INSTALLATION RESTORATION PROGRAM

Preliminary Assessment Report for

Waiawa Gulch,
Installation 15080,
Pearl City, Oahu, Hawaii

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Prepared by
Applied Geosciences and Environmental Management Section
Environmental Research Division
Argonne National Laboratory

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9700 South Cass Avenue, Argonne, Illinois 60439

**Preliminary Assessment Report for
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Installation 15080,
Pearl City, Oahu, Hawaii**

Prepared for

National Guard Bureau, Army Directorate
Aberdeen, Maryland

August 1993

Prepared by

Applied Geosciences and Environmental Management Section
Environmental Research Division
Argonne National Laboratory

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Contents

Notation	vii
Summary	1
1 Introduction.....	3
1.1 Authority for the Preliminary Assessment	3
1.2 Objectives	3
1.3 Procedures	4
1.4 Report Format	4
2 Property Characterization	5
2.1 General Property Information.....	5
2.2 Description of Facilities.....	8
2.2.1 Mobilization and Training Equipment Site	8
2.2.2 Storage Warehouses	8
2.2.3 Storage Shed for Flammable Materials	9
2.3 Property History.....	9
2.4 Permitting Status	10
2.5 Surrounding Environment and Land Use	10
2.5.1 Demographics and Land Use.....	10
2.5.2 Climate	11
2.5.3 Surface Water and Physiography	11
2.5.4 Soils	13
2.5.5 Groundwater and Hydrogeology	14
2.5.6 Sensitive Environments.....	32
3 Environmentally Significant Operations	33
3.1 Storage for Hazardous Materials and Petroleum, Oils, and Lubricants.....	33
3.1.1 Waste Oil Storage.....	33
3.1.2 Open Storage for Petroleum, Oils, and Lubricants	33
3.1.3 Other Storage of Petroleum, Oils, and Lubricants.....	35
3.1.4 Storage Shed for Flammable Materials	35
3.2 Washrack.....	36
3.3 Dry-Well System.....	36
3.4 Underground Storage Tanks	36
4 Known and Suspected Releases	38
4.1 Releases to Groundwater	38
4.2 Releases to Surface Water	38
4.3 Releases to Soil	38
4.4 Releases to Air	39
4.5 Other Releases	39
5 Human and Environmental Receptors.....	40
5.1 Groundwater.....	40
5.2 Surface Water.....	40

Contents (Cont.)

5.3	Soil.....	40
5.4	Air.....	41
5.5	Other Receptors.....	41
6	Preliminary Assessment Findings and Conclusions.....	42
6.1	Summary of Preliminary Assessment Findings	42
6.2	Recommendations for Further Action	43
7	Sources of Information	45
7.1	References	45
7.2	Other Sources.....	46
	Appendix: Argonne Investigators.....	47

Tables

1	Identifying Information for Waiawa Gulch.....	7
2	Groundwater Summary: Waiawa Gulch.....	18

Figures

1	General Location of Waiawa Gulch	6
2	Groundwater Regions on Oahu	16
3	Locations of Wells in the Vicinity of Waiawa Gulch.....	17
4	Depth to the Base of the Caprock.....	26
5	Groundwater Flow Pattern through Pearl Harbor Aquifer	28
6	Map of Head Contours in Pearl Harbor Aquifer.....	29
7	Cross Section through Pearl Harbor Aquifer from Koolau Peak through Waiawa Shaft.....	31
8	Locations of ESOs at Waiawa Gulch Storage Property.....	34

Notation

Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOH	Hawaii Department of Health
EPA	U.S. Environmental Protection Agency
ESO	environmentally significant operation
HIARNG	Hawaii Army National Guard
IRP	Installation Restoration Program
MATES	mobilization and training equipment site
PA	preliminary assessment
PACDIV	Pacific Naval Division
POL	petroleum, oils, and lubricants
RCRA	Resource Conservation and Recovery Act
USGS	U.S. Geological Survey
USP&FO	U.S. Property and Fiscal Office
UST	underground storage tank

Units of Measure

d	day
ft	foot
ft ²	square foot
gal	gallon
in.	inch
L	liter
mg	milligram
mi	mile
mi ²	square mile
qt	quart

**Preliminary Assessment Report for
Waiawa Gulch,
Installation 15080,
Pearl City, Oahu, Hawaii**

Summary

This report presents the results of the preliminary assessment (PA) conducted by Argonne National Laboratory at the Hawaii Army National Guard (HIARNG) property near Pearl City, Oahu, Hawaii. Preliminary assessments of federal facilities are being conducted to compile the information necessary for completing preremedial activities and to provide a basis for establishing corrective actions in response to releases of hazardous substances. The principal objective of the PA is to characterize the site accurately and determine the need for further action by examining site activities, quantities of hazardous substances present, and potential pathways by which contamination could affect public health and the environment. This PA satisfies, for the Waiawa Gulch property, phase I of the Department of Defense Installation Restoration Program (IRP).

Waiawa Gulch is a 19.915-acre site located in the central portion of the island of Oahu, Hawaii, in Pearl City, in the county of Honolulu. The facilities included in this PA are the mobilization and training equipment site (MATES), a washrack, a fuel dispensing station, and vehicle storage buildings. The environmentally significant operations associated with the property are (1) storage of petroleum, oils, and lubricants (POL) and of hazardous materials; (2) a washrack; (3) a dry-well system; and (4) underground storage tanks.

The review of both historical and current practices at the property indicated that the Waiawa Gulch property poses little risk to human health or the environment, although Argonne's reviewers noted several areas of concern. Current operations at the Waiawa Gulch property were found to be environmentally sound in practice and to offer little opportunity for release. All storage of new POL products, as well as of waste oils, is done with both primary and secondary containment. In addition, there are spill-containment kits available at each site where products are stored. Solvents used at the site are handled by a certified recycling company. Spent batteries are shipped with the acid in place to the U.S. Property and Fiscal Office for disposal; however, there are a few concerns related to past practices prior to the initiation of the current waste-management programs:

- All drainage at the property, both past and current, is directly deposited into Waiawa Stream, which runs along the western boundary of the property.

Information on the historical practices at the property includes the neutralization and disposal of battery acids to the drainage, the operation of the washrack without oil-water separators in place, general use of the grease racks, and no secondary containment of waste products stored on the concrete pad at the washrack area.

- There is a dry-well system adjacent to the washrack in the southwest corner of the property, with no information regarding the use of the system. The location of the dry-well system is such that any and all spills associated with the use of the washrack area, including storage of waste products, would likely have resulted in the release of product to this system. In addition, the dry-well system may have been used for disposal of waste during the years before stricter environmental controls were enacted.

Unrelated to HIARNG activities entirely, but of great concern nonetheless, is the encroachment on the western boundary of the HIARNG property by an automobile salvage operation, the Honolulu Recycling Co.

Recommendations for the Waiawa Gulch property include the following:

- Sample the soils and sediment in the Waiawa Stream bed around the drainage pipe. Analyze the soils for heavy metals associated with battery acid, for petroleum products, and for solvents that may have been used or disposed of before 1986.
- Sample both the existing water and the soils and sediment present in the dry-well system. Analyze these materials for heavy metals associated with battery acid, for petroleum products, and for solvents.

Although they are not related to the IRP work performed at the Waiawa Gulch property, the activities on the property of the Honolulu Recycling Co. cause concern. Actions should be taken immediately to remedy the encroachment and the potential impact to the HIARNG site from activities of the Honolulu Recycling Co. The types of materials being stored there can and will result in releases to the environment that would be very similar to those associated with the HIARNG activities. Strategic sampling of the HIARNG property and of likely release points along the stream bed could offer protection against future liability, should a release occur.

1 Introduction

This document is a report of the preliminary assessment (PA) conducted by Argonne National Laboratory at the Hawaii Army National Guard (HIARNG) property known as Waiawa Gulch, located in Pearl City, Hawaii.

1.1 Authority for the Preliminary Assessment

The National Guard Bureau, Army Directorate, has engaged Argonne to perform PAs of selected HIARNG properties. These assessments are being done in a manner consistent with both the Department of Defense Installation Restoration Program (IRP) and the U.S. Environmental Protection Agency's (EPA's) Potential Hazardous Waste Site Preliminary Assessment Guidance. Preliminary assessments of HIARNG properties are conducted under the authority and direction of the IRP; the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or, more commonly, Superfund); and the Superfund Amendments and Reauthorization Act of 1986 (P.L. 99-499).

1.2 Objectives

This PA report is based on existing information from the HIARNG records that were made available to Argonne investigators and from other sources. Although this PA effort did not extend to the generation of new data, it nonetheless identifies areas where existing data are incomplete, unreliable, or ambiguous and recommends ways to address such shortcomings.

The objectives of the PA are to satisfy phase I of the IRP and to

- Identify and characterize the environmentally significant operations (ESOs),
- Identify property areas or ESOs that may require a site investigation,
- Identify ESOs or areas of environmental contamination that may require immediate removal,
- Identify properties for which no further action is needed, and

- Provide information sufficient to prescore the site with the EPA's PA Scoresheets (September 1991).

1.3 Procedures

The PA began with a review of files located at the headquarters for the Hawaii Army National Guard (HIARNG), at Diamond Head, Oahu, Hawaii, on April 26, 1993. A site visit was conducted on April 27, 1993, to obtain additional information through direct observation and interviews with personnel familiar with the property and its operations. Other relevant information was obtained on April 28 and 29 from the Water Resources Board and the Land Resources Management Department in Honolulu, Hawaii. In addition, several trips were made during the week of April 26 to the Pacific Naval Division (PACDIV) at Pearl Harbor, Oahu, Hawaii, to gather historical insight on Waiawa Gulch, which was part of a naval base excised to the HIARNG in 1959.

1.4 Report Format

This PA report presents a summary and evaluation of the data relevant to the PA for this property. Section 2 describes the property and its surrounding environment and land use. Section 3 identifies and characterizes the ESOs at the site. Section 4 discusses known and suspected releases to the environment, and Section 5 discusses potential human and environmental receptors for such releases. Section 6 summarizes the findings and conclusions, discusses the quality and reliability of the supporting information, identifies areas requiring further action, and suggests how such actions can be accomplished. Section 7 lists pertinent materials reviewed. The Appendix lists the Argonne investigators.

2 Property Characterization

2.1 General Property Information

This property is a compound of 19.915 acres in Pearl City, district of Ewa, Oahu, Hawaii. The site is located in the Pearl City Industrial Park in Waiawa. The property is immediately surrounded by light industrial business, with military reservations to the north, west, and south of the property and residential homes to the east. Figure 1 shows the general location of the property, and Table 1 lists pertinent information about it.

There are eight major buildings on the property, which are shown in Figure 1. Two are vehicle maintenance shops (Buildings 21 and 22), and the others are used for storage (Buildings 13, 25, 27, 28, 63, and 65). The mission of the mobilization and training equipment site (MATES) is to provide organization and limited direct support maintenance for all ground-surface equipment assigned to the supported units. In addition, the MATES provides the storage and in-storage maintenance for all types of equipment with low usage that are not normally required for unit training assemblies. Total building floor area at the site is approximately 138,000 ft². In addition to the buildings, there are several concrete slabs for open storage of petroleum, oils, and lubricants (POL) or of hazardous materials; a washrack; a grease pit; a storage building for flammable materials; and two underground storage tanks (USTs). The water and electricity for the property are supplied by the Navy from Pearl Harbor, except for the MATES building (Building 21), which is hooked up to city and county of Honolulu water. The sanitary sewer hookup is provided by the city and county of Honolulu.

Most of the property is surrounded by a security chain-link fence that limits access. There is a small portion of the property (with no buildings or improvements of any kind) that lies outside the fence. This property is currently being encroached upon by the Honolulu Recycling Co. operations located to the northwest of the property. There are 14 or 15 full-time persons working at the property and as many as 300 on drill weekends. Four different units drill at the property. All activity at the property takes place during the day. The typical working day is from 6:30 a.m. until 4 p.m.; however, personnel are often present as late as 5 p.m.

The property has a topographic high in the northeast corner, where the storage of most of the vehicles is located. All runoff from the property naturally runs southwest and empties into a

TABLE 1 Identifying Information for Waiawa Gulch

Property address	National Guard Waiawa Gulch Storage Area 96-1176 Waihona Street Pearl City, Hawaii 96782
Property location	
Latitude	21° 24' N
Longitude	157° 58' W
FISP^a installation number	15080
Installation facility administration	CW3 Alfred Paulino
Installation material handler	Sgt. Bruce Ekins
Types of facilities	MATES Vehicle storage POL storage Washrack Grease pit UST
License information	Real Estate Directive 7458, issued July 21, 1959
Principal point of contact	Adrian Chang HIARNG Department of Defense 3949 Diamond Head Road Honolulu, Hawaii 96816-4495 (808) 735-4659

^a Facility Inventory and Stationing Plan.

storm sewer system that drains directly into Waiawa Stream. The section of Waiawa Stream that borders Waiawa Gulch along the west boundary is dry. Currently, the stream bed is scattered with debris (auto wreckage, engine parts, etc.) from the Honolulu Recycling Co.

2.2 Description of Facilities

2.2.1 Mobilization and Training Equipment Site

The mission of the MATES is to provide organization and limited direct support maintenance for all ground-surface equipment assigned to the support units. The current MATES building (Building 21) has a concrete floor with no floor drains, hollow tiles, and corrugated iron siding. The building has five work bays, and the solvents and other hazardous materials (paints, etc.) are kept in locked cabinets. The solvents used at the property are recycled by a local company (UniTek Safety-Kleen). Waste oils generated at the property are accumulated in 55-gal drums and picked up by a commercial recycling vendor. Spent batteries are currently shipped to the U.S. Property and Fiscal Office (USP&FO) with the acid in them; however, in the past, the acid was removed, neutralized, drummed, and shipped. In addition, the MATES provides the storage and in-storage maintenance for all types of equipment with low usage that are not normally required for unit training assemblies. In addition to the MATES building (Building 21), Building 22 has been used as an equipment maintenance shop and is currently used as such on a more limited basis. The main area of the building has a concrete slab floor with no drains. The old battery-charging room did not have a drain, and neutralized battery acid was reportedly dumped outside the building years ago.

2.2.2 Storage Warehouses

There are six vehicle storage warehouses (Buildings 13, 25, 27, 28, 63, and 65) located at the Waiawa Gulch storage property. All of the warehouse buildings at the property are of similar construction. Each building has a concrete floor, wood frame, corrugated iron siding, overhead incandescent lighting, and sliding doors. In addition, each building has vent screens located on two sides of the building.

2.2.3 Storage Shed for Flammable Materials

Two storage sheds (Building 22A) constructed of metal placed on concrete footings are used for the storage of flammable materials. The sheds are kept locked and are constructed to provide proper ventilation and spill containment. The sheds are labeled with the appropriate warnings to identify the hazards associated with the stored materials.

2.3 Property History

By Real Estate Directive 7458, issued July 21, 1959, the Department of the Army authorized the acquisition, by transfer from the Navy, of approximately 33 acres, subsequently corrected by survey to be 36.837 acres of Navy property (land and buildings) situated in Waiawa Gulch, district of Ewa, Oahu, Hawaii. The Waiawa Gulch property reportedly had been used for storage of vehicles owned and operated by the Navy and of other materials since August 3, 1945. By letter from the District Public Works Office, 14th Naval District (File 80:R-320, Ser 5518), dated November 7, 1961, the Department of the Navy reassigned custody and control of this land, including improvements, to the Department of the Army. The improvements consisted of six warehouses, one equipment maintenance shop, one administrative building, one equipment storage warehouse, and one latrine and storage building, in addition to related utilities and roadways within the area's perimeter, including road access to the property. The original acquisition was reduced by disposal to the current 19.915 acres under permit from the Navy.

In 1966, two buildings (Building 16, the latrine and storage building; and Building 21, the equipment storage shed) were not needed and were in poor repair. Therefore, they were demolished by the HIARNG.

In 1968, the HIARNG granted the use and occupancy of Buildings 27, 28, and 65 to the Department of the Air Force. The term of the permit (contract DACA84-4-69-14) was for one year, from October 1968 to October 1969, for the storage of household furniture and appliances. The Air Force was also required during this time to maintain an area of approximately 10 ft around each building.

In June of 1975, approximately 3 acres of the Waiawa Gulch storage area was set aside by Executive Order 02768 for use as a National Guard Armory site under the control and management

of the Department of the Army. The armory and the property associated with it are not included in this assessment because they are owned by the state of Hawaii.

2.4 Permitting Status

No Resource, Conservation, and Recovery Act (RCRA), CERCLA, or atmospheric emissions permits are required by the property. The HIARNG did receive an industrial wastewater discharge certificate (certificate 425) from the city and county of Honolulu in February of 1978. This certificate requires the property to use an oil trap prior to discharge and to maintain oil disposal records. The property does both.

2.5 Surrounding Environment and Land Use

2.5.1 Demographics and Land Use

The state of Hawaii consists of eight major islands and 124 minor islands, with a total land area of 6,425 mi² and a general coastline of 750 mi. The island of Oahu has a general coastline of 112 mi and has a total resident population of 836,231 people. The total land area of Oahu is 395,264 acres, of which 15,360 are covered by water. Approximately 12% of the land on Oahu is federally owned, 20% is owned by the state or counties, and the remaining 67% is privately owned (chiefly large estates). On Oahu, the 1989 classification of land use reported approximately 92,000 acres as urban, 155,000 acres as conservation, and 139,000 acres as agricultural (Hawaii Department of Business and Economic Development 1989). Various measures of air pollution, such as suspended particulate matter, indicate that Honolulu is one of the nation's cleanest cities. The water pollution levels at the beaches throughout the state have also been reported as very low. Only two beaches in the entire state are above the accepted EPA levels for fecal coliform bacteria.

Waiawa Gulch storage area is located in Pearl City, which had a population of 30,993 on the 1988 estimated census (Hawaii Department of Business and Economic Development 1989). Most of the land to the north, northeast, and northwest is military reservation or agriculture, with the population concentrated south, east, and southwest. Waipahu is the community to the north, west, and southwest of Pearl City and has a population of approximately 31,435. Aiea borders Pearl City to the south and southeast and has a population of 8,906. The Waiawa Gulch property is located in the 80.06 census tract, which is approximately 1 mi² and has a population of 5,995

(Hawaii Department of Business and Economic Development 1989). The land immediately surrounding the Waiawa Gulch storage area is largely light industrial and military reservations. There are three schools located approximately 1 mi east of the property, a community college 1 mi south, and a high school about 1.5 mi southwest.

2.5.2 Climate

The average annual rainfall on Oahu varies from 300 in. on the central Koolau Range to as little as 20 in. on the leeward coast. The annual rainfall at the Waiawa Gulch National Guard site averages around 30 in. (Armstrong 1983), with the wettest months being December, January, and February. Rainfall on Oahu generally results from either anticyclonic (the most common) or cyclonic wind patterns. The dominant anticyclonic pattern produces the trade winds that blow from northeast to southwest for approximately 90% of the summer months and 50% of the winter months. For this reason, the part of the island where Waiawa is located is referred to as the leeward side, no matter what direction the wind is blowing from at any given time. The anticyclonic pattern results in orographic rainfall as the moist trade winds rise up the steep slopes of the windward mountains and are subsequently cooled. Rainfall progressively decreases from the mountains to the sea, resulting in the relatively modest level of rainfall at the Waiawa Stream site.

Oahu lies just south of the tropic of Cancer and has a very mild climate throughout the year. The mean annual temperature for the city of Honolulu is about 75°F (Visser and Mink 1964). The difference in the average temperature for the coldest month (72°F in January) and the warmest month (78.5°F in August) is only 6.5°F for Honolulu. The average daily range of temperatures for Honolulu is about 9°F.

2.5.3 Surface Water and Physiography

Much of the basal groundwater that is above mean sea level discharges into surface springs at the caprock margin. The flow out of Pearl Harbor Springs has declined from about 140 million gallons per day (gal/d) in 1910 to about 50 million gal/d in 1977 (Eyre 1987), the difference being caused by increased pumpage from the Pearl Harbor Aquifer system over the same period. The discharge from the springs at Waiawa has been measured by the U.S. Geological Survey (USGS) to be 12.3 million gal/d (median) and 11.9 million gal/d (average) (Commission on Water Resource Management 1990).

The National Guard site is situated next to Waiawa Stream, which is intermittent. The stream has one major tributary, the Waimano, which joins the Waiawa about 1/4 mi upstream from the MATES facility. According to the Corps of Engineers, Waiawa is the fifth longest stream on Oahu, with a total length of approximately 15.6 mi (Commission on Water Resource Management 1990). The headwaters of the Waiawa are in the Koolau Range.

The USGS has been continuously monitoring the discharge of Waiawa Stream into Pearl Harbor, near Pearl City, since 1952. Waiawa is designated as a "medium" sized stream (Commission on Water Resource Management 1990), based on its median outflow, calculated to be 4.7 million gal/d and its mean average outflow, calculated to be 21 million gal/d. The drainage area of Waiawa Stream is calculated to be approximately 26.4 mi². While the stream is not used as a municipal or county water supply, the Oahu Sugar Co. does divert some of the stream for agricultural purposes.

The mouth of Waiawa Stream at the Middle Loch of Pearl Harbor has been recognized as an estuarine environment (Commission on Water Resource Management 1990). An estuary is defined by the Hawaii Department of Health (DOH) as an area of "deep, characteristically brackish coastal waters in well defined basins with a continuous or seasonal surface connection to the ocean that allows entry of marine fauna" (Commission on Water Resource Management 1990). The DOH has classified the water quality of each estuary or embayment as either A or AA. The water quality of the Waiawa estuary was graded A. The DOH recommends that class A waters be preserved for recreational and aesthetic enjoyment or for any other use "as long as it is compatible with the protection of and propagation of fish, shellfish, and wildlife and with recreation in and on these waters."

According to the U.S. Fish and Wildlife Service, 1/2 mi² or less of palustrine wetlands is associated with Waiawa Stream. Wetlands are defined as areas with one or more of the following characteristics: open standing water, presence of hydrophytic vegetation (plants that grow in saturated conditions), or the presence of hydric (saturated or undrained) soils (Commission on Water Resource Management 1990). There have been no reports of endangered native aquatic species in Waiawa Stream, but because of its wetlands designation, it is listed as a "moderate" (ranked 3 on a scale of 1-4, with 4 being the lowest) aquatic resource (Commission on Water Resource Management 1990).

Waiawa Stream passes through only about 10% "native" forest. The majority of the Waiawa's watershed consists of alien vegetation or cultivated fields. Three species of detrimental

plants (California grass, mangrove, and hau) have been identified along the banks of the Waiawa. These weedy plants have been known to impede water flow. Wild pigs have also been sighted near the stream. These animals are considered detrimental because they can contaminate the water with fecal matter, destroy vegetation, and accelerate erosion. Because of its low ratio of native to alien forest and because of the presence of detrimental plants and animals, Waiawa Stream is not listed as a riparian resource.

Four species of native water birds associated with wetland areas or stream environments on Oahu are designated as endangered (50 CFR 17.11 and 17.12 of January 1, 1989; updated September 1989). These species are the Hawaiian coot (*Fulica americana alai*), the Hawaiian stilt (*Himantopus mexicanus knudseni*), the Hawaiian duck (*Anas wyvilliana*), and the Hawaiian moor hen (*Gallinula chloropus sandvicensis*). However, no endangered species have been found within four miles of the National Guard property (Environmental Communications 1986).

Waiawa Stream has not been surveyed for archaeological artifacts and is not regarded as an archaeological or cultural resource. Waiawa does offer many recreational opportunities, including hiking, swimming, fishing, and hunting, and has been ranked as a "substantial" recreational resource (ranked 2 on a scale of 1-4, with 1 being the most valuable).

2.5.4 Soils

The soils at the site are of the Helemano-Wahiawa association, which are generally well drained and moderately fine textured to fine textured (Foote et al. 1972). Helemano soils consist of dark reddish-brown silty clays and are found on the sides of steep gulches. Helemano soils have slopes ranging from 30% to 90%. Wahiawa soils generally have a red silty clay surface, a subsoil of dark reddish-brown silty clay, and a substratum of weathered rock. The Wahiawa soils have slopes ranging from 0 to 25%. The Helemano soils make up about 40% of the associations; the Wahiawa soils make up about 30%; and Kunia, Lahaina, and Molokai soils make up the remainder.

The National Guard site itself is on mixed-fill land, consisting of material dredged from the ocean or hauled from nearby areas. The soil in the bed of the Waiawa Stream that runs just to the west and north of the site is a stony clay loam of the Kawaihapai Series. This series consists of well-drained soils formed in alluvium derived from the erosion of basic igneous rock.

The steep slopes on either side of the stream consist of rock outcrops of basalt and andesite. The soil beyond the ridge to the west of the stream is a silty clay loam of the Molokai Series. To the east of the site, where extensive development has taken place, the soils consist of either the silty clay loam of the Molokai Series or a silty clay of the Lahaina Series.

2.5.5 Groundwater and Hydrogeology

During the early Tertiary Period, a volcanic ridge began to form along a fracture in the earth's crust in the central Pacific. Basaltic magma erupted from the fracture, resulting in a series of shield volcanoes, some of which eventually grew to considerable heights above sea level. This process continued throughout the Tertiary Period until eventually the entire Hawaiian archipelago was created, extending from the island of Hawaii to Kure Island 1,600 mi to the northwest. The large habitable islands, from Hawaii to Niihau, extend over a distance of about 380 mi and are situated on the southeastern end of the ridge.

The shield volcanoes that formed the ridge were generally built of thin basaltic lava flows. The remnants of two such volcanoes form the island of Oahu. The Waianae Volcano was the first to emerge from the sea and forms the western part of the island. The eastern part of Oahu consists of the eroded dome of the Koolau Volcano. The Waianae dome was already deeply eroded before the Koolau dome reached its maximum height. The piling up of lavas erupted from the Koolau Volcano against the eroded lower slopes of the Waianae dome is largely responsible for the gently sloping Schofield feature plateau north of the National Guard site.

Rocks formed from lava flows comprise the most important water-bearing formations on Oahu. Unweathered lava flow rock is, in general, highly permeable, because of a combination of clinker layers, lava tubes, contraction joints that formed when the lava solidified, and irregular openings on the surfaces of the individual flows. Vesicles, while greatly increasing the porosity of flow rock, are generally not well interconnected and do not greatly affect the overall permeability. Weathering generally decreases the overall permeability of the basaltic rock. The decrease in permeability because of weathering may extend to depths of 50-75 ft.

After the eruptions responsible for the creation of the Waianae and Koolau domes, a long period of quiescence followed, during which the two domes became deeply eroded. Sediments that were deposited around the southern edge of the volcanoes resulted in a flat coastal plain that begins just to the south of the Waiawa Gulch site. Changes in sea level during the Pleistocene

Epoch significantly affected the growth and development of this plain. During low stands of sea, large valleys were carved that were subsequently filled with sediments as the seas rose. The fossil remnants of coral reefs and marine and terrestrial alluvial sediments comprise the bulk of the coastal plain deposits. These sediments are much less permeable than the highly permeable lavas that make up the original domes. Hence the coastal plain deposits form a relatively impermeable caprock over the basaltic aquifers.

Oahu is divided into several groundwater regions based on the location and extent of the primary basal aquifer for that region (Figure 2) (Eyre 1987). In many cases, the various aquifers are physically separated by nearly vertical dikes of very low permeability. The Waiawa Gulch National Guard site is in the Koolau part of the Pearl Harbor Aquifer, the largest and most productive aquifer on Oahu. In 1990, the Pearl Harbor Aquifer produced about 157 million gal/d, and it has a sustainable yield of 184 million gal/d (Wilson Okamoto & Associates, Inc. 1992).

Figure 3 shows the wealth of municipal and private wells in the vicinity of the site (Hawaii Division of Water Resource Management 1992). Each well is identified by the minute of latitude and minute of longitude in which the well appears, as well as by a unique numeric suffix. Table 2 lists all of the wells shown on Figure 3. The well identification numbers in the leftmost column correspond to the minute of latitude (first two digits) and minute of longitude (second two digits) in which the well is located. The number following the hyphen is the unique identification suffix for that latitude and longitude.

The Pearl Harbor Aquifer is bounded by the Koolau rift zone to the northeast, the Schofield Aquifer system to the north, the south rift of the Waianae Volcano to the west, and the valley fills between Kalihi and South Halawa streams to the east. The aquifer flows through the permeable basaltic lava flows of the Koolau and Waianae volcanoes. The southern boundary of the Pearl Harbor Aquifer is defined by the less permeable sedimentary deposits of the Ewa coastal plain caprock. The depth to the base of the caprock is shown contoured in Figure 4. The 0-ft contour denotes the inland margin of the caprock. North of this boundary, the surface rock consists of basaltic lava flows. The Waiawa Gulch National Guard site is just north of the caprock margin.

The caprock contains significant amounts of water, ranging in salt content from freshwater to seawater. The freshwater in the caprock comes from a number of sources, including water leaking into the caprock from the underlying basaltic aquifer, springs flowing from the basaltic aquifer at the edge of the caprock, rainfall, and return flow from irrigated fields. The capacity of

FIGURE 3 Locations of Wells in the Vicinity of Waiawa Gulch (Source: Hawaii Division of Water Resource Management 1992)

TABLE 2 Groundwater Summary: Waiawa Gulch

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2255-01	U.S. Army		15	-459	-318	SLD
2255-02	Oahu Sugar		18	-308		SLD
2255-03	Oahu Sugar		20			SLD
2255-04	Oahu Sugar		23	-211	-63	SLD
2255-05	Oahu Sugar	1900	25	-520	-225	UNU
2255-06	Oahu Sugar	1900	25	-496	-222	SLD
2255-07	Oahu Sugar	1900	21	-370	-129	SLD
2255-08	Oahu Sugar	1900	19	-154	-108	SLD
2255-09	Oahu Sugar	1900	23	-376	-137	SLD
2255-10	Oahu Sugar	1900	25	-475		LOS
2255-11	Oahu Sugar	1900	25	-475		LOS
2255-12	Oahu Sugar	1900	19	-186	-136	SLD
2255-13	Oahu Sugar	1900	22	-266	-128	SLD
2255-14	Oahu Sugar	1900	20	-216	-114	SLD
2255-15	Oahu Sugar	1900	23	-408	-112	SLD
2255-16	Oahu Sugar	1900	22	-400	-110	SLD
2255-17	Oahu Sugar	1900	25	-425	-127	SLD
2255-18	Oahu Sugar	1900	26	-431	-131	SLD
2255-19	Oahu Sugar	1900	22	-404	-108	SLD
2255-20	Oahu Sugar	1900	21	-400	-99	SLD
2255-21		1900	31	-363	-194	OBS
2255-22		1900	32	-371	-368	OBS
2255-23	Oahu Sugar	1900	23	-381	-95	SLD
2255-24	Oahu Sugar	1900	26	-194	-124	SLD
2255-25	Oahu Sugar	1900	23	-365	-73	SLD
2255-26		1900	33	-332	-317	OBS
2255-27		1900	20	-283	280	OBS
2255-28	Oahu Sugar	1900	22	-106	-81	SLD
2255-29	Oahu Sugar	1930	26	-414	-123	SLD
2255-30	Oahu Sugar	1930	20	-407	-175	SLD
2255-31	Oahu Sugar	1930	20	-403	-170	SLD
2255-32	U.S. Navy	1937	95	-4		DOM
2255-33	Honolulu BWS ^b	1954	57	-28	-3	OBS
2255-34	C&H Sugar	1955	120	-1		UNU
2255-35	C&H Sugar	1956	119	-125	-32	IND
2255-36	C&H Sugar	1956	119	-121	-32	IND
2255-37	Honolulu BWS ^b	1961	256	-89	-49	MUN
2255-38	Honolulu BWS ^b	1961	270	-89	-44	MUN
2255-39	Honolulu BWS ^b	1961	258	-141	-38	MUN
2256-01	Oahu Sugar		17	-255	-163	SLD
2256-02	Oahu Sugar		19			LOS
2256-03	Oahu Sugar		10	-265		LOS
2256-04	U.S. Navy	1889	23	-267	-177	SLD
2256-05	Oahu Sugar	1908	38	-306	-49	SLD
2256-06	Oahu Sugar	1908	38	-300	-55	SLD

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2256-07	Oahu Sugar	1908	38	-307	-33	SLD
2256-08	Oahu Sugar	1908	38	-321	-60	SLD
2256-09	Oahu Sugar	1908	45		-53	SLD
2256-10	U.S. Navy	1922	11	-162	-132	OBS
2256-11	U.S. Navy	1923	14	-196	-130	OBS
2256-12	U.S. Navy	1923	11	-171	-128	OBS
2256-13	U.S. Navy	1943	16	-259	-138	SLD
2257-01	U.S. Navy		21	-486	-400	SLD
2257-02	U.S. Navy		21	-453	-401	SLD
2257-03	U.S. Navy		18	-485	-399	SLD
2257-04	U.S. Navy		18	-466	-415	SLD
2257-05	U.S. Navy		12	-379	-323	SLD
2258-01	U.S. Navy		4		-73	SLD
2258-02	Unit Chin TRS		14	-296	-204	SLD
2258-03	U.S. Navy	1906	12	-252	-174	SLD
2258-04	U.S. Navy	1920	15	-148	-107	SLD
2258-05	U.S. Navy	1921	15	-119	-88	SLD
2258-06	U.S. Navy	1923	14	-75	-64	SLD
2258-07	U.S. Navy	1928	9	-117	-95	SLD
2258-08	U.S. Navy	1934	3	-145	-131	SLD
2258-09	U.S. Navy	1939	11	-147	-45	SLD
2258-10	Honolulu BWS ^b	1940	3	-178	-88	SLD
2258-11	U.S. Navy	1940	12	-155	-116	SLD
2259-01	U.S. Navy		17			UNU
2259-02	U.S. Navy		10			UNU
2259-03	U.S. Navy	1889	2	-508		LOS
2300-01	II Estate		14	-409	-163	SLD
2300-02	II Estate		10	-204	-123	SLD
2300-03	Oahu Sugar		18	-170	-44	SLD
2300-04	Oahu Sugar		15	-380	-33	SLD
2300-05	Clifford Yuen		14			DOM
2355-01		1938	218	0	0	OBS
2355-02	Oahu Sugar	1945	195	-5		SLD
2355-03	Honolulu BWS ^b	1947	304	-38	16	MUN
2355-04	Honolulu BWS ^b	1947	304	15		SLD
2355-05	Honolulu BWS ^b	1947	304	-40	18	MUN
2355-06	Honolulu BWS ^b	1955	258	-102	-32	MUN
2355-07	Honolulu BWS ^b	1955	258	-100	-30	MUN
2355-08	Honolulu BWS ^b	1963	158	-232	-44	OBS
2355-09	Honolulu BWS ^b	1965	159	-254	-62	MUN
2355-10	Honolulu BWS ^b	1965	159	-254	-63	MUN
2355-11	Honolulu BWS ^b	1965	159	-254	-60	MUN
2355-12	Honolulu BWS ^b	1965	159	-254	-62	MUN
2355-13	Honolulu BWS ^b	1969	159	-254	-68	MUN
2355-14	Honolulu BWS ^b	1969	159	-254	-71	MUN

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2356-01	Oahu Sugar					LOS
2356-02	You & Shimizu		23	-376	-46	SLD
2356-03	Nakata, H.		30	-326	-317	SLD
2356-04	U.S. Navy		18	-82		
2356-05	U.S. Navy		6	-56		
2356-06	U.S. Navy		6	-59		
2356-07	U.S. Navy		6	-67		
2356-08	U.S. Navy		6	-73		
2356-09	U.S. Navy		6	-69		
2356-10	U.S. Navy		6	-49		
2356-11	U.S. Navy		6	-64		
2356-12	U.S. Navy		8	-57		
2356-13	You & Shimizu	1895	24	-233	-55	SLD
2356-14	Oahu Sugar	1899	46	-504		SLD
2356-15	Oahu Sugar	1899	46	-504		SLD
2356-16	Oahu Sugar	1899	46	-504		SLD
2356-17	Oahu Sugar	1899	46	-504		SLD
2356-18	Oahu Sugar	1899	46	-504		SLD
2356-19	Oahu Sugar	1899	46	-504		
2356-20	Oahu Sugar	1899	46	-939		SLD
2356-21	Oahu Sugar	1899	46	-418		SLD
2356-22	Oahu Sugar	1899	46	-424		SLD
2356-23	Oahu Sugar	1899	46	-504		
2356-24	Oahu Sugar	1899	46	-504		
2356-25	Oahu Sugar	1899	46	-504		
2356-26	Oahu Sugar	1899	46	-504		
2356-27	Oahu Sugar	1899	46	-574		SLD
2356-28	Oahu Sugar	1899	46	-504		
2356-29	Oahu Sugar	1899	46	-504		
2356-30	Oahu Sugar	1899	46	-504		
2356-31	Oahu Sugar	1899	46	-504		
2356-32	Oahu Sugar	1899	46	-504		
2356-33	Oahu Sugar	1899	46	-504		
2356-34	Oahu Sugar	1904	56	-899	-144	
2356-35	Oahu Sugar	1904	56			
2356-36	Oahu Sugar	1904	56			
2356-37	Oahu Sugar	1904	56	-651	-150	
2356-38	Oahu Sugar	1904	56	-349	-2	
2356-39	Oahu Sugar	1904	56	-447	-32	
2356-40	Oahu Sugar	1904	56	-454	-74	
2356-41	Oahu Sugar	1904	56	-448	-20	
2356-42	Oahu Sugar	1904	56	-428	16	
2356-43	Ridley, W.	1941	81	-19		SLD
2356-44	Ridley, W.	1941	81	-19	47	SLD
2356-45	Honolulu BWS ^b	1945	25	-152	-17	SLD

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2356-46	U.S. Navy	1948	33	-28		
2356-47	U.S. Navy	1948	42	-31		SLD
2356-48	U.S. Navy	1948	21	-30		SLD
2356-49	Honolulu BWS ^b	1954	102	-225	-27	MUN
2356-50	Honolulu BWS ^b	1955	102	-225	-25	MUN
2356-51	U.S.G.S.	1958	5	-1303	-86	OBS
2356-52	Honolulu BWS ^b	1959	87	-85	-14	SLD
2356-53	Honolulu BWS ^b	1959	26	-224	-49	SLD
2356-54	Pearl, C.C.	1966	374	-178	-21	IRR
2356-55	Honolulu BWS ^b	1966	252	-290	-37	MUN
2356-56	Honolulu BWS ^b	1966	252	-297	-44	MUN
2356-57	Honolulu BWS ^b		22	-228	-55	OBS
2356-58	Honolulu BWS ^b	1973	147	-193	-44	MUN
2356-59	Honolulu BWS ^b	1973	143	-192		MUN
2356-60	Honolulu BWS ^b	1975	23	-217	-77	MUN
2356-61	Honolulu BWS ^b	1975	111	-223	-79	MUN
2356-62	Honolulu BWS ^b	1975	117	-223	-83	MUN
2356-63	Honolulu BWS ^b	1975	26	-214	-74	MUN
2356-64	Honolulu BWS ^b	1975	20	-220	-143	MUN
2356-65	Honolulu BWS ^b	1975	112	-223	-83	MUN
2356-66	J.C. Penney	1977				
2356-67	J.C. Penney	1977				SLD
2356-68	J.C. Penney	1977				SLD
2356-69	J.C. Penney	1978				
2356-70	Lau Taro Farm	1987		-261	-220	IRR
2357-01	U.S. Navy		8	-82		
2357-02	Hawaiian Electric Co.		20	-174	-34	SLD
2357-03	Waimalu Dev.	1887	25	-289	-22	SLD
2357-04	Okuda, C.	1900	23	-402		IRR
2357-05	Hawaiian Electric Co.	1932	7	-58	-8	SLD
2357-06	Oahu Sugar	1934	12	-227	-80	SLD
2357-07	Chun, K.C.	1938	22	-190	-102	IRR
2357-08	Lee, M.C.	1938	22	-50	2	IRR
2357-09	Hawaiian Electric Co.	1938	10	-54	-16	UNU
2357-10	Hawaiian Electric Co.	1938	15	-75	-25	IND
2357-11	Hawaiian Electric Co.	1938	32	-75	-16	IND
2357-12	Hawaiian Electric Co.	1938	36	-47	-12	IND
2357-13	Hawaiian Electric Co.	1939	3	-93		UNU
2357-14	Hawaiian Electric Co.	1940	6	-89	-50	UNU
2357-15	Hawaiian Electric Co.	1940	6	-44	-3	UNU
2357-16	Hawaiian Electric Co.	1940	25	-173	-70	SLD
2357-17	Hawaiian Electric Co.	1940	23	-92	-32	UNU
2357-18	Hawaiian Electric Co.	1940	25	-78	-23	IND
2357-19	Inafuku, J.	1950	9	-435	-87	SLD
2357-20	Ho, C.	1956	14	-406	-66	SLD

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2357-21	Suyetani, W.	1963	11	-156	-56	DOM
2357-22	Schiltz Brewing	1965	7	-193	-130	SLD
2357-23	Honolulu BWS ^b	1975	49	-181	-41	MUN
2357-24	Honolulu BWS ^b	1975	45	-220	-80	MUN
2358-01	U.S. Navy-Lease		15	-76		IRR
2358-02	U.S. Navy		9	-327	-61	IRR
2358-03	Honolulu City		28	-137		SLD
2358-04	U.S. Navy		5	-107	-90	SLD
2358-05	Carnavaro, G.		6	-224		SLD
2358-06	U.S. Navy	1897	17	-120	-50	SLD
2358-07	Honolulu City	1905	28	-169		SLD
2358-08	Bishop Estate	1906	8	-117	-52	IRR
2358-09	U.S. Navy	1907	13	-415	-91	SLD
2358-10	U.S. Navy	1916	10	-175	-90	SLD
2358-11	U.S. Navy	1922	5	-92	-72	SLD
2358-12	Honolulu City	1922	11	-115		SLD
2358-13	Honolulu City	1926	30	-110	-24	SLD
2358-14	U.S. Navy	1926	15	-160		IRR
2358-15	U.S. Navy	1926	15	-165	-85	
2358-16	U.S. Navy	1926	15	-161	-38	
2358-17	U.S. Navy	1926	15	-161	-48	
2358-18	U.S. Navy	1939	12	-147	-38	SLD
2358-19	U.S. Navy	1944	10	-162	-102	OTH
2358-20	Honolulu BWS ^b	1946	47	-24	-13	OBS
2358-21	Taba, S.	1948	9	-111	-66	IRR
2358-22	Taba, S.	1948	9	-160	-67	IRR
2358-23	Nakama, W.	1949	12	-138	-71	IRR
2358-24	Taba, S.	1949	23	-97	-44	DOM
2358-25	Nakama, W.	1951	13	-137	-48	IRR
2358-26	Matsukawa	1952	8	-142	-72	IRR
2358-27	Miyahara, T.	1953	8	-92	-39	IRR
2358-28	Koshimizu, K.	1953	15	-103	-22	IRR
2358-29	Taba Farm, Inc.	1953	12	-167	-38	IRR
2358-30	Sakamoto, E.M.	1953	11	-92	-20	DOM
2358-31	Taba, S.	1953	8	-108	-43	IRR
2358-32	Taba, S.	1954	5	-127	-73	IRR
2358-33	Taba, S.	1954	5	-131	-79	IRR
2358-34	Taba, S.	1954	6	-150	-97	IRR
2358-35	Watanabe, U.	1954	12	-90	-42	DOM
2358-36	Konao Sasaki	1954	13	-89	-39	DOM
2358-37	Akamine, S.	1955	13	-85	-17	IRR
2358-38	Gora, G.	1955	12	-88	-38	DOM
2358-39	Koizumi, J.	1957	10	-110	-24	SLD
2358-40	Nakama, W.	1957	18	-101	-44	DOM
2358-41	Koizumi, R.	1957	3	-163	-87	IRR

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)				Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing		
2358-42	Koizumi, R.	1958	10	-100	-52		IRR
2358-43	Kini, A.	1959	25	-5	0		DOM
2358-44	Nakama, S.	1962	14	-151	-23		IRR
2358-45	Gora, G.	1967	38	-63	-33		DOM
2358-46	Konao Sasaki	1967	45	-130	15		DOM
2358-47	Alipio, D.	1967	35	-106	-61		DOM
2358-48	Koizumi, J.	1970	5	-190	-118		IRR
2358-49	Nazarene Church	1976	21	-104	-55		DOM
2358-50	Kevin P. Young	1985	38	-42			DOM
2358-52	Buddy Gendrano	1990	15	-60	-55		DOM
2359-01	U.S. Navy	1899	30	-309	-114		UNU
2359-02	Bento, J.P.	1930	86	7	16		SLD
2359-03	U.S. Navy	1943	97	-80	-3		SLD
2359-04	Taba, S.	1953	11	-94	-43		IRR
2359-05	Oshita, S.	1953	9	-141	-48		IRR
2359-06	Sasaki, S.	1953	6	-121	-35		IRR
2359-07	Asato, F.	1953	11	-129	-52		DOM
2359-08	Horita, H.	1953	7	-89	-50		DOM
2359-09	Koshimizu	1953	8	-94	-66		DOM
2359-10	Gora, G.	1954	23	-77	-20		DOM
2359-11	Kobashigawa	1954	30	-100	-7		DOM
2359-12	Brown, G.	1954	25	-251	-115		DOM
2359-13	Nishida, I.	1955	8	-122	-42		DOM
2359-14	Horita, H.	1956	8	-163	-44		IRR
2359-15	Sasaki, S.	1958	9	-182	-29		IRR
2359-16	Asato, F.	1958	10	-152	-54		IRR
2359-17	James Oshita	1958	11	-164	-49		IRR
2359-18	Jiminez, E.	1959	24	-102	-43		DOM
2400-01	Honolulu BWS ^b	1954	200	-155	-31		MUN
2400-02	Honolulu BWS ^b	1954	200	-155	-31		MUN
2400-03	Honolulu BWS ^b	1969	200	-186	-54		MUN
2400-04	Honolulu BWS ^b	1969	200	-186	-54		MUN
2400-05	Honolulu BWS ^b	1983	207	-135	-32		UNU
2400-06	Honolulu BWS ^b	1983	211	-133	-30		UNU
2401-01	U.S. Navy	1946	96	-204	-72		UNU
2455-01	Honolulu BWS ^b	1955	168	-153	-12		OBS
2455-02	Minami, K.	1958	128	-78	-12		DOM
2455-03	Minami, K.	1964	100	-120	-80		
2456-01	Honolulu BWS ^b	1972	263	-237	-37		MUN
2456-02	Honolulu BWS ^b	1972	263	-237	-37		MUN
2456-03	Honolulu BWS ^b	1972	263	-237	-37		MUN
2456-04	Oceanview Ventures	1974	450	-115	-19		UNU
2457-01	Honolulu BWS ^b	1957	267	-131	-14		MUN
2457-02	Honolulu BWS ^b	1957	267	-148	-14		MUN
2457-03	Honolulu BWS ^b	1968	272	-151	-32		MUN

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2457-04	Honolulu BWS ^b	1968	155	-1,303	-769	OBS
2457-05	Honolulu BWS ^b	1970	145	-299	-159	MUN
2457-06	Honolulu BWS ^b	1970	151	-307	-161	MUN
2457-07	Honolulu BWS ^b	1970		(455) ^c		SLD
2457-08	Honolulu BWS ^b	1970		(338) ^c		SLD
2457-09	Honolulu BWS ^b	1970	153	-308	-159	MUN
2457-10	Honolulu BWS ^b	1970	146	-222	-71	MUN
2457-11	Honolulu BWS ^b	1970	141	-222	-70	MUN
2457-12	Honolulu BWS ^b	1970	140	-227	-70	MUN
2457-13	Honolulu BWS ^b	1971	263	-241	-37	MUN
2457-14	Honolulu BWS ^b	1971	263	-240	-37	MUN
2457-15	Honolulu BWS ^b	1971	263	-240	-37	MUN
2458-01	Honolulu BWS ^b	1940	111	102		MUN
2458-02	Oahu R.R. & L.	1952	117	-38		
2458-03	Honolulu BWS ^b	1953	120	-30	64	MUN
2458-04	Honolulu BWS ^b	1953	120	-20	62	MUN
2459-01	Oahu Sugar		40	-664		IRR
2459-02	Oahu Sugar		40	-542		IRR
2459-03	Oahu Sugar		40	-699		IRR
2459-04	Oahu Sugar		40	-666		IRR
2459-05	Oahu Sugar		40	-560		IRR
2459-06	Oahu Sugar		40	-660		IRR
2459-07	Oahu Sugar		40	-550		IRR
2459-08	Oahu Sugar		40	-537		IRR
2459-09	Oahu Sugar		40	-667		IRR
2459-10	Oahu Sugar		40	-660		IRR
2459-11	Oahu Sugar		40			IRR
2459-12	Oahu Sugar		40			IRR
2459-13	Oahu Sugar		40	-660		IRR
2459-14	Oahu Sugar		40	-660		IRR
2459-15	Il Estate	1948	146	-15	138	OBS
2459-16	Kawano, H.	1955	22	-109	-26	UNU
2459-17	Gora, G.	1957	19	-123	-85	DOM
2459-18	Kawano, H.T.	1963	22	-163	-26	DOM
2459-19	Honolulu BWS ^b	1964	202	-135	-32	MUN
2459-20	Honolulu BWS ^b	1964	202	-135	-32	MUN
2459-21	Yoshimura, D.	1965	32	-424	-228	IRR
2459-22	Alipio, D.			(114) ^c		DOM
2459-23	Honolulu BWS ^b	1977	200	-135	-38	MUN
2459-24	Honolulu BWS ^b	1977	196	-171	-40	MUN
2459-25	Cabitac, R.M.	1977	21	-104	-55	DOM
2500-01	Honolulu BWS ^b	1978	416	-130		MUN
2500-02	Honolulu BWS ^b	1978	419	-141		MUN
2557-01	State of Hawaii	1941	495	-17	23	DOM
2557-02	State of Hawaii	1950	495	-97	16	DOM

TABLE 2 (Cont.)

Well No.	Owner or User	Year Drilled	Elevation above Mean Sea Level (ft)			Major Use ^a
			Top of Hole	Bottom of Hole	Bottom of Casing	
2557-03	Honolulu BWS ^b	1977	620	-130	-30	MUN
2558-01	U.S. Navy	1948	150	-128		SLD
2558-02	U.S. Navy	1948	185	-33		
2558-03	U.S. Navy	1948	106	-31		LOS
2558-04	U.S. Navy	1948	134	-66		
2558-05	U.S. Navy	1948	149	-29		
2558-06	U.S. Navy	1948	425	-50	-43	SLD
2558-07	U.S. Navy	1948	391	-18		SLD
2558-08	U.S. Navy	1948	438	-55		OBS
2558-09	U.S. Navy	1948	400	-35	-35	
2558-10	U.S. Navy	1951	150	-20		OTH
2600-01	Kondo, T.	1954	304	-49	-27	
2600-02	Ige, Y.	1957	297	-104	-2	DOM
2600-03	Honolulu BWS ^b	1980	664	-150	-40	UNU
2600-04	Honolulu BWS ^b	1980	665	-150	-40	UNU
2600-05	U.S. Air Force	1988			-13	OBS
2657-01	Bishop Estate	1952	367	-133	273	
2657-02	Bishop Estate	1953	360	-240	-10	IRR
2658-01	Oahu Sugar	1961	702	-103	10	IRR
2658-02	Oahu Sugar	1961	700	-135	-16	IRR
2659-01	State Dowald	1986	412	-1,377	0	OBS
2659-02	Honolulu BWS ^b	1987	571	-139	-86	UNU
2659-03	Honolulu BWS ^b	1988	572	-128	-29	UNU

^a DOM, Domestic; IND, industrial; IRR, irrigation; LOS, lost; MUN, municipal; OBS, observation; OTH, other; SLD, sealed; and UNU, unused.

^b BWS, Board of Water Supply.

^c Numbers within parentheses denote total depth of well (elevation unknown).

FIGURE 4 Depth to the Base of the Caprock (Source: Visser and Mink 1964)

the caprock to store and transmit water is much less than that of the Pearl Harbor basaltic aquifer, however, and in general the caprock does not contain large supplies of developable freshwater.

The Pearl Harbor Aquifer system itself consists of a freshwater lens that floats on top of salt water that has intruded from the sea into the permeable basalt. The thickness of the freshwater lens can be estimated from the Ghyben-Herzberg formula (Eyre 1987), which states that a static body of freshwater floating on salt water will extend to a depth below sea level of 40 times the head of the freshwater lens above sea level. In reality, there is no sharp demarcation between freshwater and seawater, but instead, there is a broad transition zone in which the chloride concentration of the aquifer increases with depth. The situation is further complicated because the Pearl Harbor Aquifer is definitely not static but is flowing (see subsequent text). Nonetheless, the 40:1 ratio has been adopted as a general rule of thumb, even though the ratio appears to predict the midpoint of the transition zone, using head data, only to within 10-20% (Eyre 1987).

The principal source of recharge for the Pearl Harbor Aquifer is rainfall on the highlands of the Koolau Range. The groundwater flow pattern through the aquifer is shown in Figure 5, and the corresponding map of head contours is shown in Figure 6. Groundwater flow is essentially horizontal throughout the basin, with hydraulic gradients ranging from 0.5 to 2 ft/mi (Eyre 1983). With an average porosity throughout the aquifer of 0.10% (Mink 1980) and with a hydraulic conductivity between 1,000 and 2,000 ft/d (Soroos 1973), an average flow velocity of 1-5 ft/d is derived from Darcy's law. A value of 3.5 ft/d was derived based on the length of time that it took for the aquifer to flush after termination of irrigation above the Waiawa shaft (Eyre 1987). A more sophisticated calculation taking into account dispersion yields a value of 7-10 ft/d in the vicinity of the Waiawa shaft.

Because of the largely horizontal flow pattern of the groundwater in the Pearl Harbor Aquifer and with the regional flow direction shown in Figure 5, any contamination from the National Guard site that made it into the groundwater would be more likely to appear in the domestic and irrigation wells in block 2359 than in the municipal supply wells for Pearl City or Waipahu.

Significant vertical flow only occurs when the groundwater begins to discharge into the caprock. Flow not removed from the aquifer by pumpage is either released through surface springs at Pearl Harbor (as discussed previously in the section on surface water) or is discharged directly

FIGURE 5 Groundwater Flow Pattern through Pearl Harbor Aquifer (Source: Eyre 1983)

FIGURE 6 Map of Head Contours in Pearl Harbor Aquifer (Source: Eyre 1983)

into the caprock. Most of the flow is probably concentrated in the more permeable limestone layers that occupy the upper 200 ft or so of the caprock. In 1985, it was estimated that about 30 million gal/d was discharged into the caprock (Eyre 1987).

Some recharge also occurs from local rainfall and return of irrigation water. Returned irrigation water contains a high concentration of dissolved salts and other chemicals, as does rainwater, through the leaching of residual chemicals. The vertical infiltration rate through Waiawa soils has been measured to be approximately 5 ft/d (feet per day) (Green et al. 1982), although the variation in this number is large because of the inhomogeneity of the vertical section. Upon reaching the water table, the percolate of returned irrigation water and rainfall enters the ambient flow of the Pearl Harbor Aquifer. The recharge water percolates through unsaturated soils, weathered basalt, and unweathered basalt.

The high dissolved salt content of the recharge water and the fact that it assumes a horizontal flow direction upon entering the aquifer result in a zone near the top of the water table of higher than usual saline concentration at the mid to low elevations. Figure 7 demonstrates this effect by showing a cross section through the Pearl Harbor Aquifer from Koolau Peak through the Waiawa shaft and extending into the coastal plain. (This is cross section Y-Y' shown in Figure 5.) The more saline zone tends to stay on top of the freshwater lens and may extend downward for up to 300 ft or so below the water table (Eyre 1983). This zone thins or becomes more dilute further inland from the caprock (Hufen et al. 1980).

Figure 7 is intended to show a very schematic representation of this effect. In those areas where there has been no irrigation for extended periods of time, however, as in the case of the area to the east of the National Guard site, which has since been heavily developed, the amount of irrigation return water has declined to the point where it has no measurable effect on the water quality of the aquifer. Levels of chloride, nitrate, and bicarbonate have declined to background levels in this area; for example, the chloride concentration at the Pearl City wells east of the Waiawa shaft has declined from 140 to 40 mg/L since the end of irrigation in the area (Eyre 1983). The chloride concentration at the Waiawa shaft itself has declined from over 250 mg/L in 1982 to about 60 mg/L in 1987, after the cessation of irrigation of the fields immediately above the shaft (Eyre 1987). Because the natural recharge due to rainfall in the vicinity of the Waiawa shaft and the Pearl City wells is minimal, the decline in chloride concentrations is directly attributable to the flushing of the degraded water by the normal horizontal flow of groundwater.

FIGURE 7 Cross Section (Y-Y' on Figure 5) through Pearl Harbor Aquifer from Koolau Peak through Waiawa Shaft (Source: Eyre 1983)

While the behavior of the chloride concentrations in the wells around the Waiawa area is thought to be well understood, there are several places where high chloride levels cannot be adequately explained by irrigation or other activity. For instance, Takasaki (1971) has observed a decreasing chloride concentration with depth in several wells in the Waianae district on the western coast of Oahu. Wells exhibiting this anomalous behavior are almost always found in dry coastal areas that experience strong ocean winds. When the surf happens to be high, these areas may be blanketed by a salt mist for several days. After salt has accumulated in the soils, heavy storms apparently then leach the salt into the aquifer. Since the salty recharge water close to the shore would overlie the fresher inland water moving toward the sea, the water at the top of the aquifer would be saltier than the deeper water.

In some instances, wells that are far from any irrigated fields exhibit elevated levels of nitrates, as well as chlorides, in the shallow section. It may be that these wells are influenced by phreatophytes (trees that have deep taproots). Where these roots penetrate the water table, such plants may transpire as much as 70 in. of water in a year (Zones 1963). This prodigious transpiration rate serves to concentrate dissolved solids at the water table. Moreover, many such trees are also nitrogen-fixers and increase the level of nitrogen in the soil, which could then be converted to nitrate; however, this process is at present poorly understood (Eyre 1987).

2.5.6 Sensitive Environments

A study conducted in 1986 indicated that no environmentally sensitive areas or endangered species exist within a 4-mi radius of the property (Environmental Communications 1986).

3 Environmentally Significant Operations

The PA team from Argonne identified four ESOs at the Waiawa Gulch storage area: (1) POL and hazardous materials storage, (2) the washrack, (3) a dry-well system, and (4) USTs. Figure 8 shows the general locations of the ESOs and the topography as it relates to the drainage of surface water from the property into Waiawa Stream.

3.1 Storage for Hazardous Materials and Petroleum, Oils, and Lubricants

The MATES has several locations where POL or hazardous materials are stored. Total aboveground POL storage amounts to about 2,000 gal. Belowground storage is 6,000 gal in the form of one 3,000-gal tank for motor fuel and one 3,000-gal tank for diesel fuel.

3.1.1 Waste Oil Storage

Used oil is containerized in 55-gal steel drums and stored upright on wooden pallets in secondary-containment structures within the perimeter fencing. There is no berm to prevent spilled oil from draining to and into Waiawa Stream. The USP&FO periodically removes the waste oil for final disposal or recycling. Three drums were on hand during the property visit, for an approximate capacity of 165 gal. The possibility of a spill reaching the stream is further mitigated by the presence of spill-containment kits and fire extinguishers located at each site where storage occurs.

3.1.2 Open Storage of Petroleum, Oils, and Lubricants

A supply of POL products is stored on a cement pad within a containment structure, and a tarp flap protects the products from the elements. The following types of materials are stored on the pad:

- 55-gal steel drums of lubricating oil (various viscosities),
- 55-gal steel drum of waste diesel fuel, and
- 55-gal steel drum of solvent.

FIGURE 8 Locations of ESOs at Waiawa Gulch Storage Property

There is a positive containment structure for the open POL storage, as well as spill-containment kits and fire extinguishers located at each site. The potential of a spill reaching Waiawa Stream is small; however, the porous ground surrounding the pad increases the potential for groundwater contamination, should a spill occur.

3.1.3 Other Storage of Petroleum, Oils, and Lubricants

Just outside Building 21, where all vehicle maintenance is performed, was the storage area for in-use POL and other liquids. Here, drums were stored horizontally in wooden racks for easy access. There were 55-gal drums of lubricating oils of various viscosities, a 55-gal drum of kerosene, and a 55-gal drum of alcohol. At capacity, a total of 710 gal could be stored here. Sand-filled troughs were in place below dispensing valves. The potential of an unmitigated spill was small. Currently, all POL storage is in the washrack area. The oils and solvents are stored with the spill containment provisions described in Section 3.1.2.

3.1.4 Storage Shed for Flammable Materials

This building houses materials that are flammable. The metal shed remains locked, except when a substance is to be removed or replaced. There are no floor drains within, and materials are normally stored on shelves. Typical materials stored in the shed are the following:

- Thinner, enamel, in 1-gal cans;
- Thinner, lacquer, in 1-gal cans;
- Spray paint in 1-qt cans;
- Methanol in 5-gal cans;
- Brake fluid in 1-gal cans;
- Zinc chromate primer in 1-qt containers;

- Transmission oil in 1-qt containers; and
- Lubricating oils of various viscosities in 1-qt cans.

The potential for a released spill from this shed is minimal.

3.2 Washrack

The washrack located along the western boundary of the property is used by all units training at Waiawa Gulch. Historically, the washrack operated without an oil-water separator and would plug up with dirt and sediment frequently. Personnel would clean the separator out and dispose of the accumulated material in the Waiawa Stream. A grease pit is also located at the property.

3.3 Dry-Well System

Little is known about the dry-well system located in the southwest corner of the property. The system's location adjacent to the open POL and waste storage on the concrete slab does cause some concern. During the field trip, the ANL personnel did remove the concrete cap from the system and visually inspected it from the surface. Half of the system contained standing water that had a slight indication of a film on the surface of the water. The other half, which was separated by a 2- or 3-ft concrete wall, was a dry gravel bed. The HIARNG personnel had no information concerning any use of the system for disposal of any materials at any time in the past or present; however, the location of the well system made it a likely target for any spills that may have occurred before the current secondary containment and spill-prevention measures were present. In addition, experience suggests that the dry wells could have been used at some time in the past for the disposal of liquid wastes generated at the site.

3.4 Underground Storage Tanks

One 3,000-gal fiberglass UST for motor fuel and one 3,000-gal fiberglass UST for No. 2 diesel fuel are located at the property. The tanks replaced two underground steel tanks with capacities of 1,200 gal (No. 2 diesel fuel) and 5,000 gal (motor fuel). The new tanks are outfitted with a float system to gauge liquid level and available capacity. In addition, a new dispensing

station was built. The motor fuel pump and a diesel fuel dispensing pump are built on separate islands. The islands consist of raised concrete platforms with corrugated steel roofs and the pumps. The system meets currently recommended spill-control measures. The potential for spills will be greatest during dispensing of gasoline and filling of the underground tanks. The pumps are locked during nonduty hours.

4 Known and Suspected Releases

4.1 Releases to Groundwater

There are no documented releases to the groundwater from the MATES; however, the condition and the past use of the dry well located at the southwest corner of the property is in question. The principal use of a dry-well system is to concentrate a groundwater recharge area by diverting all of the surface flow to the dry wells during storms or floods. In doing this diversion and concentration at an industrial site, there are many times when materials that should not be introduced into the system inadvertently make their way in and are left to percolate down each time there is a storm.

4.2 Releases to Surface Water

No release of contaminants to the surface water are known; however, there is reasonable concern that any past or present spill, if not immediately contained, would have made its way directly to Waiawa Stream via the storm drainage system at the property. Each POL site at the property also has an emergency spill-containment kit and a fire extinguisher. This offers great protection against any spills being released from these activities today. Prior to the installation of an oil-water separator and secondary containment around the open POL storage area, all spills and drainage were likely discharged to the stream.

4.3 Releases to Soil

No releases of contaminants to the soils at the property are known. Most of the property is paved, and no obvious signs of stressed vegetation or oil staining were noted during the property visit. In addition, all open POL storage was secured in the secondary-containment structure located on the concrete slab across from the washrack.

4.4 Releases to Air

No releases of contaminants to the air are known. The opportunity for air release is limited to exhaust from the motor vehicles and limited vapors associated with vehicle refueling and thus is not considered a problem.

4.5 Other Releases

No other significant releases of contaminants to the environment have been identified for the Waiawa Gulch storage area.

5 Human and Environmental Receptors

5.1 Groundwater

There have been no reported releases to the groundwater associated with the Waiawa Gulch National Guard property; however, the property is in the Koolau part of the Pearl Harbor Aquifer, the largest and most productive aquifer on Oahu. In 1990, the Pearl Harbor Aquifer produced about 157 million gal/d. The principle source of recharge for the Pearl Harbor Aquifer is rainfall on the highlands of the Koolau Range.

Waiawa Gulch storage area is located in Pearl City, which has a population of approximately 30,993. Most of the land to the north, northeast, and northwest is military reservation or agriculture, with the population concentrated south, east, and southwest. Waipahu is the community to the north, west, and southwest of Pearl City and has a population of approximately 31,435 people. Aiea borders Pearl City to the south and southeast and has a population of 8,906. There is a considerable number of private and municipal wells in the vicinity of the site, and all of the local population (within the 4-mi radius) relies on groundwater as the drinking water source. Therefore, any releases that may have occurred (or that may occur in the future) have the potential to affect a significant portion of the population.

5.2 Surface Water

No releases to surface water from the Waiawa Gulch property have been reported, and Waiawa Stream is intermittent, with very little or no flow for most of the time. The Waiawa Stream has flooded infrequently during these heavy rains. At times the stream has overflowed its banks, inundating all of the MATES up to the road. The stream is not used as a municipal or county water supply. The Oahu Sugar Co. does divert some of the stream for agricultural purposes.

5.3 Soil

Access to the property is limited to on-site personnel (five or six full-time personnel and a maximum of 150 weekend personnel). The property is fenced for security and is locked in the evening when HIARNG personnel leave. In addition, there is a security patrol for the nonduty

hours at the property. The receptors for any soil contaminants are strictly limited to HIARNG personnel.

5.4 Air

There are no known releases of contaminants to the air. As stated earlier, emissions from the exhaust of motor vehicles would be the only occasion for release to air at the property. With this limited source for airborne contamination, no off-base receptors have been identified.

5.5 Other Receptors

No other receptors of contaminants from the Waiawa Gulch storage area have been identified.

6 Preliminary Assessment Findings and Conclusions

6.1 Summary of Preliminary Assessment Findings

The Waiawa Gulch storage area is a compound of 19.915 acres in Pearl City, district of Ewa, Oahu, Hawaii. The site is located in the Pearl City Industrial Park in Waiawa. The property is immediately surrounded by light industrial business, with military reservations to the north, west, and south of the property and residential homes to the east. The ESOs associated with the property are POL and hazardous materials storage, a washrack, a dry-well system, and USTs. Current operations at the Waiawa Gulch property were found to be environmentally sound in practice and to offer little opportunity for release. All storage of new POL products, as well as waste oils, is done with both primary and secondary containment. In addition, there are spill-containment kits available at each site where products are stored. Solvents used at the site are handled by a certified recycling company. Spent batteries are shipped with the acid in place to the USP&FO for disposal. There are, however, a few concerns related to past practices prior to the initiation of the current waste-management programs:

- All drainage at the property, both past and current, is directly deposited into Waiawa Stream. Information on the historical practices at the property includes the neutralization and disposal of battery acids to the drainage, the operation of the washrack without oil-water separators in place, general use of the grease racks, and no secondary containment of waste products stored on the concrete pad at the washrack area.
- Adjacent to the washrack, there is a dry-well system, with no information regarding its use. The location of the dry-well system is such that any and all spills associated with the use of the washrack area, including storage of waste products, would likely have resulted in the release of product to this system.
- Unrelated to HIARNG activities entirely, but of great concern nonetheless, is the encroachment on the western boundary of the HIARNG property by an automobile salvage operation, the Honolulu Recycling Co.

6.2 Recommendations for Further Action

The primary objective of the PA is to identify and evaluate ESOs that would result in either (1) immediate action, (2) site investigation, or (3) no further PA/IRP action. Generally, the available information indicates that the Waiawa Gulch storage area presents a minimal threat to human health and the environment; however, on the basis of the information made available to Argonne, several areas deserve further consideration to ensure protection for the local community and the environment.

Recommendations for the Waiawa Gulch property include the following:

- Sample the soils and sediment in the Waiawa Stream bed around the drainage pipe. Information concerning historical practices regarding disposal of battery acids and the storage and disposal of waste oils and solvents indicates that contaminants associated with these activities may have accumulated because of natural drainage from the property. Therefore, the soils and sediment in the drainage areas should be analyzed for heavy metals associated with battery acid and for organic compounds associated with petroleum products and solvents that may have been used or disposed of before 1986.
- Sample both the existing water and the soils and sediment present in the dry-well system. The location of this dry-well system alone justifies the need for some concern because of the storage of waste products on the concrete adjacent to the system. No information identifying the use of the wells for disposal was available; however, typically, dry wells have been used for such purposes at many properties. The standing water, as well as the soils and sediments, should be analyzed for heavy metals associated with battery acid and for organic compounds associated with petroleum products and solvents.

Although not necessarily associated with the IRP work performed at the Waiawa Gulch property, there is reason for the HIARNG to be concerned about the activities of the Honolulu Recycling Co. on the property. Actions should be taken immediately to remedy the situation. The types of materials being stored there can and will result in releases to the environment that would be very similar to those associated with the HIARNG activities. Although Waiawa Stream is dry at this location, the opportunity for a serious problem is very great, should heavy rains and flooding occur. If flooding occurred, it would be nearly impossible to identify the person or persons

actually responsible for the release. Strategic sampling of the HIARNO property and of likely release points along the stream bed could offer protection against future liability, should a release occur.

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