

**FINAL
RESTORATION PLAN
and
ENVIRONMENTAL ASSESSMENT
for the
MAY 14, 1996
CHEVRON PIPELINE OIL SPILL
into
WAI'AU STREAM and PEARL HARBOR,
OAHU, HAWAII**

Prepared by:

**The Natural Resource Trustees
for Pearl Harbor, Oahu, Hawaii**

U.S. Department of Defense
U.S. Department of the Navy

U.S. Department of the Interior
*U.S. Fish and Wildlife Service
National Park Service
Office of Environmental Policy and Compliance*

U.S. Department of Commerce
National Oceanic and Atmospheric Administration

State of Hawaii
*Department of Health
Department of Land and Natural Resources*

November 1999

FACT SHEET

Final Restoration Plan and Environmental Assessment for the May 14, 1996 Chevron Pipeline Oil Spill into Waiau Stream and Pearl Harbor, Oahu, Hawaii

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National Oceanic and Atmospheric Administration
Hawaii Department of Health
Hawaii Department of Land and Natural Resources
U.S. Department of the Navy, Commander, Naval Base Pearl
Harbor, Hawaii

Abstract: This Final Restoration Plan and Environmental Assessment (Final RP/EA) has been prepared by the State and Federal Natural Resource Trustees to address restoration of natural resources and resource services injured in the Chevron Pipeline Oil Spill of May 14, 1996 into Waiau Stream and Pearl Harbor, Oahu, Hawaii.

Contact Person: Regional Environmental Officer
Office of Environmental Policy and Compliance
Department of the Interior
600 Harrison Street, Suite 515
San Francisco, CA 94107-1376
Phone: (415) 427-1477; Fax: (415) 744-4121

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1.0 INTRODUCTION: PURPOSE OF AND NEED FOR RESTORATION

1.1 PURPOSE

The purpose of this document is to provide summarized information regarding the affected environment, natural resource injury determinations and natural resource restoration projects resulting from the May 14, 1996 Chevron pipeline oil spill into Waiau Stream and Pearl Harbor, Oahu, Hawaii, so that the public may review and provide comments on the planned restoration activities. This document also serves, in part, as the agencies' compliance with the National Environmental Policy Act and the State of Hawaii equivalent (see Section 5 for additional information).

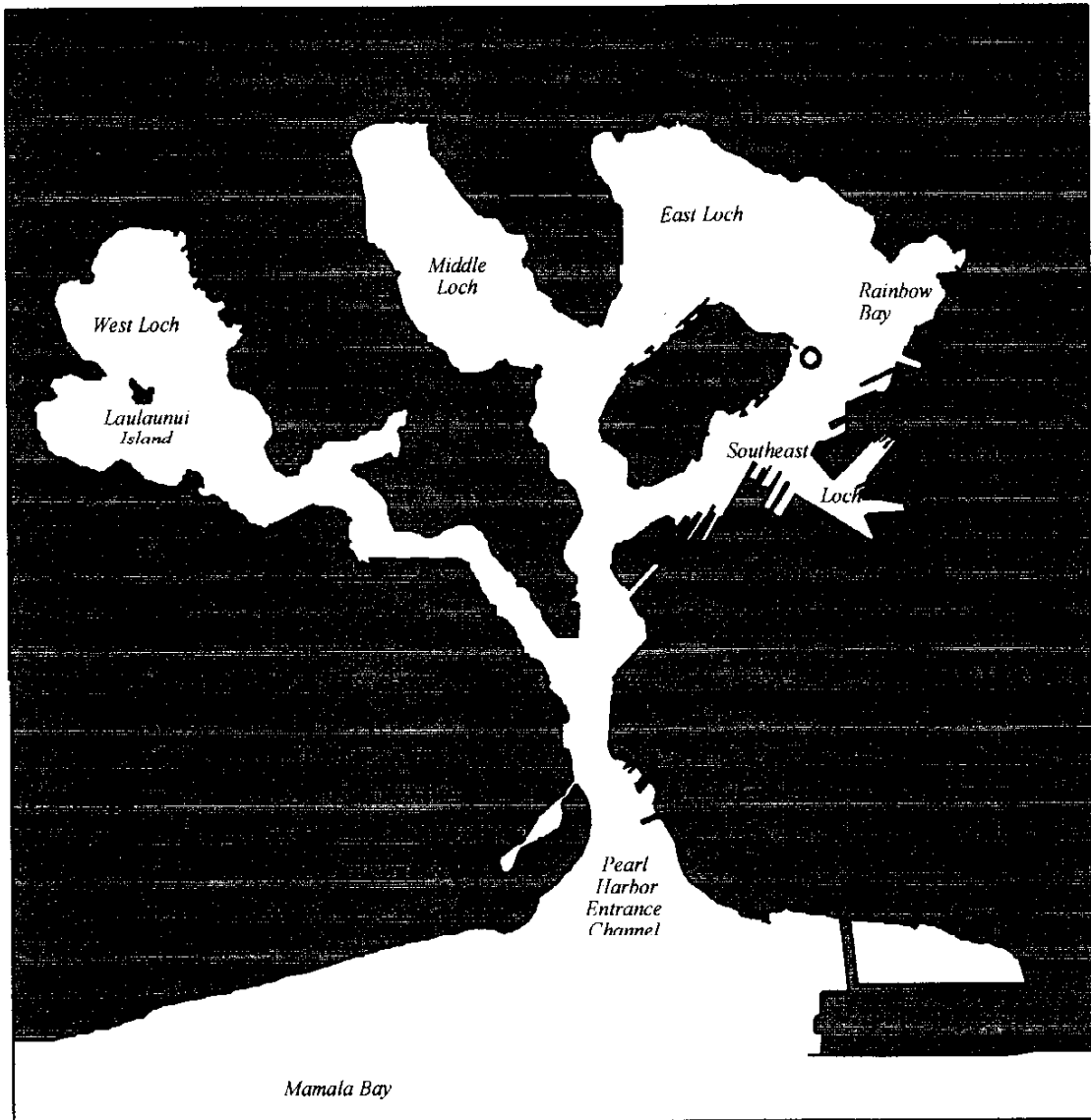
1.2 OVERVIEW

At 1:30 a.m. on May 14, 1996, a Chevron Products Company (Chevron) pipeline ruptured at a thin spot caused by external erosion and began discharging No. 6 bunker fuel oil adjacent to the Hawaiian Electric Company (HECO) Waiau Power Plant in Pearl City, Oahu, Hawaii (Figure 1). The released oil entered the nearby Waiau Stream, flowed downstream and entered East Loch of Pearl Harbor. While in the fresh water of Waiau Stream, the oil remained mostly submerged and then floated to the surface upon entering the denser salt water of Pearl Harbor. In Pearl Harbor, the floating oil initially flowed clockwise down the South Channel. Later that same day, when the winds and current shifted, the oil spread widely around East Loch and began moving down both the South and North Channels and fouling shorelines.

This Chevron pipeline is 22.6 miles long, 8 inches in diameter, and designed to transport heavy black fuel oils at rates as high as 840 gallons per minute from the Chevron Hawaii Refinery at Campbell Industrial Park on the southwest corner of Oahu to delivery points around Honolulu. The pipeline extends from the refinery through Campbell Industrial Park, through the Ewa plain, along the shoreline of Pearl Harbor, along Salt Lake Boulevard, through Camp Catlin military housing, through the airport industrial park, under Keehi Lagoon, through the Sand Island industrial area then through Kapalama to the Chevron Marine Terminal. A takeoff from the pipeline supplies fuel to HECO's Waiau Power Plant (Chevron 1996). The product transfer that resulted in the oil spill was not a transfer to the Waiau Power Plant (Seu 1999).

The pipeline transports both power plant fuel oil and bunker fuel oil for ships. Typically, the oil in the pipeline is heated to reduce its viscosity and facilitate the transportation. The oldest sections of this pipeline were installed in 1958 (Chevron 1996).

The No. 6 fuel oil released was a mixture of three components: two heavy residuum oils and a small amount (less than four percent) of light cycle oil (a component with a boiling range similar to diesel). Once blended together, this No. 6 fuel oil does not readily separate back into its components. The buoyancy of this product is nearly neutral in fresh water and is temperature sensitive. The product will float in fresh water when warmed and will sink when cooled. After its initial release into Waiau Stream and the adjacent marsh area, the product floated on the water surface and created sheens, surface pooling and perimeter staining. As it cooled, the product sank to the marsh bottom and created subsurface pools and mats (Dames and Moore 1997).



Pearl Harbor, Oahu, Hawaii



0 0.5 Miles

0 0.5 Kilometers

- ⊗ Source of spill at Waiau Stream
- USS *Arizona* Memorial
- USS *Arizona* Memorial Visitor Center

Figure 1. Pearl Harbor, Oahu, Hawaii, showing major land forms and harbor features including the locations of the May 14, 1996 Chevron pipeline oil spill, the USS *Arizona* Memorial and the USS *Arizona* Memorial Visitor Center.

For nearly two weeks after the initial pipeline breach, spilled oil continued to be mobilized from Waiau Stream and released into Pearl Harbor. The U.S. Coast Guard (USCG) reported that pockets of residual oil up to 24-inches deep in Waiau Stream and the marsh were warmed by the hot afternoon sun, mobilized to neutral buoyancy in the fresh water and then floated downstream just below the water's surface in basketball-sized "globs." These floating oil globs did not resurface and become readily visible until reaching the denser salt water of Pearl Harbor some 200-feet to 400-feet from the mouth of Waiau Stream, depending on the strength of the ebb tide and the amount of freshwater flow from the stream (USCG 1996j).

An estimated total of 982 barrels (41,244 gallons) of No. 6 fuel oil were released into Waiau Stream, creating pools of submerged oil throughout the lower portion of the 10-acre marsh. The estimated volume of oil reported released was based on information provided by Chevron and calculated by Petrospect, a Chevron contractor (Chevron 1996). The spill created a sheen of floating oil throughout East Loch, covering approximately 2,290 acres of open water during the first six days of the spill event (Gundlach 1997).

This oil spill is referred to in this Final Restoration Plan and Environmental Assessment (Final RP/EA) document as the "Incident." Chevron is the Responsible Party for this Incident and has acknowledged its liability (Chevron 1996, Pai 1996).

As described in more detail in Section 2, immediate impacts of the discharged oil included:

- the closure of Pearl Harbor to navigation and vessel traffic,
- interruption of U.S. Department of the Navy (USN) construction projects around Pearl Harbor,
- suspension of ferry service to Ford Island,
- closure of the USS *Arizona* Memorial Visitor Center (Visitor Center) on the East Loch shore at Halawa Stream,
- suspension of boat trips to the USS *Arizona* Memorial which straddles the sunken hull of the USS *Arizona* in the nearshore waters of East Loch off Ford Island,
- partial closure of the City and County of Honolulu bicycle/jogging path around the perimeter of East Loch, and
- closure of Pearl Harbor to commercial fishing and boating.

Oiling of shorelines and intertidal areas affected freshwater and saltwater wetlands, mangroves, mudflats, rocky shorelines, sandy beaches, riprap, seawalls and piers. These oiled habitats contribute to many recreationally and commercially valuable fish and wildlife species and the prey and forage items for these species. The contamination of the water column and sediments of Waiau Marsh and Pearl Harbor by this oil may have caused impacts to egg, larval, juvenile and adult stages of recreationally and commercially valuable finfish and invertebrates which utilize the Pearl Harbor estuary.

Immediate cleanup measures following the Incident were undertaken at the direction of a Unified Command which included the USCG, the USN, the State of Hawaii Department of Health (DOH) and Chevron. Cleanup measures employed during the response included: high-pressure steam cleaning of affected shorelines; boom placements to exclude, contain and recover oil; skimming

the surface waters of Pearl Harbor to remove the oil; passive collection technologies such as pom-poms and sorbent pads; and chemical cleaning agents to remove oil from USN piers.

Pollution Reports (called "polreps"), prepared by the USCG's Marine Safety Office in Honolulu, summarize and describe the chronology of events in 1996 associated with response and cleanup activities after the Incident. An excerpted chronology of oil spill response actions associated with this oil spill is provided in Appendix A.4.

A variety of traditional mechanical cleanup technologies (e.g., skimming, booming, high pressure washing) were employed during the oil spill response in an effort to mitigate impacts. Certain cleanup measures employed during the response to this Incident contributed to the spill-related injuries affecting the natural resources of Pearl Harbor. Removal of contaminated sediments from wetland areas may have adversely affected the overlying vegetation at the time of removal in addition to causing soil/sediment alterations that will prevent or substantially delay natural recovery by native vegetation.

The shoreline of the USS *Arizona* Memorial Visitor Center suffered injury as a result of the oil spill cleanup technologies employed. The entire Visitor Center was closed to the public from May 15 - 18, 1996. On May 18, Chevron contractors established a shoreline cleanup post on the Visitor Center property near the Remembrance Exhibit. Visitors were restricted from all the shoreline viewing areas of the Visitor Center from May 18 to 22, 1996 while Chevron's cleanup contractors engaged in oil spill response along the shoreline (Petrossian 1997). As many as 53 contracted cleanup workers were working at the Visitor Center at any one time (USCG 1996i).

This 1,200-foot long Visitor Center shoreline, where Halawa Stream meets Pearl Harbor, is an artificially engineered shoreline of irregular riprap consisting of USN construction debris and broken concrete pilings. Mature *naupaka* shrubs (*Scaevola taccada*) cascaded over the shoreline, protecting and sheltering the fill material and soils in and behind the riprapped shoreline from the erosive forces of wave wash and rainfall. The roots of these mature *naupaka* shrubs also acted to hold and stabilize the shoreline soils (Petrossian 1997).

The Visitor Center shoreline was repeatedly oiled from May 14 - 22, 1996, and repeatedly cleaned by Chevron's contractors during this time. The three cleanup technologies, approved by the Unified Command with the assistance of technical advisors, applied at the Visitor Center were (Petrossian 1997):

1. Episodic 1,500-pounds-per-square inch (psi), directed, high pressure washing;
2. Sustained, medium-pressure continuous washing using perforated, 2-inch polyvinyl chloride (PVC) piping hooked up to an on-site fire hydrant; and
3. The placement of sorbent booms and pom-poms along the shoreline, both in front of the riprap in Pearl Harbor and in newly eroded gaps behind the riprap.

Despite these cleanup efforts, this shoreline continued to emit an oil sheen more than a month after the initial release on May 14, 1996 (USCG 1996i).

The repeated, episodic high-pressure washing of this shoreline, the continuous medium-pressure washing of this shoreline, and the abrasive action of the sorbent booms and pom-poms, all acted to destabilize and erode shoreline soils and material filling in the riprap. The protective *naupaka*

shrub sheltering the shoreline was cut away by Chevron contractors because it was oiled. This action exposed the shoreline to the persistently erosive forces of wave action and boat wake wash. Because the Chevron cleanup crews needed unrestricted access to the shoreline, seven separate pathways, each a swath about three feet wide, were cut through the mature *naupaka* shrub barrier to the water's edge (Petrossian 1997).

The USCG did not view the emergency stabilization of the degraded and destabilized Visitor Center shoreline as an oil spill response measure (Whipple 1996). In November 1996, unusually heavy rains on leeward Oahu exacerbated the erosion of the Visitor Center shoreline. Shoreline soils eroded into Pearl Harbor by these rains created potentially unsafe conditions along the shoreline areas for visitors, employees and occasional after-hours fishermen. In November 1996, the National Park Service (NPS) undertook an emergency shoreline stabilization project using sandbags to fill in the eroded areas (Petrossian 1997).

1.3 NATURAL RESOURCE TRUSTEES AND AUTHORITIES

Both federal and State of Hawaii laws establish liability for natural resource damages to compensate the public for the injury, destruction, and loss of such resources and/or their services resulting from oil spills.

This Final RP/EA has been prepared jointly by the U.S. Department of Defense (DOD), represented by the USN; the U.S. Department of the Interior (DOI), represented by the Office of Environmental Policy and Compliance (OEPC), the NPS, and the U.S. Fish and Wildlife Service (USFWS); the U.S. Department of Commerce, represented by the National Oceanic and Atmospheric Administration (NOAA); and the State of Hawaii, represented by the DOH and the Department of Land and Natural Resources (DLNR). Collectively these agencies are referred to as the "Trustees" or "Natural Resource Trustees."

Each of these agencies acts as a Natural Resource Trustee pursuant to the Oil Pollution Act of 1990 (OPA) (33 USC 2701 *et seq.*), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300.600), for natural resources injured by the Incident. Executive Order (EO) 12777 designates the federal Trustees for oil spills while the Governor of Hawaii designates the State Trustees for oil spills in Hawaii. As a designated Trustee, each agency is authorized to act on behalf of the public under state and/or federal law to assess and recover natural resource damages and to plan and implement actions to restore natural resources and resource services injured or lost as the result of a discharge of oil. The Trustees designated the USN, represented by the Commander, Naval Base, Pearl Harbor (now known as Commander, Navy Region Hawaii), as the Lead Administrative Trustee (LAT) [15 CFR 990.14(a)].

Additionally, the Park System Resources Protection Act (Public Law 101-337) (104 Stat. 379, 16 USC 19jj) requires the Secretary of the Interior to assess damages to "Park System resources" and authorizes recovery from responsible parties whose actions caused the destruction, loss, or injury. This law provides for any monies thus recovered by the NPS to be used for response costs, damage assessments, restoration, and replacement of injured NPS resources. Double recovery of natural resource damages is prohibited.

restoration actions. This Phase provides the link between injury and restoration and has two basic components: (1) injury assessment, and (2) restoration selection. The goal of injury assessment is to determine the nature and extent of injuries to natural resources and services, thus providing a factual basis for evaluating the need for, type of, and scale of restoration actions. As the injury assessment is being completed, the Trustees develop a plan for restoring the injured natural resources and services.

During the Restoration Planning Phase, the Trustees must:

- identify a reasonable range of restoration alternatives,
- evaluate and select the preferred alternative(s),
- develop a Draft Restoration Plan presenting the alternative(s) to the public,
- solicit public comment on the Draft Restoration Plan, and
- incorporate comments into a Final Restoration Plan.

During the Restoration Implementation Phase, the Final Restoration Plan is presented to the Responsible Parties to implement or to fund the Trustees' costs for assessing damages and implementing the Restoration Plan, thus providing the opportunity for settlement of damage claims without litigation. Should the Responsible Parties decline to settle a claim, OPA authorizes Trustees to bring a civil action against Responsible Parties for damages or to seek reimbursement from the Oil Spill Liability Trust Fund.

1.5 COORDINATION WITH THE RESPONSIBLE PARTY

The OPA regulations direct the Trustees to invite the Responsible Party to participate in the damage assessment and restoration process. Although the Responsible Party may contribute to the process in many ways, final authority to make determinations regarding injury and restoration rests solely with the Trustees.

To facilitate the undertaking of a NRDA related to this Incident, Chevron and the Trustees, shortly after the spill, agreed to expedite the determination and quantification phases of the assessment process to save time and money and to focus on restoration. Although an expedited procedure such as this avoids a potentially lengthy assessment process, it also requires the Trustees and the Responsible Party to accept a level of uncertainty concerning the nature and extent of injuries.

On July 26, 1996, the Trustees executed a Memorandum of Agreement with Chevron (Chevron/Trustee MOA) specifically pertaining to the Incident. In this MOA, the Trustees and Chevron agreed to attempt to perform an expedited assessment of damages in order to minimize assessment costs and proceed with restoration of injured resources and services as soon as possible. Chevron agreed to reimburse the Trustees for the costs of these damage assessment and restoration planning activities up to certain specified funding ceilings.

Even though the Chevron/Trustee MOA had been executed shortly after the oil spill, in their October 19, 1997, "Notice of Intent to Conduct Restoration Planning," the Trustees extended an official invitation to Chevron to continue participation in the damage assessment, restoration planning and restoration implementation efforts (USDOD *et al.* 1997). The Trustees have produced documents that have been shared with Chevron in an attempt to present known or potential injuries or losses of natural resources and services and to identify candidate assessment

strategies. Coordination between the Trustees and Chevron helped to reduce duplication of studies, increase the cost-effectiveness of the assessment process, increase sharing of information, and decrease the likelihood of litigation. The Trustees sought input from Chevron and considered such information, when provided, throughout the NRDA process.

1.6 PUBLIC PARTICIPATION

Public review of the Draft RP/EA is considered an integral component to the restoration planning process. Through the public review process, the Trustees sought public comment on the analyses used to define and quantify natural resource injuries and the methods and the projects being proposed to restore injured natural resources or replace lost resource services. The Draft RP/EA provided the public with current information about the nature and extent of the natural resource injuries identified and the restoration alternatives evaluated.

Following a public notice (Honolulu Advertiser 1999), the Draft RP/EA was made available to the public for a comment period from April 12, 1999 through June 1, 1999. The Draft RP/EA was made available to the public in three ways: in electronic form for viewing and downloading on the world wide web on DOI and NOAA web pages, as part of the publicly-available Administrative Record, and in hardcopy form by request. In addition, a Public Meeting was held at 7:00 PM on May 17, 1999 at the *USS Arizona* Memorial Visitor Center auditorium in Honolulu, Hawaii to present the Draft RP/EA to the public and invite public comment.

Public review of the Draft RP/EA is consistent with all federal and state laws and regulations that apply to the NRDA process, including Section 1006 of OPA, the OPA regulations, the National Environmental Policy Act (NEPA), as amended (42 USC 4371 *et seq.*), and its implementing regulations (40 CFR Parts 1500-1508). Comments received during the public comment period were considered by the Trustees in preparing the Final RP/EA.

During this 51-day long public comment period, the Trustees received five written comments. These comments and the Trustees' responses to these comments are provided in Appendix A.1.

During the Public Meeting on the evening of May 17, 1999, 39 attendees registered by providing information on a "Sign-in Form." These Public Meeting "Sign-In Forms" are provided in Appendix A.2. One attendee at this Public Meeting provided verbal comments and this commentor's "Speaker Sign-In Form" is provided in Appendix A.2. A summary of this speaker's comments, as recorded during the Public Meeting, are provided in Appendix A.2.

After an analysis of the public comments on the Draft RP/EA, the Trustees determined that the Restoration Plan could be adopted as a final Plan without modifications to the proposed projects. The Adoption Resolution is provided at Appendix A.7. A Finding of No Significant Impact (FONSI) determination was made by each of the Trustee agencies. Copies are provided at Appendix A 8

1.7 ADMINISTRATIVE RECORD

The Trustees have compiled an Administrative Record which contains documents considered by the Trustees as they have planned and implemented the NRDA and addressed restoration and compensation issues and decisions. The Administrative Record is available for public review at the public repositories listed below. An index of documents that are part of the Administrative Record is provided in Appendix A.6 of this Final RP/EA.

The Administrative Record facilitates public participation in the NRDA process and will be available for use in future administrative or judicial reviews of the Trustees' actions to the extent provided by federal or State law. Additional information and documents, including public comments received on the Draft RP/EA, the Final RP/EA and other related restoration planning documents will become a part of the Administrative Record and will be submitted to the repositories upon their completion.

The documents comprising the Administrative Record can be viewed at the following public locations:

State of Hawaii, Department of Health
Hazard Evaluation and Emergency Response Office
919 Ala Moana Boulevard, Suite 206
Honolulu, HI 96814
(808) 586-4249
open to the public: Monday - Friday: 7:45 am - 4:30 pm

and

City and County of Honolulu
Pearl City Public Library
1138 Waimano Home Road
Pearl City, HI 96782
(808) 453-6566
open to the public: Monday, Tuesday, Thursday: 10:00 am - 8:00 pm
Wednesday, Saturday, Sunday: 10:00 am - 5:00 pm;
Friday: 1:00 pm - 5:00 pm

1.8 SUMMARY OF THE NATURAL RESOURCE DAMAGE CLAIM

The NRDA damage claim for the Incident encompasses compensatory restoration actions for injuries to the following natural resources and services:

- intertidal habitat,
- water column habitat,
- subtidal habitat,
- freshwater marsh habitat, and
- lost human use.

The proposed compensatory restoration actions seek to:

- enhance wetlands and wetland services to compensate for injuries to freshwater marsh and intertidal habitats,
- open vegetated shoreline areas to compensate for injuries to water column and subtidal habitats, and
- improve visitor services at the USS *Arizona* Memorial to compensate for the loss and diminishment of human use services resulting from injuries associated with natural resources.

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2.0 AFFECTED ENVIRONMENT

2.1 PHYSICAL AND BIOLOGICAL ENVIRONMENT

Pearl Harbor is a coastal plain estuary located between the Koolau and Waianae Mountain ranges on south-central Oahu. The harbor is the largest landlocked estuary in Hawaii and has about 8 square miles of surface water with an average depth of 28 feet and about 36 linear miles of shoreline. Pearl Harbor is divided into three main embayments called lochs (East Loch, Middle Loch and West Loch) and one smaller loch (Southeast Loch) which are remnants of drowned river valleys that join at a narrow main channel connecting the harbor with the open ocean (Coles *et al.* 1997). Waipio Peninsula lies between West and Middle Lochs while Pearl City Peninsula separates Middle Loch from East Loch. Two islands punctuate the waters of Pearl Harbor: Ford Island in East Loch and the smaller Lāulaunui Island in West Loch (Figure 1).

The harbor is relatively isolated from oceanic water circulation and the water exchange between the harbor and open ocean is relatively slow. Residence time of water within the harbor has been estimated at about six days maximum for bottom water and one to three days for surface water. Surface water circulation is primarily offshore and driven by the prevailing northeast trade winds, while weak tidal ebb and flood flows of 0.15 - 0.3 meters per second (m/sec) control the movement of bottom water in and out of the narrow harbor opening (Grovhoug 1992).

Water temperature in the harbor varies annually from 23 to 29 degrees Centigrade (°C), and salinities have ranged from 10 to 37 parts per thousand (ppt) with a mean harbor-wide salinity of 33 ppt. Salinity is highly influenced by surface water and groundwater runoff, especially at the upper reaches of the three main lochs. Warming of the surface water and freshwater discharge contribute to the development of a pronounced vertical stratification of harbor waters which in turn promotes differing current conditions between surface and bottom and a relative isolation between surface and bottom water masses (Coles *et al.* 1997).

Eight streams presently discharge into Pearl Harbor draining approximately 109 square miles of watershed. Six of these streams are perennial: Waikele, Waiawa, Waiau, Waimalu, Kalanao and Halawa. Two of the eight streams are intermittent: Honouliuli and Aiea. The perennial streams originate in the windward Koolau Mountain range and constantly bring fresh water into the Pearl Harbor estuary.

Groundwater also discharges into Pearl Harbor along the shore and in stream channels below seawater or stream water level. Five large springs along the upper loch shorelines, collectively known as the Pearl Harbor Springs, input additional fresh water into the system (Coles *et al.* 1997). The Pearl Harbor Aquifer probably has the broadest and thickest caprock in Hawaii. However, there are numerous areas where basaltic rock outcrops extend to the surface without caprock cover. In most of these areas, the basaltic rock is sufficiently weathered to serve as a caprock. In other areas, such as those adjacent to stream channels, the basaltic rock is exposed at elevations below 6.1 m. These large springs exist at these points. The largest measurable groundwater flow, estimated at between 78,000 cubic meters to 852,000 cubic meters per day, occurs at the springs (SSFM and Belt Collins 1997).

The waters of Pearl Harbor are relatively turbid from stream runoff coupled with other sources of sediment which has resulted in thick deposits of fine silt on the bottom throughout most of the lochs. Stream input of sediments has been estimated to exceed 96,000 tons annually and maintenance dredging of about nine million cubic yards has been required by the USN on four- to five-year cycles. Relative turbidity measurements indicated by Secchi disk readings in 1990 averaged only 2.5 m harbor-wide resulting from the high loading of suspended sediments and organic material produced by eutrophic conditions (Grovhoug 1992).

A variety and range of shoreline types comprise the 36 miles of linear shoreline in Pearl Harbor. The most extensive shoreline type, found predominantly throughout East Loch, Ford Island, the end of the Waipio Peninsula and the harbor entrance, is sheltered rocky/constructed seawall shoreline. The second most extensive shoreline type is wetlands, which are considered to be the most sensitive shoreline type to oil spills. These wetland shorelines are found intermittently in the upper reaches of the three main lochs. Isolated areas of fine-grained sand beaches are found sporadically along the three main lochs and on Ford Island (RPI 1986).

Vegetation along the shoreline is dominated by red mangroves (*Rhizophora mangle*) at the heads of the three main lochs forming dense, nearly impenetrable growths of bushes and trees up to 10 m high. The red mangrove is an exotic, salt-tolerant species which probably began colonizing the harbor shorelines not long after it was introduced to Molokai in 1902. Pickleweed (*Batis maritima*), first reported in Hawaii in 1859, now forms low and thickly-growing communities along certain muddy shorelines in Pearl Harbor which are periodically flooded by salt water (Wagner *et al.* 1990). Elsewhere along the harbor shoreline, the dominant vegetation is cultivated exotic grasses, trees and plants in populated areas and *kiawe* trees (*Prosopis pallida*) along the channels (Coles *et al.* 1997).

The habitat of Pearl Harbor has been an environment of shifting characteristics, both physical and biological, since humans arrived in the area. Native Hawaiians used the harbor and its shorelines for extensive fish cultivation and harvesting in unique walled fishponds. Middle 19th century agricultural development on the surrounding plains increased the rate of sediment-laden runoff into the harbor. The 1911 completion of the entrance channel allowed deep draft vessels to enter the harbor, increasing the rate of exotic species introduction. The development of the harbor and surrounding lands as a USN ship repair and resupply complex, coupled with an increase in residential development and expansive sugar cane production, yielded construction-hardened shorelines and a period in which the harbor received uncontrolled runoff and waste disposal (Coles *et al.* 1997).

The inner harbor benthic community is depicted by four zones: sand-rubble, algal-mud, channel wall and channel floor mud-silt. Naturally occurring sedimentation greatly influences the constituents of the benthic community. Stony corals are present but not widely or generally observed because they are sensitive to high sediment loads. Predominant marine biota in the area include the sea cucumber (*Ophiodesoma spectabilis*), which is common to areas where organic particulate input is high; benthic algae; sponges; sabellid (or feather duster) worms; serpulid tube worms; and various benthic shrimps and crabs (SSFM and Belt Collins 1997).

Many reports describe the abundance of fish and shellfish resources inhabiting Pearl Harbor. The harbor region served as a major Hawaiian population center in the early years and supported numerous and extensive constructed fish ponds. Many of the walled fish ponds remained intact

until the 1930s. By 1972, the number of existing fish ponds had decreased to four. However, an extensive survey of the harbor's marine biota revealed a relatively diverse and abundant estuarine marine ecosystem during a period of significant contaminant loading into the harbor (Evans *et al.* 1974). Abundant fish and invertebrate communities continue to flourish into the present (Grovhoug 1992, Coles *et al.* 1997).

Some 24 percent of the inshore fishes from Hawaii are endemic. This is the highest percentage of endemism for warm-water marine fishes worldwide. These endemic fishes in Hawaii are often the most common members of their genera (Randall 1996).

Recent biological investigations of Pearl Harbor observed a total of 434 species or higher taxa including 36 algae, 1 spermatophyte, 338 invertebrates and 59 fish. Ninety-six species (*i.e.*, 22 percent) are considered to be introduced or cryptogenic. The areas of highest species richness were in the entrance channel to Pearl Harbor and in Rainbow Bay at the northeast head of East Loch where the number of taxa was around 150. Lowest species richness occurred in the areas of highest sedimentation and turbidity at the head of West Loch where fewer than 50 taxa occurred. Based on species composition, three types of biological communities can be delineated in the harbor: one associated with the relatively oceanic conditions in channel areas, one with the highly turbid West Loch sedimentary environment, and one with conditions prevailing throughout the rest of the harbor (Coles *et al.* 1997).

Since the beginning of this century, Pearl Harbor has been at the center of USN operations in the Pacific. The Pearl Harbor Naval Complex has served to support industrial, berthing and maintenance activities for the U.S. Pacific fleet. On October 14, 1992, the Pearl Harbor Naval Complex was placed on the National Priorities List (NPL) of the nation's most contaminated hazardous waste sites (USEPA 1992). As part of a long-term program to restore the environment at its facilities, the USN is conducting an investigation of marine life and contaminants that are present in sediments of Pearl Harbor. This investigation will provide data to evaluate the potential threat from contaminants to human health and the marine environment and to identify areas that may require remediation or cleanup. In 1998, the DOH issued a notice advising that marine life taken from Pearl Harbor not be consumed (DOH 1998).

During the last century a wide variety of human activities has been concentrated along the shoreline and within the upland drainage basins that empty into the harbor. These activities include the industrial and operational activities of the USN, private industrial operations, extensive sugarcane and pineapple agriculture, golf courses, extensive residential development, and other municipal, commercial and urban activities. An estimated 5,000 acres of harbor sediments may have received contaminants from multiple sources. These sediments act as an ultimate sink or repository for many of the contaminants entering the harbor (Grovhoug 1992).

2.2 ENDANGERED AND THREATENED SPECIES

The shoreline, estuarine and freshwater areas associated with Pearl Harbor are known habitat for four species of endemic waterbirds which are listed by both federal government and by the State of Hawaii as endangered species: the Hawaiian moorhen (*Gallinula chloropus sandvicensis*) (= `alae `ula), the Hawaiian coot (*Fulica americana alai*) (= `alae ke `oke `o), the Hawaiian duck (*Anas*

wyvilliana) (= *koloa maoli*) and the Hawaiian stilt (*Himantopus mexicanus knudsoni*) (= *ae`o*) [Haw. Rev. Stat. Ch. 12 (1998), USFWS 1998a, 50 CFR Part 17].

Population levels of these endangered waterbirds have been severely reduced primarily because of the loss of wetland habitat. Other threats to these species include predation by introduced mammals, invasion of wetlands by alien plants and fish, hybridization, disease, and possibly environmental contaminants (USFWS 1998a). The secretive nature of the Hawaiian moorhen, which inhabits the islands of Kauai and Oahu, prevents adequate censusing and estimation of population numbers; however, "small numbers" are reported from Pearl Harbor. The state-wide population of the Hawaiian coot is estimated to range between 2,000 - 4,000 birds with 80 percent of these birds found on Kauai, Oahu and Maui. An estimated 300 wild Hawaiian ducks remain on the Island of Oahu. An estimated 1,200 - 1,600 Hawaiian stilts exist throughout the main Hawaiian Islands. Forty to sixty percent of this state-wide Hawaiian stilt population can be found on Oahu with Pearl Harbor supporting a portion of this population (USFWS 1998a). Approximately 50 of these Hawaiian stilt are resident at Chevron's Hawaii Refinery in Campbell Industrial Park on the southwestern corner of Oahu (Foster 1996).

Two additional species of birds, listed as threatened or endangered by the State of Hawaii, but not listed by the federal government, are found in the vicinity of Pearl Harbor. These two species include the state-threatened white tern (*Gygis alba rothschildi*) (= *manu o kū*), a diminutive, arboreal-nesting seabird which can be seen around Pearl Harbor, and the state-endangered Hawaiian owl (*Asio flammeus sandwichensis*) (= *pueo*), an endemic race of the crepuscular, ground-nesting shorteared owl [Haw. Rev. Stat. Ch. 12 (1998)].

The federally- and state-listed threatened Pacific green sea turtle (*Chelonia mydas agassizi*) (= *honu*), which feeds on sea grasses and algae (= *limu*) in Mamala Bay, has been regularly reported in Pearl Harbor (Naughton pers. comm.). At least one Pacific green sea turtle has been regularly observed in and around the sunken hull of the USS *Arizona* and is thought to be resident in that location (Adams pers. comm.). On March 21, 1998, federally-listed endangered humpback whales (*Megaptera novaeangliae*) (= *kohola*), specifically an adult and a calf, were observed within Pearl Harbor. This use of Pearl Harbor by humpback whales is considered an unusual event.

A large number of federally-listed and state-listed threatened and endangered plants are found in the State of Hawaii, including 272 taxa of endangered plants and 10 taxa of threatened plants. Of these plants, 115 taxa of endangered plants and 2 taxa of threatened plants are found on the Island of Oahu (USFWS 1998b). An unknown number of these threatened and endangered plants from Oahu may be associated with the terrestrial and shoreline areas of Pearl Harbor.

2.3 HISTORIC AND CULTURAL RESOURCES

Pearl Harbor is recognized worldwide as one of the most dramatic historic sites in the United States due to the crucial role played by Naval Base Pearl Harbor in the nation's defense from the beginning of the century to the present. Because of the Japanese attack on the Naval Base on December 7, 1941, and the resulting American casualties, coupled with its role throughout the remainder of World War II, Pearl Harbor today is widely held in near reverential, patriotic esteem.

In 1964, the U.S. Naval Base Pearl Harbor was declared a National Historic Landmark (NHL) by the Secretary of the Interior and was placed on the National Register of Historic Places in 1966. The boundary of the NHL area was officially defined in 1974 and includes both upland areas and surface waters. Upland areas included within the NHL boundary include Naval Magazine Lualualei, the Waipio Peninsula, the Pearl City Peninsula, Ford Island, Naval Station Pearl Harbor, Submarine Base Pearl Harbor, Naval Supply Center Pearl Harbor and Naval Shipyard Pearl Harbor. Surface water areas included within the NHL boundary include West Loch, Middle Loch, East Loch and the Mamala Bay entrance to Pearl Harbor on the south shore of Oahu (Helbert Hastert & Fee 1992).

Within the NHL boundary there are also several activities and related facilities of particular historic and cultural importance. Perhaps the most famous of these is the USS *Arizona* Memorial, which spans the submerged USS *Arizona*, off Ford Island and the associated Visitor Center on the shoreline of East Loch. The Visitor Center was completed in 1980 and attracts 1.4 million visitors annually. The USS *Utah* and its memorial are located on the northwest side of Ford Island. Both of these ships are designated NHLs. The USS *Nevada* Memorial is located near Hospital Point.

The NPS operates the USS *Arizona* Memorial under an agreement with the USN (NPS 1983). The specific purposes of the USS *Arizona* Memorial are:

- to preserve and interpret the tangible historical resources associated with the December 7, 1941 attack on Pearl Harbor,
- to interpret the historical events which led up to and which were a direct result of the December 7, 1941 attack, and
- to preserve and interpret the intangible historical values – the memories, attitudes and traditions – of those individuals who were present at or had intimate first-hand knowledge of the historic events which took place on December 7, 1941.

These purposes are to be carried out by the NPS for the benefit of visitors in an atmosphere of safety and relative comfort. Of primary importance in this mission is the sunken remains of the USS *Arizona*, which serves as the final resting place for the battleship's sailors and marines killed during the attack, and the distinctive concrete memorial which straddles the USS *Arizona*.

Immediately to the north of the Visitor Center is the *Bowfin* Park operated by the non-profit Pacific Fleet Submarine Memorial Association. This facility, which was completed in 1988, includes the Pacific Submarine Memorial Association Museum maintained by Naval Station Pearl Harbor and the USS *Bowfin*, a World War II vintage submarine listed on the National Register of Historic Places. The *Bowfin* Park attracts 200,000 visitors annually (Helbert Hastert & Fee 1992).

Also located in the waters off Ford Island are the mooring quays for ships berthed in the harbor during the attack on December 7, 1941. These structures are not listed as historic landmarks but their historic significance has gained increased attention in recent years (Helbert Hastert & Fee 1992).

The Oki'oki'lepe Fishpond, located along the shoreline at the confluence of West Loch and East Loch at Naval Magazine Lualualei, is listed on the National Register of Historic Places. Paaiau

Fishpond, located along the shoreline near the McGrew Point housing area in East Loch, is also within the NHL boundary, but has not been evaluated for inclusion on the National Register of Historic Places (Helbert Hastert & Fee 1992). Perhaps as many as 23 other late-19th century coastal fish ponds existed or are suspected to have existed along the margins of Pearl Harbor within the landmark boundary (SHPO, undated).

2.4 NATIONAL WILDLIFE REFUGE RESOURCES

The Pearl Harbor National Wildlife Refuge (Refuge) was established on October 17, 1976 along the shoreline of Pearl Harbor and is divided into two discrete geographic units totaling 61 acres. The 24.5-acre Waiawa Unit of the Refuge is on the western shore of the Pearl City Peninsula at the upper reach of Middle Loch and is composed of two constructed impoundment ponds with manmade islands for bird nesting. Surface water in this Unit is pumped into the ponds from a nearby spring-fed, freshwater stream and eventually empties into adjacent Pearl Harbor. The 36.5-acre Honouliuli Unit of Refuge is on the western shoreline of West Loch and is composed of two constructed impoundment ponds with manmade bird nesting islands. Surface water in this Unit is pumped into the impoundments from an onsite freshwater well and eventually empties into Pearl Harbor (USFWS, undated).

The USN owns the land comprising the two units of the Refuge. The Refuge is managed by the USFWS under a 1972 "Use Agreement" with the USN (USN and USBSFW 1972). This Agreement is in effect indefinitely but the USN may terminate or suspend the Agreement at any time for the following reasons: (1) during a national emergency declared by the President or Congress, or (2) in the event that the land ceases to be used for the specified purposes (USFWS, undated).

These two units of the Refuge serve as feeding, foraging, loafing and nesting habitat for the four species of federal and state endangered endemic waterbirds and 25 other species of federally protected migratory birds including shorebirds and waterbirds. The three management goals for this Refuge are:

1. To support the recovery and perpetuation of federally-listed endangered and threatened species especially endangered Hawaiian waterbirds;
2. To provide adequate water quality to maximize habitat size and value for migrant, endangered and resident waterbirds; and
3. To provide opportunities for quality wildlife-dependent recreation, education and research to enhance public appreciation, understanding and enjoyment of Refuge wildlife and habitats.

Public access to the Refuge is authorized only by a Special Use Permit (SUP) from the USFWS (USFWS, undated).

2.5 HUMAN USE SERVICES

The human use services in, on and around the margins of Pearl Harbor can be considered in four broad categories: tourism, recreation, fisheries and Navy Operations.

2.5.1 Tourism

The USS *Arizona* Memorial, located on the Naval Base Pearl Harbor and operated by the NPS in cooperation with the USN, is considered to be the single most heavily visited tourist attraction on the Island of Oahu. This Memorial interprets the diplomatic and military history of the December 7, 1941 Japanese attack on Pearl Harbor that marked the entrance of the United States into World War II. The USS *Arizona* Memorial consists of a Visitor Center (containing theaters, a museum, a gift shop, a Remembrance Exhibit, public viewing area of Pearl Harbor and other interpretative exhibits) on the shoreline of East Loch and a memorial structure which is situated over the sunken hull of the USS *Arizona* off the east shore of Ford Island. The USS *Arizona* is the final resting place for most of the ship's 1,177 crewmen who lost their lives during the Japanese attack and visits to the Memorial evoke powerful emotional responses from both domestic and international visitors. Approximately 4,000 visitors visited the Memorial each day during the month of May, 1996 (Billings pers. comm.).

The *Bowfin* Park and Pacific Submarine Museum are located adjacent to the Visitor Center on the shoreline of East Loch. The *Bowfin* Park is maintained as a memorial to the 52 U.S. Navy submarines and the 3,505 submariners lost during World War II. The Pacific Submarine Museum interprets the U.S. submarine campaign during World War II and depicts the history of the U.S. submarine service up to the present day. The USS *Bowfin*, a restored World War II era submarine, is permanently docked at the museum and is open for interpreted public tours. The *Bowfin* Museum received approximately 400 visitors a day during the month of May, 1996 (Billings pers. comm.).

Water-borne tours of Pearl Harbor are offered to the public aboard the cruise ship *Star of Honolulu*. The *Star of Honolulu*, a 232-foot, 1,500-passenger capacity vessel, provides scenic and historic tour cruises of Pearl Harbor under a permit from the USN.

2.5.2 Recreation

The City and County of Honolulu owns and maintains a public park called Blaisdell Park (also known as Pearl Harbor Park) along the shoreline of East Loch immediately west of Waimalu Stream. This park provides both open space and public shoreline access to Pearl Harbor for a wide range of public recreational activities including fishing, bird watching, picnicking, bicycling and games.

A paved, public bicycle/jogging path, maintained by the City and County of Honolulu's Department of Public Works along a former railroad right-of-way around the perimeter of East Loch of Pearl Harbor, extends from Halawa Stream westward for approximately five miles to Waipio Point Access Road. This bicycle/jogging path is heavily used by joggers, walkers, skaters and bicyclists. This path bisects HECO property at the Wai'anae Power Plant along a Navy right-of-way and passes within several feet of the location of the pipeline breach next to Waiau Stream.

The Rainbow Marina is located along the shoreline of Aiea Bay in East Loch of Pearl Harbor. This marina is owned by Naval Station Pearl Harbor, operated by the Naval Station Morale, Welfare and Recreation Department, and provides 88 berths for boats belonging to USN personnel and

dependents. Recreational activities offered by the marina include sailboat rentals, sailing lessons and youth sailing lessons.

Other general recreational activities that take place along the shorelines and margins of Pearl Harbor include recreational beach use, beach combing and bird watching.

2.5.3 Fisheries

Quiet waters in the upper regions of all three major Pearl Harbor lochs provide suitable habitat for the commercially important, endemic Hawaiian anchovy (*Enchasiicholina purpurea*) (= *nehu*), a species used as a baitfish in the offshore skipjack tuna (*Katsuwonus pelamis*) (= *aku*) fishery. This native anchovy is the most important baitfish resource in Hawaii and Pearl Harbor provides a major baitfish harvesting region (Naughton pers. comm., Oishi pers. comm.). The USN issues permits for insured commercial *aku* boats to collect baitfish from certain regions of Pearl Harbor.

The Marquesan (or goldspot) sardine (*Herklotsichthys quadrimaculatus*) was brought to Hawaii from the Marquesas Islands between 1955 and 1959 as a baitfish for tuna and became established, although never abundant, in Pearl Harbor (Randall 1996). Marquesan sardines are sometimes caught incidentally as part of the commercial Hawaiian anchovy fishery in Pearl Harbor (Oishi pers. comm.).

Except for the commercial baitfish fishery in Pearl Harbor, general access to Pearl Harbor for recreational fishing is restricted and generally discouraged by the USN. However, a persistent but limited subsistence, artisanal and recreational fishery by the public exists on the shorelines and around the margins of Pearl Harbor for both finfish and crustaceans. The finfish are typically caught using rod and reel and cast net and the crustaceans are caught using nets. Finfish species caught in this fishery include: striped mullet (*Mugil cephalus*) (= *'ama'ama*), Hawaiian flagtail (*Kuhlia sandvicensis*) (= *āholehole*), surgeonfish (*Acanthuridae* spp.), jacks (= *ulua* and *papio*), goatfish (= *weke*) and tilapia (*Tilapia* spp.). Crustaceans caught in this fishery include the mangrove (or Samoan) crab (*Scylla serrata*), the white crab (*Portunus sanguinolentus*) (= *kuahonu*) and the slipper lobster (*Scyllarides squammosus*) (= *ula papapa*) (Oishi pers. comm.).

2.5.4 Navy Operations

The overriding and dominant human use of Pearl Harbor is USN operations associated with the Pearl Harbor Naval Complex. The Pearl Harbor Naval Base is the USN's largest and most strategic island base in the Pacific. It extends over more than 12,600 acres of land and water and serves as the headquarters for more than 70 commands including the U.S. Pacific Fleet Commander. The Pearl Harbor Naval Complex is home for more than 18,000 sailors, 15 surface ships and 22 submarines.

The USN offers services to transiting Pacific fleet units as well as many ships of friendly allied navies when they visit Pearl Harbor. During a major fleet exercise such as "Rim of the Pacific" (RIMPAC), logistical support is provided to as many as 75 ships from 20 different nations. Such an exercise, RIMPAC 96, was underway at Pearl Harbor when the Incident occurred.

Pearl Harbor itself and the area immediately outside the entrance channel into the Harbor is described as the Pearl Harbor Naval Defensive Sea Area. The Defensive Sea Area was established by EO 8143 (May 26, 1939) during peacetime to provide control of waters and submerged lands abutting active military installations. Control of the submerged lands and waters, including the entrance channel and approaches to Pearl Harbor, remains with the United States rather than with the State of Hawaii (33 USC 475, 32 CFR 765.5). Entry control over Pearl Harbor has been delegated to the Commander, Navy Region Hawaii.