# Watershed Based Plan for Kapakahi Stream

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**O`AHU RESOURCE CONSERVATION AND DEVELOPMENT COUNCIL, INC**
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# EXECUTIVE SUMMARY

Kapakahi Stream is listed as an impaired water body under the Clean Water Act's 303(d) listing (June 16, 2004) and does not meet State water quality standards for nitrite/nitrates, total nitrogen and total phosphorus (DOH, 2004). The purpose of this watershed based plan (WBP) is to produce a plan that is likely to significantly reduce non-point source degradation to Kapakahi stream. In particular, this will involve reducing nitrate/nitrite and phosphorous loadings, trash from urban 'runoff' and airborne sources, especially areas near the convenience station operated by the City and County of Honolulu, and illegal dumping into and adjacent to the stream.

A secondary purpose of the WBP is to galvanize current stakeholder efforts and actions that are improving the upper and lower reaches of the stream. By improving the stream's water quality, community access, stream esthetics, ecological functions, and characteristics, the stream can be a keystone for continued community renewal. It will also link the natural and cultural resources at the Hawaii Plantation Village to the town center and extend this natural, cultural, and economic link along the stream to Pouhala Marsh, Pearl Harbor and the Waipio soccer complex. These links and a clean stream will create community ownership and a safer, healthier urban stream that is a community asset. The plan is for the restoration of Kapakahi stream to coincide with the building of a stream walk that will better link the Hawaii Plantation Village with Central Waipahu and a Festival Market/Business Incubator and then to the Pouhala Marsh and from there to the Waipio Soccer Complex.

The proposed plan covers the nine elements required by the Environmental Protection Agency for watershed-based plans that are developed with Section 319 funds to address issues of Section 303(d) of the Federal Clean Water Act. Estimates of the amounts of technical and financial assistance needed are being determined by our partners. A schedule for implementing NPS management measures will take place over five years.

A Kapakahi Stream Water Quality Analysis (KSWQA) (Tetra Tech, 2005, Appendix A) examined Kapakahi Stream for water quality issues in 2003 and 2004. Tetra Tech field investigations identified urban runoff flowing into Kapakahi Stream directly and indirectly through storm sewers, farming activities and natural processes that cause erosion to increase silt loads as the primary sources of excess nutrients in this watershed.

Significant accomplishments to date by the partners working within this watershed include the City and County replacing 2,200 feet of thirty plus year old sewer line in the headwaters of project area and cleanup work along Kapakahi Stream and in Pouhala Marsh; a majority of the farmland with approved conservation plan(s); the Waipahu Community Association's, funded for the construction of the Festival Market/Business Incubator; the Department of Land and Natural Resources, Division of Forestry and Wildlife (DoFaW) restoring Pouhala Marsh to a functioning wetland; and the Hawaii Nature Center developed a third grade wetland education program as well as being a lead partner in organizing regular cleanups in the area.

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Community members who have contributed to the progress of this plan are listed below.

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The O`ahu Resource Conservation and Development Council dedicates this watershed based plan to the lifetime of volunteer work that Andy C. O. Anderson enthusiastically devoted to making Waipahu a safer and more wholesome community to raise families, a more vibrant community to productively work in and a more pleasant community to enjoy through parks, libraries, and public spaces.

# 1. Introduction and Project Setting

The purpose of this watershed based plan (WBP) is to produce a plan that is likely to significantly reduce non-point source degradation to Kapakahi stream. The Kapakahi Stream was listed as an impaired water body under the Clean Water Act's 303(d) listing (June 16, 2004) for exceeding State water quality standards for nitrite/nitrates, total nitrogen, and total phosphorus. In particular, this plan will involve reducing nitrate/nitrite loadings, trash from urban 'runoff' and airborne sources, especially areas near the convenience station operated by the City and County of Honolulu, and illegal dumping into and adjacent to the stream. The plan also proposes to clean-up the current impairments which include excess sediments in the lower reaches.

A secondary purpose of the WBP is to galvanize current stakeholder efforts and actions that are improving the upper and lower reaches of the stream. A multi-stakeholder plan to restore the partially degraded Kapakahi stream is proposed, as it builds on efforts to create a stream walk, restore the Marsh, link the historic Town core with Hawaii's Plantation Village, and better integrate education partners (in particular, Waipahu High School, Leeward Community College, City and County Environmental Services, and The Hawaii Nature Center). This plan is consequently able to organize and facilitate multiple efforts and projects after which the broader community can acquire ownership of the restored stream and urban center. The restoration of Kapakahi stream is more likely to happen if it coincides with the building of a stream walk that will link Hawaii's Plantation Village with Waipahu's historic Town Core and the historic Town Core with the Pouhala Marsh and Waipio Soccer Complex.

The water quality analysis included in this WBP was performed by Tetra Tech in 2004-5 and compiled in the Kapakahi Stream Water Quality Analysis (KSWQA, Appendix A).

Section 1 includes an introduction and project setting for the plan. First the elements of the plan as required for those projects using 319 funds to address 303(d) waters is described. The section also draws on historic and current restoration efforts to provide a background to the watershed. A description of the watershed including Kapakahi Stream and Pouhala Marsh is provided.

The second section assesses Kapakahi Stream's water quality issues, as well as the pollutant load reductions required to bring Kapakahi Stream back to levels that comply with Hawaii State standards. The three main classes of pollutants impacting any section of Kapakahi Stream include nutrients, trash and sediments.

The third section lays out the strategies, goals and corresponding budgets for improving water quality in Kapakahi Stream Watershed. These strategies will involve a number of partners. This section also includes a monitoring and evaluation component to the strategies that will be implemented through the plan. Subsections are devoted to monitoring, milestones, schedule of plan implementation, and criteria for success of load reduction strategies.

Section 4 describes the suggested best management practices for improving the water quality of Kapakahi Stream. In particular, education and outreach are detailed, with education-related projects, storm drain stenciling, and school partnerships being the areas of focus. Other programmatic BMPs described include sewer maintenance, trash prevention and cleanup, and the development of nutrient management plans. Structural BMPs that could be applicable to Kapakahi Stream are also briefly listed.

### 1.1 Elements of the Kapakahi Stream Watershed Based Plan

Watershed based plans developed or implemented with Section 319 funds to address 303(d) listed waters must include at least the nine elements listed below, as is required by the U.S. Environmental Protection Agency (USEPA). These elements are covered in this report. The elements and the section(s) in which they appear are as follows:

1. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (Section 2).
2. An estimate of the load reductions expected for the management measures described under element (3) below (Section 2).
3. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under element (2) above and an identification of the critical areas in which those measures will need to be implemented (Section 3, 4).
4. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities what will be relied upon, to implement this plan (Section 3).
5. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing NPS management measures that will be implemented (Section 4).
6. A schedule for implementing NPS management measures identified in this plan that is reasonably expeditious (Section 3).
7. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented (Section 3).
8. 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 (Section 3).
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element (8) immediately above (Section 3).

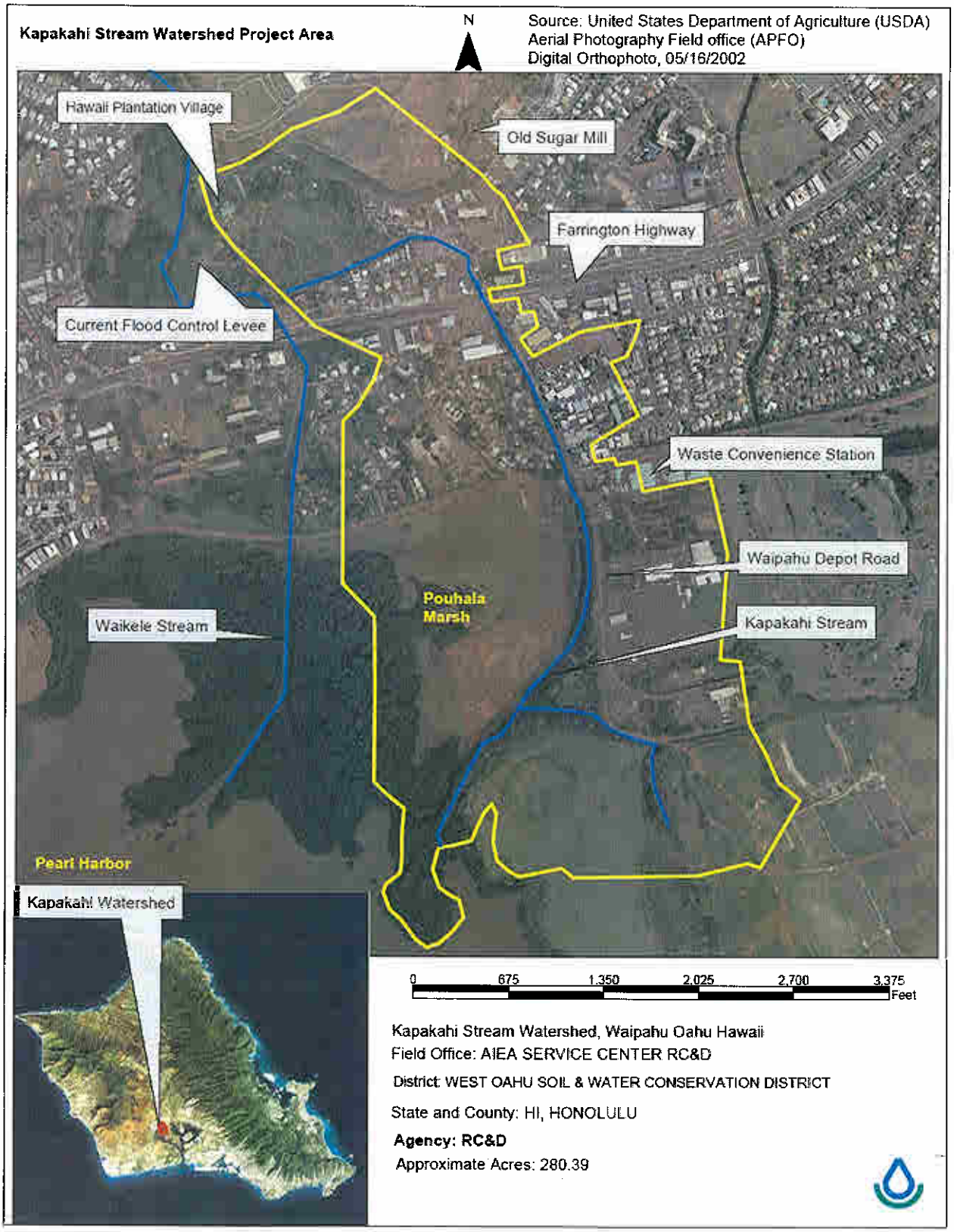
### 1.2 Kapakahi Stream Watershed

The 2,200-acre Kapakahi Watershed lies just to the east of the much larger Waikele watershed, both of which flow into Pearl Harbor (West Loch). Kapakahi stream itself and our area of interest has a watershed of approximately 280.4 acres and is located in the urban area of Waipahu on the island of O`ahu. The stream is significant in that it passes through a 70-acre wetland which has been identified as a crucial resource for the protection and habitat of several Hawaiian plant and animal species. The stream watershed is located 21 degrees 23-24' North and 158 degrees 01' East in the town of Waipahu in the City and County of Honolulu, on the island of O`ahu in the state of Hawaii. Kapakahi Stream and the area that contributes to the stream were originally identified as being 640 acres. The 640-acre estimate did not take account flat areas (primarily in the lower reaches) that do not have surface drainages into Kapakahi stream and drainages in these very flat areas that flow east into the neighboring Waipahu Watershed. Kapakahi Stream Watershed is therefore reduced to approximately 280.4 acres. The Kapakahi Stream is in the center of Figure 1, a map and aerial photo with the project area are identified.

The stream and its watershed can be divided into three parts based on land use: upper, middle, and lower (Figure 2). The upper portion of the watershed is generally the stream reach upstream of the culverts. This mostly undeveloped area is roughly 40.79 acres, and consists of the HPV, Waipahu Cultural Garden Park, the abandoned sugar mill, and minor drainage from adjacent residential development. The middle section, which is roughly 50.69 acres, extends from the culvert inlet to waste transfer station. The middle watershed area consists of all residential and commercial lands. This section is mostly impervious surface with only a few areas of grasses and undeveloped land. The lower section, which is roughly 188.91 acres, extends from the waste transfer station to the mouth of the stream. Within this section, the watershed is very flat and undeveloped. It is unknown whether surface runoff enters the stream within this section.

Significant changes have taken place in the land use in Waipahu since the era of sugar plantations and a primarily agricultural lifestyle (rice paddies and asparagus gardens were located along Farrington Highway) that existed during the late 1800s/early 1900s. In the 1970s and '80s, sugar started to fail as a viable crop (Honolulu Advertiser), leading to the conversion of more and more agricultural lands to urban/suburban development north of the H-1 freeway, e.g. Waikele, Village Park and Royal Kunia. Business activity in Waipahu's historic Town Core was devastated with the 1995 closure of the Oahu Sugar Mill. The famous Arakawas General Store also closed in 1995 and the Bigway Market in 1999, both of which are located on Waipahu Depot Street near the headwaters of the spring-fed Kapakahi Stream. Now 60 acres of the former sugar mill site are occupied by the Waipahu Mill Town Center, a light industrial park with a retail center that also utilizes the area's plantation past as a visitor attraction. The balance of the sugar mill site, which includes a smokestack, generator and administrative buildings, is presently undergoing major redevelopment into a regional YMCA facility, which includes health and fitness programs for youth and families. However, since the closing of the sugar mill located near the headwaters of the spring fed Kapakahi Stream, some of the community

**Figure 1. Kapakahi Stream Watershed Area of Interest**



businesses have faced challenges and declines. Newer developments mauka, primarily in Waipio but also in other areas of Waipahu, have provided other retail options for Waipahu residents.

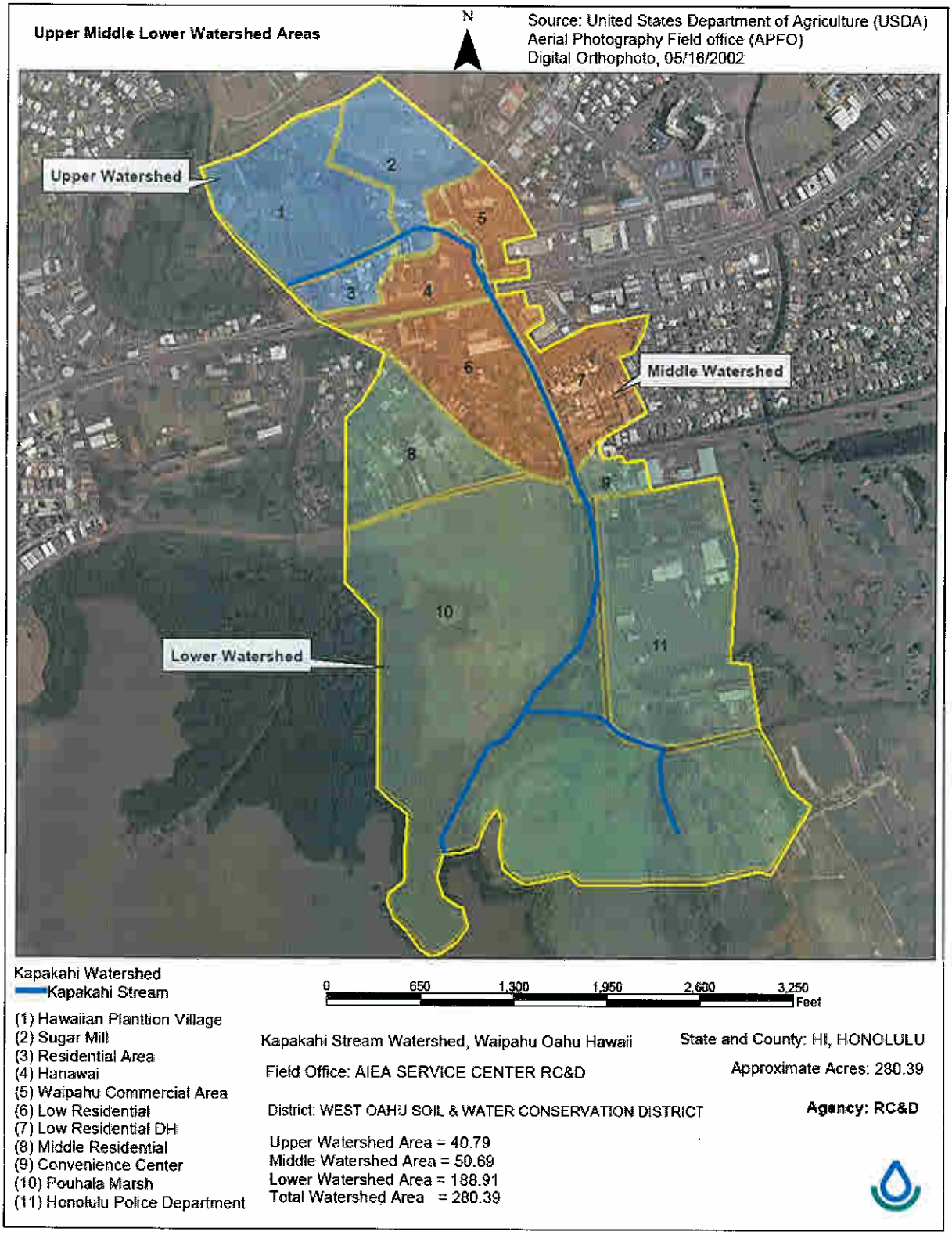
### *1.2.1 Kapakahi Stream*

The current headwaters of Kapakahi Stream originate within Hawaii's Plantation Village (HPV) as a 0.5 MGD spring (Nance, 1998). The stream, which has been channeled but is not lined with concrete, is fed by multiple local springs and a high water table. The stream flows east from the HPV parallel to the Farrington Highway. Once the stream reaches the Big Way shopping area, it flows into three 48-inch culverts below the parking area. It then reemerges at a single 54-inch culvert at the bridge crossing for the Farrington Highway. The exact location of the transition from three culverts to one under the parking lot is not known. Downstream from the bridge crossing, the stream has been straightened, running along the west side of Depot Road toward the south. It flows past the Pouhala Marsh and eventually discharges into the West Loch of Pearl Harbor.

In a 1998 biological assessment of Waikele and Kapakahi Stream, it was noted that Kapakahi stream's native biota is almost non-existent, and must "be considered one of the most biologically degraded Oahu streams (Englund, 1998)." Even though Kapakahi Stream is relatively short (.75 miles long), it has been known to contain more species of introduced fish than many Oahu streams (Englund, 1998). These introduced fish include tilapia, *Mugilogobius cavifrons*, as well as many species of live bearing fish (Poeciliidae). Invasive freshwater apple snails (*Pomacea canaliculata*) have been detected in the stream and are well established in the taro farm upstream. Apple snails were first introduced deliberately to provide a secondary source of food and income for taro-growers, but the snails have become a serious pest on the island, causing serious economic damage to wetland crops such as taro and watercress (Englund, 1998).

According to the KSWQA (Tetra Tech, 2005), the original stream channel of Kapakahi Stream was either the main channel of the Waikele Stream or at least a secondary channel that conveyed high flows from Waikele Stream. Historically, during high flow events, the urban area of Waipahu would get flooded. In order to further keep the flood flows within the Waikele Stream, a berm was built in the 1960s along the railroad grade that provided flood protection from the Waikele stream to the Waipahu town center. Consequently, the flood control levee has to date reduced flows (high water) through the Kapakahi stream channel and prevented the Waikele from flooding Waipahu.

**Figure 2. Middle, Upper and Lower areas of Kapakahi Stream Watershed**



### *1.2.2. Pouhala Marsh*

Pouhala Marsh, a 70-acre tidal wetland, is located across from the Waste Convenience Station in the lower section of the watershed (Figure 1). This marsh is the largest remaining wetland habitat in Pearl Harbor and is identified by USFWS as a wetland of critical concern for protection and habitat enhancement (USFWS, 1998 as cited in the Natural Resource Trustees for Pearl Harbor, Oahu, Hawaii, 1999). The marsh is primarily owned by the City and County of Honolulu and the State DLNR, with DLNR-DoFaW managing the entire area as a wildlife sanctuary through a land-lease agreement with the City since 1995. Historically, the marsh may have been flushed with fresh water during high flows of the Waikele stream into the Kapakahi Stream. It contains dry sections/portions/lands that were created with fill as a result of the area being proposed and prepared as a land fill. The fill is in the process of being removed in order to restore the marsh to a more natural functioning wetland.

## 1.3. Restoration Efforts

Pouhala Marsh has a history of degradation, including runoff from development, water pollution, and alien plant invasion (mangrove, Indian Fleabane, and pickleweed) (Ducks Unlimited, no date). The site was once prepared as an incinerator and land fill site. However, the marsh and adjacent sections of Kapakahi Stream have been the focus of multiple restoration efforts. The initial restoration of Pouhala Marsh was started with funding by a US Fish and Wildlife Service (USFWS) Coastal Grant in 2004. During that time, excess soil from the wetland was used to create a berm that keeps potential dumpers out. Recently, 120 truckloads of garbage were removed, and a fence was constructed to keep dogs and people from freely roaming across the wetland (DLNR Agency Update, 2004). Since then, the effort has taken on momentum as various organizations continue to dedicate time and hands to cleaning up the Marsh environment with several projects and partnerships started, completed, and in progress with the aim of restoring a section of Kapakahi Stream and in particular, Pouhala Marsh.

### *1.3.1. The Pouhala Marsh Restoration and Community Development Project*

The Pouhala Marsh Restoration and Community Development Project's mission is to restore degraded marsh land into a fully functional wetland ecosystem. It is a part of an ongoing multi-partner restoration project developed to restore native wetland ecosystem as well as provide habitat for the four endangered Hawaiian waterbirds; Hawaiian stilt or ae`o (*Himantopus mexicanus knudseni*), Hawaiian coot or `alae ke`oke`o (*Fulica alai*), Hawaiian moorhen or `alae `ula (*Gallinula chloropus sandvicensis*), and Hawaiian duck or koloa maoli (*Anas wyvilliana*). The project is designed to perform a number of actions that decrease the practice of illegal dumping, clean the area of garbage, restore the habitat for birdlife, and develop an education program to teach the public about the value of the area. Furthermore, part of the plan is also to develop a comprehensive natural resources management, education and internship/job training program in the planned Festival

Market and Business Incubator and Training Center. Once restoration efforts have been completed a comprehensive monitoring plan will be implemented in order to understand the dynamics of a restored Hawaiian wetland. Several variables will be monitored to track the success of the restoration project including vegetation mapping, avian surveys, and water quality sampling.

#### *1.3.2. The Community-Based BMP Model for Watershed Restoration*

The Community-Based BMP Model for Watershed Restoration is a 319 project that was headed by the Hawaii Nature Center. In February 2005, native wetland and riparian species were planted in the marsh as a part of the project. Monthly service projects were held between August 2003 and August 2005 to remove pickleweed and other introduced plants and trash from Pouhala Marsh and Kapakahi Stream. A variety of methods have been used to achieve the project's goal:

- Feral animal control/removal
- Develop a trail system
- Develop a community-based wildlife monitoring program
- Storm drain stenciling
- Remove pickleweed
- Remove debris
- Native plant replanting to stabilize the stream bank
- Monitor wetland and shore bird populations
- Conduct bird surveys
- Conduct presentations/interpretive walks to educate the community
- School related educational programs to teach 3rd graders

## 2. Water Quality and Pollutant Load Reductions

The Oahu Resource Conservation and Development (RC&D) contracted with Tetra Tech EM Inc. (Tetra Tech) to investigate water quality issues within the Kapakahi Stream. Tetra Tech's investigation consisted of multiple phases including (1) Watershed Investigation, (2) Hydrologic Analysis, (3) Water Quality Analysis, (4) Pollutant Load Estimates, and (5) Site Specific Best Management Practices. The Kapakahi Stream Water Quality Analysis (KSWQA) (Appendix A) that resulted from the investigation identified nitrate/nitrites and other pollutants that led to the classification of Kapakahi Stream as one of Hawaii's 2004 List of Impaired Waters in Hawaii.

### 2.1. Water Quality Issues

#### *2.1.1. Nutrients*

Total nitrogen, nitrates/nitrites and total phosphorus were identified as being in excess of Hawaii State standards for a Class 2 water body, as established under the Clean Water Act's 2004 303(d) listing (Department of Health, 2004). In particular, the standards were exceeded for all pollutants during the wet season. Class 2 waters are protected for

recreational purposes and for all uses compatible with the protection and propagation of fish, shellfish, and wildlife. Class 2 waters support agricultural and industrial supplies as well as shipping and navigation. The water quality standards provide that such waters shall not act as receiving waters for any discharge that has not received the best degree of treatment or control compatible with the criteria established for this class.

According to the KSWQA (Tetra Tech, 2005), water quality problems in Kapakahi Stream result from a combined effect of nutrient-rich groundwater making up the baseflow of the stream, surrounding land use and human activity, and occasional storm and flooding events. Point and non-point sources were identified for excess nutrients found within Kapakahi Stream. Total nitrogen is particularly problematic in that the sample of concentrations for total nitrogen was generally 10 times the allowable total nitrogen (TN) levels (See Tables 1 and 2, page 13). Page 15 of appendix A contains sample data for TN levels.

There are a variety of reasons to be concerned about elevated levels of nutrients in streams. The forms of nitrogen found in natural terrestrial and aquatic environments include ammonia (NH3), nitrates (NO3), and nitrites (NO2). The problem is that excess concentrations of nitrates, essential plant nutrients, can result in significant water quality problems. Excess nitrates, along with phosphorus, can accelerate eutrophication, causing dramatic ecosystem changes (Fares, 2004). This affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions (Fares, 2004).

**Table 1. Estimated Daily Base Flow Pollutant Loads for the Kapakahi Stream (%)**
(Source: Tetra Tech, 2005)

| | TSS | | TN | | TP | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| Base Flow Volume (ac-ft) | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| Base Flow Concentrations (mg/L) | 12.2 | 9.3 | 1.94 | 2.11 | 0.173 | 0.18 |
| Base Flow Load Capacity (lb/day) | 98.5 | 75.1 | 15.66 | 17.04 | 1.397 | 1.453 |

**Table 2. Estimated Storm Flow Pollutant Loads for the Kapakahi Stream**
(Source: Tetra Tech, 2005)

| | TSS | | TN | | TP | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| Storm Flow Volume (ac-ft) | 36.8 | n/a | 36.8 | n/a | 36.8 | n/a |
| Storm Flow Concentrations (mg/L) | 50.7 | n/a | 4.75 | n/a | 0.706 | n/a |
| Storm Flow Load Capacity | 5,060 | n/a | 474.0 | n/a | 70.46 | n/a |

During storm event sampling, the TN and TP concentrations increased significantly. The additional concentration of TN is likely from surface runoff in the watershed, possibly from residential use of fertilizer. Taro fields located above and adjacent to Kapakahi Stream results in a production of algae within the inundated fields which can discharge

directly into the stream. The TP, similar to TN, may therefore be the result of flushing of the taro fields as well as runoff from impervious surfaces in the watershed.

The sources of nutrients feeding Kapakahi stream baseflow are likely to include sewer and cesspool seepage, fertilizers from surrounding taro and vegetable farms, animal wastes, and household and commercial products that drain into the ground. Urban Groundwater proved to be an important pathway for nitrogen and phosphorus to be transported into Kapakahi Stream and makes up a significant source for the base flow of the stream, as indicated in the KSWQA (Appendix A, page 4). A TMDL report is being conducted for Pearl Harbor and is to be completed in the next couple of years.

### *2.1.2. Trash*

Trash was cited as a problem for Kapakahi Stream as part of a visual assessment in the 2002 Clean Water Act's 303(d) listing. Miscellaneous rubbish, including used auto tires, batteries, scrap metal, beverage containers, household garbage, etc frequently accumulate along most of the middle section of Kapakahi Stream. This section is often overcome with vegetation at the abandoned train bridge near the City and County of Honolulu Waipahu Convenience Center, (Figure 1). The channel spanning-vegetation creates a barrier for trash in the stream and causes it to collect at this site. Downstream of the vegetation, where storm flow from the waste transfer station enters the stream, less trash is visible in the stream and on the banks, since the mangroves were removed in the spring of 2006 and after cleanup days in April and May.

**Plate 1. Trash in Kapakahi Stream-A and B.**
(Source: RC&D)

A.

B.

Littering in and alongside Kapakahi Stream is attributed to the isolated nature of the area that encourages illegal dumping. The Waipahu Convenience Center may also be adding to the problem because when the center is closed, persons may irresponsibly opt to dump their rubbish nearby. Fugitive litter from the convenience center or from homeowner vehicles is also a source of litter. City and County of Honolulu convenience centers are reserved primarily for residential waste material. In order to provide convenience to all, no more than two loads per resident are allowed per day. Unfortunately, since the convenience center is located right across from Waipahu Depot Road, it provides easy

access to Kapakahi Stream where trash can be illegally dumped. The Waipahu Convenience Center office hours are from 7:00 am to 6:00 pm daily. BMPs to reduce illegal dumping include nonstructural BMPs such as good housekeeping practices; modifications to existing yard maintenance contract to extend the area in front of the convenience center; employees training and public educational materials on storm water pollution prevention; loading and unloading areas; and signs, including graphics, on dumpsters and other locations on enforcement and proper waste disposal (for example, users should bag fly away debris and tarp their trash).

**Plate 2. City and County Waipahu Convenience Center, located across from Kapakahi Stream**
(Source: Iwalani Sato, C&C ENV)

### *2.1.3. Sediments*

Turbidity levels are generally related to total suspended solids (TSS) concentrations, so in practice, TSS is analyzed as a surrogate for turbidity. The TSS base flow report in the KSWQA indicates the stream is generally within the State of Hawaii standards throughout the sampling period (May 19, 2003-April 19, 2003), even though Kapakahi Stream was listed via a visual assessment on the 2002 303(d) list for turbidity (Department of Health, 2004, 2002). Storm flow sampling results indicate the stream is close to maintaining State standards during storm events.

However, there is an accumulation of fine sediments within the lower reach of the channel bottom, located downstream of the Farrington Highway crossing, where the channel invert is at or below sea level with a very low gradient (Plate 1). This is problematic because high concentrations of suspended solids can lower water quality by absorbing light. The ability of water to hold oxygen necessary for aquatic life is decreased as the water becomes warmer. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. Excess sediments can also clog fish gills, reduce growth rates, decrease resistance to disease, serve as carriers of nutrients and pesticides and alter stream flow (http://www.health.state.nd.us/WQ/SW/Z6_WQ_Standards/WQ_TSS.htm).

The sources of sediments in Kapakahi Stream were identified by the KSWQA as washoff from the impervious surfaces during storm events, agricultural practices that disturb the ground surface allowing sediment to be released during irrigation, and historical storm flows from the Waikele Stream through previous diversion(s). Before Kapakahi Stream was isolated from Waikele Stream by the flood control berm, occasional high flows in the stream would help transport trapped sediment out of the stream and into Pearl Harbor. Because the flushing does not occur, the sediment accumulates in the stream.

Invasive mangroves (such as the red mangrove, *rhizophora mangle*) are compounding the sediment problem by impeding the flow of the water through Kapakahi Stream and impacting the fauna and flora that utilize the marsh and wetland ecosystem. Mangroves have intruded up the channel of Kapakahi Stream forming a wooded swamp habitat (Ducks Unlimited, n.d.-Pouhala Marsh Enhancement Plan).

Mangroves were first introduced to Hawaii in 1902 in order to stabilize the shoreline and provide forage for bees (Allen, 1998). Although mangroves have been known to provide beneficial qualities for native environments, Hawaiian habitats are smothered by the vegetation, impacting the habitat used by native water birds and migratory shorebirds (El Kadi et al., 2004). Furthermore, the root structure impedes the flow of water and traps fine and organic-rich sediments transported by the stream, changing the physical characteristics of the environment.

In order to reduce the impacts of sediments in the lower reaches of Kapakahi, invasive mangrove trees need to be removed. Joint efforts by the City and County Environmental Services, DLNR, the Hawaii Nature Center and local high schools continue to eradicate the lower watershed of invasives, including mangroves, pickleweed and water lettuce. As a part of the plan to restore the area to its original condition, the mangroves were cleared on Kapakahi stream on the right bank from the bridge towards the ocean up until January, 2005 (HNC BMP final report, n.d.).

### 2.2. Pollutant Load Reductions

The load capacity, or total maximum daily load (TMDL), of the Kapakahi Stream is defined as the amount of each pollutant the stream can convey while staying within the state water quality standards. A TMDL is developed as a mechanism for identifying all the contributors to surface water quality impacts and setting goals for load reductions for specific pollutants as necessary to meet surface water quality standards. TMDLs are required, under Section 303(d) of the federal Clean Water Act, to be developed for water bodies that cannot meet surface water quality standards.

In order to estimate the pollutant loading within the Kapakahi Stream, an understanding of how the watershed responds to storm events was determined in the KSWQA (Tetra Tech, 2005). A hydrologic analysis to determine peak flows and flow volumes, which are needed to estimate pollutant loads within the Kapakahi Stream, was performed by Tetra Tech by using the U.S. Army Corps of Engineers' Hydrologic Engineering Center-

Hydrologic Modeling System (HECHMS). HEC-HMS is used to simulate event-based or continuous precipitation runoff processes of a watershed. The model uses the watershed characteristics such as basin area, time of concentration, conveyance system geometry, and land cover to estimate the study area's reaction to rainfall events.

The load capacity of the Kapakahi Stream was calculated in the KSWQA for daily base flow, storm flow, and estimated annual load capacity (tables 3, 4, & 5). The estimated base flow and storm flow existing loads are contained in tables 1 and 2.

**Table 3. Daily Base Flow Load Capacity for the Kapakahi Stream**
(Source: Tetra Tech, 2005)

| | TSS | | TN | | TP | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| Base Flow Volume (ac-ft) | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| Base Flow Allowable Concentrations (mg/L) | 20 | 10 | 0.25 | 0.18 | 0.05 | 0.03 |
| Base Flow Load Capacity (lb/day) | 161.5 | 80.7 | 2.02 | 1.45 | 0.404 | 0.242 |

**Table 4 Storm Flow Load Capacity for the Kapakahi Stream**
(Source: Tetra Tech, 2005)

| | TSS | | TN | | TP | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| Storm Flow Volume (ac-ft) | 18.4 | 18.4 | 18.4 | 18.4 | 18.4 | 18.4 |
| Storm Flow Allowable Concentrations (mg/L) | 80 | 55 | 0.80 | 0.60 | 0.15 | 0.08 |
| Storm Flow Load Capacity (lb/year) | 3,992 | 2,745 | 39.9 | 29.9 | 7.5 | 4.0 |

**Table 5. Estimated Annual Load Capacity for the Kapakahi Stream**
(Source: Tetra Tech, 2005)

| | TSS | | TN | | TP | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| Base Flow Loads, (lbs) | 28,642 | 14,554 | 358.2 | 261.5 | 71.6 | 43.6 |
| Storm Flow Loads, (lbs) | 3,992 | 2,745 | 39.9 | 29.9 | 7.5 | 4.0 |
| Total Load Capacity (lbs) | 32,634 | 17,299 | 398.1 | 291.4 | 79.1 | 47.6 |

Table 6, taken from Tetra Tech (2005) shows the parameter values used in the Kapakahi watershed model. The table also includes a column for the amount of impervious area ("% Imp") estimated in each sub basin. The impervious area estimates are based on review of aerial photography of the Kapakahi watershed.

**Table 6. TR-55 Parameters for the Kapakahi Stream Watershed**
(Adapted from Tetra Tech, 2005)

| No. | Subbasin ID | Tetra Tech Area (acres) | RC&D Area (acres) | Land Use | Tc (min) | CN | % Imp |
|---|---|---|---|---|---|---|---|
| 1 | HPV | 22.93 | - | 38% Agriculture<br>62% Mix Use | 25 | 85 | 16 |
| 2 | Sugar Mill | 13.80 | - | 20% Mixed Use<br>80% Open Space | 31 | 79 | 20 |
| 3 | Resident | 4.06 | - | 100% Residential | 6 | 85 | 80 |
| 4 | Hanawai | 10.23 | - | 19% Residential<br>47% Commercial<br>34% Farrington HWY | 17 | 79 | 90 |
| 5 | Waipahu_Com | 7.67 | - | 100% Commercial | 14 | 79 | 95 |
| 6 | Low Residential | 19.50 | - | 33% Commercial<br>67% Residential | 58 | 79 | 70 |
| 7 | Low Res_DH | 13.29 | - | 43% Commercial<br>57% Residential | 28 | 79 | 95 |
| *8* | *Middle Residential* | | *20.17* | 10% Open Space<br>90% Residential | ** | ** | 50 |
| 9 | Convenience C. | 3.20 | - | 100% Industrial | 10 | 79 | 95 |
| *10* | *Pouhala Marsh* | | *125.97* | 16% Roads<br>84% Marsh | ** | ** | 16 |
| *11* | *Honolulu Police Dept Training Facility* | | *39.57* | 50% Police Training Facility<br>50% Open Space | ** | ** | 50 |
| | **Total** | **94.68** | ***185.71*** | | | | |
| | **Watershed Total** | **280.39** | | | | | |

NOTE: **- Numbers were not calculated due to changes between Tetra Tech and RC&D basin GIS numbers/layout.

The difference between the current stream loads (tables 1 & 2) and the capacity loads (table 4 & 5) equals the pollutant reduction required to bring the Kapakahi Stream into compliance with the State's water quality criteria. Table 7 shows the estimated percent reductions required to meet the state criteria. To achieve improved water quality within the watershed, best management practices (BMP) need to be implemented. These are discussed later in the plan.

**Table 7. Estimated Pollutant Loads Reductions for the Kapakahi Stream**
(Source: Tetra Tech, 2005)

| | TSS | | TN | | TP | |
|---|---|---|---|---|---|---|
| | Wet | Dry | Wet | Dry | Wet | Dry |
| Base Flow Reductions (lb/day) | NR | NR | -13.64 | -15.59 | -0.993 | -1.211 |
| Storm Flow Reductions | NR | NR | -434 | [1] | -63 | [1] |

Notes: NR means No Reduction is required for this pollutant
[1] All storm flow volume was applied to the wet season calculation only.

## 3. Strategies for Kapakahi Stream Watershed

In order to accomplish the goals set out in this plan, multiple actions need be taken using a collaborative approach through multiple partnerships. This will include obtaining the funds necessary to apply the following actions.

### 3.1. Actions and Corresponding Budgets

#### *3.1.1. Monitor Water Quality of Kapakahi Stream to Determine Source of Nutrients*

The sewer system was identified as one of the likely sources for excess nutrients in Kapakahi Stream, as suggested in the KSWQA. Once the lines have been replaced, it can be determined if this is the primary source of the problem. If monitoring indicates that nutrient levels are not dropping after sewer line replacement, it can be assumed that the groundwater is being influenced by another source (of increased nutrients) and not the sewer lines. It will therefore be necessary to reassess structural best management practices along Kapakahi Stream to determine relative effectiveness in the context of solving groundwater problems above the watershed before any BMPs should be implemented.

The next phase will include assessing shallow level ground water. Water quality monitoring should occur both at Kapakahi Stream headwaters, down gradient from the sewer lines, where the stream exits the farms, and near the parking lot culverts.

**Table 8. Waipahu High School Budget**

| | **Equipment and Supplies** | |
|---|---|---|
| 1 | Water sampling kits | $750 |
| 2 | Digital camera | $250 |
| 3 | One camcorder | $500 |
| 4 | Lap top | $1,600 |
| 5 | Transportation for three field trips (120 students/60 pax each bus, 2 trips, $150 each bus | $900 |
| 6 | Buffer solution, pH 7, color coded (500mL) | $10 |
| 7 | Calibration thermometer | $25 |
| 8 | Blank CDs and/or DVDs | $15 |
| 9 | 30 Project display boards | $130 |
| 10 | Water quality analysis (32@$6) | $200 |
| | **TOTAL REQUESTED** | **$4,380** |

Waipahu High School has been actively involved in the Kapakahi Stream Watershed. The school has volunteered to take on the responsibility for water quality monitoring at the headwaters of Kapakahi Stream and soon after the water passes through the area (after the taro farm) where the sewer lines are being replaced. This will continue through

June, 2007 in order to monitor both the wet and dry seasons. Table 8 includes a budget for the next two years.

### *3.1.2. Contribute to Pouhala Marsh Restoration Activities*

It will be advantageous to continue restoration efforts in the Pouhala Marsh area as it provides an open space which is a community asset in many ways. It is an important buffer for pollutant sources and sediments in Kapakahi Stream as it exits into West Loch. But furthermore, it has been noted that since the clearing of mangroves along Kapakahi Stream and in Pouhala Marsh, the Honolulu Police Department has been able to track down and stop drug dealers from using the area as a base for operations (pers. comm. D. Smith, 2006). Furthermore, the use of the area by various schools as a first hand look at wetland ecosystems is an important benefit to the school children.

The Hawaii Nature Center utilizes volunteers to help with clean-up and restoration at Pouhala Marsh in Waipahu. This marsh is used as a third grade wetland program site for the Hawai'i Nature Center. Work will involve pickleweed and mangrove removal along Kapakahi Stream and in Pouhala Marsh. In particular, the Hawaii Nature Center will hold eight more community service days at Pouhala Marsh during the 06-07 school year to perform cleanups. These activities will continue to be managed and executed by HNC Volunteer Coordinator Pauline Chin. Table 9 lists the needs of Hawaii Nature Center for their program for the 06-07 school year.

**Table 9. Hawaii Nature Center Budget**

| | **Equipment and Supplies** | |
|---|---|---|
| 1 | Shindaiwa T231XB weed whacker | $345 |
| 2 | 5-gallon industrial coolers (5 @ $40) | $160 |
| 3 | Industrial strength trash bags (10 @ $12)) | $120 |
| 4 | Lopping shears (8 @ $20) | $160 |
| 5 | Pruning saw (10 @ $20) | $200 |
| 7 | Pick (6 @ $20) | $120 |
| 8 | Rubber work gloves (60 @ $3) | $150 |
| 9 | Women's bootfoot breathable wader | $135 |
| 10 | Hawaii Nature Center banner | $60 |
| | | |
| | **Salary** | |
| 11 | Eight service projects (1 project per month from 10/06-5/07, 15 hours per project; 120@$20) | $2,400 |
| | | |
| | **TOTAL REQUESTED** | **$3,850** |

RC&D will continue to work with the DLNR who is in the process of restoring and enhancing sections of Pouhala Marsh. Table 10 outlines the budget for their project. DLNR has applied or is in the process of getting approved for Wildlife Habitat Incentive Funds. Additional funds may be needed to implement a water quality monitoring

component to detect any changes following mangrove removal and other practices likely to improve water quality in Kapakahi Stream. The O`ahu RC&D is the likely partner to perform these monitoring responsibilities. The budget for monitoring equipment and salary needed to monitor through June, 2007 is listed in Table 13.

**Table 10. DLNR Budget for Pouhala Marsh Restoration and Community Development Project**

| | | |
|---|---|---|
| USFWS Coastal Program | Cash | $260,000 |
| USFWS Natural Resources Damage Assessment | Cash | $800,000 |
| Ducks Unlimited | Cash and in-kind | $258,500 |
| City and County of Honolulu | In-kind | $126,000 |
| North American Wetlands Conservation Act | Cash | $176,000 |
| USFWS State Wildlife Grants | Cash | $10,000 |
| Hawaii Nature Center/EPA Grant | Cash | $100,000 |
| | **Total to Date** | **$1,730,500** |
| State Legislature | Cash/matching funds | $200,000 |
| USFWS | Cash | $600,000 |
| | **Total Requests** | **$800,000** |
| | **PROJECT TOTAL** | **$2,530,500** |

### *3.1.3. Increase Educational Capacity for Protecting and Enhancing Stream Ecosystems.*

The City and County of Honolulu Department of Environmental Services (ENV) and Hawaii Nature Center are two partners with whom O`ahu RC&D could support in focusing educational activities in Kapakahi Stream Watershed.

The long term goals of the City and County of Honolulu Department of Environmental Services Public Education and Outreach Program are to:

- Increase public awareness of polluted runoff and water quality issues
- Provide citizens with the tools and training to evaluate and protect their local waterways
- Collect accurate baseline water quality data
- Encourage partnerships between citizens and their local government

Cost share agreements can be developed for current events and workshops, including:

- World Water Monitoring Day
- Watershed field trips
- Earth Month Teen Video/Photography Contest
- Earth Month Keiki Festival
- Construction Industry Best Management Practices Conference
- Storm Water Best Management Practices Narrated Tours

The City and County of Honolulu Department of Environmental Services provides in-kind technical support and coordinates training materials, monitoring equipment and replacement reagents for educational purposes with other government agencies, including the Department of Health Clean Water Branch and U.S. Army Corps of Engineers Honolulu Engineer District and the ORC&D. The funding needed to support their programs come from a variety of sources.

### *3.1.4. Partner with Waipahu Community Association to Enable Construction of Kapakahi Stream Walkway and Festival Market/Business Incubator*

Kapakahi Stream Walkway

In 2001, a conceptual plan for a Kapakahi Stream Walkway was proposed to the Waipahu Vision Team by the Waipahu Community Association (WCA) for discussion and approval for funding by the City and County of Honolulu. The proposed walkway project will capitalize on a natural resource that originates in Waipahu's Cultural Garden Park and is visible along the WCA's Festival Market property on Waipahu Depot Street. The completion of the project will support the achievement of the community's economic and social revitalization goals, as follows:

1) to increase awareness and access to Waipahu's Cultural Garden Park and Hawaii's Plantation Village;
2) to link the link the natural and cultural resources at the Park and the economic redevelopment activities in the historic Town Core on Waipahu Depot Street, such as the WCA's Waipahu Festival Market/Business Incubator and Training Center,
3) to achieve the desired pedestrian connection between Waipahu's Cultural Garden Park, the Civic Center, and the Pearl Harbor Historic Trail, as described in the Waipahu Special Area Plan and the Pearl Harbor Trail Master Plan; and, most importantly,
4) to take advantage of a natural resource to increase the attractiveness of the historic Town Core area.

The attached conceptual sketch (Figure 3) illustrates the proposed routing of a 1,400 feet (approximately a quarter mile) long pedestrian walkway, with five interpretative stops along the way, to connect the Waipahu Cultural Garden Park/Hawaii's Plantation Village with the historic Town Core centered on Waipahu Depot Street. A proposed second phase of the streamwalk will go approximately 4,000 feet from the Festival Market down to the proposed Pouhala Marsh Interpretive Center. The third phase would have the streamwalk extended approximately 2,700 feet from the Interpretive Center to the Waipio Soccer Complex.

While the Kapakahi Stream Walkway is strongly supported by the community, a January 2004 meeting of the Vision Team (which included residents along the walkway route) and representatives from the City & County of Honolulu included a discussion of safety and security issues. There was agreement among the parties that every effort must be

made to minimize and control illegal and illicit activities along the stream walk by employing security measures, such as fencing along private properties and increased security patrolling of the area, particularly during evening hours.

According to a consulting engineer's report dated February 10, 2005, the project will necessitate the following permits: 1) a Section 404 Permit of the Clean Water Act and a formal determination of permit requirements from the U.S. Army Corps of Engineers; 2) a Water Quality Certification (WQC) from the Clean Water Branch, Environmental Management Division of the State Department of Health; 3) construction permits, which includes a) a Grading Plan, Erosion Control Plan, and Procedures with Best Management Practice measures and b) due to construction activities, a National Pollution Discharge Elimination System (NPDES) Permit for dewatering would be required for installation of water piping or discharge of groundwater into the Kapakahi Stream. However, since the Waipahu Cultural Garden Park is within the State Water Quality Classification 2 limits, a General Permit would be required and a Public Notice would not be required.

**Table 11. Proposed Stream Walk Budget**

| No. | Need | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| 1 | Planning/Design Phase 1 | $100,000 | | | | |
| 2 | Design/Construction Phase I | | $200,000 | | | |
| 3 | Planning/Design Phase II | | $100,000 | | | |
| 4 | Design/Construction Phase II | | | $400,000 | | |
| 5 | Planning/Design Phase III | | | $100,000 | | |
| 6 | Design/Construction Phase III | | | | ?$200,000 | ?$200,000 |
| | **TOTAL REQUESTED** | **$100,000** | **$300,000** | **$500,000** | **$200,000** | **$200,000** |

According to the City & County of Honolulu's Department of Planning & Zoning records, the proposed walkway is within preservation and residential zoning lots. Thus, the project appears to qualify as an Exempt Classification 2 improvement, which does not require an environmental assessment. And, since the walkway project will be aligned through properties within the State Urban District, it will not require a Conservation District Use Area (CDUA) Permit.

In order to continue with the development and construction of this project, approximately $300,000 will need to be secured - $100,000 for final design and engineering/planning and permitting; and $200,000 for construction. And, to ensure that this project is completed, the WCA will continue to work with the community, the City & County of

Honolulu, the staff of O`ahu RC&D, the State of Hawaii, the Hawaii Nature Center, and various federal agencies.

Festival Market/Business Incubator-Related Projects

**Figure 3. Conceptual Diagram of the Proposed Kapakahi Stream Walk**

This project will involve the renovation of the former Bigway Supermarket which is adjacent to Kapakahi Stream on Waipahu Depot Street in order to provide a space for a variety of public and commercial uses in a festival atmosphere. The site will be one of the points of interest along the first stage of the planned Kapakahi Streamwalk. The Festival

Market is intended to bring a revitalization of business activity in the community, creating more jobs and reducing the unemployment rate among low-and moderate-income residents. The plan is to work with the Waipahu Community Association (WCA) to implement landscape BMPs for the planned Festival Market/Business Incubator. At this point in time, the first challenges are finding a government sponsor to request the Corps of Engineers reassess the areas 100 year flood zone. In 2003 and 2004 there were significant winter storms in the Waikele watershed that did not threaten Waipahu, and may provide actual data that is more reflective of the actual flood plain then model and estimated data. This new information may allow for a reassessment of the 100 year flood plain, and previous estimates of what would be required to protect Waipahu from a hundred year storm.

**Table 12. Festival Market Budget**

| No. | Need | Amount |
|---|---|---|
| 1 | Construction | $400,000 |
| 2 | Signage | $10,000 |
| 3 | Kiosks (10) | $40-90,000 |
| 4 | Walk-in cooler | $25,000 |
| 5 | Parking lot improvements | $150-175,000 (split 4 ways) |
| 6 | Lighting fixtures | not known |
| | **APPROXIMATE TOTAL REQUIRED** | **$700,000** |

### *3.1.5. Determine Best Options for Reducing Flooding in Lower Reaches of Kapakahi Stream.*

Based on a City drainage report to address flood control (Waipahu Flood Control, August 2004) in the Waipahu area, it was determined that the existing berm located along a portion of Waikele Stream between Farrington Highway and Waipahu Street within the Waipahu Cultural Garden property would overtop during the 100-year flood. Due to this overtopping, it was determined that flooding along Farrington Highway and portions of Waipahu Town would appear to be caused by the additional flow from Waikele Stream entering into Kapakahi Stream and Wailani drainage canal. Additionally, both Kapakahi Stream and Wailani drainage canal are tidally influenced, have relatively flat longitudinal slopes and have limited capacities. Numerous reports from personnel working at City facilities (i.e. HPD Police Academy, Refuse Convenience Center, etc.) in that area complain of flooding and ponding problems along Waipahu Depot Road that runs adjacent to Kapakahi Stream. Whenever the tide rises, waters from the stream overtop and enter into the street creating a nuisance and safety hazard.

The O`ahu RC&D is working with the City and County to investigate the project requirements and potential funding sources for the expected survey work to determine how to reduce flooding in this area. The detail, breadth and cost of such a study would depend on the funding source and severity of the problem.

### *3.1.6. Coordinate Partners and Recognize Opportunities to Improve Water Quality and Associated Impacts on Kapakahi Stream Watershed.*

O`ahu RC&D will assume responsibility for water quality monitoring further down the stream near Pouhala Marsh to determine impacts of clearing mangroves in Pouhala Marsh and along the stream banks. The budget for monitoring is given in Table 13.

Coordination between our partners will ensure that monies are appropriated to groups for the appropriate uses and to ensure that interest and participation continues in this watershed. We will assist our partners in action implementation and funding.

**Table 13. O`ahu RC&D Budget**

| No. | Need | Amount |
|---|---|---|
| 1 | YSI handheld multi-probe | $1,900 |
| 2 | Nutrient analyses (32 @$6) | $200 |
| 3 | Coordination and facilitation salary for water quality monitoring into June, 2007 | $8,000 |
| | **TOTAL REQUESTED** | **$10,100** |

## 3.2. Monitoring and Evaluation Plan

This plan will likely follow a monitoring and evaluation schedule utilizing the adaptive management approach. Specifically, the restoration of Pouhala Marsh and parts of Kapakahi Stream will be managed adaptively by O`ahu RC&D. Adaptive management is the process whereby coordinated activities are incrementally evaluated and refined. It differs from traditional management by recognizing uncertainty and limited knowledge, and by providing a process for new information to modify existing decisions (Kershner, 1997). Ideally, adaptive management programs regularly reevaluate their plans using high quality monitoring data from both successes and failures. Monitoring and regular evaluation will be integral to the success of improving Kapakahi Stream.

### *3.2.1. Monitoring*

Monitoring will track the progress of various BMPs and restoration activities for Kapakahi Stream. This will involve collecting data from other partners and projects already in place as a source of information for this component. For example, the State is in the process of developing a comprehensive monitoring plan as a part of the Pouhala Marsh Restoration and Community Development Project. It will be implemented in order to understand the dynamics of a restored Hawaiian wetland. Several variables will be monitored to track the success of the restoration project including vegetation mapping, avian surveys, and water quality sampling. We may have to coordinate with DLNR in order to establish a routine water quality sampling program both upstream and downstream of Kapakahi. The monitoring results will then be compared to state water

quality standards to track progress in meeting the criteria and satisfying the designated uses.

The objectives for monitoring include: measure the effectiveness of BMPs at reducing nutrient and sediment loads, compare pre-and post-project water quality characteristics in stream segments cleared of mangroves, sediments, trash, etc; and assess water quality improvements as the plan proceeds. Then we can determine the need for additional controls or management options for nutrients and other pollutants.

Water quality monitoring will be most useful for detecting improvements near the Taro farming as well as downstream where earlier monitoring has occurred for the Pearl Harbor TMDL report. It will also be useful to use volunteers and data collected from Waipahu High School as part of ongoing water quality monitoring efforts in order to establish trends. Waipahu High School's monitoring program could be augmented. See Waipahu High School funding needs section.

There are of course limitations to this: getting volunteers to commit is hard for any volunteer effort. Quality of data can also be seen as questionable since volunteers usually have not received extensive training in sampling protocols. Significant training and supervision from the City and County ENV is a possibility.

### *3.2.2. Milestones*

Milestones and deliverables will be assessed regularly to determine progress and re-evaluate goals and objectives accordingly. The tasks include: development of watershed curriculum and/or tools for Waipahu High School (including provision of funding for equipment, training resources, etc), political leadership to restore the stream walk plan and construction funding; implementation of BMPs, water quality sampling/monitoring, and removal of mangroves in lower reaches of Kapakahi Stream.

**Short Term (<two years)** - Mitigate trash source at convenience center. City and County ENV is currently implementing best management practices in the area. 2,200 feet of ten inch concrete sewer line in HPV will be replaced with 12 inch polyvinyl sewer line. Monitoring in the fall or winter will help in assessing if this is a significant source of nutrients to the spring water. We will then need to assess nutrient loading to see if the water quality will fall within State standards. Concurrently, the taro farmer will plan and implement additional conservation efforts. Continued removal of invasive species through efforts by State, HNC, and various high schools can be goaled.

**Mid-Term (<5 years)** - Reduce nutrient loading per Table 7 estimates and restore stream by reestablishing native vegetation, clearing Pouhala Marsh of invasive species and trash. The construction of the streamwalk will increase community ownership. Best management practices such as buffer strips and sediment basins could be installed for the new parking lot by the planned Festival Market and Business Incubator.

**Long-Term (<5 years or longer) -** Achieve water quality standards set out in State's Clean Water Act through continuous application of BMPs listed in section 4.

### *3.2.3. Schedule of Plan Implementation*

A proposed timeline for plan implementation is given in Table 14 This is a flexible outline which may change due to the those involved and their other commitments. Securing the necessary funds will be the most significant challenge to the plan.

### *3.2.4. Criteria for Success of Load Reduction Strategies*

Measures of success should include the ability of the stream to meet Hawaii State water quality standards. Improvements of the stream should also be assessed through water quality monitoring and other methods. Monitoring results obtained through Waipahu High School, DLNR, and others should be compared to assess whether the stream is nearing compliance. Also, if the stream walk links the town to HPV and Pouhala Marsh and creates a healthier and safer community, this will show achievement.

**Table 14. Preliminary Timeline for the Implementation of Projects for Kapakahi Stream Watershed**

| Action | Year 1 | Year 2 | Years 3-5 |
|---|---|---|---|
| 1. Monitor water quality of Kapakahi Stream | | | |
| RC&D | Water quality monitoring at lower reaches of Kapakahi Stream | WQ monitoring | WQ monitoring |
| Waipahu High School | Water quality monitoring at Kapakahi Stream headwaters and below sewer line replacement area | WQ monitoring and continuing to incorporate field days and ecosystem health materials into classroom | |
| 2. Contribute to restoration activities | | | |
| DLNR | Remove mangroves, transport fill to nearby landfill | Remove Mangroves, Establish interpretive center, extend fence, | Continue enhancement activities |
| HNC | Continue Pouhala Marsh cleanups, including mangrove removal, continue third grade education program | Continue cleanup activities, education | Continue cleanup activities, education |
| 3. Increase educational capacity | | | |
| Waipahu High School | Continue 10th grade water quality curriculum with funding by RC&D for materials | Continue watershed curriculum… | Continue watershed curriculum… |
| ENV | Continue storm drain stenciling, Adopt-a-Stream, Adopt-a-Block and storm water outreach and education | Continue storm water outreach and cleanups… | Continue storm water outreach and cleanups… |
| HNC | Continue 3rd grade wetland education program | Continue wetland education…. | Continue wetland education… |
| | | | |

| | | | |
|---|---|---|---|
| **4. Enable Streamwalk construction** | | | |
| WCA | Phase I-obtain $100,000 for planning/design of streamwalk from HPV to Festival Market/Business Incubator | Obtain $300,000 for construction of phase I of streamwalk | Phase II-obtain $500,000 for streamwalk design/construction from Festival Market to Pouhala Marsh |
| **5. Determine options for reducing flooding** | | | |
| O RC&D | Encourage survey study to determine options for reducing occurrence of flooding at lower reaches of Kapakahi Stream | Conduct lower flood study and encourage study to determine upper reaches of Kapakahi Stream floodplain | Implement controls to reduce flooding |
| | | | |
| **6. Coordinate Partners and facilitate activities in Kapakahi Stream Watershed** | | | |
| O RC&D | Work With partners identified in Plan | And continue to work with partners | |
| | | | |

# 4. Best Management Practices

To ensure that Kapakahi Stream remains a Class 2 body of water and to remove the stream from the 303(d) list, best management practices (BMPs) are suggested (referenced in the KSWQA, Appendix A). BMPs can be programmatic or structural methods which are meant to prevent or reduce the movement of sediment, nutrients, pesticides or other pollutants from the land to the surface or groundwater. They are intended to provide decision makers guidance on proven methods to improve water and stormwater quality and address stormwater quantity (flooding).

## 4.1. Education and Outreach

Education is a powerful tool that can result in real solutions for poor environmental conditions and water quality problems in Kapakahi Stream. Increasing environmental stewardship through education and outreach involves enlightening the public about the connection between human activities and the health of the Kapakahi Stream. Education can work to provide residents with information on impacts of yard maintenance (fertilizer, weed killer), the storage and handling of potential pollutant sources, and waste management.

El Kadi et al. (2004) argue that for education to be effective, it must begin at an early age. By reaching a younger age group, environmental stewardship along with principles of watershed protection and pollution prevention can be brought forward into future generations. Community outreach programs can also be an effective avenue to increase watershed pollution impacts and prevention opportunity awareness. This is a tougher goal and it will require the dedication and commitment of community organizations to persist in their efforts to increase participation of the older generations.

The City and County Environmental Services (ENV) storm water public outreach program is one such example of how to increase stewardship in the area. Their public education program is based on the concept of ahupua'a and uses this as an

interdisciplinary unit to develop a sense of stewardship toward the environment and community, provide a model of collaboration for solving natural resource issues, and encourage an ethic of service (City and County Environmental Services, 2005).

One way that this WBP can work to restore Kapakahi watershed is by better integrating education partners (such as Waipahu High School, Aiea Intermediate, Campbell High School, Leeward Community College and The Hawaii Nature Center). By providing the necessary tools, materials, avenues and incentives for their respective programs, these partners can use the role of education to ensure that the public of all ages gain a better understanding of the functions of a watershed to a wetland, as well as learn habits and actions to protect and take care of the land and water. This plan will consequently rely on a joint partnership with these educational partners as well as the City and County in order to carry out their education and outreach projects and services to the community.

### *4.1.1. Education-Related Projects*

The Pouhala Marsh Environmental Education and Community Development Project, administered by the Hawaii Nature Center's Education Director with cooperation and support of the State Forestry and Wildlife Division on Oahu, is a subset of the Pouhala Marsh Ecosystem Restoration and Community Development Project. The project is organized by Ducks Unlimited, the state Department of Land and Natural Resources Division of Forestry and Wildlife, the U.S. Fish and Wildlife Service and the City Department of Environmental Services. Held on 50 days from January 2004 to May 2005, approximately 12,000 third graders from Oahu made up the primary audience for the education program. The goals of the program included fostering an awareness, appreciation and sense of stewardship of Hawaiian watersheds, wetlands, and waterbirds, with an emphasis on dispersal, adaptation, interdependence, and human impact. In-class activities and field trip explorations enabled students to learn about the threats to watersheds, wetlands, and native plant and animal species, as well as what we can do to care for them.

To continue educational support in the Pouhala Marsh area, a bill was passed in July, 2005 to provide funding to match initiative funding to develop an education and job training center for Pouhala Marsh. The interpretive education center will serve as the headquarters for the Hawaii Nature Center's wetland education program currently established in the marsh plans for future efforts in the area.

As an outreach effort, a Pouhala Marsh Guide was produced in conjunction with students from a University of Hawaii Technical Writing class and assembled by HNC. Information about the marsh and ongoing efforts in the area was compiled as a part of the Community Based Program of HNC and was distributed to the public via Waipahu Community Association, Pouhala Marsh volunteers, and other Waipahu community groups. The guide was able to educate people about the marsh and encourage them to become involved.

The City and County has also been actively involved in sponsoring education projects at Pouhala Marsh. In October, 2005, seventy tenth graders and their teachers at Waipahu High School visited Pouhala Marsh to work closely with various agencies involved in wetland restoration and how to best manage this unique ecosystem. Students and teachers rotated through stations on water quality, soil sampling, bird monitoring, and plant identification. These stations helped connect the basic science concepts students learn in the classroom, to hands-on field knowledge at the marsh. Students modeled field staff from the City and County of Honolulu Storm Water Quality Branch, Hawaii Department of Forestry and Wildlife, UH Conservation Alliance, Bishop Museum and the Natural Resources Conservation Service
(http://www.cleanwaterhonolulu.com/storm/archive/archive.html)

### *4.1.2. Storm Drain Stenciling*

Storm water urban runoff plays a significant role in affecting water quality in urban areas. In an effort to identify sources for urban runoff and focus on water quality and watersheds as an interdisciplinary unit, the City and County ENV has sponsored storm drain mapping and stenciling with community groups and high schools. Storm drain stenciling involves labeling storm drain inlets with painted messages warning citizens not to dump pollutants in the drains. The stenciled messages are generally a simple phrase (such as those that have a fish and the words "DUMP NO WASTE – PROTECT OUR WATERS…FOR LIFE ") to remind the public that storm drains connect to local water bodies and that dumping pollutes those waters. The actual activity is part of a larger educational campaign to raise awareness about storm water runoff. The ENV outreach and education storm drain stenciling program uses this activity as a practical, positive, first step toward public education, involvement, and support. The stenciled storm drains are consequently able to heighten the public's awareness and knowledge about storm water runoff and non-point source pollution.

### *4.1.3. School Partnerships*

Partnerships with three high schools in the Waipahu area have been formed through this project in order to work in the Kapakahi Stream Watershed area. Watershed tools used in the schools will include interdisciplinary subjects in the areas of science, social studies, ethics, history, health, statistics and creative writing. The practical or hands on component has been implemented with field trips to Pouhala Marsh (Plate 2). Various sites have been set up to include a water quality monitoring, wildlife habitat, and geology component.

*Waipahu High School*
Waipahu High School been actively involved in the Kapakahi Watershed. They are involved via a joint program to learn about watershed functions in Pouhala Marsh. The $10^{th}$ grade classes have been partaking in water quality and watershed courses with the aid of RC&D who has provided water quality monitoring kits and other tools and materials to compliment the coursework/curricula. In a three year budget, Waipahu High School has requested materials to sustain it's partnership in the area.

**Plate 3. Waipahu High School volunteers at a Kapakahi Stream Cleanup on April 28, 2006 sponsored by the City and County of Honolulu Department of Environmental Services and State Department of Land and Natural Resources.**
(Source: City and County Photo)

### 4.2. Other BMPs

The following discussion of management and control measures will guide the execution of strategies for reducing pollutant loads and improving water quality. Because impacts on Kapakahi's watershed can originate outside of the watershed of interest, additional BMPs intended to be implemented outside the Kapakahi Stream Watershed to address groundwater pollution are also named as possible BMPs. It is likely going to depend on a combination of economic, ecological and legal considerations as to the exact combination or selection of BMPs that will ultimately be employed to improve the conditions in the Kapakahi Watershed.

#### *4.2.1. Programmatic BMPs*

Public education is a broad term which covers many programmatic BMPs. In general the term refers to informing the residents within a watershed about the connection between their daily activities and the quality of the water in a stream. Most of the programmatic BMPs can be implemented with relatively no cost except voluntary time. Any costs that do occur are associated with material cost for educational materials, such as, flyers, brochures, paint, and signage. The following programmatic BMPs are all based on public education and are expected to increase the stream's quality and community awareness of the project. The current status of each BMP is given in italics, and a description of each BMP follows in Table 15.

**Table 15. Programmatic Best Management Practices**

| *Best Management Practice* | *Current Status* |
|---|---|
| Nutrient management plan | *studies need to be conducted* |
| Trash prevention and cleanup | *volunteer and City and County efforts in progress* |
| Education and outreach | *In progress* |
| Sewer maintenance | *pipe replacement to end January 2007* |

**Sewer Maintenance**

During the site investigation in the KSWQA, it was discovered that the 30-year old sewage line in the area appeared to be in need of maintenance. Many of the manholes and catch basins contained large amounts of sediment and trash. The sewer system was identified as one of the point sources for excess nutrients in Kapakahi Stream. According to Jack Pobuk of the City and County Department of Environmental Services, the sewer system was losing capacity because the lines were not laid out on a flat slope (Pobuk, pers. comm., 2006). Pobuk indicates that although there may have been some cracks in the old pipes, the leaks would have occurred inside the pipes and likely would not have reached the outside environment. However, sewage blockages were occurring because of a root system or a sag in the pipelines, and it was determined through a priority listing to go ahead and repair the system.

According to Pobuk, there are three general criteria that are used to determine the priority for replacing sewer lines (Pobuk, pers comm., 2006). The highest priority is reserved for those sewers that have the potential to harm public health and safety. The second highest priority is given to those sewer lines that could potentially harm the environment. Third down on the list are those sewers that are failing to meet regulatory requirements.

The plan is to lay 2,364 feet of sewer line in bigger, twelve inch pipes on flat ground so as to avoid any blockages. James Glover, the contractor for this project, received a Notice to Proceed in January 2006. The project is expected to be completed in January 2007 if everything goes smoothly. Figure 3 shows the location of the sewer line upgrade.

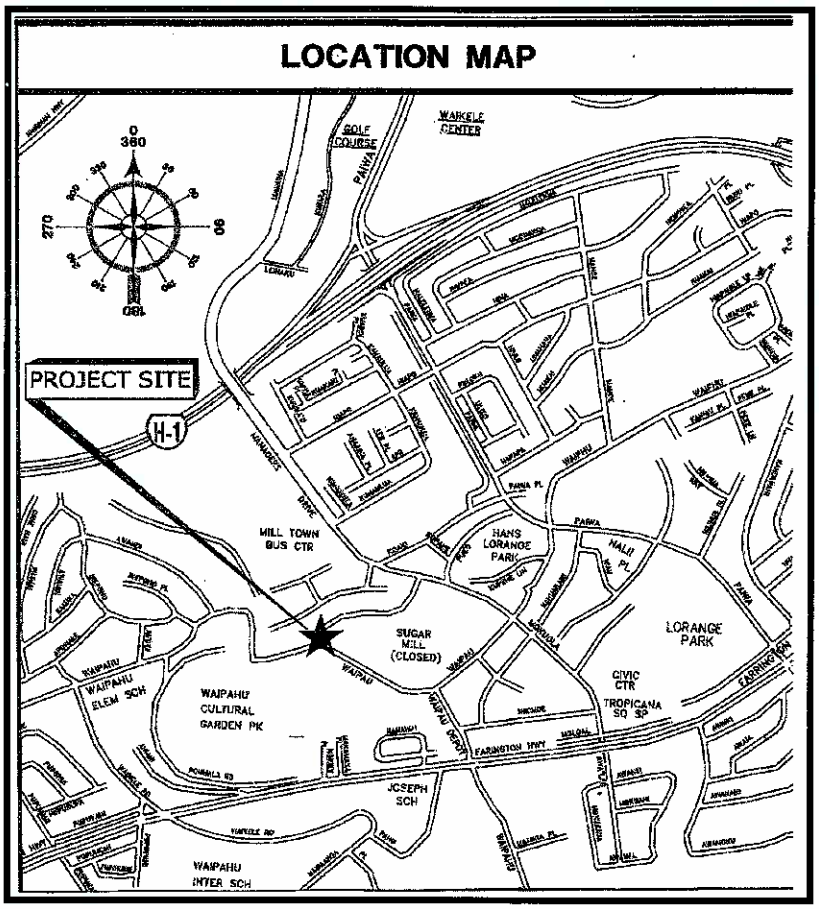
Figure 4, created by Tetra Tech (2005), also delineates the locations of curb inlets, storm manholes, pipes, and outfalls that were inventoried in Tetra Tech's report.

**Nutrient Management Plan**

The KSWQA suggests that studies of optimum nutrient uptake should be conducted in conjunction with agricultural practices outside of the Kapakahi watershed that may impact the groundwater quality, and with the farming activity at the HPV. The results may indicate a change in the amount of and application practices for fertilizer use on the various crops cultivated that impact the groundwater aquifer. The taro farm located near

the headwaters of Kapakahi Stream is currently in the process of adapting conservation measures for part of a conservation plan the farm is undertaking.

**Figure 4. Location of sewer line replacement project**
(Source: City and County Environmental Services)




## Trash Prevention and Cleanup

The KSWQA suggests that an education campaign is highly needed to discourage repetitive degrading practices along the stream banks. The educational information can be accomplished through the use of public service announcements (PSA) and leaflets. Signage could also be used to inform the public about the location and hours of operation of the waste transfer station on Waipahu Depot Road.

One of City and County Environmental Service's (ENV) goals is to reduce the occurrences of illegal dumping near or into Kapakahi Stream. By looking at successful examples in other states, the City has found that the most effective way of cleaning up polluted locations and preventing recurrences is by engaging those communities affected by the problem (http://www.opala.org). In 2003, the city invited interested parties to form the Coalition to Stop Illegal Dumping. Since then, actions to address the problem have been taken, and include drafting a definition of the problem, creating a concern line for

reporting dumping, and surveying public attitudes, and lastly, forming a public education campaign in April, 2006. The City is also working with the U.S. Environmental Protection Agency (EPA) Pacific Rim Environmental Resource Center to come up with two investigator positions within the City to focus on surveillance and enforcement.

Action steps currently taken by ENV to reduce trash along Kapakahi Stream include outreach activities such as Adopt-A-Stream implemented for Kapakahi Stream in 2006, quarterly cleanups with community groups, and coordination with the convenience center to help pick up trash alongside the road before it leaves the center for the landfill. ENV is working to add de-littering alongside the roadway to the current contract so that the area is maintained every other week. Bulky Item Service will collect bulky items along Kapakahi Stream once a month, from the Police Academy to Farrington Highway. Information with focus on education and enforcement will be distributed at City and County of Honolulu convenience centers, current events and workshops allowing time for an awareness and informational campaign to take effect. The problem is especially apparent on roads leading to City and County of Honolulu convenience centers. Distributing distinctive litter bags and trash bags will be part of a new education and enforcement program that targets flyaway trash on City and County of Honolulu roadways and the responsible drivers. The program calls for giving away 50,000 litter bags to fast food restaurants and 2,000 tarps that include bungee cords to bind the trash bags. Home Depot or City Mill may be willing to donate the tarps at their cost. This can be followed by enforcement actions on those who still let trash fly away from their truck in coordination with other government agencies.

Volunteer efforts to remove trash from the stream have been conducted through local schools, community groups, churches, businesses, City and County Environmental Services, and the Hawaii Plantation Village. A clean-up effort on the part of multiple agencies and community groups was taken on April 29, 2006, when the City and County's Department of Environmental Services and State of Hawaii Department of Land and Natural Resources Wetlands coordinated a volunteer cleanup of Pouhala Marsh consisting of 50 volunteers who cleared 60 tons of debris and mangrove seedlings from the banks of the Kapakahi Stream. Furthermore, volunteers also reported removing tires, batteries, metals, and large pieces of wood from the area. Another clean up is planned for August and October 28$^{th}$ during Make a Difference Month.

The Pouhala Marsh Ecosystem Restoration and Community Development Project has been successful in removing over 1,800 tons of accumulated garbage while securing access to the area to prevent illegal dumping and trespassing on the site (DLNR, 2004). The Hawaii Nature Center (HNC) has also been instrumental in coordinating and leading monthly Pouhala Marsh cleanups. HNC, along with a number of partners (including the Naval Station Pearl Harbor and the public) began trash removal in July 2003 and continued through August, 2005 (HNC, BMP report). Cleanups continue on a regular basis, with schedule service projects for 2006 to take place on Saturdays from 8:30-11:30 am on August 12, September 9, October 28, November 25, and December 16. So far, volunteers have removed trash, including bulky and large items, from all areas of the marsh and Kapakahi Stream.

**Figure 5. Location of curb inlets, storm manholes, pipes, and outfalls**
(Source: Tetra Tech, 2005)

### *4.2.2. Structural Best Management Practices*

The KSWQA recommended a variety of structural BMPs designed to improve the quality of stormwater runoff in Kapakahi Watershed. As groundwater is the dominant source of water quality problems within Kapakahi Stream, implementing structural BMPs to control surface sources will not be adequate in solving stream impairments. The following is a list of structural BMPs and their potential locations for Kapakahi Stream Watershed. References to more information on each BMP can be found in the KSWQA (Appendix A).

**Table 16. Structural Best Management Practices and Suggested Locations**
(Source: Adapted from Tetra Tech, 2005)

| ***Best Management Practice*** | ***Suggested Location*** |
|---|---|
| Filter strips | *Along Waipahu Depot Road and Big Way Center parking lot* |
| Swales-Vegetated or grassy | *Parking lots* |
| Infiltration/Flow-Through Planters and Rain Gardens | *At downspouts of residences and building, along residential streets* |
| Constructed Wetlands | *Within the HPV site near springs, immediately upstream of the culvert under the Big Way Center* |
| Package Treatment Facilities | *Existing manholes* |
| Pervious Pavement Systems | *Driveways* |
| Retention/Evaporation basins | *Commercial areas, large impervious areas* |
| Tree Cover | *Residential and commercial property where no trees currently exist* |
| Riparian Habitat Buffers | *Within the HPV site, lower watershed near the West Loch of Pearl Harbor* |
| Floodplain/Slough Reconnection | *Lower watershed, particularly the Pouhala Marsh site* |
| Cover Crops | *Within the agricultural areas of the HPV* |
| Remove the Waikele-Kapakahi Hydraulic Connection | *Headwaters of the Kapakahi Stream, adjacent to Waikele Stream* |

Urban runoff was identified by the KSWQA as a significant source of pollutants. The percentage of impervious cover for Kapakahi Watershed is 37.37% (Figure 6). The impacts from impervious cover affect habitat quality, which consequently affects the aquatic biota of the stream and Pouhala Marsh. BMPs that can reduce impervious cover should be emphasized and can be accomplished by using a variety of structural BMPs such as: reducing the widths and lengths of roads, reducing building and parking footprints, creating parking lot stormwater "islands," and using pervious pavers (El-Kadi et al., 2004). Therefore, the BMPs described above that include storm water management

improvements to curtail the discharged runoff are a priority concern for Kapakahi Stream. With careful planning, focused efforts and community involvement, the impacts associated with urban runoff can be averted or at least mitigated. Which ones are appropriate for Kapakahi Stream Watershed will depend on economic, feasibility, and legal considerations.

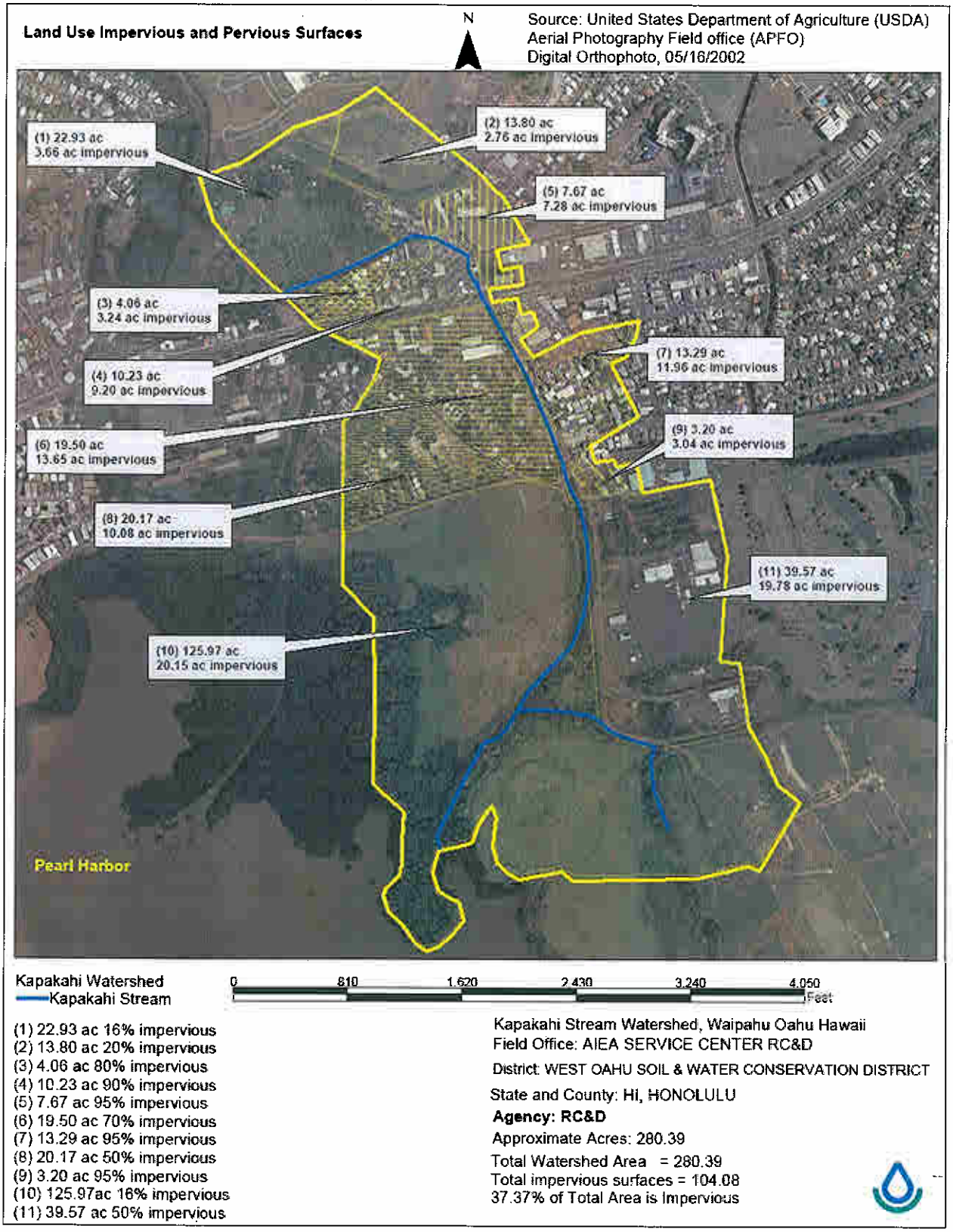
The average effectiveness/efficiencies of the structural BMPs are shown in the following table and are taken from the KSWQA report.

**Table 17. Pollutant Removal Efficiencies for Select Stormwater BMPs.**
(Source: Tetra Tech, 2005)

| BMP | Suspended Solids | Nitrogen | Phosphorus | Metals |
|---|---|---|---|---|
| Pervious Pavement | 65-100% | 65-100% | 30-65% | 65-100% |
| Infiltration/Flow-Through Planters & Rain Gardens | 50-80 | <30 | 50-80 | 50-80 |
| Swales (vegetated, grassy) | 30-65 | 15-45 | 15-45 | 15-45 |
| Vegetated Filter Strips | 50-80 | 50-80 | 50-80 | 30-65 |
| Retention/Evaporation Basins | 50-80 | 30-65 | 30-65 | 50-80 |
| Constructed Wetlands | 50-80 | <30 | 15-45 | 50-80 |
| Cover Crops | 10-20 | 30-45 | 7-15 | n/a |
| Tree Cover (1) | -- | -- | -- | -- |
| Package Treatment Facilities (2) | -- | -- | -- | -- |

*Note:*
□.(1) Tree cover does not have a value, because it does not technically remove pollutants, its function is to remove the precipitation, which would otherwise interact with the pollutants.
□.(2) No values are given for the packaged systems because the efficiency varies by manufacturer. Generally, the packaged plants operate within the same range as swales.

**Figure 6. Impervious surface in Kapakahi Stream Watershed**



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## 6. Appendix

KSWQA report