PART IV - CRITICAL COASTAL AREAS AND ADDITIONAL MANAGEMENT MEASURES

Section 6217(b) of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 requires states to implement management measures in addition to those contained in EPA's *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* [the "(g) measures"]. In general, the purpose of this "second tier" of management measures is to address water quality problems that continue despite the implementation of the (g) measures. According to the Environmental Protection Agency's (EPA) and the National Oceanic and Atmospheric Administration's (NOAA) *Program Development and Approval Guidance*, "these additional measures apply both to existing land and water uses that are found to cause or contribute to water quality impairment and to new or substantially expanding land uses within critical coastal areas adjacent to impaired or threatened coastal waters" (p. 22).

Specifically, the State must identify its threatened or impaired coastal waters and the land uses that cause or threaten these waters; delineate critical coastal areas; develop a process for determining whether additional measures are necessary to attain or maintain water quality standards in the threatened or impaired waters; describe the additional management measures the State will apply to the identified land uses and critical coastal areas; and develop a program to ensure the implementation of additional management measures. These elements are discussed in greater detail below.

1. Identification of Threatened or Impaired Coastal Waters

First, states must identify coastal waters that are not attaining or maintaining applicable water quality standards or protecting designated uses, or that are threatened by reasonably foreseeable increases in pollution loadings from new or expanding sources [§6217(b)(1)].

EPA and NOAA's *Program Development and Approval Guidance* specifies how the State's threatened and impaired waterbodies are to be identified. The State must include, at a minimum:

- coastal waters identified in the State's most recent report under Section 305(b), Clean Water Act (CWA), as "partially meeting" or "not meeting" designated uses or as "threatened";
    - coastal waters listed by the State in accordance with the requirements of Section 303(d)(1)(a), CWA, requiring Total Maximum Daily Load calculations if listing is due at least in part to nonpoint sources;
    - coastal waters listed by the State under Section 304(1), CWA, as impaired by nonpoint source pollution; and

- coastal waters identified by the State as impaired or threatened by nonpoint source pollution in an assessment submitted to EPA under Section 319, CWA, or in any updates of the assessment.

1.a. Criteria for Identification of Threatened or Impaired Waterbodies

There are two definitions of water quality. One is the general definition set forth as a goal in Section 101, CWA, to maintain "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water." This definition is commonly referred to as "fishable, swimmable waters." The second manner in which water quality is defined is by water quality standards that set forth specific numerical criteria for each body of water. The standards are set by the states, following criteria set forth by the EPA. In Hawaii, the standards are set by the Department of Health (DOH). The process for setting standards is outlined in Sections 303(a), (b), and (c), CWA.

The mechanism to determine whether a given waterbody is impaired is the segment classification system outlined in Section 303(d), CWA. An "impaired" waterbody is one where existing water quality does not meet water quality standards and will not meet applicable water quality standards even after effluent limitation requirements on point source discharges are applied. Waterbodies are "threatened" where there is reason to believe that violations of water quality standards exist but monitoring data are insufficient to establish impaired water quality.

The most important reference documents for water quality in Hawaii are the Water Quality Management Plans (WQMP), sometimes referred to as the "208" plans because they were prepared to comply with Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (also referred to as PL 92-500), further amended by the Clean Water Act of 1987. WQMPs for all four counties were first published and adopted in 1978. Revised versions reflecting public and EPA comments were published in 1980. In 1989, the City and County of Honolulu, in cooperation with DOH, undertook a complete revision and update of its Plan. DOH completed an update of the "208" WQMPs for Kauai, Maui, and Hawaii counties in November 1993. Except where noted, the following descriptions of the characteristics and quality of Hawaii's waters are taken from the most recent WQMP documents.

1.b. Water Quality Standards

The criteria for measuring the quality of coastal waters are set forth in the State Water Quality Standards, Title 11, Chapter 54 of the DOH Administrative Rules.

The standards account for the natural differences and varieties of waters in the State by establishing two general classifications, inland waters and marine waters. Inland waters consist of two water types: freshwater and mixohaline-saline waters. Seven ecological subtypes are also identified for inland waters. Four subtypes are assigned under freshwater and three under mixohaline-saline water types. Each of the ecological subtypes for inland waters is described by environmental features and characteristic biota (distinguishing species) along with information on relative abundance and distribution. Marine waters consist of three water types: embayment, open coastal waters, and oceanic waters. Six bottom subtypes are identified under embayments and open coastal waters.

Marine water types are categorized by physical and biological characteristics. Open coastal waters extend from the shoreline to the 100-fathom (600 foot) depth contour. Waters beyond the 100-fathom contour are defined as oceanic waters. Embayments are defined as land confined and physically protected marine waters with restricted openings to open coastal waters, defined by the ratio of total bay volume to the cross-sectional entrance area of seven hundreds to one or greater. The biological characteristics of marine water types are categorized on the basis of phytoplankton biomass and/or parameters which affect biomass (*i.e.*, primary productivity or photosynthesis which is influenced by growth rate factors such as sunlight and nutrients). The water types are characterized by their water chemistry, hydrography, and distinguishing biota. Marine bottom subtypes consist of six categories which are based on physical substrate, and species composition and diversity. Species are grouped in assemblages and communities that generally exhibit the same tolerances to their physical, chemical, and biological environment.

Water quality parameters and criteria used in the standards are based on the following considerations: ecological significance, sensitivity to small changes, ease of measurement in the field, available data base, and sufficient sensitivity to indicate water quality problems. Water quality parameters are designated for inland or marine waters, and bottom types. Separate criteria are established for open coastal waters and embayments whose water quality is primarily influenced by rainfall and surface water runoff. Groundwater flow through upwelling, however, is not considered (DOH 1993a, p. VI-7).

The standards include a number of different chemical, physical, and biological parameters as well as the basic standards guidelines of biological oxygen demand (BOD), suspended solids, and dissolved oxygen developed by the National Technical Advisory Committee's (NTAC) "Water Quality Criteria" (DOH 1993a, p. VI-2). Numerical criteria are set forth for total nitrogen, ammonia nitrogen, nitrate and nitrite nitrogen, total phosphorus, chlorophyll a, and turbidity. The standards also include numeric criteria for 104 toxic pollutants, including metals and organic chemicals. Appropriate narrative criteria are established for pH, dissolved oxygen, temperature, salinity, and marine bottom types. The "Basic Freedom" criteria of the NTAC (*e.g.*, floatables, settleables, oil, grease, etc.) are used in the standards, which include erosion of soil particles resulting from construction activities on land. Bottom criteria for streams are also written in narrative format.

Numerical criteria in the standards also account for variability of water quality influenced by natural conditions. Water column criteria are therefore expressed as the geometric mean of all measurements not to be exceeded by a given value. Also, 10% of the measurements are not to exceed an intermediate value; and 2% are not to exceed a given limiting value.

Microbiological criteria are established for inland waters and marine recreational waters within 1,000 feet of the shoreline. The water quality of recreational waters is expressed statistically using fecal coliform bacteria as indicators for inland waters and enterococci as indicators for marine recreational waters.

The designations of beneficial uses for water under Section 101(a)(2), CWA, provide for the protection of fish, shellfish, wildlife, and recreation. Other beneficial uses include public water supplies, propagation of fish and wildlife, recreational, agricultural, industrial, and other purposes. The uses also take into consideration utility and value of the waterbody for navigation. EPA regulations [40 CFR 131.10(Q)] require that a "use attainability analysis" be conducted for non-attainable fishable/swimmable uses as specified in Section 101(a)(2), CWA. The Hawaii State water quality standards are equal to or more stringent than EPA requirements.

The standards were most recently revised in October 1992. The revisions included clarification of definitions of terms and extended narrative descriptions of policies intended to limit pollution in inland and coastal waters. A complete description of the history and basis for Hawaii's water quality standards, and planned future revisions, is contained in Chapter VI or the November 1993 "208" Water Quality Management Plans.

1.c. Land-Water Relationships

As noted previously, Hawaii has no major river basin systems comparable to those in the continental United States. Unfortunately for Hawaii, PL 92-500 was written to address river problems and does not recognize or address the unique geomorphologic, hydrographic, and climatic features which are prevalent in island environments. When the EPA promulgated regulations to implement Section 303(e) of the Act which requires each State to assess the extent of their water pollution, stream segments were used as the mechanism for this classification. Segment classification is intended for use as a management tool for improving water quality. For nonpoint source pollution control, strategies for cleanup can be developed by relating water segments to existing adjacent land uses.

Improving the segment classification system became one of the major objectives of the State of Hawaii's "208" planning program that began in 1976. A study was designed to analyze and evaluate water quality data in relation to land uses in order to define water quality problems in a better way and to improve nonpoint source controls. This took the form of a two-part prototype study. The objectives of the first part were to describe statistically the existing water quality characteristics of Hawaiian coastal waters and to gather data on land characteristics and on coastal transport. This work had the two-fold purpose of providing a comparison of existing water quality with the then newly proposed water quality criteria and of providing background information for the possible development of a quantitative relationship between land use and adjacent water quality characteristics. The second part of the study was directed at determining the cause and effect relationships between land use and water quality, utilizing information gathered in the first part of the investigation.

The study indicated what had been suspected, that there is no strong relationship between open coastal water quality characteristics and the characteristics of the adjacent land. Although the nearshore waters have significantly greater concentrations of various constituents than open ocean waters, this effect occurs over a large area. The localized reversals cause an integration of the effects of a point source over an area encompassing from one-fourth to one-half of an island's total shoreline.

The study concluded that the oceanographic characteristics of mixing and current structure are the significant factors in open coastal water quality. The longshore current structure distributes the land effect relatively quickly over a long stretch of coastline so that the quality of water immediately adjacent to a particular coastal area does not directly reflect the land characteristics of that drainage area. The study noted that this was especially true when time and space were being considered in averaging water quality parameters. This makes it difficult to assess impacts of nonpoint source pollution discharges on other than an islandwide basis.

The results of the study demonstrated that the existing defined coastal water quality segments, developed primarily from land characteristics, did not adequately reflect the actual open coastal water quality conditions. Embayments and estuaries, on the other hand, act somewhat like lakes and rivers in that there are longer residence times which enhance the effects of land uses in the drainage area upon waters in the embayment. In such areas, significant correlations were found between land characteristics and several water quality parameters, including phosphorus, nitrogen, and turbidity.

The prototype study provided the basis for redefining Water Quality Limited Segments (WQLS) and Effluent Limitation Segments (ELS). The revised classification system was restricted to embayments and estuaries except for South Molokai (and in 1993, West Maui and Kihei). In making the designations, current and historic monitoring data and results of water quality studies were gathered from the literature and statistical compilations obtained for comparison with water quality standards. Water quality parameters such as turbidity, nitrogen and phosphorus, which generally exceeded the standards in embayments, were closely examined. The variability in water quality among various embayments was also evaluated to distinguish natural functions from man-related activities which influence water quality.

1.d. Water Quality Limited Segments

As noted in the previous section, all the coastal waters of the State have been divided into segments, and designated by DOH as either WQLSs or ELSs. This was done in 1973 as part of the State Continuing Planning Process to meet the requirements of Section 303(d)(1) and 303(e) of PL 92-500. Despite their limited value, as discussed in the description of the prototype study, these segments were used as planning areas for the 1976 Phase I Basin Plans and Section “208” plans, and continue to be used in the current plans.

Each coastal water segment is linked with an associated land area. Each island is divided into hydrographic areas based on surface topography. Subareas are defined by the related drainage area, stream system, geography, and coastal water segment. A coastal water quality limited or effluent limitation segment coincides with those coastal waters that receive discharges from point and nonpoint sources located within that defined area.

WQLSs are defined in Section 303, CWA, and EPA regulations as those water areas where existing water quality does not meet, and will not meet, applicable water quality standards even after effluent limitation requirements on point source discharges are applied. ELSs are defined as those water areas where existing water quality either meets or will meet water quality standards after effluent limitation requirements on point source discharges are applied. All coastal water areas that are not designated as WQLSs are, by definition, ELSs (DOH 1993a, p. VII-3).

The segments have been designated by DOH on the basis of common hydrological characteristics, existing water quality, and water quality standards. Population distribution, sewer districts, and water distribution were also used to determine segment boundaries. Segment designation as either WQLS or ELS reflects the amount of flow, type and quantity of pollutants, the degree of violation of water quality standards, and the interactive and dispersive capacity of the receiving waters. In addition, consideration is given to public health hazards, the actual uses of the receiving waters, the impediments to controlling pollutant discharges, and compliance with water quality limited and effluent limitation requirements, based on the best available data and information. *In every instance, the reason a segment is designated as WQLS is the high mass pollution emissions discharged by nonpoint sources* (DOH 1993a, p. VIII-3).

Section 319, added to the Clean Water Act in 1987, specifically addresses nonpoint sources. It requires each state to identify navigable waters which, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain state water quality standards. Since nonpoint source pollution is the reason for designation of specific waterbodies as WQLSs, all waterbodies to be identified under the Section 319 requirement in Hawaii are WQLSs.

The WQLSs identified by DOH in 1973 to meet the requirements of Section 303(e) of the Federal Water Pollution Control Act of 1972, were later incorporated into State of Hawaii reports required by Section 305(b) of the Act. These biennial 305(b) reports are the mechanism by which states report on the status of their water quality. The report describes the nature and extent of state water pollution and, along with other requirements, identifies WQLSs. Hawaii’s most recent 305(b) report identifies 14 WQLSs in the State. Since the report was published, West Maui and Kihei have been designated by the DOH as the 15th and 16th WQLSs because of the macroalgae blooms that have occurred in the nearshore waters (DOH 1993a, p. VIII-5).

The 16 segments were selected by DOH from areas where the State had sufficient information to make judgments about water quality. Two levels of assessments were used: segment identification based on ambient water quality monitoring, and segment identification based on other information. Areas which are not identified as WQLSs are identified as ELSs and are assumed to meet or will likely meet applicable water quality standards after point source discharge controls are applied. Table IV-1 provides information regarding types and sources of pollutants for the 16 recognized WQLSs.

TABLE IV-1
Type and Sources of Pollutants Affecting Water Quality Limited Segments

Segment/ Location	***Frequently Violated Parameters or Expected Violation***	***Major Source Contributing to Violation***
Ala Wai Canal Oahu	all parameters except dissolved oxygen (including floatable, visual objects)	urban runoff, storm drains, construction dewatering
Hanapepe Bay Kauai	total phosphorus, total Kjeldahl nitrogen, turbidity	stormwater runoff (major river), agriculture
Hilo Bay Hawaii	nitrate-nitrite N, total Kjeldahl nitrogen, coliform bacteria	natural groundwater flow, sediment resuspension, cesspools
Honolulu Harbor Oahu	total Kjeldahl nitrogen total phosphorus, turbidity	industrial, stormwater, residential runoff
Kahana Bay Oahu	turbidity, suspended solids, nitrogen	stormwater, residential runoff
Kahului Bay Maui	total Kjeldahl nitrogen, phosphates, suspended solids, turbidity	industrial, commercial, urban stormwater runoff
Kaneohe Bay Oahu	turbidity, suspended solids, nutrients (South Bay)	stormwater, urban runoff, small farms, nutrient cycling
Keehi Lagoon Oahu	turbidity, suspended solids	stormwater, urban runoff, industrial runoff

TABLE IV-1 (continued)
Type and Sources of Pollutants Affecting
Water Quality Limited Segments

Segment/ Location	*Frequently Violated Parameters or Expected Violation*	*Major Source Contributing to Violation*
Kihei Maui	nitrate-nitrite N, total Kjeldahl nitrogen, ammonia nitrogen	stormwater runoff, agricultural, natural groundwater flow
Kewalo Basin Oahu	nitrogen, phosphorus, turbidity, suspended solids	stormwater, urban runoff, commercial runoff
Nawiliwili Bay Kauai	nitrate-nitrite N, Kjeldahl nitrogen suspended solids	stormwater runoff natural (mangrove), turbidity, agricultural runoff
South Molokai Maui	phosphates, nitrate-nitrite N, turbidity, suspended solids	wind/water erosion, stormwater, agricultural runoff
Pearl Harbor Oahu	phosphorus, nitrogen, turbidity	stormwater runoff, agricultural, construction
Waialua-Kaiaka Bay, Oahu	total phosphorus, total Kjeldahl nitrogen, nitrate-nitrite N	agricultural, stormwater runoff
Waimea Bay Kauai	turbidity, suspended solids, total phosphorus, chlorophyll a, nitrate-nitrite N	erosion (major river flows), agricultural runoff, resuspension of bottom deposits
West Maui Maui	nitrate-nitrite N, total Kjeldahl nitrogen, ammonia nitrogen	stormwater runoff, agricultural, natural groundwater flow

Source: INALAB, Inc. 1992, with addition of West Maui and Kihei per DOH action.

Originally, the WQLSs were given rankings based on “recoverability.” That is, the segment which was thought to be the most difficult to address was ranked the highest. In 1988, following a thorough review by the DOH’s Water Quality Standards (Technical) Advisory Committee, all segments were ranked again based on the value and importance of the segment and its prognosis for improvement. The highest “value and importance” ranking was given to waterbodies which are frequently used and are therefore more likely to pose a potential threat to human health. Segments were also categorized as belonging to one of the following groups, reflective of their "prognosis for improvement":

- segments that are perceived to be amenable to improvement;
- segments that may be amenable to improvements; and
- segments that, for all practical purposes, are unlikely to show significant improvement.

Rather than assigning rank numbers to specific segments, segments have instead been placed in groups according to their usage characteristics and amenability to improvement:

<u>High use areas amenable to improvements</u>
- Hilo Bay, Hawaii
- Kaneohe Bay, Oahu
- Keehi Lagoon, Oahu

<u>Medium use areas which are amenable to improvements</u>
- Hanapepe Bay, Kauai
- Waimea Bay, Kauai
- Waialua-Kaiaka Bay, Oahu
- South Molokai, Molokai
- West Maui, Maui
- Kihei, Maui

<u>Areas which may be amenable to improvements</u>
- Ala Wai Canal, Oahu
- Honolulu Harbor, Oahu
- Kewalo Basin, Oahu
- Pearl Harbor, Oahu
- Kahului Bay, Maui

<u>Areas where improvements would be difficult to attain</u>
- Nawiliwili Bay, Kauai
- Kahana Bay, Oahu

DOH notes that the ranking system is subject to correction as a result of future monitoring data and better information on nonpoint source pollution (DOH 1993a, p. VIII-6).

Hanauma Bay and Kawela Bay on Oahu, and Hanalei Bay on Kauai, have been identified for consideration as future WQLSs. These segments are suspected to experience frequent violations of water quality standards due to nonpoint sources of pollution; thus, these are "threatened" waterbodies. Additional information is needed, however, to confirm the classification of these segments as "impaired" WQLSs.

A summary description of each of the 16 WQLSs identified by DOH and the reasons they are so identified follows. The information for Oahu is taken from the

1990 update of the City and County of Honolulu's "208" Plan, while the information for the Neighbor Islands is taken from the 1993 report updates. New information from studies not included in the Plans is provided, as appropriate. This list will be revised when DOH updates its Section 303(d), CWA, list of impaired waterbodies. In January 1996, DOH began soliciting nominations from the public for impaired waterbodies, and conducting an assessment on each nominated waterbody.

(i) OAHU:
The following descriptions of the WQLSs on Oahu are based on information contained in the *Water Quality Management Plan for the City and County of Honolulu* prepared jointly by the City Department of Public Works and DOH (C&C of Honolulu 1990), supplemented by information from the DOH's *Hawaii's Assessment of Nonpoint Source Pollution Water Quality Problems* (DOH 1990a). There are eight WQLSs on Oahu. The segments include most of the embayments and estuaries on Oahu except Hanauma Bay, portions of Maunalua Bay, and Barbers Point Harbor. The City and County of Honolulu has developed specific information on each of the segments, including the frequently violated parameters and sources of pollutants.

Kahana Bay - Kahana Bay is a drowned river valley, located on the northeast coast of Windward Oahu. Its boundary is the 30-foot depth contour from Mahie Point to where the 30-foot and 18-foot contours converge. One mile of Kahana Stream is also included. The bay has a total area of 294 acres (DOH 1990a, p. V-7). The Kahana State Park, with an area of 7.96 square miles, covers almost the entire drainage area of 8.33 square miles. The offshore boundary of the segment extends from Mahie Point northward to the 30-foot depth contour, then westward along the 30-foot contour following northward until the 30-foot and 18-foot contours converge to meet the shoreline (C&C of Honolulu 1990, p. 8-16).

Kahana Bay is a natural embayment, used for swimming, boating, and other water recreational sports (C&C of Honolulu 1990, p. 8-16). It is an example of a waterbody where natural events have a greater influence on water quality than human activities. The entire valley is a State Park. It is essentially a pristine area, with only limited development at the lower end of the valley (DOH 1990a, p. V-7).

There are no point source discharges into the bay. Several native Hawaiian families are living in Kahana Valley and are served by residential cesspools. The resident population is estimated to be 130 people living in 30 households. Currently, most of the families living in the valley are in the process of building new homes out of the flood plain. These homes will have septic tanks and leach fields. The existing cesspools will be eliminated. Public convenience stations are located in the State Park and the City Beach Park and discharge wastes into cesspools. Sediments and nutrients are transported into the bay by Kahana Stream and overland routes (C&C of Honolulu 1990, p. 8-18).

Total freshwater runoff into the bay is estimated at 30 million gallons per day (mgd). Of the eight parameters tested by the DOH at its monitoring station, five parameters have values exceeding the maximum criteria allowed for that parameter. Major violations have been found for ammonia nitrogen, total nitrogen, total phosphorus, turbidity, and chlorophyll (C&C of Honolulu 1990, p. 8-16). The high levels of nitrogen and phosphorus are primarily due to the lush vegetative growth in the valley and the stream estuary. According to a 1977 study, the increase of solids concentration is attributable to tidal flux and overland flows. Increases in nutrient levels are attributed to 1) accumulation from overland flows; 2) release through sediment desorption; and 3) products of biological decay of organic matter. The low velocity of flows in the bay allow deposition of sediment with absorbed nutrients and for desorption to occur (C&C of Honolulu 1990, pp. 8-16 and 8-18).

Kaneohe Bay - Kaneohe Bay is the largest embayment in the State of Hawaii with a surface area of 18 square miles. It is 7.9 miles long and 2.6 miles wide and has a volume of 70,263 million gallons. Mean depth is 27 feet. The land area of the basin is 40 square miles and average stream flows are 64 mgd. Subareas of Kaneohe Bay include Heeia Boat Harbor, Kaneohe Yacht Club, and Kaneohe Marine Corps Air Station Harbor. The water quality limited segment boundary extends northwestward from Pyramid Rock along the 18-foot depth contour to Chinaman's Hat, and westward to Kualoa Point (C&C of Honolulu 1990, p. 8-19).

Historically, Kaneohe Bay teemed with marine life. Major problems arose as a result of the introduction of hoofed animals, and more significantly, because of the extensive farming of pineapple prior to 1940. Pineapple cultivation caused extensive sedimentation of the bay. Also the bay itself was severely stressed by a massive (about 11 million cubic yards) coral reef dredging between 1939 and 1942 as part of seaplane landing area construction. Most of this material was used for landfill in the bay, primarily at what is now known as the Kaneohe Marine Corps Air Station. The bay was again stressed by the construction of a sewage disposal outfall in the center of the south bay which introduced unnaturally large amounts of nutrients. Following these stresses came urbanization in the late 1950s through the 1970s. One major problem was uncontrolled grading which exacerbated the stresses of erosion and sedimentation from pineapple cultivation, and brought new sediments to the bay. It is now well documented that major inflows of freshwater from high intensity rainfall can build up in the bay, creating a lens which can reach up to 5 feet in depth floating on the surface of the bay. Runoff problems are compounded by channelization in the watershed, the paving over of formerly permeable surfaces in the basin, and the filling and loss of wetlands and fishponds along the shores, which acted in the past to detain stormwater runoff.

The bay has shown improvement in water quality over the past decade, and today is somewhat stabilized. Elimination of all municipal effluent discharges into the bay has been accomplished. There is still one small private sewage treatment plant (STP) in the upper Kaneohe Stream watershed at Hawaii Pacific University's Hawaii Loa campus. The effluent from the STP is used for spray irrigation or discharged into injection wells. The only other injection well in the basin is at Kualoa Park. Most of Kaneohe, Ahuimanu, and Kahaluu are served by municipal sewers, but the rural areas from Ahuimanu to Waikane are still being served by household cesspools. The estimated number of cesspools in the drainage basin prior to Kahaluu's sewer development in 1995 was 2,880, serving a population of 10,160 people. Since Kahaluu has been sewered, there are approximately 270 remaining cesspools in the Waiahole and Waikane areas (C&C of Honolulu 1990, p. 8-21).

There has been a dramatic decline in phosphorus and turbidity since 1979, when sewage discharge was diverted from the bay (C&C of Honolulu 1990, p. 7-6). The termination of sewage discharges and better management of construction activities have resulted in improved survival of some species of coral and other organisms. However, urban runoff continues to be a major source of pollution to the bay (DOH 1990a, p. V-10).

DOH maintains five water quality monitoring stations in the Bay: two onshore stations and one station each in the south, middle, and north sectors. The parameters frequently violated are turbidity and nitrogen during winter storms. The major sources affecting turbidity and suspended solids parameters are natural runoff, urban stormwater, and small farming. The same sources plus winter storms affect the nitrogen parameters. Direct groundwater seepage into the bay is estimated to be 60 mgd and storm runoff, 40 mgd (C&C of Honolulu 1990, p. 8-19).

Runoff from the numerous streams during winter storms conveys large quantities of silt and other material which settle into the bay. The entire bay is affected by suspended particles, especially in the southern section of the bay where the residence time with respect to the ocean has been estimated to be almost 24 days. Estimates of sediment loading into Kaneohe Bay from storm runoff range from 33,000 to 131,000 tons per year (C&C of Honolulu 1990, p. 8-22).

Ala Wai Canal - The Ala Wai Canal is a manmade canal extending southeast by northwest from Kapahulu Avenue to Ala Moana Park. The Ala Wai Boat Harbor is located at the mouth of the canal. The canal was completed in 1929 to reclaim marsh lands fed by the perennial Manoa and Palolo streams and to control mosquitoes. The marsh, located in what is now the McCully-Kapiolani District, consisted of taro patches, rice paddies, and duck and fish ponds. The canal was originally dredged to Kewalo Basin, and then out to the sea. Later in the 1950s, the present channel at the Ala Wai Boat Harbor was dredged and the channel along Ala Moana Park was filled in (C&C of Honolulu 1990, P. 8-22).

The canal is 9,770 feet long. Its width varies from 160 to 260 feet and depth from -15.0 feet to -6.0 feet. The area of the canal and boat harbor is 126 acres. The water quality limited segment includes the entire length of the canal, the boat harbor, and the boat channel to the 30-foot depth contour. The harbor is recognized as an embayment. A portion of the canal is an estuary (C&C of Honolulu 1990, p. 8-22).

The principal drainage area is 12.3 square miles in size. Other drainage areas are: Waikiki-Kapahulu, 0.73 square miles; Makiki District, 2.57 square miles; and Ala Moana-Kalia, 0.71 square miles. The entire drainage area consists of 16.28 square miles. In addition, the Piikoi-Pensacola drain, serving an area of

0.75 square miles discharges about one half of its peak discharge of 1,260 cubic feet per second (cfs) into the Ala Wai Boat Harbor. The other half is discharged into Kewalo Basin (C&C of Honolulu 1990, p. 8-22).

Extensive field measurement programs to assess the physical, biological, and water quality conditions of the canal were undertaken in 1992 as part of the Ala Wai Improvement project. The programs included a bathymetry survey, current measurements within the canal and the nearshore coastal areas, a dye flushing test, tidal measurements, and biological and water quality surveys (Edward K. Noda & Associates 1992a, p. v).

The major contributions come from erosion in the forest reserve areas at the upper end of Manoa Valley; groundwater inflow; storm runoff from residential and commercial developments; direct runoff from Ala Wai Field, Park, and Golf Course; dumping of household and yard wastes into the Manoa and Palolo streams; and two minor point source discharges, washwater from the Ala Wai Marine Railway dry dock operation (only under emergency conditions), and 2.60 mgd discharge of warm water from the air conditioning system of the Yacht Harbor Condominium. The entire drainage area is served by municipal sewers except for the Crater Road area of West Kaimuki and Makiki-Puowaina. These areas have household cesspools and serve an estimated population of 1,341 people (C&C of Honolulu 1990, p. 8-24).

The Ala Wai serves as a sedimentation basin for its tributary streams and receives storm runoff from Manoa, Palolo, Makiki, Waikiki and other areas. The average stream flow into the canal is estimated to be between 20-30 mgd. Sediments are deposited in the Ala Wai Canal because the low flow velocity in the canal is less than the settling velocity of the sediment. Large quantities of sediment are believed to be generated in the watershed areas by natural erosion process. The canal was dredged by the City in 1966 and again by the State in the late 1970s (C&C of Honolulu 1990, p. 8-24). From the results of present and past studies of sediments in the canal, it is estimated that the rate of siltation has been relatively consistent at 9,000 to 11,000 cubic yards per year (Edward K. Noda & Associates 1992b, p. 4). Without the canal, much of this sediment would be released into coastal waters.

As the collecting point for the Makiki, Manoa, Palolo, and Kapahulu watersheds, the canal accumulates sediments, nutrients, some heavy metal contaminants, and solid waste trash. As a result, water in the canal is discolored by phytoplankton growth, suspended sediments, and visually objectionable trash. In addition, some incidences of bacterial infections have been reported (Edward K. Noda & Associates 1993, p. 2-6). Water circulation from the point where the Manoa Stream meets the canal to the end of the canal near Kapahulu is poor. Floating debris collect under the *makai* side of the McCully Street Bridge, creating an unsightly mess.

The *Ala Wai Canal Improvement Feasibility Report* (Edward K. Noda & Associates 1992a) recommends the injection of 20 to 30 cfs of sea water into the Kapahulu end of the canal from either deep water wells or via a pipeline from the ocean. This small amount of additional water would increase the flow sufficiently to disrupt phytoplankton growth and restore clarity to the canal. A *Management Plan for the Ala Wai Canal Watershed* (Edward K. Noda & Associates 1992b) contains recommendations to reduce the amounts of trash, debris, and other pollutants entering the canal. *A Maintenance Plan for the Ala Wai Canal* (Edward K. Noda & Associates 1992c) recommends that dredging be done as soon as possible to prevent flooding, and at shorter intervals and different places in the future, to maintain water quality in the canal at lower costs. The dredging should take place before the seawater system is constructed.

Kewalo Basin - Kewalo Basin is a manmade harbor, approximately 78 acres in area. Constructed by the U.S. Navy in 1945, it is home port for the local tuna fleet, chartered sport fishing boats, and excursion craft serving the tourist industry. Facilities adjacent to the basin include the U.S. Fish and Wildlife Service (USFWS), University of Hawaii's Kewalo Look Marine Lab, and Ala Moana Park. The basin is surrounded by shopping centers, a major highway, and the light industrial areas, commercial shops and restaurants of Kakaako and Kewalo. Kewalo Basin is classified as an embayment. The water quality segment encompass the entire basin and channel out to the 30-foot depth contour (C&C of Honolulu 1990, pp. 8-25 and 8-26).

Low levels of dissolved oxygen and unsatisfactory levels of pH have been measured at the outlet of the Ala Moana Park drains to the northeast sector of the basin. It is suspected that allowable limits for the nitrogen, phosphorus, and turbidity parameters are exceeded during periods of heavy storm runoff. Circulation of water in the basin is hindered by its design. As a result, the urban pollutants that collect in the basin remain concentrated for extended periods (DOH 1990a, pp. V-11 and V-12).

The primary sources of pollutants entering Kewalo Basin are the drains collecting urban runoff from commercial, industrial, and residential sectors of Honolulu. There are seven drains of which three serve major facilities including Ala Moana Park drain (canal), Ward Avenue drain, and Kakaako drain. About one half of the peak discharge from Ala Moana Park canal enters Kewalo Basin, the other half drains into Ala Wai Boat Harbor (C&C of Honolulu 1990, p. 8-26).

There are two injection wells or seepage pits in the drainage area. The nature of the discharges is not known. Municipal sewers are available for the entire drainage basin. Street debris, oil, chemicals, nutrients, and heavy metals are transported by urban runoff into Kewalo Basin. There are no discharges of any sediments from streams since the drainage area is entirely urbanized (C&C of Honolulu 1990, p. 8-27).

Keehi Lagoon - Keehi Lagoon, with an area of 1,116 acres, is the largest lagoon in the State. It is located in a heavily industrialized area between Kapalama-Sand Island and Honolulu International Airport in the east-west direction. The Mapunapuna and Shafter Flats industrial parks and the Middle Street interchange of H-1 are located to the north. Keehi Boat Harbor and Keehi Marine Drydock are located along the Kapalama shoreline and serve boating and sailing interests. Kalihi Stream from the northeast and Moanalua Stream from the northwest meet at the head of the lagoon at Keehi Lagoon Beach Park. Keehi Lagoon is classified as an embayment; Keehi Harbor and Keehi Drydock Boat Harbor are classified as shallow draft recreational harbors. The water quality segment encompasses the entire lagoon to the 30-foot depth contour (C&C of Honolulu 1990, p. 8-27).

The lagoon is used intensely for nehu bait fishing, crabbing, water skiing, recreational fishing, and other water contact sports. Boating activities are especially heavy during weekends and holidays. A boat washing facility is part of the boat harbor (C&C of Honolulu 1990, p. 8-27).

Although circulation in Keehi Lagoon is good, it regularly experiences violations of water quality parameters for phosphorus and turbidity. Currents may transport polluted waters from Honolulu Harbor into the lagoon and recirculate suspended matter within it (DOH 1990a, p. V-11). Other pollutant sources are sediments deposited in the lagoon by Moanalua and Kalihi streams; storm runoff from industrial areas of Mapunapuna, Shafter Flats, Kapalama, and Kalihi Kai; and the resuspension of settled sediments in shoals by boating activities (C&C of Honolulu 1990, pp. 8-27 and 8-28).

The elimination of the municipal and U.S. Army raw sewage discharges in nearshore waters off Sand Island and the airport outfall of Ahua Point have greatly improved water quality in the lagoon. The number of cesspools receiving commercial and industrial wastes in the Mapunapuna and Kapalama areas is not known. Considering the number of lots in the tracts, the number of cesspools could amount to 150. There are at least three or more injection wells within the airport area. Young Laundry discharges 0.48 mgd of laundry wastes in its airport well (C&C of Honolulu 1990, p. 8-28). The Honolulu Airport Fueling Facility at the airport has an emergency discharge permit. The discharge of industrial wastes from Hawaiian Construction & Dredging Sand Island Plant into the lagoon is considered a minor discharge and is limited to 0.01 mgd (C&C of Honolulu 1990, p. 8-28).

Nutrients, plant cuttings, and sediment loads are discharged in Keehi Lagoon by Kalihi and Moanalua streams. In residential areas, plant cuttings and yard debris are frequently dumped in the stream channel and reach the lagoon. Policing of illegal dumping is difficult because it can occur at any time (C&C of Honolulu 1990, p. 8-28).

Honolulu Harbor - Honolulu Harbor is the largest commercial deep draft harbor in the State. The harbor is crescent shaped, with a water surface area of 537 acres. It is about 2 miles long and from 600 to 2,900 feet wide. Coral reefs and Sand Island, a 500-acre manmade island, protect the harbor from the open ocean. Goods and freight processed at the harbor cover the entire spectrum, from pineapple and cattle to automobiles and petroleum products. The harbor handles over 11 million tons of cargo annually (C&C of Honolulu 1990, p. 8-30).

Honolulu Harbor is classified as an embayment. The water quality segment encompasses the entire harbor from Keehi Lagoon to the Fort Armstrong main channel entrance to the 30-foot depth contour (C&C of Honolulu 1990, p. 8-30). Both Nuuanu and Kapalama streams discharge into the harbor. Nuuanu Stream extends from Pier 15 to its watershed area at the Koolau Range. The drainage area of 8.4 square miles consists of industrial, commercial, and residential developments. Kapalama is an interrupted stream with a drainage area of 2.6 square miles (C&C of Honolulu 1990, p. 8-31).

The most frequently violated parameters are total nitrogen, total phosphorus, turbidity, dissolved oxygen, and pH. Prior to about 1972, the pineapple canneries and Gasco discharged 10.3 mgd of industrial wastes into Kapalama Canal and Honolulu Harbor. The BOD load was equivalent to a raw sewage discharge from 150,000 people. Since that time, the wasteload into Kapalama has been limited to the discharge of thermal water. The current flow from Hawaiian Electric Company's Honolulu Power Plant is 304 mgd (C&C of Honolulu 1990, pp. 8-30 and 8-31).

Although municipal sewers are available, DOT maintains its own sewers within the docks and piers in some areas. Between Piers 19 and 29, DOT maintains several cavitette systems. The effluents are discharged into cesspools. Because the systems are failing, DOT plans to eliminate the cavitette-cesspool systems and redirect the flows to the municipal sewers (C&C of Honolulu 1990, p. 8-31).

Studies of the harbor indicate that nitrogen, phosphorus, and turbidity levels in the water regularly exceed State water quality standards. Significant levels of copper, zinc, chromium, nickel, lead, chlordane, and dieldrin have been identified in DOH sampling (DOH 1990a, p. V-6). Pollutants enter the harbor mainly from nonpoint sources. Kapalama Stream (canal) discharges into Kapalama Basin at Pier 39, and the larger Nuuanu Stream enters the main basin at Pier 15, upstream of Pier 11. Storm drain outlets discharge into the harbor throughout the periphery of the harbor (C&C of Honolulu 1990, p. 8-31).

Most of the sediments deposited in Honolulu Harbor comes from Nuuanu and Kapalama streams. No data are available, but the U.S. Army Corps of Engineers (USACOE) estimated that 50,000 cubic yards of sediments are discharged in the harbor each year from all sources. According to USACOE, the sediments are composed of high percentages of land derived silty clays and a small percentage of sand. The harbor is dredged at about five year intervals (C&C of Honolulu 1990, p. 8-32).

Pearl Harbor - Pearl Harbor is the State's largest harbor. The naval shipyard, maintenance supply center, public works center, ammunition depot, and other ancillary facilities are located around the harbor. It is headquarters for CINCPAC and the 14th Naval District. The harbor consists of East Loch, Middle Loch, West Loch, and Southeast Loch and Ford Island, and has a water surface area of about 8 square miles. More than 12 miles of docks and four drydocks are available for ship repairs (C&C of Honolulu 1990, p. 8-34).

Pearl Harbor is classified as a developed estuary. The segment area include the entire harbor and the mouths of perennial streams discharging into the harbor. The offshore boundary of the segment extends to the 30-foot depth contour between the Reef Runway to Oneula Beach (C&C of Honolulu 1990, p. 8-32).

By its geologic origin, Pearl Harbor has been the “sink” of the southern coastal plain of Oahu. Its three lochs represent the drowned valleys of three major stream systems. These “valleys” have been altered in shape by marine erosion and sediment. The most drastic changes to the harbor are those which occurred during and after World War II (DOH 1990a, p. V-14).

Five streams -- Halawa, Aiea, Kalauao, Waimalu, and Pearl City -- are tributary to East Loch. Waiawa enters Middle Loch, and Waikele and Honouliuli drain into West Loch. The drainage area for the lochs are 23.7, 26.4, and 60 square miles, respectively, for a total of 111 square miles (C&C of Honolulu 1990, p. 8-32).

Beneficial uses identified for Pearl Harbor include bait fish and shellfish propagation in West and East Lochs, shipping, navigation, industrial water supply in East Loch, and water fowl habitat in Middle and West Lochs (C&C of Honolulu 1990, p. 8-34).

The major spring complex seeping into the harbor includes Kapakahi Springs (3.0 mgd) into West Loch; Waiawa Spring (9.1 mgd) and Wailani Spring (1.1 mgd) into Middle Loch; and Kalauao Spring (15.8 mgd) and Waiau-Waimano Spring (13.2 mgd) into East Loch. The total average fresh water discharge from spring and streams into the lochs is 35.8, 28.2, and 45.3 mgd, respectively, or 109.3 mgd for the harbor (C&C of Honolulu 1990, p. 8-34).

There are five point source discharges within the harbor operated by the U.S. Navy and one (Fort Kamehameha STP) discharging at the main ship channel. The Fort Kamehameha discharges include the supernatant from the Industrial Waste Treatment Plant. Flows from Pearl City Fuel Annex, Shipyard Drydock, and the three air compressor plants are intermittently discharged to the harbor (C&C of Honolulu 1990, p. 8-36). The two nonmilitary point sources, Waiau Power Plant, and the C&H Sugar Refinery at Aiea Heights, discharge thermal water. Most of the urban areas between Aiea-Halawa and Waipahu are served by municipal sewers. The number of household cesspools in Aiea-Waiau and Waipahu is estimated to be 400 (C&C of Honolulu 1990, p. 8-36).

The parameters that are frequently violated in Pearl Harbor include nitrogen, phosphorus, turbidity, fecal coliform, temperature, and chlorophyll a. The last dredging of Pearl Harbor was undertaken in 1979. In 1986, USACOE estimated that 257,000 cubic yards of bottom sediment in Middle Loch needed to be dredged (C&C of Honolulu 1990, p. 8-37).

Waialua-Kaiaka Bay - This WQLS includes two adjacent waterbodies on the North Shore of Oahu. Kaiaka Bay is classified as an embayment, while the much broader Waialua Bay is classified as marine waters. Haleiwa Boat Harbor, located at the original mouth of Anahulu River, is also an embayment. The

WQLS's boundary extend westerly from Puaena Point to the 60-foot depth, then along the 60-foot depth contour towards Kaena Point past Kaiaka Bay, then southwest toward the shore at Kaimana Place (C&C of Honolulu 1990, p. 8-39).

Both bays receive drainage from major streams. The Poamoho and Kaukonahua streams are tributaries of Kiikii Stream which flows into Kaiaka Bay together with Paukauila Stream which includes Helemano and Opaeula streams. The area of the drainage basin is 79.8 square miles and extends eastward to the Koolau mountain range and southward to the Waianae mountain range (C&C of Honolulu 1990, p. 8-39).

Leakage of fresh water through caprock into Opaeula, Helemano, Poamoho, and Kaukonahua streams and the bay is estimated to be 7.05 mgd. Peak storm flows (100 year storm) estimated for Kiikii Stream are 39,000 cfs; and for Paukauila Stream, 18,700 cfs. As much as 70% of the streams are diverted to over 30 plantation reservoirs (C&C of Honolulu 1990, p. 8-39). Anahulu River and its tributaries (Kawaiiki and Kawainui streams) discharge into Waialua Bay. At Waialua Bay, Anahulu River has a drainage area of 16.0 square miles and a 100-year peak discharge of 16,200 cfs. Fresh water leakage through the caprock into Anahulu River and into the bay is estimated to be 4,79 mgd (C&C of Honolulu 1990, p. 8-39).

Data collected at the DOH monitoring station indicate that the maximum criteria of most parameters are exceeded except for dissolved oxygen. Most noteworthy are total phosphorus, nitrate and nitrite nitrogen, chlorophyll a, and turbidity (C&C of Honolulu 1990, pp. 8-39 and 8-41). The major sources of pollutants discharging into the embayments are sediments from the drainage basins, household cesspools, injection wells from treatment plants, and a point source discharge of thermal water. There are 13 private STPs and one municipal wastewater treatment plant (WWTP) in the Waialua and Haleiwa communities. The effluents from these plants are discharged into seepage pits or injection wells. Combined flows from the plants are 0.141 mgd. The Waialua Sugar Company discharges 14.0 mgd of thermal water into Kiikii Stream near Waialua Beach Road (C&C of Honolulu 1990, p. 8-41).

There are 2,312 household cesspools in the Waialua and Haleiwa area, serving a population of 7,232 people. The estimated 0.578 mgd discharge into the groundwater eventually reaches the coastal waters. The 0.310 mgd effluent from the Naval Communication Center, Wahiawa, is discharged in Poamoho Gulch and eventually reaches Kaiaka Bay (C&C of Honolulu 1990, p. 8-41). Areas of cesspools in Waialua and Haleiwa will be served by municipal sewers in the future and private STPs and the Paalaa Kai will be eliminated, with flows diverted into the City system (C&C of Honolulu 1990, p. 8-41).

(ii) MAUI:

The following descriptions of the WQLSs on Maui and Molokai are based on information contained in the Department of Health's *Assessment of Nonpoint Source Pollution* (DOH 1990a), supplemented by information from the *Water Quality Management Plan for the County of Maui* prepared jointly by DOH and the County of Maui (DOH 1993c). There are four WQLSs in Maui County, three on the island of Maui and one on Molokai. The four WQLSs and their watersheds are described below.

Kahului Bay - Kahului Bay is located on the north coast of the Island of Maui between the slopes of two volcanoes, Haleakala and West Maui. It covers an area of 242 acres and is bounded by the breakwaters which extend from the west and east shores at about right angles to each other. Kahului Harbor is located on the southern portion of the Bay (DOH 1990a, p. V-8).

Drainage into Kahului Bay is largely in the form of runoff from the urban centers of Wailuku and Kahului. In addition, ship and barge traffic, the Kahului airport, lands used for sugarcane cultivation, and east portions of the West Maui mountains (forest land) contribute pollutants. No streams or springs enter Kahului Bay; however, a lens of less saline water resides on the surface of the bay. The presence of this lens suggests extrusion from basal groundwater sources (DOH 1990a, p. V-8).

State monitoring of Kahului Bay indicates that water quality standards for nitrogen, phosphorus, and turbidity are regularly exceeded. Incidents of bacterial contamination which result from cruise ship spills and storm drain outputs have been reported. For the most part, the waters of the bay are generally poor in quality (DOH 1990a, p. V-8). The powerful longshore current, which sweeps around the north tip of East Maui, likely affects the residence time of pollution in Kahului Bay. Waters at the mouth of the harbor are generally turbid, and underwater visibility is generally poor due to strong winds which keep waters turbulent and murky (DOH 1990a, p. V-8).

A number of activities occur in Kahului Bay. Kahului Harbor is the Island's main port. An estimated 98.9% of all goods coming into Maui are transported through Kahului Harbor. Harbor activities include ship operation and maintenance, oil handling and bunkering, warehousing, trucking, storage, stevedoring, marine repair, and limited drydocking (DOH 1990a, p. V-9). In addition, a cluster of hotels, beaches, the Kahului Breakwater Park, and a public boat ramp border the Bay. The bay's shoreline access is excellent. People fish along the piers, breakwaters, and the coast between the harbor and Nehe Point. Large surf breaks in the harbor during periods of North Pacific swells (DOH 1990a, p. V-9).

West Maui - The West Maui area was designated as a WQLS in 1992 primarily because of the algal blooms that have been occurring there and which are suspected to be caused by excessive nutrients from runoff. Violations in this area are all for nitrogen parameters -- total Kjeldahl nitrogen, nitrate-nitrite N, and ammonia nitrogen (DOH 1993c, p. VIII-13). A study now in progress includes the assessment and ranking of nutrient loads entering coastal waters from selected West Maui watersheds. A second study will investigate whether or not secondary-treated sewage effluent injected into disposal wells on land is discharging into nearshore waters with its nutrient loads intact (DOH 1993c, p. VIII-13).

Federal funds obtained by EPA and NOAA are being used to support a West Maui watershed coordinator, as well as additional applied research projects on the link between land use activities and surface and ground water quality. DOH will utilize its Geographic Information System to prepare maps and information layers for selected West Maui watersheds to provide an integrated view of activities contributing nutrient loads to adjacent coastal waters. DOH intends to incorporate the results from these projects into nutrient/sediment watershed management plans for West Maui and similar sensitive coastal areas throughout the State (DOH 1993c, p. VII-14).

Kihei - The Kihei WQLS was designated at the same time as West Maui, for the same reasons. Violations in this area are also similar: total Kjeldahl nitrogen, nitrate-nitrite N, and ammonia nitrogen (DOH 1993c, p. VIII-13).

South Molokai - The South Molokai segment is bounded by the 18-foot depth contour from Laau Point eastward to Pohakuloa and covers an area of 11,417 acres (DOH 1990a, p. V-15). The area which drains into South Molokai extends from Laau Point to Mauna Loa, then to Kualapuu, and ends just west of Kaunakakai. Streams within this area are perennial in their upper reaches and intermittent or nonexistent at the coastline. During heavy rains, however, these streams will fill with water, overflow their banks, and flood the entire southern coastline with turbid runoff. Runoff transported by these streams are generated from abandoned pineapple fields, cropland, pastures, a State highway system, a network of dirt roads, and the town of Kaunakakai. Of particular concern are the dirt pineapple field roads and poorly managed pasture land (DOH 1990a, p. V-15).

On Molokai, drought conditions and incessant strong winds reduce soil moisture, preventing the growth of adequate cover. When rains do occur, they are often intense and heavy, creating immense amounts of runoff which can transport sediments and pollutants. Flows into South Molokai are heaviest into the Palaau coastal plains located just west of Kaunakakai (DOH 1990a, p. V-15).

The waters of South Molokai are classified as open coastal waters. State monitoring of South Molokai shows significant violations of water quality standards for suspended solids and nutrients (especially orthophosphate). Suspended solids have been noted to exceed the standard by 100 times over (DOH 1990a, p. V-15).

Mudflats predominate on the island's south coast where there were once a large number of fishponds. Dense stands of mangroves limit offshore activity. Although water activities of the southern coast are minimal, the area retains value as an important wildlife area and supports park facilities (DOH 1990a, p. V-16). Parks and recreational facilities on Molokai's south shore include: Kakahaia National Wildlife Refuge, One Alii Beach Parks 1 & 2, and Malama Park.

(iii) KAUAI:

The following descriptions of the WQLSs on Kauai are based on information contained in the Department of Health's *Assessment of Nonpoint Source Pollution* (DOH 1990b) supplemented by information from the *Water Quality Management*

Plan for the County of Kauai prepared jointly by DOH and the County of Kauai (DOH 1993b). There are three WQLSs on Kauai. A description of the segments and their drainage areas follows.

Nawiliwili Bay - Nawiliwili Bay is located on the southeast coast of Kauai, two miles from Lihue. It is a well-developed embayment of 333 acres, bounded by an imaginary line from Kukii Point to the breakwater. It is formed by the confluence of three streams, Huleia, Puali, and Nawiliwili. Huleia is the largest stream, arising from the Waialeale-Kawaikini mountains in central Kauai. It flows through forest, agricultural, pasture, and other lands. The lower part of Huleia Stream widens into a significant estuary. Although the Nawiliwili and Puali streams drain flatter and less erosive lands they also contribute nonpoint pollutants. A rock quarry located on the Nawiliwili Stream is a major contributor of sediment to the bay (DOH 1993b, p. V-12).

Although there are no longer any point source discharges into Nawiliwili Bay, State monitoring shows that water quality standards for nitrogen and turbidity are regularly exceeded. These levels are suspected to be the product of vegetative growth along the river and seasonal input from storm water sources. Dense growths of *hau* and American (red) mangrove decompose and introduce considerable amounts of organic material into the bay. In addition, heavy rains transport silt and nutrients from sugarcane land into the bay and give it, at times, a brown color (DOH 1993b, p. V-13).

Nawiliwili Bay supports a deep draft commercial harbor and a small boat harbor with charter fishing operations. The bottom consists of fine sand and silt. Depths range from 70 to 100 feet; periodic dredging is required to maintain navigable depths in the harbor (DOH 1993b, p. V-13). Recreational activities include fishing and crabbing in the bay and adjoining Huleia River, and surfing and canoe paddling in the area fronting Kalapaki Beach on the north shore of the bay (DOH 1993b, p. V-14).

Hanapepe Bay - Hanapepe Bay is located on the southwest corner of Kauai, between Hanapepe and Port Allen. The boundary of the Hanapepe Bay segment extends along the 1,000 foot long breakwater on the eastern shore and the 30-foot depth contour to a point south of Pualo Point, enclosing 297 acres of water surface (DOH 1993b, p. V-3).

The Hanapepe River begins in forest uplands and travels through pasture and range land, sugar cane lands, and the small towns of ‘Eleele, Port Allen, and Hanapepe. Hydrologic modifications have greatly affected the bay. Erosion of the western end of the one-half-mile-long beach at the head of the bay has been accelerated because of construction of a breakwater (DOH 1993b, p. V-3).

State water monitoring records indicate that the waters of the bay regularly exceed State standards for turbidity. Discoloration of the bay as a result of flood flow discharges is a common occurrence. However, the waters generally clear rapidly (DOH 1993b, pp. V-3 and V-4).

An important Hawaiian salt production area and salt marshes with great wildlife value are located on the east banks of the bay. Some commercial activity occurs at Port Allen in Hanapepe Bay but for the most part, activity in the bay is recreational. Activities include swimming, pole and line fishing, and small boating (DOH 1993b, p. V-4).

Waimea Bay - The Waimea Bay WQLS is located on the southeast coast of Kauai. It is bounded by the 18-foot contour from Oomano Point to Koki Point and includes the Waimea River and Kikiaolo Boat Harbor. It comprises 1,214 acres. Two rivers flow into the bay, the Waimea and the Makaweli. The lower course of the Waimea River is estuarine for approximately two miles (DOH 1993b, p. V-17).

Historically, three sugar mills discharged cane trash and wastewater into the coastal waters of southern Kauai. These discharges contained silt that were carried by ocean currents to Waimea Bay. Bagasse is now used as a fuel source and the mill wastewater is returned to sugar cane fields for irrigation. The only remaining discharges are of irrigation tailwater (DOH 1993b, p. V-17).

There are no water quality monitoring stations in the area. However, the inshore waters of Kekaha Beach are often observed to be turbid. This is caused by the redistribution of mud discharged from the Waimea River during flood seasons. A bottom sediment sample dredged at a depth of 180 feet offshore of the Waimea River mouth indicated thick mud deposits. If the muddy condition of Waimea Bay is found to be primarily due to resuspension of sediments, DOH will consider removing the designation of the bay as a WQLS (DOH 1993b, p. V-17).

There is a boat launching ramp at Kikiaola light draft vessel harbor. Uses of Waimea Bay include pole and line fishing, throw netting, board surfing, canoe paddling, limu gathering, gill netting, and torching (DOH 1993b, p. V-18).

(iv) HAWAII:

The following description of the WQLS on Hawaii is based on information contained in the DOH's *Assessment of Nonpoint Source Pollution* (DOH 1990a), supplemented by information from the *Water Quality Management Plan for the County of Hawaii* prepared jointly by the Hawaii State Department of Health and the County of Hawaii (DOH 1993a). Hilo Bay is the only WQLS on Hawaii.

Hilo Bay - Hilo Bay is located on the northeast coast of the Island of Hawaii. It is bounded by the 30-foot depth contour, from the tip of the 10,079-foot long breakwater to Paukaa Point, and covers an area of 1,788 acres. Included in the segment is the Waiakea Pond and Wailoa River (DOH 1990a, p. V-4).

Five natural discharges enter into the Hilo Bay segment: Wailoa River, Wailuku River, Pukihae Stream, Pohakaunanaka (intermittent stream), and Maili Stream. These rivers and their tributaries originate on the slopes of Mauna Kea and Mauna Loa, and drain forests, pasture and range land, agricultural fields, and urban areas. In the higher elevations, eucalyptus trees are raised. Cattle graze the Puu Oo area above the forest reserve and the mauka fringe of the city of Hilo. Sugar, the principal crop of the island, is grown in the Hilo Bay watershed along the rural areas north of Hilo along the Belt Highway. A major agricultural change is the conversion of 8,000 acres of sugar cane land to macadamia nut orchard. Cattle, hogs, poultry, vegetables, flowers, and landscaping plants are also grown in the area surrounding Hilo. Urban areas which drain into the bay include Hilo's parks, business and residential zones, infrastructure, and harbor (DOH 1990a, p. V-4).

The Wailuku (300 mgd) and Wailoa rivers (100 mgd to 300 mgd), compose the major discharges or water and sediment to the bay. It is estimated that in 1979, the Wailuku River discharged over 36,900 tons of suspended sediment (DOH 1990a, p. V-4). Large surface and subsurface flows enter the bay and form a fresh water layer on the surface of the bay. The vertical stratification which is maintained by the prevailing shoreward trade winds of the area prolongs the residence time of water in the bay and encourages the growth of phytoplankton in its upper fresh water layer. In addition, the slow seaward movement of the bay's lower waters are generally insufficient to flush out suspended silts from the bay. Silt and mud which accumulate contribute to the bay's turbidity (DOH 1990a, p. V-5).

Nutrient rich waters increase the growth of microscopic life and algae which enter as both surface and subsurface flows, contributing to the turbidity of the bay. Nutrient rich flows include the surface flows of the Wailoa River as well as subsurface flows from sources near Reeds Bay, Coconut Island, and the Keaukaha area. Subsurface flows contribute flow volumes as high as 200 mgd.

State monitoring of water for Hilo Bay shows frequent violations of water quality standards for nitrogen, phosphorus, and turbidity. In 1978, Hilo Bay was included as a survey site for a DOH study on the occurrence of heavy metals, chlorinated pesticides, and polychlorinated biphenyls (PCBs) in the Hawaiian environment. The study found exceptionally high levels of arsenic in sediments in Hilo Bay and, in particular, from Waiakea Pond. Other contaminants found in Hilo Bay included lead, zinc, chromium, chlordane residues, and PCBs (DOH 1990a, p. V-5). Despite these high levels, however, there is no indication of any health hazard.

The high levels of arsenic in the bay and in Waiakea Pond have resulted from waste discharges containing arsenic trioxide, a compound used to treat fiber boards to prevent termite damage at the former Hawaiian Cane Products plant. Sediment core samples taken in Waiakea Pond, at the former site of the plant, have been found to contain the highest levels of arsenic. Hilo Bay sediments, however, show considerably lower arsenic levels from the entrance of the Wailoa River to the outer parts of the harbor.

Hilo Bay is also affected by seepage from cesspools. Water quality analyses conducted by DOH in the Waiakea and Ice Ponds have shown high counts of fecal coliform in the past. As the sewer system is expanded and cesspool use is discontinued, water quality in these and similar areas is expected to improve (DOH 1993a, p. X-4).

A recent study focused on sewage pollution in the bay. The study confirmed DOH monitoring results and notes that Hilo Bay, its estuaries and adjacent marine waters are subject to chronic nonpoint source sewage pollution. The data in the study report indicate that high bacterial counts are not the result of sewage treatment plant failures but rather sewage contained in freshwater runoff, with the ultimate source commercial and residential cesspools [Dudley and Hallacher (n.d.), pp. 32-34].

In spite of its water quality problems, Hilo Bay is an important wildlife and fishery area. Hilo Bay, in addition, is highly visible to residents and tourists and supports a fair amount of recreational boating (DOH 1990a, p. V-6).

1.e. Other Waterbodies That May Be Impaired or Threatened

As previously noted, DOH has identified Hanauma Bay and Kawela Bay on Oahu, and Hanalei Bay on Kauai, for consideration as future WQLSs. These segments are suspected of being subject to frequent violations of water quality standards due to polluted runoff. Additional information is needed, however, to confirm the classification of these segments as WQLSs.

As part of a national program to clean up and protect waterways across the country, EPA in 1989 required every state to conduct surveys and submit lists of those waters not meeting water quality standards for toxic substances. DOH compiled a list of 21 bodies of water that either showed evidence or were suspected of being contaminated. Chemical or metal pollutants, not bacteriological or organic contaminants, were the main concern. The waterbodies listed generally have high levels of commercial or industrial activity, or are in areas where runoff from urban or agricultural districts contribute to toxic substance problems (*Honolulu Star-Bulletin* 4 June 1989).

Fourteen of the 21 waterways listed in 1989 were then, and continue to be, designated as WQLSs. These have already been discussed. An additional four are subparts of already-designated segments, *e.g.*, Kapalama Canal, draining into Honolulu Harbor/Keehi Lagoon; Wailoa and Wailuku rivers, draining into Hilo Bay; and Waimea River on Kauai, emptying into Waimea Bay. Only three of the waterbodies identified as having problems in 1989 are not part of a WQLS: Kailua Bay, Wahiawa Reservoir, and Waimanalo Bay on Oahu. These are discussed below.

Kailua Bay - Kailua Bay has been the subject of some controversy. Several environmental groups -- Hawaii's Thousand Friends, Save Our Bays and Beaches, and the Sierra Club -- blame the two-mile long sewage treatment outfall off Mokapu Point for discoloration of the water in Kailua Bay and swimmers' illnesses, while the City and County of Honolulu blames nonpoint source pollution from Kaelepulu Steam and Kawainui Channel (*Windward Sun Press* 26 December 1991 to 1 January 1992).

A study of Kailua Bay conducted by the University of Hawaii Water Resources Research Center (WRRC) which began in July 1990 and continued through June

1993 took samples at 13 sites along Kaelepulu Stream and pond, at the Mokapu outfall, and at Kawainui Channel. Results indicate that deterioration of water quality along the beach at Kailua Bay is primarily affected by the streams. The polluted runoff comes from soil, nutrients, and wastes from the marsh and residences adjacent to the streams; storm drains; raw sewage from sewer breaks and emergency bypasses from the Enchanted Lake emptying into Kaelepulu Stream; and feces from birds in the wetlands (*Honolulu Star-Bulletin* 6 Feb. 1992; *Windward Sun Press* 9-15 April 1992).

Wahiawa Reservoir (Lake Wilson) - Waters from Kaukonahua Stream have been impounded in Wahiawa Reservoir (Lake Wilson) since 1906 by Waialua Sugar Company for the irrigation of its mauka sugar cane fields. The entire Kaukonahua Stream flow of 39 mgd from a drainage basin of 10 square miles is stored for irrigation. In addition to irrigation, the reservoir is used for recreation, fish propagation, and wastewater reclamation. The reservoir is a public fishing area and now supports natural population freshwater game fishes. In addition to channel catfish and tucunare, there are also large-mouth bass, small-mouth bass, bluegill sunfish and oscar, along with non-game species such as tilapia, carp, and others (C&C of Honolulu 1990, pp. 10-62 and 10-63).

Secondary treated effluent from Wahiawa WWTP has been discharged into the South Fork of the reservoir since 1928, and from Whitmore Village WWTP into the North Fork since 1968. Chlorination of the effluent from both plants is carefully monitored to prevent potential fish kills from chlorine residuals (C&C of Honolulu 1990, p. 10-63).

The quality of the effluent is excellent (C&C of Honolulu 1990, p. 10-61). However, a number of fish kills have occurred in the reservoir, especially during the summer months when the reservoir water level wa s low. The demand for irrigation water is greatest during the summer months when drawdown from the reservoir has been known to interfere with the reoxygenation capacity of the water. Consequently, low dissolved oxygen levels were contributing factors to anoxia of the fishes (C&C of Honolulu 1990, p. 10-63).

According to the DNLR's Division of Aquatic Resources, fish kills during high water levels did not occur prior to 1986. Since May 1986, there have been eight documented incidents of fish kills involving up to about 9,000 fishes. All of the fish kills have occurred in the immediate vicinity of the Wahiawa WWTP discharge. A toxic substance is suspected by the State, but the actual causal agent(s) remain unknown (C&C of Honolulu 1990, p. 10-63).

Studies by the WRRC for the City and County of Honolulu indicated that the reservoir may be in an eutrophic condition. The principal sources of nutrients are wastewater effluent and storm runoff on the ratio of 3 to 1. Sediments in the streams and reservoir serve as a sink for phosphorus under both aerobic and anaerobic conditions. Nitrogen is released from the sediment during anaerobic conditions. Surface nutrient concentrations are higher during low water levels due to lower dilution ratio, mixing, and resuspension of sediments (C&C of Honolulu 1990, p. 10-63).

A number of different treatment and diversion alternatives have been considered by the City to mitigate the impacts of the Wahiawa WWTP discharge into the reservoir, including additional treatment at the WWTP and diversion of the effluent outside of the reservoir. Although the additional alternatives would mitigate conditions in the reservoir, nutrient inflow will continue from urban runoff and sediment desorption. A total in-lake management program including mechanical aeration at the forebay basin at selected depths to promote vertical mixing of lake water, removal of nutrients from the lake by "biotic" harvesting of undesirable fishes such as tilapia and threadfin shad, and controlling fish population has also been considered (C&C of Honolulu 1990, pp. 10-64 and 10-65).

A major factor in resolving the water quality problems of Lake Wilson is the planned closure of Waialua Sugar Company. Lake Wilson is not considered to be State waters because its waters are used solely for irrigation water of the plantation. If the demise of the plantation occurs, the reservoir could be classified Class 2 inland water, with specific water quality criteria applicable for streams (C&C of Honolulu 1990, p. 10-67).

Waimanalo Bay - The Waimanalo Bay community has been concerned about water quality in the bay, particularly since 1991 when heavy rains caused Meadow Gold Dairies' wastewater containment facilities to overflow into Inoaole Stream which empties into the ocean at Bellows Beach. A lawsuit against the dairy resulted in a settlement that will fund a five-year monitoring project of water quality in the bay. Meadow Gold has since spent $1.3 million improving its wastewater containment facilities and budgeted and additional $300,000 to complete the project (*Honolulu Advertiser* 30 June 1993; *Windward Sun Press* 1-7 July and 22-28 July 1993).

WRRC has received grant funds to undertake a project that will assist the Waimanalo Neighborhood Board in developing a work plan for the Waimanalo Community Water Quality Project's five-year monitoring program (John Harrison, pers. comm., October 1993).

From the above descriptions, it is evident that further monitoring and information-gathering need to be carried out in order to determine whether any of the mentioned waterbodies or segments should be classified as a WQLS. For a number of the indicated waterbodies, the process of gathering the new information needed to make such a determination has already begun.

2. Identification of Land and Water Uses

Once threatened and impaired waters are identified, states must identify the land or water uses that "individually or cumulatively" cause or contribute to these coastal water quality impairments. The "preferred source" of information on the correlation between land or water uses and water quality is "refereed" technical journals, though other sources may be acceptable to fill gaps caused by a shortage of information. NOAA and EPA encourage states to use maps to display identified land and water uses.

Hawaii has not yet formally undertaken this task, though some of this information is likely available from a variety of sources.

3. Identification of Critical Coastal Areas

Next, Section 6217, CZARA, requires that states delineate critical coastal areas adjacent to threatened and impaired waters and where new or expanding land or water uses will contribute to a future threat or impairment of coastal waters. Areas already established under existing authorities may be suitable for designation as critical coastal areas. Critical coastal areas should be of sufficient size such that, when additional management measures are implemented in these areas, the reduction in nonpoint source pollution entering the adjacent waterbodies should enable these waterbodies to meet State water quality standards.

Hawaii has not yet undertaken this task.

4. Implementation of Additional Management Measures

Finally, once the land and water uses and critical coastal areas have been identified, states must describe and implement additional management measures applicable to those land or water uses and areas in order to address the sources of polluted runoff.

EPA and NOAA's *Program Development and Approval Guidance* identifies two categories of additional management measures: those to be implemented immediately and those to be implemented after the effect of implementing the (g) measures[1] is known.

For the waters identified as threatened or impaired, states must evaluate the relative contributions from point and nonpoint sources of pollution. If a problem is due to nonpoint sources, then the state should judge whether existing pollution prevention activities and/or the implementation of the (g) measures will be adequate to address the threat or impairment. If existing information indicates that the implementation of the (g) measures will not be adequate to address the sources, then those land or water uses or critical coastal areas are to be subject immediately to additional measures. Otherwise, the state should just monitor the effectiveness of the (g) measures and verify whether water quality standards are being attained or maintained and designated uses protected. If there is no significant water quality improvement after a sufficient schedule of monitoring (by 2006, according to recent EPA and NOAA guidelines), then the State will need to provide for the implementation of additional management measures.

[1](g) measures are those described in EPA's *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* or comparable alternatives developed by the State. These management measures for Hawaii are described in Part III.

The State has not yet undertaken the task of evaluating the relative contributions from point and nonpoint sources of pollution, nor judged whether existing pollution prevention activities and/or the implementation of the (g) measures will be adequate to address the threat or impairment to coastal waters. Consequently, Hawaii will not describe additional management measures or develop a program to ensure implementation of the additional management measures at this time. These tasks will be completed as resources and staffing permit.

5. Technical Assistance

Section 6217(b)(4), CZARA, requires states to provide "technical and other assistance to local governments and the public for implementing" additional management measures. Technical assistance may include assistance in developing ordinances and regulations, technical guidance, modeling to predict and assess the effectiveness of measures, training, financial incentives, demonstration projects, and other innovations to protect coastal water quality and designated uses.

Hawaii intends not only to provide technical assistance relating to additional management measures, but also relating to the (g) measures or comparable alternatives developed by the State. Through its Clean Water Act Section 319 nonpoint source pollution control grants, Hawaii has been providing technical assistance to local governments and the public since 1987. That Section 319 grant program will continue as long as funding is provided by Congress and the State.

Technical assistance relating to additional management measures will be developed after additional management measures have been adopted.