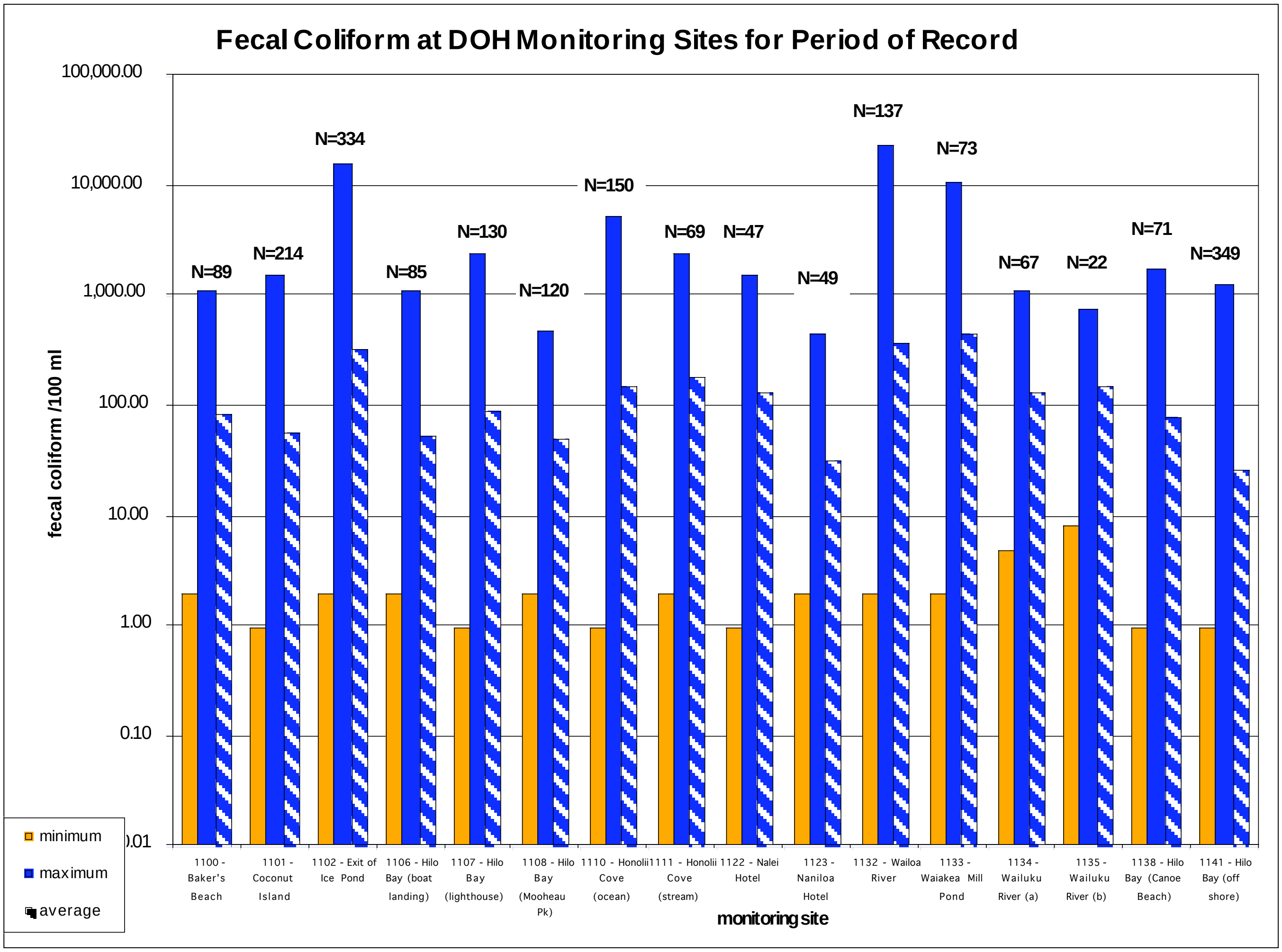


Figure 15, Results of fecal coliform monitoring at DOH sampling sites in Hilo Watershed

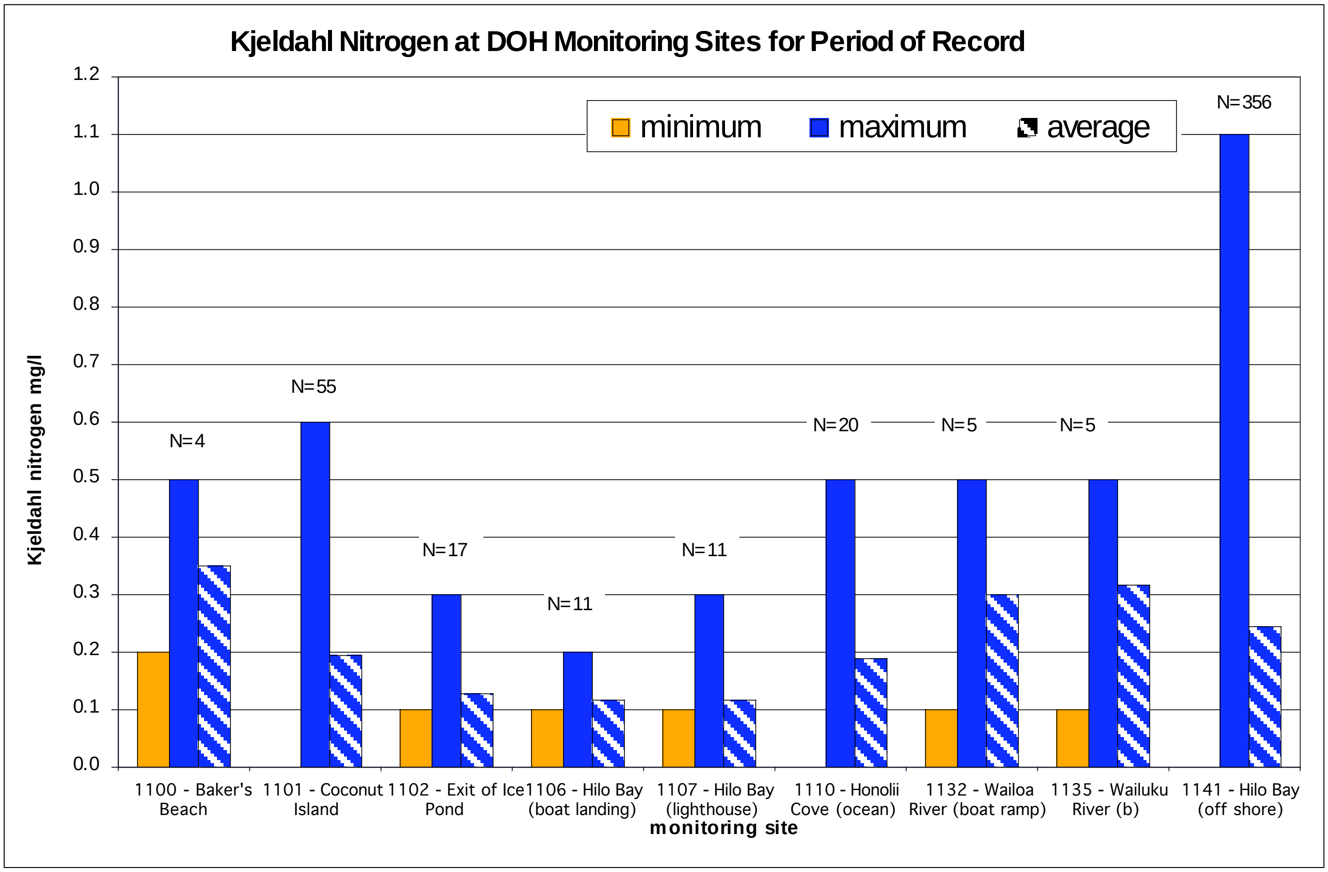


Figure 16, Results of Kjeldahl nitrogen monitoring at DOH sampling sites in Hilo Watershed

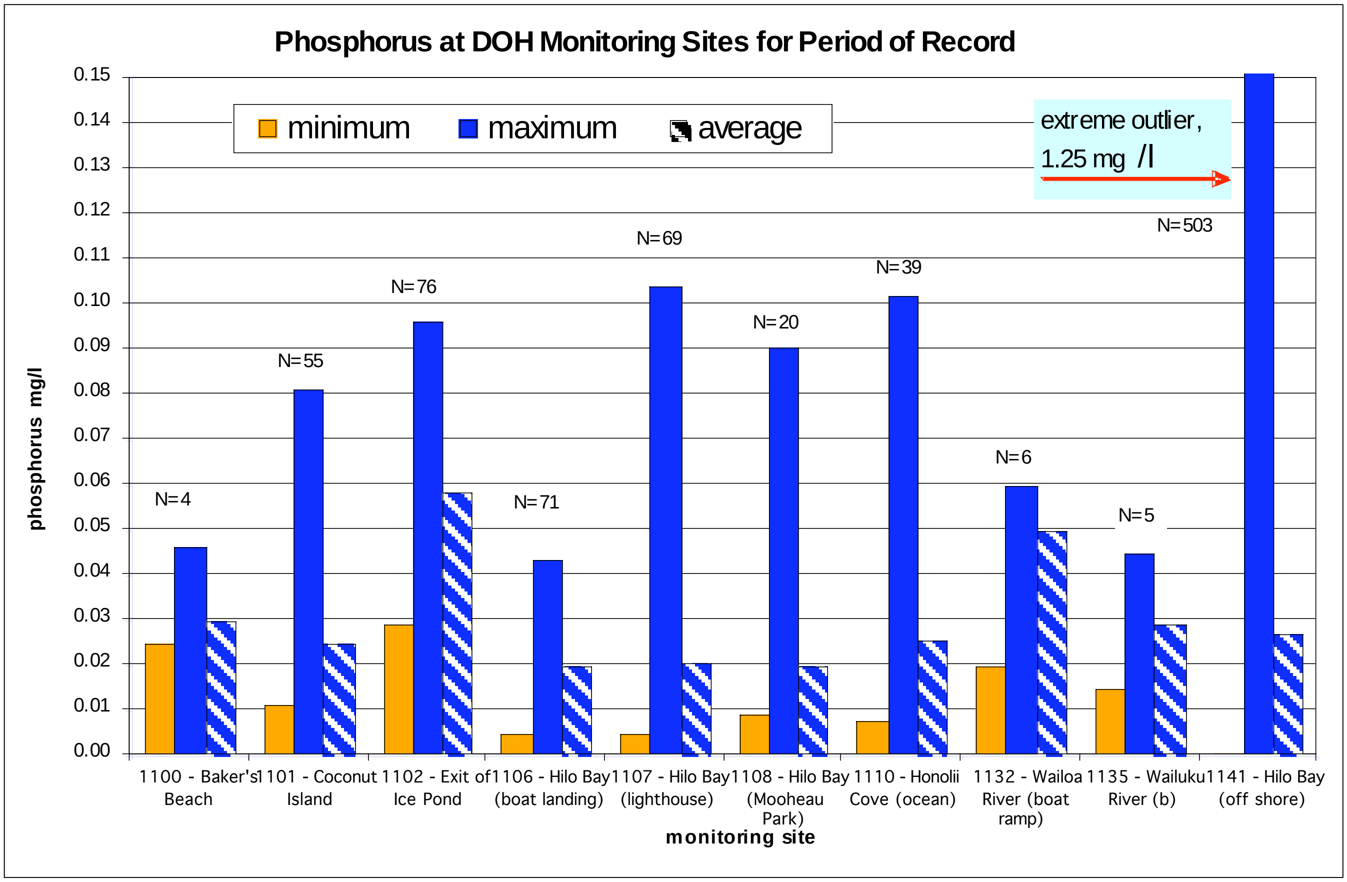


Figure 17, Results of phosphorus monitoring at DOH sampling sites in Hilo Watershed

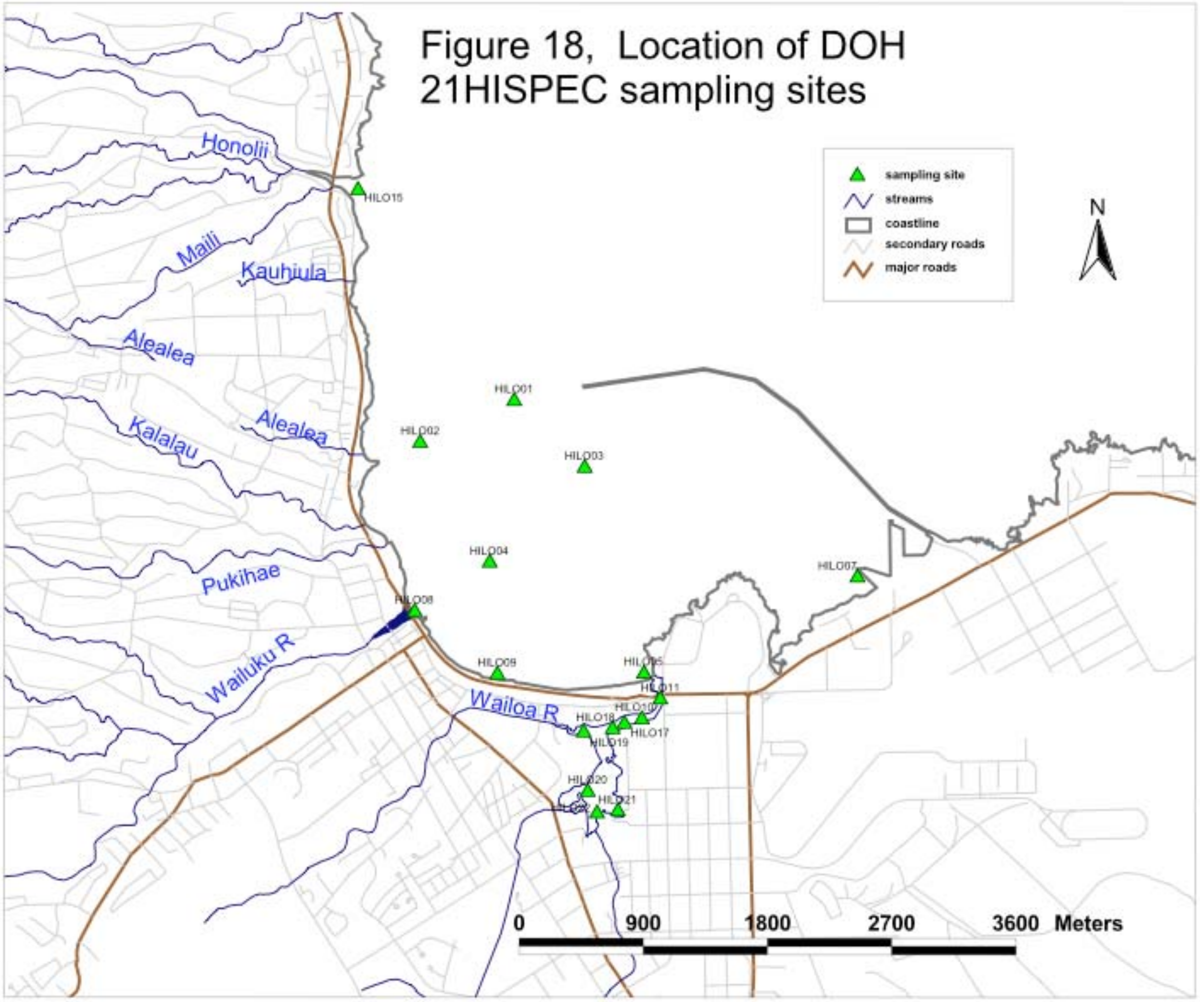


Figure 18, Location of DOH
21HISPEC sampling sites
sampling site
streams
coastline
secondary roads
major roads
N
Honolii
Maili
Kauhiula
Alealea
Alealea
Kalalau
Pukihae
Wailuku R
Wailoa R
HILO15
HILO01
HILO02
HILO03
HILO04
HILO07
HILO08
HILO09
HILO11
HILO18
HILO17
HILO19
HILO20
HILO21
0
900
1800
2700
3600 Meters

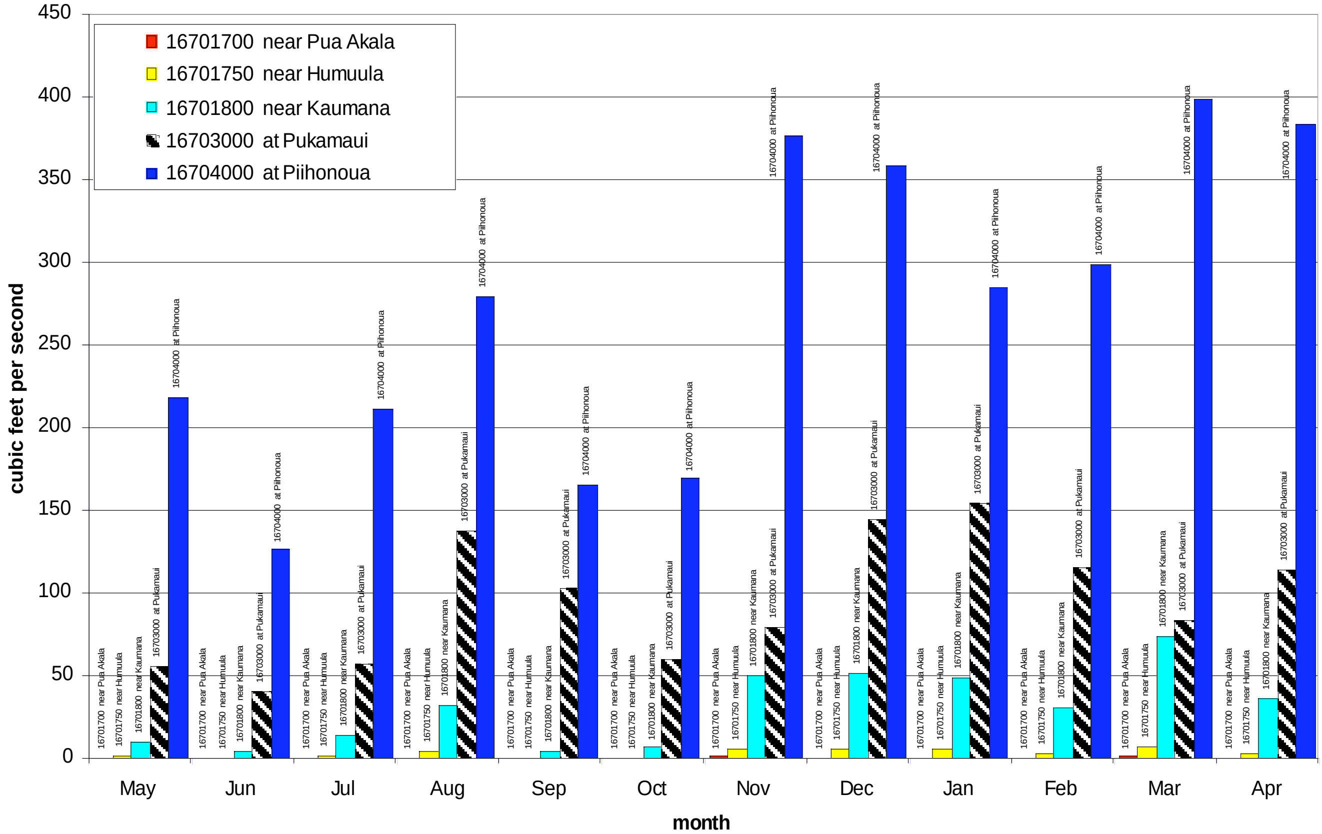


Figure 19, Discharge at Wailuku River USGS Monitoring Sites

Table 1, Enterococcus monitoring history at DOH sampling sites in Hilo Watershed (highlighted sites are currently active)

site	min	max	average	count	first	last
1101 - Coconut Island	0.30	310.00	10.57	96	11/6/1989	12/2/1998
1102 - Exit of Ice Pond	0.50	3,970.00	36.10	207	3/9/1987	2/28/2005
1106 - Hilo Bay (boat landing)	0.60	610.00	24.20	40	10/9/1989	9/23/2003
1107 - Hilo Bay (lighthouse)	0.30	1,000.00	31.31	114	10/9/1989	9/29/1999
1108 - Hilo Bay (Mooheau Park)	0.60	144.00	13.28	38	10/9/1989	10/19/1992
1110 - Honolii Cove (ocean)	0.30	870.00	39.77	363	11/6/1989	3/3/2005
1122 - Nalei Hotel	7.00	7.00	7.00	1	6/25/1990	6/25/1990
1132 - Wailoa River (boat ramp)	1.00	1,500.00	63.38	85	4/23/1990	12/2/1998
1133 - Waiakea Mill Pond	4.00	480.00	111.54	24	4/23/1990	6/22/1992
1134 - Wailuku River (a)	49.00	49.00	49.00	1	6/25/1990	6/25/1990
1138 - Hilo Bay (Canoe Beach)	0.30	740.00	29.13	337	4/23/1990	3/3/2005
1141 - Hilo Bay (off shore)	0.60	350.00	11.22	83	5/18/1987	10/6/1997

Table 2, Enterococci per 100 ml of water from 16 shoreline stations located throughout the vicinity of Hilo Bay (N= number of sample-days) Dudley et al. study 1991

	August 1989 to July 1990			August 1990 to June 1991		
Site	**N**	**Geo. mean**	**Range**	**N**	**Geo.mean**	**Range**
Honolii	34	143	31 - 3120	46	52	0 - 3000
Wailuku River	46	37	0 - 4000	46	21	0 - 340
Wailoa River	52	20	0 - 1060	20	33	0 - 640
Suisan	41	13	0 - 1440	6	22	0 - 162
V.C.B.	61	79	0 - 1580	51	44	0 - 1860
G.O.	18	51	2 - 1040	9	211	31 - 2020
Maile Apt.	54	37	0 - 3360	11	32	0 - 1800
Canoe Beach	19	9	0 - 1120	16	33	2 - 800
Cocoanut Is.	17	25	0 - 1020	8	27	0 - 400
Radio Bay	48	11	0 - 520	11	24	0 - 1600
Ice Pond	37	10	0 - 235	16	41	4 - 720
Reed's Bay	48	42	0 - 3100	40	31	0 - 1760
Puhi Bay	43	5	0 - 251	13	18	0 - 560
Onekahakaha	32	16	0 - 118	41	10	0 - 295
Kealoha	32	9	0 - 600	10	25	7 - 74
Richardsons	32	6	0 - 160	42	14	0 - 1840

Table 3, *C. perfringens* monitoring history at DOH sampling sites in Hilo Watershed
(highlighted sites are currently active)

site	min	max	average	count	first	last
1101 - Coconut Island	0.70	18.00	2.59	31	7/26/1994	12/2/1998
1102 - Exit of Ice Pond	0.70	10.00	1.59	104	1/25/1993	2/28/2005
1106 - Hilo Bay (boat landing)	2.10	2.10	2.10	1	10/22/2002	10/22/2002
1107 - Hilo Bay (lighthouse)	0.70	710.00	15.94	63	1/31/1994	9/29/1999
1110 - Honolii Cove (ocean)	0.20	110.00	6.18	243	1/25/1993	2/28/2005
1132 - Wailoa River (boat ramp)	1.00	96.00	7.81	55	2/7/1994	12/2/1998
1138 - Hilo Bay (Canoe Beach)	0.20	68.00	4.69	273	4/12/1993	3/3/2005
1141 - Hilo Bay (off shore)	1.00	14.00	2.70	10	7/8/1996	10/6/1997

Table 4, Fecal coliform monitoring history at DOH sampling sites in Hilo Watershed
(highlighted sites are currently active)

site	min	max	average	count	first	last
1100 - Baker's Beach	2.00	1,100	86.42	89	6/19/1973	6/6/1978
1101 - Coconut Island	1.00	1,600	56.36	214	6/4/1973	6/3/1996
1102 - Exit of Ice Pond	2.00	16,000	325.44	334	6/13/1973	6/3/1996
1106 - Hilo Bay (boat landing)	2.00	1,100	54.91	85	6/19/1973	11/30/1992
1107 - Hilo Bay (lighthouse)	1.00	2,400	92.56	130	6/19/1973	6/3/1996
1108 - Hilo Bay (Mooheau Pk)	2.00	490	50.28	120	4/16/1986	9/21/1992
1110 - Honolii Cove (ocean)	1.00	5,400	148.13	150	6/5/1973	6/3/1996
1111 - Honolii Cove (stream)	2.00	2,400	181.38	69	6/13/1973	12/9/1975
1122 - Nalei Hotel	1.00	1,600	129.64	47	6/19/1973	6/25/1990
1123 - Naniloa Hotel	2.00	460	32.73	49	6/19/1973	12/9/1975
1132 - Wailoa River	2.00	24,000	373.99	137	4/16/1986	9/21/1992
1133 - Waiakea Mill Pond	2.00	11,000	450.10	73	6/19/1973	6/22/1992
1134 - Wailuku River (a)	5.00	1,100	136.27	67	1/7/1974	6/25/1990
1135 - Wailuku River (b)	8	790	153.50	22	1/19/1976	11/28/1977
1138 - Hilo Bay (Canoe Beach)	1.00	1,800	79.45	71	4/23/1990	6/3/1996
1141 - Hilo Bay (off shore)	1.00	1,300	27.28	349	2/11/1980	5/7/1991

Table 5, Fecal streptococcus monitoring history at DOH sampling sites in Hilo Watershed
(highlighted sites are currently active)

site	min	max	mean	count	first	last
1100 - Baker's Beach	15.00	15.0	15.00	1	1/21/1974	1/21/1974
1101 - Coconut Island	3.00	3.0	3.00	1	6/4/1973	6/4/1973
1102 - Exit of Ice Pond	2.00	2,4000	189.98	41	8/13/1973	7/28/1982
1106 - Hilo Bay (boat landing)	4.00	4.0	4.00	1	1/21/1974	9/21/1992
1107 - Hilo Bay (lighthouse)	9.00	9.90	9.00	1	1/21/1974	1/21/1974
1108 - Hilo Bay (Mooheau Park)	2.00	1700	21.92	24	1/21/1974	7/12/1982
1110 - Honolii Cove (ocean)	2.00	4700	92.63	8	1/16/1974	3/11/1985
1111 - Honolii Cove (stream)	3.00	11,000	931.84	19	8/13/1973	2/25/1974
1122 - Nalei Hotel	3.00	3.0	3.00	1	1/21/1974	1/21/1974
1123 - Naniloa Hotel	4.00	4.0	4.00	1	1/21/1974	1/21/1974
1132 - Wailoa River (boat ramp)	2.00	2,4000	264.36	11	1/21/1974	2/14/1977
1133 - Waiakea Mill Pond	3.00	1500	58.83	12	8/13/1973	2/11/1974
1134 - Wailuku River (a)	6.00	5400	149.61	18	1/21/1974	3/11/1985
1135 - Wailuku River (b)	48	2,400	459.00	12	1/19/1976	2/14/1977

Table 6, Nitrogen monitoring history at DOH sampling sites in Hilo Watershed
(highlighted sites are currently active)

site	min	max	avg	count	first	last
Nitrogen ion (N) mg/l						
1100 - Baker's Beach	0.230	0.540	0.405	4	12/6/1976	6/6/1978
1101 - Coconut Island	0.020	0.690	0.288	55	6/4/1973	12/6/1982
1102 - Exit of Ice Pond	0.350	1.424	0.514	63	3/16/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.01	1.17	0.21	57	9/25/1990	9/2/1997
1107 - Hilo Bay (lighthouse)	0.009	0.862	0.158	56	10/22/1990	8/4/1997
1108 - Hilo Bay (Mooheau Park)	0.061	0.269	0.153	20	9/25/1990	8/3/1992
1110 - Honolii Cove (ocean)	0.050	0.540	0.179	34	6/5/1973	9/2/1997
1132 - Wailoa River (boat ramp)	0.350	0.850	0.580	6	3/8/1976	6/20/1977
1135 - Wailuku River (b)	0	1	0.48	6	3/8/1976	6/20/1977
1141 - Hilo Bay (off shore)	0.010	1.160	0.234	451	10/2/1979	10/6/1997
Nitrogen, ammonium (NH4) as NH4, mg/l						
1101 - Coconut Island	0.000	0.260	0.105	24	7/9/1979	12/6/1982
1102 - Exit of Ice Pond	0.000	0.180	0.021	63	3/16/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.001	0.050	0.018	57	9/25/1990	9/2/1997
1107 - Hilo Bay (lighthouse)	0.001	0.060	0.020	56	10/22/1990	8/4/1997
1108 - Hilo Bay (Mooheau Park)	0.001	0.014	0.005	20	9/25/1990	8/3/1992
1110 - Honolii Cove (ocean)	0.003	0.050	0.026	25	9/26/1990	9/2/1997
1141 - Hilo Bay (off shore)	0.000	0.500	0.058	443	10/2/1979	10/6/1997
Nitrogen, Kjeldahl, mg/l						
1100 - Baker's Beach	0.200	0.500	0.350	4	12/6/1976	6/6/1978
1101 - Coconut Island	0.000	0.600	0.197	55	6/4/1973	12/6/1982
1102 - Exit of Ice Pond	0.100	0.300	0.129	17	3/16/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.100	0.200	0.120	11	11/28/1994	9/2/1997
1107 - Hilo Bay (lighthouse)	0.100	0.300	0.118	11	10/31/1994	8/4/1997
1110 - Honolii Cove (ocean)	0.000	0.500	0.190	20	6/5/1973	9/2/1997
1132 - Wailoa River (boat ramp)	0.100	0.500	0.300	5	3/8/1976	6/20/1977
1135 - Wailuku River (b)	0.000	1.000	0.320	5	3/8/1976	6/20/1977
1141 - Hilo Bay (off shore)	0.000	1.100	0.244	356	10/2/1979	10/6/1997
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l						
1100 - Baker's Beach	0.010	0.100	0.050	4	12/6/1976	6/6/1978
1101 - Coconut Island	0.010	0.210	0.065	55	6/4/1973	12/6/1982
1102 - Exit of Ice Pond	0.230	0.600	0.443	63	3/16/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.000	0.600	0.119	57	9/25/1990	9/2/1997
1107 - Hilo Bay (lighthouse)	0.010	0.200	0.045	56	10/22/1990	8/4/1997
1108 - Hilo Bay (Mooheau	0.000	0.200	0.075	20	9/25/1990	8/3/1992
1110 - Honolii Cove (ocean)	0.010	0.100	0.056	34	6/5/1973	9/2/1997
1132 - Wailoa River (boat	0.100	0.500	0.170	6	3/8/1976	6/20/1977
1135 - Wailuku River (b)	0.100	0.200	0.120	5	3/8/1976	6/20/1977
1141 - Hilo Bay (off shore)	0.000	0.330	0.034	455	10/2/1979	10/6/1997

Table 7, Nitrogen data from USGS station 16717000 Honolii Stream nr Papaikou

parameter	min	max	avg	count	first	last
Total nitrogen, water, unfiltered, mg/l	0.2300	1.5000	0.6762	13	10/29/1980	11/17/1981
Total nitrogen, water, filtered, mg/l	0.2600	1.2000	0.5517	12	10/29/1980	7/27/1982
Organic nitrogen, water, unfiltered, mg/l	0.1000	1.3000	0.5186	21	10/29/1980	10/27/1986
Organic nitrogen, water, filtered, mg/l	0.0000	2.1000	0.4338	21	10/29/1980	2/25/1981
Phosphorus, water, unfiltered, mg/l	0.0000	0.3700	0.0226	154	12/13/1973	5/18/1993
Phosphorus, water, filtered, mg/l	0.0100	0.1900	0.0256	85	3/8/1979	5/18/1993

Table 8, Nitrogen monitoring history at USGS sampling sites in Hilo Watershed

Station	Count	First	Last	Parameter
16704000 Wailuku River at Piihonua	20	1/25/1978	9/24/1979	ammonia plus organic nitrogen, suspended sediment, total, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	20	10/29/1980	9/1/1982	ammonia plus organic nitrogen, suspended sediment, total, milligrams per liter as nitrogen
16704000 Wailuku River at Piihonua	21	11/28/1977	9/24/1979	ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	19	10/29/1980	7/29/1991	ammonia plus organic nitrogen, water, filtered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	1	7/29/1991		ammonia plus organic nitrogen, water, filtered, modified jirka method, milligrams per liter as nitrogen
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
16704000 Wailuku River at Piihonua	57	10/31/1974	9/24/1979	ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	83	10/29/1980	5/18/1993	ammonia plus organic nitrogen, water, unfiltered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	1	7/29/1991		ammonia plus organic nitrogen, water, unfiltered, modified jirka method, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	31	10/29/1980	12/8/1986	ammonia, water, filtered, milligrams per liter as NH4
16717000 Honolii nr. Papaikou	80	10/29/1980	5/18/1993	ammonia, water, filtered, milligrams per liter as nitrogen
16704000 Wailuku River at Piihonua	6	5/16/1979	9/24/1979	ammonia, water, unfiltered, milligrams per liter as NH4
16717000 Honolii nr. Papaikou	4	10/29/1980	2/4/1981	ammonia, water, unfiltered, milligrams per liter as NH4
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	ammonia, water, unfiltered, milligrams per liter as nitrogen
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	ammonia, water, unfiltered, milligrams per liter as nitrogen
16704000 Wailuku River at Piihonua	27	9/26/1977	9/24/1979	ammonia, water, unfiltered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	64	10/29/1980	8/4/1992	ammonia, water, unfiltered, milligrams per liter as nitrogen
16704000 Wailuku River at Piihonua	2	11/21/1972	6/12/1973	nitrate, water, filtered, milligrams per liter
16717000 Honolii nr. Papaikou	23	11/26/1969	3/28/1973	nitrate, water, filtered, milligrams per liter
16704000 Wailuku River at Piihonua	4	10/26/1971	6/12/1973	nitrate, water, filtered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	16	10/26/1971	6/20/1973	nitrate, water, filtered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	3	7/24/1974	9/30/1974	nitrate, water, unfiltered, milligrams per liter as nitrogen
16701750 Wailuku R. nr. Humuula	2	2/12/1976	6/7/1976	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen
16701800 Wailuku near Kaumana	2	12/15/1975	5/6/1976	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen
16704000 Wailuku River at Piihonua	3	12/27/1973	9/24/1979	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	101	8/3/1973	5/18/1993	Nitrite plus nitrate, water, filtered, milligrams per liter as nitrogen
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	Nitrite plus nitrate, water, unfiltered, milligrams per liter as nitrogen

Table 8, Nitrogen monitoring history at USGS sampling sites in Hilo Watershed continued…

16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	Nitrite plus nitrate, water, unfiltered, milligrams per liter as nitrogen
Station	**Count**	**First**	**Last**	**Parameter**
16704000 Wailuku River at Piihonua	62	10/31/1974	9/24/1979	Nitrite plus nitrate, water, unfiltered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	103	7/24/1974	8/4/1992	Nitrite plus nitrate, water, unfiltered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	41	10/29/1985	5/18/1993	Nitrite, water, filtered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	15	6/10/1974	8/4/1992	Nitrite, water, unfiltered, milligrams per liter as nitrogen
16717000 Honolii nr. Papaikou	16	10/29/1980	9/1/1982	Organic nitrogen, water, filtered, milligrams per liter
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	Organic nitrogen, water, unfiltered, milligrams per liter
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	Organic nitrogen, water, unfiltered, milligrams per liter
16704000 Wailuku River at Piihonua	22	11/29/1977	9/24/1979	Organic nitrogen, water, unfiltered, milligrams per liter
16717000 Honolii nr. Papaikou	21	10/29/1980	10/27/1986	Organic nitrogen, water, unfiltered, milligrams per liter
16704000 Wailuku River at Piihonua	1	9/24/1979		Total nitrogen, water, filtered, milligrams per liter
16717000 Honolii nr. Papaikou	12	10/29/1980	7/27/1982	Total nitrogen, water, filtered, milligrams per liter
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	Total nitrogen, water, unfiltered, milligrams per liter
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	Total nitrogen, water, unfiltered, milligrams per liter
16704000 Wailuku River at Piihonua	57	10/31/1974	9/24/1979	Total nitrogen, water, unfiltered, milligrams per liter
16717000 Honolii nr. Papaikou	13	10/29/1980	11/17/1981	Total nitrogen, water, unfiltered, milligrams per liter
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	Total nitrogen, water, unfiltered, milligrams per liter as nitrate
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	Total nitrogen, water, unfiltered, milligrams per liter as nitrate
16704000 Wailuku River at Piihonua	57	10/31/1974	9/24/1979	Total nitrogen, water, unfiltered, milligrams per liter as nitrate
16717000 Honolii nr. Papaikou	13	10/29/1980	11/17/1981	Total nitrogen, water, unfiltered, milligrams per liter as nitrate

Table 9, Phosphorus monitoring history at DOH sampling sites in Hilo Watershed (highlighted sites are currently active)

site	min	max	avg	count	first	last
Phosphorus, mg/l						
1100 - Baker's Beach	0.025	0.046	0.030	4	12/6/1976	6/6/1978
1101 - Coconut Island	0.011	0.081	0.025	55	6/4/1973	12/6/1982
1102 - Exit of Ice Pond	0.029	0.096	0.058	76	3/16/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.010	0.040	0.02	71	9/25/1990	9/2/1997
1107 - Hilo Bay (lighthouse)	0.005	0.104	0.020	69	10/22/1990	8/4/1997
1108 - Hilo Bay (Mooheau Park)	0.009	0.090	0.020	20	9/25/1990	8/3/1992
1110 - Honolii Cove (ocean)	0.008	0.102	0.026	39	6/5/1973	9/2/1997
1132 - Wailoa River (boat ramp)	0.020	0.060	0.050	6	3/8/1976	6/20/1977
1135 - Wailuku River (b)	0.015	0.0450	0.0290	5	3/8/1976	6/20/1977
1141 - Hilo Bay (off shore)	0.001	1.252	0.027	503	10/2/1979	10/6/1997
Phosphorus, orthophosphate as P, mg/l						
1101 - Coconut Island	0.010	0.025	0.010	24	7/9/1979	12/6/1982
1102 - Exit of Ice Pond	0.010	0.074	0.054	63	3/16/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.00	0.030	0.01	57	9/25/1990	9/2/1997
1107 - Hilo Bay (lighthouse)	0.001	0.049	0.010	56	10/22/1990	8/4/1997
1108 - Hilo Bay (Mooheau Park)	0.001	0.082	0.011	20	9/25/1990	8/3/1992
1141 - Hilo Bay (off shore)	0.000	0.217	0.013	464	10/2/1979	10/6/1997
1110 - Honolii Cove (ocean)	0.003	0.032	0.012	25	9/26/1990	9/2/1997

Table 10, Phosphorus data from USGS station 16717000 Honolii Stream near Papaikou

parameter	first	last	count	min	max	avg
Phosphorus, water, unfiltered, mg/l	12/13/1973	5/18/1993	154	0.0000	0.3700	0.0226
Phosphorus, water, filtered, mg/l	3/8/1979	5/18/1993	85	0.0100	0.1900	0.0256

Table 11, Phosphorus monitoring history at USGS sampling sites in Hilo Watershed

Station	Count	FirstDate	Last Date	Parameter
16701750 Wailuku R. nr. Humuula	2	2/12/1976	6/7/1976	Orthophosphate, water, filtered, milligrams per liter
16701800 Wailuku near Kaumana	2	12/15/1975	5/6/1976	Orthophosphate, water, filtered, milligrams per liter
16704000 Wailuku River at Piihonua	2	12/27/1973	6/3/1974	Orthophosphate, water, filtered, milligrams per liter
16717000 Honolii nr. Papaikou	18	8/3/1973	2/22/1983	Orthophosphate, water, filtered, milligrams per liter
16704000 Wailuku River at Piihonua	3	5/16/1979	6/25/1979	Phosphate, water, unfiltered, milligrams per liter
16704000 Wailuku River at Piihonua	25	9/26/1977	9/24/1979	Phosphorus, water, filtered, milligrams per liter
16717000 Honolii nr. Papaikou	4	5/16/1979	9/25/1979	Phosphate, water, unfiltered, milligrams per liter
16717000 Honolii nr. Papaikou	85	3/8/1979	5/18/1993	Phosphorus, water, filtered, milligrams per liter
16717000 Honolii nr. Papaikou	1	7/29/1991		Phosphorus, water, filtered, modified jirka method, milligrams per liter
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	Phosphorus, water, unfiltered, milligrams per liter
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	Phosphorus, water, unfiltered, milligrams per liter
16704000 Wailuku River at Piihonua	62	10/31/1974	9/24/1979	Phosphorus, water, unfiltered, milligrams per liter
16717000 Honolii nr. Papaikou	154	12/13/1973	5/18/1993	Phosphorus, water, unfiltered, milligrams per liter
16704000 Wailuku River at Piihonua	6	5/16/1979	9/24/1979	Phosphorus, water, unfiltered, milligrams per liter as phosphate
16717000 Honolii nr. Papaikou	55	5/16/1979	12/8/1986	Phosphorus, water, unfiltered, milligrams per liter as phosphate
16701750 Wailuku R. nr. Humuula	2	2/12/1976	6/7/1976	Orthophosphate, water, filtered, milligrams per liter as phosphorus
16701800 Wailuku near Kaumana	2	12/15/1975	5/6/1976	Orthophosphate, water, filtered, milligrams per liter as phosphorus
16704000 Wailuku River at Piihonua	2	12/27/1973	6/3/1974	Orthophosphate, water, filtered, milligrams per liter as phosphorus
16717000 Honolii nr. Papaikou	75	8/3/1973	5/18/1993	Orthophosphate, water, filtered, milligrams per liter as phosphorus
16717000 Honolii nr. Papaikou	1	7/29/1991		Phosphorus, water, unfiltered, modified jirka method, milligrams per liter
16701750 Wailuku R. nr. Humuula	2	11/4/1977	9/14/1978	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus
16701800 Wailuku near Kaumana	2	11/1/1977	7/26/1978	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus
16704000 Wailuku River at Piihonua	5	10/26/1971	9/12/1978	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus
16717000 Honolii nr. Papaikou	23	7/26/1971	8/4/1992	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus

Table 12, Chlorophyll monitoring history at DOH sampling sites in Hilo Watershed
(highlighted sites are currently active)

site ID	min	max	average	count	site ID	parameter	first	last
1101 - Coconut Island	10.00	400.00	115.00	6	1101	Chlorophyll a (probe) ug/l	1/18/1982	12/6/1982
1102 - Exit of Ice Pond	0.00	100.00	3.94	61	1102	Chlorophyll a (probe) ug/l	4/20/1981	8/4/1997
1106 - Hilo Bay (boat landing)	0.10	201.00	7.84	57	1106	Chlorophyll a (probe) ug/l	9/25/1990	9/2/1997
1107 - Hilo Bay (lighthouse)	0.10	654.00	20.12	56	1107	Chlorophyll a (probe) ug/l	10/22/1990	8/4/1997
1108 - Hilo Bay (Mooheau Park)	0.30	36.00	3.72	20	1108	Chlorophyll a (probe) ug/l	9/25/1990	8/3/1992
1110 - Honolii Cove (ocean)	0.20	91.80	5.62	25	1110	Chlorophyll a (probe) ug/l	9/26/1990	9/2/1997
1141 - Hilo Bay (off shore)	0.00	1,375.00	41.08	405	1141	Chlorophyll a (probe) ug/l	9/8/1980	10/6/1997

Table 13, Turbidity monitoring history at DOH sampling sites in Hilo Watershed
(highlighted sites are currently active)

		NTU				
Site	**count**	**min**	**max**	**average**	**first**	**last**
1100 - Baker's Beach	2	0.50	0.50	0.50	12/6/1976	4/17/1978
1101 -Coconut Island	46	0.20	16.00	1.87	6/4/1973	12/6/1982
1102 - Exit of Ice Pond	109	0.10	2.50	0.43	3/16/1981	2/28/2005
1106 - Hilo Bay (boat landing)	47	0.20	10.10	1.49	9/4/1991	9/23/2003
1107 - Hilo Bay (lighthouse)	44	0.40	290.00	9.26	9/4/1991	8/4/1997
1108 - Hilo Bay (Mooheau Park)	9	1.90	32.00	7.99	9/4/1991	8/3/1992
1110 - Honolii Cove (ocean)	216	0.20	32.20	3.07	6/5/1973	3/3/2005
1132 - Wailoa River (boat ramp)	6	0.20	1.00	0.43	3/8/1976	6/20/1977
1135 - Wailuku River (b)	5	0.70	1.80	1.06	3/8/1976	6/20/1977
1138 - Hilo Bay (Canoe Beach)	185	1.90	84.30	9.45	1/4/1999	3/3/2005
1141 - Hilo Bay (off shore)	29	0.50	6.00	1.60	10/2/1979	10/22/2002
min	2	0.10	0.50	0.43		
max	216	1.90	290.00	9.45		
avg	63	0.62	43.31	3.38		

Table 14, Turbidity monitoring history at USGS sampling sites in Hilo Watershed

Station	Count	Date	Last Date	Parameter
16701750 Wailuku R. nr. Humuula	3	2/12/1976	11/4/1977	Turbidity, water, unfiltered, Jackson turbidity units
16701800 Wailuku near Kaumana	3	12/15/1975	11/1/1977	Turbidity, water, unfiltered, Jackson turbidity units
16704000 Wailuku River at Piihonua	51	10/26/1971	6/12/1978	Turbidity, water, unfiltered, Jackson turbidity units
16717000 Honolii nr. Papaikou	47	5/5/1970	2/26/1976	Turbidity, water, unfiltered, Jackson turbidity units
16717000 Honolii nr. Papaikou	4	5/5/1970	8/20/1970	Turbidity, water, unfiltered, milligrams per liter as silicon dioxide
16701750 Wailuku R. nr. Humuula	1	9/14/1978		Turbidity, water, unfiltered, nephelometric turbidity units
16701800 Wailuku near Kaumana	1	7/26/1978		Turbidity, water, unfiltered, nephelometric turbidity units
16704000 Wailuku River at Piihonua	17	5/23/1978	9/24/1979	Turbidity, water, unfiltered, nephelometric turbidity units
16717000 Honolii nr. Papaikou	59	10/25/1982	5/18/1993	Turbidity, water, unfiltered, nephelometric turbidity units

Table 15, USGS flow data from NWIS website daily mean flow rates in cu ft/sec.

station ID	station	sq. mi.	years of data	first	last	count	min	max	avg	other parameters
16701700	Wailuku R. nr Pua Akala	10.20	<2	1/1/1964	10/31/1965	670	0	46	0.2	
16708000	Kapehu ditch nr Hilo	n/a	24	1/4/1938	6/30/1962	8,276	0	12	2.33	
16707000	Kapehu ditch diversion nr Hilo	n/a	8	1/6/1954	6/30/1962	2,952	0	17	2.36	
16701750	Wailuku R. nr Humuula	34.80	17	2/1/1965	9/30/1982	6,451	0	803	3.14	many biological, physical, and chemical parameters
16700950	Lyman Sprgs. no. 2 nr Piihonua	n/a	14	1/23/1981	9/30/1995	5,364	0.3	52	4.7	temp., conductance, pH
16701200	Waiakea Str. nr Hilo	33.60	10	1/6/1957	6/30/1967	3,682	0	608	5.82	
16701300	Waiakea Str. @ Hilo	35.80	<1	1/10/2003	9/30/2004	366	0	359	6.87	
16705000	Hilo bd. sch. ditch @ intake nr Hilo	n/a	15	1/11/1931	6/16/1946	3,213	0.17	33	13.85	
16700600	Waiakea Str. @ Hoaka Rd.	n/a	<1	1/10/2003	9/30/2004	366	0	440	17.09	
16701800	Wailuku R. nr Kaumana	43.40	16	10/1/1966	9/30/1982	5,844	0	5,380	30.35	many biological, physical, and chemical parameters
16701800	Honolii Str. nr Hilo	8.00	8	3/1/1924	6/30/1932	2,924	0.3	2,120	53.03	
16709000	Kapehu Str. @ Piihonua nr Hilo	4.84	8	12/1/1928	12/31/1936	2,954	2.2	1,280	54.09	
16703000	Wailuku R. @ Pukamaui	97.00	17	4/17/1923	5/24/1940	5,284	0	8,970	96.03	
16717000	Honolii Str. nr Papaikou*	11.60	92	6/1/1911	9/30/2003	14,030	0.8	6,410	129.51	many biological, physical, and chemical parameters
16704000	Wailuku R. @ Piihonua	149.00	75	7/1/1928	9/30/2003	27,179	0.22	22,200	273.02	many biological,

APPENDIX 1: COUNTY OF HAWAII SOIL EROSION AND SEDIMENTATION CONTROL PROGRAM

Draft Objectives (2-11-2005)

1. Update the County's grading ordinance and advocate the implementation of best management practices to minimize or prevent pollutants in discharges from a construction site

2. Provide better enforcement of the grading ordnance and best management practices

3. Incorporate provisions to assist SWCDs to better manage their conservation programs

4. Integrate/coordinate Chapter 10 regulations with State authorities such as DOH, NPDES and UIC permits, and DLNR, SCAP permits and SHPD and regulations to eliminate redundancies and improve efficiency

5. Provide continuing education and training programs for inspectors, contractors, engineers and the general public

APPENDIX 2: STAKEHOLDERS, LANDOWNERS AND MANAGERS IN HILO BAY WATERSHED

Agency	Name	Title	Address	City	Phone	E-mail
USGS	Gordon Tribble			Honolulu		
	Dale Nishimoto		Hilo office closing in June	moving to Hon	933-6920	denishim@usgs.gov
COE	Derek Chow	Sr Proj Man/Civil & PW Brch				
	Warren Kani	Engineer				
NRCS	Harry Toki	Dist Conservatnst		Hilo	933-8381; 933-8353	hary.toki@hi.usda.gov
FWS	Dick Wass	Hakalau Wildlife Refuge	32 Kinoole St; Suite 101	Hilo	933-6915	
	Patrick Glenn					
SWCD					895-3480	
Hamakua	Tom Young				969-3114	
SWCD -	Francis Pacheco, Chair					
Waikea						
SWCD -	Robbie Hind, chair/rancher				885-6602	
Mauna Kea	Margaret Becca					
DLNR						
DOFAW	Roger Imoto	Branch Manager	19 E Kawili St	Hilo	974-4220	rimoto@dofawha.org
	Steve Bergfeld		19 E Kawili St	Hilo		sbergfeld@dofawha.org
Land Division			75 Aupuni St Rm 204	Hilo	974-6203	
Aquatic Resources	Bob Nishimoto	Aquatic Biologist	75 Aupuni St Rm 204	Hilo	974-6201	
	John Kahiapo	Educational Sp	75 Aupuni St Rm 204	Hilo	974-6201	
DOBOR	Nancy Murphy	District Manager		Kailua-Kona	326-7896	
DOCARE				Honolulu	587-0077	
SHPD				Kailua-Kona	327-3690	
OCCL				Honolulu	587-0377	
State Parks	Glen Taguchi					
DOH	Thomas See	Enforcement		Honolulu		
	Cliff Furukado	Clean Water	1582 Kam Ave	Hilo	933-0401	
	Jerry	Wastewater	1582 Kam Ave	Hilo		
	Dave Penn	TMDL		Honolulu		
OHA	Ululani Sherlock	Community Resource Coordinator	162-A Baker Ave	Hilo	920-6418	ululanis@oha.org
HI Homelands		Mauna Kea Dis		Waimea		

	Mike Robinson forester	DHHL: East Hawaii District	160 Baker Ave	Hilo	974-4250	
	James (Kimo) DuPont	DHHL Director W Hawaii District		Waimea	887-6053	
DOT	Ian Birnie	Harbormaster		Hilo		
Co Planning	Chris Yuen	Director			961-8288	
	Roy Takemoto	Deputy Director (moving to Mayors office)				
	Alice Kawahara	CZM program				
Co PW	Bruce McClure	Director				
	Galen Kuba	Eng Div Head	101 Pauahi St Ste 7	Hilo	961-8327	
Co Env Man	Barbara Bell	Director	25 Aupuni St#210	Hilo	961-8083	
	Nelson Ho	Deputy Director	25 Aupuni St #210	Hilo	961-8083	
Solid Waste	Lono Tyson	Division Head	108 Railroad Ave	Hilo	961-8339	
Wastewater	Peter Boucher	Division Head	108 Railroad Ave	Hilo	961-8338	
Water Supply	Milton Pavao	Department Head	345 Kekuanaoa St	Hilo	961-8050	
Operations	Dennis Lee	Division Head	889 Leilani St	Hilo	961-8790	
WQ Assurance	Keith Okamoto	Division Head	889 Leilani St	Hilo	961-8670	
Res & Dev	Jane Testa	Director	25 Aupuni St #219	Hilo	961-8366	
Co Council	Stacy Higa, Chair	District 1				
	Donald Ikeda	District 2				
Mayor	Harry Kim					
CTAHR -						
Marine Science	Tracy Wiegner					
Marine Science	Walt Dudley					
Geology	Don Thomas					
Geology	Jene Michaud					
Chemistry	Randi Schneider					
Geography	Sonia Juvik					
AECOS Labs	Karen Klein			Kona		
Landowners						
DLNR						
DHHL	Mike Robinson			Hilo		
C Brewer	may have sold some land					
World Union				Hilo		
US Gov						
Kamehameha Sc	Peter Simmons	Regnl Operatns Dir	78-6831 Ali'I Dr; Suite 232	Kailua-Kona	322-5310	pesimmon@ksbe.edu

State Other						
HI Culture	Lunakanawai Hauanio		PO Box 522	Kealakekua	328-1969	luna_kona@yahoo.com
	Reynolds Kamakawiwoole			Honokaa	775-0683; cell 937-3452	rnakooka@msn.com
Environmental						
Nature Conservancy	Rob Shallenberger			Waimea	937-1775	
Sierra Club	Charles Stanton				965-0474	

APPENDIX 3: MANAGEMENT AGENCIES ACTING IN THE HILO BAY WATERSHED WITH AREAS OF COMPETENCE

Current & Planned Water Resource Management Efforts

Entity	**Management Effort**
State	
DOH Wstwtr	Discharge permits
DOH CWB	TMDL; wate quality monitoring; revising State WQ standards; storm drain stencil
DLNR/DOFAW	wild pig control/ eradication; manage hunting and forests
DLNR/Aq Res	Bob Nishimoto - fishery management HB; hatchery; fees, permits, limits
DLNR/SWCD	
DOT	Ian Birnie Harbormaster (leaves in June), harbor improvements; MOU w/ cruise ships??; storm water management with County?? road construction and road and landscape maintainance including herbicide application
CZM	Hawaii NEMO program; CZM/DOH HI Implementation Plan for Polluted Runoff Control (report 7/00)
DHHL	Mike Robinson contact for land managed in Upper Mauna Kea (grazing)
SWCD	subdivision of DLNR
Land Use Com	
Ag Dept	pesticide branch: inspctions, application/proper storage & handling classes; list of certified applicators
DHHL	Mike Robinson
US	
USDA	includes NRCS, USFS, RC&D
USDA/NRCS	Farm Bureau Programs; Conservation Plans-sediment control, water quality resource management, techincal assistance; flood control
USDA/USFS	Hakalau NWR; pig control; reforestation; invasive species control
USDA/RC&D	non profit status; provides grant funding
EPA	Grant money; resources; assistance
FEMA	flood protection (life and property)
USGS	Monitoring
NOAA/NMFS	
USFWS	
COE	stream permits, breakwater (study and alterations), mitigation projects
Nat Mar Wild	National Marine Wildlife Sanctuary - whales
Commerce/NOAA	law enforcement
WPRFMC	Western Pacific Regional Fishery Management Council www.wpcouncil.org
Coast Guard	Cruise ship law enforcement?
County	
Planning	Revisions to General Plan - zoning/ land use planning, variances,etc; enforcement/penalties? Hilo Bayfront Proposed Recreation Projects July 2002; Friends of Downtown Hilo
Pub Wks	Potential COE computer modeling of Hilo Bay TAC Revising County Erosion and Sedimentation Control Ordinance; grubbing & grading permits & enforcement; flood control, channel/road maintenance, herbicide application

	submitted projects for stormwater control grant money (USBR?)
DOT	herbicide spraying, stormwater runoff, tree trimming/landscaping
Water	responsible for County drinking water facilities and compliance with State standards
Env Man	Solid Waste - Recycling; bottle bill; illegal dumping program land fill (potential groundwater issues) - requested to extend life by increasing height Expanding wastewater services???; EPA money to assist with addressing gang cesspools Brownfields money;outfall dye dilution study; renewing Hilo NPDES permit; compliance moniroting data
Env Man Com	Commission meets bi-monthly; 1 member from each of 9 districts represent the area re env issue
Parks & Rec	Beach clean ups; maintain and manage beach areas and parks; water safety
Community	
WAG	Restn Plan; Watershed Man Plan; Ed/Outreach; clean ups; monitoring
Canoe Clubs	John Kekua, Gerard Leeloy; interest in Bayfront (canoe shelters are illegal);
HSS	Hawaii Speleological Society; Lave Tube Cave Subcommittee; articles/information from Dr Halliday; Kaumana Cave information
Keep Am Bea	Litter clean ups
Fishing Clubs	
Hunting Clubs	
Youth Groups	High school clubs, Boy and Girl Scouts, etc; work on clean ups, stenciling,
Sailing Club	
Sevice Groups	Rotary, Lions, Kiwanis
Surfing Clubs	
Education	
UHH	Studies and monitoring, technical assistance (COE model??); student help Marine Science (Walt Dudley, Leon Hallaker, Lisa Parr); Natural Sciences (Jene-Geology); Natural Resources Management; Geography (Juviks) EPSCoR; UHRC (grant and staffing assistance)
UHM	Environmental Center/WRRC Restoration Plan; resources Tropical Ag Extension Service - provide office supplies like copy machine, meeting room
Environmental	
Nature Cons	
Sierra Club	Blue Water Campaign; Blue Water Response Team/ Hot Line
Businesses	
Hotels	Hilo Hawaiian, Naniloa, Seaside, Uncle Billie's
Fishing stores	Tokunaga
Kayak shops	
Surfbrd shops	
Dive shop	

APPENDIX 4: DOH WQ Data From STORET Database May 2005

001100 **Baker's Beach**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7313889, longitude: 155.0622222
depth: 0 feet

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Fecal Coliform, MPN	6/19/1973	6/6/1978	89	2	1100	86.42
Total Coliform, MPN	6/19/1973	6/6/1978	89	2	4600	305.84
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	1/21/1974	1	15	15	15.00
Turbidity, NTU	12/6/1976	4/17/1978	2	0.5	0.5	0.50
Nitrogen ion (N), mg/l	12/6/1976	6/6/1978	4	0.2300	0.5400	0.4050
Nitrogen, Kjeldahl, mg/l	12/6/1976	6/6/1978	4	0.2000	0.5000	0.3500
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	12/6/1976	6/6/1978	4	0.0100	0.1000	0.0500
pH, None	12/6/1976	12/6/1976	1	7.50	7.50	7.50
Phosphorus, mg/l	12/6/1976	6/6/1978	4	0.0250	0.0460	0.0328
Salinity, ppth	12/6/1976	6/6/1978	4	21	28	25.25
Temperature, water, deg C	12/6/1976	6/6/1978	4	23.5	26.5	24.70
Total Suspended Solids (TSS), mg/l	4/17/1978	6/6/1978	3	18	33	26.67
Dissolved oxygen (DO), mg/l	12/6/1976	6/6/1978	4	7.1	7.9	7.35

001101 **Coconut Island**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7325, longitude: 155.0711111
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	11/6/1989	12/2/1998	96	0.30	310.00	10.57
Clostridium perfringens, #/100ml	7/26/1994	12/2/1998	31	0.70	18.00	2.59
Fecal Coliform, #/100ml	6/4/1973	6/3/1996	214	1.00	1,600.00	56.36
Total Coliform, #/100ml	6/4/1973	9/21/1992	135	1.00	24,000.00	499.84
Fecal Streptococcus Group Bacteria, #/100ml	6/4/1973	6/4/1973	1	3.00	3.00	3.00
Turbidity, NTU	6/4/1973	12/6/1982	46	0.20	16.00	1.87
Nitrogen ion (N), mg/l	6/4/1973	12/6/1982	55	0.0200	0.6900	0.2880
Nitrogen, ammonium (NH4) as NH4, mg/l	7/9/1979	12/6/1982	24	0.0000	0.2600	0.1054
Nitrogen, Kjeldahl, mg/l	6/4/1973	12/6/1982	55	0.0000	0.6000	0.1969
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	6/4/1973	12/6/1982	55	0.0100	0.2100	0.0647
Phosphorus, mg/l	6/4/1973	12/6/1982	55	0.0110	0.0810	0.0247
Phosphorus, orthophosphate as P, mg/l	7/9/1979	12/6/1982	24	0.0100	0.0250	0.0100
Chlorophyll a (probe), ug/l	1/18/1982	12/6/1982	6	10.00	400.00	115.00
Total Organic Carbon (TOC), mg/l	2/11/1980	12/8/1980	9	1.50	4.30	2.41
Total Suspended Solids (TSS), mg/l	1/9/1978	12/6/1982	39	4.00	172.00	31.28
Dissolved oxygen (DO), mg/l	4/15/1974	9/13/1982	45	6.60	10.00	7.52
pH, None	4/15/1974	12/6/1982	29	7.10	8.40	7.90
Salinity, ppth	4/15/1974	12/2/1998	138	5.00	34.00	24.91
Secchi disk depth, m	9/11/1978	12/6/1982	28	1.00	10.00	3.29
Temperature, water, deg C	4/15/1974	12/6/1982	50	22.00	27.00	25.00

001102 **Exit of Ice Pond**
Organization: Hawaii Dept. of Health
primary type Estuary
latitude/longtitude latitude: 19.7272222, longitude: 155.0652778
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	3/9/1987	2/28/2005	207	0.5	3,970	36.10
Clostridium perfringens, #/100ml	1/25/1993	2/28/2005	104	0.7	10	1.59
Fecal Coliform, MPN	6/13/1973	6/3/1996	334	2	16,000	325.44
Total Coliform, MPN	6/13/1973	10/5/1992	277	23	24,000	2,026.83
Fecal Streptococcus Group Bacteria, MPN	8/13/1973	7/28/1982	41	2	2,400	189.98
Turbidity, NTU	3/16/1981	2/28/2005	109	0.1	3	0.43
Nitrogen ion (N), mg/l	3/16/1981	8/4/1997	63	0.3500	1.4240	0.5144
Nitrogen, ammonium (NH4) as NH4, mg/l	3/16/1981	8/4/1997	63	0.0000	0.1800	0.0214
Nitrogen, Kjeldahl, mg/l	3/16/1981	8/4/1997	17	0.1000	0.3000	0.1294
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	3/16/1981	8/4/1997	63	0.2300	0.6000	0.4430
Phosphorus, mg/l	3/16/1981	8/4/1997	76	0.0290	0.0960	0.0583
Phosphorus, orthophosphate as P, mg/l	3/16/1981	8/4/1997	63	0.0100	0.0740	0.0538
Total Organic Carbon (TOC), mg/l	9/25/1990	8/29/1994	46	0.3	1	0.64
Total Suspended Solids (TSS), mg/l	3/16/1981	8/4/1997	17	1	36	5.59
Chlorophyll a (probe), ug/l	4/20/1981	8/4/1997	61	0	100	3.94
Dissolved oxygen (DO), mg/l	3/16/1981	2/28/2005	153	5.82	91	22.07
Dissolved oxygen saturation, %	8/11/2003	6/30/2004	30	71.1	97	85.40
Silica, mg/l	9/25/1990	8/29/1994	46	4	23	14.48
Secchi disk depth, m	4/20/1981	9/13/1982	3	1	5	3.33
Salinity, ppth	4/20/1981	2/28/2005	217	4	23	8.01
pH, None	9/13/1982	2/28/2005	117	6.6	9	7.77
Temperature, water, deg C	4/20/1981	2/28/2005	122	20	27	22.30

001106 **Hilo Bay (boat landing)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7297222, longitude: 155.075
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	10/9/1989	9/23/2003	40	0.60	610.00	24.20
Clostridium perfringens, #/100ml	10/22/2002	10/22/2002	1	2.10	2.10	2.10
Fecal Coliform, #/100ml	6/19/1973	11/30/1992	85	2.00	1,100.00	54.91
Total Coliform, MPN	6/19/1973	9/21/1992	82	2.00	5,400.00	551.49
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	1/21/1974	1	4.00	4.00	4.00
Turbidity, NTU	9/4/1991	9/23/2003	47	0.20	10.10	1.49
Nitrogen ion (N), mg/l	9/25/1990	9/2/1997	57	0.0070	1.1680	0.2070
Nitrogen, ammonium (NH4) as NH4, mg/l	9/25/1990	9/2/1997	57	0.0007	0.0500	0.0183
Nitrogen, Kjeldahl, mg/l	11/28/1994	9/2/1997	11	0.1000	0.2000	0.1182
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	9/25/1990	9/2/1997	57	0.0000	0.6000	0.1188
Phosphorus, mg/l	9/25/1990	9/2/1997	71	0.0050	0.0430	0.0201
Phosphorus, orthophosphate as P, mg/l	9/25/1990	9/2/1997	57	0.0003	0.0300	0.0130
Total Organic Carbon (TOC), mg/l	9/25/1990	8/29/1994	46	0.80	4.50	1.35

Total Suspended Solids (TSS), mg/l	11/28/1994	9/2/1997	11	6.00	30.00	10.45
Silica, mg/l	9/25/1990	8/29/1994	46	1.50	14.90	4.59
Chlorophyll a (probe), ug/l	9/25/1990	9/2/1997	57	0.10	201.00	7.84
Dissolved oxygen (DO), mg/l	11/20/1990	9/23/2003	58	5.60	8.90	6.85
Dissolved oxygen saturation, %	8/25/2003	9/23/2003	2	85.50	88.30	86.90
pH, None	9/25/1990	9/23/2003	55	6.90	8.40	7.99
Salinity, ppth	9/25/1990	9/23/2003	83	2.00	34.40	22.47
Temperature, water, deg C	9/25/1990	9/23/2003	60	21.20	26.90	24.57

001107 **Hilo Bay (lighthouse)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7308333, longitude: 155.09
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	10/9/1989	9/29/1999	114	0.30	1,000.00	31.31
Clostridium perfringens, #/100ml	1/31/1994	9/29/1999	63	0.70	710.00	15.94
Fecal Coliform, #/100ml	10/19/1992	9/21/1992	130	1.00	2,400.00	92.56
Total Coliform, MPN	6/19/1973	9/21/1992	85	2.00	24,000.00	1,902.31
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	1/21/1974	1	9.00	9.00	9.00
Turbidity, NTU	9/4/1991	8/4/1997	44	0.40	290.00	9.26
Total Suspended Solids (TSS), mg/l	10/31/1994	8/4/1997	11	3.00	33.00	15.36
Nitrogen ion (N), mg/l	10/22/1990	8/4/1997	56	0.0090	0.8620	0.1576
Nitrogen, ammonium (NH4) as NH4, mg/l	10/22/1990	8/4/1997	56	0.0007	0.0600	0.0202
Nitrogen, Kjeldahl, mg/l	10/31/1994	8/4/1997	11	0.1000	0.3000	0.1182
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	10/22/1990	8/4/1997	56	0.0100	0.2000	0.0450
Phosphorus, mg/l	10/22/1990	8/4/1997	69	0.0050	0.1040	0.0204
Phosphorus, orthophosphate as P, mg/l	10/22/1990	8/4/1997	56	0.0006	0.0490	0.0096
Silica, mg/l	10/22/1990	8/29/1994	45	0.50	6.50	2.39
Total Organic Carbon (TOC), mg/l	10/22/1990	8/29/1994	45	0.90	5.10	1.72
Chlorophyll a (probe), ug/l	10/22/1990	8/4/1997	56	0.10	654.00	20.12
Dissolved oxygen (DO), mg/l	10/22/1990	8/4/1997	55	6.10	8.60	6.80
pH, None	10/22/1990	8/4/1997	53	6.70	8.30	8.03
Salinity, ppth	10/22/1990	9/29/1999	150	11.00	33.80	26.53
Temperature, water, deg C	10/22/1990	8/4/1997	55	21.90	27.50	24.84

001108 **Hilo Bay (Mooheau Park)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7280556, longitude: 155.0861111
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVERAGE
Enterococcus Group Bacteria, #/100ml	10/9/1989	10/19/1992	38	0.600	144	13.284
Fecal Coliform, #/100ml	4/16/1986	9/21/1992	120	2	490	50.275
Total Coliform, MPN	6/19/1973	9/21/1992	102	4	11,000	913.000
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	7/12/1982	24	2	170	21.917
Turbidity, NTU	9/4/1991	8/3/1992	9	1.9	32	7.989
Nitrogen ion (N), mg/l	9/25/1990	8/3/1992	20	0.061	0.269	0.153
Nitrogen, ammonium (NH4) as NH4, mg/l	9/25/1990	8/3/1992	20	0.001	0.014	0.005
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	9/25/1990	8/3/1992	20	0.000	0.200	0.075
Phosphorus, mg/l	9/25/1990	8/3/1992	20	0.009	0.090	0.020
Phosphorus, orthophosphate as P, mg/l	9/25/1990	8/3/1992	20	0.001	0.082	0.011
Silica, mg/l	9/25/1990	8/3/1992	20	0.500	13	3.955
Total Organic Carbon (TOC), mg/l	9/25/1990	8/3/1992	20	0.900	3.400	1.685
Chlorophyll a (probe), ug/l	9/25/1990	8/3/1992	20	0.300	36	3.720
Dissolved oxygen (DO), mg/l	10/22/1990	8/3/1992	18	5.600	8.200	6.756
pH, None	9/25/1990	8/3/1992	16	6.900	8.200	7.725
Salinity, ppth	9/25/1990	10/19/1992	43	10	35	24.328
Temperature, water, deg C	9/25/1990	8/3/1992	19	22.5	27.5	24.716

001110 **Honolii Cove (ocean)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19deg. 45min. 33sec. N, longitude: 155deg. 5min. 38sec. W
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococci #/100 ml	11/6/1989	3/3/2005	363	0.30	870.00	39.77
Clostridium perfringens #/100 ml	1/25/1993	3/3/2005	243	0.20	110.00	6.18
Fecal Coliform MPN	6/5/1973	6/3/1996	150	1.00	5,400.00	148.13
Total Coliform MPN	6/5/1973	9/21/1992	103	4.00	24,000.00	1,969.50
Fecal Streptococcus MPN	1/16/1974	3/11/1985	8	2.00	470.00	92.63
Turbidity NTU	6/5/1973	3/3/2005	215	0.20	32.20	3.09
Total susp. solids mg/l	11/28/1994	9/2/1997	11	4.00	22.00	10.55
Chlorophyll a ug/l	9/26/1990	9/2/1997	25	0.20	91.80	5.62
Dissolved Oxygen mg/l	4/16/1974	3/3/2005	257	5.78	97.70	18.50
Dissolved Oxygen sat. %	8/11/2003	6/30/2004	40	80.60	101.70	94.48
Nitrogen ion mg/l	6/5/1973	9/2/1997	34	0.0500	0.5400	0.1786
Nitrate mg/l	9/26/1990	9/2/1997	25	0.0030	0.0500	0.0260
Kjeldahl Nitrogen mg/l	6/5/1973	9/2/1997	20	0.0000	0.5000	0.1900
nitrite and nitrate N	6/5/1973	9/2/1997	34	0.0100	0.1000	0.0556
Phosphorus mg/l	6/5/1973	9/2/1997	39	0.0080	0.1020	0.0258
orthophosphate mg/l	9/26/1990	9/2/1997	25	0.0030	0.0320	0.0116
Silica mg/l	9/26/1990	8/29/1994	14	0.80	3.40	2.44
Total organic carbon mg/l	9/26/1990	8/29/1994	14	1.00	10.60	2.31
pH	4/16/1974	3/3/2005	107	6.40	8.43	8.17
Salinity ppt	6/3/1974	8/29/1994	384	0.33	35.00	25.84
Temperature deg. C	4/16/1974	3/3/2005	274	19.11	27.50	24.01

001111 **Honolii Cove (stream)**
Organization Hawaii Dept. of Health
primary type River/Stream
latitude/longtitude latitude: 19deg. 45min. 37sec. N, longitude: 155deg. 4min. 58sec. W
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Fecal Coliform, MPN	6/13/1973	12/9/1975	69	2.00	2,400.00	181.38
Total Coliform, MPN	6/13/1973	12/9/1975	69	11.00	24,000.00	4,259.30
Fecal Streptococcus Group Bacteria, MPN	8/13/1973	2/25/1974	19	3.00	11,000.00	931.84

001122 **Nalei Hotel (front of)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7313889, longitude: 155.0655556
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	6/25/1990	6/25/1990	1	7.00	7.00	7.00
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	1/21/1974	1	3.00	3.00	3.00
Fecal Coliform, MPN	6/19/1973	6/25/1990	47	1.00	1,600.00	129.64
Total Coliform, MPN	6/19/1973	6/25/1990	47	3.00	4,600.00	749.36

001123 **Naniloa Hotel (old diving board)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7341667, longitude: 155.0683333
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Fecal Coliform, MPN	6/19/1973	12/9/1975	49	2.00	460.00	32.73
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	1/21/1974	1	4.00	4.00	4.00
Total Coliform, MPN	6/19/1973	12/9/1975	49	1.00	24,000.00	990.45

001132 **Wailoa River (boat ramp)**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7252778, longitude: 155.0744444
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	4/23/1990	12/2/1998	85	1.00	1,500.00	63.38
Clostridium perfringens, #/100ml	2/7/1994	12/2/1998	55	1.00	96.00	7.81
Fecal Coliform, #/100ml	4/16/1986	9/21/1992	137	2.00	24,000.00	373.99
Total Coliform, MPN	6/19/1973	9/21/1992	104	3.00	24,000.00	2,377.34
Fecal Streptococcus Group Bacteria, MPN	1/21/1974	2/14/1977	11	2.00	2,400.00	264.36
Turbidity, NTU	3/8/1976	6/20/1977	5	0.20	0.50	0.32
Nitrogen ion (N), mg/l	3/8/1976	6/20/1977	6	0.35	0.85	0.578
Nitrogen, Kjeldahl, mg/l	3/8/1976	6/20/1977	5	0.1000	0.5000	0.1667
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	3/8/1976	6/20/1977	6	0.3500	0.8500	0.5783
pH, None	3/8/1976	9/12/1977	7	6.50	7.30	7.03
Phosphorus, mg/l	3/8/1976	6/20/1977	6	0.02	0.06	0.05
Dissolved oxygen (DO), mg/l	3/8/1976	9/12/1977	7	8.20	10.80	9.60
Salinity, ppth	3/8/1976	12/2/1998	83	0.00	8.00	3.82
Temperature, water, deg C	3/8/1976	9/12/1977	7	20.00	25.00	21.69

001133 **Waiakea Mill Pond**
Organization Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19deg. 43min. 2sec. N, longitude: 155deg. 2min. 45sec. W
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVERAGE
Enterococcus Group Bacteria, #/100ml	4/23/1990	6/22/1992	24	4	480	111.54
Fecal Coliform, MPN	6/19/1973	6/22/1992	73	2	11,000	450.10
Total Coliform, MPN	6/19/1973	6/22/1992	73	2	24,000	1,827.00
Fecal Streptococcus Group Bacteria, MPN	8/13/1973	2/11/1974	12	3	150	58.83
Salinity, ppth	1/28/1991	6/22/1992	13	0	3	1.65

001134 **Wailuku River (a)**
Organization: Hawaii Dept. of Health
primary type River/Stream
latitude/longtitude latitude: 19.7297222, longitude: 155.0913889
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria	6/25/1990	6/25/1990	1	49	49	49.00
Fecal Coliform	1/7/1974	6/25/1990	67	5	1,100	136.27
Total Coliform	1/7/1974	6/25/1990	63	240	11,000	1,799.84
Fecal Streptococcus Group Bacteria	1/21/1974	3/11/1985	18	6	540	149.61

001135 **Wailuku River (b)**
Organization: Hawaii Dept. of Health
primary type River/Stream
latitude/longtitude latitude: 19.7305556, longitude: 155.0930556
depth: 0 feet

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Fecal Coliform, MPN	1/19/1976	11/28/1977	22	8	790	153.50
Total Coliform, MPN	1/19/1976	11/28/1977	22	540	16,000	4,151.36
Fecal Streptococcus Group Bacteria, MPN	1/19/1976	2/14/1977	12	48	2,400	459.00
Turbidity, NTU	3/8/1976	6/20/1977	5	1	2	1.06
Nitrogen ion (N), mg/l	3/8/1976	6/20/1977	6	0.290	0.660	0.4833
Nitrogen, Kjeldahl, mg/l	3/8/1976	6/20/1977	5	0.100	0.500	0.320
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	3/8/1976	6/20/1977	5	0.100	0.200	0.120
Phosphorus, mg/l	3/8/1976	6/20/1977	5	0.015	0.0450	0.0290
Dissolved oxygen (DO), mg/l	3/8/1976	9/12/1977	7	9	10	9.49
pH, None	3/8/1976	9/12/1977	6	7	8	7.42
Salinity, ppth	3/8/1976	9/12/1977	6	0	1	0.17
Temperature, water, deg C	6/14/1976	9/12/1977	6	18	25	21.97

001138 **Hilo Bay (Canoe Beach) – monitoring is ongoing as of 5/15/05**
Organization: Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19.7258333, longitude: 155.0786111
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	4/23/1990	3/3/2005	337	0.30	740.00	29.13
Clostridium perfringens, #/100ml	4/12/1993	3/3/2005	273	0.20	68.00	4.69
Fecal Coliform, #/100ml	6/19/1973	6/3/1996	71	1.00	1,800.00	79.45
Total Coliform, MPN	4/23/1990	9/21/1992	27	7.00	3,500.00	432.67
Turbidity, mg/l	3/29/2004	3/3/2005	185	1.90	84.30	9.45
Dissolved oxygen (DO), mg/l	1/4/1999	3/3/2005	226	5.50	97.50	19.27
Dissolved oxygen saturation, %	8/11/2003	6/30/2004	40	78.20	100.30	90.06
pH, None	11/12/2002	3/3/2005	77	7.42	8.30	8.09
Salinity, mg/l	3/29/2004	3/15/2004	333	5.65	32.40	23.02
Temperature, water, deg C	1/4/1999	6/30/2004	199	19.90	27.28	24.02

001141 **Hilo Bay (off shore)**
Organization : Hawaii Dept. of Health
primary type Ocean
latitude/longtitude latitude: 19deg. 44min. 43sec. N, longitude: 155deg. 4min. 53sec. W
depth: 55 feet

PARAMETER	FIRST	LAST	COUNT	MIN	MAX	AVG
Enterococcus Group Bacteria, #/100ml	5/18/1987	10/6/1997	83	0.60	350.00	11.22
Clostridium perfringens, #/100ml	7/8/1996	10/6/1997	10	1.00	14.00	2.70
Fecal Coliform, #/100ml	2/11/1980	5/7/1991	349	1.00	1,300.00	27.28
Total Coliform, MPN	10/2/1979	5/7/1991	94	2.00	5,400.00	211.23
Turbidity, NTU	10/2/1979	10/22/2002	429	0.10	171.00	2.02
Secchi disk depth, m	10/2/1979	8/28/1990	92	1.00	15.00	5.41
Total Suspended Solids (TSS), mg/l	10/2/1979	10/6/1997	336	1.00	973.00	41.57
Nitrogen ion (N), mg/l	10/2/1979	10/6/1997	451	0.0100	1.1600	0.2339
Nitrogen, ammonium (NH4) as NH4, mg/l	10/2/1979	10/6/1997	443	0.0000	0.5000	0.0581
Nitrogen, Kjeldahl, mg/l	10/2/1979	10/6/1997	356	0.0000	1.1000	0.2435
Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N, mg/l	10/2/1979	10/6/1997	455	0.0000	0.3300	0.0336
Phosphorus, mg/l	10/2/1979	10/6/1997	503	0.0006	1.2520	0.0267
Phosphorus, orthophosphate as P, mg/l	10/2/1979	10/6/1997	464	0.0000	0.2170	0.0133
Silica, mg/l	8/28/1990	8/29/1994	108	0.10	12.00	1.73
Total Organic Carbon (TOC), mg/l	2/11/1980	8/29/1994	128	0.80	16.80	2.06
Chlorophyll a (probe), ug/l	9/8/1980	10/6/1997	405	0.00	1,375.00	41.08
Dissolved oxygen (DO), mg/l	10/2/1979	10/22/2002	438	4.60	13.20	7.11
pH, None	10/2/1979	10/6/1997	330	6.70	8.40	8.01
Temperature, water, deg C	10/2/1979	10/22/2002	421	20.80	28.00	24.81
Salinity, ppth	10/2/1979	10/22/2002	473	10.70	38.00	30.50

Special Sampling Done to Address Concerns Over Arsenic in Sediment

001140 **Hilo Bay estuary**
Organization : Hawaii Dept. of Health
primary type Estuary
latitude/longtitude latitude: 19deg. 44min. 0sec. N, longitude: 155deg. 4min. 0sec. W
depth: 0 feet

PARAMETER	FIRST	LAST	COUNT
arsenic as,tot ug/l	9/27/1976	9/27/1976	5
arsenic sed mg/kg dry wgt	9/27/1976	4/27/1978	30
cadmium cd,tot ug/l	9/27/1976	9/27/1976	5
cd mud dry wgt mg/kg-cd	9/27/1976	4/27/1978	30
chromium sed mg/kg dry wgt	9/27/1976	4/27/1978	30
chromium cr,tot ug/l	9/27/1976	9/27/1976	5
copper cu,tot ug/l	9/27/1976	9/27/1976	5
copper sed mg/kg dry wgt	9/27/1976	4/27/1978	30
lead pb,tot ug/l	9/27/1976	9/27/1976	5
lead sed mg/kg dry wgt	9/27/1976	4/27/1978	30
nickel ni,Total ug/l	9/27/1976	9/27/1976	5
nickel sed mg/kg dry wgt	9/27/1976	4/27/1978	30
zinc zn,tot ug/l	9/27/1976	9/27/1976	5
zinc sed mg/kg dry wgt	9/27/1976	4/27/1978	30
mercury sed mg/kg dry wgt	9/27/1976	4/27/1978	30

Hilo01 **Hilo Bay #1**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 44min. 40sec. N, longitude: 155deg. 4min. 56sec. W
primary type Ocean
depth 60 ft

PARAMETER	FIRST	LAST	COUNT
water temp cent	9/8/1980	9/10/1980	18
transp secchi meters	9/8/1980	9/10/1980	6
DO mg/l	9/8/1980	9/10/1980	18
DO satur percent	9/8/1980	9/10/1980	18
pH su	9/8/1980	9/10/1980	18
Salinity ppth	9/8/1980	9/10/1980	18
residue tot nflt mg/l	9/8/1980	9/10/1980	18
Total N N mg/l	9/8/1980	9/10/1980	18
NH3+NH4- n Total mg/l	9/8/1980	9/10/1980	18
un-ionzd NH3-N mg/l	9/8/1980	9/10/1980	18
un-ionzd NH3-NH3 mg/l	9/8/1980	9/10/1980	18
tot Kjel N mg/l	9/8/1980	9/10/1980	18
NO2&NO3 N-Total mg/l	9/8/1980	9/10/1980	18
phos-tot mg/l P	9/8/1980	9/10/1980	18
t org c c mg/l	9/8/1980	9/8/1980	2
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
Chlorophyl a ug/l	9/8/1980	9/10/1980	18
phos-t ortho mg/l P	9/8/1980	9/10/1980	16
Turbidity lab NTU	9/8/1980	9/10/1980	18

Hilo02 **Hilo Bay #2**

Organization: Hawaii Dept. of Health

latitude/longtitude latitude: 19deg. 44min. 32sec. N, longitude: 155deg. 5min. 24sec. W

depth: 40 feet (bottom)

PARAMETER	**FIRST**	**LAST**	**COUNT**
Total N N mg/l	9/27/1976	9/27/1976	1
tot Kjel N mg/l	9/27/1976	9/27/1976	1
phos-tot mg/l P	9/27/1976	9/27/1976	1
arsenic sed mg/kg dry wgt	9/27/1976	9/9/1980	4
cd mud dry wgt mg/kg-cd	9/27/1976	9/9/1980	3
chromium sed mg/kg dry wgt	9/27/1976	9/9/1980	4
copper sed mg/kg dry wgt	9/27/1976	9/9/1980	4
lead sed mg/kg dry wgt	9/27/1976	9/9/1980	4
nickel sed mg/kg dry wgt	9/27/1976	9/9/1980	4
zinc sed mg/kg dry wgt	9/27/1976	9/9/1980	4
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
pcp sed ug/kg dry wgt	9/27/1976	9/18/1979	2
chlordan c isomer bot ug/kg	9/18/1979	9/18/1979	1
chlordan t isomer bot ug/kg	9/18/1979	9/18/1979	1
nonachlr t isomer bot ug/kg	9/18/1979	9/18/1979	1
alphabhc sed ug/kg dry wgt	9/18/1979	9/18/1979	1
p,p'ddt sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p' ddt mud dry ug/kg	9/18/1979	9/18/1979	1
p,p'ddd sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p' ddd mud dry ug/kg	9/18/1979	9/18/1979	1
p,p'dde sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p'dde mud ug/kg	9/18/1979	9/18/1979	1
aldrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
dieldrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
endrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
mthxyclr mud dry ug/kg	9/18/1979	9/18/1979	1
PCB-1254 sed ug/kg dry wgt	9/18/1979	9/18/1979	1
lindane mud dry ug/kg	9/18/1979	9/18/1979	1
residue diss-180 c mg/l	9/27/1976	9/27/1976	1
mercury sed mg/kg dry wgt	9/27/1976	9/9/1980	4
Turbidity lab NTU	9/27/1976	9/27/1976	1

Hilo03 **Hilo Bay #3**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 44min. 15sec. N, longitude: 155deg. 4min. 45sec. W
depth: 35 feet

PARAMETER	FIRST	LAST	COUNT
water temp cent	9/8/1980	1/19/1976	18
transp secchi meters	9/8/1980	1/19/1976	6
DO mg/l	9/8/1980	1/19/1976	16
DO satur percent	9/8/1980	3/8/1976	16
pH su	9/8/1980	3/8/1976	18
Salinity ppth	9/8/1980	3/8/1976	18
residue tot nflt mg/l	9/8/1980	6/14/1976	16
Total N N mg/l	9/27/1976	3/8/1976	19
NH3+NH4- n Total mg/l	9/8/1980	3/8/1976	18
un-ionzd NH3-N mg/l	9/8/1980	3/8/1976	18
un-ionzd NH3-NH3 mg/l	9/8/1980	3/8/1976	18
tot Kjel N mg/l	9/27/1976	3/8/1976	19
NO2&NO3 N-Total mg/l	9/27/1976	3/8/1976	19
phos-tot mg/l P	9/27/1976	1/19/1976	19
tot coli mpn conf/100ml	9/27/1976	1/19/1976	1
fec coli mpn ec med/100ml	9/27/1976	1/19/1976	1
residue diss-180 c mg/l	9/27/1976	3/8/1976	1
phos-t ortho mg/l P	9/8/1980	3/8/1976	16
Turbidity lab NTU	9/27/1976	3/8/1976	19

Hilo04 **Hilo Bay #4**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 57sec. N, longitude: 155deg. 5min. 15sec. W
depth: 30 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/27/1976	9/27/1976	1
cd mud dry wgt mg/kg-cd	9/27/1976	9/27/1976	1
chromium sed mg/kg dry wgt	9/27/1976	9/27/1976	1
copper sed mg/kg dry wgt	9/27/1976	9/27/1976	1
lead sed mg/kg dry wgt	9/27/1976	9/27/1976	1
nickel sed mg/kg dry wgt	9/27/1976	9/27/1976	1
zinc sed mg/kg dry wgt	9/27/1976	9/27/1976	1
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
mercury sed mg/kg dry wgt	9/27/1976	9/27/1976	1

Hilo05 **Hilo Bay #5**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 36sec. N, longitude: 155deg. 4min. 26sec. W
depth: 12 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
Total N N mg/l	9/27/1976	9/27/1976	1
tot Kjel N mg/l	9/27/1976	9/27/1976	1
NO2&NO3 N-Total mg/l	9/27/1976	9/27/1976	1
phos-tot mg/l P	9/27/1976	9/27/1976	1
arsenic sed mg/kg dry wgt	9/27/1976	8/11/1986	9
cd mud dry wgt mg/kg-cd	9/27/1976	8/11/1986	8
chromium sed mg/kg dry wgt	9/27/1976	8/11/1986	9
copper sed mg/kg dry wgt	9/27/1976	8/11/1986	9
lead sed mg/kg dry wgt	9/27/1976	8/11/1986	9
nickel sed mg/kg dry wgt	9/27/1976	8/11/1986	9
zinc sed mg/kg dry wgt	9/27/1976	8/11/1986	9
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
pcp sed ug/kg dry wgt	9/27/1976	9/24/1981	3
chlordan c isomer bot ug/kg	9/18/1979	8/12/1986	7
chlordan t isomer bot ug/kg	9/18/1979	8/12/1986	7
nonachlr t isomer bot ug/kg	9/18/1979	8/12/1986	7
alphabhc sed ug/kg dry wgt	9/18/1979	8/12/1986	7
p,p'ddt sed ug/kg dry wgt	9/27/1976	8/12/1986	8
o,p' ddt mud dry ug/kg	9/18/1979	8/12/1986	7
p,p'ddd sed ug/kg dry wgt	9/18/1979	8/12/1986	7
o,p' ddd mud dry ug/kg	9/18/1979	8/12/1986	7
p,p'dde sed ug/kg dry wgt	9/18/1979	8/12/1986	7
o,p'dde mud ug/kg	9/18/1979	8/12/1986	7
aldrin sed ug/kg dry wgt	9/18/1979	8/12/1986	7
dieldrin sed ug/kg dry wgt	9/18/1979	8/12/1986	7
endrin sed ug/kg dry wgt	9/18/1979	8/12/1986	7
mthxyclr mud dry ug/kg	9/18/1979	8/12/1986	7
PCB-1254 sed ug/kg dry wgt	9/18/1979	8/12/1986	7
hcb sed ug/kg dry wgt	9/18/1979	8/12/1986	7
lindane mud dry ug/kg	9/18/1979	8/12/1986	7
residue diss-180 c mg/l	9/27/1976	9/27/1976	1
mercury sed mg/kg dry wgt	9/27/1976	8/11/1986	9
Turbidity lab NTU	9/27/1976	9/27/1976	1

Hilo06 **Hilo Bay #6**

Organization: Hawaii Dept. of Health

latitude/longtitude latitude: 19deg. 44min. 15sec. N, longitude: 155deg. 3min. 43sec. W

depth: 30 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
water temp cent	9/8/1980	9/10/1980	18
transp secchi meters	9/8/1980	9/10/1980	6
DO mg/l	9/8/1980	9/10/1980	18
DO satur percent	9/8/1980	9/10/1980	18
pH su	9/8/1980	9/10/1980	18
Salinity ppth	9/8/1980	9/10/1980	18
residue tot nflt mg/l	9/8/1980	9/10/1980	18
Total N N mg/l	9/27/1976	9/10/1980	17
NH3+NH4- n Total mg/l	9/8/1980	9/10/1980	18
un-ionzd NH3-N mg/l	9/8/1980	9/10/1980	18
un-ionzd NH3-NH3 mg/l	9/8/1980	9/10/1980	18
tot Kjel N mg/l	9/27/1976	9/10/1980	19
NO2&NO3 N-Total mg/l	9/27/1976	9/10/1980	19
phos-tot mg/l P	9/27/1976	9/10/1980	19
arsenic sed mg/kg dry wgt	9/27/1976	8/11/1986	9
cd mud dry wgt mg/kg-cd	9/27/1976	8/11/1986	8
chromium sed mg/kg dry wgt	9/27/1976	8/11/1986	8
copper sed mg/kg dry wgt	9/27/1976	8/11/1986	9
lead sed mg/kg dry wgt	9/27/1976	8/11/1986	9
nickel sed mg/kg dry wgt	9/27/1976	8/11/1986	9
zinc sed mg/kg dry wgt	9/27/1976	8/11/1986	9
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
pcp sed ug/kg dry wgt	9/18/1979	9/24/1981	2
chlordan c isomer bot ug/kg	9/18/1979	8/12/1986	7
chlordan t isomer bot ug/kg	9/18/1979	8/12/1986	7
nonachlr t isomer bot ug/kg	9/18/1979	8/12/1986	7
alphabhc sed ug/kg dry wgt	9/18/1979	8/12/1986	7
p,p'ddt sed ug/kg dry wgt	9/18/1979	8/12/1986	7
o,p' ddt mud dry ug/kg	9/18/1979	8/12/1986	7
p,p'ddd sed ug/kg dry wgt	9/18/1979	8/12/1986	7
o,p' ddd mud dry ug/kg	9/18/1979	8/12/1986	7
p,p'dde sed ug/kg dry wgt	9/18/1979	8/12/1986	7
o,p'dde mud ug/kg	9/18/1979	8/12/1986	7
aldrin sed ug/kg dry wgt	9/18/1979	8/12/1986	7
dieldrin sed ug/kg dry wgt	9/18/1979	8/12/1986	7
endrin sed ug/kg dry wgt	9/18/1979	8/12/1986	7
mthxyclr mud dry ug/kg	9/18/1979	8/12/1986	7
PCB-1254 sed ug/kg dry wgt	9/18/1979	8/12/1986	7
hcb sed ug/kg dry wgt	9/18/1979	8/12/1986	7
lindane mud dry ug/kg	9/18/1979	8/12/1986	7
residue diss-180 c mg/l	9/27/1976	9/27/1976	1
phos-t ortho mg/l P	9/8/1980	9/10/1980	18

mercury sed mg/kg dry wgt	9/27/1976	8/11/1986	9
Turbidity lab NTU	9/27/1976	9/10/1980	19

Hilo07 **Hilo Bay #7**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 58sec. N, longitude: 155deg. 3min. 33sec. W
depth: 20 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
Total N N mg/l	9/27/1976	9/27/1976	1
tot Kjel N mg/l	9/27/1976	9/27/1976	1
NO2&NO3 N-Total mg/l	9/27/1976	9/27/1976	1
phos-tot mg/l P	9/27/1976	9/27/1976	1
arsenic sed mg/kg dry wgt	9/27/1976	9/8/1980	2
cd mud dry wgt mg/kg-cd	9/27/1976	9/8/1980	2
chromium sed mg/kg dry wgt	9/27/1976	9/8/1980	2
copper sed mg/kg dry wgt	9/27/1976	9/8/1980	2

Hilo07 **Hilo Bay #7 continued…**

PARAMETER	FIRST	LAST	COUNT
lead sed mg/kg dry wgt	9/27/1976	9/8/1980	2
nickel sed mg/kg dry wgt	9/27/1976	9/8/1980	2
zinc sed mg/kg dry wgt	9/27/1976	9/8/1980	2
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
pcp sed ug/kg dry wgt	9/26/1976	9/18/1979	2
chlordan c isomer bot ug/kg	9/18/1979	9/18/1979	1
chlordan t isomer bot ug/kg	9/18/1979	9/18/1979	1
nonachlr t isomer bot ug/kg	9/18/1979	9/18/1979	1
alphabhc sed ug/kg dry wgt	9/18/1979	9/18/1979	1
p,p'ddt sed ug/kg dry wgt	9/26/1976	9/18/1979	2
o,p' ddt mud dry ug/kg	9/26/1976	9/18/1979	2
p,p'ddd sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p' ddd mud dry ug/kg	9/18/1979	9/18/1979	1
p,p'dde sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p'dde mud ug/kg	9/18/1979	9/18/1979	1
aldrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
dieldrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
endrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
mthxyclr mud dry ug/kg	9/18/1979	9/18/1979	1
PCB-1254 sed ug/kg dry wgt	9/18/1979	9/18/1979	1
hcb sed ug/kg dry wgt	9/18/1979	9/18/1979	1
lindane mud dry ug/kg	9/18/1979	9/18/1979	1
residue diss-180 c mg/l	9/27/1976	9/27/1976	1
mercury sed mg/kg dry wgt	9/27/1976	9/8/1980	2
Turbidity lab NTU	9/27/1976	9/27/1976	1

Hilo08 **Hilo Bay #8 (Wailuku River mouth)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 53sec. N, longitude: 155deg. 5min. 25sec. W
depth: 20 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
Total N N mg/l	9/27/1976	9/27/1976	1
tot Kjel N mg/l	9/27/1976	9/27/1976	1
NO2&NO3 N-Total mg/l	9/27/1976	9/27/1976	1
phos-tot mg/l P	9/27/1976	9/27/1976	1
arsenic sed mg/kg dry wgt	9/27/1976	9/27/1976	1
cd mud dry wgt mg/kg-cd	9/27/1976	9/27/1976	1
chromium sed mg/kg dry wgt	9/27/1976	9/27/1976	1
chromium cr,tot ug/l	9/27/1976	9/27/1976	1
copper sed mg/kg dry wgt	9/27/1976	9/27/1976	1
lead sed mg/kg dry wgt	9/27/1976	9/27/1976	1
nickel sed mg/kg dry wgt	9/27/1976	9/27/1976	1
zinc sed mg/kg dry wgt	9/27/1976	9/27/1976	1
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
fec strep mpn tubecode	9/27/1976	9/27/1976	1
residue diss-180 c mg/l	9/27/1976	9/27/1976	1
mercury sed mg/kg dry wgt	9/27/1976	9/27/1976	1
Turbidity lab NTU	9/27/1976	9/27/1976	1

Hilo09 **Hilo Bay #9 (Mooheau Park)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 36sec. N, longitude: 155deg. 5min. 4sec. W
depth: 1 foot (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/18/1979	9/18/1979	1
cd mud dry wgt mg/kg-cd	9/18/1979	9/18/1979	1
chromium sed mg/kg dry wgt	9/18/1979	9/18/1979	1
copper sed mg/kg dry wgt	9/18/1979	9/18/1979	1
lead sed mg/kg dry wgt	9/18/1979	9/18/1979	1
nickel sed mg/kg dry wgt	9/18/1979	9/18/1979	1
zinc sed mg/kg dry wgt	9/18/1979	9/18/1979	1
mercury sed mg/kg dry wgt	9/18/1979	9/18/1979	1

Hilo10 **Hilo Bay #10 (Wailoa River boat ramp)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 27sec. N, longitude: 155deg. 4min. 27sec. W
depth: 5 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/27/1976	9/8/1980	5
cd mud dry wgt mg/kg-cd	9/27/1976	9/8/1980	4
chromium sed mg/kg dry wgt	9/27/1976	9/8/1980	5
copper sed mg/kg dry wgt	9/27/1976	9/8/1980	5
lead sed mg/kg dry wgt	9/27/1976	9/8/1980	5
nickel sed mg/kg dry wgt	9/27/1976	9/8/1980	5
zinc sed mg/kg dry wgt	9/27/1976	9/8/1980	5
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
blfec strep mpn tubecode	9/27/1976	9/27/1976	1
pcp sed ug/kg dry wgt	9/27/1976	9/18/1979	3
chlordan c isomer bot ug/kg	4/27/1978	9/18/1979	2
chlordan t isomer bot ug/kg	4/27/1978	9/18/1979	2
nonachlr t isomer bot ug/kg	4/27/1978	9/18/1979	2
alphabhc sed ug/kg dry wgt	4/27/1978	9/18/1979	2
p,p'ddt sed ug/kg dry wgt	4/27/1978	9/18/1979	2
o,p' ddt mud dry ug/kg	4/27/1978	9/18/1979	2
p,p'ddd sed ug/kg dry wgt	9/27/1976	9/18/1979	3
o,p' ddd mud dry ug/kg	4/27/1978	9/18/1979	2
p,p'dde sed ug/kg dry wgt	9/27/1976	9/18/1979	3
o,p'dde mud ug/kg	4/27/1978	9/18/1979	2
aldrin sed ug/kg dry wgt	4/27/1978	9/18/1979	2
dieldrin sed ug/kg dry wgt	9/27/1976	9/18/1979	3
endrin sed ug/kg dry wgt	4/27/1978	9/18/1979	2
mthxyclr mud dry ug/kg	4/27/1978	9/18/1979	2
PCB-1254 sed ug/kg dry wgt	4/27/1978	9/18/1979	2
lindane mud dry ug/kg	4/27/1978	9/18/1979	2
mercury sed mg/kg dry wgt	9/27/1976	9/8/1980	5
ratio fec col fec strp	9/27/1976	9/27/1976	1

Hilo11 **Hilo Bay #11 (Wailoa River)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 33sec. N, longitude: 155deg. 4min. 25sec. W
depth: 5 feet

PARAMETER	FIRST	LAST	COUNT
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
fec strep mpn tubecode	9/27/1976	9/27/1976	1
ratio fec col fec strp	9/27/1976	9/27/1976	1

Hilo12 **Hilo Bay #12**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 44min. 15sec. N, longitude: 155deg. 3min. 25sec. W
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1

Hilo13 **Hilo Bay #13 (puhi Bay #3)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 44min. 6sec. N, longitude: 155deg. 3min. 3sec. W
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1
fec strep mpn tubecode	9/27/1976	9/27/1976	1
ratio fec col fec strp	9/27/1976	9/27/1976	1

Hilo15 **Hilo Bay #15 (Honolii cove)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 45min. 32sec. N, longitude: 155deg. 5min. 40sec. W
depth: 1 foot

PARAMETER	FIRST	LAST	COUNT
tot coli mpn conf/100ml	9/27/1976	9/27/1976	1
fec coli mpn ec med/100ml	9/27/1976	9/27/1976	1

Hilo17 **Hilo Bay #17 (Wailoa River)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 24sec. N, longitude: 155deg. 4min. 32sec. W
depth: 3 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/20/1977	9/8/1980	3
cd mud dry wgt mg/kg-cd	9/18/1979	9/8/1980	2
chromium sed mg/kg dry wgt	9/20/1977	9/8/1980	3
copper sed mg/kg dry wgt	9/20/1977	9/8/1980	3
lead sed mg/kg dry wgt	9/20/1977	9/8/1980	3
nickel sed mg/kg dry wgt	9/20/1977	9/8/1980	3
zinc sed mg/kg dry wgt	9/20/1977	9/8/1980	3
pcp sed ug/kg dry wgt	9/18/1979	9/18/1979	1
chlordan c isomer bot ug/kg	9/18/1979	9/18/1979	1
chlordan t isomer bot ug/kg	9/18/1979	9/18/1979	1
nonachlr t isomer bot ug/kg	9/18/1979	9/18/1979	1
alphabhc sed ug/kg dry wgt	9/18/1979	9/18/1979	1
p,p'ddt sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p' ddt mud dry ug/kg	9/18/1979	9/18/1979	1
p,p'ddd sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p' ddd mud dry ug/kg	9/18/1979	9/18/1979	1

PARAMETER	FIRST	LAST	COUNT
p,p'dde sed ug/kg dry wgt	9/18/1979	9/18/1979	1
o,p'dde mud ug/kg	9/18/1979	9/18/1979	1
aldrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
dieldrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
endrin sed ug/kg dry wgt	9/18/1979	9/18/1979	1
mthxyclr mud dry ug/kg	9/18/1979	9/18/1979	1
PCB-1254 sed ug/kg dry wgt	9/18/1979	9/18/1979	1
hcb sed ug/kg dry wgt	9/18/1979	9/18/1979	1
lindane mud dry ug/kg	9/18/1979	9/18/1979	1
mercury sed mg/kg dry wgt	9/20/1977	9/8/1980	3

Hilo18 **Hilo Bay #18 (Wailoa River)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 24sec. N, longitude: 155deg. 4min. 37sec. W
depth: 3 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/20/1977	8/11/1986	9
cd mud dry wgt mg/kg-cd	4/27/1978	8/11/1986	8
chromium sed mg/kg dry wgt	9/20/1977	8/11/1986	9
copper sed mg/kg dry wgt	9/20/1977	8/11/1986	9
lead sed mg/kg dry wgt	9/20/1977	8/11/1986	9
nickel sed mg/kg dry wgt	9/20/1977	8/11/1986	9
zinc sed mg/kg dry wgt	9/20/1977	8/11/1986	9
pcp sed ug/kg dry wgt	4/27/1978	9/23/1981	3
chlordan c isomer bot ug/kg	4/27/1978	8/12/1986	8
chlordan t isomer bot ug/kg	4/27/1978	8/12/1986	8
nonachlr t isomer bot ug/kg	4/27/1978	8/12/1986	8
alphabhc sed ug/kg dry wgt	4/27/1978	8/12/1986	7
p,p'ddt sed ug/kg dry wgt	4/27/1978	8/12/1986	8
o,p' ddt mud dry ug/kg	4/27/1978	8/12/1986	8
p,p'ddd sed ug/kg dry wgt	4/27/1978	8/12/1986	8
o,p' ddd mud dry ug/kg	4/27/1978	8/12/1986	7
p,p'dde sed ug/kg dry wgt	4/27/1978	8/12/1986	7
o,p'dde mud ug/kg	4/27/1978	8/12/1986	7
aldrin sed ug/kg dry wgt	4/27/1978	8/12/1986	7
dieldrin sed ug/kg dry wgt	4/27/1978	8/12/1986	7
endrin sed ug/kg dry wgt	4/27/1978	8/12/1986	8
mthxyclr mud dry ug/kg	4/27/1978	8/12/1986	8
PCB-1254 sed ug/kg dry wgt	4/27/1978	8/12/1986	7
hcb sed ug/kg dry wgt	9/18/1979	8/12/1986	7
lindane mud dry ug/kg	4/27/1978	8/12/1986	8
mercury sed mg/kg dry wgt	9/20/1977	8/11/1986	9

Hilo19 **Hilo Bay #19 (Wailoa River)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 23sec. N, longitude: 155deg. 4min. 43sec. srsid13459886w
depth: 3 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/20/1977	9/8/1980	9
cd mud dry wgt mg/kg-cd	4/27/1978	9/8/1980	8
chromium sed mg/kg dry wgt	9/20/1977	9/8/1980	9
copper sed mg/kg dry wgt	9/20/1977	9/8/1980	9
lead sed mg/kg dry wgt	9/20/1977	9/8/1980	9
nickel sed mg/kg dry wgt	9/20/1977	9/8/1980	11
zinc sed mg/kg dry wgt	9/20/1977	9/8/1980	11
pcp sed ug/kg dry wgt	9/20/1977	9/18/1979	8
chlordan c isomer bot ug/kg	9/20/1977	9/18/1979	8
chlordan t isomer bot ug/kg	9/20/1977	9/18/1979	8
nonachlr t isomer bot ug/kg	9/20/1977	9/18/1979	8
alphabhc sed ug/kg dry wgt	9/20/1977	9/18/1979	8

p,p'ddt sed ug/kg dry wgt	9/20/1977	9/18/1979	8
o,p' ddt mud dry ug/kg	9/20/1977	9/18/1979	8
p,p'ddd sed ug/kg dry wgt	9/20/1977	9/18/1979	8
o,p' ddd mud dry ug/kg	9/20/1977	9/18/1979	8
p,p'dde sed ug/kg dry wgt	9/20/1977	9/18/1979	8
o,p'dde mud ug/kg	9/20/1977	9/18/1979	8
aldrin sed ug/kg dry wgt	9/20/1977	9/18/1979	8
dieldrin sed ug/kg dry wgt	9/20/1977	9/18/1979	8
endrin sed ug/kg dry wgt	9/20/1977	9/18/1979	8
mthxyclr mud dry ug/kg	9/20/1977	9/18/1979	8
PCB-1254 sed ug/kg dry wgt	9/20/1977	9/18/1979	8
lindane mud dry ug/kg	9/20/1977	9/18/1979	8
mercury sed mg/kg dry wgt	9/20/1977	9/8/1980	11

Hilo20 **Hilo Bay #20 (Waiakea Pond)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 7sec. N, longitude: 155deg. 4min. 43sec. W
depth: 3 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/20/1977	8/12/1986	13
cd mud dry wgt mg/kg-cd	4/27/1978	8/12/1986	12
chromium sed mg/kg dry wgt	9/20/1977	8/12/1986	13
copper sed mg/kg dry wgt	9/20/1977	8/12/1986	13
lead sed mg/kg dry wgt	9/20/1977	8/12/1986	13
nickel sed mg/kg dry wgt	9/20/1977	8/12/1986	13
zinc sed mg/kg dry wgt	9/20/1977	8/12/1986	13
pcp sed ug/kg dry wgt	9/20/1977	9/23/1981	9
chlordan c isomer bot ug/kg	9/20/1977	8/12/1986	14
chlordan t isomer bot ug/kg	9/20/1977	8/12/1986	14
nonachlr t isomer bot ug/kg	9/20/1977	8/12/1986	14
alphabhc sed ug/kg dry wgt	9/20/1977	8/12/1986	14
p,p'ddt sed ug/kg dry wgt	9/20/1977	8/12/1986	14
o,p' ddt mud dry ug/kg	9/20/1977	8/12/1986	14
p,p'ddd sed ug/kg dry wgt	9/20/1977	8/12/1986	14
o,p' ddd mud dry ug/kg	9/20/1977	8/12/1986	14
p,p'dde sed ug/kg dry wgt	9/20/1977	8/12/1986	14
o,p'dde mud ug/kg	9/20/1977	8/12/1986	14
aldrin sed ug/kg dry wgt	9/20/1977	8/12/1986	14
dieldrin sed ug/kg dry wgt	9/20/1977	8/12/1986	14
endrin sed ug/kg dry wgt	9/20/1977	8/12/1986	14
mthxyclr mud dry ug/kg	9/20/1977	8/12/1986	14
PCB-1254 sed ug/kg dry wgt	9/20/1977	8/12/1986	14
hcb sed ug/kg dry wgt	9/23/1981	8/12/1986	6
lindane mud dry ug/kg	9/20/1977	8/12/1986	14
mercury sed mg/kg dry wgt	9/20/1977	8/12/1986	13

Hilo21 **Hilo Bay #21 (Waiakea Pond)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 5sec. N, longitude: 155deg. 4min. 36sec. W
depth: 10 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/20/1977	8/12/1986	14
cd mud dry wgt mg/kg-cd	4/27/1978	8/12/1986	13
chromium sed mg/kg dry wgt	9/20/1977	8/12/1986	14
copper sed mg/kg dry wgt	9/20/1977	8/12/1986	14
lead sed mg/kg dry wgt	9/20/1977	8/12/1986	14
nickel sed mg/kg dry wgt	9/20/1977	8/12/1986	14
zinc sed mg/kg dry wgt	9/20/1977	8/12/1986	14
pcp sed ug/kg dry wgt	9/20/1977	9/23/1981	9
chlordan c isomer bot ug/kg	9/20/1977	8/12/1986	13
chlordan t isomer bot ug/kg	9/20/1977	8/12/1986	13
nonachlr t isomer bot ug/kg	9/20/1977	8/12/1986	13
alphabhc sed ug/kg dry wgt	9/20/1977	8/12/1985	12
p,p'ddt sed ug/kg dry wgt	9/20/1977	8/12/1986	13
o,p' ddt mud dry ug/kg	9/20/1977	8/12/1986	13
p,p'ddd sed ug/kg dry wgt	9/20/1977	8/12/1986	13
o,p' ddd mud dry ug/kg	9/20/1977	8/12/1985	12
p,p'dde sed ug/kg dry wgt	9/20/1977	8/12/1985	12
o,p'dde mud ug/kg	9/20/1977	8/12/1985	12
aldrin sed ug/kg dry wgt	9/20/1977	8/12/1985	12
dieldrin sed ug/kg dry wgt	9/20/1977	8/12/1985	12
endrin sed ug/kg dry wgt	9/20/1977	8/12/1986	13
mthxyclr mud dry ug/kg	9/20/1977	8/12/1986	13
PCB-1248 sed ug/kg dry wgt	4/27/1978	4/27/1978	2
PCB-1254 sed ug/kg dry wgt	9/20/1977	8/12/1985	10
hcb sed ug/kg dry wgt	9/23/1981	8/12/1986	5
lindane mud dry ug/kg	9/20/1977	8/12/1986	13
mercury sed mg/kg dry wgt	9/20/1977	8/12/1986	14

Hilo22 **Hilo Bay #22 (Waiakea Pond)**
Organization: Hawaii Dept. of Health
latitude/longtitude latitude: 19deg. 43min. 1sec. N, longitude: 155deg. 4min. 45sec. W
depth: 6 feet (bottom)

PARAMETER	FIRST	LAST	COUNT
arsenic sed mg/kg dry wgt	9/18/1979	4/27/1987	13
cd mud dry wgt mg/kg-cd	9/18/1979	4/27/1987	13
chromium sed mg/kg dry wgt	9/18/1979	4/27/1987	13
copper sed mg/kg dry wgt	9/18/1979	4/27/1987	13
lead sed mg/kg dry wgt	9/18/1979	4/27/1987	13
nickel sed mg/kg dry wgt	9/18/1979	4/27/1987	13
zinc sed mg/kg dry wgt	9/18/1979	4/27/1987	13
pcp sed ug/kg dry wgt	4/27/1978	9/23/1981	8
chlordan c isomer bot ug/kg	4/27/1978	8/12/1986	13
chlordan t isomer bot ug/kg	4/27/1978	8/12/1986	13
nonachlr t isomer bot ug/kg	4/27/1978	8/12/1986	13
alphabhc sed ug/kg dry wgt	4/27/1978	8/12/1986	12

p,p'ddt sed ug/kg dry wgt	4/27/1978	8/12/1986	13
o,p' ddt mud dry ug/kg	4/27/1978	8/12/1986	13
p,p'ddd sed ug/kg dry wgt	4/27/1978	8/12/1986	13
o,p' ddd mud dry ug/kg	4/27/1978	8/12/1986	12
p,p'dde sed ug/kg dry wgt	4/27/1978	8/12/1986	12
o,p'dde mud ug/kg	4/27/1978	8/12/1986	12
aldrin sed ug/kg dry wgt	4/27/1978	8/12/1986	12
dieldrin sed ug/kg dry wgt	4/27/1978	8/12/1986	11
endrin sed ug/kg dry wgt	4/27/1978	8/12/1986	13
mthxyclr mud dry ug/kg	4/27/1978	8/12/1986	13
PCB-1254 sed ug/kg dry wgt	4/27/1978	8/12/1986	12
hcb sed ug/kg dry wgt	8/12/1986	8/12/1986	1
lindane mud dry ug/kg	4/27/1978	8/12/1986	13
mercury sed mg/kg dry wgt	9/18/1979	4/27/1987	13

2037 **Honolii Stream @ Hilo**
Organization : USEPA mdsd
latitude/longtitude latitude: 19deg. 46min. 15sec. N, longitude: 155deg. 5min. 33sec. W

PARAMETER	FIRST	LAST	COUNT
field ident number	08-01-1984	08-01-1984	2
pcd12378 dioxin tis pg/g	08-01-1984	08-01-1984	2
hcd12347 8 dioxin tis pg/g	08-01-1984	08-01-1984	2
hcd12367 8 dioxin tis pg/g	08-01-1984	08-01-1984	2
hcd12378 9 dioxin tis pg/g	08-01-1984	08-01-1984	2
hcd12346 78 dioxin fishpg/g	08-01-1984	08-01-1984	2
tcd2378 furan tis pg/g	08-01-1984	08-01-1984	2
pcd12378 furan tis pg/g	08-01-1984	08-01-1984	2
pcd23478 furan tis pg/g	08-01-1984	08-01-1984	2
hcd12347 8 furan tis pg/g	08-01-1984	08-01-1984	2
hcd12367 8 furan tis pg/g	08-01-1984	08-01-1984	2
hcd12378 9 furan tis pg/g	08-01-1984	08-01-1984	2
hcd23467 8 furan tis pg/g	08-01-1984	08-01-1984	2
hcd12346 78 furan tis pg/g	08-01-1984	08-01-1984	2
hcd12347 89 furan tis pg/g	08-01-1984	08-01-1984	2
hexclbd tis mg/kg wet wgt	08-01-1984	08-01-1984	1
124tcben tis mg/kg wet wgt	08-01-1984	08-01-1984	1
endrin tis mg/kg wet wgt	08-01-1984	08-01-1984	1
hpchlrep tis mg/kg wet wgt	08-01-1984	08-01-1984	1
heptchlr tis mg/kg wet wgt	08-01-1984	08-01-1984	1
hcb tis mg/kg wet wgt	08-01-1984	08-01-1984	1
tcdd tispg/g wetwgt	08-01-1984	08-01-1984	2
isopropa lin tis mg/kg	08-01-1984	08-01-1984	1
chlordan c isomer tis-ug/g	08-01-1984	08-01-1984	1
chlordan t isomer tis-ug/g	08-01-1984	08-01-1984	1
alphabhc tis mg/kg wet wgt	08-01-1984	08-01-1984	1
mnclbipn tot tis wet mg/kg	08-01-1984	08-01-1984	1
p p'dde tis mg/kg wet mg/kg	08-01-1984	08-01-1984	1
diclbipn tot tis wet mg/kg	08-01-1984	08-01-1984	1
triclbpn tot tis wet mg/kg	08-01-1984	08-01-1984	1
tetclbpn tot tis wet mg/kg	08-01-1984	08-01-1984	1
peclbipn tot tis wet mg/kg	08-01-1984	08-01-1984	1
hpclbipn tot tis wet mg/kg	08-01-1984	08-01-1984	1
octclbpn tot tis wet mg/kg	08-01-1984	08-01-1984	1
dieldrin tis mg/kg wet wgt	08-01-1984	08-01-1984	1

nclbipnl tot tis wet mg/kg	08-01-1984	08-01-1984	1
dcdlbipn tot tis wet mg/kg	08-01-1984	08-01-1984	1
gbhc-tis lindane wet mg/kg	08-01-1984	08-01-1984	1
pcnb tis wet mg/kg	08-01-1984	08-01-1984	1
instrmnt lab/fld ratio num	08-01-1984	08-01-1984	2
mercury fish ppm-wet	08-01-1984	08-01-1984	2
fish species numeric	08-01-1984	08-01-1984	2
anatomy code	08-01-1984	08-01-1984	2
biphenyl tiss wet wgt mg/kg	08-01-1984	08-01-1984	1
hexclbph fish tis wet mg/kg	08-01-1984	08-01-1984	1
nonachlr trns tis wet mg/kg	08-01-1984	08-01-1984	1
nonachlr cis tis wet mg/kg	08-01-1984	08-01-1984	1
1234tet clrbenz tis mg/kg	08-01-1984	08-01-1984	1
PCBs fish wet wgt mg/kg	08-01-1984	08-01-1984	1
mtxchlor fish wet wgt ug/g	08-01-1984	08-01-1984	1
mirex f ish wetw gt ug/g	08-01-1984	08-01-1984	1
treflan fish wet wgt mg/kg	08-01-1984	08-01-1984	1
dursban fish wet wgt mg/kg	08-01-1984	08-01-1984	1
pca fish tis wet wgt mg/kg	08-01-1984	08-01-1984	1
oxychlrd tiss wet mg/kg	08-01-1984	08-01-1984	1
fish species f &wl	08-01-1984	08-01-1984	2
anatomy alpha code	08-01-1984	08-01-1984	2
dioxin study alphacod	08-01-1984	08-01-1984	2
triclben 135tis wet mg/kg	08-01-1984	08-01-1984	1
triclben 123tis wet mg/kg	08-01-1984	08-01-1984	1
tetclben 1245tis wet mg/kg	08-01-1984	08-01-1984	1
tetclben 1235tis wet mg/kg	08-01-1984	08-01-1984	1
penclben tis wet wt	08-01-1984	08-01-1984	1
dipndisu tis wet wt	08-01-1984	08-01-1984	1
octclsty tis wet wt	08-01-1984	08-01-1984	1
Nitrofen tis wet wt	08-01-1984	08-01-1984	1
perthane tis wet wt	08-01-1984	08-01-1984	1
dicofol tis wet wt	08-01-1984	08-01-1984	1

000076 **Hilo Bay**
Organization: USEPA Region IX wtr-2
latitude/longtitude latitude: 19deg. 44min. 30sec. N, longitude: 155deg. 4min. 50sec. W
station type indicator description: surface water
legacy storet station type: /typa/ambnt/estury
summary: wide range of toxic substances just a few samples analyzed over the period 1980-1987

PARAMETER	FIRST	LAST	COUNT
toxics epa iden fy	09-08-1980	09-08-1980	1
arsenic sed mg/kg dry wgt	09-08-1980	09-15-1987	4
arsenic tis mg/kg wet wgt	09-09-1980	09-04-1984	4
berylium sed mg/kg dry wgt	09-08-1980	09-15-1987	4
cd mud dry wgt mg/kg-cd	09-08-1980	09-04-1984	3
chromium sed mg/kg dry wgt	09-08-1980	09-15-1987	4
copper sed mg/kg dry wgt	09-08-1980	09-15-1987	4
lead sed mg/kg dry wgt	09-08-1980	09-15-1987	4
nickel sed mg/kg dry wgt	09-08-1980	09-15-1987	4
nickel tis mg/kg wet wgt	09-19-1983	09-16-1987	5
thallium tis-wet mg/kg	09-19-1983	09-16-1987	5
silver sed mg/kg dry wgt	09-19-1983	09-15-1987	3
zinc sed mg/kg dry wgt	09-08-1980	09-15-1987	4
antimony sed mg/kg dry wgt	09-08-1980	09-15-1987	4
antimony tis-wet mg/kg	09-09-1980	09-16-1987	6
selenium sed mg/kg dry wgt	09-19-1983	09-15-1987	3
selenium tis mg/kg wet wgt	09-19-1983	09-16-1987	5
diclbrmt tot ug/l	09-08-1980	09-19-1983	2
carbn tet tot ug/l	09-08-1980	09-19-1983	2
12diclet tot ug/l	09-08-1980	09-19-1983	2
bromofrm whl-wtr ug/l	09-08-1980	09-19-1983	2
cldibrmt tot ug/l	09-08-1980	09-19-1983	2
chlrform tot ug/l	09-08-1980	09-19-1983	2
toluene tot ug/l	09-08-1980	09-19-1983	2
benzene tot ug/l	09-08-1980	09-19-1983	2
acenapht hylene tot wug/l	09-08-1980	09-04-1984	3
acnapthy ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
acnapthy tis mg/kg wet wgt	09-09-1980	09-04-1984	4
acenapht hene tot wug/l	09-08-1980	09-04-1984	3
acnapthe ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
acnapthe tis mg/kg wet wgt	09-09-1980	09-09-1980	1
acrolein tot wug/l	09-08-1980	09-19-1983	2
acrolein ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
acrolein tis mg/kg wet wgt	09-09-1980	09-19-1983	4
acrylonitrile tot wug/l	09-08-1980	09-19-1983	2
acrylnit ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
acrylnit tis mg/kg wet wgt	09-09-1980	09-19-1983	4
anthrace ne tot wug/l	09-08-1980	09-04-1984	3
anthrace ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
anthrace tis mg/kg wet wgt	09-09-1980	09-04-1984	4
benzbflu orant Total ug/l	09-08-1980	09-04-1984	3
benzbflu orantmud dryug/kg	09-10-1980	09-04-1984	3
benzbflu oranttis wetmg/kg	09-09-1980	09-04-1984	4
benzene ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
benzene tis mg/kg wet wgt	09-09-1980	09-19-1983	4
benzidin tis mg/kg wet wgt	09-09-1980	09-04-1984	4
benzo(k) fluorant tot wug/l	09-08-1980	09-04-1984	3
benzkflu ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
benzkflu tis mg/kg wet wgt	09-09-1980	09-04-1984	4
benzo(a) pyrene tot wug/l	09-08-1980	09-04-1984	3
benzapyr ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
benzapyr tis mg/kg wet wgt	09-09-1980	09-04-1984	4

berylium tis mg/kg wet wgt	09-09-1980	09-16-1987	6
beta bhc ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
beta bhc tis mg/kg wet wgt	09-09-1980	09-16-1987	7
deltabhc tot ug/l	09-08-1980	09-04-1984	3
deltabhc ssed ug/kg dry wgt	09-10-1980	09-15-1987	2

deltabhc tis mg/kg wet wgt	09-09-1980	09-16-1987	7
bis2chlo roethyle tot wug/l	09-08-1980	09-04-1984	3
b2cetetr ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
b2cetetr tis mg/kg wet wgt	09-09-1980	09-04-1984	4
bis2chlo roethoxy tot wug/l	09-08-1980	09-04-1984	3
b2cetoxm ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
b2cetoxm tis mg/kg wet wgt	09-09-1980	09-04-1984	4
bis2chlo roisopro tot wug/l	09-08-1980	09-04-1984	3
b2cipetr ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
b2cipetr tis mg/kg wet wgt	09-09-1980	09-04-1984	4
bromofor ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
bromofor tis mg/kg wet wgt	09-09-1980	09-19-1983	4
nbb phth Total ug/l	09-08-1980	09-04-1984	3
nbb phth mud-dry ug/kg	09-10-1980	09-04-1984	3
nbb phth tis-wet mg/kg	09-09-1980	09-04-1984	4
carbn tet ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
carbn tet tis mg/kg wet wgt	09-09-1980	09-19-1983	4
Chlorobe nzene tot wug/l	09-08-1980	09-19-1983	2
clbenzen ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
clbenzen tis mg/kg wet wgt	09-09-1980	09-19-1983	4
cldibrmt ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
cldibrmt tis mg/kg wet wgt	09-09-1980	09-19-1983	4
Chloroethane tot wug/l	09-08-1980	09-19-1983	2
clethane ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
clethane tis mg/kg wet wgt	09-09-1980	09-19-1983	4
chlrform ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
chlrform tis mg/kg wet wgt	09-09-1980	09-19-1983	4
chrysene tot wug/l	09-08-1980	09-04-1984	3
tblchrysene ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
chrysene tis mg/kg wet wgt	09-09-1980	09-04-1984	4
diclbrmt ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
diclbrmt tis mg/kg wet wgt	09-09-1980	09-19-1983	4
dcldflmt tis mg/kg wet wgt	09-09-1980	09-09-1980	1
diethylphthalate tot wug/l	09-08-1980	09-04-1984	3
dethphth ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
dethphth tis mg/kg wet wgt	09-09-1980	09-04-1984	4
dimethyphthalat tot wug/l	09-08-1980	09-04-1984	3
dmetphth ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
dmetphth tis mg/kg wet wgt	09-09-1980	09-04-1984	4
12diphen ylhydraz tot wug/l	09-08-1980	09-04-1984	3
12dphnhy ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
12dphnhy tis mg/kg wet wgt	09-09-1980	09-04-1984	4
endsulsf tot ug/l	09-08-1980	09-04-1984	3
endsulsf ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
endsulsf tis mg/kg wet wgt	09-09-1980	09-16-1987	7
b-endo sulfan tot wug/l	09-08-1980	09-04-1984	3
b-endosul ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
b-endosul tis mg/kg wet wgt	09-09-1980	09-16-1987	6
a-endo sulfan tot wug/l	09-08-1980	09-04-1984	3
aendosul ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
aendosul tis mg/kg wet wgt	09-09-1980	09-16-1987	7
endrinal dehyde tot wug/l	09-08-1980	09-04-1984	4
endrinal ssed ug/kg dry wgt	09-08-1980	09-10-1980	2

endrinal tis mg/kg wet wgt	09-09-1980	09-04-1984	4
ethylbenzene tot wug/l	09-08-1980	09-19-1983	2
ethylben ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
ethylben tis mg/kg wet wgt	09-09-1980	09-19-1983	4
fluorant hene tot wug/l	09-08-1980	09-04-1984	3
flantene ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
flantene tis mg/kg wet wgt	09-09-1980	09-04-1984	4
fluorene tot wug/l	09-08-1980	09-04-1984	3
fluorene ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
fluorene tis mg/kg wet wgt	09-09-1980	09-04-1984	4
hexachlo rocyclop tot wug/l	09-08-1980	09-04-1984	3
hexclcpd ssed ug/kg dry wgt	09-10-1980	09-10-1980	1
hexclcpd tis mg/kg wet wgt	09-09-1980	09-04-1984	4
hexachlo robutadi tot wug/l	09-08-1980	09-08-1980	1
hexclbd tis mg/kg wet wgt	09-09-1980	09-04-1984	4
hexachlo roethane tot wug/l	09-08-1980	09-04-1984	3
hexaclet ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
hexaclet tis mg/kg wet wgt	09-09-1980	09-04-1984	4
indeno(1 23cd)pyr tot wug/l	09-08-1980	09-04-1984	3
i123cdpr ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
i123cdpr tis mg/kg wet wgt	09-09-1980	09-04-1984	4
isphrone tot ug/l	09-08-1980	09-04-1984	3
isphrone ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
isphrone tis mg/kg wet wgt	09-09-1980	09-04-1984	4
methylbromide tot wug/l	09-08-1980	09-19-1983	2
methylbr ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
methylbr tis mg/kg wet wgt	09-09-1980	09-19-1983	4
methylch loride tot wug/l	09-08-1980	09-19-1983	2
methylcl ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
methylcl tis mg/kg wet wgt	09-09-1980	09-19-1983	4
methylen echlorid tot wug/l	09-08-1980	09-19-1983	2
mthlencl ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
mthlencl tis mg/kg wet wgt	09-19-1983	09-19-1983	3
Nitrosod ipropyla tot wug/l	09-08-1980	09-04-1984	3
nitdnpra ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
nitdnpra tis mg/kg wet wgt	09-09-1980	09-04-1984	4
Nitrosod iphenyla tot wug/l	09-08-1980	09-04-1984	3
nitrsdpa ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
nitrsdpa tis mg/kg wet wgt	09-09-1980	09-04-1984	4
Nitrosod imethyla tot wug/l	09-08-1980	09-04-1984	3
nitrsdma ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
nitrsdma tis mg/kg wet wgt	09-09-1980	09-09-1980	1
napthale ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
napthale tis mg/kg wet wgt	09-09-1980	09-04-1984	4
Nitroben zene tot wug/l	09-08-1980	09-04-1984	3
Nitroben ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
Nitroben tis mg/kg wet wgt	09-09-1980	09-04-1984	4
parachlo rometacr tot wug/l	09-08-1980	09-04-1984	3
pclmcres ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
pclmcres tis mg/kg wet wgt	09-09-1980	09-04-1984	4
phenanthrene tot wug/l	09-08-1980	09-04-1984	3
phenanth ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
phenanth tis mg/kg wet wgt	09-09-1980	09-04-1984	4
phenol tis mg/kg wet wgt	09-09-1980	09-04-1984	4
pyrene tot wug/l	09-08-1980	09-04-1984	3
pyrene ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
pyrene tis mg/kg wet wgt	09-09-1980	09-04-1984	4
silver tis mg/kg wet wgt	09-19-1983	09-16-1987	5

tetrachl oroethyl tot wug/l	09-08-1980	09-19-1983	2
tetclete ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
tetclete tis mg/kg wet wgt	09-09-1980	09-19-1983	4
thallium sed mg/kg dry wgt	09-19-1983	09-15-1987	3
toluene ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
toluene tis mg/kg wet wgt	09-09-1980	09-19-1983	4
triclete ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
trichlor ofluorom tot wug/l	09-08-1980	09-08-1980	1
trclflmt ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
trclflmt tis mg/kg wet wgt	09-09-1980	09-19-1983	2
vinylchl ssed ug/kg dry wgt	09-08-1980	09-08-1980	1

11diChloroethane tot wug/l	09-08-1980	09-19-1983	2
11diclet ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
11diclet tis mg/kg wet wgt	09-09-1980	09-19-1983	4
11diChloroethyle tot wug/l	09-08-1980	09-19-1983	2
11dceten ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
11dceten tis mg/kg wet wgt	09-09-1980	09-19-1983	4
111trich loroetha tot wug/l	09-08-1980	09-19-1983	2
111tclet ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
111tclet tis mg/kg wet wgt	09-09-1980	09-19-1983	5
112trich loroetha tot wug/l	09-08-1980	09-19-1983	2
112tclet ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
112tclet tis mg/kg wet wgt	09-09-1980	09-19-1983	4
1122tetr aChloroe tot wug/l	09-08-1980	09-08-1980	1
1122tcle ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
1122tcle tis mg/kg wet wgt	09-09-1980	09-19-1983	4
benzo(gh i)peryle tot wug/l	09-08-1980	09-04-1984	3
bzghiper ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
bzghiper tis mg/kg wet wgt	09-09-1980	09-04-1984	4
benzo(a) anthrace tot wug/l	09-08-1980	09-04-1984	3
benzaant ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
benzaant tis mg/kg wet wgt	09-09-1980	09-04-1984	4
12diclet ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
12diclet tis mg/kg wet wgt	09-09-1980	09-19-1983	4
12diChlorobenzen tot wug/l	09-08-1980	09-04-1984	3
12dclben ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
12dclben tis mg/kg wet wgt	09-09-1980	09-04-1984	4
12diChloropropan tot wug/l	09-08-1980	09-19-1983	2
12dclprp ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
12dclprp tis mg/kg wet wgt	09-09-1980	09-19-1983	4
12diChloroethene tot wug/l	09-08-1980	09-19-1983	2
12tdcete ssed ug/kg dry wgt	09-08-1980	09-08-1980	1
12tdcete tis mg/kg wet wgt	09-09-1980	09-19-1983	4
124trich lorobenz tot wug/l	09-08-1980	09-04-1984	3
124tcben ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
0649 124tcben tis mg/kg wet wgt	09-09-1980	09-04-1984	4
dibenz(a h)anthra tot wug/l	09-08-1980	09-04-1984	3
dbahanth ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
dbahanth tis mg/kg wet wgt	09-09-1980	09-04-1984	4
13diChloropropen tot wug/l	09-08-1980	09-08-1980	1
13dcprpe tis mg/kg wet wgt	09-09-1980	09-19-1983	4
13diChlorobenzen tot wug/l	09-08-1980	09-04-1984	3
13dclben ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
13dclben tis mg/kg wet wgt	09-09-1980	09-04-1984	4
14diChlorobenzen tot wug/l	09-08-1980	09-04-1984	3
14dclben ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
14dclben tis mg/kg wet wgt	09-09-1980	09-04-1984	4
2Chloroethyl viny tot wug/l	09-08-1980	09-19-1983	2

2clevetr ssed ug/kg dry wgt	09-10-1980	09-10-1980	1
2clevetr tis mg/kg wet wgt	09-09-1980	09-19-1983	4
2Chloron aphthale tot wug/l	09-08-1980	09-04-1984	2
2clnapth ssed ug/kg dry wgt	09-10-1980	09-10-1980	1
2clnapth tis mg/kg wet wgt	09-09-1980	09-04-1984	6
2Chlorop henol tot wug/l	09-08-1980	09-04-1984	3
2clpheno ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
2clpheno tis mg/kg wet wgt	09-09-1980	09-04-1984	4
2Nitroph enol tot wug/l	09-08-1980	09-04-1984	3
2nphenol ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
2nphenol tis mg/kg wet wgt	09-09-1980	09-04-1984	4
dinoctph tot ug/l	09-08-1980	09-04-1984	3
dinoctph ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
dinoctph tis mg/kg wet wgt	09-09-1980	09-04-1984	4
24diChlorophenol tot wug/l	09-08-1980	09-04-1984	3

24dcphen ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
24dcphen tis mg/kg wet wgt	09-09-1980	09-04-1984	4
24dimeth ylphenol tot wug/l	09-08-1980	09-04-1984	3
24dmphen ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
24dmphen tis mg/kg wet wgt	09-09-1980	09-04-1984	4
24dinitr otoluene tot wug/l	09-08-1980	09-04-1984	3
24dntolu ssed ug/kg dry wgt	09-08-1980	09-04-1984	4
24dntolu tis mg/kg wet wgt	09-09-1980	09-04-1984	4
24dinitr ophenol tot wug/l	09-08-1980	09-04-1984	3
24dnphen ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
24dnphen tis mg/kg wet wgt	09-09-1980	09-04-1984	4
246trich lorophen tot wug/l	09-08-1980	09-04-1984	3
246tcphn ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
246tcphn tis mg/kg wet wgt	09-09-1980	09-04-1984	4
26dinitr otoluene tot wug/l	09-08-1980	09-04-1984	3
26dntolu ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
26dntolu tis mg/kg wet wgt	09-09-1980	09-04-1984	4
33diChlorobenzid tot wug/l	09-08-1980	09-04-1984	3
33dcbnzd ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
33dcbnzd tis mg/kg wet wgt	09-09-1980	09-16-1987	7
4bromoph enylphen tot wug/l	09-08-1980	09-04-1984	3
4brppetr ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
4brppetr tis mg/kg wet wgt	09-09-1980	09-04-1984	4
4Chlorop henylphe tot wug/l	09-08-1980	09-04-1984	3
4clppetr ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
4clppetr tis mg/kg wet wgt	09-09-1980	09-04-1984	4
4Nitroph enol tot wug/l	09-08-1980	09-04-1984	3
4nphenol ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
4nphenol tis mg/kg wet wgt	09-09-1980	09-04-1984	4
46dinitr oorthocr tot wug/l	09-08-1980	09-04-1984	3
46dnocre ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
46dnocre tis mg/kg wet wgt	09-09-1980	09-04-1984	4
PCB-1221 tis mg/kg wet wgt	09-09-1980	09-16-1987	7
PCB-1232 tis mg/kg wet wgt	09-09-1980	09-16-1987	9
PCB-1248 tis mg/kg wet wgt	09-09-1980	09-16-1987	7
PCB-1260 tis mg/kg wet wgt	09-09-1980	09-16-1987	7
PCB 1016 tot wug/l	09-08-1980	09-04-1984	3
PCB-1016 tis mg/kg wet wgt	09-09-1980	09-16-1987	7
tcdd tot wug/l	09-08-1980	09-08-1980	1
aldrin tis mg/kg wet wgt	09-09-1980	09-16-1987	7
cdanewet tech&met tis mg/kg	09-09-1980	09-16-1987	5
dnb phth tis-wet mg/kg	09-09-1980	09-04-1984	4
endrin tis mg/kg wet wgt	09-09-1980	09-16-1987	7

hpchlrep tis mg/kg wet wgt	09-09-1980	09-16-1987	7
heptchlr tis mg/kg wet wgt	09-09-1980	09-16-1987	7
hcb tis mg/kg wet wgt	09-09-1980	09-04-1984	4
PCB-1242 tis mg/kg wet wgt	09-09-1980	09-16-1987	7
PCB-1254 tis mg/kg wet wgt	09-09-1980	09-16-1987	7
toxaphen tis mg/kg wet wgt	09-09-1980	09-16-1987	7
triclete tis mg/kg wet wgt	09-09-1980	09-19-1983	4
vinylchl tis mg/kg wet wgt	09-09-1980	09-19-1983	4
phenol tot ug/l	09-08-1980	09-04-1984	3
phenol ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
napthalene tot wug/l	09-19-1983	09-19-1983	1
pcp tot ug/l	09-08-1980	09-04-1984	3
pcp tis mg/kg wet wgt	09-09-1980	09-04-1984	4
pcp ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
chlordan c isomer tis-ug/g	09-15-1987	09-16-1987	2
chlordan c isomer bot ug/kg	09-15-1987	09-15-1987	1
chlordan t isomer tis-ug/g	09-15-1987	09-16-1987	2
alphabhc tis mg/kg wet wgt	09-09-1980	09-16-1987	7
alphabhc ssed ug/kg dry wgt	09-10-1980	09-15-1987	2

b2ethxph tis mg/kg wet wgt	09-09-1980	09-04-1984	4
b2ethhxl phthalat tot ug/l	09-08-1980	09-04-1984	3
b2e phth mud-dry ug/kg	09-10-1980	09-04-1984	3
dnb phth Total ug/l	09-08-1980	09-04-1984	3
dnb phth mud-dry ug/kg	09-10-1980	09-04-1984	3
benzidin tot ug/l	09-08-1980	09-04-1984	3
benzidin ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
vinylchl oride tot ug/l	09-08-1980	09-19-1983	2
trichlor ethylene tot ug/l	09-08-1980	09-19-1983	2
aldrin tot ug/l	09-08-1980	09-04-1984	3
aldrin ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
alphabhc tot ug/l	09-08-1980	09-04-1984	3
beta bhc tot ug/l	09-08-1980	09-04-1984	2
gammabhc lindane tot.ug/l	09-08-1980	09-04-1984	3
gbhc-mud lindane dryug/kg	09-10-1980	09-10-1980	1
chlrdane tech&met tot ug/l	09-08-1980	09-04-1984	3
cdanedry tech&met mudug/kg	09-10-1980	09-10-1980	1
dieldrin tot ug/l	09-08-1980	09-04-1984	3
dieldrin ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
endosuln whl smpl ug/l	09-19-1983	09-19-1983	1
endrin tot ug/l	09-08-1980	09-04-1984	3
endrin ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
toxaphen tot ug/l	09-08-1980	09-04-1984	3
toxaphen ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
dieldrin tis mg/kg wet wgt	09-09-1980	09-16-1987	7
heptchlr tot ug/l	09-19-1983	09-04-1984	2
heptchlr ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
hpchlrep tot ug/l	09-08-1980	09-04-1984	3
hpchlrep ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
mthxyclr mud dry ug/kg	09-15-1987	09-15-1987	1
PCB-1221 tot ug/l	09-08-1980	09-04-1984	3
PCB-1221 ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
PCB-1232 tot ug/l	09-08-1980	09-08-1980	1
PCB-1232 ssed ug/kg dry wgt	09-08-1980	09-15-1987	3
PCB-1242 tot ug/l	09-08-1980	09-04-1984	3
PCB-1242 ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
PCB-1248 tot ug/l	09-08-1980	09-04-1984	3
PCB-1248 ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
PCB-1254 tot ug/l	09-08-1980	09-04-1984	3

PCB-1254 ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
PCB-1260 tot ug/l	09-08-1980	09-04-1984	3
PCB-1260 ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
PCB-1016 ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
hcb tot ug/l	09-08-1980	09-04-1984	3
hcb ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
hexclbd tot ug/l	09-19-1983	09-04-1984	2
hexclbd ssed ug/kg dry wgt	09-10-1980	09-04-1984	3
gbhc-tis lindane wetmg/kg	09-09-1980	09-16-1987	7
g-chlrdn mud ug/kg	09-15-1987	09-15-1987	1
dimethyl napthsed ug/kg	09-19-1983	09-19-1983	1
oh ion oh mg/l	02-24-1987	02-24-1987	1
mercury sed mg/kg dry wgt	09-08-1980	09-15-1987	4
mercury tis mg/kg wet wgt	09-09-1980	09-16-1987	5
lead tis mg/kg wet wgt	09-09-1980	09-16-1987	5
copper tis mg/kg wet wgt	09-09-1980	09-16-1987	6
zinc tis mg/kg wet wgt	09-09-1980	09-16-1987	6
cr-fish ug/g or mg/kg wt	09-19-1983	09-16-1987	4
cadmium tis mg/kg wet wgt	09-09-1980	09-16-1987	6
cd Total fish dwt ug/gm	09-09-1980	09-09-1980	1
acetone sed dry wgtug/kg	09-19-1983	09-19-1983	1
2hexanon sed dry wgtug/kg	09-19-1983	09-19-1983	1
styrene sed dry wgtug/kg	09-19-1983	09-19-1983	1
bnzylalc sed dry wgtug/kg	09-19-1983	09-19-1983	1
benzoica sed dry wgtug/kg	09-19-1983	09-19-1983	1
dbnzofur sed dry wgtug/kg	09-19-1983	09-19-1983	1
crbn dis Total ug/l	09-19-1983	09-19-1983	1
vinyl ac Total ug/l	09-19-1983	09-19-1983	1
aniline Total ug/l	09-19-1983	09-04-1984	2
2hexanon Total ug/l	09-19-1983	09-19-1983	1
styrene Total ug/l	09-19-1983	09-19-1983	1
o-xylene Total ug/l	09-19-1983	09-19-1983	1
bnzylalc Total ug/l	09-19-1983	09-04-1984	2
benzoica Total ug/l	09-19-1983	09-04-1984	2
2mnaptha Total ug/l	09-19-1983	09-04-1984	2
245tclph Total ug/l	09-19-1983	09-04-1984	2
dbnzlamn Total ug/l	09-19-1983	09-04-1984	2
endrinke tiswetwt mg/kg	09-15-1987	09-16-1987	3
chlordan a-fish ww ug/kg	09-16-1987	09-16-1987	1
dibenzo furan tot ug/l	09-19-1983	09-04-1984	2
acetone tot ug/l	09-19-1983	09-19-1983	1
mtxchlor fish wet wgt ug/g	09-15-1987	09-16-1987	3
endrinke sed dry wt ug/kg	09-15-1987	09-15-1987	1
t1 3-dcp tot wat ug/l	09-08-1980	09-08-1980	1
c1 3-dcp fish wet wgtmg/k6	09-09-1980	09-19-1983	4
c1 3-dcp tot wat ug/l	09-08-1980	09-19-1983	2
napthal enes pc . ug/l	09-08-1980	09-04-1984	2
p p'ddt tot ug/l	09-08-1980	09-04-1984	3
p p'ddd tot ug/l	09-08-1980	09-04-1984	3
p p'dde tot ug/l	09-08-1980	09-04-1984	3
arsenic as tot ug/l	09-08-1980	09-15-1987	4
berylium be tot ug/l	09-08-1980	09-15-1987	4
cadmium cd susp ug/l	09-15-1987	09-15-1987	1
cadmium cd tot ug/l	09-08-1980	09-15-1987	4
chromium cr tot ug/l	09-08-1980	09-15-1987	4
copper cu tot ug/l	09-08-1980	09-15-1987	4
lead pb tot ug/l	09-08-1980	09-15-1987	4
thallium tl Total ug/l	09-19-1983	09-15-1987	3

nickel ni Total ug/l	09-08-1980	09-15-1987	4
silver ag tot ug/l	09-19-1983	09-15-1987	3
zinc zn tot ug/l	09-08-1980	09-15-1987	4
antimony sb tot ug/l	09-08-1980	09-15-1987	4
selenium se tot ug/l	09-19-1983	09-15-1987	3
p p'ddt ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
p p'ddd ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
p p'dde ssed ug/kg dry wgt	09-10-1980	09-15-1987	2
mercury hg Total ug/l	09-08-1980	09-15-1987	4
iron fe susp ug/l	09-16-1987	09-16-1987	1
p p'ddt tis mg/kg wet wgt	09-09-1980	09-16-1987	7
p p'ddd tis mg/kg wet wgt	09-09-1980	09-16-1987	6
p p'dde tis mg/kg wet wgt	09-09-1980	09-16-1987	7

APPENDIX 5. BACKGROUND ON GRUBBING AND GRADING ORDINANCES AND PROBLEMS

Land Clearing and Grubbing and Grading

- The State of Hawai‘i seeks to control erosion and sedimentation through legislation.

- Chapter 180 of the Hawai‘i Revised Statutes (HRS 180) sets the criteria for the creation of Soil and Water Conservation Districts (SWCD), a program administered by the State Department of Land & Natural Resources (DLNR); defines the SWCD as a governmental subdivision of the State of Hawai‘i; and defines the powers and duties of the DLNR, the SWCD and its Directors.

- Soil Erosion and Sediment Control comes under HRS 180C, which states that a “Conservation Plan” is a plan for the control of erosion and sediment from a land disturbing activity; and “Land Disturbing Activity” is any land change that may result in soil erosion from water or wind and the movement of sediment into State waters or onto lands in the State including but not limited to tilling, clearing, grading, excavating and filling.

- HRS 180C mandated counties to enact an ordinance to contain standards for the control of erosion and sediment from land disturbing activities [HRS 180C-2(b)(3)], and to include a provision whereby standards are met if lands are being managed in accordance with practices acceptable to the SWCD [HRS 180C-2(b)(4)].

- The SWCD Conservation Program manages agriculturally based land disturbing activity, with free technical assistance given by the Natural Resources Conservation Service (NRCS), a division of the U.S. Department of Agriculture (USDA). Chapter 10 of the Hawaii County Code (HCC), Erosion and sediment Control, is structured to manage urban or construction-based land disturbing activities.

- Contractors initiating land-disturbing activity in urban areas (i.e., construction) must pay for grubbing and grading permits and technical assistance from professional engineers.

- According to DPW officials, all agricultural land disturbing activity whether initiated in rural or urban settings is best managed by of SWCD, while construction based land disturbing activity whether initiated in rural or urban settings fall under the jurisdiction of DPW.

- Though the SWCD’s do not have direct enforcement authority, they may choose to cancel a landowner’s conservation program due to non-compliance. This will require the landowner to obtain a grubbing/grading permit from the county of Hawaii at his own cost.

- Lack of enforcement of HRS 180C by the SWCD has lead to a threat of cancellation of the SWCD by DPW, if HRS 180C violations are not followed up with corrective actions imposed by SWCD.

- There are concerns regarding funding of the SWCD by the State of Hawaii: Hawaii County is the only local government agency to provide direct….

- In an attempt to safeguard the public, property and the environment, grading is regulated for the purpose of erosion and sedimentation control.

- Chapter 10 of the HCC requires grading permits in certain situations.

- However, the technical knowledge required to determine whether or not a permit is required is neither common knowledge nor is it knowledge held by the average Permittee, or the person who has the interest in the land (i.e., the owner or designated representative).

Permitting requirements are described in the recently amended Chapter 10 of the Hawaii County Code (HCC), Erosion and sediment Control. Here we transcribe the elements directly related to erosion control in urban areas:

Chapter 10—Erosion and Sedimentation Control
Article 1, Section 10: Minimum BMPs
Regardless of whether a permit is required pursuant to this chapter, all grading, grubbing and stockpiling activities shall provide BMPs to the maximum extent practicable to prevent damage by sedimentation to streams, watercourses, natural areas and the property of others.

a) Drainage. On-site drainage shall be handled in such a way so as to control erosion, prevent damage to downstream properties and to return waters to the natural drainage course free of sedimentation or other pollution.

b) Dust control. All work areas within and without the actual grading area shall be maintained free from dust which will cause a nuisance or hazard to others.

c) Vegetation. Whenever feasible, natural vegetation, especially grasses, should be retained. If it is necessary to be removed, trees, timber, plants, shrubbery and other woody vegetation, after being uprooted, displaced or dislodged from the ground by excavation, clearing or grubbing, shall not be stored in or deposited along the banks of any stream, river or natural watercourse. The director may require the removal and disposal of such vegetation from the site within a reasonable time but not to exceed three months.

c) Erosion Controls. All disturbed areas shall be stabilized with erosion control measures that may include staging, construction, clearing only areas essential for construction, locating potential non-point pollutant sources away from steep slopes, water bodies and critical areas, routing construction traffic to avoid existing or newly planted vegetation; protecting natural vegetation with fencing, tree armoring and retaining wall or tree wells; stockpiling topsoil, covering the stockpile to prevent dust, and reapplying the topsoil; covering or stabilizing all soil stockpiles; using wind erosion control; intercepting runoff above disturbed slopes and conveying it to a permanent channel or storm drain; construction benches, terraces, or ditches at regular intervals to intercept runoff on long or steep disturbed or man-made slopes; providing linings or other methods to prevent erosion of storm water conveyance channels; using check dams where needed to slow flow velocities; using seeding and fertilizing, mulching, sodding, matting, blankets, bonded fiber matrices, or other effective soil erosion control technique; and providing vehicle wheel wash facilities for vehicles before thy leave the site.

e) Sediment Control. In addition to the erosion control measures above, providing practices to capture sediment that is transported in runoff to prevent the sediment from leaving the site. Filtration and detention (gravitational settling) are the main processes used to remove sediment from construction site runoff. Sediment control measures include sediment basins sediment traps; filter fabric silt fences; straw bales, sand bag, or gravel bag barriers; inlet protection; stabilized construction entrances, and other measures to minimize off site tracking of sediment by construction vehicles, and vegetated filter strips.

f) Material and Waste Management. Measures to insure the proper storage of toxic material and prevent the discharge of pollutants associated with construction materials and wastes shall be implemented.

g) Timing of Control Measure Implementation. Timing of control measure implementation shall be in accordance with the approved erosion control pan is such plan is required. At a minimum disturbed areas of construction site that will not be re-disturbed for 21 days or ore will be stabilized (grasses or graveled) by no later than the 14th day after last disturbance.

Article 2, Section 10-15

(2) For grading of areas of more than fifteen thousand square feet, an erosion control plan, prepared by an engineer or land surveyor, and approved by the director and showing the contours and elevations of the land before and after the completion of the proposed grading. This map shall include the location of existing large trees, designated historic and archaeological sites, and definable rock outcroppings, lava tubes, detailed plans, and specifications of all drainage devices and utilities, including bank protection, walls, cribbing, dams, silting or sediment basins, landscaping, screen panting, erosion control plantings, or other BMPs or protective devices that be constructed in connection with, or as a part of the proposed work, together with a map showing the drainage area and estimated runoff of the area served by any drains.

All of these technical requirements lead to the potential solution that the technician, i.e., the bulldozer or excavation equipment operator, should be the Permittee. An operator/permittee would probably have working knowledge of the terms put forth in the permitting requirements, therefore allowing for 1) close adherence to requirements, and 2) accountability (i.e., fines and loss of operator’s license) for permit infractions. This solution to this issue has actually been proposed by NRCS in discussions with DLNR and SWCD, but has not been considered appropriate by the state and county.

Chapter 10 of the HCC also provides a list of projects that do not require permits if the work conforms to the provisions of Section 10-26. It appears that some of the work on the “no permit required” list can lead to serious erosion and sedimentation due to runoff problems during and after significant rain events. One of the most glaring examples is “Grading within building lines of a structure authorized by a valid building permit”. With this exception as an example, it seems that effective grubbing and grading laws, intent on erosion and sedimentation control, are dependent on close communication and cooperation with the agencies governing building permits.

APPENDIX 6. PUBLIC REVIEW OF DRAFT HILO BAY WATERSHED RESTORATION PLAN

Transcription of hand-written comments turned in by reviewers, with responses in [*italics*]

STEVE BERGFELT AND LISA HADWAY (DOFAW-HILO OFFICE)

Additional DOFAW management activities to be added to background section (*all these activities will be incorporated into the final draft***)**

1. Invasive Species: DOFAW actively works on controlling invasive species within the watershed area. DOFAW is currently working on gorse, Himalayan raspberry, *Clidemia*, banana poka, and palm grass using mechanical and chemical methods and biological control (pathogens). The Big Island Invasive Species Committee is working on the control of *Miconia* within the watershed.

2. Threatened and Endangered Species: DOFAW is currently working with the Kau silversword, *Cyanea platyphylla*, *Cyanea shipmanii*, *Clermontia peleana* and Nene.

3. Commercial timber: The Waiakea Timber management area falls within the watershed area. A land license has been issue to Tradewinds to harvest the timber. No harvest has yet begun. Best Management Practice will be followed.

4. Hunting: Ron Bach now manages the hunting program in the area—contact him for more up to date information. Hunting is allowed on all Forest reserves and game management areas within the watershed. Feral pigs and mouflon sheep are the main game animals. Game birds are also hunted in the upper areas of the forest reserves.

5. Hilo Forest Reserve: DOFAW's management activities in the Hilo Forest Reserve are as follows:

Fence line maintenance—within the last year, DOFAW removed trees threatening the Puu OO ranch fence (3 miles of fence line). This will make it easier for the rancher to maintain his fence and keep cattle out of the forest reserve.

Cattle removal—there are feral cattle in the upper reaches of the Hilo Watershed. DOFAW is currently working on a feral cattle removal program. Nubmers will be significantly reduced within 3 years.

Trail and road maintenance—DOFAW periodically maintains roads and trails within the watershed boundaries to facilitate access for management as well as for public access for hunting and other forms of recreation.

Fire prevention, pre-suppression and suppression-- DOFAW is an active member of the Big Island Wildfire coordinating group. BIWCG's purpose is to allow the fire agencies on the Big Island to work together more efficiently to provide fire services for the people and resources of Hawaii island. DOFAW trains and equips 38 personnel for fire suppression activities. We maintain 17 fire vehicles and 2 fire caches on the island for fire suppression.

Comment re DOFAW's role in the restoration plan:

"once the science has been completed DOFAW will participate if it shows the lands we manage are a major problem. We feel the lands we manage are in the best shape of any within the watershed boundaries." *[this is one reason we need research on sediment sources: NRCS and farmers claim sediments come from conservation lands, DOFAW refute this, and we cannot impose BMPs until we have evidence for the sources of sediments.*]

LISA HADWAY (DOFAW-HILO OFFICE)

1. p. 13: Kipuka 21 is a fenced of kipuka within the Hilo Forest Reserve, not a new NARS as implied by the manuscript. [*noted, will be corrected*]

3. p. 14: Though cattle may be causing more damage than pigs in parts of the watershed, I do not know this as a fact. This sentence implies that it is a fact. Please delete the second part of the sentence that reads "and that cattle are currently causing more habitat damage than pigs in some areas" second paragraph staring with "other conservation lands" [*noted, will be corrected*]

4. p. 18: add sailing and jet skiing to uses of Bay—not sure if these are legal uses or of concern for water quality, but, but they take place and should be considered or addressed. Another use that takes place at Bay front , which is of concern, is ATV use. I have seen multiple ATVs and Dirt Bikes ripping up and down the beach at Bay front. [*noted, water sorts will be added*]

5. p. 19: update list of DOFAW management activities—add invasive species control, fire suppression

6. p. 20: add USFWS Hakalau Refuge Management Plan as one of the management plans in effect for the watershed [*noted, will be added*]

7. p. 31: What about water-borne diseases such as Lepto, etc. Do they fit into a water quality sampling regime? [*No one monitors for leptospira because no standard method exists for their detection/enumeration in environmental waters. The tests that do exist are almost useless for differentiating between non-pathogenic strains (which are numerous) and pathogenic strains. Clinical tests exist to detect them once they infect an animal. It is not practicable to say that we recommend identifying sources and monitoring.]*

8. p. 34: change Department of F and W to Division of F and W. [*done*]

9. p. 42: suggest adding another research objective: "tree cover and influence on water quality/quantity-N inputs from invasives such as Albizia. [*see demonstration project in new BMP and Demo. Project section added in final version of plan*]

10. p. 45: comment on the use of coral reef monitoring by volunteers: "concerns over consistency". "I have concerns that volunteers will not be a reliable and consistent source of data and monitoring. I believe this phase of the work needs to be done by trained scientists/grad

students." [*as explained in the text, we feel that with appropriate supervision, such monitoring can be useful, especially as we are unlikely to obtain any funds for research by professionals on these issues. Furthermore, monitoring by volunteers greatly increases the educational aspect of the WRP, and this is a key objective at this point*]

MIKE ROBINSON (DHHL)

Comments to Mary James by teleconference August 5, 2005

1. The report is very positive, not regulatory or threatening.
2. Check through the report and correct abbreviations to DHHL (eg. not DHH)
3. 1999-2000 DOFAW prepared BMPs for forestry. These should be included in the appendix. [*we will include either as appendix or by referring to them and listing their availability on the web*].
4. BMP for ag was part of the Clean Water program in the 1990s. There were 5 areas for BMPs: ag, forestry, tourism, and 2 others. The State requires that grant applicants meet BMPs to get State grant money. [*existence of these BMPs will be mentioned. However, without monitoring of BMPs, and studies of before and after levels of water pollution, we do not know whether they are working or not; also, it is difficult to ascertain whether or not BMPs are actually being implemented, or how well*]
5. Re the 2002 DHHL Master Plan – check with Darrell Yagodich (808-586-3836) in the Oahu DHHL Planning Department (homestead) regarding management efforts and watershed. Significant urban areas/housing. [*unclear whether housing will be developed in the watershed, or just on DHHL lands in general*.]
6. Contact James Leary a soil scientist at UH Manoa (808-956-9214) who is coming to Hilo late August and ask if clearing gorse will increase nutrient release. Suggest that we coordinate with him. He may be able to recommend land use practices and tweak one of his grants to help us. [*thank you for this information; this fits in with the overall concern about invasive legumes altering nutrient regimes*]

Conversation with Jeff and Mary on July 19th when WRP was delivered:

1. DHHL does not do any more ranching. South of Saddle Road is on long-term lease with DOFAW. Rest of land controlling gorse via spray and reforestation. Want to start forest for fog drip – want to plant 1K acres in trees. 4K-5K acres of gorse. DOFAW manages some of the areas. Developing a 250 ft wide circle of trees to shade out gorse. Using 7 biological controls, also burn and herbicide. Will take 20-30 years for project. May start grazing and homesteading.
2. Makai area – lower part was former sugar cane land. Trees help stabilize soil and bring in long term income.
3. Final Environmental Assessment for Controlling Gorse; Koa Salvage – Reforestation & Gorse Containment – August 9, 2001
4. Working with James Leary at UH Manoa. He is sampling for nitrogen fixers.

Comments on manuscript

1. p. 3, last sentence of second paragraph: "excellent" [*this refers to our 5 year plan in which research over three years occurs prior to identification of BMPs*]

3. p. 14: clarify that the "lands above the refuge" are managed by DHHL (line 6) [*ok*]

4. p. 14: Change DHL to DHHL throughout [*ok*]

5. p. 14: line 7. Add "DHHL has not renewed the cattle leases in this area and a program has begun to contain and control gorse." [*ok*]

6. p. 20: add DHHL gorse control program [*ok*]

7. p. 24, last paragraph, line 7 from bottom: "DOFAW and DHHL have started coordinating land management efforts" [*ok*]

8. p. 40. Re community education on BMPs" "a good example are the DOFAW forestry guidelines or publications" [*noted*]

9. stakeholder list: update DHHL name and contacts; also note that address for DHHL may be changing in next two months. [*ok*]

9. eliminate DHHL second time listed in Management agencies list; also eliminate grazing and add invasive species control and koa forest restoration as areas of competence. [*it seems like the making of a watershed partnership right there between DOFAW, DHHL, WAG—partnership formation and maintenance of community organizations are recommended as a bmp in our new section; note that such activities are fundable through 319 funds (A. Shilekis, pers. comm.]*

10. update DLNR contacts in stakeholder list appendix 2 [*notes are illegible*]

TOM YOUNG COMMENTS FOR HAMAKUA SWCD, PER TOMMY CRABB-CHAIR

1. re the summary, Tom maintains that " sources of nutrients are fertilizers (home owner and some agriculture, sewage sources (cesspools, sewer and end of pipe effluent that finds its way back in the bay from the outfall); one of the major sources of nutrients is a products of the degradation of the natural material in the upper watershed. The parent rock material being young geologically contributes nutrients". [*this comments illustrates why we desperately need research and education—a very vocal member of the community and officer of the SWCD insists that more nutrients come from conservation land than ag and urban areas; such unsubstantiated statements influence the community and may prevent it from agreeing to restoration efforts or review of agricultural bmps. In comment 4, Mr. Young completely misinterprets the report by Runcie and Kinzie (2002), using it to say that algae are not good indicators of stream water quality, when in fact what the report says is that two algae species are excellent indicators of nutrient levels in bay waters as long as a strict experimental protocol is followed. It is in fact that protocol, developed for Kaneohe Bay, which we suggest be followed in Hilo Bay. The work*

was funded by DOH, and much more extensive use should be made of the results and the expertise generated by the Kaneohe project]

2. re our comments on improvement of and monitoring of agricultural BMPs, Young maintains that "the BMPs have been developed and agreed to by all the parties that interact in the watershed. There are outstanding MOUs as to these agreements [unclear if outstanding means very good or not yet implemented]. Voluntary application of BMPs is only reviewed statistically but not individually as per the Freedom of Information Act. [*We presume this means that the % of farms in compliance is reported, rather than the actual farms in compliance? Or the % of farms with plans rather than the identity of farms with plans?*] [*the authors of the WRP feel that the onus is on NRCS and SWCD to demonstrate their system is actually reducing nutrient, pesticide and sediment inputs to streams and oceans, relative to a situation with no voluntary BMPs*]. To view BMPs go to a NRCS office and review the resource conservation practices that are on file [*We're not so much interested in viewing the BMPs as in knowing how well they are being implemented and whether they are having any effect on water quality. This requires measurement of water quality downstream from farms with BMPs—i.e., scientific monitoring of NRCS and SWCD activities to determine their effectiveness. This is standard Quality Control and Assurance procedure*].

3. re section 2.1, where the report states that "we have strong circumstantial evidence that ground water contributes large amounts of N" , Young says "please cite sources this needs to be discussed." [*this is in fact discussed in the body of the report; and we have two citations supporting this for Hawaii*]

4. re section 8, where we talk about bio-monitoring using algae and / or coral growth, Young comments on the use of algae as bioindicators. From previous conversations with him I know he is referring to looking at algal cover on rocks in streams to determine nutrient presence / eutrophication in streams. But what we are referring to is nutrient levels in the estuary/bay. The Coral Reef Initiative (Kinzie, Runcie, Hoover, Smith, etc.) have worked out good salt water algal indicators of nutrient loads, and we can use the same methods in Hilo. These same researchers could serve as consultants for Hilo, as they have the expertise already. Young's specific comment is: "algae in Hawaii steams are a poorly understood subject. Filamentous algae are the predominant species in our streams, and it will proliferate in situations of low flow that do not coincide with high nutrient availability but seems to be a function of maturity and lack of flushing intensity. Coral is also dependent on algae and is poorly understood as to its response to elevated nutrient:. [*it is unclear what Mr. Young means by coral being dependent on algae—macroalgae can cover coral and prevent feeding and other physiological functions*]

5. "The data available on nutrients are outdated and a lot of things have changed. New work is necessary prior to any assessment of remedial work". [*Whether Mr. Young is right or wrong, this is the current attitude among a large portion of the community and county officials, and the restoration plan must deal with it. At the very least, education must precede BMPs, and research must go along with education*]

6. re hunting areas in watershed reserve: " this subject needs to be expanded because of the long standing tradition within the resident population." [*please see demonstration project on ungulate control in new bmp section of report*]

7. SWCD are assisted by NRCS, not overseen by NRCS [*noted*]

8. re visual assessments: " this is a poor methodology in Hawaii and is not conclusive as in large farming areas on the mainland" [*visual assessment should not be used to determine water quality, we agree; however, as a monitoring method that allows you to track changes over time or allows you to compare different areas—e.g. those with and without management—it is acceptable as long as it is consistently applied*]

9. re turbidity: " non-anthropogenic contribution needs to be dealt with, it is not supposed to be accumulative with man made turbidity" [*the authors agree that it has to be measured and quantitative. However, whether it is cumulative or not is beside the point, the point is that water quality limits are set based on human health and/or on ecosystem function/biodiversity conservation. If the natural inputs allow the ecosystem to function, and to do not impair human health, but as soon as you add human inputs you exceed these limits, then you have to make a decision as to whether you want to modify the natural area to reduce inputs, stop all human inputs, some combination of the two, or not allow humans to use the area. The key thing is to know the inputs, and make a decision on acceptable uses of the area after one has this information*]

10.re Appendix 5, where it discusses the lack of enforcement of HRS 180C: "there is a general ignorance as to the authority of the SWCD. The Clean Water Act spells out that toxic chemicals in toxic amounts shall be regulated and that there should be a voluntary program for non-point sources of pollution. If a land occupier chooses not to voluntarily treat their environmental problems, then the State is required to use their back up authority (see recent attorney general opinion, can be found by calling Dennis Lau DOH)" [*note that we consider enforcing existing rules as a bmp; this includes the state imposing penalties on those who do not voluntarily deal with their pollution problems*]

11. Agricultural Grading Exemption is for bona fide ag-producers in cooperation with a SWCD board of directors on a comprehensive conservation plan. [*noted*]

12. Targeting storm events is not going to produce a database that will lead to compliance with the clean water act or in the meeting of water quality standards. What is needed is a sampling of indicator streasm thru-out Hawaii that will give us a thorough set of data points that is so lacking at the present time. We need ambient thru storm events so that we understand the dynamics of the watershed. [*agreed, and we are not proposing to sample only during storm events. The problem is that storm events are often missed, because they are rare relatively to non-storm conditions. So, they must be targeted to ensure that an adequate sample of sediment and nutrient loads are measured during storm events. If it is true that all sediments come down during storm events, then BMPs can be chosen that are targeted at storm events—e.g., a water diversion or sedimentation basin may actually be necessary because increasing tree cover, etc. will not be sufficient*]

GALEN KUBA, HAWAII COUNTY PUBLIC WORKS, ENGINEERING DIVISION CHIEF (COMMENTS WRITTEN ON MANUSCRIPT)

1. p. 10, comments re the type of cost-benefit analysis done for flood control project: "need to discuss with NRCS and ACOE—probably difficult to attach a $ value" [*yes, it is difficult, but necessary if the cost of environmental degradation is ever to be included in the cost of our overall activities. This is an active field of research in environmental economics. It can provide important guidance in development decisions*]

p. 14. Re flood control structure in the watershed: add Palai stream to the list of modified streams in 4th full paragraph [*ok*]. Also "the ACOE and the County of Hawaii are planning two flood control projects [*not one as described in this paragraph—will update*]. A partial diversion is also being planned for Waiakea stream above Kupulani Street that would divert peak flows around urban feed areas. Both projects are in the feasibility cost sharing phase of development and are subject to further economic and engineering analysis by the ACOE". [*corrections and update noted, will include in final version*]

p. 15. Line 3 from top, please change "small operations" to read "small developments that have negligible drainage impacts" [*noted, will change*]. Line 7, please add that modifications to storm drains are planned "under the Czara New Urban Development Measure." On last sentence of this paragraph, please add the words "for Hilo town" [*noted, will do*]

p. 19. Again, list the two planned flood control structures in this section [*will do*]. Add the urban new development measure by Susan Miller [*unclear what this is*].

p. 50. Appendix 1. Eliminate objectives 1, 3 and 4 from this draft list of objectives, as these are the amendments made to the proposed ordinance [*done*]

p. 54, paragraph 5: rewrite to say "The SWCD Conservation Program manages agriculturally based land disturbing activity, with free technical assistance given by the Natural Resources Conservation Service (NRCS), a division of the U.S. Department of Agriculture (USDA). Chapter 10 of the Hawaii County Code (HCC), Erosion and sediment Control, is structured to manage urban or construction-based land disturbing activities [*done*]. Paragraph 6: add "engineers" at the end [*done*]. Paragraph 7, change "falls under the jurisdiction of" to read "is best managed by" [*done*]. Join paragraph 8 to paragraph 7 [*done*]. Paragraph 9: Change to read: " Though the SWCD's do not have direct enforcement authority, they may choose to cancel a land owner's conservation program due to non-compliance. This will require the land owner to obtain a grubbing/grading permit from the county of Hawaii at his own cost. [*done*]" Paragraph 10: change to read: There are concerns regarding funding of the SWCD by the State of Hawaii: Hawaii County is the only local government agency to provide direct… [*will change, but note that comment unreadable at the end*]

p. 55, 1st paragraph: eliminate the word "drainage". [*done*] Middle section of page: please amend these permitting requirements as per the new chapter 10 [*done*]. 4th item from the bottom—eliminate the reference to dust control regulations by DPW, as the county has not enacted any regulations to address these issues. [*done*]

p. 56. Galen Kuba disagrees with the alternative of the bulldozer operator or equipment contractor being the permittee, as it is harder to track the contractors. [*noted*]. Re the list of project not requiring permits in Chapter 10—please amend this list to reflect the new chapter [*will do*; *have been added to Appendix 5*]. Comment on last paragraph: note that there are no regulations to control roof runoff [*will note this lack of regulations*]

DICK WASS, REFUGE MANAGER, HAKALAU FOREST NATIONAL WILDLIFE REFUGE, USFWS

p. 14: add cattle to the species being controlled by DOFAW in Hilo Forest Reserve, and note that the cattle referred to as causing problems are mostly if not all feral [*done; this comment was already modified as per L. Hadway*]

p. 20: add these items to the list of ongoing management efforts: "Hakalau Forest National Wildlife Refuge (USFWS)—conservation of native and endangered plants and animals. Restoration of native forest through tree propagation and outplanting. Control and removal of feral pigs and feral cattle. Control of invasive weeds including Florida blackberry, gorse, banana poka and holly. A Conservation Plan covering all management activities (fuel break construction, fence construction, road maintenance, gravel mining, tree planting, weed control, facilities construction, etc.) was prepared by NRCS and approved by the Mauna Kea Soil and Water Conservation District." [*ok*]

p. 21. To item 8, add upland restoration as well as wetland restoration. [*no, this paragraph is specific to wetland ecosystems*]

p. 22. Add the following objectives to the list: encourage restoration of native forest; reduce feral cattle and pig populations; encourage agricultural practices that use less pesticides and that conserve soil. [*these items are very specific compared to the broader objectives in this list; we will include them elsewhere in the plan, where they may be more appropriate*]

Map of Hilo Bay watershed: make sure that the two parcels that include the Refuge are labeled as such [*will try*].

WILLIAM HALLIDAY, GEOLOGIST, NATIONAL SPELEOLOGICAL SOCIETY

p. 11, line 2. Add: it consists of a mixed crevice and conduit pseudokarst [*please clarify—does this refer to Waiakea pond or to the overall substrate in the area? We had not received a reply by the deadline for report completion]*

p. 12. 2nd paragraph, 3rd line from end: change if to where [*done*]

p. 24, first full paragraph, 5th line from end. Add to read: "..seepage and underground conduit flow in lava tubes…" [*done*]

p. 35, in 8.5; add: "require homeowners currently discharging raw sewage into lava tubes or crevices to terminate this practice immediately" [*done*]

p. 39. Item 1, add to read "…where are the tubes (available from the Hawaii Speleological Survey of the National Speleological Society)" [*ok*]

p. 46, center: add to read: "…doctors, audiologists and …" [*please clarify why audiologists are important in this context*; *no reply received by deadline*]

Figure 3: Alenaio Stream is incorrectly shown as a surface stream. Except in flood, it is a subterranean pseudokarstic stream" [*noted*]

LES, WAIAKEA SWCD

p. 15, under grubbing and grading: SWCDs provides grubbing/grading plans under contract to the county; yes, there is very little enforcement [*noted*]

These G and G permits should be mandatory and also should be closely monitored—given the level of development—new housing, etc. [*this concern will be noted in final plan, we do already stress the need for revision and enforcement of grubbing and grading ordinances*]

New developments should have means to handle the water, such as dry wells, or accumulation basins. [*will include under a suggested list of construction BMPs*]

p. 15, under Agricultural Lands: "Maybe agricultural lands should have mandatory conservation plans prepared—monitoring would be difficult but necessary. Proactive planning should reduce polluted runoff." [*this is discussed under actions to review and monitor the BMPs applied under NRCS / SWCD auspices*]

p. 16, still under Ag. Lands: "Conservation plans for agriculture are in lieu of grubbing/grading permits" [*thank you, information also given by Galen Kuba, clarification included in Appendix on grubbing and grading*]

p. 19, items 5 and 6: "funding for channel stabilization (waterways, canals) is through ACOE" [*noted—ACOE funding of channel stabilization; this overlaps with G. Kuba's comments on ACOE flood control projects currently under feasibility study*]

p. 33, re item 13, note that "Bio-filtering / bio-capture of nutrients is demonstrated as effective for effluent clean up, and 319 funds are available for demo projects; see Siverton, Oregon demo site [*info will be added to the wetland BMP/demo project proposed later in report*]

p. 34—note that the SWCD acting in the watershed is the Waiakea SWCD [*noted*].

p. 35, section 8.4: "public needs to be informed and educated; money should be allocated especially for this; we are the primary stakeholders" [*agree, will refer to this wording in our section on Education as a BMP*]

p. 37, re reviewing SWCD soil management plans: "note that NRCS assists SWCDs with 1) technical help (planning, engineering, etc.) and 2) funding programs (NRCS seems to be moving to a funding based program); many programs already exist for funding of projects, check with NRCS about EQIP, WRP, WHIP

"conservation plans require closer and more timely monitoring" [*unclear if this refers to a need for more rapid monitoring than just one year after initial funding of conservation plans; but we will note the perceive need for close monitoring*]

RON BACHMAN, WILDLIFE BRANCH, DOFAW

p. 14, section 3.6 on Hunting Areas: "Managed public hunting for pigs, sheep and goats in conducted throughout the areas listed in this section although not all of these areas are part of the official designation : "Restricted Watershed" as described in Attachment Chapter 105."

"Mauna Kea Forest Reserve, adjacent Hawaiian Home Lands and Piihonua Lease could reasonably be included as they too influence lower areas by runoff in a particularly significant way; where gorse has taken over and seeds are washed into the watershed. Gorse was under control until sheep eradication orders removed these grazers. Gorse is now growing along the entire length of the Wailuku River. Feral pigs evade hunting dogs by dashing into gorse thickets and, as a consequence, their numbers are increasing" [*this information is very useful in helping us design research and BMPs—several land managers are using feral ungulates to control invasive plants; we need to look into feral ungulate management that does not suddenly disrupt ecological relationships that have recently become established and area actually helping to maintain community integrity and ecosystem function*]

p.19, item 10 under existing management efforts: "Cattle trespass from ranches adjacent to the restricted watershed are a source of renewal for the resident population in Hilo Watershed. Recent emphasis in boundary fencing upkeep and errant cattle removal by DOFAW is to be supplemented by the project proposal: Feral Cattle Hunt (see attachment) [*comment is complementary to those made by L. Hadway and S. Bergfeld; will add this information and summarize the cattle hunt plan, an example of a wildlife management BMP.*]

TRACY WIEGNER, UH HILO

Dr. Wiegner has multiple short comments of a scientific editing nature, too many to be addressed here separately, these will be responded to during editing. Her major observations re the plan can be summarized as follows:

p. 8.
Suggest using bacteria in biomonitoring as well.
Suggest lower gage should be established in Wailuku River
Not comfortable with using NRCS visual assessment protocol for monitoring

p.9. re the TMDL data: "I'm concerned about Waiakea data—there is construction occurring in 2 locations in ephemeral part of stream—probably skewing the results."

p. 17: note that arsenic can be taken up by phytoplankton using the pathway as phosphorus

p. 18: where do cruise ships currently dump their waste? [*legally at sea, 3 miles out, after pre-treatment, but there are no inspections of treatment facilities on board, and there are records of violations—dumping in Hawaii in inner island areas, including protected areas*]

p. 21. Re the table of listed impaired waters: "How do you do a visual assessment on Alenaio stream, when it never flows?"

p. 22: "should include a list with state standards and compare values for Hilo sites to them" [*this is difficult to do, as the standards are not fixed and vary with the season and the number of samples taken. The standards are posted on the DOH web site. Also remember that there is a difference between the state standards and the visual assessment standards].*

p. 22, 23: Visual assessment is not a valid way of assessing water quality; it would be good to show once and for all with observational and experimental data that visual assessment is not an accurate measure of water quality.

p. 22: why aren't fecal indicator bacteria being measured in streams, given that they may be coming from streams into the bay? [*we assume that this is due to 1) lack of resources and 2) the fact that monitoring is designed to determine beach closures, not to detect and correct the source of contamination*]

p. 23: please clarify whether a secchi disk is used in the visual assessment for turbidity, and what criteria were used for developing the visual assessment for turbidity system [*this information is not given in the visual assessment guidelines; as far as we can tell, the observer can consider any object or no object at all, and secchi disks are not mentioned; in addition to the scaling system already described, the following narrative is also provided re the assessment of turbidity: "Clarity of the water is an obvious and easy feature to asses. The deeper an object in the water can be seen, the lower the amount of turbidity. Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear, but only 20 cm deep, do not rate it as if an object became obscured at a depth of 20 cm. This measure should be taken after a stream has had the opportunity to "settle" following a storm event. This element cannot be measured after recent heavy rains (come back to the site another day). Recognize that organics acids can create tea-colored water; this is not turbidity and should not be counted as turbid. Identify the condition and note the score on the datasheet*]

p. 24: is Honolii stream considered altered or unaltered [*will check*]

p. 24: what does "allocating loads" mean in the TMDL process? [*it means that after the overall pollutant levels are identified, and the hydrology of the stream determined, the various pollutant sources (e.g. farmland, urban areas, logging, industry] are given a limit of how much they can* *contribute to the pollutant load in the stream, so that no more pollution enters the stream than what the stream can "handle", or process biologically, chemically, and hydrologically*]

p. 24, re the study by under way by Dr. Wiegner and Dr. Richard Makenzie: nutrient loads will be a rough estimate, as there is no gage at the lower site on the Wailuku; "the study is not funded to make enough measurement to really calculate annual loads". Also, the study won't actually tell us what is coming from agricultural areas, it will only separate forest areas from urban areas.

p. 25: re her recommendations as cited in the draft: "I would say—identify sources of nutrients, sediments and bacteria to bay using tracers for particular sources" [*will modify the original statement to reflect this*]

p. 26: again, please show the state standards on the graphs [*we will try to provide a meaningful summary of the state standards*]

p. 26: we need to actually measure the amount of fresh water seepage into the bay, along with its nutrient content [*agreed, see research recommendations later*]

p. 30. The station on Honolii stream at Papaikou measures water from an agricultural area, so you should not really consider this as typical of other streams in the area [*note, will change the wording, N levels in Honolii therefore may be more typical of an agricultural area*.]

p. 30. Eliminate statement about Dr. Wiegner's "unexpectedly low" levels of N in Wailuku, because she doesn't "know how her values compare to theirs" [*ok*]

p. 30: "are the chlorophyll samples taken by USGS benthic or from the water column? Benthic is more appropriate." [*will check*]

p. 31: re stream flow data: "only 2 locations are gaged and they are high in the watershed, not at the river mouths" [*We are not sure how many of the USGS stations are currently active. We have no reason to doubt Dr. Wiegener's statement that there are only 2 stations gauged right now. Obviously these two stations are inadequate to the task of monitoring discharge for the purposes of obtaining a big picture of where contaminants are coming from in the watershed].*

p. 31: note that the recent loss of the USGS office on the Big Island is seriously hampering monitoring efforts here…

p. 31. One of the problems with the existing data sets is that data were not gathered in a coordinated fashion, so that different types of information do not correspond in time and space with each other [*agree, this is why we recommend a good research design, beyond a monitoring design*]

p. 32-33. Re Objectives of Restoration Plan: for item 1, also need to know when doe the sediments come into the bay—base flow, storm flow, wet season, dry season, and the amounts. Same goes for nutrients in Wailuku and Wailoa river (item 3). Also, add 3 more objectives to the list: 1. Identify the sources of bacteria in the bay, and develop BMP to reduce them [*first need to determine sources, then develop bmps; if bacteria do not originate in in sewage/animal waste, then there is no need to reduce them].* 2. Determine the impact of invasive species in rivers and estuaries (plants and animals). 3. Determine the effects of paving and stream channel modifications on water quality of streams and bay (sediment loads, important ecological services provided by stream beds, like denitrification). [with respect to this last objective, the impacts of stream channel modification are fairly well-known, and BMPs to restore stream beds or lessen the impact of the modifications should be considered [*The most common alteration to channelized streams is to put a small sub-channel in the bottom of the channel to allow for a constant flow of water even at very low discharge rates. Channelization basically turns a stream into a storm sewer/garbage dump and any "ecological services" provided by the stream are lost. Whatever goes into the channel will wash down the channel unaltered. Restoration of these means removing the concrete and returning them to a natural substrate. This is unlikely to happen*]. [*With respect to new objective 1, we will include something on this, as others have brought it up—i.e. animal vs. human vs. soil, cesspool vs. sewer leaks, ground water vs. surface water; some of these are already addressed in the draft plan. With respect to new objective 2, we will add this as an objective, but with a focus on feral ungulates as well as on marine organisms; the issue of invasive algae is already mentioned and is of great concern. With respect to the first part of the comment, we agree, and note that later in the plan we recommend a research design that includes all water sources and all seasons*].

p. 33. Re approaches to achieving objectives: one approach is to understand the "response of Hilo Bay to drought, flood and redevelopment" [*good point, though with this as an end goal, even more research and modeling will be needed*]. Also, make sure the monitoring plan is long-term, otherwise it is not useful.

p. 34: re cruise ships: "Hilo needs to charge fee to passengers for services in town" *[this is why we recommend a study to find out where the taxes levied on cruise ships are going, and suggest that the County of Hawaii insist that revenues from ships calling in Hilo should stay in Hilo*]

p. 34, re wetlands: wetlands will help reduce sediment and nutrient inputs to bay [*wetland restoration is one of the BMPs we recommend*]

p. 34, re item 12: "UH Hilo cold be a center for fresh and coastal water research in the state" [*that would be great, but UH Manoa already has the WRRC and CTAHR, so it is unlikely that large investment in this area will happen in Hilo. However, research to be done in Hilo area should definitely be done by Hilo-based researchers*]

p. 34. Item 13: include USDA Forest Service and UHGS as partners in any MOU [*will include in list*]

p. 35: re reducing the number of cesspools: "give tax incentives for hookups; need to help communities financially to hook up, it costs a lot of money; give them some kind of assistance or incentive" [*agreed, either an incentive or a direct grant to the County do to the job is required; this is one BMP that could be immediately financed*]

p. 36: re grubbing and grading: “use fines for research” [*fines will probably never provide much in the way of research funds, better to invest the fines back into the enforcement agency, which provides incentive for the agency to enforce its rules. More to the point fines are unlikely ever to be levied in Hawaii*]

p. 37, re ACOE model of Hilo Bay Circulation: Compare model with water quality parameters to crate a nutrient and sediment budget for Hilo Bay [*this suggestion is not entirely clear, but we do agree that the model should be available to serve the community’s needs for further information on Hilo, and especially to future researchers, and that if the model can be made more inclusive right from the start it should be done that way. It should remain proprietary ACOE information after it is developed, especially as it was funded through the County of Hawaii.*]

p. 39. Re modules: “would modules be produced after 5 year initial period? It would be hard to do many of them before that without the critical information” [*no, modules or any other form of education must start immediately. The modules can highlight the current state of knowledge, focusing on both the weaknesses and strengths of the current information available, and can indicate the need for more research, and in fact they should highlight the role of research in management, to increase community support for research*]

p. 41: other researchers who could participate in research: Dr. Lisa Muehlstein (UH Hilo microbiologist); Dr. Jim Beets (UH Hilo Marine Science, fish specialist); Dr. Richard Mackenzie (USDA Forest Service, wetlands ecologist); Dr. Jason Turner (UH Hilo Marine Science, food web ecologist); Dr. Fred Mackenzie (UH Manoa water chemistry). On p. 45, more names are given under Biological studies: Karla McDermid (UH Hilo Marine Sciences, seaweed); Misaki Takabyashi (UH Hilo Marine Sciences, coral) [*names noted; this list highlights the broad base of research expertise and management potential at UH Hilo*]

p. 46: consider monitoring insects as well, as they provide food for vertebrates and provide an indirect link between water quality and vertebrate diversity [*noted, but would have to work with exotic insects at these lowland sites; fish monitoring is practical because the monitoring can be done by the fishers themselves, rather than by an insect ecologist*]

PETER HEFFRON, HBWAG AND TEACHER IN LOCAL SCHOOL SYSTEM

In general, I think it is an <u>excellent</u> draft paper. My main observation is that the paper presents the Hilo Bay Watershed challenges in a sequence that does not feel “natural” or logical. Suggested Ordering: Executive Summary > The Problem > The Solution > Background > Appendices: Budget > Logframe > Maps > other documents. Also, I would include a section on Risk Analysis (“constraints”), perhaps as a sub-section in “8.3—Approach to Achieving Objectives.” List the top few priority issues that could derail each action and state what would be done to prevent, mitigate, or respond to each issue. This will add credibility to the plan.
[This is a major rearrangement of plan structure and cannot be done at this point. The HBWAG should produce a document that reflects their own organizational needs and priority setting].

1-Summary

It's good, but the intro may be too 'abrupt' for the average reader. An initial paragraph on watersheds, water quality, and development, and the link between these would be helpful. Something to grab people's attention and draw them in…. Also, mention of a model watershed restoration initiative could be useful, especially if in Hawaii. Helps re-ensure people their efforts and resources wont necessarily go down a rat hole.
[The summary has been updated to include more information, but has not been adapted for the general reader, as it is meant for technical personnel at DOH.]

2—Project Background
This section is well put together, in my opinion. The only thing that makes me a bit anxious is the five-year time frame (especially item#6) focused on research and monitoring—as the Hilo Bay Watershed disintegrates at an accelerating rate (based on the personal observations and the experience of countless other watersheds).
[We are hesitant to recommend embarking upon site specific physical restoration projects before defining the extent/causes. We do suggest some other measures that are not site specific that can be implemented.]

I think the part of the watershed degradation problem related to increasing—but not systematically documented—pressure on this watershed is not adequately represented in this or any of the other sections of the draft paper. For example, we have relatively unplanned rapid urban/suburban expansion in our watershed (runoff, sewerage, and other issues) and relatively unplanned rapid expansion of cruise-ship visits (air and water pollution—no environmental impact assessments). Both examples could have severe effects on the watershed that could cost far more to remedy than to prevent/mitigate.
[No data were provided during the community input process or the later research process on the rate and pattern of growth in Hilo over the last few years. This was not detailed as a concern in the initial discussions. However, note that we address this topic under the BMPs dealing with Low Impact Development and Zoning.]

The "mindset" of a five-year research and monitoring project (the restoration plan) would likely preclude preventive as well remedial action in a timely manner. My suggestion is to keep perhaps 'two-thirds' of the five year effort in practical research and monitoring, but explicitly move the other third of the effort into policy analysis, stakeholder (governmental, non-governmental) involvement, lobbying and advocacy for watershed sustainability, etc.
[This concern is addressed in section 11.5—"Immediate implementation of critical actions." And section 11.6 "Education plan (education as a BMP)"]

I realize this may be controversial, but that in parallel (as opposed to starting after the first five years), based on lessons learned in other watersheds, takes action to prevent or reduce negative impacts on the watershed, impacts that by the time they are fully analyzed and understood, may well have altered the Hilo Bay Watershed beyond economically/socially/environmentally feasible remediation. Put yet another way, the draft plan conveys no sense of the trends such as rapid growth affecting the watershed, and no sense of urgency. Without going overboard or being too alarmist, a small injection of these things (i.e., "reality") is warranted and might improve chances for carrying out the WRP.
[We are certainly cognizant of the fact of Hilo's unbridled growth and the risk it poses to the health of the watershed. However we consider it more credible to present the facts in as unbiased a tone as possible. In the prevailing social climate any hint of fear-mongering vis-à-vis impending environmental calamity may be looked upon as specious by those with a vested interest in maintaining the status-quo.]

Crucial BMPs that do not require solid evidence or comprehensive understanding of the problem, should be implemented, even if on a pilot basis, as soon as possible during the first five years. Many BMPs are sufficiently "generic," only requiring fine-tuning to suit local conditions, to have a positive effect in the Hilo Bay Watershed…Again, I think we advocate somewhere in the plan some kinds of social interventions starting right away.
[Again, we make some suggestions for immediate actions in sections in the main text, and in the new section on BMPs and demonstration projects]

3—WATERSHED BACKGROUND
Overall, this section looks good.

Hydrology

Might it be apropo to mention global warming/climate change and the potential effects on the Hilo Bay Watershed?
[See BMP # 14.]

Also, I believe we have officially been in a drought for several years, even though this is the rainiest part of the island. This should be mentioned to balance the assumption that this watershed doesn't have to worry about an abundance of fresh water.
[It would be good to keep this in mind insofar as it could strengthen the case for taking measures to improve the watershed given that we can expect even higher flow rates than have been experienced in the watershed over the several years of drought. Note that we require 5 years of data in our monitoring plan to detect trends in pollution levels.]

3.4—Land Ownership
A map would be useful. This section needs a bit more information covering, for example, how the large landowners interact (or don't) and how the HBWAG plans on involving them in the restoration work.
[See comments on DLNR-DHHL collaboration]

Mention should also be made of the Federal Government, which owns the land at the top of the watershed and which plans on contributing to an expansion of the highway that bisects the watershed. A new Army Stryker Brigade is slated to be based close to the top of the watershed. Although its impacts on the watershed, if any, are not known to most (there is an EIA, however), it should at least be mentioned in the restoration plan as something to explore further.[*we are looking for information on this*]

Urban Areas

If possible, please mention what the watershed used to be like per early Hawaiians and explorers. I would say a little about the ahupua'a concept and what the Hilo downtown area was like 200 years ago (i.e., marshes, taro patches, etc.).
[Uncertain about the utility of such a description. There seems little hope of restoring the watershed to pre-European contact condition, this was not a goal mentioned by the community.]

The word "landfill" is mentioned only once in the draft paper, yet landfill problems are likely to be among the more dominant ones over the next 5 years and beyond (it is a major crisis even

now). The present Hilo landfill will be closed in five months. And it is unlined. It is bound to have negative impact on ground water and probably Hilo Bay for many years. Thus it should be mentioned in the plan, ideally with a strategy to include it in the restoration plan's monitoring activities.
[Agree that the landfill issue is important and should be considered in any restoration plan. However,at this point the only action we could take is to monitor water flow from the area of the landfill and determine whether it is contaminate; such monitoring should already be carried out on a regular basis by county officials. Did the WAG receive information that monitoring was showing polluted waters in the area of the landfill? It would be worth checking into the quality, regularity and scale of monitoring for the landfill, to determine whether it is sufficient to detect any problems.

The Friends of Downtown Hilo planning process and collaboration with the HBWAG's efforts should be mentioned.
Done

8.1—Overall Conceptual Approach to Restoration
Can't we say the ultimate goal is a sustainable watershed, and a watershed management plan will help us get there; and say that the water restoration proposal focuses on the water quality elements of the problem? As presented in the draft, this section seems a bit 'disjointed.' In WAGSC discussions we used the analogy of two umbrellas. The first umbrella is the watershed and the watershed management plan. The second, smaller umbrella—the water restoration initiative—lies under the first umbrella. Logically, ideally, we would have opened the first (watershed) umbrella before the water restoration umbrella, but since that wasn't to be, we need to work on both simultaneously, in a coordinated manner.
[Embarking on a discussion of sustainability will get us off-track with the EPA requirements. This is a topic for the WAG to develop and write up].

8.2—Objectives of Restoration Plan
The main objective seems to be missing: improve the water quality of Hilo Bay
[Incorporated now].

JENE MICHAUD, UH-HILO HYDROLOGIST
p. 10, first line. Is *Paukaa* misspelled *Pauka*? .
Yes, should be Paukaa

Last paragraph on p. 10. We really don't know the ratio of stream to groundwater freshwater inputs. Instead of saying that "most" of the freshwater is from streams (is it?), why not say that in this area--unlike areas to the south--there are perennial stream contributing freshwater to the coastline. Strike the word "Pahala" (the ash in this area has a different source than the Pahala ash in Kau).
[We are citing from M & E Pacific's (1980) Hilo Bay Comprehensive Survey]

Table on p. 11. Does the source state the methods used to estimate the groundwater fluxes? Please cite the original source of the groundwater data in the table and map. (I assume you got the info from M and E Pacific, but where did they get it from?)
[They used a flow net (derived from head levels in wells) produced by John Mink – local groundwater hydrologist, but do not include any citation. They support their findings regarding the magnitude of groundwater flux by citing the work of Fischer et al. who looked at freshwater springs into Hilo Bay using infrared imaging ca. 1966.]

P discussion on p. 12. Were the elevated P levels for total P or dissolved P? Can you be sure that higher P levels in the wet season are due to "surface" runoff. . It could be partly from higher P fluxes in groundwater (groundwater fluxes will increase with recent rainfall) or re-mobilization of P that previously sorbed to the rocks that the groundwater was moving through.
[P levels were Total - M&E report pg. VII-26 Yes, I suppose so. We were quoting from M&E. We cannot be sure that the highher P levels in the wet season are due to "surface" runoff].

"Surface" runoff is not a useful term because during baseflow conditions the streamflow is derived from groundwater. Storm runoff is probably a mix of true surface runoff, runoff traveling through the shallow subsurface and groundwater.
[Yes, "surface runoff" is an ambiguous term.]

Pesticides in GW (fifth paragraph on p. 10). Double check the maps to make sure if the contaminated wells are in the Hilo Bay watershed, and give a general description of the locations of the contaminated wells that are in the watershed. Please note that there is a new map out for 2004.
[New maps for 2004 not yet available from DOH The URL we give for the maps in the bibliography is wrong and should be changed to http://hawaii.gov/health/environmental/water/sdwb/conmaps/pdf/conmaps03.pdf]

p. 16 - History of sewage systems. Please add the following (from Kelly et al, 1981)
[done].

Hilo's first sewer system, which delivered raw sewage inside the breakwater was completed in 1905-1906. The system was expanded in 1935-1937 to incorporate a longer outfall and hook up Waiakea Town. The capacity of the Waiakea segment was *too* small, and at times raw sewage was discharged into Wailoa River. In 1952, 3.5 million gallons per day of raw sewage were discharged from the outfall, but most of the town relied *on* cesspools, not the sewage system. In 1962, the Hilo Sewer System served about 20% of the Hilo population. The sewage system was upgraded in 1966 to include primary treatment, locate the outfall outside of the breakwater (off Puhi Bay), and other improvements. The treatment plant was upgraded to secondary treatment sometime after 1980.
note: if possible please report when the secondary treatment and Puhi Bay outfall were completed. I don't know the date offhand.

Sewer connections on p. 16 - fourth line from the bottom. Please add that typical costs for connecting are on the order of $5,000-$15,000 per house, depending on the amount of lava rock that must be excavated and whether a pump needs to be installed. This cost is the major barrier to more hook ups. To address lack of hook ups we must address the cost barrier. Can we do anything to soften this barrier?
P. 16. The report should note that the sewage outfall has a NPDES permit. Can you refer us to information on the permit or self-monitoring data? *We are not considering the outfall as a source of pollution for Hilo Bay*
P. 16. You should mention the gang cesspools, which are currently the focus of regulatory action. Contact Dan Chang at DOH for more information. .
[Mentioned as BMP]

P. 17 (bioaccumulation of arsenic). There is a sentence that says that fish DO bioaccumulate AND it is rapidly excreted. Which is it? It can't be both.

Bioaccumulation within an individual is not the same as biomagnification up the food chain, so amounts are small. Language in text modified to clarify this issue].

P. 17 (gas plant). The 2000 flood stirred up creosote (?) from the gas plant and spread it over the soccer fields, some of which were closed for a long time. This issue deserves more attention in this report.
[Unfamiliar with the incident. Need to find information from Hilo DOH rep. Not reported as a water quality issue associated with turbidity, fecal contamination or nutrients by DOH, however, so not included in this plan, which addresses the issues for which the bay was specifically listed in the 303d list of impaired waters]

P. 17 current uses of the bay. The report neglects to mention commercial shipping.
[It is mentioned as occurring, in relation to the breakwater]

For regulatory purposes, please mention that Hilo bay is regulated as class A waters and list the water quality objectives of class A waters (see p. 54-9 of Hawaii Administrative Rules, Tittle `` (DOH), Ch 54 Water Quality Standards). Please provide similar information for the tributaries. DOH may be able to clarify for the streams. *;*
[Done for Hilo Bay.]

P. 19, to the UHH researchers please add Jon-Pierre Michaud (chemistry dept) who has expertise in toxicology and is working on pesticide exposures via stream biota. *Was already mentioned later in plan.*

P. 22. Please clarify the DOH guidelines regarding the temporal and spatial sampling frequency required to determine if a water quality exceeds regulatory guidelines. For streams, you need 10 samples, but over what length of time? The same question applies to 2% criteria. DOH written documentation does not seem to say, so you may need clarification from DOH.) It would be extremely interesting to know, on a stream by stream and parameter by parameter basis, whether the existing sampling program is sufficient to determine if violations are or are not occurring.
[We already had a brief description of these standard and systems in Section 7. Detail are available on the web at the DOH website and in the latest list of Impaired Waters for Hawaii, which can be downloaded from the same site.]

Sediment Toxicity Data. Did anyone ever interpret all that sediment data (metals and organic chemicals) (plus some aqueous assays for metals and organic chemicals) that were taken in Hilo Bay and Waiakea pond from 1976-1987? (or the similar USGS data for streams?) The Restoration plan does not cite any report associated with the data. I believe that a worthwhile research project would be to interpret this data in terms of ecological and human health concerns. Since the data is already collected, we would get a large amount for our expenditure.
[Spoke to Terence Teruya at DOH Clean Water Branch about this data. There are some problems with it, and the lab that did the analyses was subsequently closed down by the EPA. Think Terry did some analysis of the data.]

It is essential that the report includes a table that lists the DOH regulatory standards for Hilo Bay and the streams flowing into it. Please indicate whether (when?) Hilo Bay is held to the wet versus dry standard (ask DOH for clarification). Also mention or list the standards for metals and organic chemicals listed on p. 54-11 of (see p. 54-9 of Hawaii Administrative Rules, Tittle `` (DOH), Ch 54 Water Quality Standards).

[We feel it is not essential. It is not the objective of this plan to interpret and improve upon the DOH's standards. HAR is available on the web].

The tables and charts would be improved by inclusion of information on the applicable regulatory standard for the parameter under discussion.
[Regulatory standards are not clear-cut enough to be included on a single page in most cases.]

The document should be reformatted so that the figure caption appears on the same page as the figure itself.
[Agreed.]

I don't recall whether the report addresses whether the bay is well oxygenated. When I looked at Storet Legacy data from Hilo Bay I found that (from 4/4/74-10/6/97) 18% of DO samples were below the regulatory standard. This seems significant.
[D.O. will vary a lot depending where (depth, site) samples were taken].

Section 7.13 (streamflow data). The report should mention that there was a large body of streamflow data, plus some water quality data at a USGS station near where the Wailuku River enters Hilo Bay (station 16713000), but the data have been retracted due to quality assurance issues. There was also a large amount of very valuable sediment data for this site, but until the quality assurance issues with the streamflow can be resolved, the sediment data cannot be considered perfectly reliable either. It is my opinion that the USGS should be pressured to issue a revision stating which data can be considered reliable. Some options to consider include partnering with the agency that paid for the data (and presumably has a vested interest in getting updated information) or asking the USGS how much they would charge to issue a revision.
[Recent discussions with the USGS indicate that it is, in fact, the sediment data that is unreliable while the flow data has been checked.]

The report should mention Leptospirosis, as it does pose a potentially significant health threat (risk of death) to those who recreate or work in streams, even if only a small number of people become seriously ill. This is a notable omission in the DOH monitoring efforts. Education needs to address Lepto. I am forced to recommend to my students that they not wade or swim in streams, which is a problem for doing water sampling.
[It should be noted that Leptospira are not easy to monitor for, especially if you care if it is the pathogenic kind. Environmental waters are full of non-pathogenic types which are almost impossible to distinguish from the pathogenic strains. Standard laboratory methods for detecting them in water do not exist. People working in the streams should wear waders. The waters were not listed for leptospirosis, as there are no state standards for this.]

The following two items should definitely be included in the reference list: The first is a wonderful reference
[Done]

Kelly, M. (Marion), B. Nakamura, and D.B. Barrere. Hilo Bay, a chronological history : land and water use in the Hilo Bay area, island of Hawaii. prepared for U.S. Army Engineer District, Honolulu Publisher: [Honolulu] : Bernice P. Bishop Museum, c1981 Description: xiii, 341 p., [3] folded sheets : ill., maps ; 28 cm.
Halbig, J. B. Barnard, Bartlett, Overfield, and Abbott. A baseline study of ground water geochemistry in the Kawaihae and Hilo areas on the island of Hawaii. prepared for] Dept. of Planning and Economic Development, State of Hawaii. Publisher: [Honolulu] : Dept. of Planning and Economic Development, 1986. Description: vi, 74 p. : ill. ; 28 cm.

The following reference is in the library, but I don't know how important it is.
Title: Hilo Bay pollution study / prepared by the Student-Originated-Studies Program ; National Science Foundation, Student Project Directors: Michael S. Osato, Mary Lou Yuen ; Faculty Project Advisor: Dr. John G. Chan. Publisher: Hilo, 1971. Description: iv, 165 p. : ill. ; cm.

Main Comments on Proposed Monitoring Plan (p. 42-44)
Instead of specifying the details implementing the monitoring plan, why not be specific about the goals and seek competitive bids for the implementation of the plan? The competitive bids may have better or more effective plans than we can come up with in the next month.
[Depends on our interpretation of our mandate.]

In most cases I am opposed to the use of volunteers for data collection. Quality data will suffer.
[Disagree. Monitoring can be done effectily with well trained, well-organized volunteers. It also depends what kind of data the volunteers are collecting. It does not require a PhD scientist to collect data. Furthermore, the educational return of working with volunteers is huge.]

I feel rather strongly that visual assessment should be discontinued in favor of quantitative measures.
[No, visual techniques can be useful for monitoring if calibrated to quantitative data, as we propose.]

There is already a large amount of water quality data, and before we spend money getting more, we should try to interpret the data we already have. I propose that we contract out a study to examine the existing data for the purpose determining if there is a relationship between stream water quality (suspended sediment concentrations, nutrient concentrations, turbidity), and a) streamflow levels, previous rainfall, b) soils (Mauna Kea vs. Mauna Loa shields), and c) land use. Similar studies could be entertained to examine the variability of Bay nutrients, *C. perfringens,* and turbidity in relationship to rainfall (which could affect groundwater fluxes), streamflow, and high surf.
[We think the existing data is woefully inadequate to the task of identifying sources of pollution in the Bay.As we must have stated elswhere, the data was mostly collected for the purposes of public safety, not pollutant source identification. Feel that little can be learned from examining existing data.]

To re-emphasize, we need to know more about how stream water quality varies with streamflow level and soil type. Otherwise we may have trouble interpreting how stream water quality varies with landuse.
[Agreed Yes.]

In addition to looking at sources of pollutants we need to do baseline monitoring (a few key parameters in a few key locations) so we know how water quality is changing over time. This baseline data is essential for prioritizing restoration projects determining their effectiveness. It appears (if I can believe the data sets I got from Peter Rapa, which may be incomplete for recent years) that DOH has stopped monitoring certain parameters that are probably exceeding regulatory standards in certain spots.
[Base flow data will be useful in identifying sources of groundwater pollution, such as the contributions from onsite disposal systems. We feel, however that restoration will/should probably focus more on storm flows as turbidity is the principal reason for the Bay's inclusion on the 319 list and storms are when the greater amount of sediment is flowing into the Bay. DOH has stopped monitoring for most parameters at most sites. They only sample at a couple of beach sites now.]

If money were no object, I would recommend a spatially intensive monitoring scheme to establish the spatial variability in Bay nutrients, turbidity, chlorophyll-a, and *C. perfringens* .

However I feel that this is a lower priority than the monitoring and mentioned in the previous paragraph.
[We respectfully disagree. We think that identifying the sources of turbidity and other contaminants throughout the watershed is the top priority, and that base flow quality characterization is secondary.]

The extant land use data that is in GIS-readable format isn't that great. The biggest problem is identifying active vs. inactive ag lands. So I would agree that better land use data is a priority, but it may cost more than you have budgeted.
[note that such data will become available shortly from other agencies—eg NRCS]

Ultimately we need to better understand nutrient cycling within the Bay itself, as that is the key to understanding the *impact* of the nutrient fluxes. This is the sort of thing that could be done with a $300,000 NSF grant, but can probably wait until we have a better handle on the amount AND FORMS/SPECIES of nutrient fluxes.
Understanding the cesspool/groundwater system is very important. It should be possible to identify N from cesspools (as opposed to fertilizer) using stable nitrogen isotopes (possibly in conjunction with oxygen isotopes). This data, in conjunction with bacterial data and a mathematical groundwater model linked to a cesspool map could get a handle on this issue. Once challenge will be the shortage of wells in Hilo. I would roughly estimate $200,000 for this project.
[This would be an interesting and worthwhile project to recommend.]

Additional Comments on Proposed Monitoring Plan
Please note that in much of the Hilo Bay watershed, there are severe constraints on the number of locations where samples can be taken. These constraints relate to: lack of roads, deep inaccessible river channels, safety; and landowner permissions. Replicate sample sites (more than one site per land use) are really not possible.
[We feel that samples obtained from as high as is practicable can tell us a lot. If someone can get up there to farm or hunt then presumably someone can get up there to take a sample.]

You should budget about $10,00 *each* for automated storm flow samplers.
[Okay.]

If students are hired to do field sampling, we should budget for transportation, as many do not have cars. [*Yes].*
In general, the listed costs of the research plan are much lower than would be required to do a quality job. [*We did not intend these figures to be final. Individual proposals, with budgets, will have to be developed by researchers and others once DOH decides which aspects of the WRP it is interested in funding, or by researchers seeking independent funds]*

What do you mean by "manual samplers" for N and P?[*grab samplers]*
During storms, you cannot get representative TSS data from grab samples. Representative TSS data (and reliable TP data) must be taken from flow- and depth- integrated samples, which are practically impossible to get unless you have a cable-way like the one at the Piihonua site. This appears to be a (financially) unavoidable limitation.
[We feel that, while they may not be entirely representative, grab samples would provide useful data of sufficient quality to make determinations about relative contributions of sediment by different streams during storm runoff events at an acceptable cost. We believe in thinking outside the box. There are many people out there who can probably come up with alternative methods to sample water, given sufficient incentive]

Please contact Kathleen Ruttenberg (kcr@soest.hawaii.edu) for ideas about monitoring for P sources and studying the P dynamics in the Bay. As P cycles between various forms the bio-availability changes.

Comments on Waiakea Pond and Wetland Restoration (p. 45)

It is not at all clear that there is community support for wetland restoration. Perhaps we should suggest a feasibility study rather than a demonstration project.

This could be very true and should be investigated by the WAG for community acceptance. There is extensive data to support the ecological services provided by wetlands. The community should be educated about these ecological services.

If you do stick with a recommendation for a demonstration project, you will need funding for lab measurements of nutrients.

Concluding Comments

I spent a lot of time reviewing the restoration plan but ran out of time, which is why I don't have any comments on the education plan. Again, I wonder if it might be better to focus on the goals we want to accomplish and a broad plan for how to accomplish them, but not go into too much detail on implementation. There may be controversy on some of the goals. Is there a plan for reviewing and coming to a consensus?

We had difficulty getting a consensus from the WAG on what the goals of restoration should be.

STEPHEN SKIPPER, RC & D, NRCS

Summary

Between sentence 2, 1 & 2: In the mid to late 90's the Wailuku River drainage basin experienced a drastic change in land use activities. Following the departure of sugar plantation operations and the cessation of continuous harvest and tillage cycles much of the area was stabilized by volunteer cover, modified for residential development and smaller areas were planted to other crops. Overall, annual tilled and open or bare land acreage has been drastically decreased. Any water quality and erosion and sedimentation data gathered during the former period may no longer present a valid picture of current sources and levels of impairment in this watershed. *[done]*

2nd paragraph last sentence add: "and the possibility of setting unattainable standards of for water quality".

Project Background

2.1 Review accuracy of M&E data in the last sentence…"one of the largest basal groundwater spring areas of the world" (Amazon Basin and others notwithstanding,)

We'll take M&E's word for it, it is after all a quote.

Watershed Background - S. Skipper, RC&DC comments.

3.10 Agricultural, Lands – Paragraph 3 needs some revision. Please refer to similar comments on section **8.5-3** on data and Conservation Plans and practices. The last paragraph in this section is misleading to a degree in that the **NRCS Hawaii Field Office Technical Guide (FOTG)** is locally adapted and contains standards and specifications for all conservation practice application. **The NRCS National Conservation Planning Procedures Handbook (NPPH)** is also used to link and associate practices in a systematic manner for specific types of plans. Planners use these manuals to insure that practices are appropriate and integrated to apply a "conservation systems" approach in development of the Conservation Plan documents. The

Hawaii FOTG is accessible on the web through the NRCS Hawaii website. Conservation practice application effectiveness is also well documented. **NOTE: I said application. If a plan and associated practices are not applied they t can't be viewed as complete or effective.**
Modified as requested

CURRENT USES OF THE BAY
3.13 PG. 18 Surfing and Swimming Hilo Bayfront as it is called is one of the longest and best left hand surfing breaks in the State of Hawaii. It has a narrow swell window and breaks infrequently predominantly from October through February. The surf spot has a long cultural history and is referenced by Isabel Byrd Bishop in her novel **Six Months in the Sandwich Islands**. There is a large contingent of dedicated wave riders that use surf based website information to predict the swell events and the spot can accommodate larger amounts of surfers due to the expansive nature of the surfing area.
[modified as requested].

Swimming is not uncommon at the Wailuku river mouth but the beach is small. Most of this type of activity would be better termed "wading" especially along the Bayfront Beach or Canoe Beach section of the shoreline and Wailoa Boat Ramp where children often can be seen playing in the shallows on the weekends while parents participate in paddling or fishing activities.
A common complaint is water turbidity and skin irritations that have been observed from time to time from some unidentified sea creature(s). Since this popular surfing spot sits at the mouth of the river with largest volume of water in the state some studies should be undertaken along the reach of the riparian system to locate and quantify potential pollutant/bacterial entry points. Most of the inputs into the marine environment are likely traveling into the bay in or on the waters of the Wailuku. (S. Skipper – pers. comm.)
[recommended].

EXISTING MANAGEMENT EFFORTS &WATER RELATED MASTER PLANS
2.) Pg 19. Somewhere in this section you might want too include plans for a project along Kaumana Dr. from Chong St. Bridge to ½ mile above Wilder Road that is associated with the Waipahoehoe Stream corridor. This will consist of a series of smaller projects to protect homes and is associated with the Wailuku-Alenaio Watershed project. The County of Hawaii will be the project sponsor.
[done]

Technical assistance has and will be provided by NRCS.
S. Skipper, RC&DC comments.
NRCS - Existing Management Efforts and Water Related Master Plans - NRCS is involved in ongoing efforts to promote stewardship by development of Conservation Plans for agricultural producers in the Hilo Bay Watershed as well as other areas outside of the watershed. Some of these plans will be associated with USDA Farm Bill cost sharing funds to implement erosion control, grazing management and habitat enhancement and protection programs.
In addition there will be a review and selection of watershed areas (some in the WRP area) for participation in the Conservation Security Program (CSP), another Farm Bill Program that targets watershed areas and operators for stewardship incentive payments for applying higher levels of conservation shown in their individual Conservation Plan.
The NRCS Field Office (FO) and is also responsible for working with the local Soil and Water Conservation Districts to accomplish a GIS based Resource Inventory for the F.O. work area. This inventory will include soils, watercourses, critical habitat, drought affected grazing lands,

coastal ponds, potential water quality problem areas, confined animal sites, wellhead locations, fire hazard areas, noxious species and watershed project areas and many other resource concerns. The Resource Inventory will include a sub-inventory of the Hilo Bay Watershed Restoration Plan boundary area and have several layers of information in that section as well.
The NRCS Big Island RC&D Coordinator and RC&D Council are involved in assisting the HBWAG with grant development, grant seeking and fiscal sponsorship of any received funds. The RC&D Coordinator is also providing technical assistance and input on the Resource Inventory and local water quality issues as a former co-researcher and student coordinator in a previous Hilo Bay water quality study (**A Study of Sewage Pollution Distribution and Dispersion in Hilo by and Contiguous Waters** Dudley, Hallacher, et al) work with University of Hawaii @ Hilo 1988 -91.[*incuded*]
6. Sources Of Information On Water Quality In Hilo Bay - S. Skipper, RC&DC comments. Might be better to start out with, "There is little current research on the Hilo Bay ecosystem and previous research is sparse at best."
[sone]

This section should include the first mention of **: A Study of Sewage Pollution Distribution and Dispersion in Hilo Bay and Contiguous Waters,** Dudley, Hallacher, et al. This 2 year comprehensive study is mentioned elsewhere in the text and in the appendix but not in this intro. section. This was a long term study and represents an equal or larger body of data than some of the other mentioned studies. Probably the most comprehensive bacterial NPS study to date of the contiguous waters of Hilo Bay. It also has data from other observations regarding surface and subsurface current speed and direction, salinity stratification and specific data gathered on bacterial dispersal at the Honolii Surfing Beach. [*done*]
8.5 Immediate implementation of critical actions: Undertake a study of soils in the watershed before dooming all cesspools to see which are most appropriate for cesspools, septic systems and which landscapes should have centralized sewage. Some soils may provide adequate filtration for cesspools where others would be more suitable for septic systems. Some soil areas would only be suitable for centralized sewage due to characteristics. Generally the younger landscapes south of the Wailuku River are the most unsuitable for cesspools.
[Mentioned, but don't know if soil information alone is adequate for making the determination of suitability of on-site systems. Population density should also be considered.]

8.5 -3 & 4 - pg.37 – Review and analyze existing SWCD soil management plans/Consolidation of BMPs by NRCS – There is a fairly complete record of all that you are suggesting here and it has been in place for decades.
[note some modifications to the language here; however, we feel that an external review of the efficacy of this system would be advisable]

This section needs to be revised. SWCD does not accomplish "soil management plans" (the term is Conservation Plans) for the most part, save for the few done by their 1 planner in the Hilo NRCS Field Office. Plans are done by the NRCS staff with review and approval or denial by the respective SWCD board at monthly meetings.
NRCS generally supervises elements of plan installation, but not always if producers are comfortable installing. NRCS employees are required to provide designs and specifications for all practices. All programmatic (FARM BILL and other) projects are inspected after installation and need to meet NRCS standards and specifications (see **FOTG** above) before cost share payments are made to producers. All conservation practices in the plan (BMPs in watershed lingo) are also designed according to NRCS specifications. **In essence the NRCS Field Office**

Technical Guides (FOTG) Number 1 through 5 are the "consolidation of agricultural BMPs by NRCS" that you are requesting.
[modifications made].

Conservation Plans are installed and completed at various levels according to producer need and ability to accomplish. The highest level of Conservation Plan is the Resource Management System (RMS) level plan and it addresses all identified resource concerns at that level. Resource concerns are determined by pre-planning field inventories and producer concerns, goals and operational considerations. Everything from cultural resources, soils, water quality and endangered species are reviewed on standardized inventory check sheets.
Conservation Plan implementation is extensively documented in the NRCS Progress Reporting Management System (PRMS) and soil erosion reduction rates, water conservation rates, acres planted to ground cover, wetland acres created, habitat acres created or protected, no. of acres of planted to buffers etc., etc., etc are all recorded in the system showing the net savings, gains and quantifying the whole process.
In the past any citizen could access the NRCS, PRMS at the county level to see field office progress through the NRCS and NRCS Hawaii Home pages. Maybe you still can. I haven't been in the field office for 2 years so I'm not sure. In addition the implication here is that Agricultural activities seem to be targeted. There is a low level of agriculture in the watershed compared to the total acreage.
Completing a resource inventory prior to much of this effort would align activities and determine if some of them are needed at all. The review of the completed inventory would provide a great deal of information about what is occurring in the watershed with land use and cover. Contacting landowners to find out what their concerns and priorities are would help direct energy toward problem identification, stake holder concern validation and landowner buy in..
8.6 Education Plan – pg. 37 - S. Skipper, RC&DC comments.
<u>Formal Education:</u> The real trick here is figuring out HOW you are going to be included in any formal curriculum. DOE may not want to play with any of this and may need to be involved from the outset in the curriculum development if this is to be formalized. This may take a long time to accomplish and may not be as practical as the informal approach.
The CANON ENVIROTHON competition is very successful in the mainland and encompasses a wide range of environmental management concepts from water quality and biological integrity to agriculture, forestry and soils. It would be of great benefit here for the schools. This contest is well supported by the National Association of SWCDs on the mainland.. It should be incorporated here as an annual competition.
CANON was providing $ 4000.00 for pilot program development.
[*information added*]
Pg. 41 – In the section on researchers perhaps include Drs. Leon Hallacher, Ichthyology, Marine Biology and Walter Dudley Oceanography, Dr. Randy Schneider, Chemistry and possible UHH Marine Option Program (MOP) Student Research Projects, including possible transect setting and monitoring under the summer Quantitative Underwater Environmental Survey Techniques (QUEST) Program. This could be used to set transects for density and diversity of fish and coral species that could be checked at a minimum annually or incorporated into other student research projects for more frequent review. [*done*]
Pg. 42 – Objectives of socio-economic research
1.) Is this really necessary?? Hilo Bay as opposed to Hilo Watershed. The cruise ship industry probably has minimal effect on the watershed but I get the drift here.

2.) It is not clear yet what is being done or not done in the watershed with respect to management that is contributing to the perceived problems. Inventory and research first and then recommend management. Maybe that is what you are saying here. I don't think all of the recommendations can be accomplished concurrently. Should we have an implementation schedule on this to clarify general phases of the WRP???

S. Skipper, RC&DC comments.

9. Proposed Management Structure, Phase 1 of Restoration Plan

Informal Education - There are a wide range of existing generic, to State of Hawaii specific watershed education and information materials in many forms, from videos, posters, coloring books and community watershed activity guidebooks. Several watershed partnership organizations NGOs and particularly USDA have materials of this type.

I have produced local videos and currently the cost is $1500.00 per minute for finished professional grade product. It might be more effective to produce a series of locally produced SPOTS that could be run on channels here for increased public awareness. I think it might be cheaper to search for and organize existing materials that could be adapted. Concept is really the key and the general concepts on water quality and watershed stewardship can be learned from existing sources. Also if curriculum is developed it needs to be incorporated (buy in) by DOE before large amounts of money are spent.

Mr. Skipper makes some good points here.

It would also be best to produce anything locally on watershed dynamics **after** the research is completed so that it is reflective of what happened here with the whole process of the HBWAG. That would be a real documentary that would incorporate process, history, research and recommendations. This what we thought and heard, this is what we found out from research, this is how we told everyone and finally, this is what we did.

ROY TAKEMOTO, DEPUTY DIRECTOR, COUNTY PLANNING DEPARTMENT

Summary. The Summary is often the only section read. We are partial to subheadings where the main points and organization become apparent with a quick scan. Suggested subheadings include: study area, plan objectives, findings, action plan.

[format was modified]

Project Background. The normal reader does not care how this plan conforms with the EPA criteria. Perhaps that element-by-element analysis can be in an appendix. It is useful to know what prompted this study, so the first paragraph is well-written. I would perhaps quote EPA's nine elements in one list, then synthesize how those elements have been applied by restating the elements as plan objectives or determining the plan's organization.

[Report is meant to be technical]

Watershed Background. A major section that seems to be missing is a discussion on previous studies and history of Hilo Bay—how did we get where we are. For example, the arsenic from the canec plant—is this still a concern in the sediments? If so, how does this affect the bottom feeders (crabs and mullet)?

[We do address all these points in this section]

The other subsections could perhaps be organized by source (the land subsections), pathways (hydrology), and receiving waters. The receiving waters section discusses uses but does not

discuss circulation. The biology section has some discussion on the benthos, but not much detail provided. Where applicable, distinctions in subwatershed characteristics should be discussed to understand which contribution areas and receiving waters are critical areas. On the hydrology, perhaps the difference in rainfall by elevation is pertinent. Because most of the rainfall is orographic, the amount of rainfall reduces above a certain elevation. Is the entire watershed to the top of Mauna Kea really critical, or can we outright dismiss this higher elevation area as lesser priority?
[We do not have sufficient information on the relative contributions by each subwatershed]

Water Quality Data. The plan is an opportunity to synthesize the state of knowledge and deficiencies. Is there one composite map showing the sampling locations of the various parameters?
[No, many stations, small 8.5" x 11" paper]
Can the plan relate the parameters to the public health or ecosystem concern by reorganizing the parameters under subheadings?
[Unclear what this means]

Restoration Actions. This is the heart of the plan. The actions should be clearly substantiated by the findings. The first recommended action stood out—reduction of cesspools. On the one hand, the plan acknowledges the uncertainty of cesspool contribution to nutrient load: "This could indicate runoff from fertilizers, but also contamination from cesspools and septic tank leachate. Monitoring of wastewater indicators together with nitrogen at selected areas will help determine the source, as will tracing studies." (p. 35). Then a leap of logic without substantiation is made: "However, the state of knowledge of the general contribution of cesspool leachate to ground water is sufficient to call for the elimination of cesspools in the hydrologically active areas." Such drastic unsubstantiated recommendations (drastic in terms of cost and resources to implement) undermine the credibility of the plan. Research is an important immediate need. The plan has a good discussion of the research objectives (p. 41); however, these objectives and the specific projects should be widely discussed before funding applications are submitted to ensure useful answers are being sought for the right questions. If this plan is the place to justify the research projects and would serve as the basis for EPA funding, then we would like to know this so that we can direct more focused review on this portion of the plan.
Given that we are uncertain about everything, we feel that the least uncertainty lies in the area of wastewater, which is associated with human health issues and risks, and for which alternative treatment plans have already been developed extensively.

Jeff Zimpfer, UH Sea Grant Non-point Source Pollution Extension Officer
Need to add information on county wide storm water management. May want to add something about impervious surfaces in the built up areas of the watershed and perhaps add demonstration projects with pervious pavement
[done].

May want to consider the effects of feral animals on water impairment, especially pigs. May want to look and invasive plant species too, gorse, albizia, strawberry guava, etc.
[done].

You may want to think about modeling the effects of septic a cesspools.
We think it would be better to monitor the effects of septic and cesspools.

Figures 13 – 17 are sort of meaningless. Means do not tell you much the raw data would be better and plot it over time and include with it flow data, precip etc and then put on the same graph what the state standards are to give the readings some context.

There is no flow data for these DOH sites. They are in the ocean. It ***would*** *be interesting to compare using precipitation data. Someone should do this. State standards are not a static thing, they depend on how many samples have been taken, where they are taken, and so forth.*

APPENDIX 7—DEFINITION OF CLASS A WATERS BY HAR §11-54-03

It is the objective of class A waters that their use for recreational purposes and aesthetic enjoyment be protected. Any other use shall be permitted as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with recreation in and on these waters. These waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or control compatible with the criteria established for this class. No new sewage discharges will be permitted within embayments. No new industrial discharges shall be permitted within embayments, with the exception of:

Acceptable non-contact thermal and drydock or marine railway discharges, in the following water bodies:
Honolulu Harbor, Oahu;
Barbers Point Harbor, Oahu;
Keehi Lagoon Marina Area, Oahu;
Ala Wai Boat Harbor, Oahu; and
Kahului Harbor, Maui.

Storm water discharges associated with industrial activities (defined in 40 C.F.R. Section 122.26(b) (14)) which meet, at the minimum, the basic water quality criteria applicable to all waters as specified in section 11-54-04, and all applicable requirements specified in the chapter 11-55, titled "Water Pollution Control"; and

Discharges covered by a National Pollutant Discharge Elimination System general permit, approved by the U.S. Environmental Protection Agency and issued by the Department in accordance with 40 C.F.R. Section 122.28 and all applicable requirements specified in chapter 11-55, titled "Water Pollution Control",