MAUNALUA BAY REGIONAL WATERSHED STRATEGY

A COMMUNITY APPROACH

2009

Vision

A Maunalua Bay where Marine Life is Abundant, the Water is Clean and Clear, and People take Kuleana in Caring for the Bay

MĀLAMA MAUNALUA

MAUNALUA BAY
REGIONAL WATERSHED STRATEGY:
A COMMUNITY APPROACH

This Document was prepared by Alyssa Miller, Mālama Maunalua Coordinator, Carol Wilcox, Watershed Team leader, in collaboration with: Gerry Davis (National Oceanographic and Atmospheric Agency) Risa Oram (Local Action Strategy Committee to address Land Based Pollution Threats to Coral Reefs), Kathy Chaston (NOAA), Eric Co (formerly of The Nature Conservancy of Hawaii, now with NOAA), Ron Salz (GEOCGI,LLC). March, 2009

I. EXECUTIVE SUMMARY

Mission and Goals: Mālama Maunalua's mission is to conserve and restore a healthy and productive Maunalua Bay through community kuleana. The Maunalua Region, in southeast Oahu, encompasses approximately 28 square miles, nearly 8 miles of shoreline, and 6.5 square miles of ocean. (Figure 1) The region is home to 60,000 people. A variety of stressors have degraded habitats, drastically reduced marine life, degraded reef resources and reduced the overall water quality and the health of Maunalua Bay. The Hawaii Department of Health (DOH) has designated Maunalua Bay an ***impaired*** water body. These impairments have negative implications for the health, economic well-being and cultural integrity of the region's residents. The 2006 Mālama Maunalua Conservation Action Plan (CAP) identified the critical threats to the Bay as: polluted runoff and sediment, invasive alien algae, and unsustainable harvesting practices.

While the Bay has been seriously damaged, the potential for restoring the Bay is high if these stressors are reduced. Mālama Maunalua and its partners seek to significantly improve water quality and systematic health of the marine environmental conditions in Maunalua Bay. Specific management goals include retaining water on land, reducing sediment inputs, and reducing pollutant inputs from residential and commercial areas.

We believe that a clean and productive bay, with a healthy reef and marine population, is within our capability if we all act together. Given present trends, if we do nothing the Bay will predictably decline into a watery wasteland, unsuitable for fish or people in our children's time.

The Maunalua Regional Watershed Strategy: This document reports our progress and findings over the last three years and provides a framework for mitigating polluted runoff and sediment flow and reduction of freshwater input into the Bay from all of the watersheds. Strategies for addressing the other two threats (alien algae and unsustainable fishing) are in other Malama Maunalua documents. We have modified conventionally accepted watershed restoration and management tools developed for continental watersheds to be more appropriate for island geography, and the more urban Maunalua Bay region. We anticipate that these tools will have wide application to other areas of these Islands.

We have geographically defined the Maunalua Region and ten *āpana*[1] within that region. The Maunalua *āpana* have characteristics similar to *ahupua'a*, in that each *āpana* consists of a watershed (basin) and its associated nearshore waters in Maunalua Bay. This approach recognizes that the health of the Bay's marine systems is inextricably bound to

[1] *Āpana*. 1. Piece, slice, portion, fragment, section, segment, installment, part, land parcel, lot, district, sector, ward, precinct. Hawaiian Dictionary, Pukui & Elbert

the health of the watershed. Maps are included in the document to illustrate the geographic designations.

The vast majority of the sediment is delivered into the Bay through numerous urban stormwater systems, which we call Stormwater Management Unit, or "SMU"s. An SMU consists of a) a stormwater conveyance system b) an outlet into Maunalua Bay and c) a marine "cell" in the nearshore area. These SMUs are of an ideal scale for management and monitoring projects. Therefore, SMUs are the focus of our management strategy.

The initial focus of the regional strategy will be on the *āpana* of Wailupe. It is hoped that what we do and learn in Wailupe will serve as a model for the other regional *āpana*, as well as for the rest of Hawai'i.

The main components of this Maunalua Regional Strategy framework are:

- Information-gathering: collecting baseline data in order to understand the *composition and extent* of pollutant loads that will need to be addressed in each *āpana*, and the type and number of *sources* from which they derive;
- Identification of alternative solutions tailored to each SMU, via individual *āpana* management plans;
- Identification of outcomes;
- An evaluative monitoring framework to measure success; and
- Targeted outreach activities to key stakeholder groups.

Achieving our goals requires a highly collaborative process that convenes community, scientists, government, non-government organizations (NGOs) and businesses in a common effort. The Maunalua Regional Watershed Strategy emphasizes stakeholders, partnerships, networks, and actions necessary to enable effective solutions.

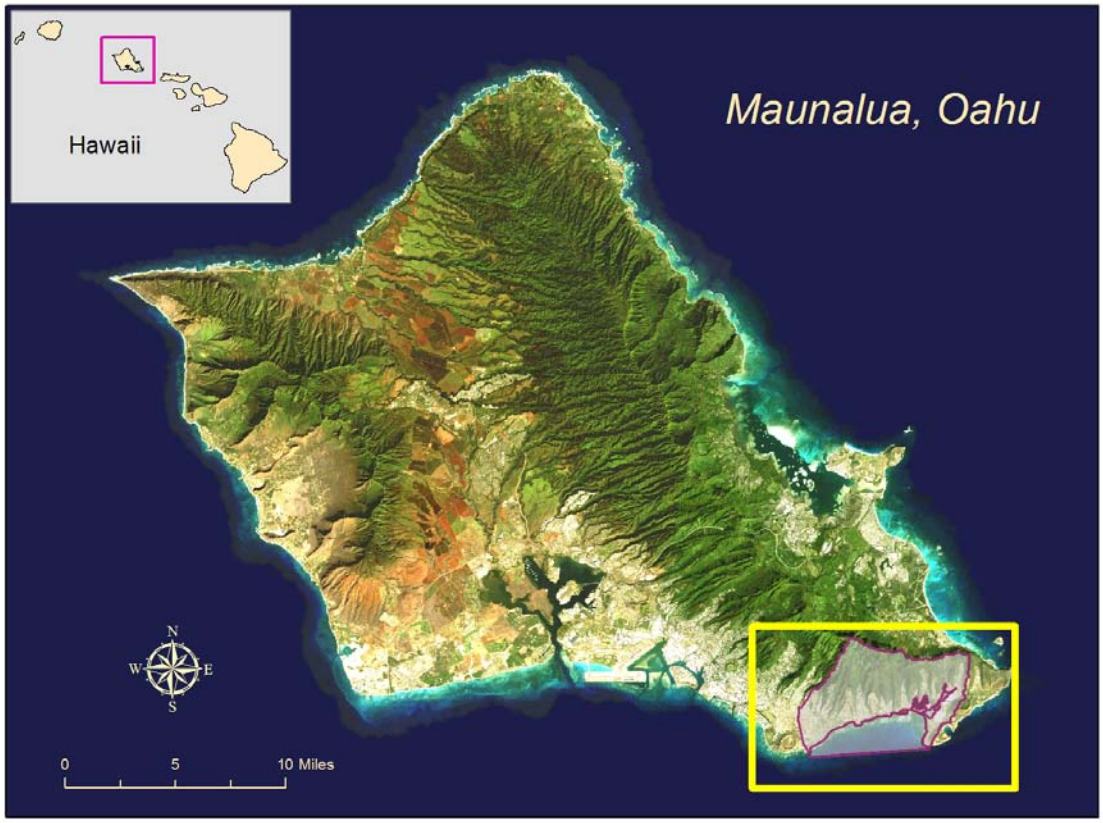

Figure 1: Maunalua Region, Oahu

II. MAUNALUA REGION: DELINEATED AND DESCRIBED

The Maunalua region encompasses Maunalua bay and its 10 *āpana*. The region is approximately 28 square miles in area, with nearly 8 miles of shoreline and 6.5 square miles of ocean. (Figure 2)

The north-south boundaries of the region extend toward the mountains (mauka) to the ridgeline of the Koʻolau Range, and in the seaward (makai) direction into the nearshore waters. The east-west boundaries are between Kūpikipiki ʻō Point to the west (at 21°15.51′N latitude and 157°47.63′ W longitude) and Kawaihoa Point to the east (at 21°15.74′ N latitude and 157°42.59′ W longitude).

The climate in the region varies over short distances. Generally, there is a warm/dry season (*ka`u*) from May through September, when trade winds blow 80 to 95 percent of the time from the northeast, and a cooler, wetter season known as *ho`oilo* occurring from October through April, when trade winds decrease 50 to 80 percent. Rainfall in the region ranges from as little as 20 inches per year at the most southern coastal areas such as *Kūpikipikiʻō* and Portlock, to 100 inches per year or more at the higher elevations of the Ko`olau Range to the north. During *ho`oilo, Kona* (leeward*)* storms can be fierce,

bringing days of heavy rain and high winds that are responsible for most of the flooding in the region. These storms are variable, occurring as many as five times in one year, and absent other years.

The Bay (Kai Kū `Ono)

Maunalua Bay is characterized by large reef flats extending well out from the shoreline to a fore-reef that drops to 15 to 20 feet in depth. Beyond the fore-reef the sea floor gradually increases in depth, broken up by small sudden drop-offs that tell the story of sudden increases in sea level rise over the past hundreds of thousands of years. The broad reef flat is a home to a diversity of native marine algae (limu) that provide food and shelter for a variety of marine life, including small juvenile fish, crabs, shrimps, sea cucumbers, and octopus. Bigger fish such as goatfish (weke, moana), bonefish (oʻio), jacks (ʻōmilu), surgeon fishes (ex., manini) and mullet use the channels that are carved into the reef flat to forage on these plants and animals. The fore-reef, (marked at the surface by wave break), is home to the greatest coral reef growth and harbors the greatest diversity of marine life in Maunalua Bay. Surgeonfish, butterflyfish, parrotfish (uhu), goatfish (weke), eels (puhi), octopus (he'e), crabs, and many other animals rely on the corals for food and shelter. In addition, larger, more easily recognizable sea life like dolphins, turtles, sharks, manta rays, whales, and monk seals frequent the bay.

The Bay has beautiful beaches and provides a large number of recreational opportunities, including surfing, SCUBA diving, parasailing, outrigger canoe paddling, fishing, jet skiing and boating. The Bay also provides outstanding scenic resources for its approximately 60,000 residents and thousands of annual visitors.

The Land (Āina)

The 10 watersheds of the Maunalua region are derived from the eroded Koʻolau shield volcano and are typically small and narrow with extensive areas of impervious rock and unstable or erodible soils. Valleys appear V-shaped, with extremely steep side slopes, separated by narrow ridges. All Maunalua watersheds have also been greatly modified, not only by natural forces but by grazing and urbanization.

Approximately 45% of the Maunalua region is urbanized; 42% is non-urban (mostly steep slopes), and less than 1% is in agricultural use. Although most mid- and lower-watershed areas are dominated by alien species, most upper watersheds retain some intact areas of native forest. These upper areas offer hiking trails and views of the native forest remnants along with spectacular ridge-to-ocean vistas on both sides of the Koʻolau mountain range.

All streams of the region are intermittent, although some flow year-round in the uppermost portions. Most streams are channelized (re-aligned) and lined with concrete in a box-channel configuration. The exceptions are Wailupe stream, which has been re-aligned and hardened with boulders in segments, but has not been concrete-lined, and a few sections of the other streams, such as where Waialae Nui Stream runs through the Waialae Golf Course. (Figure 4)

Prior to urbanization, the region was distinguished by consistent base (subsurface) flows and a significantly large number of springs that provided fresh water to lower stream reaches, shoreline wetlands, and inshore habitats of the bay. With the increase in urbanization and the modernization of Kalanianaole Highway, a significant portion of the flow was diverted into the existing storm water conveyance system via culverts, roads, drains, and other structures.

Urban (Built) Environment

Prior to 1950s, the region was "the country," populated primarily with small ranches, dairies, farms and homes. Today every watershed is densely urbanized and, with the addition of ridge developments, the region has a dozen distinct neighborhoods comprising a population of at least 60,000 people. There are at least eight shopping malls or retail clusters and other large commercial sites. Only a portion of one *āpana* (Kamilo Nui) remains in agriculture.

As the region has developed, the hardening of large areas for roads, parking lots, commercial sites and housing, and the lining of streams and drainages with concrete has progressively increased the impervious area of each watershed. By U.S. Continental standards, a general rule of thumb are that a watershed with over 10% impervious surface should be considered impaired[2]. Preliminary estimates of impervious surface ratios of Maunalua's watersheds confirm that many have greatly surpassed the 10% mark, though more accurate estimates are still needed. (Figure 3)

The impairment in Maunalua is even greater than indicated by benchmarks of impervious surface. A historical lack of appreciation of the value of natural streams in Hawai'i has resulted in their destruction far beyond that which has taken place on the mainland. There has been a pattern of straightening and lining streams and allowing urban areas to encroach to within feet of existing stream channels. Kalaniana'ole Highway and other roads along Maunalua Bay have destroyed estuaries and shoreline wetlands and blocked groundwater flows into the bay. This pattern of encroachment creates unique and difficult challenges for future flood management, pollution control and stream rehabilitation efforts.

[2] Impairment is defined as the basic functions and services provided by a natural watershed being significantly compromised (functions such as infiltration, fish and wildlife habitats, natural water quality improvement such as pollutant filtration, flood storage, opportunities for recreation and aesthetic appreciation, and natural products for our use at little or no cost).

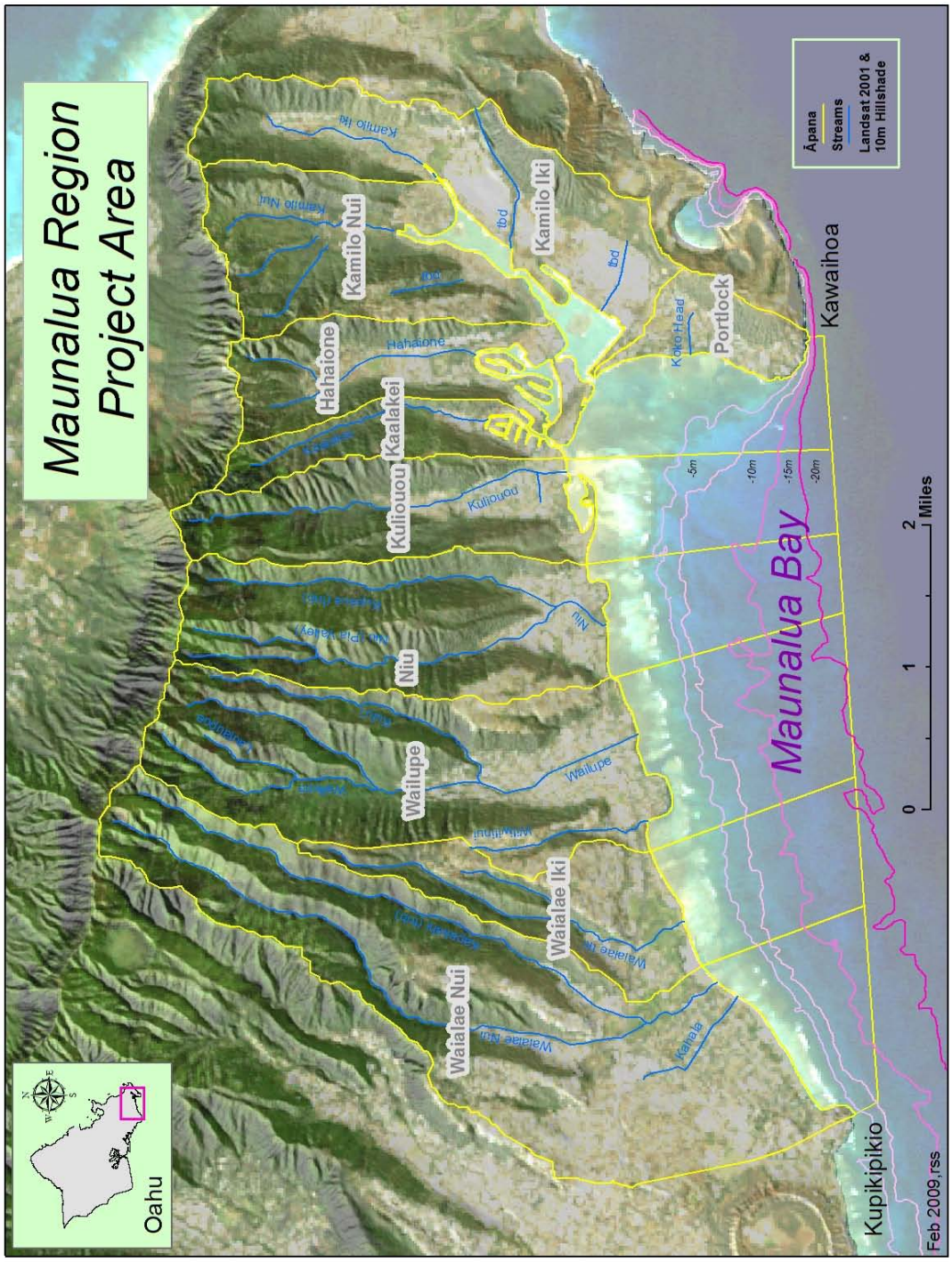
Maunalua Region
Project Area
Oahu
Kamilo Nui
Kamilo Iki
Hahaione
Kaalakei
Kuliouou
Niu
Wailupe
Waialae Iki
Waialae Nui
Maunalua Bay
Kawaihoa
Portlock
Koko Head
Kupikipikio
Āpana
Streams
Landsat 2001 &
10m Hillshade
0
1
2
Miles
-5m
-10m
-15m
-20m
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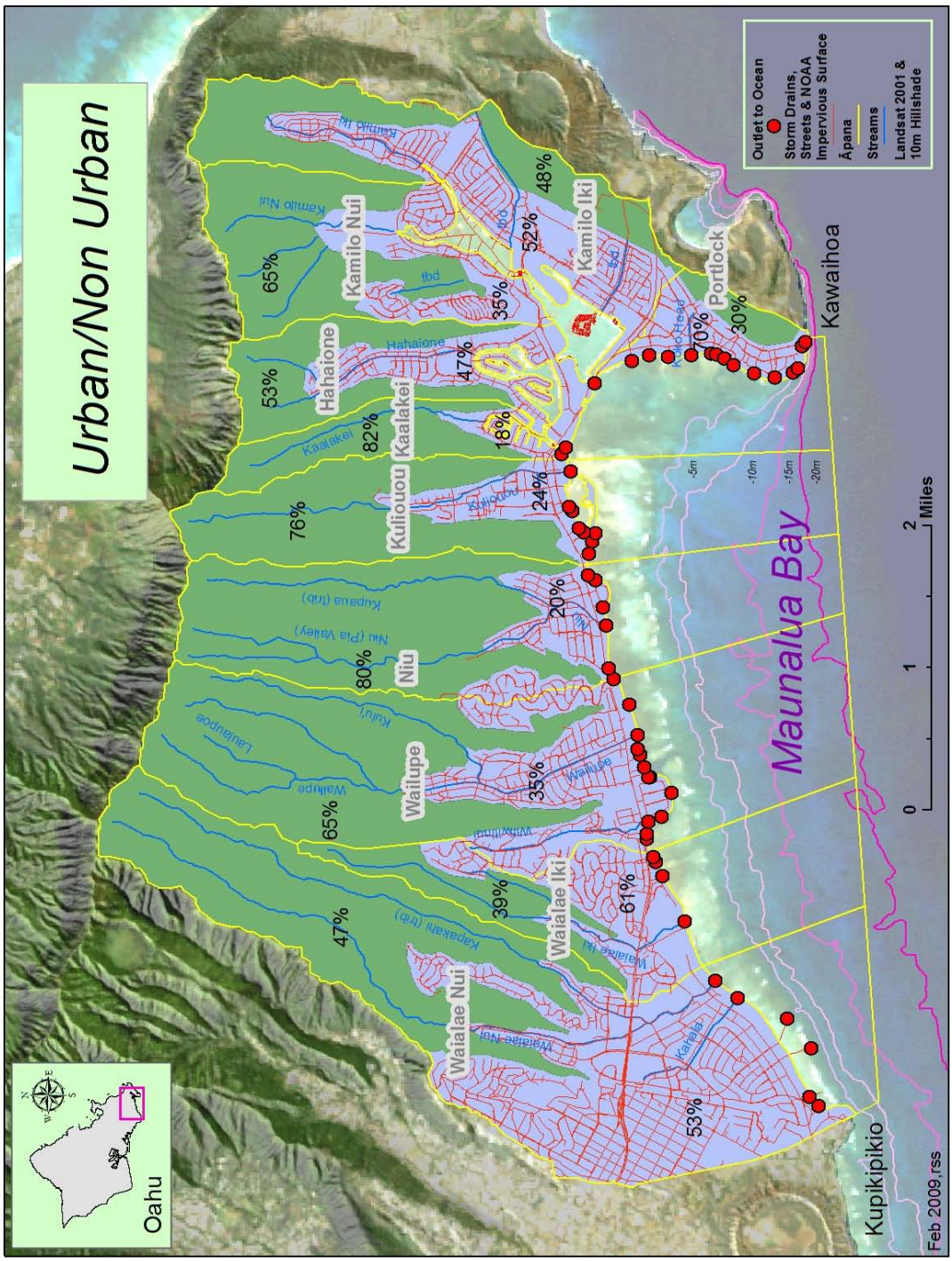
Figure 2


Urban/Non Urban
Outlet to Ocean
Storm Drains, Streets & NOAA Impervious Surface
Āpana
Streams
Landsat 2001 & 10m Hillshade
Maunalua Bay
Kawaihoa
Kupikipikio
Portlock
Kamilo Iki
Kamilo Nui
Hahaione
Kaalakei
Kuliouou
Niu
Wailupe
Waialae Iki
Waialae Nui
48%
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80%
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35%
39%
61%
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70%
30%
0
1
2
Miles
Oahu
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Figure 3

III. PRESENT CONDITION OF MAUNALUA BAY AND WATERSHEDS

Working with UH scientists, NOAA and The Nature Conservancy Hawai'i, Mālama Maunalua identified the three most serious threats to the bay (polluted runoff and sediment, invasive marine algae, and unsustainable marine resource harvesting practices) and documented them in the 2006 Conservation Action Plan (CAP).

Each of these threats is formidable. In combination, they become even more detrimental. For example, invasive marine algae, fertilized by land-based pollutants, serve to capture sediment. Not only is the time the sediment resides in the water thereby increased, but the invasive algae actually promote ideal conditions for their own proliferation. Such sediment conditions also breed anaerobic, toxic environments which give the invasive species a serious advantage over the coral reefs and native animals. Invasive species also out-compete native algae and corals for space and thus displace native reef fish. This situation exacerbates the effects of unsustainable harvesting. The result is that the catch of some species in the bay has declined more than 80% over the past 50 years.[3] Additionally, coral cover is currently 15-20% below the State average.[4]

Mālama Maunalua and its partners are concurrently addressing the three major threats. This Regional Strategy deals with the first threat, polluted runoff and sediment.

Land Based Pollutants and Their Effects

This strategy focuses on those elements judged to be the key drivers of degradation in the system. Key stressors for Maunalua Bay are excessive volume and velocity of stormwater being conveyed off the land, and sediment and pollutant loads carried by these high-speed flows.

Since 1983, the State of Hawaii, Department of Health (DOH) Clean Water Branch has been periodically monitoring water quality in Maunalua Bay at a single fixed ocean monitoring station located near Niu. The DOH has also recently established 13 Marine Recreational Monitoring sites along beaches across Maunalua Bay. **In 2002, 2004 and 2006, due to elevated levels of bacteria, suspended solids and nutrients, the DOH listed Maunalua Bay as water quality impaired[5] for recreation and as a habitat for fish and other aquatic life and wildlife.** Preliminary findings from 2008 coral reef studies also indicate chronic coral stress from land-based sediment and toxicants.

In a naturally occurring watershed, the greatest amount of runoff water is generated in the upper watershed and moves to the lower watershed during rains. Much of it is contained on land through retention in the streambed, wetlands, on the plains and in the estuarine areas. Urban development and associated stream channelization have affected the land's physical capacity to process freshwater. Realigned and hardened streams lose their natural capacity for slowing water, infiltration and detention. The result is an overall

[3] Department of Aquatic Resources Commercial Catch Data
[4] CRAMP Studies, The Nature Conservancy Hawaii ongoing research
[5] Clean Water Act Section 303(d)

increase in volume and water velocities in streams and storm drain channels. This water carries sediment and other pollutants into the bay.

Sedimentation, a natural occurrence in all watersheds, is generated primarily in the upper watershed and moved downhill by water. However, due to several factors, the levels of sediment discharged into Maunalua Bay greatly surpass the bay's capacity to remove it through ocean currents and wave action.

Loss of vegetative cover in the upper watershed increases sediment loads. Vegetative loss is attributed to the impact of feral animals, the introduction of invasive species, and the general decline in rainfall throughout the islands. The consequences of lack of ground cover are increased landslips and slides, reduced stability and permeability of the soils and increased erosion of the topsoil, and an environment less receptive to re-vegetation. There is little data on the extent of the problem in Maunalua Bay. We do know that in Maunalua (with the possible exception of Wailupe, the only unlined stream) by far the greatest amount of sediment is generated in the upper watershed.

Sediment loads in the lower watersheds are also excessive. The causes include decades of grazing, land modifications and construction and the resultant effects: loss of native vegetation, stream bank cutting, gullying, landslips and slides, exposed soils, landscaping, and inappropriate vegetation. Retention and filter functions have been lost. Once entrapped in the impervious surfaces of the urban area and storm drain system, each particle of sediment is destined for Maunalua Bay.

In the ocean the sediment binds with a variety of pollutants resulting in an often toxic mixture that precludes the regeneration and growth of coral, fishes and many other marine organisms. In salt water, sediment also binds with bacteria and settles as a smothering anaerobic lid over nearshore habitats. The resultant anoxic conditions also lead to the production of toxic sulfides. This brew is cyclically re-suspended and resettled, and continually fortified with new deposits by wave action. In the result is a net increase in sediment in the bay. ***Sediment is the threat that keeps growing and killing.***

Other non-point source (NPS) pollutants from residential and commercial areas have been introduced into the system through surface runoff. Evidence of biological perturbation and stress from nutrients, petrochemicals, pesticides, PCBs and heavy metals is found in various parts of the bay. Nutrients, particularly phosphorus and nitrogen, are widely detected and are most likely generated from residential use of fertilizers, detergents and cleaners. City streets and other impervious surfaces yield NPS pollutants such as motor oil, gasoline, antifreeze, and other toxicants.

Controlling stormwater and associated pollutants at their sources is critical. It is extremely challenging in this urbanized region, where mitigation is minimal and space is limited.

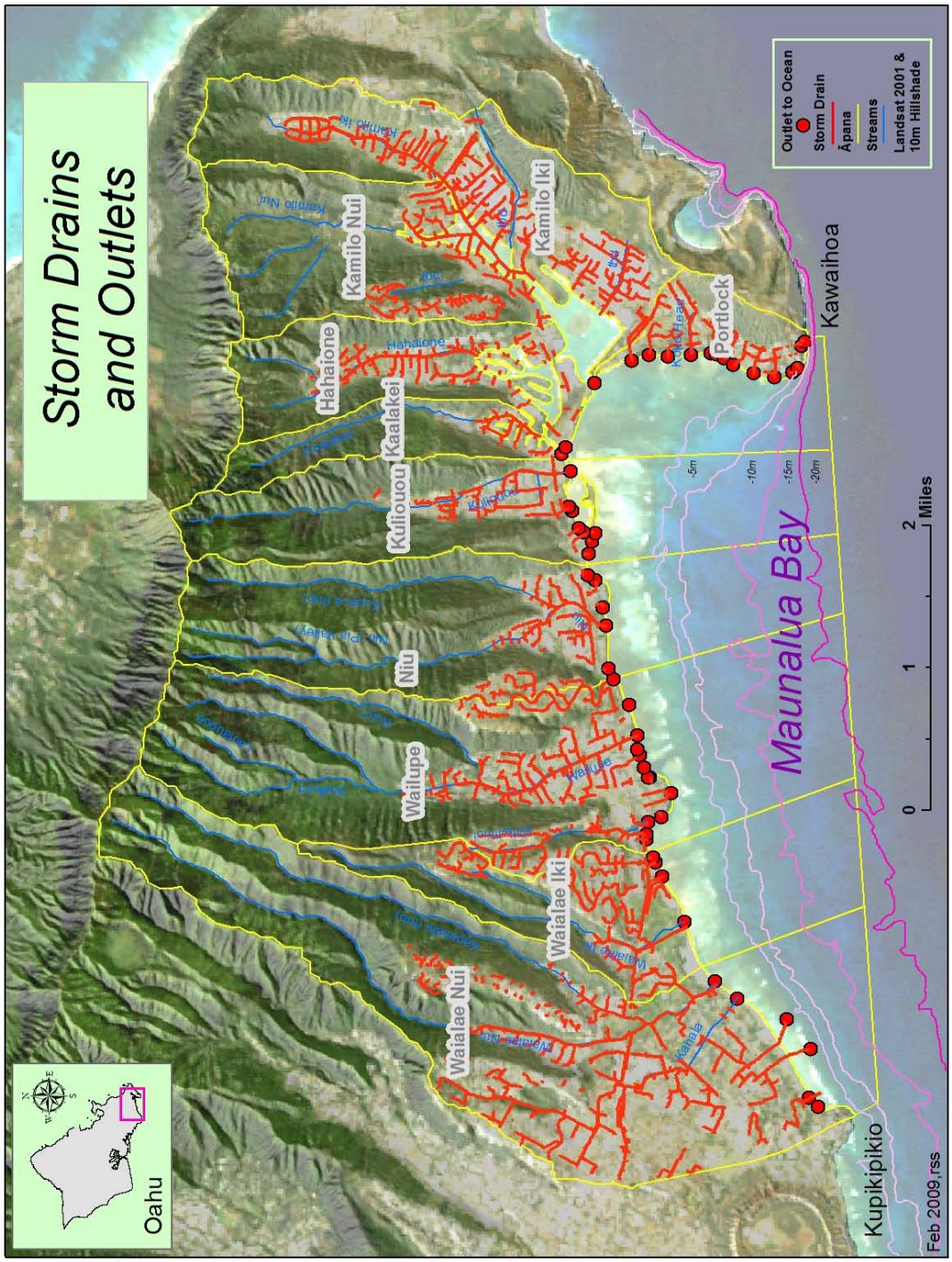

Figure 4

There are 52 streams and storm drain outlets that dump water and pollutants into Maunalua Bay. The storm drain systems are mostly concrete lined. Once a molocule of sediment is captured, it is destined for the bay. This is the base map for Mālama Maunalua planning purposes.

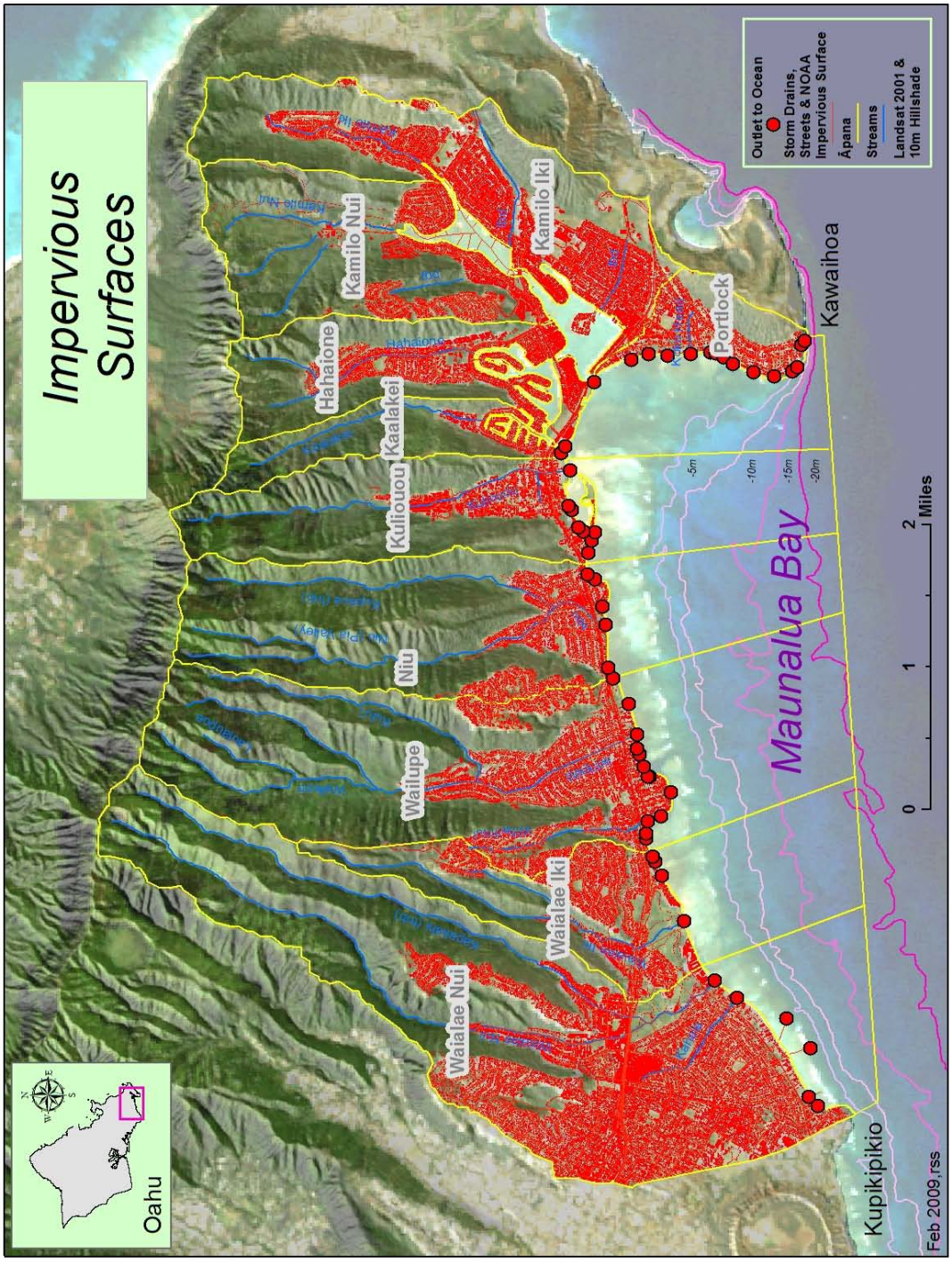

Figure 5

The cumulative impact of lined storm drains, streets, rooftops and driveways presents an impervious cover that approaches 90% in some areas. Our goal is to restore watershed functions by re-creating permeable surfaces.

IV. GOALS AND A PROPOSED FRAMEWORK FOR MANAGEMENT

Restoring watershed functionality and the health of Maunalua Bay is both a land management and a people management issue. The following are key components for creating effective management solutions that restore functionality to Maunalua's āpana.

A. Management Goals for Restoring Watershed Functionality

- **Retain (i.e. filter, detain, slow, or otherwise process) water on land**
- **Reduce sediment inputs**
- **Reduce pollutant inputs from residential and commercial areas**

A broad goal for the region is to transform large freshwater pulses into gradual releases by retaining as much water as possible on land, where it can be stored for future use or allowed to percolate slowly into the groundwater table. A related set of goals involves reducing upper watershed sediment through targeted structural solutions and reducing sediment and NPS pollutant loads from residential and commercial areas, primarily via changing residents' everyday water use, land management and product use behaviors.

B. Units of Management

To plan, implement and manage the solutions, we find it useful to break down the Mauanalua Region into geographic units of *āpana* and smaller Stormwater Management Units.

Āpana Management

We have geographically defined the Maunalua Region and ten *āpana* that empty in Maunalua Bay. Six empty directly: Waiʻalae Nui, Waiʻalae Iki, Wailupe, Niu, Kuliʻouʻou, and Portlock. Four empty indirectly through Kuapā pond: Kaʻalakei, Hahaʻione, Kamilo Nui and Kamilo Iki. Maps are included in the document to illustrate the geographic designations.

The Maunalua *āpana* have characteristics similar to *ahupuaʻa* in that each *āpana* consists of a watershed (basin) and its associated nearshore waters in Maunalua Bay. This approach recognizes that the health of the Bay's marine systems is inextricably bound to the health of the watershed.

The solutions for the bay require a wide range of participants to consider all these links between the land and the sea. We must consider physical, biological and socioeconomic variables. Our solutions must address environmental and our community values. Our holistic management approach integrates multiple agencies and disciplines.

Stormwater Management Units

Because Maunalua āpana are extensively hardened, nearly all sediment and pollutants are delivered to the Bay via the *stormwater conveyance system*. Consequently, we will focus on these systems, along with their *outlets* into the bay and a marine *cell* of affected nearshore waters. We call these Stormwater Management Units (SMUs).

Stormwater Conveyance System: Each outlet is associated with its own stormwater conveyance system, the "plumbing" of the urban area, which includes streams and all storm drain structures, such as drains, pipes, culverts, channels, ditches, and outlets. These systems range from a few street drains to hundreds of drains on one outlet.

Marine Outlets: We have identified 52 stormwater and stream outlets which discharge into Maunalua Bay. This count does not include the two channel outlets from the Kuapā Pond (Hawai'i Kai Marina), or the many outlets that discharge into the pond itself. (Figure 6)

Cells: A circulatory cell in the bay is associated with each stormwater outlet. These cells, created by the bay's circulation patterns, dictate where discharged water, sediment and pollutants are moved and deposited. These are key locations for conducting monitoring to evaluate pollutant discharges and overall ecosystem health.

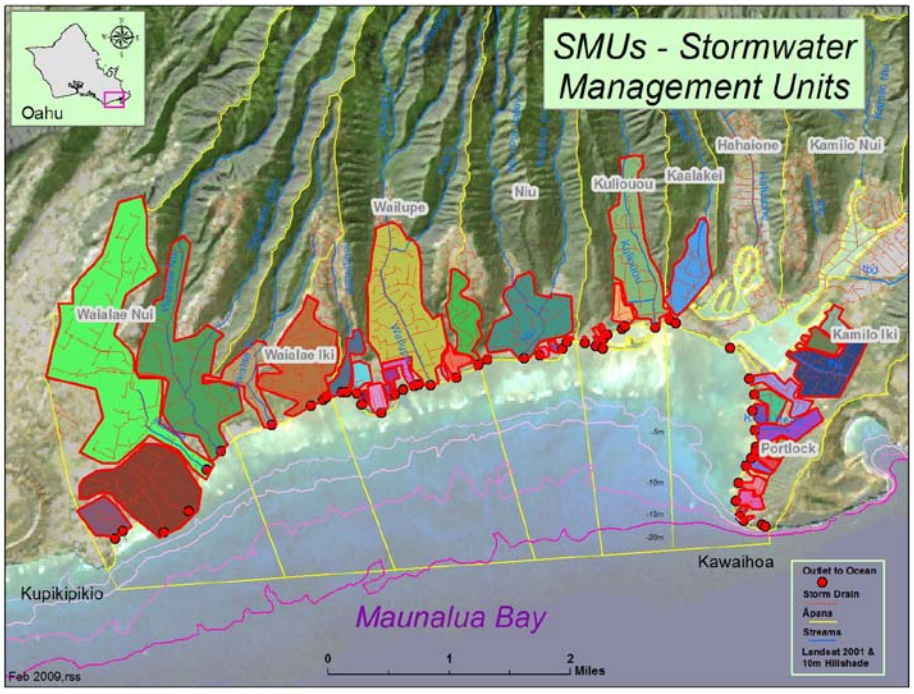

Figure 6

C. Baseline Information

Establishing baseline data of existing sediment and pollutant discharge levels, sediment residency times and biological health in Maunalua Bay is a prerequisite to developing and implementing solutions and measuring success. However, establishing these baselines for the Maunalua region is a significant challenge. There are no comprehensive historical records for rainfall, stream flows, biota, water quality, reef health or marine life. Maunalua's streams are intermittent and periodic, with a long dry season between May and October. We have documented the key threats, i.e., sediment, pollutants, and invasive species and major impacts such as reef loss and fishery decline. However, additional biological, hydrological and other information is needed to understand and address specific sources of problems within each āpana, as well as to sufficiently measure the success of our future management actions.

Mālama Maunalua has a solution for this lack of information. We are blessed with talented government and non-governmental organization (NGO) partners, who have launched a suite of interrelated studies to answer questions about the present condition of the Bay and its potential for recovery. The following baseline data collection efforts have been launched or are planned for the near future.

Marine Resources: Beginning in 2007, bi-annual surveys have been conducted by The Nature Conservancy Hawai'i to assess baseline levels and condition of fish stocks, condition of infauna and coral reefs, and general condition of habitats. This long-term resource monitoring effort will enable us to detect changes in resource health over time.

Biomarkers of Exposure in Coral: The purpose of this study, begun in early 2008 by UH Kewalo Marine Laboratory (KML), is to identify the main pollutants affecting organisms in the bay, quantify levels present and identify specific stream sources. Thus far, data has been collected from three locations in the bay.

Physical Models of the Bay: This study, conducted by KML and Eric Wolanski, Ph.D., will identify sediment and runoff inputs into the bay, size and duration of the sediment plumes, the retention of sediments, flushing rates and levels of sediment re-suspension. Thus far, instruments have been deployed in the bay near Kuli`ou`ou. This study will be augmented by data collected by the U.S.Geological Survey (USGS) Maunalua Bay study in winter 2008-2009 (described below).

USGS Maunalua Bay Study: Winter 2008-2009. USGS will conduct a range of studies to better understand the role of currents and waves in transporting sediment and pollutants in Maunalua Bay, and the nature of groundwater discharge into the bay. USGS will deploy six instrument packages at various locations around the bay. Each package will record current speed and direction, wave height, temperature, salinity and turbidity for every hour for about three months. In addition, USGS will install a bottom-mounted camera for imaging sediment on corals, a land camera-system to image sediment plumes from run-off, and a local weather station to compare wind conditions with wave characteristics.

Measurements of groundwater discharge and its character will also be made along the coast and shallow reef flat along the entire bay.

Evaluation and Comparison of Suspended Sediment Discharge at Wailupe and Kuliouou Streams: A cooperative effort of the U.S. Army Corps of Engineers and USGS, this recently-launched study utilizes stream flow and suspended sediment monitoring stations at two locations in each stream to evaluate and compare sediment loads from both basins. A monitoring station is in operation on Wailupe Stream and will soon be in operation on Kul'iou'ou Stream.

Expansion of Biomarkers of Exposure in Coral Study: This study will identify the biological effects of the toxicants identified previously, and the distribution patterns of sediment and runoff identified in the modeling study to determine threshold levels that need to be reached for ecological effects, and to determine target levels for mitigation efforts.

Substratum study: This effort, to commence in early to mid 2009, involves core sampling of sediments across the bay by University of Hawaii SOEST scientists to determine change over time in substratum characteristics and date transitions from functional ecosystem to the present compromised state.

Maunalua Volunteer Rain Gage Monitoring Program: For 2009, Mālama Maunalua will initiate a rain gage project to begin collecting precipitation data for the region from each of the 10 *āpana*. Rainfall measurement data for the Maunalua region are nearly nonexistent, yet vitally important to understanding baseline conditions, and modeling stream flow and discharge and pollutant loading. This project will create partnerships with schools and residents to install rain gages in each of the 10 watersheds in order to create a baseline dataset and ongoing feedback for management

Mālama Maunalua Volunteer NPS Monitoring Program: Seasonal monitoring near discharge points (outlets) during peak flows by volunteers will augment data collected by KML. Efforts will begin with sediment and nutrients. Other toxicants, such as petrochemicals and heavy metals, may be added to the list of monitored substances based upon baseline monitoring findings. One purpose of this study is to attempt to devise a relatively accessible and meaningful sediment monitoring program for other communities.

Rapid Stream Assessments: A stream reconnaissance survey is planned for all 10 streams to briefly characterize the channel, identify riparian conditions, hot spots, opportunities and challenges. The method will be based on the Unified Stream Assessment (USA) and modified to be appropriate to Hawai'i.

Rapid Stream and Watershed Assessment for Wailupe: This will be modified version of the Unified Subwatershed and Site Reconnaissance (USSR) to be Hawaii-appropriate. The USSR is a survey of neighborhoods and businesses to determine various sources that may be contributing pollutants to local waterways and the condition of existing street and storm drain systems.

D. Promising Tools and Best Management Practices (BMPs)

Many tools exist to reduce sediment and NPS pollutants, although few have been applied to Hawaii`s streams. The following is a list of structural tools and other applications which appear to be appropriate to the physical, ecological and social setting of the Maunalua region.

Structural Solutions include:

- rebuilt wetlands at the few remaining open coastal and riparian sites to filter sediment and nutrients and create parklands;
- channel modifications and retrofits, such as artesian galleries, softening or removal of hardened surfaces, reduction in stream slope, increases in channel roughness;
- retention and detention structures for volume control;[6]
- infiltration systems such as settling basins and trenches, French drains, porous pavement, which are particularly effective applied to parking lots, neighborhood streets, and other large-scale impervious areas;
- separators and filtration devices, designed to remove sediments, hydrocarbons and other pollutants from stormwater runoff;
- vegetated corridors along streams and canals;
- stream bank stabilization/erosion control measures; and
- feral animal control combined with re-vegetation of the non-urban area.

Nonstructural Solutions

Nonstructural measures are preventive measures implemented through planning design, maintenance and education. These include:

- BMPs for site planning;
- BMPs for construction, specific to the region;
- individual residential BMPs (includes practices such as household pollution prevention, yard management, landscaping, runoff control, and water harvesting), to minimize environmental degradation; to be provided through educational materials and events;
- preventive maintenance programs,(e.g. community “Adopt a storm drain” program, neighborhood volunteer clean-up of streams, storm drains and discharge points preceding rainy seasons); and
- water quality monitoring. (While not in itself a pollutant-reduction measure, monitoring is a valuable tool in raising community awareness of land-sea connections, and for increasing demand for solutions to problems).

[6] Detention basins or vaults at upper watershed areas coupled with a proper maintenance program could potentially prevent a large percentage of sediment loads from being transported to the bay. Vegetated swales and diversions to irrigation (for example at golf courses) can also assist in filtration and the stable conveyance of stormwater runoff.

The challenge ahead lies in identifying a 'best mix' of approaches and tailoring these approaches to meet the requirements of each *āpana*. Maunalua will be a good testing ground for the island because we can compare results from both lined and unlined streams.

E. Early Opportunities

It is important to identify early opportunities for success, especially where impacts are regional or affect multiple *āpana*. Opportunities abound in the urban setting, in parks, schools, shopping centers, condos, new development or large land areas under one owner. There also are numerous sites within the stormwater conveyance system itself where technologies which increase functionality might be installed (e.g. Sediment collectors or separators, water slowing devices, etc.). We propose to identify opportunities, at the regional level and *āpana* level through rapid surveys and assessment**.**

Examples of early opportunities identified for the region and Wailupe *āpana* are described in the 2009 Maunalua Watershed Action Agenda

F. Āpana Action Plans

Mālama Maunalua plans to facilitate the development of watershed management and rehabilitation plans for each *āpana* through collaborative partnerships. The plans will deal with the unique challenges and needs within each urban watershed.

Fixing the streams and storm drain systems are major undertakings. We have one chance at the "big fixes," such as restoring wetlands or redesigning catchments and channels so it's important to get it right. For that we need careful planning. And, the projects will not usually be implemented quickly.

The management plan for each *āpana* will address all stakeholders and identify clear approaches to effect "on-the-ground" change within the *āpana*. Each plan should characterize the watershed conditions, identify, investigate, and address the current and emerging issues facing the watershed, and identify a feasible collection of solutions. We have tailored our approach to watershed planning to fit the realities of our conditions. The process of developing each plan should be well documented in order to serve as a potential model for subsequent urban watershed plans.

Mālama Maunalua has identified Wailupe (Figures 7 and 8) as the focus of the first plan. Data gathering and collaborative planning arrangements have also been initiated for Kuli ʻou ʻou.

The procedures and outcomes of these steps will vary among *āpana*. However the monitoring component will be implemented across the entire bay and encompass all *āpana*. The basic form is described in the following section.

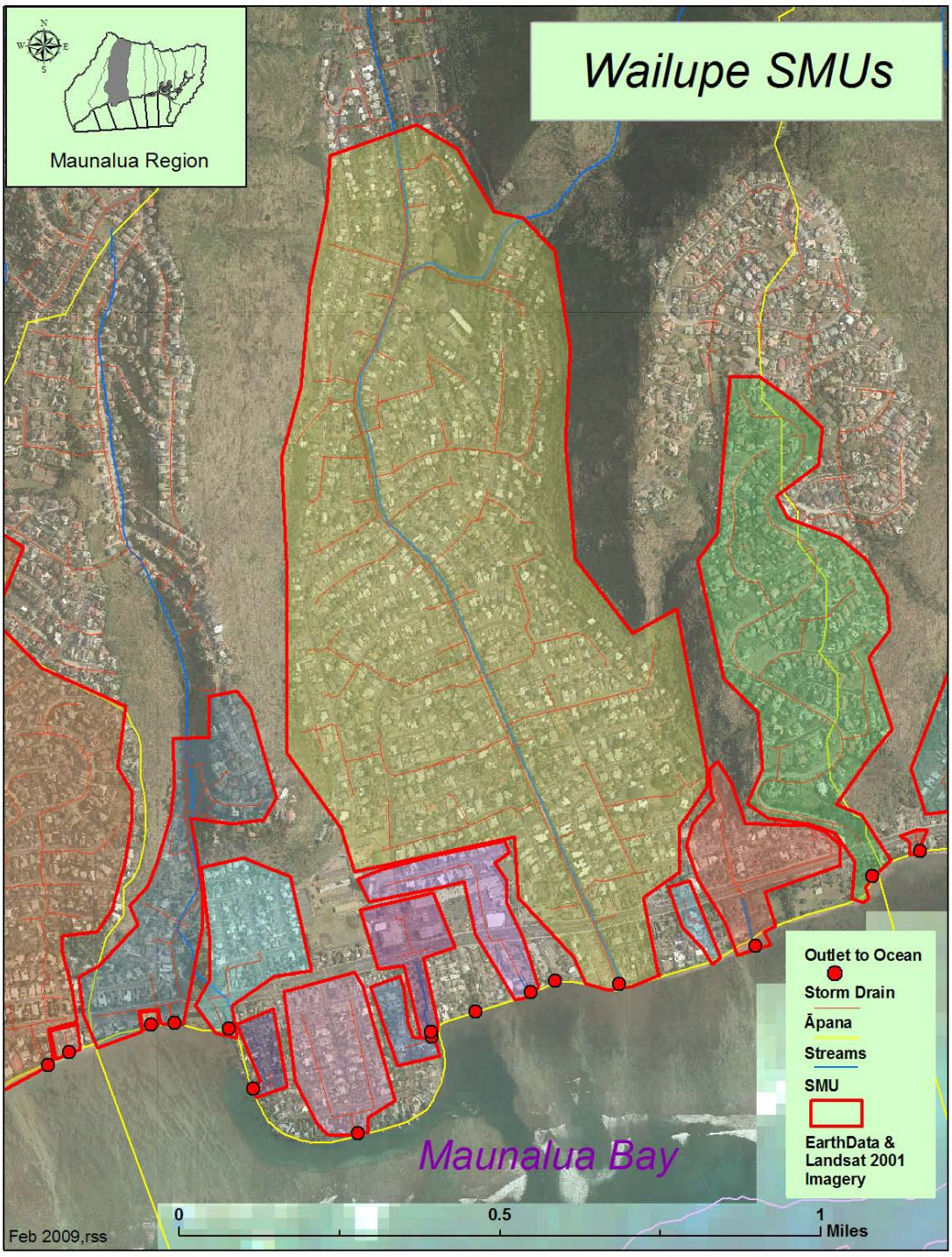

Figure 7

Wailupe *āpana* has 14 outlets and, theoretically corresponding SMUs, although data regarding their location is sketchy at times.

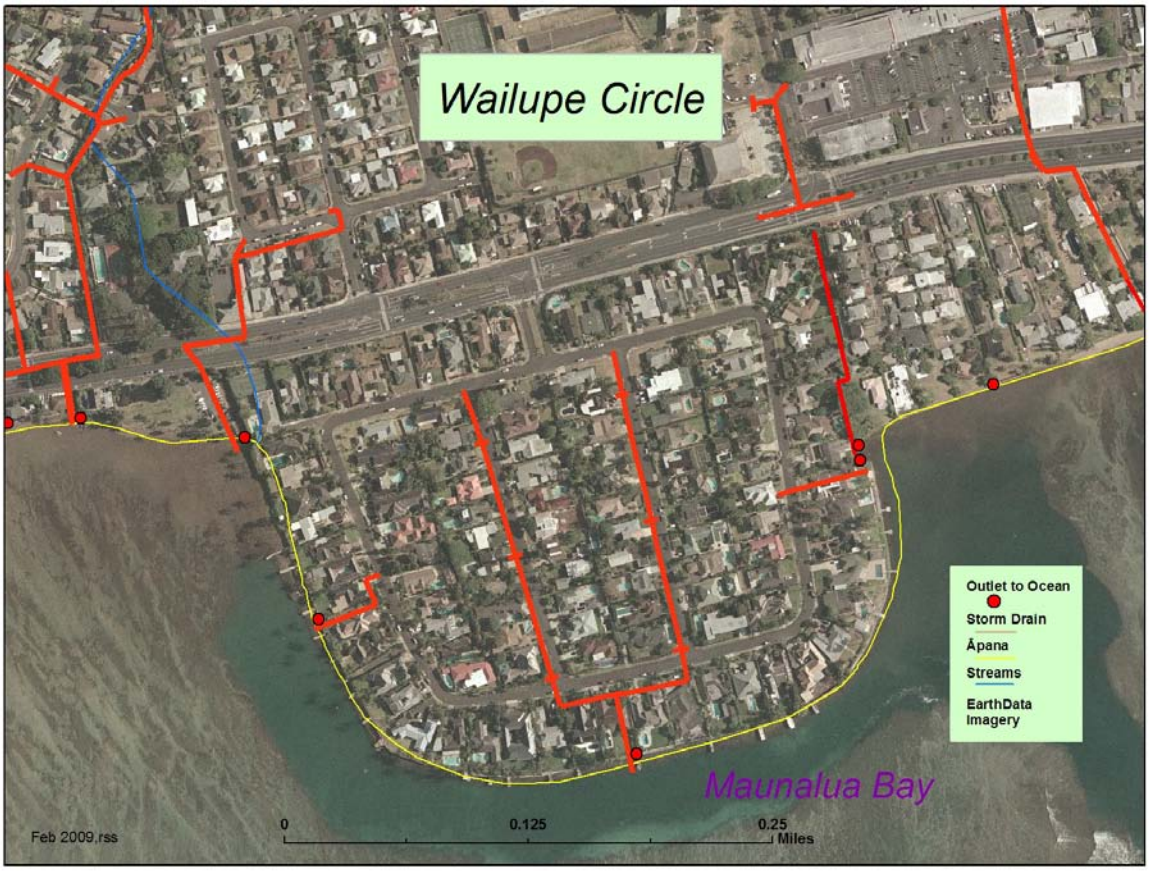

Figure 8

The storm drain GIS maps that we have developed will be available on our website.

G. Targeted Monitoring Programs to Evaluate Success

An indicator of success would be the amount of sediment and NPS-reduction which resulted from our efforts. The baseline data being developed by our partners is the beginning. This information will have statewide applicability.

Development of the monitoring programs is guided by the questions below and by an Evaluative Framework that we have developed. The framework includes include both scientific and community monitoring efforts on land and in the ocean.

Sediment:

- What are historical sediment deposition trends?
- What are present rates of sediment discharge?
- Are sediment discharge levels decreasing?
- Is sediment containment in the bay decreasing?
- Are coral reef biomarkers showing improvement?
- Are indicators of sediment stress decreasing?
- Is overall improved health of reefs and substratum apparent?

Pollutants:

- What are the key NPS pollutants discharged into each cell?
- Are discharge levels going down in each cell over time?
- How do discharge levels compare to historical conditions?
- How long do the pollutants reside in the Bay?
- Are biomarkers showing improvement?
- Are indicators of toxicant stress decreasing?
- Is overall improved health of reefs and substratum apparent and measurable?

The Evaluative Framework addresses monitoring for sediment and monitoring for associated NPS pollutants. Both baseline data and ongoing monitoring data needed to answer the questions are identified.

Sediment Monitoring

Several types of ongoing monitoring programs will provide data to authenticate physical models and determine whether sediment reduction goals are being achieved. Stream flow gages and sediment autosamplers (turbidity) have been installed at Wailupe and Kuli‘ou‘ou Streams. The goal is to eventually install similar monitoring technology at all 10 streams. In addition, in a new Maunalua Bay Citizen Monitoring program, volunteers will monitor turbidity near discharge points. Another type of monitoring currently being considered involves placing sediment traps across the bay where deposition and removal rates are monitored throughout the year. Continuing biological assessments of habitat health and coral stress due to sediment will also reveal whether threshold levels and target levels are being achieved.

NPS Pollutant Monitoring

Habitat assessments and biomarker health will also provide indicators of targeted non-point source pollutant reduction. Volunteer monitoring of associated Non-Point Source Pollutants near discharge points (outlets) during peak flows will record levels of sediment, nutrients, and specific toxicants as identified on a stream-by-stream basis.

H. Measuring Success

- Any action that makes a difference in the health of the bay is success. Every remediation, big or small, on any SMU or residential neighborhood or business, is a success. Every Drop Counts.

- Any beneficial change in watershed policy and practices is success.

- Any degree to which the community participates in watershed improvement through changes in behavior, public advocacy and basic understanding is success.

- Any degree to which the following questions can be answered will be a measure of success.

  - Are discharge levels of sediment, nutrients and other targeted NPS pollutants decreasing in each stream segment and/or marine cell over time? This question addresses the need to assess source-specific treatments, e.g. sediment reduction at upper –vs. - mid-reach areas of *āpana*, NPS pollutants from residential and commercial areas.

  - Is the health of the associated marine systems improving? For example are corals showing reductions in sediment stress? Are recruitment and age structure and diversity of coral populations improving?

Success: This channel segment, long loaded with tons of sediment destined for Maunalua Bay, was cleaned by the Department of Transportation in January 2008 at the request of the community.

Success is measured in many ways.

V. COLLABORATION AND PARTNERSHIPS FOR REGIONAL WATERSHED MANAGEMENT

Mālama Maunalua is committed to regional management based on the Hawaiian ahupuaʻa, which understands the integration of watersheds and their nearshore waters as large, complex, and interdependent ecological systems. Management across multiple sectors of society and governance is equally complex. The present management system is not working. Change is needed, and it needs to be community-driven and collaborative.

We seek collaboration among community, NGOs, businesses, decision-makers, and the government agencies, especially those associated with land development and with stormwater systems and land based pollution. We seek cooperative partnerships to address regional and *āpana* management needs and expand community and government interest in improving Maunalua Bay.

As we begin 2009, our largest collaborative effort will be participation in a planning process for Wailupe Watershed with the community and with the U.S. Army Corps of Engineers (USACE), the State, the City and County of Honolulu and multiple other agencies. The USACE has also identified Kuli`ou`ou *āpana* as a priority site for flood mitigation and stream rehabilitation. We have an ideal opportunity for comparative research and remediation projects in a concrete-lined (Kuli`ou`ou) and unlined (Wailupe) stream.

Mālama Maunalua will work together with funding partners to address long-range funding needs for watershed rehabilitation across the region.

Mahalo to those who have joined the Maunalua community in caring for our Maunalua Bay:
Hawaiʻi
City and County of Honolulu – Department of Environmental Services
City and County of Honolulu – Division of Facilities Maintenance
Hawaiʻi DBEDT-Coastal Zone Management Program
Hawaiʻi Department of Health- Clean Water Branch (DOH)
Hawaiʻi Department of Health- Environmental Planning Office
Hawaiʻi Department of Land and Natural Resources, Division of Aquatic Resources (DAR)
Hawaiʻi Department of Land and Natural Resources, Division of Boating and Ocean Recreation (DOBOR)
Hawaiʻi Department of Land and Natural Resources, Division of Conservation Enforcement (DOCARE)
Hawaiʻi Department of Land and Natural Resources, Division of Forestry & Wildlife (DOFAW)
Hawaiʻi Department of Land and Natural Resources, Office of Conservation & Coastal Lands (DLNR/OCCL)
Hawaiʻi Department of Transportation- Highways Division (DOT)
Hawaiʻi Fishing News
Hawaiʻi Local Action Strategy Committee to address Land Based Pollution Threats to Coral Reefs (LAS)

Hui Nalu Canoe Club
Koʻolau Mountains Watershed Partnership (KMWP)
Liveable Hawaiʻi Kai Hui
Mālama Hawaiʻi
O `ahu Soil and Water Conservation District
Surfrider Foundation
The Nature Conservancy Hawaii (TNCH)
The Polynesian Voyaging Society (PVS)
U.S. Department of Agriculture O `ahu Resource Conservation and Development Council
U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS)
U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA)
U.S. Department of the Army, Corps of Engineers (USACOE)
U.S. Department of the Interior, Fish and Wildlife Service (FWS)
U.S. Environmental Protection Agency (EPA)
U.S. Geological Survey (USGS)
University of Hawaiʻi Kewalo Basin Marine Laboratory
University of Hawaiʻi Sea Grant College Program
University of Hawaiʻi/DLNR Hawaii Coral Reef Initiative Research Program

The Mālama Maunalua's Action Agenda for 2009 is found in the companion document*:*
Mālama Maunalua Conservation Action Plan Update, 2009.